The Parliament of the Commonwealth of Australia

Renewable power

A case study into selected renewable energy sectors in Australia for the inquiry into developing Australia's non-fossil fuel energy industry

Background information—interim report

House of Representatives
Standing Committee on Industry and Resources

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Canberra

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Foreword

At the beginning of the current Parliament, the House of Representatives Standing Committee on Industry and Resources began an inquiry into the development of Australia's non-fossil fuel energy industry. The Committee commenced the inquiry with a case study into Australia's uranium resources and its potential to mitigate greenhouse gas emissions. Having completed this case study, the Committee turned its attention to the state of development of a range of renewable energy sectors in Australia and their prospects for economically viable electricity generation, storage and transmission.

To date, the Committee has received an impressive number of submissions and other documents from some 150 organisations, individuals and regional communities. This is itself an indication of the great interest among Australians in the place of renewable energy sources in the nation's future electricity generation mix.

Regrettably, it was not possible, in the time available to the Committee before the end of the Parliament, to undertake a full programme of public hearings and inspections for the renewable energy case study. The Committee had planned to conduct hearings in several states and with a wide range of organisations, companies and individuals that had submitted to the inquiry.

With the end of the 41st Parliament now approaching, the Committee has decided to publish this paper, which is largely comprised of background information on each of the renewable sectors under examination, as an interim report ahead of further work that may be undertaken by the Committee on this topic. The report, which was initially prepared for members' private use, largely reproduces previously published and publicly available information and research.

The report does not represent the Committee's conclusions or summarise the evidence presented to it to date. However, the background information may stimulate further thinking on the part of members and interested members of the public, should the case study be continued in the next Parliament.

It seems both likely and highly desirable that in the years ahead renewable energy sources will come to play a more significant part in the nation's electricity generation mix. Forecasters predict the strongest growth in the biogas, biomass, wind and solar energy sectors. As would be expected, the potential of the sectors under examination here varies considerably, and each sector faces a number of impediments to further growth. These impediments merit the attention of the Committee.

In thanking all those who have taken the time to prepare submissions, the Committee believes that the evidence received to date represents an excellent platform on which an important final report could be completed by the Committee during the 42nd Parliament.

The Hon Geoff Prosser MP
Chairman

Membership of the Committee

Chairman	The Hon Geoff Prosser MP
Deputy Chair	Mr Michael Hatton MP
Members	The Hon Dick Adams MP
	The Hon Bronwyn Bishop MP
	The Hon Alan Cadman MP
	Mr Martin Ferguson MP
	Mr Barry Haase MP
	The Hon Robert Katter MP
	The Hon Jackie Kelly MP
	Mr David Tollner MP

Committee Secretariat

Secretary	Mr Russell Chafer
Inquiry Secretary	Mr Jerome Brown
Research Officer	Mr Muzammil Ali
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Terms of reference

On 8 May 2007 the Minister for Industry, Tourism and Resources, the Hon Ian Macfarlane MP, referred the following case study to the Committee.

The House of Representatives Standing Committee on Industry and Resources shall inquire into and report on the development of the non-fossil fuel energy industry in Australia.

The Committee shall undertake a comparative study of the following renewable energy sectors—solar, wave, tidal, geothermal, wind, bioenergy and hydrogen. The case study will examine the relative state of development of these sectors and their prospects for economically viable electricity generation, storage and transmission.

List of abbreviations

Acronyms and units

AAD	Australian Antarctic Division
ABARE	Australian Bureau of Agricultural and Resource Economics
ACCI	Australian Chamber of Commerce and Industry
ACF	Australian Conservation Foundation
AEST	Advanced Electricity Storage Technologies initiative
AFC	alkaline fuel cell
AGO	Australian Greenhouse Office
AIE	Australian Institute of Energy
AIG	Australian Industry Group
ALGA	Australian Local Government Association
ANU	Australian National University
ANZSES	Australian and New Zealand Solar Energy Society
AP6	Asia Pacific Partnership on Clean Development and Climate
ATA	Alternative Technology Association
AusWEA	Australian Wind Energy Association
BCSE	Australian Business Council for Sustainable Energy

BOS	balance of system
CFE	Centre for Fuels and Energy (Curtin University of Technology)
CHP	combined heat and power plant
CIS	Centre for Independent Studies
CSES	Centre for Sustainable Energy Systems (Australian National University)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSP	concentrated solar power
CST	concentrating solar thermal
DEH	Australian Government Department of the Environment and Heritage
DITR	Australian Government Department of Industry, Tourism and Resources
DOE	Department of Energy (United States of America)
EBA	Environment Business Australia
EIA	Environmental Impact Assessment
ENA	Energy Networks Association Ltd
EPA	Environmental Protection Authority
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
ERAA	Energy Retailers Association of Australia
ESAA	Energy Supply Association of Australia
EUAA	Energy Users Association of Australia
GHG	greenhouse gas

GIA	(IEA) Implementing Agreement for Cooperation in Geothermal Research and Technology
GMI	Global Marketing Initiative (to support the commercial development of CSP)
GW	gigawatt (giga = billion, 10^9 watts)
GWe / GWt	gigawatts of electrical / thermal power
GWEC	Global Wind Energy Council
GWh	gigawatt-hour of electrical power
HCPV	heliostat concentrator photovoltaic
HDR	hot dry rock (geothermal energy source)
IEA	International Energy Agency
IEA FC	IEA Advanced Fuel Cells Implementing Agreement
IES	Institute of Environmental Studies (University of New South Wales)
IPO	initial public offering
kg	kilogram
kWe	kilowatts of electrical power
kWh	kilowatt-hour (unit of electrical energy)
LETA	Low Emissions Technology and Abatement programme
LETDF	Low Emission Technology Demonstration Fund
MCFC	molten carbonate fuel cell
MRET	Mandatory Renewable Energy Target
Mt	million tonnes
Mtoe	million tonnes of oil equivalent

MTSA	multi-tower solar array
MWe / MWt	megawatts of electrical / thermal power (mega = million, 10^6 watts)
MWh	megawatt-hour of electrical power
NEDO	New Energy and Industrial Technology Development Organization (Japan)
NEM	(Australian) National Electricity Market
NGF	National Generators Forum
NHAA	National Hydrogen Association of Australia
NHIA	National Hydrogen Institute of Australia
NSEC	National Solar Energy Centre
OCGT	open-cycle gas turbines
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of Petroleum Exporting Countries
PACE	Plan for Accelerating Exploration initiative (South Australia)
PAFC	phosphoric acid fuel cell
PEMFC	proton exchange membrane fuel cell
PV	photovoltaic
PVRP	Photovoltaic Rebate Program
R&D	research and development
REAA	Renewable Energy Action Agenda
REDI	Renewable Energy Development Initiative
REEEP	Renewable Energy and Energy Efficiency Partnership
REEF	Renewable Energy Equity Fund
REGA	Renewable Energy Generators of Australia

RISE	Research Institute for Sustainable Energy (Murdoch University)
RRPGP	Renewable Remote Power Generation Program
SOFC	solid oxide fuel cell
t	tonnes
TW	terawatt (tera = trillion, 10^{12} watts)
TWa	terawatt-year
TWh	terawatt-hour of electrical power
UNSW	University of New South Wales
W	watt

Glossary[1]

Bioenergy	Bioenergy refers to the conversion of organic matter into energy. Various organic materials may be used to generate energy, including solid biomass (i.e. forest product wastes, agricultural residues and wastes, and energy crops), biogas, liquid biofuels, and the organic component of industrial waste and municipal solid waste.
Electricity	Electricity is a form of energy produced by the flow of electrons in a substance known as a conductor. The best conductors are metals such as copper and aluminium, and are commonly used in electrical wiring. Electricity can be converted readily to heat and light and used to power machines. It can also be transported with relative ease. These characteristics make electricity a convenient and manageable form of energy, and contribute both to its value as a commodity and its versatility as a source of power. Electricity is a secondary energy source in that it is produced by the conversion of other energy sources such as the chemical energy in coal, natural gas and oil. Sun and wind are primary energy sources.
Energy storage	Technologies for storing energy from sources which are intermittent in character, notably wind and solar energy. Storage solutions assist in addressing intermittent renewable generation contributions to the electricity grid and potentially increase the renewable energy capacity contribution.

1 The glossary has been compiled from the following sources: Energy Futures Forum, *The Heat is On: The Future of Energy in Australia*, CSIRO, Canberra, 2006, pp. 22–23; A Jolley, 'Technologies for Alternative Energy', *Climate Change Working Paper No. 7*, March 2006, Centre for Strategic Economic Studies, Victoria University, viewed 16 February 2007, <http://www.cfses.com/documents/climate/07_Jolley_Technologies_for_Alternative_Energy.pdf>; Queensland Department of Natural Resources, Mines and Water, 'Geothermal energy: hot dry rocks', *Facts mine series*, 2006, viewed 1 March 2007, <http://www.nrw.qld.gov.au/factsheets/pdf/mines/m7.pdf>; National Electricity Market Management Company Ltd, *An Introduction to Australia's National Electricity Market*, NEMMCO, Melbourne, 2005, pp. 28, viewed 13 March 2007, <http://www.nemmco.com.au/nemgeneral/000-0187.pdf >; International Energy Agency, *Renewable Energy: Market and Policy Trends in IEA Countries*, OECD/IEA, Paris, 2004, viewed 25 June 2007, <http://www.iea.org/textbase/nppdf/free/2004/renewable1.pdf>.

Fuel cells	Fuel cells are electrochemical devices that convert the energy of a chemical reaction directly into electricity. Fuel cells, which have applications in both the stationary energy and transport sectors, are the key enabling technology for a 'hydrogen economy'—the widespread use of hydrogen as an energy-storage medium.
Geothermal energy	In geothermal power plants, steam, heat or hot water from geothermal reservoirs provides the force that spins turbine generators which produce electricity. The used geothermal water is then returned down an injection well into the reservoir to be reheated, to maintain pressure, and to sustain the reservoir. There are four types of geothermal sources: hydrothermal sources—hot water and steam at depths of between 100m and 4 500m; geopressurised sources—hot brine usually associated with methane in pressurised water aquifers at depths of 3–6 km; hot dry rock (HDR)—abnormally hot geologic formations with little or no water; and magma— molten rock reservoirs either very deep or in the vicinity of volcanoes at temperatures of 700–1 200°C.
Hot dry rock (HDR) or hot fractured rock (HFR)	Hot dry rock resources are found in granite rock layers buried up to several kilometres underground, beneath layers of sedimentary rock. Extracting the heat occurs by pumping water down into the hot granite through a borehole that may be several kilometres deep. This assists in opening up existing very small cracks in the granite, increasing the permeability of the rock. The water is converted to steam by the heat and is channelled to the surface through another borehole, where it can be used to drive a turbine and thereby generate electricity. HDR is potentially a renewable source of base load power and Australia is considered to have some of the best reserves of hot dry rocks in the world.
Hydrogen	Hydrogen is an energy 'carrier', rather than a source of energy (such as coal or gas), and an energy storage medium that has to be generated either from fossil fuels or biomass by using their own embedded energy, or from water by supplying energy. Hydrogen has potential uses in many applications, such as fuelling vehicles, providing process heat for industrial processes, supplying domestic heating needs

	and fuelling power plants.
Kilowatt hour (kWh)	The kilowatt-hour (kWh) is a unit of energy equivalent to one kilowatt (1 kW = 1 000 W) of power expended for one hour of time. This equals 3.6 million joules (megajoules or MJ). The kilowatt-hour is not a standard unit in any formal system, but it is commonly used in electrical applications.
National Electricity Market (NEM)	The Australian National Electricity Market is a wholesale market for the supply of electricity to retailers and end-users which commenced operation in December 1998. It now consists of six interconnected regions that largely follow the state boundaries of Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania.
Photovoltaics (PV)	Photovoltaic technology converts the light energy (solar photons) of the sun directly into an electric current using semiconductor materials. Solar cells are the basic unit of PV technologies and may be connected together to form a panel. When photons enter the solar cell, electrons in the semiconductor material are freed, generating direct electric current. PV panels are versatile and can be mounted in a variety of sizes and applications such as on building roofs and roadside emergency phones.
Reliability	Power system reliability is a measure of the power system's capacity to continue to supply sufficient power to satisfy customer demand, allowing for the loss of generation capacity.
Renewable energy	Renewable energy is energy derived from sources that cannot be depleted or can be replaced, such as solar, wind, biomass (waste), ocean, or hydro.
Security of supply	In the context of the Australian National Electricity Market, security of supply is a measure of the power system's capacity to continue operating within defined technical limits despite the disconnection of a major power system element, such as an electricity generator or interconnector. Security of supply ensures the ongoing and reliable supply of electricity to supply demand at all times.
Solar energy	Energy from the sun can be categorised in two ways: as heat energy (thermal energy), which is harnessed using solar thermal systems, or as light energy, which is harnessed using

	photovoltaics (PV).
Solar thermal power	Solar thermal systems use the sun's thermal energy to generate electricity, usually by heating a fluid such as water and using it to drive a turbine.
Tidal energy	Tidal power, which is a subset of ocean energy, is derived from the kinetic energy of water moving from a higher to lower elevation. A large daily tidal variation of at least four metres is required to produce useful amounts of energy. A dam is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator.
Watt (W)	International System of Units standard unit of power, which is the rate of conversion (or transfer) of energy per unit time. One watt is the equivalent of one joule per second. One kilowatt (kW) is equal to 1 000 watts, one megawatt (MW) is equal to one million watts, one gigawatt (GW) is equal to one billion watts, and one terawatt (TW) is equal to one trillion watts.
Wave energy	Waves are ultimately a form of solar energy. The sun heats up the Earth's surface, causing winds that, in turn, drive waves. As the wave travels, the winds continually pump energy into them. By the time the waves hit a coast they contain considerable power. There are a large number of wave technologies at conceptual level.
Wind energy	Wind energy is a form of solar energy and represents 0.25 per cent of the sun's energy reaching the lower atmosphere. Wind comes from the movement of air resulting from thermal gradients and the earth's rotation. Depending on climatic conditions and surface topography, wind can vary significantly in intensity over a day, over a season, or over a year. A good wind resource is usually characterised by an average wind speed of over 6.5 metres per second (23 km/hr).