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GREENHOUSE GAS EMISSIONS FROM AUSTRALIAN TRANSPORT: A MACRO MODELLING APPROACH

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PREFACE

This paper presents the results of a Bureau of Transport and Regional Economics (BTRE) study involving a general equilibrium modelling (or 'top-down') approach to deriving projections of greenhouse emissions from the Australian transport sector.

The study represents the BTRE's first published application of its recently acquired computable general equilibrium model in the area of transport emissions. As a result of this work, the model is now well equipped to analyse the economy-wide impact of a range of environmental policies, should this be required for future policy development purposes.

The study also complements 'bottom-up' modelling (ie detailed modelling of the transport sub-sectors), which the BTRE has undertaken concurrently on behalf of the Australian Greenhouse Office (AGO). These results have recently been published as *Greenhouse Gas Emissions from Australian Transport: Trends to 2020*.

The project has received professional support from the Centre of Policy Studies (CoPS), Monash University through a consultancy contract. The BTRE gratefully acknowledges the significant contributions made by Dr Philip Adams at the various stages of the project development, including implementation of the proposed model enhancements, coaching BTRE staff to use and gain a better understanding of the model, and commenting on earlier drafts of this paper.

The BTRE also wishes to thank Simon Wear from AGO for his contribution to the formation of assumptions for the base ('business as usual') case and for AGO's comments on the draft.

The research team comprised Dr William Lu (project leader) and Dr Krishna Hamal. Bruce Anderson provided research assistance. Tony Moleta provided advice on the direction of model enhancements from a policy perspective. Dr David Cosgrove and David Mitchell supplied fuel efficiency estimates from the 'bottom-up' vehicle fleet models. Dr Mark Harvey directed the project.

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Executive Director

Bureau of Transport and Regional Economics
Canberra
February 2003

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SUMMARY

This report uses an enhanced version of the MMRF–GREEN model to make projections of greenhouse gas emissions from the Australian transport sector. It is assumed that in the coming decade:

- the Australian economy will expand at an average annual rate of 3.4 per cent;
- population will grow at an average annual rate of 0.93 per cent;
- consumer preferences will remain the same as in recent years;
- fuel efficiency in the private use of transport services will improve at a slower rate than in the past;
- fuel-using technology in the trucking industry will improve at a faster rate than in the past; and
- the world oil price will gradually fall from around US$30 per barrel in 2000–01 to US$20 per barrel in 2005–06 and remain slightly below that level thereafter.

Given these assumptions, the model predicts total emissions in Australia (excluding the land use change sector) and total combustion emissions. In relation to the transport sector, the model predicts:

- total transport emissions will reach 89.4 million tonnes CO_2-e in 2009–10, 45.4 per cent higher than the 1990 level;
- road transport emissions will remain the dominant source of total transport emissions and will grow at an average annual rate of 1.9 per cent, reaching 78.2 million tonnes CO_2-e in 2009–10; and
- emissions from non-road transport will grow slightly faster (2.8 per cent per annum) than from road, principally driven by the high growth of emissions from air transport (4.1 per cent per annum) with growth of emissions from rail and water transport being largely static.

Sensitivity analyses carried out under high and low GDP growth scenarios suggest that a half percentage point increase (decrease) in the assumed annual growth rate for GDP causes transport emissions to be 3.4 per cent greater (less) than the base case for 2009–10.

If the crude oil price is assumed to remain at the current level of US$29.57 per barrel over the forecast period, transport emissions in 2009–10 will be 1.5 per cent below the standard reference case.

The results of this study mimic to a large extent the results of ‘bottom-up’ modelling, which the BTRE has undertaken. Whereas this study projects growth in transport emissions between 1990 and 2010 of 45.4 per cent, the bottom up modelling forecasts an increase of 46.5 per cent over this period. The small differences between the two sets of results may be explained largely in terms of differences in the data inputs used.

CHAPTER 1 INTRODUCTION

This report sets out projections of greenhouse gas (GHG) emissions from the Australian transport sector using an enhanced version of the MMRF–GREEN model.

MMRF–GREEN is a dynamic multi-regional, multi-sectoral model of the Australian economy with capabilities for climate change analysis. The model has evolved from the comparative static Monash Multi-Regional (MMR) model (Meagher et al. 1993; Peter et al. 1996) and the dynamic single region MONASH model (Dixon and Rimmer 2000). Its first application was to a project on GHG Emissions Trading undertaken by the Centre of Policy Studies (CoPS) for the Victorian State government in cooperation with the Allen Consulting Group in 2000.[1] MMRF–GREEN is one of the four main computable general equilibrium (CGE) models currently used to assess the economy-wide and industry-specific impacts of policies to control GHG emissions in Australia (Pezzy and Lambie 2001).

In November 2000, the BTRE acquired the basic version of the MMRF–GRREN model from CoPS. Several important enhancements were made to the model before it was applied to forecast GHG emissions from the transport sector. These include:

- disaggregation of the 'petroleum products' by incorporating an explicit multi-product refining industry;
- revised treatment of household demand for fuels and motor vehicles;
- disaggregation of the transport industry into road, rail, sea, air and other transport services;
- transfer of the enhanced tax features from MONASH to MMRF–GREEN for inclusion of recent changes to the indirect tax system, that is, the New Tax System (NTS); and
- improvement of the emissions accounting for the transport sector within the CGE modelling framework.

In order to provide the best possible estimates for future transport GHG emissions in Australia, assumptions about key macro-economic variables,

1. See Adams, et al. (2000a and b).

international oil prices and technical/taste change variables were reviewed and updated. In particular, the projections have incorporated valuable information from the BTRE bottom-up modelling on possible future changes in the output of the transport sector and in fuel intensity.

Chapter 2 highlights the key features of the basic version of MMRF–GREEN model. Then, enhancements to the basic model are described. Chapter 4 discusses assumptions about key macro variables, international oil prices and changes in technology and tastes. Results of projections are presented in chapter 5. Sensitivity analyses are provided in the last chapter.

CHAPTER 2 THE MMRF–GREEN MODEL

The MMRF–GREEN model has its origin in the MMR/MMRF model and the MONASH model (Dixon and Rimmer 2000), both of which were developed from the ORANI model (Dixon et al. 1982). A greenhouse module has been added to permit GHG emissions forecasting and greenhouse policy analysis. A description of the basic version of the MMRF–GREEN model can be found in Adams et al. (2000c and 2000d).

OVERALL STRUCTURE AND DYNAMICS[2]

The basic version of MMRF–GREEN distinguishes eight regions (six States and two Territories) and 37 commodities/industries. The model recognises:

- domestic producers classified by industry and domestic region;
- investors similarly classified;
- eight region-specific household sectors;
- an aggregate foreign purchaser of the domestic economy's exports;
- eight state and territory governments; and
- the Federal Government.

Other features of the model include:

- intra-regional, inter-regional and international trade based on regional input–output data developed at CoPS;
- greenhouse gas emissions from each of the 37 industries and eight regions;
- inter-fuel substitution in electricity generation; and
- mechanisms that allow for take-up of abatement measures in response to greenhouse policy measures.

MMRF–GREEN produces sequences of annual solutions with accumulation relationships for capital stocks forming the links between years. It incorporates most of the dynamic features of the MONASH model. These include:

2. This and following sections draw heavily from Adams et al. (2000d). For a more comprehensive exposition of the model, refer to Adam et al. (2000c).

- equations describing the relationship between investment and the capital stock in year-to-year simulations;
- equations explaining the relationship between year-to-year capital growth and rate-of-return expectations;
- equations that facilitate the running of forecasting and dynamic policy simulations; and
- regional data for industry investment/capital ratios, for industry rates of return and for dynamic adjustment parameters.

MODELLING GHG EMISSIONS

The original version of the MMRF–GREEN model breaks down emissions according to emitting agent (37 industries and residential), emitting state or territory (8) and emitting sources/sinks (5). Most of the emitting sources are from fuel combustion (*Black coal*, *Natural gas*, *Brown coal* or *Petroleum products*)[3]. The other source, named *Activity*, covers emissions such as fugitives and agricultural emissions not arising from fuel burning. The resulting 38x8x5 matrix covers all emissions except those arising from land clearing. Gases included are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), all expressed in CO_2–e (equivalent) units of global warming power.

Fuel-burning emissions are modelled as being proportional to fuel usage. The model does not allow for any invention, which might, say, allow fuel users to release less CO_2–e per litre of *Petroleum products* burned. On the other hand, the model does allow for exogenous input-saving technical progress, for example, reductions in the amount of *Petroleum products* burned per unit of output (or per vehicle/ton kilometre travelled).

In MMRF–GREEN, industries and consumers have the option of switching from one form of energy into another, in response to changes in relative prices of fuels. For example, the *ElectSupply* industry might source less of its power from *ElectCoal* and more from *ElectGas*, resulting in a drop in emissions. The elasticity of substitution between the types of electricity is set equal to 5.[4] For other energy-intensive commodities (namely *Agriculture*, *Forestry*, *BlackCoal*, *NatGas*, *BrownCoal*, *Food*, *WoodPaper*, *Chemicals*, *Cement*, *Steel*, *Aluminium*, *OthMet_prods*, *RoadTrans*, *OtherTrans*) consumed by industries, MMRF–GREEN allows for abatement possibilities by including a similar, but weaker, form of input substitution. In most cases, a substitution elasticity of 0.1 is imposed between the commodities and other inputs. For *Petroleum products*, *ElectSupply*, and *UrbanGasDis*, the substitution elasticity is 0.25.

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3 Italics are used to highlight commodities or industries defined in the model. Full descriptions can be found in the list of abbreviations at the end of this paper.

4. This implies that a 1 per cent increase in the price of *ElectCoal* relative to that of *ElectGas* will lead to a 5 per cent fall in the ratio of *ElectCoal*/*ElectGas* used by the *ElectSupply* industry.

In the base MMRF–GREEN simulations, non-combustion emissions were modelled as directly proportional to the output of the related industries.

The sink potential of *Forestry* was treated conservatively, being linked to *Forestry* activity as a whole, which includes logging, rather than to the rate of planting. If *Forestry* is growing rapidly, as it does in our policy scenarios, one should expect it to be devoting a high fraction of effort to planting, rather than felling. This would, at least temporarily, increase the sink effect beyond what has been estimated.

CHAPTER 3 ENHANCEMENTS TO THE MMRF–GREEN MODEL

Five major enhancements were made to the basic version of the MMRF–GREEN model, including:[5]

- Incorporation of an explicit multi-product refining industry enabling evaluation of the impact of fuel-specific tax options covering petrol, aviation fuels, automotive diesel oil (ADO) and liquefied petroleum gas (LPG).
- Improvement of the treatment of fuels and motor vehicles in the model's household-demand system;
- Adding detail to the transport sector, including disaggregation of the transport sector into road, rail, sea, air and other transport services;
- Adding the capability for simulating the impacts of the New Tax System (NTS); and
- Improvement of the transport emissions accounting mechanism within MMRF–GREEN.

These enhancements are briefly described below.

MULTI-PRODUCT REFINING INDUSTRY

In the basic version of MMRF–GREEN, each industry produces just one product. For example, the product produced by the *Petrol* industry is *Petroleum products*, which is highly aggregated. This high level of aggregation not only precludes the possibility of a proper measurement of transport emissions within the MMRF–GREEN model, but also makes it difficult to evaluate the impact of fuel-specific tax policies.

Disaggregation of *Petroleum products* is accomplished by introducing a multi-product refining industry. The prime source of data is unpublished ABS statistics showing detailed commodity sales by input-output user at the seven-digit level of the Input–Output Commodity Classification (IOCC). The modified *Petrol* industry produces six *Petroleum products*, namely:

5. These enhancements were results of a joint research project undertaken by CoPS and BTRE.

- Petroleum for automotive use only (*PetrolAuto*),
- Petroleum for aviation use only (*AvGasoline*),
- Aviation turbine fuel (*AvTurbine*),
- Diesel for automotive use (*Diesel*),
- LPG for automotive use (*LPG*),
- Other petroleum products, including kerosene, heating oil, fuel oil, paraffin wax, grease base stock, petroleum jelly and petroleum solvents (*PetrolOther*).

It is assumed at the moment that the elatisticity of transformation is 1.0 for all industries. This means that if the producer price of, say, diesel increased by 1 per cent relative to the average of producer prices for all petroleum products, then 1 per cent more diesel would be produced relative to the overall production of petroleum products.

Disaggregation of the petroleum products has made it possible to model fuel-specific tax policies such as excise duties on petrol and diesel. It leads to more accurate estimation of emissions from the transport sector within MMRF–GREEN.

THE DUMMY INDUSTRY APPROACH FOR PRIVATE TRANSPORT SERVICES

In the basic version of MMRF–GREEN, fuels and motor vehicles are specified as substitutes in the household demand system due to the adoption of a stylised Linear Expenditure System (LES). This inconsistency has been eliminated by introducing a dummy industry that provides private transport services to households.

The dummy industry approach is not new. It has been previously applied in models of this type to deal with household consumption of dwellings. Its first application to the household consumption of motor vehicles is described in Lee (2000).

The dummy industry approach involves creating a new industry called private transport services (*PrivTranServ*). This industry provides private transport services to households exclusively, using privately owned motor vehicles as its capital goods, and fuel and other goods as its intermediate inputs. Under this new treatment, motor vehicles and fuels have become complements.

MORE DETAILED TRANSPORT SECTOR

The level of disaggregation for the transport sector in the original version of the MMRF–GREEN model was not great, with only road and non-road transport separated out.

The enhanced version of MMRF–GREEN has the non-road transport broken down into rail transport (*RailTrans*), water transport (*WaterTrans*), air transport (*AirTrans*) and other transport (*OtherTrans*).

The distinction between passenger and freight transport for each mode can be made by identifying whether they are used by business as direct or margin commodities.

In the forecasting simulations for this report, no possibility of substitution was allowed between modes.[6]

THE NEW TAX SYSTEM

The government's initial tax reform package (A New Tax System — ANTS (Treasurer 1998)) contains detailed qualitative information about the Government's tax plan, but does not provide detailed quantitative information on the proposed changes to indirect tax rates. The only detailed data reported in the ANTS paper are results generated by the Treasury's PRISMOD model for changes to producer prices and consumer prices by commodity.

MMRF–GREEN followed the approach taken by Dixon et al. (1999) in their GST work to deduce changes in the indirect tax rates that underlie the published PRISMOD results.

First, MMRF was configured as an input–output model in the style of PRISMOD. Then a simulation was conducted under Treasury assumptions of no change in wage rates, exchange rate appreciation of 3.5 per cent, and no change in rental prices of capital relative to asset prices. The shocks were PRISMOD's results for changes in producer and consumer prices coupled with best guesses made by Dixon et al. (1999) for the changes in taxes collected on the inputs to each industry (based on qualitative information in the ANTS paper) and with the information supplied by the BTRE on tax changes on petroleum products. The changes in basic prices projected by MMRF–GREEN were then compared with the price changes projected by PRISMOD. Wherever significant differences were observed, the initial guesses for changes in taxes collected on the inputs to each industry were refined and the MMRF–GREEN simulation was re-run. In this way CoPS arrived at a set of changes in taxes on inputs to industries and consumption which reflect those used in the PRISMOD modelling. It is these tax changes that were imposed in the MMRF–GREEN basecase projections.[7]

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6. The most recent version of MMRF–GREEN allows for substitution possibilities between road freight transport and rail freight transport.

7. The tax debate started with the Government's tax proposal,'Tax reform: not a new tax, a new tax system' (ANTS, (Treasurer 1998)), then proceeded to the revised package (sometime labelled as ANTS2) and ended with the New Tax System (NTS). ANTS is slightly different from NTS, the main differences being in the tax treatment of fresh food and some transport fuels. The effects of these changes were fully taken into account, even though the simulation was not directly based on the NTS.

EMISSIONS ACCOUNTING FOR TRANSPORT WITHIN MMRF–GREEN

In common with most other CGE models, transport emissions accounting in the basic version of MMRF–GREEN is weak. Disaggregation of fuels and transport modes and introduction of the *PrivTranServ* industry have made it possible to estimate transport emissions in a more direct and explicit way. It would also provide a useful framework to examine the impacts of greenhouse policies on various sectors of the transport industry.

Improvements made to the MMRF–GREEN database for energy use and emissions mainly focused on petroleum products, which are the primary transport fuels. The improved database has a number of desirable features, including:

- greater consistency between emissions and fuel consumption data;
- greater consistency between value and quantity of fuel use; and
- a systematic apportionment of transport fuels (and hence emissions) to economic agents (industries).

Table 3.1 summarises revised estimates of total emissions for the MMRF–GREEN base year (1993–94). There are 42 emitting agents (41 industries and residential) in 8 states and territories (not shown in the table) and 10 emitting sources/sinks. The revised emission matrix has dimensions of 42x8x10, compared with a 38x8x5 emission matrix before disaggregation. A comparison of emissions from the MMRF-GREEN database with those reported in AGO (2000) is provided in table 3.2. Overall, the difference between the two is less than 1 per cent.

Table 3.1 forms the basis for estimating transport emissions in the base year (1993–94). Accounting for emissions by rail, water and air transport is relatively straightforward though care needs to be taken to exclude road transport that supports these activities. In the case of road transport emissions, there are three emitting categories: (1) private use of passenger cars, which is represented by the newly created *PrivTranServ* industry; (2) 'hire and reward' part of road transport services, which consist of trucking and public transport; and (3) ancillary transport, which refers to own business transport use by all other industries. Appendix I discusses the method employed to estimate emissions due to transport.

TABLE 3.1 EMISSIONS BY SOURCE 1993–94 (‘000 TONNES CO_2–E)

	BlackCoal	NatGas	BrownCoal	PetrolAuto	AvGasoline	AvTurbine	Diesel	LPG	PetrolOther	Activity	Total
Agriculture	0	116	0	1,565	0	0	3,733	39	430	88,176	94,058
Forestry	0	45	0	83	0	0	744	0	55	-25,830	-24,903
Iron ore	514	38	0	18	0	0	180	0	20	0	769
Non-iron ore	588	265	0	151	0	0	1,013	31	271	0	2,319
Black coal	0	79	0	25	0	0	362	0	61	11,328	11,854
Crude oil	83	801	0	1	0	0	11	0	2	8,527	9,425
Natural gas	92	88	0	1	0	0	12	0	2	3,261	3,456
Brown coal	25	240	0	0	0	0	3	0	1	4,884	5,154
Food, beverages and tobacco	2,773	535	0	309	0	0	522	177	51	0	4,367
Textiles, clothing and footwear	295	43	0	34	0	0	50	10	7	0	439
Wood and paper products	1,909	219	0	508	0	0	267	34	37	0	2,974
Chemical products excl. petrol	2,433	1,272	0	68	0	0	113	1,343	0	584	5,814
Petrol	180	0	0	35	0	0	0	0	5,372	0	5,587
Non-metal construction materials excl.	691	321	0	30	0	0	143	6	68	0	1,259
Cement	869	1,004	0	32	0	0	92	0	13	5,560	7,570
Iron and steel	6,538	1,450	0	17	0	0	38	10	164	0	8,217
Alumina and aluminium	2,391	265	0	15	0	0	369	27	76	3,682	6,826
Other metal products	9,074	1,011	0	524	0	0	3,957	1,043	800	0	16,409
Motor vehicles and parts	173	114	0	25	0	0	18	0	6	0	337
Other manufacturing	793	212	0	103	0	0	73	6	62	0	1,249
Electricity generation - black coal	73,624	0	0	0	0	0	0	0	0	0	73,624
Electricity generation - brown coal	0	0	44,968	0	0	0	0	0	0	0	44,968
Electricity generation - gas	0	5,985	0	0	0	0	0	0	0	0	5,985
Electricity generation - petroleum products	0	0	0	7	0	0	6	0	56	0	69
Electricity generation - other (mainly hydro)	0	0	0	0	0	0	0	0	0	0	0
Electricity supply	51	53	0	64	0	0	54	0	4	0	225
Urban gas distribution	72	14,568	0	52	0	0	17	0	1	0	14,710
Water and sewerage services	35	0	0	15	0	0	709	44	42	0	844
Construction services	151	280	0	616	0	0	792	11	811	0	2,661
Wholesale trade, retail trade,	1,945	746	0	4,548	0	0	1,748	22	453	0	9,462
Road transport services	0	179	0	1,154	0	0	4,358	525	124	0	6,341
Rail transport	0	315	0	146	0	0	2,345	0	76	0	2,882
Water transport	290	10	0	437	0	0	1,495	0	957	0	3,189
Air transport	0	0	0	634	230	3,645	6	0	0	0	4,516
Other transport services	0	0	0	49	0	0	123	6	13	0	191
Communication services	0	727	0	719	0	0	322	0	38	0	1,806
Financial and business services	0	406	0	1,561	0	0	2,132	208	511	0	4,819
Dwelling ownership	0	0	0	126	0	0	0	0	3	0	128
Public services	1,144	2,412	0	2,814	0	0	2,200	208	456	0	9,234
Other services	145	146	0	638	0	0	511	0	79	15,649	17,168
Private transport services	0	0	0	24,968	0	0	435	1,530	205	0	27,138
Residential	265	2,216	0	0	0	0	0	488	752	0	3,720
Total	**107,143**	**36,161**	**44,968**	**42,089**	**230**	**3,645**	**28,953**	**5,769**	**12,075**	**115,821**	**396,855**

Notes: The *Activity* column shows: fugitives for coal, oil and gas; animal gas, soil disturbance and fertiliser use for agriculture, and emissions mainly from rubbish dumps for other services. Forestry is a net sink. Production of cement and alumina/aluminium also release non-combustion gases.

Sources: Fry 1997; Australian National Greenhouse Gas Inventory Committee 1996 and AGO 2000.

TABLE 3.2 COMPARISON OF EMISSIONS BY SECTOR, MMRF-GREEN AND AGO, 1993-94 ('000 TONNES CO2–E)

Sector	*MMRF-GREEN*	*AGO*	*Difference (%)*
Total	396,855	398,695	-0.46
Energy	309,034	310,873	-0.59
Combustion emissions	281,034	282,793	-0.62
Stationary energy	215,445	217,105	-0.76
Transport	65,589	65,688	-0.15
Fugitive emissions	28,000	28,081	-0.29
Agriculture	88,176	88,176	0.00
Waste	15,649	15,649	0.00
Industrial processes	9,826	9,827	-0.01
Land use change and forestry	-25,830	-25,830	0.00
Forestry	-25,830	-25,830	0.00
Land use change	Not included	Not included	na

Sources: MMRF–GREEN database and AGO 2000.

Table 3.3 provides a summary of data for combustion and transport emissions in 1993–94. A number of observations can be made with respect to the table.

- Transport emissions in the base year (1993–94) total 65.6m tonnes, accounting for 23.3 per cent of the total combustion emissions.
- Nearly all transport emissions came from burning petroleum products such as petrol, aviation fuels, diesel and LPG.[8]
- Of all emissions from burning petroleum products, 70.3 per cent are from transport.
- Road transport is the main source of transport emissions, accounting for about 89.3 per cent of the total, followed by air transport (5.9 per cent), water transport (2.3 per cent) and rail transport (2.5 per cent[9]).
- Within the road transport sector, private use of motor vehicles contributes 46.2 per cent of total road transport emissions, followed by ancillary transport[10] (43.4 per cent) and 'hire & reward' part of the road transport (10.4 per cent).

8. The 'hire and reward' parts of the road transport and marine transport industries also use some natural gas and coal, which accounts for less than 1 per cent of the total transport emissions.

9. For rail transport, emissions due to use of electricity are excluded. These are accounted for under 'stationary energy'.

10. Ancillary transport refers to 'own business transport use'. For example, fuels used by the agriculture sector for transport purposes and their associated emissions are categorised as 'ancillary transport'.

- Within ancillary transport, the public sector is responsible for 19 per cent (4.8 million tonnes CO_2-e) or 8.3 per cent of the total road transport emissions.

TABLE 3.3 COMBUSTION AND TRANSPORT EMISSIONS 1993–94 (‘000 TONNES CO2–E)

	BlackCoal	NatGas	BrownCoal	PetrolAuto	AvGasoline	AvTurbine	Diesel	LPG	PetrolOther	Total-petrol	**Total**
Total combustion emissions	**107,143**	**36,161**	**44,968**	**42,089**	**230**	**3,645**	**28,953**	**5,769**	**12,075**	**92,762**	**281,034**
Total transport	338	72	0	41,503	224	3,645	16,268	2,507	1,033	65,180	**65,589**
Road	0	68	0	41,066	0	0	14,660	2,507	0	58,233	**58,301**
Private	0	0	0	24,968	0	0	435	1,530	0	26,934	**26,934**
Hire & reward	0	68	0	1,141	0	0	4,358	525	0	6,024	**6,092**
Ancillary transport	0	0	0	14,957	0	0	9,866	452	0	25,275	**25,275**
Government	0	0	0	2,781	0	0	1,854	188	0	4,823	**4,823**
Other	0	0	0	12,176	0	0	8,012	264	0	20,452	**20,452**
Rail	0	0	0	0	0	0	1,525	0	76	1,601	**1,601**
Air	0	0	0	0	224	3,645	0	0	0	3,869	**3,869**
Water	338	3	0	437	0	0	83	0	957	1,477	**1,818**
Transport shares (%)											
Total transport (% of total combustion emissions)	0.3	0.2		98.6	97.3	100.0	56.2	43.4	8.6	70.3	**23.3**
Road (% of total transport)	0.0	95.5		98.9	0.0	0.0	90.1	100.0	0.0	89.3	**88.9**
Private (Road=100)	0.0	0.0		60.8	0.0	0.0	3.0	61.0	0.0	46.3	**46.2**
Hire & reward (Road=100)	0.0	100.0		2.8	0.0	0.0	29.7	20.9	0.0	10.3	**10.4**
Ancillary transport (Road=100)	0.0	0.0		36.4	0.0	0.0	67.3	18.0	0.0	43.4	**43.4**
Government	0.0	0.0		6.8	0.0	0.0	12.6	7.5	0.0	8.3	**8.3**
Other	0.0	0.0		29.6	0.0	0.0	54.7	10.5	0.0	35.1	**35.1**
Rail (% of total transport)	0.0	0.0		0.0	0.0	0.0	9.4	0.0	7.4	2.5	**2.4**
Air (% of total transport)	0.0	0.0		0.0	100.0	100.0	0.0	0.0	0.0	5.9	**5.9**
Water (% of total transport)	100.0	4.5		1.1	0.0	0.0	0.5	0.0	92.6	2.3	**2.8**

Sources: Australian National Greenhouse Gas Inventory Committee 1996; AGO 2000 and BTRE estimates.

CHAPTER 4 ASSUMPTIONS FOR BASECASE PROJECTIONS

Assumptions made for the basecase projection are based on:

- macroeconomic forecasts from Access Economics;
- national-level forecasts of inbound tourism numbers from the Tourism Forecasting Council (TFC) and forecasts of real foreign-tourist expenditure by region from Access Economics;
- population projections from Australian Bureau of Statistics;
- estimates for changes in industry production technologies and in household preferences from CoPS;
- forecasts for the quantities of agricultural and mineral exports, and estimates of capital expenditure on major minerals and energy projects from the Australian Bureau of Agricultural and Resource Economics (ABARE); and
- forecasts of international oil prices from Consensus Economics.

MACROECONOMIC ASSUMPTIONS

Over the forecasting period, real GDP growth is assumed to be 3.4 per cent per annum, compared with 4.4 per cent in the historical period (table 4.1). The slowing down of the economy in the coming decade is largely caused by slower growth of private consumption and investment. The assumed growth rate for employment is 1.4 per cent per annum for the forecasting period compared with 2.3 per cent over the historical period. A more detailed description of macroeconomic assumptions can be found in appendix II.

ASSUMPTIONS ABOUT POPULATION GROWTH

Within MMRF–GREEN, regional population can be treated as an endogenous or exogenous variable. It may be determined endogenously by natural growth, foreign migration and interregional migration. Interregional migration is determined by economic factors such as relative wage differentials.

TABLE 4.1 BASECASE MACROECONOMIC FORECASTS

(Per cent per annum)

	Historical period (1993/94–1999/2000)	*Forecasting period (1999/2000–2011/12)*
Real GDP	4.4	3.4
Private consumption	4.4	3.2
Public consumption (state)	2.6	1.9
Public consumption (federal)	2.6	1.9
Total investment	9.5	2.4
Investment in dwellings	5.9	1.8
Imports	10.3	4.2
Employment	2.3	1.4

Notes: The macroeconomic assumptions are imposed at the state level and the figures reported in the table are implied by exogenously determined growth rates of Gross State Products (GSP) and their components for all states. Real export volumes are determined endogenously within MMRF–GREEN and are adjusted to make GSP equal to the sum of its components.

Sources: MMRF–GREEN version 2 database.

Regional population may be set exogenously by setting as endogenous any of the following regional labour market variables:

- regional unemployment rate;
- regional participation rates; or
- regional wage relativities.

In the forecasting simulation for this report, growth of regional population was set exogenously. The most recent population projections undertaken by ABS (2000a) were inserted into the model. The mean growth rate of population for the forecasting period is 0.93 per cent per annum, down from 1.16 per cent in the historical period (table 4.2).

The size of the total emissions outcome is not very sensitive to assumptions made about population in the MMRF–GREEN model. This is because growth of aggregate regional consumption is specified as being determined directly by growth of regional household disposable income.

A change in population does, however, affect the level of consumption for individual commodities through its effect on the 'subsistence' part of total household expenditure. MMRF–GREEN uses the Linear Expenditure System (LES) to model consumer demand, with total demands being split into subsistence quantities and luxury usage. The total subsistence demand for each good is specified to be proportional to the number of households (population) and to the individual household subsistence demands. Reducing the growth rate for population means that total subsistence expenditure becomes smaller, and luxury expenditure will become larger. The composition of consumption changes (with different population assumptions) depending the expenditure elasticity of demand for each commodity. The difference in the composition of commodities (including the demand for fuel used in private motor vehicles) caused by different assumptions about population growth is, however, expected to be small.

TABLE 4.2 POPULATION GROWTH FORECASTS
(Per cent per annum)

	Historical period (1993/94–1999/2000)	*Forecasting period (1999/2000–2011/12)*
National population growth	1.16	0.93
NSW	1.01	0.84
VIC	1.01	0.71
QLD	1.89	1.53
SA	0.35	0.27
WA	1.70	1.37
TAS	-0.09	-0.20
NT	2.02	1.51
ACT	0.51	0.71

Source: ABS (2000a); ABS (2000b and c).

ASSUMPTIONS FOR CHANGES IN TASTES AND TECHNOLOGY

In MMRF–GREEN, household tastes or preferences are described by a utility function leading to the demand function of the form:

$$X_i = T_i{*}G_i(Y, P) \qquad (1)$$

where X_i is household consumption of good i; Y is household income; P is a vector of commodity prices; G is total consumption expenditure per household; and T_i is a taste change variable.

The percentage change form of equation 1 is:

$$x_i = t_i + g_i \qquad (2)$$

where x_i is percentage change in household consumption of good i; t_i is change in household tastes; and g_i is percentage change in household expenditure on good i caused by changes in prices and household incomes.

Assumptions about changes in household tastes (t_i) are summarised in column 1 of table 4.3. Most of these assumptions are based on trends extrapolated from a MONASH model simulation for the period 1986–87 to 1996–97. For example, it is assumed that consumption of private transport services (*PrivTranServ*) will increase at a rate 1.0 per cent a year slower than can be explained on the basis of changes in prices and changes in the average budget of households.[11]

Column 2 of table 4.3 shows the assumptions for the average annual rates of change in the usage of commodities as intermediate inputs per unit of production in the using industries, and as inputs per unit of capital creation. For non-petroleum and non-transport related commodities, the assumptions are based on trends extrapolated from a MONASH simulation for the period 1986–87 to 1996–97 and are applied to both the historical (1993/94–1999/2000) and the forecasting periods (2000/01–2011/12). Assumptions on input-using technology for some of the petroleum products and some transport commodities are derived from a semi-historical simulation based on MMRF–GREEN over 1993–94 to 1999–2000[12]. Assumptions about *PetrolAuto*- and *Diesel*-using technology were adjusted for the forecasting period to reflect the slower improvement in the fuel efficiency for *PetrolAuto* used by the *PrivTranServ* industry, and the faster improvement in the fuel efficiency for *Diesel* used by the *RoadTrans* industry.

Ideally, assumptions about fuel-using technology should be made different for different industries, notably transport industries for which information on changes in fuel intensity is available. Appendix III explores the conceptual relationship between fuel-using technology defined in MMRF–GREEN and fuel intensity in bottom-up models. The basecase assumption about fuel-using technology reflects the changes in fuel intensity assumed in bottom-up models for the car and truck fleets. For example, it is assumed that fuel intensity in the *PrivTranServ* industry will decline at a slower rate (-0.3) in the future than in the past (-0.5), and that fuel intensity in the *RoadTrans* industry will fall at a faster rate (-1.9) than in the past (-1.3).

The assumptions for each industry concerning average annual changes in primary-factor usage per unit of output are shown in column 3 of table 4.3. Primary-factor inputs in MMRF–GREEN consist of labour, capital and agricultural land. For example, the assumption for electricity generation is that output will increase on average by 3.1 per cent a year relative to the industry's overall usage of primary factors.

11. The values for household preferences towards *PrivTranServ*, *RoadTrans* and *WaterTrans* were determined through a semi-historical simulation within MMRF–GREEN.

12. The purpose of the simulation was to allow fuel-using technology to vary over the historical period so that backcast values for fuel consumption and emissions would match as closely as possible with actual values published AIP (1999) and AGO (2000).

TABLE 4.3 INDUSTRY TECHNOLOGY AND HOUSEHOLD TASTE ASSUMPTIONS

(Per cent per annum)

Commodities	*Household preferences (1)*	*Intermediate input-using technology (2)*	*Primary-factor using technology (3)*
Agriculture	0.52	0.05	-2.3
Forestry	-0.87	1.75	0.0
Iron ore	0.00	-0.27	-4.1
Non-iron ore	1.77	-1.61	-2.4
Black coal	-3.67	-2.08	0.0
Crude oil	-1.34	0.00	0.0
Natural gas	-1.34	0.50	0.0
Brown coal	-1.34	0.00	0.0
Food, beverages and tobacco	0.55	0.24	-1.3
Textiles, clothing and footwear	-2.74	-0.39	-1.7
Wood and paper products	0.08	0.10	-0.2
Chemical products excl. petrol	2.07	2.56	-0.1
Petrol for automotive use	0.00	-0.70[a] (-1.66)[b]	0.0
– *by PrivTranServ*	0.00	-0.30 (-0.50)[b]	0.0
Petrol for aviation use	0.00	-1.00	0.0
Aviation Turbine fuel	0.00	-1.00	0.0
Diesel for automotive use	0.00	-0.53[a] (-0.33)[b]	0.0
– *by RoadTrans*	0.00	-1.90 (-1.30)[b]	0.0
LPG	0.00	0.30	0.0
Other petroleum products	-2.70	-1.00	0.0
Non-metal construction materials excl. cement	0.03	0.48	-1.1
Cement	0.18	-1.17	-0.4
Iron and steel	5.18	1.34	-1.4
Alumina and aluminium	6.71	1.99	-2.5
Other metal products	-1.34	1.32	-0.1
Motor vehicles and parts	0.00	2.50	-0.4
Other manufacturing	0.71	3.69	-1.8
Electricity generation - black coal	0.29	0.25	-3.1
Electricity generation - brown coal	0.29	0.25	-3.1
Electricity generation - gas	0.29	2.50	-3.1
Electricity generation - petroleum products	0.29	0.00	-3.1
Electricity generation - other (mainly hydro)	0.29	0.50	-3.1
Electricity supply	0.29	0.00	-3.1
Urban gas distribution	0.29	0.57	-2.7
Water and sewerage services	-0.54	-0.17	-2.4
Construction services	0.00	1.76	0.0
Wholesale trade, retail trade, accommodation	-2.14	-1.79	0.0
Road transport services	-1.00	0.54	-0.8
Rail transport	-0.10	-0.24	-2.2
Water transport	-1.00	-1.00	-1.2
Air transport	1.66	-2.10	-3.6
Other transport services	-0.31	0.81	0.0
Communication services	-0.01	5.00	-4.5
Financial and business services	1.91	3.26	-1.8
Dwelling ownership	0.00	0.00	0.3
Public services	0.11	0.00	-0.4
Other services	1.18	1.59	0.0
Private transport services	-1.00	0.00	0.0

[a] Weighted average based on industries' shares of total fuel consumption.

[b] Figures in parentheses are historical trends (1993/4–1999/2000).

Sources: MMRF–GREEN version 2 database; BTRE estimates.

ASSUMPTIONS FOR EXPORTS, PRODUCTION AND CAPITAL EXPENDITURE

Table 4.4 presents assumptions for exports, production and real investment in the agriculture, minerals and energy industries. These forecasts are taken from existing CoPS assumptions, which in turn are taken from ABARE. The forecasts for export volumes reflect ABARE projections to 2004–05, and exogenously imposed long-term trends for the years 2004–05 to 2011–12. The forecasts for production reflect ABARE estimates to 2014–05. Most of the basecase forecasts for real gross investment in the mining and energy industries are endogenous in MMRF–GREEN. However, in some years between 1999–2000 and 2009–10, for some of the industries in some regions, investment is exogenously set in light of forecasts provided by ABARE. For example, in the period 2000–01 to 2009–10, investment in the Queensland aluminium industry reflects the construction of the Gladstone Alumina plant. Allowance is also made for construction of the PNG-QLD natural gas pipeline.

ASSUMPTIONS ABOUT FUTURE OIL PRICES

Assumptions about changes in international oil prices will have an important bearing on future emissions. International oil prices have doubled over the past two years and the market remains very uncertain.

The assumptions made in the standard reference case are based on forecasts made by Consensus Economics. Its projections of crude oil prices average a number of analyst projections from sources such as the Energy Information Administration (US), and mineral exchanges (New York Mercantile Exchange and the London Futures Market). A brief review has been undertaken of expert opinions on future developments of international oil prices and is included in appendix IV.

In the basecase projections, it is assumed that oil prices will drop from around US$29.60 per barrel WTI in 2000–01 to around US$20 per barrel WTI in 2005–06 and remain at that level to the end of forecasting period. This is equivalent to assuming that between 2001–02 and 2005–06, international oil prices will drop by 7.96 per cent per annum. From 2006–07 on, it is assumed that there will be no change in international oil prices.

TABLE 4.4 ASSUMPTIONS ABOUT CHANGES IN EXPORTS, PRODUCTION AND REAL INVESTMENT IN AGRICULTURE, MINERALS AND ENERGY INDUSTRIES

(Per cent per annum)

	NSW	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*
Export volumes								
Agriculture	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Iron ore	na	na	na	na	2.9	na	na	na
Non-iron ore	2.9	2.9	2.9	2.9	2.9	na	na	na
Black coal	2.9	na	2.9	na	na	na	na	na
Crude oil	0.0	-0.5	-0.9	-1.4	0.8	na	1.9	na
Natural gas	na	na	na	na	3.8	na	na	na
Petroleum products	-0.2	0.3	-0.3	0.9	0.7	na	na	na
Alumina and aluminium	3.4	3.4	5.1	3.4	3.4	na	na	na
Production								
Agriculture	na	na	na	na	na	na	na	na
Iron ore	na	na	na	na	na	na	na	na
Non-iron ore	na	na	na	na	na	na	na	na
Black coal	na	na	na	na	na	na	na	na
Crude oil	0.0	-0.5	-1.0	-1.4	0.8	na	1.0	na
Natural gas	1.0	3.7	-0.6	-2.4	3.8	na	11.6	na
Petroleum products	1.0	1.3	1.6	0.9	1.9	-0.4	na	na
Alumina and aluminium	3.4	3.3	5.0	0.0	3.8	na	na	na
Real Investment								
Agriculture	na	na	na	na	na	na	na	na
Iron ore	na	na	na	na	na	na	na	na
Non-iron ore	na	na	na	na	na	na	na	na
Black coal	-0.6	na	1.1	-4.3	na	na	na	na
Crude oil	na	-1.3	-1.5	-2.8	0.6	na	2.5	na
Natural gas	na	1.3	-2.6	-2.6	2.5	na	11.2	5.4
Petroleum products	na	na	na	na	na	na	na	na
Alumina and aluminium	1.1	0.7	8.2	0.4	2.2	0.2	-2.1	2.8

Note: The numbers in this table are expressed in terms of average annual percentage growth rates for the period 1996–97 to 2011–12. *na* indicates that growth in the relevant variable/industry was endogenously determined in all years of the forecast period.

Source: Adams et al. (2000d).

CHAPTER 5 PROJECTIONS

Future emissions from the transport sector depend on the amount of fuel used by consumers and industries, which is in turn determined by the growth of consumer demand for private transport services and growth of industry output, notably transport industry output.

PROJECTIONS FOR INDUSTRY OUTPUT

Table 5.1 presents simulation results for growth in sectoral output and GDP. A number of key points emerge from the table.

First, average annual economic growth measured in GDP will be slower in the forecasting period (3.6 per cent per annum, 1997/98–2009/10) than in the historical period (4.1 per cent per annum, 1993/94–1997/98).[13]

Second, consumer demand for private transport services—represented by the output of the *PrivTranServ* industry—is expected to grow at a slower pace over the forecasting period (1.9 per cent) than in the historical period (2.6 per cent), reflecting largely changes in the total vehicle kilometres travelled projected by the BTRE bottom-up models.[14]

Third, growth of the 'hire and reward' part of road transport industry is projected to be slightly faster in future (4.1 per cent) than in the past (4.0 per cent), reflecting stronger growth in outputs of industrial sectors than of the service sectors (see below).

Fourth, output of the air transport industry will continue to grow strongly (nearly 6.3 per cent per annum in the forecasting period) though the growth rate will become slightly subdued compared with the historical period.

Fifth, output of both rail and water transport is expected to grow slightly faster in the forecasting period than in the historical period, but their growth rates are expected to be well below those projected for road and air transport.

13. In this section, the definition of historical and forecasting periods is slightly different from the one used earlier. For discussing emission projection results, historical period is referred to as those years for which official published emissions data are available.

14 Pers. Comm. D. Cosgrove, BTRE.

TABLE 5.1 OUTPUT GROWTH PROJECTIONS

(Per cent per annum)

Industries	*1993/94–1997/98*	*1997/98–2009/10*
Agriculture	1.71	3.95
Forestry	3.31	3.87
Iron ore	2.25	3.44
Non-iron ore	2.38	2.52
Black coal	2.77	2.73
Crude oil	-0.04	0.01
Natural gas	3.48	3.48
Brown coal	2.03	2.29
Food, beverages and tobacco	2.07	5.87
Textiles, clothing and footwear	-2.74	4.71
Wood and paper products	3.01	3.67
Chemical products excl. petrol	2.01	6.91
Petrol	2.00	2.43
Non-metal construction materials excl. cement	6.60	3.46
Cement	5.09	1.76
Iron and steel	2.31	7.16
Alumina and aluminium	4.67	5.13
Other metal products	4.18	6.75
Motor vehicles and parts	1.53	4.13
Other manufacturing	5.01	7.24
Electricity generation - black coal	4.28	3.27
Electricity generation - brown coal	2.79	2.79
Electricity generation - gas	4.54	5.01
Electricity generation - petroleum products	0.67	1.18
Electricity generation - other (mainly hydro)	0.68	0.47
Electricity supply	3.33	3.03
Urban gas distribution	3.78	3.46
Water and sewerage services	3.43	3.54
Construction services	10.11	2.94
Wholesale trade, retail trade, accommodation	3.15	2.46
Road transport services	4.00	4.13
Rail transport	2.74	2.86
Water transport	1.35	1.74
Air transport	6.59	6.27
Other transport services	3.94	4.09
Communication services	9.57	8.61
Financial and business services	6.65	6.76
Dwelling ownership	3.39	3.99
Public services	3.28	2.73
Other services	5.53	4.89
Private transport services	2.55	1.90
GDP	4.09	3.63[a]

[a] Between 1997-98 and 1999–00, the actual GDP growth rate is higher than 3.4 per cent per annum assumed for 1999/00–2009/10, thereby leading to a higher annual average growth rate for the period over 1997/98–2009/10.

Finally, for the remaining 36 industries, output of 22 industries is expected to grow faster in the forecasting period than in the historical period. Most of these industries belong to the industrial sectors, which are relatively more transport-intensive. This would have important implications on the demand for the 'hire and reward' part of road transport services and transport services provided industries themselves.

TOTAL AND TRANSPORT EMISSIONS PROJECTIONS

Table 5.2 summarises the projection results for total and transport emissions in Australia. These are 'business-as-usual' (or basecase) projections. Actual emissions in the historical period are also included in the table for comparison purposes.

TABLE 5.2 TRANSPORT EMISSION PROJECTIONS

(million tonnes, CO_2–e)

	1990	*1993–94*		*1997–98*		*2009–10*	*1993/94–1997/98*	*1997/98–2009/10*	*2009–10 Over*
	AGO (actual)	*AGO (actual)*	*BTRE Est.*	*AGO (actual)*	*BTRE Proj.*	*BTRE Proj.*	*% pa**	*% pa*	*1989–90 (%)*
Total emissions	389.8	398.7		455.9	430.5	594.2	3.4	2.7	52.4
Combustion emissions	270.0	281.0		331.3	304.3	399.0	4.2	2.3	47.8
Total transport	61.5	65.6		72.6	70.5	89.4	2.6	2.0	45.4
Road	54.9	58.3		64.8	62.4	78.2	2.7	1.9	42.4
Private			26.9		27.8	31.5	0.8	1.1	
Hire & reward			6.1		6.7	9.0	2.4	2.5	
Ancillary transport			25.3		27.9	37.6	2.5	2.5	
Public sector			4.8		5.2	6.0	1.7	1.2	
Other			20.5		22.7	31.7	2.6	2.8	
Non-road	6.6	7.3		7.8	8.1	11.3	2.3	2.8	71.5
Rail	1.7	1.6		1.6	1.7	2.1	0.0	1.3	20.9
Air	2.6	3.9		4.4	4.7	7.6	3.1	4.1	192.2
Water	2.3	1.8		1.8	1.7	1.6	0.0	-0.3	-30.4

* Annual average growth rates of emissions from sub-sectors of road transport were calculated from the estimates derived from the MMRF–GREEN forecasting simulation. Other growth rates were derived from the actual NGGI data published by AGO (1996 and 2000).

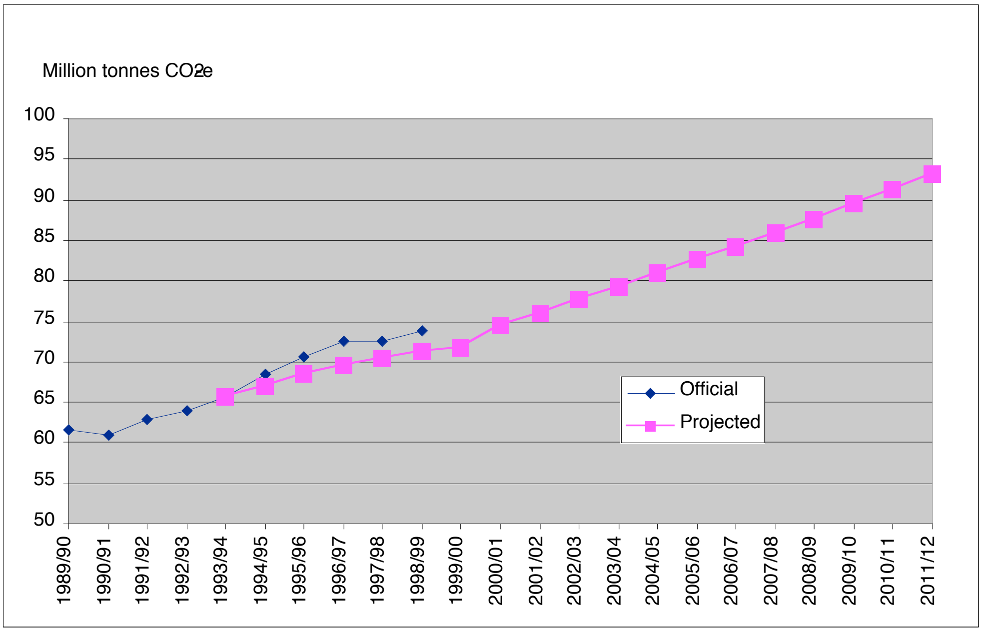
Sources: AGO (1996 and 2000); BTRE estimates.

Growth of total emissions is expected to slow down for the forecasting period (1997/98–2009/10), reflecting slower growth of GDP and continuing improvement in fuel-saving technology. By 2009–10, total emissions in Australia are projected to reach 594 million tonnes CO_2-e, 52.4 per cent higher than the level in 1990.

Combustion emissions are projected to grow at an average annual rate of 2.3 per cent for the forecasting period. This is significantly below the historical trend (4.2 per cent, 1993/94–1997/98) and also below the projected growth rate of total emissions.

During 1993/94–1997/98, total transport emissions grew at an annual average rate of 2.6 per cent. This growth rate is expected to be reduced to 2.0 per cent per annum in the forecasting period, bringing total transport emissions to 89.4 million tonnes CO_2-e in 2009–10, which will be 45.4 per cent higher than the emission level in 1990. The backcast values for total transport emissions line up quite closely with the official estimates published by AGO (2000) for 1993/94–1998/99 (see figure 5.1).

FIGURE 5.1 TRANSPORT EMISSIONS (ACTUAL AND FORECAST)
(million tonnes CO_2-e)

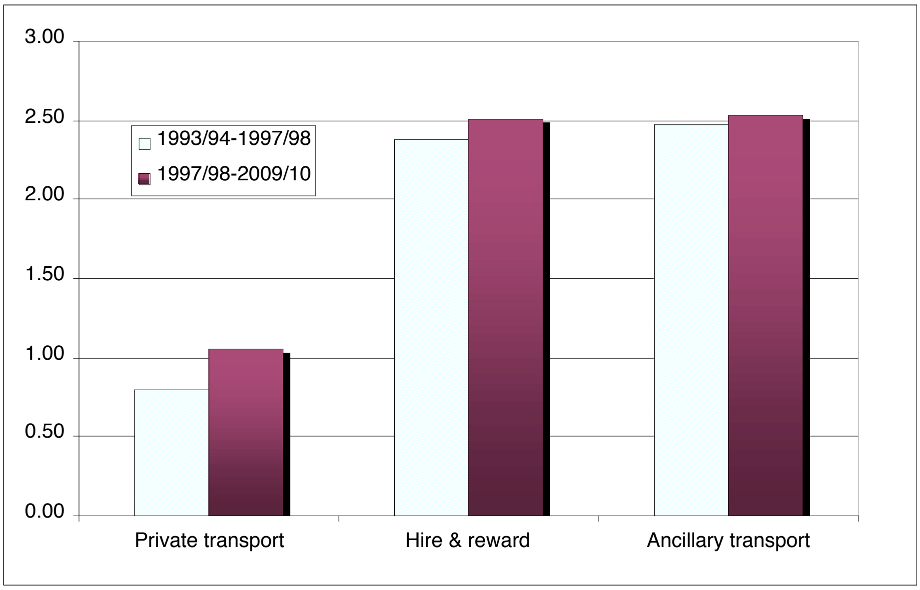


Road transport will remain the dominant source of total transport emissions and will grow at an annual average rate of 1.9 per cent (compared with 2.7 per cent in historical period), reaching 78.2 million tonnes CO_2-e in 2009–10.

Within the road transport industry, emissions from private use of motor vehicles are expected to grow faster (from 0.8 per cent to 1.1 per cent per annum), reflecting the expected slower improvement of fuel efficiency for the sector. Emissions from the 'hire and reward' part of road transport and from ancillary transport will continue its earlier trend, growing at a slightly faster rate (see figure 5.2).

FIGURE 5.2 PROJECTED GROWTH RATES FOR ROAD TRANSPORT EMISSIONS BY SUB-SECTOR

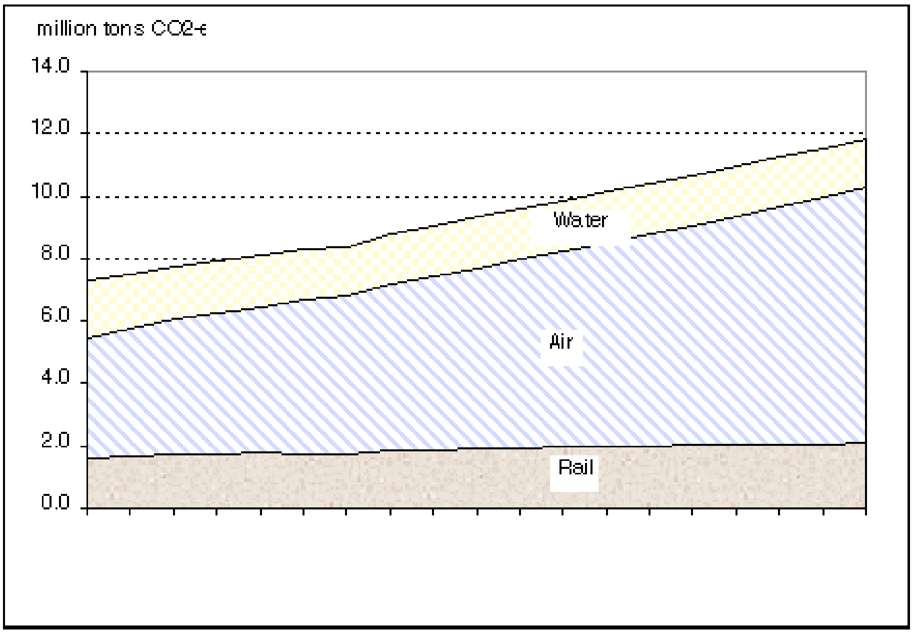
(Per cent per annum)



Emissions from non-road transport will grow slightly faster (2.8 per cent per annum) than from road, principally driven by the high rate of growth in emissions from air transport (over 4 per cent per annum), with growth of emissions from rail and water transport being largely static (figure 5.3).

FIGURE 5.3 PROJECTIONS OF NON-ROAD TRANSPORT EMISSIONS

(million tons CO_2-e)



CHAPTER 6 SENSITIVITY ANALYSIS

Sensitivity analyses were conducted by varying assumptions for GDP growth rates and for future changes in international oil prices. The scenarios are summarised in table 6.1.

TABLE 6.1 VARIATIONS TO THE BASECASE ASSUMPTIONS

(Per cent per annum)

Scenarios	*Variable*	*Alternative assumptions for GDP growth*	*Alternative assumption about oil prices*
1	GDP	3.9 (basecase +0.5)	Basecase assumption
2	GDP	2.9 (basecase -0.5)	
3	Oil prices	Basecase assumption	US$29.6 per barrel (2000/01–2011/12)
4	Oil prices	GDP growth endogenous	US$29.6 per barrel (2000/01–2011/12)

ALTERNATIVE GROWTH SCENARIOS

Scenario 1 (2) adds (deducts) 0.5 of a percentage point to (from) the basecase assumption for annual GDP growth. Under the high (low) growth scenario, road transport emissions in 2009–10 will be 3.0 per cent higher (lower) than for the basecase. Variations in emissions from non-road transport are larger, principally driven by changes in air transport emissions. Demand for air transport has been specified as being more responsive to income growth than that for other forms of transport. Because of the dominance of road transport, variations in total transport emissions exhibit a similar pattern of road transport emissions trends (see table 6.2).

TABLE 6.2 TRANSPORT EMISSIONS: HIGH/LOW GDP GROWTH SCENARIOS COMPARED WITH THE BASECASE

(million tonnes, CO_2-e)

	Basecase (2009–10)	*High growth (2009–10)*	*Low growth (2009–10)*	*High growth: change relative to basecase (%)*	*Low growth: change relative to basecase (%)*
Total emissions	594.2	623.2	565.8	4.9	-4.8
Transport emissions	89.4	92.5	86.4	3.4	-3.4
Road transport	78.2	80.5	75.8	3.0	-3.0
Other transport	11.3	12.0	10.5	6.5	-6.4
Air transport	7.6	8.3	6.9	9.0	-8.6
GDP (% per annum)	**3.4**	**3.9**	**2.9**		

HIGH INTERNATIONAL OIL PRICES

Scenarios 3 and 4 assume that international oil prices will remain at the 2000–01 level, that is, around US$30 per barrel (see table A3.1 for detail).

The impacts of higher international oil prices on GHG emissions were analysed under the following two different macroeconomic settings:

- GDP is treated as exogenous in both the basecase and high international oil price scenario (scenario 3) ; and
- GDP is treated as exogenous in basecase and as endogenous in high international oil price scenario (scenario 4).

The first macroeconomic setting assumes that the Australian economy is not affected by changes in international oil prices. This means that the economy, under the high international oil price scenario, will grow at the same annual rate as that for the basecase. High international oil prices are expected to increase the costs of producing petroleum products, leading to an increase in prices of these products. This in turn will reduce demand for petroleum products through substitution and hence lower the level of GHG emissions from petroleum products. The impact is, however, expected to be small because of the inelastic demand for petroleum products, notably by the transport sector.

The second setting is more realistic than the first one in the sense that it allows international oil prices to influence GDP growth. High international oil prices are expected to increase prices of goods and services in Australia thereby reducing domestic demand and export competitiveness. This, in turn, will slow the growth of the Australian economy. The second setting includes, in addition to price effects, the impact of a lower activity level on the demand for petroleum products as a result of higher international oil prices.

Results of the sensitivity analyses for scenarios 3 and 4 are presented in tables 6.3 and 6.4 respectively. While both scenarios produced an almost identical outcome in terms of total emissions (-0.3 per cent from the basecase in 2009–10), scenario 4 resulted in a larger decline in transport emissions (-1.5 per cent) than the case for scenario 3 (-1.1 per cent). The difference is likely to be caused by lower economic activity level due to higher international oil prices. Under scenario 4, the annual average rate of GDP growth is 3.3 per cent compared with 3.4 per cent assumed in scenario 3.

Most reductions in transport emissions come from road transport. Under scenario 4, road transport emissions in 2009–10 will be 1.5 per cent lower than in the basecase compared with 1.0 per cent lower under scenario 3.

TABLE 6.3 TRANSPORT EMISSIONS: SCENARIO 3

(million tons, CO_2-e)

	Standard basecase (2009–10)	*Scenario 3: higher oil prices (2009–10)*	*Change relative to standard basecase (%)*
Total emissions	594.2	592.4	-0.3
Transport emissions	89.4	88.4	-1.1
Road transport	78.2	77.4	-1.0
Other transport	11.3	11.1	-1.7
GDP (%): 2000/01–2009/10	3.4	3.4	

TABLE 6.4 TRANSPORT EMISSIONS: SCENARIO 4

(million tons, CO_2-e)

	Standard basecase (2009–10)	*Scenario 4: higher oil prices (2009–10)*	*Change relative to standard basecase (%)*
Total emissions	594.2	592.6	-0.3
Transport emissions	89.4	88.0	-1.5
Road transport	78.2	76.9	-1.5
Other transport	11.3	11.1	-1.4
GDP (%): 2000/01–2009/10	3.4	3.3	

The overall results of sensitivity analyses show that GHG emissions are not very responsive to changes in international oil prices. Some simple back-of-the-envelop (BOTE) calculations help to explain the results.

In the BOTE analysis, the direct impact of an oil price shock is first estimated for production costs (or producer price) and then on retail prices of petroleum products.

According to the model-estimated input–output database, oil accounts for around 20 per cent of the total production costs for the petroleum industry in

1999–2000.[15] Hence a 50 per cent rise in international oil prices translates into roughly a 10 per cent (50x0.2) rise in production costs for the petroleum industry.

Unit production cost accounts for less than 50 per cent per cent of the retail price of most petroleum products. Take petrol as an example. It is estimated that in 1999–2000 production costs comprised only around 40 per cent of the retail price of petrol. So, a 10 per cent rise in production costs would lead to a 4 per cent (10x0.4) rise in the retail price of petrol, everything else being constant.

The price elasticity of demand for petrol implied by the BOTE calculation is therefore -0.38 (= –1.5/4). A 10 per cent change in fuel prices at the refinery translates to a 4 per cent change in fuel prices at the service station pump. The final BOTE demand elasticity may be determined from scenario 4 where a 10 per cent increase in refinery prices raised the price to fuel users by 4 per cent. The 4 per cent increase in fuel prices lowered transport emissions by 1.5 per cent (column 3 table 6.4), implying an elasticity of demand of -0.38. The main reason for this is that the BOTE calculation did not include the effect of the oil shock on production costs through other intermediate inputs such as other petroleum products. If such an effect had been included, the estimated price elasticity of demand for petrol would have been lower.

15. Another 18 per cent is accounted for by intermediate petroleum products (PetrolOther), which is not directly shocked. The effect is indirectly captured via the modelled industry linkage.

APPENDIX I EMISSIONS ACCOUNTING FOR THE TRANSPORT SECTOR

In MMRF–GREEN, GHG emissions are measured in CO_2-e units of global warming power. The model produces estimates for three greenhouse gases: CO_2, CH_4 and N_2O. CO_2-e emissions are estimated according to the formula:

$$CO_2\text{-e} = 1^* \; CO_2 + 21^* \; CH_4 + 310^* \; N_2O$$

Transport emissions come mainly from the burning of petroleum products. Estimation of transport emissions involves two steps: the first is to estimate total emissions from burning petroleum products, and the second to allocate these emissions to transport and other emitters.

EMISSIONS FROM BURNING PETROLEUM PRODUCTS

Emissions from burning petroleum products were estimated on the basis of total consumption of petroleum products and their associated emission intensities. Total consumption of petroleum products by fuel type for the base year (1993–94) was derived by taking a simple average of 1993 and 1994 consumption data published in AIP (1997).

Emissions from burning petroleum products by businesses (industries) and consumers were derived by multiplying total emissions from burning petroleum products by shares of the intermediate demand (BAS1) and consumer demand (BAS3) for fuels. A number of adjustments were made to the original BAS1 values contained in the MMRF–GREEN database before they were applied to estimate emissions from burning petroleum products by fuel type and user.

- The producer price of diesel for the base year used in this study is $0.32 per litre. Multiplication of price data and AIP consumption data yields the controlled total for diesel use in value terms. This total is then allocated to industries using BAS1 shares.
- The producer price of LPG used in this study for the base year is $0.19 per litre. An approach similar to that for diesel was used to estimate the controlled total for LPG and LPG use by industry. However, BAS1 shares were adjusted to reflect information from ABARE (Bush et al. 1999) on LPG use.

- For petrol, aviation fuels and other petroleum products, emissions from some transport industries (*WaterTrans*, *AirTrans* and *RailTrans*) are also controlled by using information from NGGI 1994 (ANGGIC 1996).

The estimated emissions matrix for petroleum products is shown in table 3.1.

TRANSPORT EMISSIONS

Shares of road, rail, air and water transport in total emissions were estimated on the basis of published data from NGGI 1994 (ANGGIC 1996) and Hassall and Associates (1994). These shares are presented in tables A1.1 to A1.4.

Proportion of road transport emissions in total emissions from petroleum products

Table A1.1 presents the proportion of road transport emissions in total emissions from the 42 emitters (41 industries plus residential) in 1993–94. According to column 2 of the table, road transport accounts for 38 per cent of the total road transport industry's emissions from natural gas. In other words, the road transport industry uses only 38 per cent of natural gas for road transport purposes and remaining 62 per cent is possibly used for non-transport purposes.

Column 4 of table A1.1 shows that, nearly all emissions from burning *PetrolAuto* are allocated to the road transport industry. The exception is the agricultural and forestry industries. According to Hassall and Associates (1994), the agricultural industry uses 79 per cent of *PetrolAuto* for road transport purposes, while the forestry industry does not use *PetrolAut*o for road transport purposes at all.

The split of diesel is more complicated. For industries on which information is available, shares were derived according to the available data. For example, according to Hassall and Associates (1994), only 18 per cent of diesel used in the *Agriculture* is for transport purposes (column 7 of table A1.1). For some other industries, shares were set according to common sense. For example, it was assumed that all diesel used by the *PrivTranServ* industry is for transport purposes. For industries for which no information is available or no easy judgement could be made, a uniform 26 per cent was assumed.[16]

Proportion of air transport emissions in total emissions from petroleum products

Table A1.2 suggests that air transport industry accounts 97 per cent of total emissions from *AvGasoline* and 100 per cent of total emissions from *AvTurbine*.

[16] A consultancy was recently commissioned by BTRE to Apelbaum Consulting Group to improve estimates of diesel used for transport and non-transport purposes. The results of the consultancy are yet to be included in the future version of the MMRF-GREEN model.

These fuels are used mainly for air transport purposes. The figures do not include *AvGasoline* and *AvTurbine* used by domestic carriers on international routes.

Proportion of rail transport emissions in total emissions from petroleum products

According to Table A1.3, the rail transport industry accounts for 65 per cent of total emissions from diesel used by that industry and 100 per cent of total emissions from *PetrolOther*. This means that 35 per cent of the rail industry's total diesel consumption is used for purposes other than rail transport (such as road transport), whereas none of *PetrolOther* is being used for purposes other than rail transport.

Proportion of water transport emissions in total emissions from petroleum products

The water transport industry is assumed to account for 100 per cent of total emissions from *BlackCoal*, *PetrolAuto* and *PetrolOther* used in that industry, 32 per cent of total emissions from natural gas and 6 per cent from diesel.

TABLE A1.1 PROPORTION OF ROAD TRANSPORT EMISSIONS IN TOTAL EMISSIONS FROM PETROLEUM PRODUCTS

Industry	*Black Coal*	*Natural Gas*	*Brown Coal*	*Petrol Auto*	*Aviation Gasoline*	*Aviation Turbine*	*Diesel*	*LPG*	*Petrol Other*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
1 Agriculture	0.00	0.00	0.00	0.79	0.00	0.00	0.18	0.00	0.00
2 Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 IronOre	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
4 NonIronOre	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
5 BlackCoal	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
6 Oil	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
7 NatGas	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
8 BrownCoal	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
9 Food	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
10 TCF	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
11 Woodpaper	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
12 Chemicals	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
13 Petrol	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
14 Nmet_prods	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
15 Cement	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
16 Steel	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
17 AlumMagnes	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
18 OthMet_prods	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
19 CarsParts	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
20 Other_man	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
21 ElectBlack	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
22 ElectBrown	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
23 ElectGas	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
24 ElectOil	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
25 ElectOther	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
26 ElectSupply	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
27 UrbanGasDis	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00	0.00
28 Water	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.90	0.00
29 Construction	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.95	0.00
30 TradeHotels	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.90	0.00
31 RoadTrans	0.00	0.38	0.00	0.99	0.00	0.00	1.00	1.00	0.00
32 RailTrans	0.00	0.00	0.00	0.99	0.00	0.00	0.35	0.00	0.00
33 WaterTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00
34 AirTrans	0.00	0.00	0.00	0.99	0.00	0.00	1.00	0.00	0.00
35 OtherTrans	0.00	0.00	0.00	0.99	0.00	0.00	1.00	1.00	0.00
36 Communic	0.00	0.00	0.00	0.99	0.00	0.00	1.00	0.00	0.00
37 FinBusServ	0.00	0.00	0.00	0.99	0.00	0.00	1.00	0.90	0.00
38 Dwelling	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
39 PubServ	0.00	0.00	0.00	0.99	0.00	0.00	0.84	0.90	0.00
40 OthServ	0.00	0.00	0.00	0.99	0.00	0.00	1.00	0.00	0.00
41 PrivTranServ	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00
42 Residential	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00

Source: BTRE.

TABLE A1.2 PROPORTION OF AIR TRANSPORT EMISSIONS IN TOTAL EMISSIONS FROM PETROLEUM PRODUCTS

Industry	*Black Coal*	*Natural Gas*	*Brown Coal*	*Petrol Auto*	*Aviation Gasoline*	*Aviation Turbine*	*Diesel*	*LPG*	*Petrol Other*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
1 Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 IronOre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 NonIronOre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 BlackCoal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6 Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7 NatGas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8 BrownCoal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9 Food	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 TCF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11 Woodpaper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12 Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13 Petrol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14 Nmet_prods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 Cement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16 Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17 AlumMagnes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18 OthMet_prods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19 CarsParts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20 Other_man	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21 ElectBlack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22 ElectBrown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23 ElectGas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24 ElectOil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25 ElectOther	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26 ElectSupply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27 UrbanGasDis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28 Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29 Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30 TradeHotels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31 RoadTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32 RailTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33 WaterTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34 AirTrans	0.00	0.00	0.00	0.00	0.97	1.00	0.00	0.00	0.00
35 OtherTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36 Communic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37 FinBusServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38 Dwelling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39 PubServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40 OthServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41 PrivTranServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: BTRE.

TABLE A1.3 PROPORTION OF RAIL TRANSPORT EMISSIONS IN TOTAL EMISSIONS FROM PETROLEUM PRODUCTS

Industry	*Black Coal* (1)	*Natural Gas* (2)	*Brown Coal* (3)	*Petrol Auto* (4)	*Aviation Gasoline* (5)	*Aviation Turbine* (6)	*Diesel* (7)	*LPG* (8)	*Petrol Other* (9)
1 Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 IronOre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 NonIronOre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 BlackCoal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6 Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7 NatGas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8 BrownCoal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9 Food	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 TCF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11 Woodpaper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12 Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13 Petrol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14 Nmet_prods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 Cement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16 Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17 AlumMagnes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18 OthMet_prods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19 CarsParts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20 Other_man	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21 ElectBlack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22 ElectBrown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23 ElectGas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24 ElectOil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25 ElectOther	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26 ElectSupply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27 UrbanGasDis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28 Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29 Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30 TradeHotels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31 RoadTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32 RailTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	1.00
33 WaterTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34 AirTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35 OtherTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36 Communic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37 FinBusServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38 Dwelling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39 PubServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40 OthServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41 PrivTranServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: BTRE.

TABLE A1.4 PROPORTION OF WATER TRANSPORT EMISSIONS IN TOTAL EMISSIONS FROM PETROLEUM PRODUCTS

Industry	*Black Coal*	*Natural Gas*	*Brown Coal*	*Petrol Auto*	*Aviation Gasoline*	*Aviation Turbine*	*Diesel*	*LPG*	*Petrol Other*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
1 Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 IronOre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 NonIronOre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 BlackCoal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6 Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7 NatGas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8 BrownCoal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9 Food	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 TCF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11 Woodpaper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12 Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13 Petrol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14 Nmet_prods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 Cement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16 Steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17 AlumMagnes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18 OthMet_prods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19 CarsParts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20 Other_man	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21 ElectBlack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22 ElectBrown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23 ElectGas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24 ElectOil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25 ElectOther	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26 ElectSupply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27 UrbanGasDis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28 Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29 Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30 TradeHotels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31 RoadTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32 RailTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33 WaterTrans	1.00	0.32	0.00	1.00	0.00	0.00	0.06	0.00	1.00
34 AirTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35 OtherTrans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36 Communic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37 FinBusServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38 Dwelling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39 PubServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40 OthServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41 PrivTranServ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: BTRE.

APPENDIX II MACROECONOMIC ASSUMPTIONS

Table A2.1 shows the year on year historical growth of GSP from 1994–95 to 1999–00, and the projected average annual growth rates from 2000–01 to 2011–12 for each region. The level of GSP (derived from using base year estimates (1993–94) of GSP from ABS and average annual growth rates) is shown in the table A2.2.

In MMRF–GREEN, national GDP growth is determined endogenously if GSP growth for all the regions is imposed exogenously. Table A2.1 also presents the implied growth projections for GDP using the GSP assumptions for each state/territory.

TABLE A2.1 ANNUAL GROWTH RATE OF GSP AND IMPLIED GDP

(Per cent)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1995	3.6	3.2	5.5	0.4	7.0	2.9	7.1	4.2	4.0
1996	4.2	3.5	4.1	5.1	5.4	3.3	6.0	2.6	4.2
1997	3.8	2.9	5.2	1.7	3.1	0.4	2.9	1.6	3.4
1998	4.7	4.8	4.2	6.6	5.9	0.3	4.3	6.4	4.9
1999	5.3	7.0	6.2	2.3	3.6	5.1	8.1	3.0	5.4
2000	4.0	4.8	5.8	3.8	3.8	0.9	1.0	5.2	4.4
2001	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2002	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2003	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2004	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2005	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2006	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2007	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2008	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2009	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2010	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2011	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
2012	3.2	3.1	3.9	2.3	4.6	1.8	5.8	3.6	3.4
Average annual growth rate									
1994–2000	4.3	4.4	5.2	3.3	4.8	2.2	4.8	3.8	4.4
2000–2012	3.2	3.1	3.9	2.3	4.7	1.8	5.8	3.6	3.4

Source: Access Economics (2000).

TABLE A2.2 GSP AND IMPLIED GDP

(Billion dollars)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1994	172.8	122.3	76.4	34.1	49.9	10.0	4.9	10.1	480.5
1995	179.1	126.2	80.6	34.3	53.4	10.3	5.2	10.5	499.6
1996	186.6	130.7	83.9	36.0	56.3	10.6	5.6	10.8	520.4
1997	193.7	134.5	88.2	36.6	58.0	10.7	5.7	11.0	538.3
1998	202.8	141.0	92.0	39.1	61.4	10.7	6.0	11.7	564.6
1999	213.5	150.8	97.7	40.0	63.6	11.3	6.4	12.0	595.3
2000	222.1	158.1	103.3	41.5	66.0	11.4	6.5	12.6	621.5
2001	229.1	162.9	107.4	42.4	69.0	11.6	6.9	13.1	642.4
2002	236.4	167.9	111.6	43.4	72.2	11.8	7.3	13.5	664.2
2003	243.9	173.1	116.0	44.4	75.6	12.0	7.7	14.0	686.7
2004	251.6	178.4	120.6	45.4	79.1	12.2	8.1	14.5	709.9
2005	259.5	183.8	125.3	46.5	82.8	12.4	8.6	15.1	734.0
2006	267.7	189.5	130.2	47.5	86.6	12.6	9.1	15.6	759.0
2007	276.2	195.3	135.4	48.6	90.7	12.9	9.6	16.2	784.8
2008	285.0	201.3	140.7	49.7	94.9	13.1	10.2	16.7	811.6
2009	294.0	207.5	146.2	50.9	99.3	13.3	10.8	17.3	839.3
2010	303.3	213.9	152.0	52.0	103.9	13.6	11.4	18.0	868.0
2011	312.9	220.4	158.0	53.2	108.7	13.8	12.1	18.6	897.7
2012	322.8	227.2	164.2	54.4	113.8	14.0	12.8	19.3	928.4

Source: Access Economics (2000).

Access Economics forecasts were used as the reference case growth assumptions. The advantage of using Access Economics assumptions is that all regional growth trends and components thereof have been developed within a consistent modelling framework. Access Economics projections of GSP growth by region imply a national growth rate of 3.4 per cent, which is very close to the mean average annual growth rate of 3.3 per cent assumed by the main CGE modellers in their projections of the Australian GHG emissions.

Using the maximum deviation as a basis for high and low growth sensitivity scenarios implies a sensitivity bound of +/– 0.5 of a percentage point per year, in other words, a high growth rate of 3.9 per cent and a low growth rate of 2.9 per cent.

COMPONENTS OF GSP

The components of GSP growth that are set exogenously in MMRF–GREEN for the projections include regional household consumption, regional investment and regional import volumes. Real government consumption is indexed to real household consumption. Real export volumes by region are determined by

MMRF–GREEN and are adjusted to reconcile growth in the components of GSP to total GSP growth.

The assumptions used for regional growth in household consumption, government consumption and import volumes, all obtained from Access Economics, are shown in tables A2.3 to A2.8.

TABLE A2.3 ANNUAL GROWTH RATE OF REAL HOUSEHOLD CONSUMPTION AND IMPLIED NATIONAL RESULTS

(Per cent)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1995	5.06	5.29	6.34	4.67	4.45	1.7	9.68	2.73	5.16
1996	4.41	3.61	3.89	3.27	4.24	3.14	8.68	2.11	3.98
1997	2.52	3.58	2.92	0.22	1.96	1.53	-1.78	2.33	2.57
1998	3.9	5.72	5.68	4.78	5.17	3.54	7.64	5.27	4.9
1999	4.78	5.37	6.58	3.13	4.36	1.82	6.45	4.3	5.03
2000	4.49	5.16	4.86	3.57	3.76	3.79	6	5.92	4.62
2001	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.16
2002	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.16
2003	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.17
2004	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.17
2005	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.17
2006	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.17
2007	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.17
2008	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.18
2009	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.18
2010	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.18
2011	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.18
2012	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.19
Average annual growth rate									
1994–2000	4.2	4.8	5.0	3.3	4.0	2.7	6.5	3.9	4.4
2000–2012	3.2	2.79	3.68	2.4	3.95	1.48	4.31	2.94	3.17

Source: Access Economics (2000).

TABLE A2.4 REAL HOUSEHOLD CONSUMPTION AND IMPLIED NATIONAL RESULTS

(Billion dollars)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1994	102.3	71.7	48.7	21.6	27.1	6.8	2.4	5.4	286.3
1995	107.5	75.5	51.8	22.7	28.3	7.0	2.7	5.6	301.1
1996	112.3	78.3	53.8	23.4	29.5	7.2	2.9	5.7	313.1
1997	115.1	81.1	55.4	23.5	30.1	7.3	2.9	5.8	321.1
1998	119.6	85.7	58.6	24.6	31.6	7.5	3.1	6.2	336.8
1999	125.3	90.3	62.4	25.3	33.0	7.7	3.3	6.4	353.8
2000	130.9	95.0	65.4	26.2	34.3	8.0	3.5	6.8	370.1
2001	135.1	97.6	67.8	26.9	35.6	8.1	3.6	7.0	381.8
2002	139.5	100.3	70.3	27.5	37.0	8.2	3.8	7.2	393.9
2003	143.9	103.1	72.9	28.2	38.5	8.3	3.9	7.4	406.3
2004	148.5	106.0	75.6	28.9	40.0	8.4	4.1	7.6	419.2
2005	153.3	109.0	78.4	29.5	41.6	8.6	4.3	7.9	432.5
2006	158.2	112.0	81.3	30.3	43.2	8.7	4.5	8.1	446.2
2007	163.3	115.1	84.3	31.0	44.9	8.8	4.7	8.3	460.4
2008	168.5	118.3	87.4	31.7	46.7	9.0	4.9	8.6	475
2009	173.9	121.6	90.6	32.5	48.5	9.1	5.1	8.8	490.1
2010	179.5	125.0	93.9	33.3	50.4	9.2	5.3	9.1	505.7
2011	185.2	128.5	97.4	34.1	52.4	9.4	5.5	9.4	521.8
2012	191.2	132.1	101.0	34.9	54.5	9.5	5.8	9.6	538.4

Source: Access Economics (2000).

TABLE A2.5 ANNUAL GROWTH RATE OF REAL GOVERNMENT CONSUMPTION AND IMPLIED NATIONAL RESULTS

(Per cent)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1995	5.1	5.3	6.3	4.7	4.5	1.7	9.7	2.7	5.2
1996	4.4	3.6	3.9	3.3	4.2	3.1	8.7	2.1	4.0
1997	2.5	3.6	2.9	0.2	2.0	1.5	-1.8	2.3	2.6
1998	3.9	5.7	5.7	4.8	5.2	3.5	7.6	5.3	4.9
1999	4.8	5.4	6.6	3.1	4.4	1.8	6.5	4.3	5.0
2000	4.5	5.2	4.9	3.6	3.8	3.8	6.0	5.9	4.6
2001	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2002	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2003	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2004	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2005	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2006	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2007	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2008	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2009	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2010	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2011	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
2012	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2
Average annual growth rate									
1994–2000	4.2	4.7	5.0	3.3	3.9	2.1	6.3	3.7	4.3
2000–2012	3.2	2.8	3.7	2.4	4.0	1.5	4.3	2.9	3.2

Source: Access Economics (2000).

TABLE A2.6 REAL GOVERNMENT CONSUMPTION AND IMPLIED NATIONAL RESULTS
(Billion dollars)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1994	31	21.5	13.8	7.4	7.8	2.3	1.8	6.6	92.1
1995	32.6	22.6	14.6	7.8	8.1	2.3	2.0	6.8	96.8
1996	34.0	23.4	15.2	8.0	8.5	2.4	2.2	6.9	100.6
1997	34.9	24.3	15.7	8.0	8.6	2.4	2.1	7.1	103.1
1998	36.2	25.7	16.6	8.4	9.1	2.5	2.3	7.5	108.2
1999	38.0	27.1	17.6	8.7	9.5	2.5	2.4	7.8	113.6
2000	39.7	28.4	18.5	9.0	9.8	2.6	2.6	8.2	118.9
2001	40.9	29.2	19.2	9.2	10.2	2.7	2.7	8.5	122.6
2002	42.3	30.1	19.9	9.4	10.6	2.7	2.8	8.7	126.5
2003	43.6	30.9	20.6	9.7	11.0	2.8	2.9	9.0	130.5
2004	45.0	31.8	21.4	9.9	11.5	2.8	3.1	9.2	134.6
2005	46.4	32.6	22.2	10.1	11.9	2.8	3.2	9.5	138.9
2006	47.9	33.5	23.0	10.4	12.4	2.9	3.3	9.8	143.2
2007	49.5	34.5	23.8	10.6	12.9	2.9	3.5	10.1	147.8
2008	51.1	35.4	24.7	10.9	13.4	3.0	3.6	10.4	152.4
2009	52.7	36.4	25.6	11.1	13.9	3.0	3.8	10.7	157.3
2010	54.4	37.4	26.5	11.4	14.5	3.1	3.9	11.0	162.2
2011	56.1	38.5	27.5	11.7	15.0	3.1	4.1	11.3	167.4
2012	57.9	39.6	28.5	12.0	15.6	3.1	4.3	11.7	172.7

Source: Access Economics (2000).

TABLE A2.7 ANNUAL GROWTH RATE OF REAL IMPORT VOLUMES AND IMPLIED NATIONAL RESULTS

(Per cent)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1995	21.6	17.3	12.9	10.2	21.1	-27.6	21.8	-50.0	18.2
1996	8.4	2.9	1.9	-0.6	7.2	-3.0	8.8	-14.3	5.2
1997	8.9	9.6	11.7	15.2	15.3	23.1	8.1	66.7	10.3
1998	9.9	9.7	9.1	11.2	23.6	-10.0	55.3	-10.0	11.1
1999	10.7	5.0	7.9	-8.4	3.9	4.6	-27.7	11.1	6.8
2000	18.4	9.3	12.1	12.2	4.0	8.6	178.4	0.0	14.0
2001	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.0
2002	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.0
2003	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.0
2004	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2005	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2006	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2007	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2008	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2009	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2010	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2011	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
2012	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1
Average annual growth rate									
1994–2000	12.9	8.8	9.0	6.4	12.2	-4.7	27.7	-4.7	10.9
2000–2012	3.4	4.3	5.3	2.9	5.7	-9.3	1.8	12.5	4.1

Source: Access Economics (2000).

TABLE A2.8 REAL IMPORT VOLUMES AND IMPLIED NATIONAL RESULTS

(Billion dollars)

Year ending 30 June	*NSW*	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*NT*	*ACT*	*Australia*
1994	24.1	20.4	7.2	2.9	4.8	0.4	0.3	12.0	60.0
1995	29.4	23.9	8.1	3.2	5.8	0.3	0.4	6.0	71.0
1996	31.8	24.6	8.2	3.2	6.2	0.3	0.4	5.0	74.7
1997	34.6	26.9	9.2	3.6	7.2	0.3	0.4	9.0	82.3
1998	38.1	29.5	10.0	4.1	8.9	0.3	0.6	8.0	91.5
1999	42.1	31.0	10.8	3.7	9.2	0.3	0.5	9.0	97.7
2000	49.9	33.9	12.1	4.2	9.6	0.3	1.3	9.0	111.4
2001	51.6	35.4	12.8	4.3	10.2	0.3	1.3	10.0	115.8
2002	53.4	36.9	13.4	4.4	10.7	0.3	1.4	11.0	120.5
2003	55.2	38.5	14.1	4.5	11.4	0.2	1.4	12.0	125.3
2004	57.1	40.2	14.9	4.7	12.0	0.2	1.4	14.0	130.4
2005	59.0	41.9	15.7	4.8	12.7	0.2	1.4	15.0	135.7
2006	61.0	43.7	16.5	5.0	13.4	0.2	1.5	17.0	141.2
2007	63.1	45.6	17.4	5.1	14.2	0.2	1.5	20.0	147.0
2008	65.3	47.6	18.3	5.3	15.0	0.2	1.5	22.0	153.0
2009	67.5	49.6	19.2	5.4	15.8	0.1	1.5	25.0	159.3
2010	69.8	51.8	20.2	5.6	16.7	0.1	1.6	28.0	165.8
2011	72.2	54.0	21.3	5.7	17.7	0.1	1.6	31.0	172.6
2012	74.6	56.4	22.4	5.9	18.7	0.1	1.6	35.0	179.7

Source: Access Economics (2000).

APPENDIX III RELATING FUEL-USING TECHNOLOGY TO FUEL INTENSITY

MMRF–GREEN allows for changes in the intermediate input-using technology used by each industry to produce commodities. Assumptions about changes in intermediate input-using technology in relation to the use of petroleum products have an important bearing on changes in future transport emissions. The purpose of this appendix is to establish a link between the 'fuel-using technology' variable in top-down models and the concept of fuel intensity used in bottom-up models so that the information contained in the latter can be, wherever possible, incorporated into MMRF–GREEN forecasting simulations.

FUEL INTENSITY IN BOTTOM-UP MODELS

Fuel intensity is the reverse of fuel efficiency. It is often measured in litres per 100 kilometres for road vehicles. In bottom-up models, fuel intensity is one of the primary factors affecting changes in total fuel consumption and hence vehicle-related GHG emissions.

Bottom-up models such as BTRE's CARMOD typically use the following equation to estimate fuel consumption:

$$FC = VS * \frac{VKT}{VS} * \frac{FC}{VKT} \qquad \text{A3.1}$$

where *FC* is total fuel consumption; *VS* is the total number of vehicles in stock; *VKT*/*VS* is the average vehicle kilometres travelled; and *FC*/*VKT* is fuel intensity *(FI)* measured in litres per 100 kilometres. Because *VS***VKT*/*VS* equals the total vehicle kilometres travelled (*TVKT*), equation A4.1 can be reduced to:

$$FC = TVKT * FI \qquad \text{A3.2}$$

In percentage change form, equation A4.2 can be written as:

$$fc = tvkt + fi \qquad \text{A3.3}$$

Equation A3.3 says that percentage change in total fuel consumption (*fc*) depends on percentage change in the total vehicle kilometres travelled (*tvkt*) and percentage change in average fuel intensity (*fi*).

Table A3.1 presents preliminary estimates of average annual rates of change in fuel intensity from CARMOD and TRUCKMOD for new cars, the entire car stock and the truck stock for 1993/94–1997/98 and 1997/98–2011/12. Fuel intensity for new cars declined by 1.1 per cent annually during 1993/94–1997/98. A further decline of 0.8 per cent per annum is expected for 1997/98–2011/12. This prediction is based on the assumption that existing known fuel-saving technological changes that are likely to be economically viable will be fully exploited.

The decline in fuel intensity for the entire car fleet is slower than for new cars over both the historical and forecasting periods. This is especially true for the forecasting period during which the rate of improvement in fuel efficiency is expected to be slower. The main reason is that the Australian car fleet is projected to age more during the forecasting period compared with the historical period.[17]

TABLE A3.1 CHANGES IN FUEL INTENSITY

(Average annual rate of change)

	1993/94–1997/98	*1997/98–2011/12*
New cars (including 4WDs) – litres /100km	-1.1	-0.8
Entire car stock – litres /100km	-0.5	-0.3
Truck stock (all commercial freight vehicles)		
MJ / km	0.3	-0.3
MJ / tonne km	-1.3	-1.9

Source: Preliminary estimates from BTRE's CARMOD and TRUCKMOD.

Interpretation of change in fuel intensity for trucks is less straightforward. There are two ways to specify changes in fuel intensity for trucks: one that takes account of load factor (MJ/tkm) and one that does not (MJ/km). In a situation where average load changes significantly over time, it is more appropriate to use the fuel intensity indicator measured in MJ/tkm. According to BTRE preliminary estimates, the decline in fuel intensity is expected to be greater (-1.9 per cent per annum) in the forecasting period than in the historical period (-1.3 per cent per annum). The key factor driving this is the increasing trend in fuel intensity (measured in MJ/km) during the historical period due to the effects on fuel consumption per vehicle of growth in vehicle sizes offsetting fuel saving technological change. The trend for increases in average load in the future is assumed to remain the same as in the past, but the rate of fuel saving technological change will be greater.[18]

17. Pers. Comm. D. Cosgrove, BTRE.

18. Pers. Comm. D. Mitchell, BTRE.

INTERMEDIATE FUEL-USING TECHNOLOGY AND FUEL INTENSITY

Like most CGE models, MMRF–GREEN specifies intermediate demand as being proportional to industry output. In the case of industries' demand for fuel, the relationship can be expressed as follows:

$$fc_j = z_j + a_j \qquad \text{A3.4}$$

where fc_j is the percentage change in fuel consumption by industry j; z_j is the percentage change output in industry j; and a_j is the change in fuel-using technology in industry j.

The concept of fuel-using technology (a_j) is broader than the fuel-intensity (fi) defined in bottom-up models. In general, changes in fuel-using technology could be decomposed into two components: one due to changes in fuel intensity (fi_j) — equivalent to fi defined in the bottom-up models; and the other due to changes in other factors (o_j) — notably changes in output mix. This leads to:

$$a_j = fi_j + o_j \qquad \text{A3.5}$$

In both the historical and forecasting simulations, the average annual growth rates of the *PrivTranServ* industry ($z_{PrivTranServ}$) were set equal to those for the TVKT estimated from the BTRE bottom-up models. During 1999/00–2011/12, TVKT in Australia were projected to increase at an average annual rate of 1.8 per cent, compared with 2.4 per cent over the historical period (1993/4–1999/00).[19]

Assumptions about changes in fuel intensity for *PetrolAuto* and *Diesel* used in the *PrivTranServ* industry ($fi_{PrivTranServ}$) were also based on the estimates derived from the BTRE bottom-up models, which are shown in table A3.1. It was assumed that the fuel intensity would decline at a slower rate (-0.3 per cent per annum) over the forecasting period than the historical period (-0.5 per cent per annum).

Ideally, TVKT could be broken down by fuel type. But this information is not readily available from the BTRE bottom-up models. Observations are that TVKT using *PetrolAuto* have been growing at a slower rate than TVKT in Australia. For the historical period, the annual average percentage change in TVKT using *PetrolAuto* for the *PrivTranServ* industry ($o_{PrivTranServ}$) was assumed to be –1.0 per cent. This was halved for the forecasting period, reflecting a lower rate of shifting away from *PetrolAuto* expected in the future.

For industries other than the *PrivTranServ* industry, no distinction was made for fuel-using technology (a_j) between fuel intensity (fi_j) and changes in output mix

19. Pers. Comm. D. Cosgrove, BTRE.

(o_j) because of lack of information. It was assumed that the fuel-using technology (a_j) for *PetrolAuto* improves at an average annual rate of 1.0 per cent for the forecasting period.

In the case of *Diesel* used by the 'hire and reward' part of the road transport industry, changes in fuel intensity in the trucking industry[20] (measured in MJ per tonne kilometres, table A3.1) were used as a proxy for changes in fuel-using technology in that industry.

20. This is roughly the same as the 'hire & reward' part of the road transport industry (RoadTrans) in MMRF–GREEN.

APPENDIX IV ASSUMPTIONS ABOUT FUTURE OIL PRICES

Oil prices impact on greenhouse gas emissions from transport through:

- the effect on overall transport demand as prices change;
- substitution between transport modes in response to changes in relative prices; and
- substitution between different types of fuel within each mode in response to changes in relative fuel prices.

Table A4.1 shows the projections of the price per barrel of West Texas Intermediate (WTI) crude oil. Many analysts do not believe that the current high crude oil prices are sustainable as 'greenfield' oil reserves in non-OPEC regions become viable, and expect crude oil prices to trend downwards towards $US19 barrel by 2006.

Consensus Economics projections of crude oil prices average a number of projections by industry analysts such as the Energy Information Administration (US), and mineral exchanges (New York Mercantile Exchange and the London Futures Market). Consensus Economics projections were used for crude oil because they are based on a wide range of expert opinion. A high crude oil price scenario is also shown in table A4.1. This assumes that world crude oil prices will remain at the 2000–01 level over the projection period. This was used for a high world crude oil price sensitivity scenario.

TABLE A4.1 HISTORICAL AND PROJECTED CRUDE OIL PRICES

Financial year ending	*Reference case $US/barrel WTI*	*Percentage change from previous year*	*Sensitivity scenario $US/barrel WTI*	*Percentage change from previous year*
1994	21.00		21.00	
1995	20.40	-2.86	20.40	-2.86
1996	22.56	10.59	22.56	10.59
1997	23.20	2.84	23.20	2.84
1998	18.68	-19.49	18.68	-19.49
1999	17.52	-6.18	17.52	-6.18
2000	25.10	43.26	25.10	43.26
2001	29.57	17.79	29.57	17.79
2002	26.57	-10.13	29.57	0
2003	23.58	-11.25	29.57	0
2004	21.83	-7.42	29.57	0
2005	20.21	-7.42	29.57	0
2006	19.53	-3.36	29.57	0
2007	19.57	0.20	29.57	0
2008	19.61	0.20	29.57	0
2009	19.65	0.18	29.57	0
2010	19.68	0.18	29.57	0
2011	19.74	0.30	29.57	0
2012	19.82	0.41	29.57	0
Average annual rate of change				
2001–2006		-7.96		0
2006–2012		0		0

Source: Consensus Economics (2000).

ABBREVIATIONS

ABARE	Australian Bureau of Agriculture and Resource Economics
ABS	Australian Bureau of Statistics
ADO	Automotive diesel oil
AGO	Australian Greenhouse Office
AIP	Australian Institute of Petroleum
ANGGIC	Australian National Greenhouse Gas Inventory Committee
BOTE	Back-of-the-envelope
CGE	Computable general equilibrium
CoPS	Centre of Policy Studies
GHG	Greenhouse gases
GSP	Gross State Product
GDP	Gross Domestic Product
IOCC	Input–Output Commodity Classification
LES	Linear Expenditure System
LPG	Liquefied Petroleum Gas
NTS	New Tax System
TFC	Tourism Forecasting Council
TVKT	Total Vehicle Kilometres Travelled
WTI	West Texas Intermediate

MMRF–GREEN COMMODITIES/INDUSTRIES

Commodity/Industry		Description
1	*Agriculture*	Agriculture
2	*Forestry*	Forestry
3	*IronOre*	Iron ore
4	*NonIronOre*	Non-iron ore
5	*BlackCoal*	Black coal
6	*Oil*	Crude oil
7	*NatGas*	Natural gas
8	*BrownCoal*	Brown coal
9	*Food*	Food, beverages and tobacco
10	*TCF*	Textiles, clothing and footwear
11	*Woodpaper*	Wood and paper products
12	*Chemicals*	Chemical products excl. petrol
13	*Petrol*	Petrol
14	*Nmet_prods*	Non-metal construction materials excl. cement
15	*Cement*	Cement
16	*Steel*	Iron and steel
17	*AlumMagnes*	Alumina and aluminium
18	*OthMet_prods*	Other metal products
19	*CarsParts*	Motor vehicles and parts
20	*Other_man*	Other manufacturing
21	*ElectBlack*	Electricity generation - black coal
22	*ElectBrown*	Electricity generation - brown coal
23	*ElectGas*	Electricity generation - gas
24	*ElectOil*	Electricity generation - petroleum products
25	*ElectOther*	Electricity generation - other (mainly hydro)
26	*ElectSupply*	Electricity supply
27	*UrbanGasDis*	Urban gas distribution
28	*Water*	Water and sewerage services
29	*Construction*	Construction services
30	*TradeHotels*	Wholesale trade, retail trade, accommodation
31	*RoadTrans*	Road transport services
32	*RailTrans*	Rail transport
33	*WaterTrans*	Water transport
34	*AirTrans*	Air transport
35	*OtherTrans*	Other transport services
36	*Communic*	Communication services
37	*FinBusServ*	Financial and business services
38	*Dwelling*	Dwelling ownership
39	*PubServ*	Public services
40	*OthServ*	Other services
41	*PrivTranServ*	Private transport services

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