Chapter 2

Australia Country Report

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CHAPTER 2

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1. Executive Summary

This report provides the basis for informed decision making in the Australian energy sector. Australian energy projections were derived using the *E4cast* model, a dynamic partial equilibrium model of the Australian energy sector. The BREE *E4cast* modelling framework incorporates domestic as well as international trade in energy sources. It provides a complete treatment of the Australian energy sector, representing energy production, trade and consumption at a detailed level. As a result, the model can be used to produce a full range of results, including Australian energy balance tables.

Key results in the latest Australian energy projections worth highlighting and reported in this paper are in terms of energy supply and demand. Electricity generation is projected to grow by 49 percent over the period (1.1 percent a year) to total 377 terawatt hours in 2049-50. Coal's share (including with carbon capture and storage) of this production is projected to fall to 13 percent in 2049-50, while gas (including with and without carbon capture and storage, and integrated solar-gas technologies) rises to 36 percent. About half of Australia's electricity is projected to be generated by renewable sources in 2049-50.

Primary energy consumption is projected to grow by 21 percent (0.5 percent a year) to 7389 petajoules in 2049-50. This moderate growth projection is a result of a projected long-term fall in energy intensity, and the greater role of renewable technologies. Overall, the results suggest that Australia's energy future will be markedly different to its current structure. Changes in energy use by fuel and by sector will alter consumption patterns, while a substitution away from carbon-

intensive fuels to renewable energy sources will support a cleaner energy future.

- The projections include existing government policies, including the Renewable Energy Target and carbon pricing. They also incorporate the latest estimates of electricity generation technology costs from the Australian Energy Technology Assessment (BREE 2012).

2. Introduction

2.1. Historical Australian energy context

2.1.1. Energy resources

Australia is endowed with abundant, high quality and diverse energy resources. Australia has around 34 percent of the world's uranium resources, 14 percent of the world's black coal resources, and almost 2 percent of world conventional gas resources. Australia has only a small proportion of world resources of crude oil. Australia also has large, widely distributed wind, solar, geothermal, hydroelectricity, ocean energy and bioenergy resources.

The development of these resources has contributed to the competitiveness of energy-intensive industries and provided considerable export income. Australia is one of the few OECD economies that are significant net exporter of energy commodities, with the major exports being coal, liquefied natural gas (LNG), uranium and petroleum.

Uranium is not consumed domestically; therefore, it is not included in the energy balance projections presented in the following sections.

Australia is the world's ninth largest energy producer, accounting for around 2.4 percent of the world's energy production (IEA 2012). Energy production in Australia has fallen over the past two years, to be 16 140 petajoules in 2010-11, mainly as a result of weather related supply disruptions (BREE 2012).

The main fuels produced in Australia are coal, uranium and gas. While Australia produces uranium, it is not consumed domestically and all output is exported. Coal accounted for around 60 percent of total energy production in

energy content terms in 2010-11, followed by uranium (20 percent) and gas (13 percent). Crude oil, condensate and naturally occurring LPG represented 6 percent of total energy production in that year, and renewable energy the remaining 2 percent.

2.1.2. Australian energy consumption

Australia is the world's twentieth largest primary energy consumer, and ranks eighteenth on a per person energy use basis (IEA 2012b). Since 2000-01, growth in energy consumption in Australia has averaged 2.0 percent a year (BREE 2012b).

Although Australia's energy consumption is growing, the rate of growth has been declining over the past 50 years. Following annual growth of more than 5 percent during the 1960s, growth in energy consumption fell during the 1970s to an average of around 4 percent a year, largely as a result of the two major oil price shocks. During the 1980s and 1990s, the growth rate averaged around 2.3 percent a year. The growth rate has constantly been declining ever since.

Australian primary energy consumption consists mainly of coal, oil and gas. In 2010-11, black and brown coal accounted for around one-third of the primary energy mix, its lowest contribution since the early 1970s, as a result of substitution away from coal toward other fuels in electricity generation. Oil accounted for a little under 40 percent of primary energy consumption, followed by gas (about 25 percent) and renewable energy sources (4 percent).

The main users of energy in Australia are the electricity generation, transport and manufacturing sectors. Together, these sectors accounted for more than 88 percent of energy consumed in 2010-11.

2.1.3. Australia's energy exports

Australia is a net energy exporter, with domestic energy consumption representing only one-third of total energy production, including uranium. Australia's energy exports were 13 312 petajoules in 2010–11 in energy content terms. In value terms, energy exports accounted for 32 percent of the total value of Australia's commodity exports in 2010–11. Australia's largest energy export

earners are coal, crude oil and LNG. In 2010–11 exports were $43.7 billion for coal, $12.2 billion for crude oil and condensate and $10.4 billion for LNG.

Australia is a net importer of liquid hydrocarbons, including crude oil and most petroleum products.

2.2. Energy policy

2.2.1. Energy White Paper 2012

The Energy White Paper 2012, laying out Australia's energy policy, was released by the Australian Government in November 2012 (Australian Government 2012). It sets out a strategic policy framework to address the challenges in Australia's energy sector and position Australia for a long term transformation in the way it produces and uses energy.

The Energy White Paper identifies four priority action areas to support Australia's energy transformation:

1. delivering better energy market outcomes for consumers;
2. accelerating our clean energy transformation;
3. developing Australia's critical energy resources, particularly gas resources; and
4. strengthening the resilience of Australia's energy policy framework.

2.2.2. Clean Energy Future Plan

In Australia, a carbon price was introduced on 1 July 2012, making large emitters of carbon financially liable for their carbon emissions. It is fixed for the first three years before transitioning to an emissions trading scheme. During the fixed price period, an unlimited number of permits will be available at a fixed price, and these must be purchased and surrendered for each tonne of reported emissions. The price in 2012-13 is $23 a tonne of carbon dioxide equivalent (CO_2-e), increasing by 2.5 percent in real terms until 30 June 2015. From 1 July 2015, the carbon price will transition to an emissions trading scheme where the number of available permits will be capped and the permit price will be determined in the marketplace (Australian Government, 2011).

2.2.3. Renewable Energy Target

The Renewable Energy Target complements the carbon price by providing additional support for renewable energy investment and industry development in the transition period to more mature carbon prices and technology costs. The RET scheme is designed to deliver on the Australian Government's commitment that the equivalent of at least 20 percent of Australia's electricity comes from renewable sources by 2020.

2.2.4. Energy Efficiency

The National Strategy on Energy Efficiency (NSEE) is the main mechanism by which all governments in Australia coordinate national action on energy efficiency. The Ministerial Council on Energy is responsible for the delivery of several important measures in the NSEE.

3. Key Assumptions

There are a number of economic drivers that will shape the Australian energy sector over the next two decades. These assumptions underlie the modelling, and include:

- Population growth;
- Economic growth;
- Energy prices;
- Electricity generation technologies;
- End use energy technologies; and
- Government policies.

The assumptions relating to these key drivers are presented in the *Australian Energy Projections* (Syed, 2012). In brief, Australian population is assumed to grow from 23.35 million in 2012-13 to 36.26 in 2049-50. Over the projection period, Australia's real GDP is expected to grow at an average annual growth rate of

2.5 percent. Carbon prices included in the modelling from 2012-13 to 2049-50 are provided by the Australian Treasury (2011). Electricity generation technology costs, as mentioned earlier, are based on the recent BREE report, *Australian Energy Technology Assessment* (BREE, 2012b). This report provided the best available and most up-to-date cost estimates for 40 electricity generation technologies under Australian conditions, taking into consideration the impact of carbon pricing. These technologies encompass a diverse range of energy sources including renewable energy (such as wind, solar, geothermal, biomass and wave power), fossil fuels (such as coal and gas), and nuclear power.

4. Energy Projection Results

Australian energy projections from 2012-13 to 2049-50 on energy consumption, electricity generation, and production are provided in Tables 1 to 5 below.

4.1. Energy Consumption

- Total primary energy consumption is projected to grow by around 21 percent (0.5 percent a year) over the period 2012-13 to 2049-50, to reach 7369 petajoules. This moderate growth reflects a long-term decline in the energy intensity of the Australian economy, which has been accelerated by a number of policy drivers such as carbon pricing. Importantly, it also reflects the greater role of renewable technologies, which use less energy inputs to generate electricity than fossil fuels (Table 1 and 2).
- Large-scale changes are expected in Australia's energy mix over the coming decades. The share of coal in total primary energy consumption is projected to fall sharply from 31 percent in 2012-13 to just 6 percent by 2049-50. Oil will remain an important energy source in Australia, while gas will be the

fastest growing non-renewable energy source, with its share increasing to 34 percent by 2049-50.

- Renewable energy use is projected to nearly quadruple in volume terms over the period to 2049-50 (at 3.6 percent a year). The share of renewables is projected to increase from 5 percent of total primary energy consumption in 2012-13 to 14 percent in 2049-50. The fastest growing energy sources are expected to be solar and wind.
- The share of the electricity sector in Australia's energy demand will fall substantially from 38 percent in 2012-13 to 26 percent in 2049-50, although it will still be the second largest user of primary energy in Australia. The key drivers of this change are the greater use of more efficient renewable technologies and the impact of higher energy prices.
- The transport sector will become the largest user of primary energy in Australia, increasing its share slightly to one-third of primary energy consumption by 2049-50. The fastest growing consumer of primary energy will be the mining sector, with an average growth of 3.5 percent a year expected over the projection period.
- The projected outlook for energy consumption in this report differs substantially from previous BREE long term energy projections. This is because of the use of more up to date and lower projected costs for many renewable technologies. This is projected to result in a greater penetration of renewable energy in terms of the total energy mix. These renewable technologies use less energy in conversion to electricity than traditional fossil fuels and this is projected to lower the growth in demand for primary energy.

Table 2-1: Primary energy consumption, by energy type

	Level			Share		Average annual growth 2012-13 to 2049-50
	2012-13	2034–35	2049-50	2012-13	2049–50	
Energy type	**PJ**	**PJ**	**PJ**	**%**	**%**	**%**
Non-renewables	5793	5980	6337	95	86	0.2
Coal	1882	1036	478	31	6	-3.6
black coal	1212	962	478	20	6	-2.5
brown coal	670	74	0	11	0	-21.7
Oil	2359	2888	3391	39	46	1.0
Gas	1552	2056	2469	26	34	1.3
Renewables	276	755	1032	5	14	3.6
Hydro	62	62	62	1	1	0.0
Wind	51	231	282	1	4	4.7
Bioenergy	149	299	346	2	5	2.3
Solar	14	104	236	<1	3	7.8
Geothermal	0	59	106	0	1	
Total [a]	**6069**	**6735**	**7369**	**100**	**100**	**0.5**

[a] numbers in the table may not add up to their totals due to rounding

4.2. Primary energy consumption, by sector

Electricity generation, transportation and manufacturing are estimated to account for 88 percent of Australia's total primary energy consumption in 2012–13. These sectors combined are projected to account for 77 percent of projected primary energy consumption in 2049–50 (Table 2).

The electricity generation sector accounts for the largest share (38 percent) of primary energy consumption in 2012–13. Total primary energy consumption in

electricity generation is projected to decline from 2293 petajoules in 2012–13 to 1927 petajoules in 2049–50. The combined effect of the RET, carbon pricing, and importantly the growth in renewables electricity generation are expected to encourage a change in the energy mix, with a significant shift away from coal to renewable energy.

Table 2-2: Primary Energy Consumption, by Sector

	Level			Share		Average annual growth 2012-13 to
	2012-13	**2034-35**	**2049-50**	**2012-13**	**2049-50**	**2049-50**
Sector	**PJ**	**PJ**	**PJ**	**%**	**%**	**%**
Electricity	2293	1996	1927	38	26	-0.5
Agriculture	105	145	171	2	2	1.3
Mining	310	899	1089	5	15	3.5
Manufacturing	1268	1256	1332	21	18	0.1
Transport	1760	2 095	2 467	29	33	0.9
Commercial & residential	333	344	385	5	5	0.4
Australia [a]	**6069**	**6735**	**7369**	**100**	**100**	**0.5**

[a] Numbers in the table may not add up to their totals due to rounding.

4.3. Electricity generation

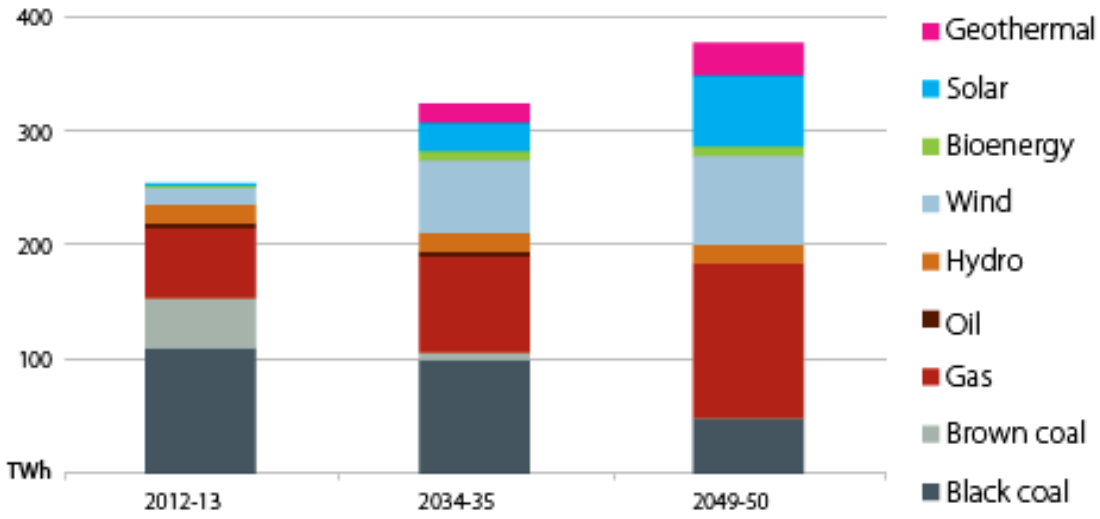
- Gross electricity generation is projected to grow by around 49 percent (1.1 percent a year) to reach 377 terawatt hours in 2049-50. This growth is expected to come from expansion of renewables and gas-fired electricity generation (Table 3).
- The projected rate of growth in electricity generation in this report is slightly less than 1.1 percent a year, which is less than the 1.4 percent reported in the previous BREE report (2011).
- The impact of lower cost renewable generation and carbon pricing is expected to lead to a dramatic decline in coal-fired generation (Figure 1). The share of coal in electricity generation is projected to fall from 60 percent in 2012-13 to 13 percent in 2049-50. The remaining coal fired electricity generation capacity is projected to include carbon capture and storage technology.
- Gas fired electricity generation is projected to double over the projection period, to account for 36 percent of total generation in 2049-50. This also includes carbon capture and storage technologies, including integrated gas-solar technologies.
- About half of Australia's electricity is expected to be generated by renewables by 2049-50. The use of renewable energy resources in electricity generation is projected to rise by 4.8 percent a year, from 13 percent of total generation in 2012-13 to 51 percent in 2049-50. Wind is expected to be the largest source of renewable electricity generation (21 percent by 2049-50). Solar is projected to be the second largest contributor (16 percent by 2049-50), and is the fastest growing of all sources over the projection period.
- The strong growth in renewable electricity generation is a result of the increased competitiveness of renewable technologies under carbon pricing, as well as expected advances in technologies and a decline in their capital costs.

Table 2-3: Electricity generation, by energy type (TWh)

	Level			Share		Average annual growth 2012-13 to
	2012-13	**2034-35**	**2049-50**	**2012-13**	**2049-50**	**2049-50**
Energy type				**%**	**%**	**%**
Non-renewables	219	194	183	87	49	-0.5
Coal	153	104	48	60	13	-3.1
black coal	109	100	48	43	13	-2.2
brown coal	44	5	0	17	0	
Gas	62	85	136	25	36	2.1
Oil	4	4	0	2	0	-8.6
Renewables	34	130	194	13	51	4.8
Hydro	17	17	17	7	5	0.0
Wind	14	64	78	6	21	4.7
Bioenergy	2	7	7	1	2	3.9
Solar	1	25	62	<1	16	12.3
Geothermal	0	17	29	0	8	
Total [a]	**253**	**324**	**377**	**100**	**100**	**1.1**

[a] Numbers in the table may not add up to their totals due to rounding.

Figure 2-1: Projected electricity generation mix



4.4. Final Energy Consumption, by Energy Type

Total final energy consumption, the amount of energy used in end-use applications, is projected to increase from 4 207 petajoules in 2012–13 to 5 868 petajoules in 2049–50, a rise of 39 percent over the projection period and an average annual rate of increase of 0.9 percent (Table 4). Electricity (1.1 percent) and renewable energy (1.4 percent) are projected to continue to grow strongly to meet energy demand in end-use sectors over the projection period. This will contribute to the declining relative share of coal and gas in final energy consumption by 2049–50 (from 3 percent to 2 percent, and from 22 percent to 17 percent, respectively). The decline in gas consumption is predominantly because of rising prices to 2049–50. The demand for petroleum products increases from growing mining and residential sectors. The consumption of renewables grows strongly at the rate of 1.4 percent a year.

Table 2-4: Final energy consumption, by energy type

	Level			Share		Average annual growth 2012-13 to
	2012-13	2034-35	2049-50	2012-13	2049-50	2049-50
Energy	**PJ**	**PJ**	**PJ**	**%**	**%**	**%**
Coal	134	119	124	3	2	-0.2
Petroleum products	2180	2709	3241	52	55	1.1
Gas	908	912	1006	22	17	0.3
Renewables	134	185	224	3	4	1.4
Electricity	851	1091	1272	20	22	1.1
Total [a]	**4207**	**5016**	**5868**	**100**	**100**	**0.9**

[a] numbers in the table may not add up to their totals due to rounding

4.5. Energy Production

- Australian energy production (excluding uranium) is projected to grow by 69 percent (an average annual rate of 1.4 percent) over the projection period, to reach 27 803 petajoules in 2049-50. Coal and gas are projected to account for 96 percent of Australia's energy production in 2049-50 (Table 5).
- Production of black coal, which includes thermal and metallurgical coal, is projected to grow at 1.2 percent a year, to 17 973 petajoules (around 539 million tonnes) in 2049-50.
- An increasing proportion of this production will be exported, with coal exports projected to increase by 1.4 percent a year to 17 496 petajoules in 2049-50. World coal demand, particularly for metallurgical coal, is expected to continue to grow over the next four decades, albeit at a slower rate in the latter half of the projection period.

- Strong growth in domestic and global demand for gas will continue to drive the development of new gas fields and LNG capacity in Australia. Australian gas production, including LNG, is projected to nearly triple (equal to growth of 2.9 percent a year), to reach 8595 petajoules in 2049-50. The western market will remain the largest gas market in Australia, although its growth in output is expected to be slower than that of the eastern and northern markets.
- LNG exports are projected to more than triple, to reach 6127 petajoules (around 113 million tonnes) in 2049-50. This includes new LNG projects in all markets, including projects based on coal seam gas and floating LNG technologies.
- Projections of declining oil production and constraints around petroleum refining suggest Australia's net trade position for crude oil and refined petroleum products will weaken over the projection period, with net imports projected to increase at an average rate of 2.1 percent a year.

With the exception of crude oil and refined petroleum products, Australia will remain a net exporter of energy commodities over the period to 2049-50. Demand for Australia's energy resources is expected to remain robust over the projection period, particularly in China, India and other developing economies. This will be supported by growth in economic activity and industrial production, which is expected to provide a solid platform for growth in their energy consumption. The ratio of Australia's primary energy consumption to non-uranium energy production is projected to decline from 37 percent in 2012-13 to 26 percent in 2049–50.

Table 2-5: Energy production, by source

	Level			Share		Average annual growth 2012-13 to
	2012-13	2034-35	2049-50	2012-13	2049-50	2049-50
Energy type	**PJ**	**PJ**	**PJ**	**%**	**%**	**%**
Non-renewables	16221	26906	26771	98	96	1.4
Coal	12333	18463	17973	75	65	1.0
black coal	11664	18390	17973	71	65	1.2
brown coal	670	74	0	4	0	-21.7
Oil	775	252	98	5	<1	-5.4
LPG	89	98	104	1	<1	0.4
Gas	3023	8092	8595	18	31	2.9
Renewables	276	755	1032	2	4	3.6
Hydro	62	62	62	<1	<1	0.0
Wind	51	231	282	<1	1	4.7
Bioenergy	149	299	346	1	1	2.3
Solar	14	104	236	0	1	7.8
Geothermal	0	59	106	0	<1	
Total	**16497**	**27660**	**27803**	**100**	**100**	**1.4**

5. Conclusion and Policy Implications

The outlook presented in this report represents a significant structural change in Australia's future energy landscape. The current projections show that Australian energy consumption will continue to grow over the next forty years, albeit at a much lower rate than experienced in the past twenty years. It is expected that the share of fossil fuels will decline from 87 percent in 2012-13 to 49 percent (including CCS fossil fuel technologies) of total electricity generation in 2049-50 (excluding roof-top PV generation). The share of fossil fuels in total primary consumption is projected to decline from 95 percent in 2012-13 to 86 percent in 2049-50. By 2049-50, three-quarter of electricity generation in Australia is projected to come from renewables and carbon capture and storage technologies.

Within the non-renewables category, the share of gas is projected to increase in energy use and production. There is a significant increase in the use of gas (natural gas and coal seam gas), primarily for electricity generation – the largest user of primary energy, and LNG production. Gas-fired electricity generation is based on mature technologies with competitive cost structures relative to many renewable energy technologies. Thus, it has the potential to play a major role as a transitional fuel until lower-emission technologies become more cost effective in the short to medium term.

Renewable energy is projected to have the strongest growth prospects. The highest growth trajectory is expected to apply to the lowest cost renewable energy sources – namely large-scale solar PV and wind energy and, to a lesser extent, geothermal energy.

Transition to a low carbon economy will require long term structural adjustment in the Australian energy sector. While Australia has an abundance of energy resources, this transformation will need to be underpinned by significant investment in energy supply chains to allow for better integration of renewable energy sources and emerging technologies into our energy systems. It will be critical to ensure that the broader energy policy framework continues to support cost-effective investment in Australia's energy future, and timely adjustments to market settings in response to emerging pressures, and market developments.

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