



Australia's Electricity Generation Mix 1960-2009

A REPORT BY GREEN ENERGY MARKETS FOR ENVIRONMENT VICTORIA

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1. Introduction

Green Energy Markets Pty Ltd has been engaged by Environment Victoria to undertake a review of Australia's electricity generation mix since 1960.

This analysis comprises two parts. Firstly we have compiled data for national electricity generation using Electricity Supply Association of Australia (ESAA) and ABARE data from 1960 to 2008.

Secondly we have completed a more detailed analysis of electricity generation and associated emissions for the National Electricity Market (NEM) for the period 2001-2009 for which there are detailed records. This analysis includes all states operating within the National Electricity Market (NEM) – NSW, Victoria, Queensland, South Australia and Tasmania - and so does not represent the Northern Territory and Western Australia. It also excludes off-grid generation. Analysis includes all large-scale renewable electricity (RE) generators. It does not include solar (and other small scale renewable) power systems which have not registered as a power station under the Renewable Energy Target – the overwhelming majority of all domestic sized systems in Australia.

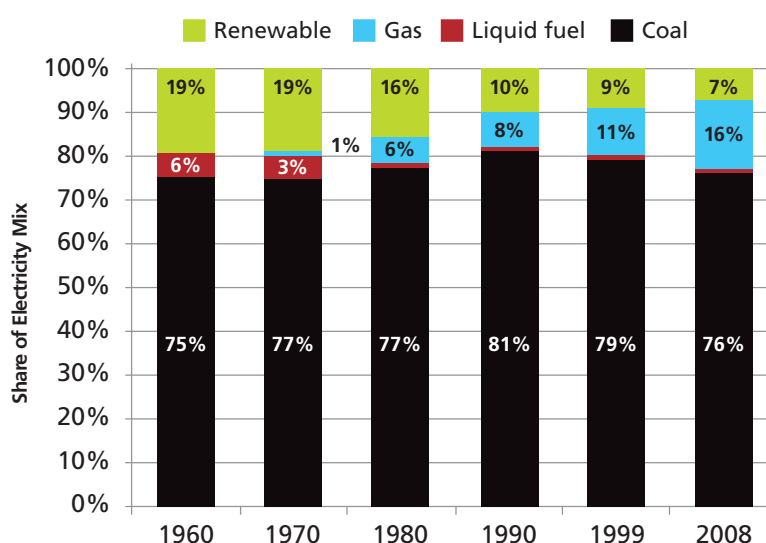
2. Australia's national electricity generation mix (all states and territories) 1960-2008

Derived from ESAA historical data and ABARE research, Australia's national electricity mix from 1960-2008 is summarised in Figure 1 with actual generation by fuel type presented in Figure 2. The share of coal-fired generation across Australia has remained steady over this period, while the share of RE has declined from 19 per cent in 1960 to 7 per cent in 2008.

This decline has occurred despite the Renewable Energy Target (RET) scheme which was designed to increase the share of renewable energy¹ by 2% by 2010 (above the assumed 1997 baseline share of 10.7%). While annual targets for the scheme have been reached, the absence of growth in RE generation is primarily a result of a decline in 'baseline' hydro power generation particularly in recently years due to drought conditions resulting in lower inflows to storages. This has been somewhat offset by a major growth in wind power along with a more moderate growth in bioenergy².

Gas has significantly increased its share over the past five decades. Compared to the electricity generation mix in NEM states only which follows in Section 3, the inclusion of the Northern Territory and Western Australia results in a greater share of generation from gas, with lower shares from coal-fired generation and renewables.

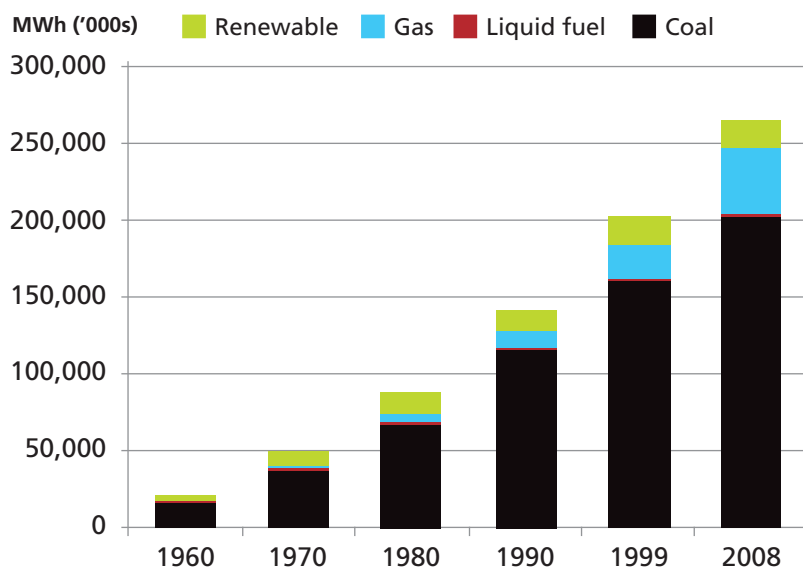
Figure 1 — Australian Electricity Generation Mix 1960-2008



Note: 1960-90 data is calendar year data sourced from ESAA³. Data for 1999 and 2008 is 1998/99 and 2007/08 financial year data, sourced from ABARE⁴. For further details, see methodology.

Figure 2 shows that total electricity generation in Australia has grown over 10-fold from 1960 to 2008. Over this time coal-fired generation grew more than 12-fold from 16 terawatt hours (TWh)⁵ to 202TWh, while gas grew to 42TWh in 2008 from nothing in 1960 and renewable energy grew from 4TWh to just 18TWh.

Figure 2 — Australian Electricity Generation by Fuel Type, 1960-2008



Note: 1960-90 data is calendar year data sourced from ESAA. Data for 1999 and 2008 is 1998/99 and 2007/08 financial year data, sourced from ABARE. For further details, see methodology.

3. National Electricity Market energy mix 2001-2009

Total generation across the NEM by calendar year is presented in Table 1 and Figure 3, with market shares of generation by year and by fuel type shown in Figure 4. Total generation across the NEM grew at an average annual rate of 2% from 2001 to 2009, with growth in all years except 2009 which recorded a decline of 1%.

Table 1 – NEM Electricity Generation Summary ('000 MWh⁶)

	Coal-fired	Gas-fired	Liquid fuel-fired	Renewable	Total	Coal share
2001	159,477	9,371	91	20,104	189,042	84%
2002	163,667	9,730	95	17,788	191,279	86%
2003	167,007	8,524	23	20,448	196,002	85%
2004	173,474	10,520	44	17,894	201,931	86%
2005	172,619	11,030	28	20,894	204,571	84%
2006	177,956	12,726	17	19,525	210,223	85%
2007	175,800	19,378	80	18,586	213,844	82%
2008	179,208	17,932	58	18,330	215,528	83%
2009	173,244	19,334	56	20,479	213,113	81%

Figure 3 — NEM Electricity Generation by Fuel Type, 2001-09

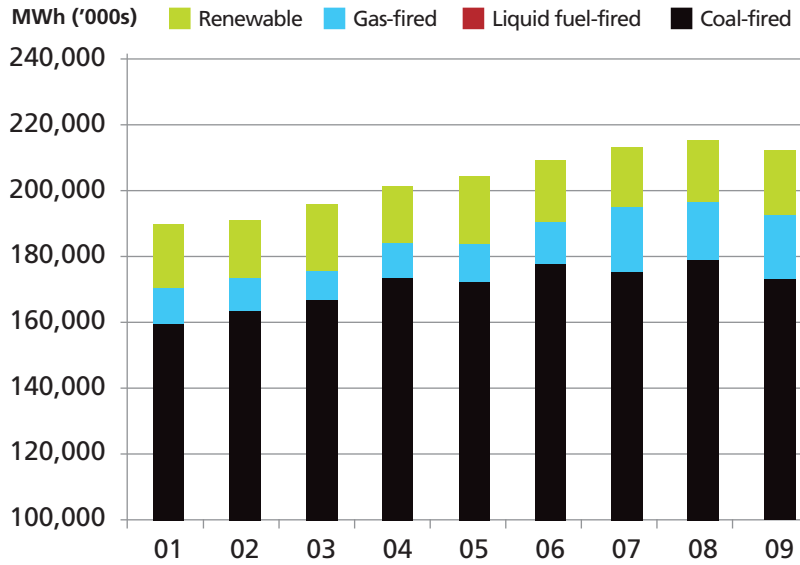
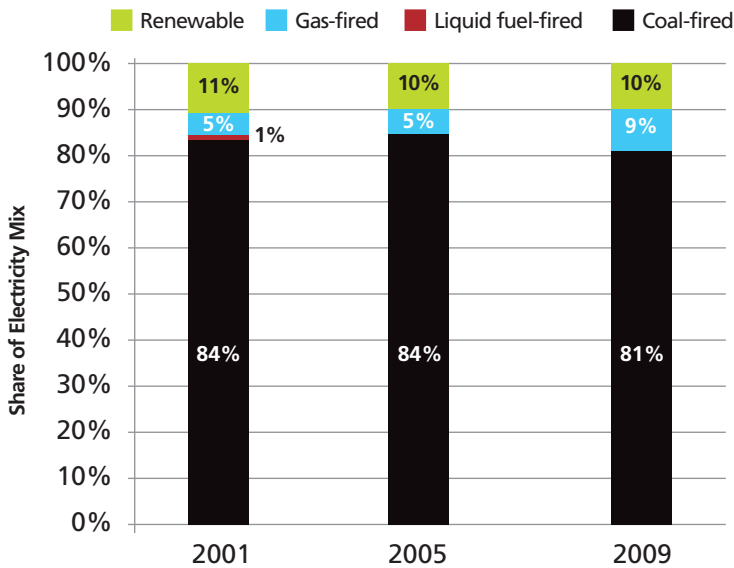


Figure 4 — NEM Electricity Generation Mix – 2001, 2005 and 2009



Coal-fired generation

Coal-fired power generation across the National Electricity Market (NEM) has been steadily growing over the period 2001 to 2009, with 159 terawatt hours (TWh) generated in 2001 increasing to 173TWh in 2005 and 2009 – an average annual growth rate of 1%. However, there has been some variability during that period including -3% to +4% growth from year to year.

Due to the slightly faster rate of overall demand growth, coal's market share has declined from 84% during both 2001 and 2005 to 81% during 2009.

Generation from black-coal fired generators in QLD, SA and NSW has been growing at a faster rate than brown coal-fired generation from Victorian plant. During this period, three new black coal-fired power stations were built while one was decommissioned, all in Queensland, with no new brown coal-fired stations.

Gas-fired generation

Gas-fired generation has grown at an average annual rate of 9% from 2001 to 2009, from an extremely small base of just 9.4TWh in 2001 to 11TWh and 19TWh in 2005 and 2009 respectively. This growth rate is primarily due to a staggering 54% average annual growth in Queensland and 16% annual growth in NSW on the back of the Queensland 18% Gas target scheme and the NSW Greenhouse Gas Reduction Scheme. Tasmania also experienced huge growth, from no gas-fired power capacity in 2001 to three gas-fired generators in 2009.

Five new gas-fired power stations were commissioned in QLD during this period, with three new stations in NSW. In addition one power station in QLD was converted from an inefficient peaking plant operating on liquid fuel, to a coal seam gas-fired combined cycle plant. In comparison, in Victoria three new peaking power stations were commissioned over the period but no combined cycle plant and as a result annual generation has fluctuated, with some increase in generation emerging over the last few years.

The share of gas-fired power in the NEM generation mix has consequently grown from 5% in 2001 and 2005 to 9% in 2009. On a national level, the share of gas is greater and is also growing steadily, from 8% in 1990 to 16% in 2008.

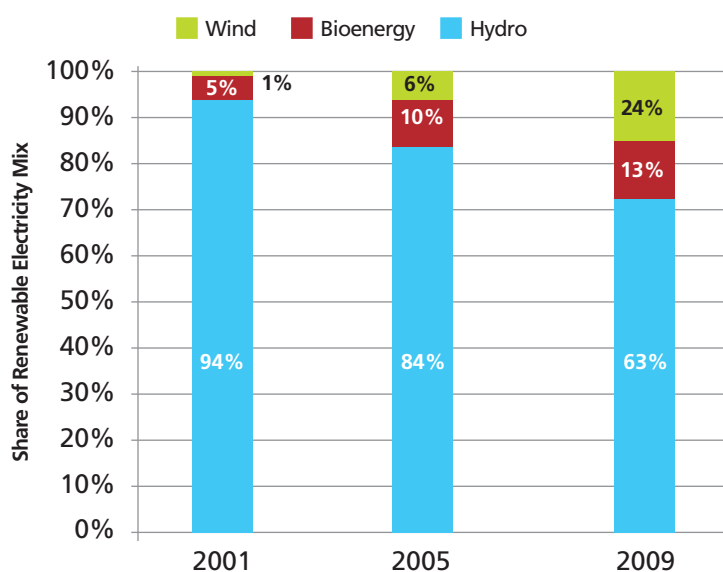
Renewable electricity generation

There is no clear pattern of growth in large-scale RE generation over the period – with significant fluctuations from year to year – from a decline of 12% in 2002 and 2004 to a growth of 17% in 2005. In 2001, 2005 and 2009 RE generation is estimated to have totalled 20.1TWh, 20.9TWh and 20.5TWh respectively, with the 20.9TWh the highest annual output for the period.

In terms of the NEM generation mix, due to the growth in electricity demand and generation over the period, the share of large scale RE generation actually declined from 11% during 2001 to 10% during 2005 and 2009. This does not take into account the recent growth in small-scale solar power generation, however solar power generation was only just ramping up in 2009 off an extremely low base and during 2009 would not have had noticeable impact on the total share of RE in the generation mix⁷.

The share of the various fuels across RE generation in the NEM can be seen in Figure 5.

Figure 5 — Renewable Energy Generation Mix 2001-09



Liquid fuel-fired generation

Liquid fuels are responsible for so little generation (open cycle peaking plant) they register a generation mix of less than 1%. They are generally on a decline.

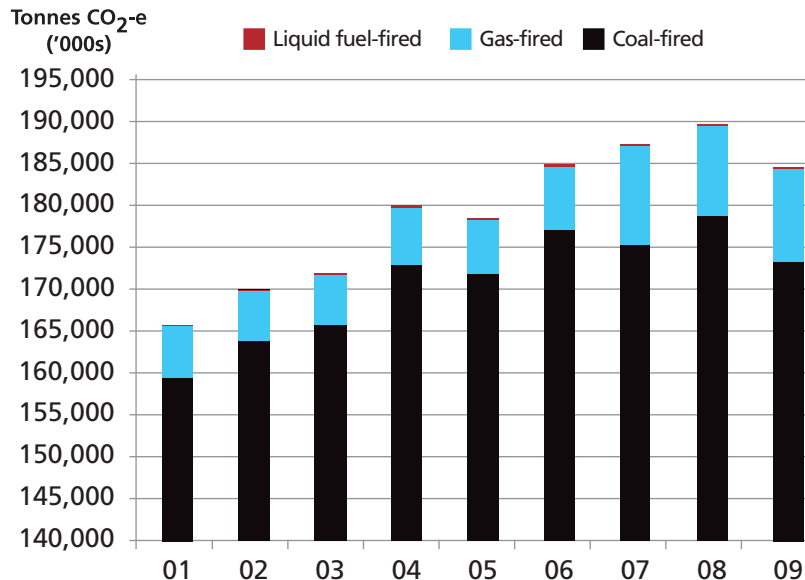
Emissions

Emissions from generation in the NEM during 2001 to 2009 are summarised in Table 2 and shown in Figure 6. Emissions over the period climbed from 166 million tonnes CO₂-e⁸ during 2001 to 184 million tonnes during 2009, representing an average annual growth of 1.4%, just shy of the 1.5% average annual growth in generation. This demonstrates a negligible change in the emissions-intensity of NEM electricity generation over this time period.

Table 2 Emissions Summary from NEM Generation ('000s tonnes CO₂-e)

	Coal-fired	Gas-fired	Liquid fuel-fired	Total	Coal share
2001	159,534	5,944	69	165,547	96%
2002	163,744	6,127	69	169,940	96%
2003	166,323	5,305	17	171,645	97%
2004	172,917	6,846	38	179,801	96%
2005	171,715	6,447	25	178,187	96%
2006	177,141	7,373	16	184,529	96%
2007	175,339	11,787	71	187,197	94%
2008	178,634	10,684	51	189,370	94%
2009	173,259	11,127	50	184,436	94%

Figure 6 — Emissions from NEM Generation 2001-09



Methodology

Historical national data for the years 1960 -1990 was derived from ESAA historical data⁹. Australian overall generation fuel mix data for 1999 (financial year 1998-99) and 2008 (FY 2007-08) as shown in Figures 1 and 2 was sourced from ABARE¹⁰.

Generation data for each of the scheduled power stations for the years 2001 through to 2009 was sourced from the Australian Energy Market Operator. Generation data for each of the non-scheduled RE generators was derived from Renewable Energy Certificate (REC) creation data available through the Commonwealth and Victorian RE target schemes. REC creation was then adjusted for the relevant generation baseline for each plant. Where a plant had no REC creation in a given year, but had a baseline, the generation was estimated¹¹.

Generation data for Tasmania prior to 2006 was estimated based on financial year data reported by Hydro Tasmania.

Smaller non-scheduled gas-fired generation (predominantly cogeneration) operating in the NEM contributes less than 1% of electricity generation¹². The exact level of generation from these plants cannot accurately be determined and therefore were excluded from this analysis. Small-scale solar generation contributes less than 1% of electricity generation and also cannot be accurately measured. It was also excluded from the analysis.

Greenhouse emission factors used in this analysis were based on data from ACIL Tasman¹³ and the Australian Government National Greenhouse Account Factors¹⁴. Emission factors for coal include emissions associated with mining of coal but not the emissions associated with its transportation, while emissions factors for gas-fired and liquid-fuel fired power stations are for the total fuel cycle (i.e. they include all Scope 3 emissions).

Endnotes

1. Note that the RET includes renewable thermal energy (i.e. solar water heating) as well as renewable electricity, however the thermal component does not count towards RE figures in this report.
2. Since 2009, with the cessation of the drought, hydro generation is showing some recovery, with at least an additional 3TWh of scheduled generation in 2010 – bringing total scheduled hydro from 11.4TWh to 14.4TWh.
3. Electricity Supply Association of Australia
4. Australian Bureau of Agricultural and Resource Economics
5. One terawatt hour is equivalent to one million megawatt hours (MWh)
6. Megawatt hours
7. However, domestic sized grid-connected solar power generation capacity is growing rapidly, from around 190 megawatts (MW) cumulative capacity across Australia in 2009 to over 500MW in 2010, with a growing impact on overall RE generation.
8. Carbon dioxide equivalent
9. ESAA Historical data CD, Book 2 'Energy Production' [by Type of Plant] and Book 3 'Fuel consumed in power stations'.
10. ABARE (2010) *Energy in Australia 2010* and ABARE (2001) *Australian Energy: Projections to 2019-20*.
11. Murray 2 generation is included in NSW data, although AEMO considers this to be within the Victorian region.
12. For the period prior to 2010.
13. ACIL Tasman (2009) *Fuel resource, new entry and generation costs in the NEM*.
14. Australian Government Department of Climate Change (2009) *National Greenhouse Accounts Factors*, November 2008

**About Green Energy Markets:**

Green Energy Markets (GEM) is a dynamic research and advisory business established in 2008 with a focus on reducing greenhouse gas emissions, increasing renewable energy and distributed generation, and improving energy efficiency. Our services are directed at sustainable energy businesses, government and government agencies, energy producers and energy consumers.

For more see: <http://www.greenenergymarkets.com.au>

**About Environment Victoria:**

Environment Victoria is the peak non-government, not-for-profit environment organisation in Victoria. As the state's leading environment group, we believe that our future depends on all Victorians. That's why our goal is to mobilise all 5 million to safeguard our environment. At the heart of our work is our belief that people are part of the environment, and not separate to it. So we work with people from all walks of life and levels of environmental awareness to solve the challenges common to all of us.

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Front cover photos:

Snowy Mountains Hydro scheme at Tumut, Snowy Hydro
Mining at Hazelwood, Justin McManus,
2 photos of Yallourn Power Station, Environment Victoria
Solar panels, Carlo Taccari
Waubra sunrise, Acciona
Turbine in the sun, Pacific Hydro

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