

Chapter 1

Executive Summary



1.1 Summary

KEY MESSAGES

- This national assessment of Australia’s energy resources examines Australia’s identified and potential energy resources ranging from fossil fuels and uranium to renewables. It reviews and assesses the factors likely to influence the use of Australia’s energy resources to 2030 including the technologies being developed to extract energy more efficiently and cleanly from existing and new energy sources.
- Australia has an abundance and diversity of energy resources. Australia has more than one third of the world’s known economic uranium resources, very large coal (black and brown) resources that underpin exports and low-cost domestic electricity production, and substantial conventional gas and coal seam gas resources. This globally significant resource base is capable of meeting both domestic and increased export demand for coal and gas, and uranium exports, over the next 20 years and beyond. There is good potential for further growth of the resource base through new discoveries. Identified resources of crude oil, condensate and liquefied petroleum gas (LPG) are more limited and Australia is increasingly reliant on imports for transport fuels.
- Australia has a rich diversity of renewable energy resources (wind, solar, geothermal, hydro, wave, tidal, bioenergy). Except for hydro where the available resource is already mostly developed and wind energy where use is growing strongly, these resources are largely undeveloped and could contribute significantly more to Australia’s future energy supply.
- Greater use of many energy sources with lower greenhouse gas emissions (especially renewable energy sources) is currently limited by the immaturity of technologies and the cost of electricity production. Advances in technology supported by industry and government actions are expected to result in commercial electricity production by 2030 from sources that are currently only at the demonstration stage.
- Australia’s energy usage in 2030 is expected to differ significantly from that of today under the influence of the 20 per cent Renewable Energy Target and other government policies such as the proposed emissions reduction target. In addition the Government has established the Clean Energy Initiative which includes the Carbon Capture and Storage and Solar Flagship Programs, and the Australian Centre for Renewable Energy.
- Australia’s long-term energy projections show total energy production nearly doubling due to strong export demand, primary energy consumption rising by 35 per cent, and electricity demand increasing by nearly 50 per cent by 2030. Whilst coal is expected to continue to dominate Australia’s electricity generation, a shift to lower-emissions fuels is expected to result in a significant reduction in coal’s share and increases in gas and renewable energy, particularly wind.
- Australia’s energy infrastructure is concentrated in areas where energy consumption is highest and major fossil fuel energy resources are located. Greater use of new energy resources, particularly renewable energy sources, will require expansion of Australia’s energy infrastructure, including augmentation of the electricity transmission grid.

1.2 Introduction

Australia's abundance of energy is a key contributor to Australia's economic prosperity. The Australian energy sector directly accounts for 5 per cent of gross industry value-added; 20 per cent of total export value; supports a large range of manufacturing industries; and provides significant employment and infrastructure. The demand for energy is increasing as Australia's economy and population grow.

A secure supply of adequate, clean, reliable energy at an affordable price is vital for Australia's economic growth and prosperity. To date Australia's energy needs have been largely met by fossil fuels. Australia's abundant and low-cost coal resources are used to generate three-quarters of domestic electricity and underpin some of the cheapest electricity in the world. Australia's transport system is heavily dependent on oil, some of which is imported.

Australia's economy, and the energy sector in particular, is undergoing transformational change to reduce greenhouse gas emissions and help mitigate the impacts of global climate change. The energy sector currently accounts for more than half of Australia's net carbon dioxide (CO₂) emissions. The move to a lower emissions economy requires a shift from the current heavy dependence on fossil fuels to a greater use of energy sources and technologies that reduce carbon emissions, such as renewable energy and carbon capture and storage. At present renewable energy sources account for only modest proportions of Australia's primary energy consumption (around 5 per cent) and electricity generation (7 per cent), although their use has been increasing strongly in recent years. Recent and proposed developments in Australia's energy policy seek to significantly boost the role that renewable energy plays in the next two decades.

The objective of this report by Geoscience Australia and the Australian Bureau of Agricultural and Resource Economics (ABARE) is to provide a comprehensive and integrated assessment of Australia's energy resources to assist industry investment decision-making and development of government policy on energy resources. Included in the outlook to 2030 is an assessment of Australia's identified and potential energy resources; a review of the technologies being developed to extract energy more efficiently and cleanly from both existing and emerging energy sources; and consideration of other factors such as the global energy market that are likely to influence the development and use of Australia's energy resources in the next 20 years.

The assessment is made against a background of significant change and uncertainty about future

energy demand and use, both in Australia and globally. World economies – including Australia and its major trading partners – are still recovering from the economic downturn associated with the global financial crisis in 2008–09. Preliminary International Energy Agency (IEA) data suggest that world energy demand dipped by up to 2 per cent in 2009, the first decline in energy consumption since 1981.

The rate of growth of future global energy demand is uncertain and will strongly depend on global policies and actions to reduce CO₂ levels in the Earth's atmosphere. Without such actions, global energy demand is expected to continue to grow robustly over the next twenty years, dominated by fossil fuels. The adoption of emissions reduction policies could be expected to constrain growth in energy demand and raise the price of fossil fuels, increasing the attractiveness of lower carbon technologies, especially renewable energy.

As the global economy recovers and energy demand grows, the response by governments in Australia and globally to climate change will largely determine future energy demand. This in turn will impact on demand for Australia's energy resources both as exports to the world markets and the nature of Australia's domestic energy consumption.

1.3 Australia in the world energy market

- Australia is richly endowed with natural energy resources and holds an estimated 38 per cent of uranium resources, 9 per cent of coal resources, and 2 per cent of natural gas resources in the world.
- Australia produces about 2.4 per cent of world energy and is a major supplier of energy to world markets, exporting more than three-quarters of its energy output. In 2008–09 Australia's energy exports reached nearly 14 000 PJ, worth \$77.9 billion.
- Australia is currently the world's largest exporter of coal and coal exports accounted for more than half of exports on an energy content basis. Australia is one of the world's largest exporters of uranium, and is ranked sixth in terms of liquefied natural gas (LNG) exports. In contrast, Australia has only about 0.3 per cent of world oil reserves. Net imports of liquid fuels account for nearly half of consumption.
- Australia is the world's twentieth largest consumer of energy, and fifteenth in terms of per capita energy use.

- Australia’s energy market differs from that of many other OECD countries and world energy markets. Coal plays a much larger role in Australia’s primary fuel mix, reflecting Australia’s large, low-cost resources located near demand centres and close to the eastern seaboard. The penetration of gas in Australia is similar to that of the OECD and world average, as is that of wind and solar. On the other hand, Australia has less hydro energy resources, makes less use of bioenergy than some countries, and does not use nuclear power.

1.4 Australia’s energy resources and market

- Australia’s energy production was 17 360 PJ in 2007–08. The main energy sources produced, on an energy content basis, were coal (54 per cent), uranium (27 per cent) and gas (11 per cent). Renewable energy accounts for nearly 2 per cent of total production.
- Primary energy consumption was 5772 PJ in 2007–08. Coal accounted for around 40 per cent of this, followed by oil (34 per cent) and gas

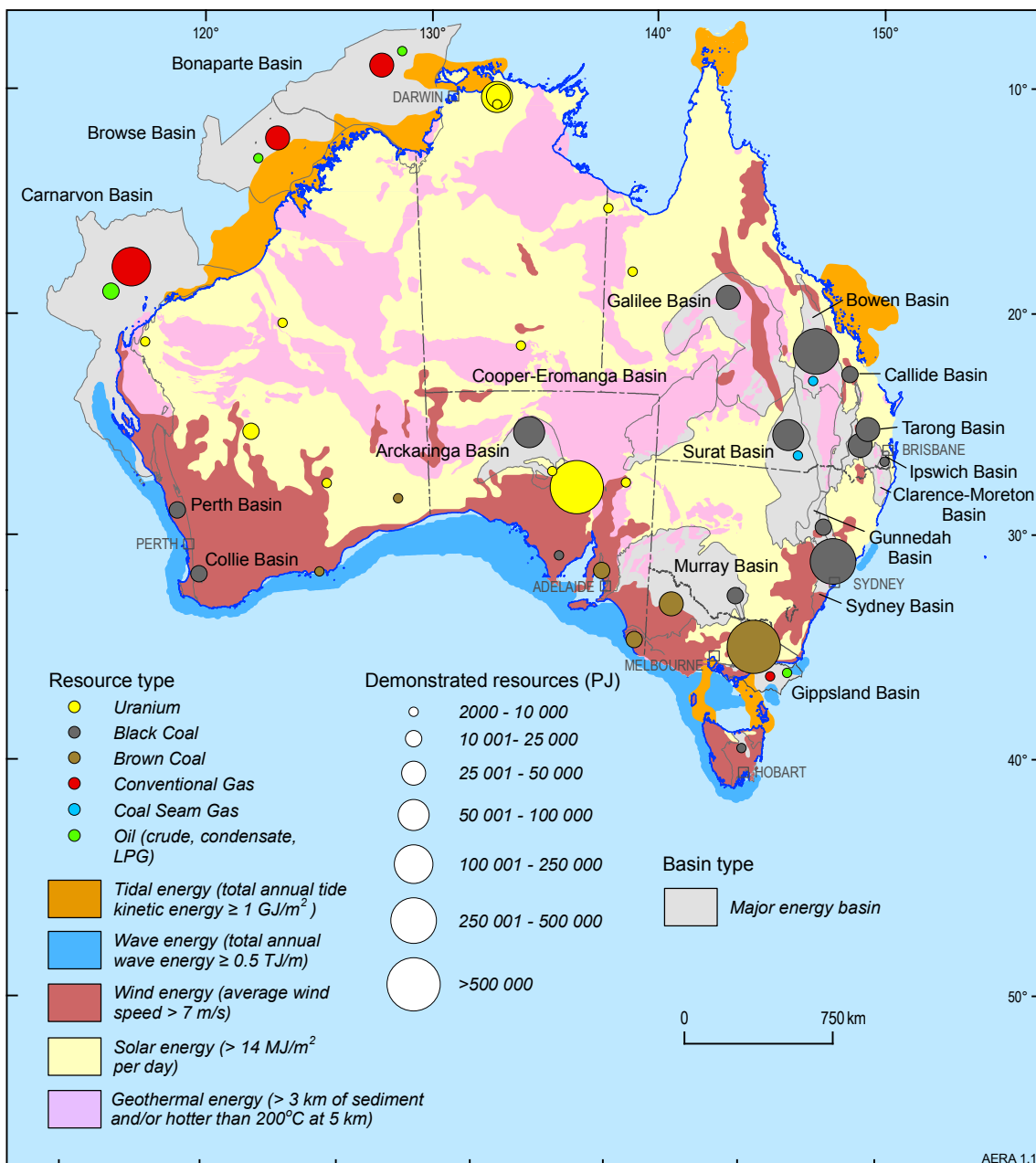


Figure 1.1 Australia’s major energy resources, excluding hydro and bioenergy

Note: Total resources are in many cases significantly larger than the remaining demonstrated resources which do not include inferred and potential (yet to be discovered) resources.

Source: Geoscience Australia

(22 per cent). Renewable energy accounts for 5 per cent of primary energy consumption, most of which is bioenergy. Wind and solar account for only 0.3 per cent of primary energy consumption.

- Total electricity production was around 925 PJ (257 TWh) in 2007–08. Coal accounts for about three-quarters of Australia's electricity generation, followed by gas (16 per cent). Renewable energy sources account for an estimated 7 per cent of electricity generation, most of which is hydro.
- Australia has abundant, high quality fossil fuel resources, notably coal (black and brown) and gas (conventional, coal seam gas and potentially tight gas) resources which are widely distributed across the country (table 1.1; figure 1.1). Resources of oil (crude oil, condensate, and LPG) are more limited (especially crude oil resources), and Australia relies increasingly on imports to meet demand for transport fuels. With the exception of crude oil, Australia's fossil fuel resources are expected to last for many more decades, even with increased levels of production.
- Coal is Australia's largest energy resource. About 70 per cent of Australia's large, low-cost economic demonstrated resources (EDR) of black coal (883 400 PJ, 39 Gt) are located in the Sydney and Bowen basins but the total identified coal resource is much larger (about 2.5 million PJ, 114 Gt) and more broadly distributed and includes major undeveloped resources in additional areas such as the Gunnedah, Arckaringa, Surat and Galilee basins in Queensland, South Australia and New South Wales. Australia's EDR of black coal are sufficient for about 90 years at 2008 production levels. Australia is the world's largest exporter of metallurgical coal and the second largest exporter of thermal coal, with total coal exports worth \$54.7 billion in 2008–09.
- Brown coal resources are similarly large and concentrated in the Gippsland Basin (Victoria) where they are used for electricity generation. There are also substantial undeveloped resources in the Murray Basin. Australia's EDR of brown coal are sufficient for nearly 500 years at 2008 production levels.
- Australia has the world's largest uranium resources with reasonably assured resources of uranium recoverable at less than US\$80/kg (equivalent to EDR) estimated to be 651 280 PJ (1163 kt U), equivalent to about 140 years at 2008 production levels. High levels of exploration are expected to add to the resource base. Australia is one the world's leading exporters of uranium and has a number of proposed new mines to meet increasing world demand. Australia

also has a major share of the world's thorium resources, a potential future nuclear fuel.

- Gas is Australia's third largest energy resource. Australia's has significant conventional gas resources lying mostly offshore in the Carnarvon, Browse and Bonaparte basins off the north-west coast of Western Australia with smaller resources in south-east (Gippsland Basin) and central Australia. These support growing domestic demand in the three gas markets as well as LNG exports (15.4 Mt, \$10.1 billion in 2008–09) from Western Australia and the Northern Territory. Current demonstrated (economic and sub-economic) resources of conventional gas stand at 180 400 PJ (164 tcf). EDR are adequate for 63 years at current rates of production. These figures do not include the gas resources in recent discoveries which are not yet fully defined, the resources likely to be added by reserves growth nor resources from potential new discoveries. Significant additional export capacity is also under construction and proposed.
- Australia also has significant unconventional gas resources, especially coal seam gas (CSG) resources associated with the major coal basins of eastern Australia. CSG resources and production have grown strongly and CSG is playing an increasingly important role in eastern gas markets. CSG EDR are estimated to be 16 590 PJ (15 tcf) but total demonstrated resources exceed 46 590 PJ with more likely to be available from the even larger estimated potential in-ground CSG resources. Plans have been announced for CSG-based LNG projects in Queensland.
- Australia's oil resources are in decline with remaining crude oil resources estimated to be 8414 PJ (1431 million barrels, mmbbl) and located mostly in the Carnarvon and Gippsland basins. Australia's total liquid petroleum resources are boosted to 30 794 PJ by the condensate (16 170 PJ, 2750 mmbbl) and LPG (6210 PJ, 1475 mmbbl) resources associated with major, largely undeveloped gas fields in the Carnarvon, Browse and Bonaparte basins off the north-west coast of Australia. Australia's oil resources could be extended by new discoveries in deep water basins (both proven and untested) and further growth at existing fields. Without significant new discoveries of crude oil, or development of condensate and LPG resources associated with offshore gas resources, or other alternatives, Australia is likely to be increasingly dependent on imports for transport fuels.
- Australia also has significant demonstrated shale oil resources of around 84 600 PJ (14 387 mmbbl) that are currently not utilised

because of economic and environmental constraints.

- Australia's potential renewable resource base is also very large, and includes wind, solar, bioenergy, geothermal, wave and tide as well as hydro resources. Hydro and increasingly wind energy are used in electricity generation. Biomass and solar energy are both being used for heating and electricity generation. However, Australia's renewable energy resources are largely undeveloped: a number involve technologies still at the proof-of-concept or early stages of commercial demonstration.
- Australia's hydro electric power stations have a combined installed capacity of 7.8 GW and produce about 4.5 per cent of Australia's total electricity, the largest contribution of any renewable energy. Most are located in Tasmania and in the Snowy Mountain Hydro-Electric Scheme in south-east Australia where they account for about 60 per cent and 20 per cent of electricity generation in Tasmania and New South Wales, respectively. However, water availability is a key constraint on future growth in hydro energy in Australia.
- Australia's wind resources are among the best in the world, primarily located in western, south-western, southern and south-eastern coastal regions but extending hundreds of kilometres inland. These resources are being progressively utilised by an increasing number of large-scale (more than 100 MW) wind farms using large modern wind turbines. Wind energy is the fastest-growing energy source with an installed capacity of about 1.7 GW, which produced about 1.5 per cent of Australia's electricity in 2007–08.
- High solar radiation levels over large areas of the continent provide Australia with some of the best solar resources in the world. Use of solar energy is currently modest (around 0.1 per cent of Australia's primary energy consumption) consisting mainly of off-grid and residential installations using solar thermal water heating with lesser production of electricity from photovoltaic (PV) cells. Substantial research and development programs in both government and industry are aimed at developing and commercialising large scale solar energy.
- Australia has significant (Hot Rock) geothermal energy potential associated with buried heat-producing (from natural radioactive decay) granites that could be a source of low emissions base load electricity generation. Lower temperature geothermal resources are associated with naturally-circulating waters in aquifers deep in sedimentary basins and are potentially suitable for electricity generation and/or direct use. Several projects are at the exploration, proof-of-concept or early commercial demonstration stage. Potential also exists for use of ground source heat pumps in heating and cooling buildings.
- Ocean energy (wave and tidal) is a potential new source of energy. Australia has a world-class wave energy potential along its south-western and southern coast with high energy densities, and large areas experiencing constant favourable wave heights (exceeding 1 m). Australia also has significant tidal energy resources, including an average kinetic energy resource of around 2.4 PJ at any time, located mostly along Australia's northern coastline. A number of technologies are being trialled at various sites.
- Bioenergy is a diverse energy source based on biomass (organic matter) that can be used to generate heat and electricity and to produce liquid transport fuels. Bioenergy currently accounts for about 4 per cent of Australia's primary energy consumption with the biggest contributors being bagasse (sugar cane residue) and wood waste in heating and electricity generation with some capture of methane gas from landfill and sewage facilities. A small amount of transport fuel (ethanol and biodiesel) is also produced. Greater use of bioenergy could be made through increased use of agricultural residues and wastes, wood waste, and non-edible biomass, including new generation crops.
- Current impediments to immediate large scale utilisation of Australia's substantial and diverse renewable resources include their generally higher costs relative to other energy sources (except for hydro), their often remote location from markets and infrastructure, and the relative immaturity (except for hydro and wind) of many renewable technologies.

1.5 Outlook for Australia's energy resources and market to 2030

- Significant changes are anticipated in the Australian energy market over the next two decades as a consequence of the expanded Renewable Energy Target (RET) and other government policies. Other factors expected to affect the market include the rate of economic and population growth, energy prices, and costs and developments in alternative energy technologies. Domestic use of nuclear power is not considered in the outlook period.

- Technology is expected to play a critical role in the transition toward a lower emissions economy. This includes technology to improve efficiency in extraction and use of energy, to reduce costs of cleaner technologies, and to develop and commercialise new technologies to access new energy sources.
- Australia's energy demand will continue to rise over the period to 2030, but the rate of growth is expected to continue to slow. This reflects the long term trend in the Australian economy toward less energy intensive sectors, and energy efficiency improvements both of which can be expected to be reinforced by policy responses to climate change. The contribution of gas and renewables is expected to increase significantly.
- ABARE's latest long-term Australian energy projections examine the effects of a 5 per cent emissions reduction target below 2000 levels by 2020, combined with the RET (20 per cent of electricity supply by 2020) and other existing policy measures, on Australia's energy market.
- Australia's total energy production (including uranium exports), is projected to increase by 3.2 per cent per year to reach around 35 057 PJ by 2029–30.
- Australia's primary energy consumption is projected to increase by 1.4 per cent per year to reach around 7715 PJ by 2029–30. The primary fuel mix is expected to change significantly, with the share of coal expected to decline to 23 per cent by 2029–30. In contrast, the share of gas is expected to rise to 33 per cent and wind to 2 per cent. Renewable energy is projected to account for 8 per cent of Australian energy consumption by 2029–30.
- Electricity generation is projected to reach 366 TWh in 2029–30, an increase of 1.8 per cent per year. Coal is expected to continue to dominate Australia's electricity generation (43 per cent of total in 2029–30) but a shift to lower emissions energy sources is expected to result in significant increases in the use of gas (37 per cent) and renewables (19 per cent), particularly wind (12 per cent).
- Australia's energy infrastructure is concentrated in areas where energy consumption is highest and major fossil fuel energy resources are located, particularly along the eastern seaboard of Australia. A significant expansion in Australia's energy infrastructure, particularly electricity generation and transmission, will be required in the next two decades if Australia is to meet its changing demand for energy. Utilising new energy resources, particularly renewable energy sources, will require a more flexible and decentralised electricity transmission grid.
- Australia's energy exports are projected to continue to grow to 2030 to meet rising global demand for energy. Net energy trade is projected to increase by 3.9 per cent per year, to reach 27 340 PJ in 2029–30. Exports of coal, uranium and LNG are all expected to rise significantly.
- World primary energy demand is projected to increase by 40 per cent between 2007 and 2030, representing an average annual growth rate of 1.5 per cent, in the IEA 2009 World Energy Outlook reference scenario. More than three-quarters of the increase in primary energy demand will continue to be for fossil fuels. Of the fossil fuels, coal is expected to be the fastest growing fuel and is projected to account for 29 per cent of world primary energy demand in 2030 (slightly higher than its current share), followed by gas which is projected to maintain its current share of 21 per cent. Renewable energy sources are projected to account for 14 per cent of primary energy use in 2030.
- Under a scenario where countries adopt emission reduction policies to stabilise the concentration of greenhouse gas emissions in the atmosphere at 450 parts per million of CO₂-equivalent (the IEA's 450 scenario), growth in world energy demand to 2030 is projected to be significantly constrained, rising by only 20 per cent on current levels. Lower demand for coal would see the share of coal in the primary energy mix fall sharply (to 18 per cent in 2030). Renewable energy and nuclear power drive much of the growth in energy demand, with the share of renewables in primary energy use to rise more sharply (to 22 per cent).
- The energy sector, especially fossil fuels, will continue to play an important role in the Australian economy both in terms of domestic energy supply and increasingly in exports. However, it is clear that the 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.

Table 1.1 Summary of Australia's energy resources, December 2008

Resource	Development status	Economic demonstrated resources PJ	Total demonstrated resources PJ	Production 2007–08 PJ	Installed electricity generation capacity GW	Electricity production 2007–08 TWh	Export value 2008–09 \$million
Non-renewable energy resources							
Black coal	Electricity generation, exports of thermal and metallurgical coal	883 400	1 046 500	8722	24	143	54 671
Uranium ^a	Exports	651 280	660 240	4747	-	-	990
Brown coal	Electricity generation	362 000	896 300	709	6.7	60	-
Conventional gas	Electricity generation, direct use, LNG exports	122 100	180 400	1709	14	42 (includes CSG)	10 086
Coal seam gas (CSG)	Electricity generation, direct use, proposed LNG exports	16 590	46 590	124	Included in conventional gas	Included in conventional gas	-
Condensate	Transport fuel	12 560	16 170	257	-	-	Included in crude oil
Crude oil	Transport fuel	6950	8414	697	1 (distillate)	-	8755 (-5966 net exports)
LPG	Transport fuel	4614	6210	105	-	-	1044
Oil shale	Undeveloped resource	Economic evaluation of resources in progress	84 600	-	-	-	-
Thorium ^{a, b}	Undeveloped potential resource	No commercial market at present	76 kt	-	-	-	-
Renewable energy resources							
Geothermal	Undeveloped large Hot Rock and Hot Sedimentary Aquifer resources, not fully defined	Economic evaluation dependent on demonstration projects in progress	Exceeds 2 572 280 ^c	0.003 ^d	0.0001	0.0007 ^d	-
Hydro	Electricity generation; resource largely developed	30 TWh/year ^e (gross economically exploitable capacity)	100 TWh/year ^e (technically exploitable capacity)	43	7.8	12	-

Resource	Development status	Economic demonstrated resources PJ	Total demonstrated resources PJ	Production 2007–08 PJ	Installed electricity generation capacity GW	Electricity production 2007–08 TWh	Export value 2008–09 \$million
Wind	Electricity generation; large potential resources	Substantial economic resource, large-scale commercial wind farms in operation	More than 600 000 km ² with average wind speeds of 7 m/s or higher	14	1.7	3.9	-
Solar	Large potential resources. Solar heating and (off-grid) solar PV electricity generation	Large-scale solar power stations under research and development	Average solar radiation per year 58 million PJ	7	0.1	0.1	-
Ocean (Wave and tidal)	Large undeveloped resources, demonstration projects in progress	Economic evaluation dependent on demonstration projects in progress	Average total tidal kinetic energy at any time on continental shelf – 2.42 PJ Average total wave energy at any time on continental shelf – 3.47 PJ	-	0.0008	-	-
Bioenergy	Significant under-utilised resources, potential new resources	Commercial production of electricity and heat from bagasse, biogas and other biomass. Commercial production of biofuels	Bagasse, wood waste, sewage gas, land-fill gas, forest and agricultural residues, and energy crops	226	0.9	2.2	-
				Biofuels 199 ML	-	-	-

a Recoverable at <US\$ 80/kg. **b** A conversion into energy content equivalent for thorium was not available at the time of publication. **c** Total identified geothermal energy resources potentially available (including inferred resources), actual amount available depends on efficiency of extraction. **d** 2006–07 production. **e** World Energy Council, 2007, Survey of Energy Resources 2007

Note: Economic and total demonstrated resources for fossil fuels, uranium, thorium and geothermal based on McKelvey resource classification; not applied to renewable energy sources other than geothermal. Total resources are in many cases significantly larger than the remaining demonstrated resources which do not include inferred and potential (yet to be discovered) resources.

Source: Geoscience Australia; ABARE 2009, Australian Energy Statistics