a review of energy and greenhouse gas **emission projections for western australia**

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Damien Riwoe, Clara Cuevas-Cubria and Muhammad Akmal

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Australian Bureau of Agricultural and Resource Economics
GPO Box 1563 Canberra 2601

Telephone +61 2 6272 2000 Facsimile +61 2 6272 2001
Internet www.abareconomics.com

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introduction

The Western Australian Greenhouse and Energy Taskforce (hereafter referred to as the taskforce) has engaged ABARE to review ABARE's latest long term energy and greenhouse gas (GHG) emissions outlook (Akmal and Riwoe 2005) for Western Australia, taking the following issues into account:

- the electricity generation mix, in light of the latest projections of the Western Australian Office of Energy and the Independent Market Operator
- the isolation of flaring from stationary energy emission estimates
- the projection of liquefied natural gas (LNG) production and associated fugitive emissions
- the impact of the Mandatory Renewable Energy Target (MRET) scheme and Western Australian renewable energy policy, including the 6 per cent renewable energy target
- the use of emission factors that are specific to Western Australia.

This review is conducted using *E_4cast*, ABARE's energy forecasting and analysis framework. The analysis draws explicitly on ABARE's regular analysis of Australian commodity markets, particularly for the medium term.

2

overview of the *E*$_4$*cast* model and key assumptions

E$_4$*cast* overview

ABARE uses the *E*$_4$*cast* modeling framework to develop detailed and consistent projections of Australian energy consumption and production. *E*$_4$*cast* is a partial equilibrium model of the Australian energy sector that approximates the principal interdependencies between energy production, conversion and consumption in Australia. It is used to project, on an annual basis, energy consumption, by fuel type, by industry and by state or territory. It explicitly takes into account real incomes and industry production trends, fuel prices and technical change (or energy efficiency improvements). A brief overview of the key features of the current version of *E*$_4$*cast* is provided in box 1.

Regional coverage in the model comprises: New South Wales, including the Australian Capital Territory; Victoria; Queensland; South Australia; Western Australia; Tasmania; and the Northern Territory.

The broad fuel and industry coverage of the model is outlined in tables 1 and 2. *E*$_4$*cast* explicitly covers the demand for eighteen fuels across twenty-seven end use and conversion sectors. The industry coverage includes specific representation of Australia's major energy intensive industries, comprising: wood, paper and printing; petroleum refining; chemical, rubber and plastic products; nonmetallic mineral products; iron and steel manufacturing; aluminium smelting; other basic nonferrous metals; and electricity generation. The transport sector is also represented in detail, comprising road (passenger and other); rail; water (international, domestic); and air (international, domestic) transport.

Demand functions for each of the main fuel types (such as electricity, natural gas, coal and petroleum products) in each industry sector (by state and territory) have been estimated econometrically and incorporate own price, cross price, income or activity, and technical change effects.

The *E*$_4$*cast* modeling framework incorporates domestic as well as international trade in energy sources. Export forecasts for black coal and liquefied natural gas (LNG) are taken from ABARE's commodity forecasts and represented

1 fuel coverage in *E*$_4$*cast*

Black coal

Brown coal

Coal byproducts
- coke oven gas
- blast furnace gas

Coke

Oil (crude oil and condensate)

Solar (residential solar hot water)

Biomass (bagasse, wood and wood waste)

Liquefied petroleum gas (LPG)

Other petroleum products

Electricity
- peak
- offpeak

Hydroelectricity

Wind energy

Natural gas

Coal seam gas

Ethane

Biogas (sewage and landfill gas)

2 industry coverage

Sectors/subsectors	ANZSIC code
Conversion	
Coke oven operations	2714
Blast furnace operations	2715
Petroleum refining	2510, 2512–2515
Petrochemicals	na
Electricity generation	361
Fuel use in conversion	na
Transmission losses	na
End use	
Agriculture	Division A
Mining	Division B
Manufacturing and construction	Division C
– wood, paper and printing	23–24
– chemical, rubber and plastic products	2520–2599
– nonmetallic mineral products	26
– iron and steel (excludes coke ovens and blast furnaces)	2700–2713, 2716–2719
– basic nonferrous metals	272–273
> aluminium smelting	2722
> other basic nonferrous metals	2720–2721, 2723–2729
– other manufacturing and construction	na
Transport	Division I (excludes sectors 66 and 67)
– road transport	61
> passenger motor vehicles	na
> other road transport	na
– railway transport	62
– water transport	63
> domestic water transport	6301
> international water transport	6302
– air transport	64
> domestic air transport	na
> international air transport	na
– pipeline transport	6501
Commercial and services	Sectors 37, 66 and 67; Divisions F, G, H, J, K, L, M, N, O, P and Q
Residential	na
Solvents, lubricants and bitumen	na

Source: Based on Australian Bureau of Statistics and New Zealand Department of Statistics, *Australian and New Zealand Standard Industrial Classification*, 1993 edition.

in the model directly. Net trade in oil and refined petroleum products is determined within the model. Interstate flows in electricity and natural gas are also modeled explicitly, with the direction of trade determined by the model. However, for reasons of simplicity, interstate trade in refined petroleum products and coal is not modeled.

E_4cast provides a detailed treatment of the Australian energy sector, including energy production, trade and consumption. As a result, the model can be used to produce a range of results, including Australian and state energy balance tables.

assumptions

The activity variable used in each of the fuel demand equations is pivotal to the model. For all nonenergy intensive sectors, gross state product (GSP) is used to approximate changes in income or business activity at the state level. For energy intensive industries, that are typically characterised by large and lumpy capacity expansion, projected industry output (production) at a state level is used as the activity variable. The energy intensive industries modeled in this way are aluminium smelting, other basic nonferrous metals and iron and steel manufacturing.

Western Australia's gross state product increased at a relatively moderate pace of 2.7 per cent in 2004-05, following robust growth of 8.1 per cent in 2003-04 (figure A). According to the Western Australian Department of Treasury and Finance (2006), state GSP is forecast to grow by 5.0 per cent in 2005-06. Over the medium term to 2010-11, economic growth in Western Australia is assumed to average 3.7 per cent a year.

Beyond the medium term and out to 2029-30, the Western Australian economy is assumed to grow at a relatively lower rate of 3.3 per cent a year. Over the entire outlook period of 27 years, economic growth in the state is assumed to average 3.4 per cent a year. Over the same period, Australian GDP is assumed to grow by 3.0 per cent a year.

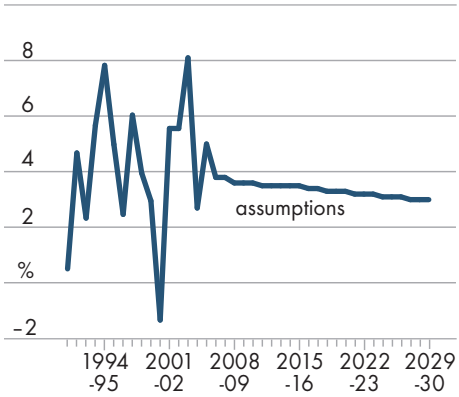
box 1: key features of *E*$_4$*cast*

In 2000, ABARE commenced development of its *E*$_4$*cast* energy forecasting and analysis framework. The first version of the model was documented in Dickson et al. (2001). Since then the model has been enhanced and refined in a number of directions, providing a sound platform for the development and analysis of medium and long term energy and greenhouse gas emission projections. Key features of the 2005 version of *E*$_4$*cast* are outlined below.

- *E*$_4$*cast* is a dynamic partial equilibrium framework that provides a detailed treatment of the Australian energy sector, representing energy production, trade and consumption.
- The Australian energy system is divided into seven conversion sectors and twenty end use sectors.
- Fuel coverage is extensive, including eighteen primary and secondary fuels.
- Results for all states and territories (the ACT is included in New South Wales) are provided.
- Detailed representation is provided of energy demand. The demand for each fuel is modeled as a function of income or activity, fuel prices (own and cross) and technical change effects.
- Primary energy consumption is distinguished from final (or end use) energy consumption, consistent with the approach used by the International Energy Agency (2004).
- Projections are provided for the period 2003-04 to 2029-30.
- Demand parameters are estimated econometrically using data for the period 1973-74 to 2000-01.
- Business activity is generally represented by gross state product (GSP).
- Energy intensive industries are modeled explicitly, taking into account large and lumpy capacity expansions. The industries modeled in this way are:
  - aluminium smelting
  - other basic nonferrous metals (mainly alumina)
  - iron and steel.
- Peak and offpeak electricity demands are modeled explicitly.
- The electricity generation module includes seventeen generation technologies – three peak and fourteen base load technologies.
- Key policy measures modeled explicitly are:
  - the Australian Government's mandatory renewable energy target scheme
  - the New South Wales Government's greenhouse gas benchmarks scheme and
  - the Queensland Government's cleaner energy strategy (referred to as the 13 per cent gas scheme).
- Supply of natural gas (including coal seam gas and ethane) is modeled at the basin level, taking into account future gas discoveries and reserves growth. A total of sixteen sources of gas, including an external supply source for eastern Australia, are represented in the model.

With estimated production of 10.9 million tonnes in 2003-04, Western Australia accounts for 65 per cent of Australia's alumina output. Over the medium term, alumina production in the state is assumed to increase by 28 per cent to 14 million tonnes, as a result of expected capacity expansions at the Wagerup (2 million tonnes) and Worsley (0.25 million tonnes) refineries and a 0.6 million tonne a year efficiency upgrade at the Pinjarra refinery. Underpinned by an assumed 1 million tonne a year expansion at the Worsley refinery during the mid-2020s and minor efficiency improvements elsewhere, alumina production in the state is assumed to exceed 16 million tonnes by the end of the outlook period.

A economic growth in western australia



Direct reduced iron (DRI) output in Western Australia from the state's (and Australia's) only DRI plant at Port Hedland amounted to 1.7 million tonnes in 2003-04, with estimated gas consumption of nearly 32 petajoules (or 22 per cent of the manufacturing sector's total gas use for that year). Following a gas explosion in May 2004, the plant was shut down and it is assumed that the plant will remain closed over the entire outlook period. The production of pig iron from the recently commissioned HISmelt plant in Western Australia (again the only facility of its kind in Australia) is assumed to reach full capacity (0.8 million tonnes) in 2008-09. Beyond the medium term, pig iron production in the state is assumed to grow at 0.5 per cent a year, reflecting efficiency improvements.

Currently, Western Australia has one LNG export project, the North West Shelf, the annual supply capacity of which is around 11.7 million tonnes from four trains. With the construction of a fifth train at the project, LNG capacity in the state is set to increase to nearly 16 million tonnes in 2008. By the end of the outlook period in 2029-30, Western Australia's LNG exports are assumed to exceed 53 million tonnes, growing at an average annual rate of 7.6 per cent. This outlook assumes the development of several projects that are currently in the planning phase, including Gorgon LNG, Pluto, Pilbara LNG and Browse, as well as additional trains at the North West Shelf and Gorgon.

renewable energy target

It is assumed that the Western Australian Government's 6 per cent renewable energy target for the South West Interconnected System (SWIS) will be achieved by 2009-10. The SWIS region accounts for around 56 per cent of total electricity generation in the state (Government of Western Australia 2003). As electricity generation in *E_4cast* is modeled at the state level and not at the regional level, it is assumed that renewable electricity will account for at least 3.4 per cent (0.56 X 0.06 = 0.034) of Western Australia's total electricity generation in 2009-10. In 2003-04, renewable electricity accounted for 1.3 per cent of total electricity generation in the state.

greenhouse gas emissions and emission factors

In this study, emissions of carbon dioxide (CO_2) are analysed, covering the fuel combustion and fugitive emissions sectors. Accordingly, all references to emissions in this report should be taken to refer to carbon dioxide emissions only. The emission factors that are used in this analysis vary by industry and are sourced from the *Western Australian Greenhouse Gas Inventory 1990, 1995, 2002* (AGO 2005a).

3

projections of electricity generation in western australia

electricity generation mix

Currently, gas fired generation accounts for nearly 60 per cent of Western Australia's total electricity generation. With an estimated share of 37 per cent, coal is the second most important source of electricity in the state. Renewable electricity represents 1.3 per cent of the present electricity mix. More than half of the state's total electricity generation occurs in the South West Interconnected System (SWIS), which is the focus of the 6 per cent renewable energy target. In the following section, the current status and capacity forecasts of the SWIS, according to Western Power and the Independent Market Operator (IMO), are discussed. This is followed by a discussion of statewide projections developed using E_4cast.

south west interconnected system

In 2000-01, electricity generation occurring in the SWIS represented around 56 per cent of total electricity generation in Western Australia (Western Australian Office of Energy 2003). While the majority of gas fired electricity generation occurs outside the SWIS, the opposite is true of coal fired electricity generation. For example, in 2003-04 nearly 78 per cent of generation in the SWIS was sourced from coal fired power stations and less than 22 per cent was sourced from gas. Renewable electricity generation represented around 0.5 per cent.

The installed 'sent-out capacity' (the capacity of generators taking account of their utilisation rate) in the SWIS region is around 3300 megawatts (Western Power 2004). Of this, around 1900 megawatts (or 58 per cent) is accounted for by coal plants. Another 1200 megawatts is accounted for by gas plants, with renewable generators (mainly wind) accounting for less than 0.5 per cent.

The makeup of electricity generation capacity in the SWIS is likely to change over the coming years, with several new plants coming on line, as well as several power plants being decommissioned, reflecting a shift to gas fired generation. Using a derived utilisation rate based on the sent-out capacity reported by Western Power, there is nearly 1900 megawatts of committed and proposed future sent-out generation capacity in the SWIS (IMO 2005). Nearly 1000 megawatts of this is in gas plants. The plants being decommissioned amount to nearly 600 megawatts, with around 70 per cent of this being coal generation (Western Power 2004).

electricity generation projections

This overall shift to gas fired generation is reflected in ABARE's electricity generation projections for Western Australia as a whole, shown in table 3. It is expected that over the next few years, while there will be a distinct shift from coal to gas fired capacity development, sent-out generation from gas plants will be somewhat restricted as a result of input constraints and pipeline capacity. However, these constraints are expected to ease over the projection period.

For the period from 2003-04 to 2013-14, total electricity generation in Western Australia is projected to grow by 37 per cent to 34 terawatt hours (TWh) (table 3). Over the same period, coal fired generation is projected to increase on average by 1.8 per cent a year to 11 TWh, accounting for 19 per cent of the projected expansion in total electricity generation. Gas fired generation, on the other hand, is projected to increase to more than 21 TWh in 2013-14, growing at an average rate of 3.7 per cent a year.

3 electricity generation, by fuel
western australia

	Coal	Gas	Total
	TWh	TWh	TWh
2003-04	9.2	14.9	24.9
2009-10	10.3	18.8	31.0
2013-14	11.0	21.3	34.2
2019-20	12.2	25.8	39.9
2029-30	14.2	34.8	51.1

The coal and gas fired electricity generation projections to 2013-14 in this study are broadly consistent with Western Power's projected installed capacity in the SWIS region. The Western Power capacity forecasts are reported on a 'sent out to network' basis during summer peak conditions, when daytime temperatures can reach as high as 41°C. After taking account of the decommissioned plants, Western Power has projected a sent-out coal fired capacity of 1398 megawatts for the SWIS in 2013-14.

Currently, Western Australia's capacity use factor – the amount of electricity actually produced per unit of capacity – of coal fired generation is relatively low compared with those for the other states. Assuming the capacity use factor of coal fired generation in Western Australia rises to around 90 per cent in 2013-14, this would represent just over 11 TWh of coal fired electricity generation for that year. The SWIS accounts for a large, but not the entire, proportion of coal fired capacity. Therefore the projected coal fired generation of 11 TWh in 2013-14 in this report is slightly less than Western Power's capacity forecasts for the same year.

Over the entire outlook period, electricity generation in Western Australia is projected in *E$_4$cast* to grow at an average rate of 2.8 per cent a year to more than 51 TWh in 2029-30. Underpinned by an above average growth rate of 3.3 per cent a year, the share of gas in the electricity mix is projected to increase from 60 per cent currently to 68 per cent in 2029-30.

renewable energy

Currently, renewable energy contributes around 1.3 per cent to total electricity generation in Western Australia, of which 65 per cent is from the Ord River hydroelectric generator, which is not in the SWIS. There are, however, a number of renewable projects that are in the SWIS that are expected to commence production over the next few years. These include the Alinta and Emu Park wind farms, with a total capacity of nearly 170 megawatts. Biogas and biomass generation capacity is expected to rise to 28.8 megawatts and 25 megawatts respectively by 2009-10.

Because of the intermittent and seasonal nature of these technologies, the utilisation rates of such plants are lower than thermal nonrenewable plants. As such, the sent-out generation expected from these plants is lower than the nameplate capacity would indicate.

Underpinned by the 6 per cent renewable energy policy for the SWIS, which is specifically modeled in *E$_4$cast*, renewable generation in the state is projected to increase by a factor of 3.8 to 1.2 TWh in 2009-10. This would represent almost 4.0 per cent of Western Australia's electricity generation. On the basis of assumptions about the long run marginal cost of the available technologies, it is projected that wind plants will account for 85 per cent of this forecast expansion, and

4 projected renewable electricity generation
western australia

	2003-04	2004-05	2009-10	2014-15	2019-20	2024-25	2029-30
	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Hydroelectric	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Wind	0.23	0.71	3.03	3.11	3.19	3.27	3.35
Biomass	0.04	0.04	0.30	0.30	0.31	0.32	0.33
Biogas	0.14	0.19	0.36	0.38	0.49	0.65	0.85
Total	1.16	1.68	4.43	4.53	4.73	4.98	5.27
	TWh	TWh	TWh	TWh	TWh	TWh	TWh
Hydroelectric	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Wind	0.06	0.20	0.84	0.86	0.89	0.91	0.93
Biomass	0.01	0.01	0.08	0.08	0.09	0.09	0.09
Biogas	0.04	0.05	0.10	0.11	0.14	0.18	0.24
Total	0.32	0.47	1.23	1.26	1.31	1.38	1.46

biomass and biogas for the balance.

However, this strong growth is not projected to continue beyond 2009-10. The measures providing impetus for renewable generation development are assumed to cease after this year as the MRET scheme does not extend beyond this time and the 6 per cent target has been achieved. Beyond 2009-10 and out to 2029-30, renewable electricity generation is projected to grow at a relatively low rate of 0.4 per cent a year to 1.5 TWh in 2029-30. Consequently, the share of renewable energy in the state's electricity generation mix is projected to fall back to less than 3.0 per cent by the end of the outlook period. This growth could differ if measures such as MRET or the 6 per cent target were extended beyond this time or if other policy measures were implemented.

4

projections of primary energy consumption and greenhouse gas emissions in Western Australia

At a projected average rate of growth of 2.7 per cent a year over the outlook period, primary energy consumption in Western Australia is projected to increase from 765 petajoules in 2003-04 to 1538 petajoules in 2029-30 (table 5). The projected growth in primary energy consumption in these estimates is slightly higher than the results reported in ABARE's previous energy projections (Akmal and Riwoe 2005) and mainly reflects the higher forecast growth in GSP over the medium term.

Of the increase, 57 per cent is projected to be accounted for by gas and 34 per cent by oil (comprising crude oil, condensate and naturally occurring LPG). As a result, the share of gas in the state's primary energy mix is projected to increase from 49 per cent in 2003-04 to 53 per cent at the end of the outlook period. Growth in black coal consumption is expected to be relatively subdued, increasing by only 55 petajoules over the period, and accounting for only 7 per cent of the increase in total consumption.

5 total primary energy consumption, by fuel
western australia

	2003-04	2004-05	2009-10	2014-15	2019-20	2024-25	2029-30
	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Black coal	124.3	130.8	150.1	156.7	164.2	171.2	178.8
Oil	251.1	254.5	293.5	339.9	390.2	447.3	513.1
Gas	372.7	403.4	524.2	611.4	691.8	738.1	816.6
Renewables	16.6	17.5	22.8	23.9	25.6	27.5	29.5
Total	764.7	806.1	990.6	1 132.0	1 271.8	1 384.1	1 537.9

6 total primary energy consumption, by sector
western australia

	2003-04	2004-05	2009-10	2014-15	2019-20	2024-25	2029-30
	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Agriculture	15.1	15.2	16.0	16.8	17.6	18.5	19.3
Mining	102.8	115.2	155.3	226.6	289.1	320.9	379.8
Manufacturing and construction	202.9	225.7	299.2	312.3	326.4	340.3	362.8
Electricity generation	263.5	266.6	309.6	338.4	371.4	405.6	442.3
Transport and storage	148.0	151.0	174.7	198.6	224.8	253.0	284.4
Commercial and services	7.7	7.5	8.2	9.7	10.7	11.9	13.1
Residential	19.2	19.4	21.5	23.3	25.3	27.3	29.4
Nonenergy fuel uses	5.5	5.6	5.9	6.2	6.4	6.7	6.9
Total	764.7	806.1	990.6	1 132.0	1 271.8	1 384.1	1 537.9

On the back of a nearly sevenfold increase in the state's LNG exports, the largest rise in energy consumption on a sectoral basis is projected to occur in the mining sector, which is projected to more than triple from 103 petajoules in 2003-04 to 380 petajoules in 2029-30 (table 6). As a result, the share of mining in Western Australia's energy consumption is projected to increase from 13 per cent in 2003-04 to nearly 25 per cent by the end of the outlook period.

With a share of 34 per cent, electricity generation is Western Australia's largest energy consuming sector. Energy consumption in the sector is forecast to grow on average by 2 per cent a year to 442 petajoules in 2029-30 – an increase of 68 per cent.

stationary carbon dioxide emissions

In 2003-04, carbon dioxide emissions from the stationary energy sector in Western Australia totaled 36 million tonnes. These are projected to rise to 71 million tonnes by 2029-30 (table 7). Stationary emissions, as defined in this study, include emissions from all the major industries listed in table 2, except the transport sector. In addition, following the National Greenhouse Gas Inventory guidelines (AGO 2005b), emissions of greenhouse gases arising from the use of gas and coal in the iron and steel industry are also excluded from the stationary energy sector and are included as part of the industrial processes sector (not discussed here). Furthermore, the use of natural gas

7 carbon dioxide emissions from the stationary energy sector, by fuel
western australia

	2003-04	2004-05	2009-10	2014-15	2019-20	2024-25	2029-30
	Mt	Mt	Mt	Mt	Mt	Mt	Mt
Black coal	11.2	11.2	12.1	12.7	13.3	13.9	14.6
Petroleum products	7.2	7.2	8.3	9.8	11.5	13.4	15.8
Gas	16.9	20.0	25.0	29.2	33.0	35.1	38.8
Biomass	1.2	1.2	1.3	1.4	1.5	1.5	1.6
Total	36.3	39.6	46.7	53.1	59.3	64.0	70.8

as fertiliser feedstock is also excluded from the stationary energy sector emissions analysis. Based on figures calculated from ABARE's latest fuel and electricity survey and correspondence with Wesfarmers, it is assumed that 70 per cent of total gas consumption in the basic chemicals industry is fertiliser feedstock.

Consumption of natural gas is projected to be the major source of stationary energy carbon dioxide emissions over the projection period, increasing to more than half of stationary energy emissions by 2029-30 because of its increased use. Liquid fuels are projected to be the second highest contributor to stationary energy emissions, accounting for 16 million tonnes of carbon dioxide emissions at the end of the outlook period. Combustion of black coal, primarily in the state's electricity industry, is projected to account for around 15 million tonnes of carbon dioxide emissions by 2029-30.

fugitive emissions

For the purpose of this study, fugitive emissions are defined as emissions associated with coal, oil and gas extraction. These include emissions associated with oil refining, gas transmission and distribution, and venting and flaring related to oil and gas production.

In 2003-04, fugitive emissions for Western Australia were estimated to be 1.4 million tonnes. This figure is projected to rise to nearly 8 million tonnes in 2029-30 (table 8). Currently, flaring accounts for the highest proportion of fugitive emissions, but is overtaken by venting by the end of the period. This reflects increasing gas production as well as developments coming on line in relatively high carbon dioxide concentration basins, such as Browse.

The E_4*cast* modeling framework does not include region specific projections of oil exploration or crude oil production. Hence, it is not possible to provide an estimate of emissions from this activity that is specific to Western Australia.

The projections for venting shown in table 8 are based on ABARE assumptions of venting rates and include a large proportion of emissions from the Gorgon project being sequestered but no sequestration in the Browse development. The extent to which carbon sequestration will occur in future developments is unclear. Several sequestration options have been proposed for the Gorgon development, while no sequestration plans have so far been disclosed for the Browse develop-

8 total fugitive carbon dioxide emissions, by activity
western australia

	2003-04	2004-05	2009-10	2014-15	2019-20	2024-25	2029-30
	Mt	Mt	Mt	Mt	Mt	Mt	Mt
Gas							
– venting	0.649	0.868	1.311	2.238	3.687	3.906	4.418
– flaring	0.757	0.923	1.302	2.174	2.880	2.996	3.490
– transmission and distribution	0.010	0.011	0.014	0.015	0.016	0.017	0.019
– total	1.415	1.801	2.626	4.428	6.584	6.919	7.927
Oil refining	0.033	0.032	0.034	0.036	0.038	0.040	0.042
Total	1.448	1.834	2.660	4.464	6.622	6.959	7.969

9 total fugitive carbon dioxide emissions with sequestration in browse, by activity
western australia

	2003-04	2004-05	2009-10	2014-15	2019-20	2024-25	2029-30
	Mt	Mt	Mt	Mt	Mt	Mt	Mt
Gas							
– venting	0.649	0.868	1.311	2.238	2.412	2.489	3.001
– flaring	0.757	0.923	1.302	2.174	2.880	2.996	3.490
– transmission and distribution	0.010	0.011	0.014	0.015	0.016	0.017	0.019
– total	1.415	1.801	2.626	4.428	5.309	5.502	6.511
Oil refining	0.033	0.032	0.034	0.036	0.038	0.040	0.042
Total	1.448	1.834	2.660	4.464	5.347	5.542	6.552

ment. Given the relatively high carbon dioxide concentrations of Gorgon and Browse, such plans could have significant effects on future fugitive emissions.

If sequestration at the Browse development were carried out at a rate similar to Gorgon, this could reduce the projected total Western Australian fugitive emissions in 2029-30 to 6.6 million tonnes (table 9).

Total carbon dioxide emissions in Western Australia are projected to more than double over the projection period to 98 million tonnes (table 10). Total emissions (that is, the sum of stationary, fugitive and transport emissions) were 48 million tonnes in 2003-04 and are projected to grow on average by 2.8 per cent a year to 2029-30. While initially representing approximately 3 per cent of total emissions, fugitive emissions are projected to rise to 8 per cent of total emissions, based on expected strong growth in future gas developments.

10 total fugitive carbon dioxide emissions, by type
western australia

	2003-04	2004-05	2009-10	2014-15	2019-20	2024-25	2029-30
	Mt	Mt	Mt	Mt	Mt	Mt	Mt
Stationary	36.3	39.6	46.7	53.1	59.3	64.0	70.8
Fugitive	1.4	1.8	2.7	4.5	6.6	7.0	8.0
Transport	9.8	10.0	11.6	13.2	15.0	16.8	18.9
Total	47.6	51.5	60.9	70.7	80.8	87.8	97.7

references

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