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Renewable Energy Used for Electricity Generation in Australia

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Glossary

Alternating Current	An electric current that reverses its direction of flow at regular intervals.
Bagasse	Sugar cane fibre (waste) produced during the sugar cane refinery process.
Base-load	That part of electricity demand which is continuous, and does not vary over a 24-hour period. Approximately equivalent to the minimum daily load.
Direct Current	An electric current that flows in only one direction.
Green energy	The term has no strict definition although it is used widely in the energy literature. The term refers to energy generated by renewable accredited technologies and incorporates perceptions of cleanliness and sustainability.
MW	Capacity of electricity plant is measured in megawatts (MW). If a 1 MW capacity plant is run for one hour, it generates 1 MWh of electricity, for 1 000 hours, either 1 000 MWh or 1 GWh.

Acronyms

ACCC	Australian Competition and Consumer Commission
AC	Alternating current
AGO	Australian Greenhouse Office
DC	Direct current
EDL	Energy Developments Limited
ESAA	Electricity Supply Association of Australia
GEM	Green electricity market
GHG	Greenhouse gases
GWh	Gigawatt hours (10^9 watt hours)
GST	Goods and services tax
IEA	International Energy Agency
kW	Kilowatt (10^3 watts)
MWh	Megawatt hours (10^6 watt hours)
NEM	National Electricity Market
OECD	Organisation for Economic Cooperation and Development
PV	Photovoltaic
RAPS	Remote Area Power Systems
RSAPS	Renewable Stand Alone Power Systems
SEDA	Sustainable Energy Development Authority of New South Wales
SWERF	Solid Waste Energy Recycling Facility
V	Volt

Major Issues

Renewable energy currently contributes some 10.7 per cent total electricity supply. By far the largest contributor is large-scale hydro with smaller contributions from bagasse, mini-hydro, waste-to-energy and hot water systems. Only minor contributions are currently made from wind farms and solar photovoltaic (PV) systems, which are often offered as replacement renewable alternatives, perhaps somewhat naively, to traditional fossil fuel generated electricity.

The use of renewable generated electricity is set to increase by around 2 per cent (9 500 GWh of electricity annually) by 2010 with the introduction of Federal Government legislation. This increase will boost the contribution of the use of renewable energy in electricity generation to 12.7 per cent by 2010. It is expected that over the period 2010 to 2020, the use of renewable generated electricity will remain at this level. It has been estimated that the 2 per cent increase will require some $300 million of infrastructure investment annually for ten years or some $3 billion in total. Many industry proponents, however, back the measure despite the cost.

One of the primary reasons for the introduction of the mandatory 2 per cent increase, was an expected substantial reduction in greenhouse gas emissions which would result from electricity being generated by 'clean and green' renewable technologies compared to emission intensive coal-fired power stations. Australia's Kyoto commitment was to limit greenhouse gas emissions growth to 108 per cent of the 1990 baseline. However, it has been estimated that the 2 per cent measure will only result in savings of up to 7 million tonnes of greenhouse gases which in comparison to total emissions is quite small.

There are significant developments occurring in both wind and solar renewable technologies. Increase in the use of these technologies is emerging, although, in comparison to fossil fuel generated electricity, they remain expensive and unable to supply continuous base-load power, which underpins electricity supply in most Western economies including Australia. Australia is at the forefront of research and development in photovoltaic solar energy. This work is being undertaken by Pacific Solar, a joint venture between Unisearch (the research arm of the University of New South Wales) and Pacific Power. Other work is also being undertaken in other renewable energy fields in Australia, particularly waste-to-energy and bagasse systems.

The mandatory 2 per cent increase in the use of renewable electricity generation will provide a substantial financial incentive to support research and development into an

Australian renewable energy industry. As Australia is only a relatively small market, any large-scale renewable electricity generation developments would need a strong focus on export opportunities. There is high demand for small-scale electricity generating renewable electricity generation technologies in many Asian countries.

The development of renewable electricity generation offers opportunities and benefits but also has hurdles to confront. Renewable electricity generation will most commonly be small scale and be located close to its point of use (known as distributed or embedded generation). Advantages of generating systems located close to where the electricity is used is that there is little loss in transmission and distribution, such as with large-scale traditional power plants and distribution systems.

Renewable technologies sited much closer to the point of use are however more highly visible. There has been opposition to the building of wind turbines in highly visible sites, despite the benefits of the generation of renewable energy. Other issues that confront the introduction of renewable energy systems are high up-front cost and the shift of responsibility from electricity utility to the end user for infrastructure maintenance following the installation of renewable electricity generation capacity. Additional costs such as the installation of net metering capable of measuring excess electricity flow back into the electricity grid may also be involved. Also, at issue, are the repurchasing policies of large individual electricity retailers. Whilst some retailers offer generous repurchasing policies for small players, there is no broad scale industry standard.

Recent declines in wholesale and retail prices of electricity with the development of the competitive national electricity market (NEM) present difficulties for renewable energy development. Cost reductions have been associated with an increasing competitive electricity retail market and a number of technological improvements, as for example in coal mining operational practices, which feed through into cheaper fuel and generating costs. These declines have come just at a time when renewable energy technologies are attempting to establish themselves. Most renewable energy mixes remain uncompetitive in cost terms against fossil fuel electricity generation.

There has been some success with the introduction of green electricity schemes, although market penetration has been small attracting only a small percentage of total customers who consume small quantities of electricity. Many businesses and households appear unprepared to pay more for what amounts to be an undifferentiated product. The green energy program has attracted what might be called dedicated followers but has not impacted largely as a substantial market sector.

Introduction

The aim of this paper is to outline some of the current issues pertaining to the use of renewable energy in electricity generation in Australia.

Renewable energy has always been high on the agenda of advocates of sustainable development because it does not involve the use of finite resources. Renewable energy is defined as any source of energy that can be used without depleting its reserves. These sources include sunlight or solar energy, wind, wave and ocean, hydro and biomass energy. Biomass refers to any recently produced organic matter. If the organic matter is produced in a sustainable manner, it is considered a renewable energy source.

The paper outlines the contribution to Australia's energy use from renewable sources and, in particular, the use of renewable energy in electricity generation. Each of the sectors in the renewable energy mix is described. Apart from large-scale hydro, which presently accounts for the bulk of electricity generation from renewable sources, the other sectors contribute only in a minor way.

The paper refers to the introduction of green energy schemes that now operate in most Australian States and Territories. These schemes offer consumers the opportunity to purchase green energy (generated by accredited renewable energy suppliers) at higher prices. The additional premiums are used to pay for the additional costs of providing renewable (green) electricity.

The paper outlines a number of difficulties that confront the development of renewable energy technologies such as the high initial costs associated with renewable energy infrastructure. Also, an issue is a change of responsibility from large-scale electricity retailers to end user associated with the end user for infrastructure maintenance following the installation of renewable electricity generation capacity, which will require readjustment.

Electricity generation from renewables is anticipated to increase by 2 per cent to around 12.7 per cent of total electricity generating capacity by 2010. This will result from new mandatory Federal Government legislative requirements. The *Renewable Energy (Electricity) Bill 2000* establishes the framework for the implementation of this requirement. If passed, the Bill will result in substantial new investment in the sector. This required increase will create a major challenge for the renewables sector, as the bulk of the new supply will need to come from renewable technologies such as biomass, mini-hydro, wind, solar and other technologies that presently only contribute in a small way to renewable supply.

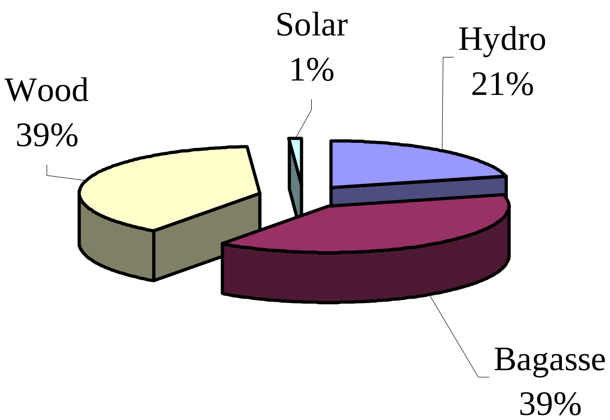
Part of the rationale for further development of the renewable energy industry in Australia was expected reductions of greenhouse gas (GHG) emissions associated with electricity generation, the largest GHG emissions contributor. Reductions of emissions are closely allied with Australia's commitment to limit the growth in greenhouse gas emissions made at Kyoto, in Japan in 1997 (The Kyoto Protocol). Whilst some savings will result from the expansion of the renewable energy sector, these savings in aggregate will be only quite small, especially for the next decade or so.

For broad comparative purposes, the paper outlines some major renewable energy developments in a number of overseas countries. In particular, a number of European countries have long promoted the use of renewable energy in the power supply sector. In addition, a number of these countries have become major manufactures and suppliers of renewable technology.

Renewable Energy Use in Australia

The use of renewable energy to generate electricity is only one of its applications. The term 'energy' is a generic term pertaining to the capability of doing work and should not be substituted for 'electricity'. Renewable energy, as well as being used for electricity generation can be used to produce heat and steam for industrial processes, home heating for warmth and heating water. The major renewable energy sources in use in Australia are outlined in Figure 1.

Figure 1: Renewable Energy Sources in Australia



Source: ABARE 1999.

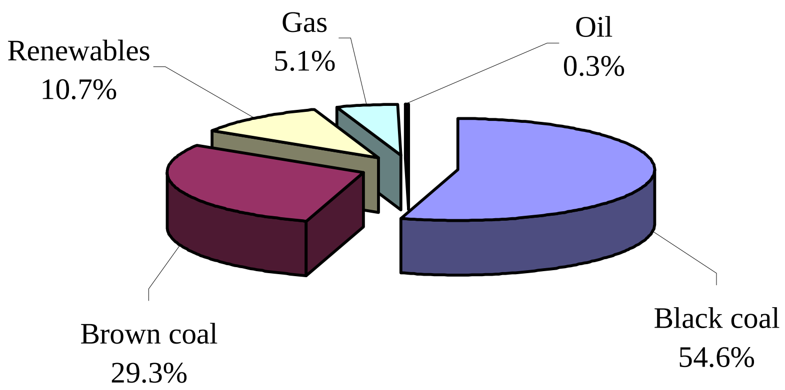
It can be seen from Figure 1 that the two largest contributers to total renewable energy use are bagasse and wood (each 39 per cent), followed by hydro at 21 per cent. Solar is well behind the other sectors at 1 per cent. The bulk of energy generated from wood is used for home heating whereas bagasse is primarily used for the generation of energy related activities (including process heat and electricity) in the sugar cane industry. Some excess electricity generated from bagasse in the sugar industry is exported to the grid. Energy generated by hydro (both large-scale and mini) is almost exclusively used for electricity generation and presently provides the bulk of renewable electricity generating capacity in Australia. Solar hot water systems, and many of the other forms of traditional renewable energy, namely biomass (now largely bagasse), waste-to-energy, solar photovoltaics (PV), wind, solar thermal, fuel cells, and—further down the track—geothermal, wave and tidal power have varying potential as sources of renewable energy generation. Solar water heaters are examples of solar thermal systems in that heat is captured from solar radiation. The use of solar water heaters makes a contribution (see next section) in that water heated by this means negates the requirement to heat this equivalent amount of water by other means, for example, by electricity generated from coal-fired power stations.

Renewable Energy Used in Electricity Generation

In the electricity generating sector, renewable energy currrently contributes some 10.7 per cent of total generating capacity[1] most of which comes from large-scale hydro electricity schemes, notably the Snowy Mountains Hydro-electric Authority in southern New South Wales and Hydro Tasmania.

The bulk of Australia's electricity generation is presently sourced from black and brown coal. Australia's electricity generation by fuel type is shown in Figure 2. Australia has abundant high quality reserves of both black and brown coal and natural gas. These readily exploitable low-cost resources have been one of the major contributing factors leading to Australia having amongst the cheapest electricity tariffs in the OECD.[2] Predominant use of these low cost resources is likely to continue for the foreseeable future. Coal and gas-fired electricity plants supply continuous base-load power, which is essential for industrial and commercial use and also for household use. Renewable energy supplies (excluding large-scale hydro) have often been seen as supplementing conventional base-load power supply. Even large-scale hydro generated electricity has limitations in that generation capacity is lost in times of low river flow and reduced dam capacity in drought periods. One advantage of hydro is that it can be readily activated for high demand peak load periods. Many forms of renewable energy—especially solar and wind—have the decided disadvantage that they can only generate electricity when the sun is shining or the wind is blowing. Storage of electricity, other than in small scale remote systems has to date proved impractible and expensive; in other words electricity is best used directly, regardless of the source of generation.

Figure 2: Electricity Generation by Fuel Type



Source: AGO and modifications after ESAA, 1999.

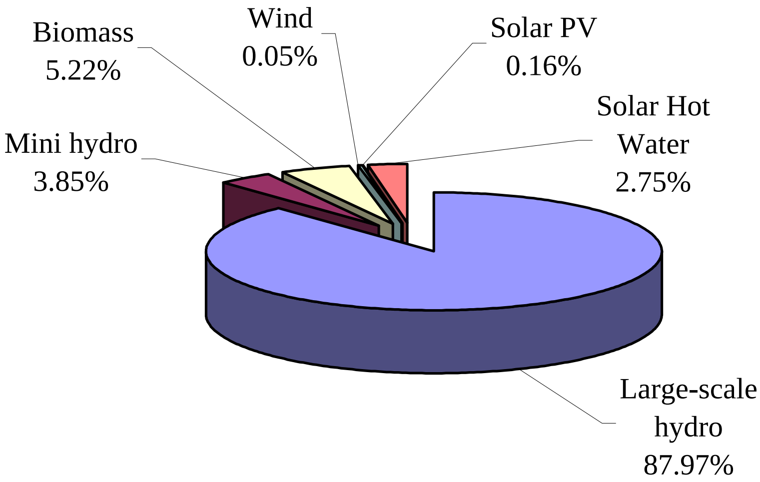
Details of the major fuel used in electricity generation are outlined in Box 1.

Box 1: Major Fuels Used in Electricity Generation

Black coal at 54.6 per cent of the total is the major fuel used for electricity generation. Large base-load power stations in New South Wales and Queensland are located in relative close proximity to black coal fields in the Hunter Valley, New South Wales and the Ipswich and Tarong coal fields, near Brisbane, Queensland respectively. The large base-load power stations located in the Latrobe Valley, Victoria, source their coal supplies from the nearby brown coal (lignite) deposits. Gas presently supplies 5 per cent of the fuel for electricity generation although this is projected to increase with the further development of both existing and new gas fields and the extension of gas pipeline infrastructure. Major pipeline developments include the Eastern Gas Pipeline project connecting Longford in Victoria to Winton in New South Wales and the possible building of the PNG gas pipeline, which would extend from PNG across Torres Strait and along the Queensland coast to Gladstone, and possibly Brisbane. These pipeline developments will provide the impetus for the development of additional gas-fired power stations.

As previously mentioned, renewable energy presently supplies 10.7 per cent of electricity generation. The present contribution of renewables to electricity generation is outlined in Figure 3. It is apparent that the bulk of electricity generation presently comes from large-scale hydro electricity generating systems—87.97 per cent. There is a massive fall away to the next largest sector of biomass at 5.33 per cent followed by mini-hydro systems at 3.85 per cent. The remainder is made up from solar hot water systems, wind, solar photovoltaic systems (including photovoltaic grid connected and remote area power supply) and solar thermal systems. Solar hot water systems use solar energy to heat water and do not in themselves generate any electricity. However, what is measured is the quantity of electricity that would have been required to heat the equivalent amount of hot water.

Figure 3: Electricity Generated by Renewables



Source: Redding Energy Management, 1999.

The Renewable Energy Mix

A survey conducted by Redding Energy Management assessed the level of installed electricity generation capacity from renewable energy sources and this is outlined in Table 1.

Table 1: Renewable Electricity Generation (end 1997) Capacity Output

Resource—Technology combination	Installed capacity MW	Generated output GWh/y
Large-scale hydro	7 580	16 000
Mini hydro	200	700
Bagasse		
Bagasse cogeneration	250	400
Black liquor	49	90
Other	6	40
Municipal		
Landfill gas	80	400
Sewerage gas	15	20
Wind, main grid	0.2	0.4
Wind, small grid	2.5	4.4
Photovoltaic, grid	0.14	0.3
Solar thermal	0.045	<1
Photovoltaic, RAPS	13	29
Wind, RAPS	1	2
Solar hot water	190	500
Total	8 390	18 200

Source: Redding Energy Management 1999. Note: See explanation linking the terms MW and GWh in Glossary.

Large-scale Hydro

Large-scale hydro in Australia comprises the Snowy Mountains in southern New South Wales and Hydro Tasmania. The Snowy Mountains Hydro-electric Scheme is one of the most significant engineering feats ever completed in Australia. It was built for the dual purpose of diverting water from the eastward and southerly flowing Snowy catchment system into the westward flowing Murray and Murrumbidgee rivers, and generating substantial amounts of hydro electricity from water flows of the various dams and water diversions systems within the complex. Hydro Tasmania is regarded in many quarters as one of the most influential government bodies in Tasmania with responsibility for the building of dams and managing almost all the electricity generation sector of Tasmania.

Because of the almost total dominance of these two facilities in the renewable electricity-generating sector, it would appear that if Australia wished to expand output of electricity generation from renewables, then the answer would be to further develop large-scale hydro. This could be done either by expanding these two systems or building another series of dams with incorporated generating turbines. Many large-scale dams are still being built in other parts of the world, an example being the huge controversial dam on the Yangtze River in China, with incorporated hydro electricity generating capacity. The

Chinese Government maintains that the dam will control chronic flooding and produce electricity to feed a rapidly growing economy. However, there are many detractors of this development, both within China and other parts of the world.

Many Australians are now aware of the substantial environmental impact large dams have, and it would appear unlikely any further large scale dams with incorporated hydro electricity generating capacity will be built in Australia. The proposed building of a dam on the Gordon below Franklin in Tasmania became the focus of Australia wide attention back in the early 1980s and Federal Government intervention prevented the building of the dam. Also, there has been political pressure to reinstate previously diverted water to the Snowy River from the Murray-Darling systems. It was recently announced [3] that the New South Wales and Victorian governments have reached agreement in-principal on a proposed outcome to the Snowy Water Inquiry. However, the Commonwealth will not be in a position to respond to the Snowy Water Inquiry until the Environmental Impact Statement process on the *Corporatisation of the Snowy Mountains Hydro-electric Authority* is completed. It is hoped that by mid-November 2000, the Commonwealth will announce its response. Any water diversion from the Murray-Darling would make less water available for hydro generation and for irrigation purposes along the Murray and Murrumbidgee rivers. Another factor is that most of the areas suitable for dam development in Tasmania now lie in world heritage classified areas.

Mini or Small-scale Hydro

A classification scheme widely used breaks hydro into a range of sizes from a few hundred watts to over hundreds of megawatts. At the low end of the scale, small hydro can be divided into three categories: micro (less than 100 kW), mini (100 kW to <1 MW) and small (1 MW to <10 MW). Micro-hydro systems operate by diverting part of the river flow through a penstock or pipe, which drives a turbine to produce electricity. Micro-hydro systems are preferable from an environmental point of view in that river flow patterns are not disrupted and no flooding of valleys behind dam walls upstream is required. A recent study commissioned by the Sustainable Energy Development Association (SEDA) of New South Wales has found there are some 36 sites with a potential generating capacity of greater than one GWh/year without major inundation schemes or alteration to river flow. In Queensland, there are some five to eight projects with capacities 1–3 MW capacity at evaluation stage.

Biomass

Bioenergy is energy produced using biomass, which is organic matter. Biomass energy is derived from plant and animal material, such as wood from forests, residues from agricultural and forestry processes and, industrial, human or animal wastes. Wet biomass, such as piggery effluent or sludge, can produce combustible gases, made up largely of methane. Biomass such as wood and bagasse can be burnt to produce heat, or alternatively gasified to produce a clean burning fuel.

One of the most important sources of biomass is bagasse, which is sugar cane waste. A number of Australian sugar refineries produce their own energy from the burning of bagasse and there are a number of substantial new bagasse plants under development, some of which are detailed in Box 2.

Box 2: Bagasse Developments

At present, the sugar mills in Queensland, New South Wales and Western Australia have a combined capacity of 300 MW.[4] A major bagasse plant development at Rocky Point, in southern Queensland, is presently under construction. This plant will have a capacity of some 30 MW producing some 200 000MWh (or 200 GWh) of electricity annually when completed. The plant will operate year round, using locally sourced wood waste for fuel (obtained as a by-product of forestry operations) outside the normal 20-week sugar cane crushing when the bagasse waste will be unavailable. Excess generated electricity will be exported to the grid. A large number of sugar mills located along the Queensland coast are evaluating further opportunities to use bagasse as a combustible source for small-scale electricity plants.

The use of waste-to-energy is an important source of renewable energy and it has substantial potential. Details of a number of developments are outlined in Box 3.

Box 3: Waste-to-Energy Developments

In New South Wales, there is some 20 MW of installed generation capacity using gas produced from waste decomposing in landfill, enough to power 20 000 homes. Energy Developments Ltd (EDL), operates 14 waste-to-energy landfill sites in Australia, with a combined capacity of 70 MW, and has been actively expanding these activities in the United Kingdom and the United States. EDL has become an international leader in generating energy from waste in municipal dumps. A number of projects use methane gas produced from microbial decomposition of organic matter. The gas is drained and burnt in gas turbines to generate electricity. In addition to the operation of landfill waste-to-energy sites, EDL operates a solid waste energy recycling facility (SWERF) at a municipal waste facility near Wollongong, New South Wales. The facility is designed to recover reusable and recyclable resources prior to the conversion of organic components into gas and then electricity.

Wind

Australia's wind turbine industry is presently in its infancy. There has been considerable growth in this sector with the building of a number of medium size wind farms, for example Pacific Power's 5 MW facility at Crookwell, New South Wales. A number of new wind farm development proposals are under serious consideration. New grid electricity generation from wind turbines is gradually becoming competitive with conventionally-fuelled systems in many areas of the world and could become the cheapest form of purely fuel-free renewable electricity production in Australia within the next five to ten years. It has been estimated that wind energy could supply 10 per cent of Australia's total electricity generating capacity in the medium term.[5] However, based on current and planned infrastructure, such projections would appear highly optimistic. For example, electricity generating capacity in Victoria at the end of 1999 stood at 8 297 MW and major planned wind farm project at Codrington and Toora only have a combined capacity of 38 MW.

Both the average wind speed and the variability of speed determine the quality of a wind energy resource at a given location. These factors will determine both the amount of energy which a wind generator of given size can supply in a year, and the extent to which wind energy can provide guaranteed capacity.

Australia has a large wind energy resource by world standards. There are many areas on the coastlines of the southern states of Tasmania, South Australia, Victoria and Western Australia, which are subject to the prevailing winds termed the 'roaring forties'. There are other areas in Australia that are suitable to build wind farms because of favourable prevailing winds and the CSIRO along with other organisations have undertaken and are undertaking studies to outline this potential.

Australia's present wind generating capacity is outlined in Table 2. Most of the facilities are less than one megawatt and most are hybrid systems, that is systems providing electricity from back up fuels such as diesel. Wind systems are modular—the more units, the more output. Large wind farms can be spread over wide expanses of land. Wind farms may not unduly interfere with rural life as animal grazing and crops can extend up to the wind turbine. Wind turbines do however have an environmental impact, the most notable being visual, with other considerations being turbine generated wind noise and possible effects on bird migratory patterns.

There is also opportunity for Australia to participate in developing wind technology, in manufacturing, assembly techniques or power system/electrical design. As things stand now, about two-thirds of a wind farm project cost is attributed to the importation of turbine components.[6]

A number of significant wind farm developments are outlined in Box 4.

Table 2: Location and Capacity of Wind Turbines

Location	State	Capacity MW
Crookwell	New South Wales	4.8
Esperance	Western Australia	2.0
King Island	Tasmania	0.75
Kooragang Island	New South Wales	0.60
Thursday Island	Queensland	0.45
Denham	Western Australia	0.23
Malabar	New South Wales	0.15
Cooper Pedy	South Australia	0.15
Flinders Island	Tasmania	0.10
Breamlea	Victoria	0.006
Murdoch	Western Australia	0.005
Aurora	Victoria	0.001
Coconut Island	Queensland	0.001
Total		9.243

Source: Department of Industry Science and Resources, 1999.

Table 2 shows that the current capacity of Australia wind generators is very low, less than 10 MW.

There are however, a substantial number of new wind renewable energy projects in the planning stage. These developments are outlined in Table 3.

Table 3: Planned Wind Turbine Installations

Site	State	Developer	Estimated Capacity (MW)
Albany	WA	Western Power Corporation	21.6
Blayney	NSW	Pacific Power, Advance Energy	10.0
Codrington	Vic	Pacific Hydro Limited	18.2
Lake Bonney	SA	P Hutchinson	15.0
Toora	Vic	Stanwell Corporation	20.0
Windy Hill	Qld	Stanwell Corporation	12.0
Windy Hill	Qld	Stanwell Corporation	13.0
Woolnorth	Tas	Hydro Tasmania	10.5
Woolnorth	Tas	Hydro Tasmania	120.0
Total			240.3

Source: Hydro Tasmania; Note: planned operations as at the end of 1999.

Box 4: Planned Wind Developments

1. Hydro Tasmania has embarked on the first stage of construction of a 130 MW wind farm at Woolnorth, in the north west of Tasmania. The company presently operates a small wind farm at Huxley Hill on King Island, which began operating in 1998. The King Island facility has three turbines with a total capacity of 750 kW. The Woolnorth development would become Australia's largest wind farm. Hydro Tasmania has reached agreement for the purchase of some 3 000 hectares of land for the proposed development. This purchase negates to some extend the possibility of project veto by adjoining neighbours as happened to wind farm development proposals at Cape Bridgewater, Victoria in 1999.
2. Western Power Corporation's Albany WA project would comprise 12 wind turbines with three 35 m blades mounted on 65 m towers with a total capacity of around 22 MW. According to the WA Energy Minister, Mr Colin Barnett, the project will involve capital expenditure of around $45 million. The wind farm is expected to be in operation by July 2001. The project is expected to supply 75 per cent of Albany's power requirements, enough electricity for 17 000 homes and result in the savings of some 76 000 tonnes of carbon dioxide emissions by burning less coal and natural gas to generate electricity.[7]
3. Stanwell Corporation Ltd, a Queensland Government-owned generator utility operates a 12 MW wind farm on the Atherton Tablelands at Windy Hill, about 5 km from Ravenshoe. The $20 million project was completed in mid-2000 and was undergoing final stages of commissioning in September. The project is expected to generate electricity for about 3 500 households and result in savings of some 25 000 tonnes of carbon dioxide emissions.[8] The company plans to build a second wind farm with a capacity of 13 MW at the same location depending on a positive evaluation of the initial 12 MW facility. Environmental factors including aesthetics, impact on wildlife, noise levels and compatibility with telecommunications systems will be part of the assessment process.
4. Stanwell Corporation has received approval for the construction of a $35 million wind farm at Toora, Victoria. The project will consist of a 13-turbine farm with a capacity of 20 MW. Each turbine would be about 70 m high, with a propeller blade of up to 35 m. The wind farm is expected to take about 12 months to build. The council set the area at Toora aside for the future development of wind farming some 10 years ago.[9]
5. Pacific Hydro Limited, an Australian owned company, publicly listed on the Australian Stock Exchange, completed construction of a 18.2MW wind farm at Codrington, south western Victoria, in July 2001. The $33 million project—its 14 turbines will generate enough electricity for 15 000 homes—is the first wind farm built by Pacific Hydro. By 2004, the company plans to have up to eight wind farms in Victoria and Western Australia—where wind conditions are more conducive to commercial wind farms.[10] Construction will commence in the later part of 2000. Powercor Australia, a Victorian electricity distributor, has signed an in principal agreement to purchase electricity from the wind farm.
6. Pacific Power expects to complete the construction of a wind farm with a capacity of 10 MW at Blayney, New South Wales, by the end of 2000. The $18 million joint venture will feature 15 turbines and generate enough energy to supply 3 500 homes. The wind farm will be built, owned and operated by Pacific Power, with the electricity generated sold under contract of a New South Wales distributor, Advance Energy, for its green power scheme.[11]

Solar

Australia has extensive areas with access to good solar resources. Despite its promise in a land of abundant sunshine, solar photovoltaic technology has so far failed to make a major impact on Australia's energy market.[12] It would appear that the science has to date been overshadowed by its high cost. Solar energy can be converted into both electricity via solar photovoltaic cells, commonly called PV, and heat via thermal solar systems.

Solar Photovoltaic

Photovoltaic (PV) cells convert sunlight directly into electricity with no noise, emissions or pollution. The cells are wired together in-groups, sealed in glass covered panels and put on rooftops or solar farms in designated configurations in appropriate positions. The panels transform the energy from the sunlight into low voltage Direct Current (DC) electricity, which is converted via an inverter into standard 240 volt Alternating Current (AC) used in most homes. According to many commentators, solar PV remains very appropriate for small isolated communities, although a major role is not seen for solar PV in grid supplied electricity generation. Solar PV systems are expensive and with efficiencies of 15 to 20 per cent (conversion of sunlight into electrical energy), other renewable technologies to date have appeared more attractive. However, commercial innovations in design and manufacturing by companies such as Pacific Solar and BP Solarex are aimed at reversing these perceptions.

In Australia, Solar PV systems presently supply infinitesimal quantities of generated electricity (as at the end of 1997, there was only of the order of 13 MW installed capacity). Most of this is in remote area power supply systems. Telecommunications remains a major market where small quantities of electricity are required to keep distant and very remote telecommunications equipment running. Other uses include the generation of electricity used in equipment for railway signalling, navigational aid, metal cathodic protection and remote fuelling installation equipment. A number of relatively small-scale solar farm grid connected systems have been built. These include Kalbarri in Western Australia, Singleton and Queanbeyan in New South Wales and Wilpena Pound in South Australia. The Queanbeyan solar farm, belonging to Great Southern Energy, a New South Wales electricity distributor, comprises a solar powered 50 kW generator consisting of 720 PV panels, each rated at 77 W and arranged on nine separate modules of 80 panels. It generates in the order of 100 000kWh (100 MWh) of electricity per year.

Demonstration solar sites have also been established by a number of electricity utilities to further evaluate the solar PV technology. Details of these sites are outlined in Box 5.

Box 5: Solar PV Demonstration Sites

Two prominent solar PV sites include Citipower's Energy Park called Project Aurora, and Energy Australia's Olympic Village, Homebush Bay, Sydney, New South Wales.

At the Olympic Village, each house in the suburb has been fitted with PV solar panelling on rooftops, which should generate 1600 kW hours a year (1.6 MWh), and for the village in total generate around 1 000MWh of electricity. For comparative purposes, the average suburban house would use around 8 to 10 MWh of electricity per year, hence, the Olympic Village complexes have supplemented their energy needs with space and water heating from other energy sources. Furthermore, electricity would need to be used carefully and optimally.

Australia is at the forefront of research directed towards the development of solar power. Pacific Solar, a joint venture between Pacific Power (a New South Wales electricity generator and Unisearch, a research arm of the University of New South Wales) has invested considerable effort into solar research. Pacific Solar plans to begin manufacturing new proprietary polycrystalline silicon thin film technology solar panels. The panels or modules of panels will be designed to fit onto or into standardised roof panels, each with a low cost current converter attached—with each panel or module ready to plug into the grid-connected system. The prospect of being able to sell surplus power into the grid, with the simplicity of drawing from the grid when the sun is not shining, is considerably more appealing than installing elaborate battery storage systems.

Whilst PV cells still remain expensive, the world market is growing at around 30 per cent per year, and costs continue to decline. There is speculation that this technology may have a major impact on the way energy is provided to the community in the years to come. A large percentage of all residences or building complexes may be fitted with modular PV panels, not only providing power for their own needs, but feeding excess supply to the broader electricity grid. Solar PV, from a very small base is overtaking wind as the fastest growing generation technology. Major PV manufacturing companies include British Petroleum, now advertising itself as bp (beyond petroleum), Enron, and Siemens. Estimates vary as to when the cost of PV will fall to the point of mainstream competitiveness. It is generally accepted that this should occur in the next decade given the continuation and expansion of the market development programs in place.[13]

Solar Thermal

The traditional solar hot water system uses solar thermal technology to provide hot water. As previously mentioned, hot water heated in this fashion negates the requirement to use electrical power to heat the equivalent amount to hot water. Redding Energy Management (see Table 1) estimates that as at the end of 1999, some 500 GWh of electricity would be required to heat the equivalent amount of hot water presently being heated by the current level of installed hot water systems.

Solar thermal systems are also used for electricity generation. Solar collectors (big dishes) focus the sun's energy in order to boil water or other fluids in some cases, create steam and drive steam turbines. The former solar thermal facility at White Cliffs, belonging to Australian Inland Energy, a New South Wales Government owned electricity distributor has been re-configured such that the sun's rays are now focussed on a PV cell arrangement to generate electricity. Capacity of solar thermal systems in Australia as at the end of 1997 were less than 0.1 MW and this technology is still considered experimental, despite the White Cliffs plant operating with this configuration for some 20 years.

Tidal, Wave and Ocean

There is no renewable energy being generated from either tidal, wave or ocean action in Australia at present. Tidal power utilizes the twice daily variation in sea level caused primarily by the gravitational effect of the moon, and to a lesser extent, the sun, on the world's oceans. A promising $360 million project proposal has been put forward to harness tidal power in the Derby region of Western Australia, although it has received a setback in that a competiting option using a gas-fired plant has received initial approval for development from the Western Australian State Government. However, the Labor Opposition in Western Australia has backed the development of the tidal option. The project proponents, Tidal Energy Australia, are seeking up to $75 million in Government assistance, some $60 million in Federal funding from greenhouse abatement funding programs and some $15 million from State funds to build various earthwork infrastructure.

Wave power results from the harnessing of energy transmitted to waves moving across the ocean surface. Wave demonstration plants operate at Port Kembla, New South Wales and Portland, Victoria.

Geothermal

Geothermal generated electricity is not expected to be available in Australia for some time. Geothermal systems can comprise near-surface geothermal heat pumps, the utilisation of energy from hot spring geysers, and the tapping of deep seated hot rock geothermal heat sources. The near surface geothermal heat pump system is dominantly associated with space heating requirements whereas the later two systems can be utilised for both space heating or electricity generation.

Geothermal Heat Pumps

The geothermal heat pump is used in individual buildings (most often commercial). An example of such is the new Australian Geological Survey Organisation (AGSO) building in Canberra. The geothermal system comprises a series of heat pumps which carry water through loops of pipes buried in bore holes, 100 to 200 metres deep, enabling an exchange of heat with the earth. This relatively constant temperature that prevails at these depths in the earth's crust (16 to 17 degrees Celsius) is transferred to the building and then either raised or lowered with conventional power to the temperatures required.

Hot Spring Geysers and Hot Rock Geothermal Systems

Hot spring geysers are natural occurring geological features located in areas of active volcanism (for example, the North Island of New Zealand). There are no such natural features in Australia.

Hot rock geothermal systems offer some potential in Australia. The proposed method of electricity generation from hot rock geothermal systems involves drilling boreholes into mega-heated (estimates range in temperatures up to 300 degrees celsius) deep-seated granitic basement complexes that can be several kilometres below the earth's surface. Water is then pumped down the boreholes, superheated by the large basement rock complexes, converted to steam, and returned to the surface. The steam drives steam turbines in a power station to generate electricity. A number of areas of high potential are presently under evaluation including the Hunter Valley near Newcastle and somewhat further afield in the Cooper/Eromanga Basin in north east South Australia. The area near Newcastle has particular appeal because of its location, close to an urban usage area. A hot rock geothermal project, once established would last for a century or so, and as such is not strictly renewable but is regarded as so in general context. The large mass of basement rock would retain its heat despite the feeding of cold water into the mass through surface boreholes.

Green Power Schemes

Green energy schemes in most Australian States and Territories offer consumers the opportunity to purchase so called green energy (generated by accredited renewable energy suppliers) at higher prices. Green power products sold by accredited electricity retailers are rigorously monitored under a national Green Power Accreditation Program, administered by government energy agencies in all states and territories. The premiums are used to cover the higher cost of renewable energy in addition to the generation of some monies for research and development to enable further the penetration of renewables into the electricity-generating sector. Great Southern Energy, a New South Wales electricity distributor, established an Earthsaver program in 1997 and now supply green energy to some 2 500 customers.

Development Constraints of Renewable Electricity Generation Capacity

The development of renewable electricity generation offers opportunities and benefits but also has hurdles to confront.

Renewable energy systems have high up-front installation costs, which immediately detract from their development, as customers mostly opt for cheaper so called ‘traditional’ fossil fuel generated energy. Many of the renewable technologies have been around for centuries although almost invariably many of these systems have been replaced by energy supplied by fossil fuels. Whilst costs of renewable technologies have declined by orders of magnitude, in absolute terms, they remain many time more expensive than fossil fuel generated electricity. Although costs of renewable technologies have been declining, so have the costs of traditional fossil fuel generated energy. Technological advancements, as for example in coal mining operational practices, feed through into cheaper fuel (coal) and generating costs.

Recent declines in wholesale and retail prices of electricity with the development of the competitive national electricity market (NEM) also present difficulties for renewable energy development. Cost reductions have been associated with an increasing competitive electricity retail market and a number of technological improvements. Another factor leading to significant price declines for fossil fuel generated energy in Australia has been the massive labour shedding programs associated with the corporatising and privatising of formerly owned State Government owned and operated monopoly electricity entities. These price declines have come just at a time when renewable energy technologies are attempting to establish themselves. Most renewable energy mixes remain uncompetitive in cost terms against fossil fuel electricity generation.

Many renewable energy developments in the world have to date been supported by government initiated programs incorporating subsidies and tax credits. The 2 per cent initiative is yet another of these approaches. The ultimate objective from Government fiscal support is the encouragement and development of renewable energy technology such that with ongoing technological advance and economies of scale, costs will decline to the point where renewable energy technologies are incorporated into mainstream energy supply.

Another difficulty with a shift from the ‘status quo’ and utilisation of renewable energy systems such as photovoltaic PV would be an associated shift of responsibility from an electricity utility to the end user for infrastructure maintenance. Additional costs such as the installation of net metering capable of measuring excess electricity flow back into the electricity grid may also be involved. Also, at issue, are the repurchasing policies of large individual electricity retailers. Whilst some retailers offer generous repurchasing policies for small players, there is no broad scale industry standard.

Renewable electricity generation will most commonly be small scale and be located close to its point of use (known as distributed or embedded generation). Advantages of generating systems located close to where the electricity is used is that there is little loss in either transmission or distribution, such as with large-scale traditional power plants and distribution systems.

Renewable technologies sited much closer to the point of use are however more highly visible. There has been opposition to the building of wind turbines in highly visible sites, despite the benefits of the generation of renewable energy. An irony is that some members of a community that promote renewable energy use are the same members that oppose wind farm development in particular locations. The development of wind farms in areas of low wind frequency would be pointless and wasteful.

The 2 per cent Mandatory Increase in the Use of Renewables

The Federal Government has initiated the introduction of legislation to increase the use of renewable energy used for the generation of electricity. The *Renewable Energy (Electricity) Bill 2000* was introduced into the Lower House on 22 June 2000. On enactment of this legislation, Australian electricity retailers and other large buyers of electricity, will be required to source 9 500GWh (approximately 2 per cent of total supply) of electricity per year from new renewable sources from 2010. Electricity retailers will be required to buy renewable energy certificates in a green electricity market (GEM) to cover a nominated portion of their electricity purchases. The measure will increase the use of renewable energy for electricity generation to around 12.7 percent of total electricity generating capacity by 2010. The measure is an example of demand stimulation with the intention to accelerate the uptake of renewable energy in grid-based electricity supply. A wide range of renewable energy sources have been identified as being eligible for the purposes of the 2 per cent measure. These are: solar, wind, ocean, wave and tidal, hydro, geothermal, biofuels, specified wastes, solar water heating, pump storage hydro, Renewable Stand Alone Power Systems (RSAPS), and co-firing renewables with fossil fuels and fuel cells using a renewable fuel.[14] A notable exception as being classified as ineligible is waste coal seam methane gas. Whilst this is a hydrocarbon, and as such not strictly renewable energy, it is abundant and it is an aggressive greenhouse gas. Its capture and use for electricity generation would be a good environmental outcome.

The requirement of the 2 per cent measure will remain at least at the legislated level throughout the period from 2010 to 2020. The administration of the scheme will involve the purchasing and trading of renewable energy certificates. Owners of eligible renewable energy generation assets will hold the renewable energy certificates in the first instance, until traded among liable third parties. Liable parties will be required to surrender renewable energy certificates, through the Regulator, equivalent to their total liability in that year. The government has agreed that penalties for non-compliance should be set at $40/MWh for the term of the measure. Penalties will be redeemable if the shortfall is made up within the next three years.[15]

Table 4: Interim Targets

Year	Required additional GWh
2001	400
2002	1100
2003	1800
2004	2600
2005	3400
2006	4500
2007	5600
2008	6800
2009	8100
2010	9500

Source: The Australian Greenhouse Office. Note: The commencement of the Scheme is 1 January 2001.

Meeting the 2 per cent Target

The 2 per cent target (which will be enforceable) will be phased in with annual interim targets (see Table 4), over the period 2001–2010. Interim targets have been recommended to ensure that there would be consistent progress towards achieving the additional 9 500GWh of renewable electricity generation by 2010 and that all of the investment did not occur in the final years of the scheme. The preferred phasing path has been designed to gradually grow to allow industry to adjust to the target, with a faster growth rate in the final years.

Investment Requirements for the 2 per cent Target

Electricity generated from renewable electricity generation (apart from large-scale hydro schemes in place) is of an order of magnitude more expensive than electricity generated from conventional means. Although costs have been declining with the introduction of newer technologies, these still remain higher than conventionally generated electricity. It is envisaged however that costs for renewable energy will continue to decline as investment in these areas ramp up to cater for the new supply requirement.

The Electricity Supply Association of Australia (ESAA) estimates the 2 per cent renewable measure, which aims to have 9 500GWh of new renewable power produced annually from 2010, will require $3 billion in capital outlays to establish the necessary infrastructure and will add $300 million (plus GST) to electricity charges.[16]

Magnitude of the Task of Implementing the 2 per cent Target

Australia presently has 8 390MW of renewable energy electricity capacity, which produces some 18 200GWh of electricity per annum (see Table 1). Hence, the task at hand to generate an additional 9 500GWh of electricity per annum by renewable means by 2010, is an increase of just over 50 per cent of current production of renewable electricity generation. The ESAA has estimated that an additional 3 000 MW of renewable capacity will need to be bought on line to generate the required amount of renewable electricity. It is apparent from the data outlined in Table 1, and the information in the summary overviews of the renewable energy mix, there is very little current capacity in any of the renewable categories apart from large-scale hydro, that will readily be accessible to contribute to the new measures. The obvious question is where will the future capacity in renewables come from? Projects either under construction or consideration only amount to a fraction of the 3 000MW capacity required. For example, biomass projects under present consideration amount to some 200 to 300 MW and wind projects amount to some 240 MW.

Industry commentators expect biomass projects (including waste-to-energy) will account for about half of the new generation capacity, with wind providing around 20 per cent, efficiency gains in large-scale hydro and mini-hydro systems 10–20 per cent and solar PV and solar thermal the rest. With such a breakdown, there is an expectation that additional renewable capacities will be biomass 1 500 MW, wind 600 MW, hydro systems 450 MW and solar 450 MW.

No allowance is made in these estimations for geothermal, tidal, wave and ocean renewable systems. These schemes would no doubt be large scale and would tend to operate in a base-load fashion if built. However, the ratio of contribution to the new renewable energy capacity is largely based on expected costs of implementation, biomass being the least and solar PV and solar thermal at the higher end of the cost curve. There is a high degree of uncertainty as to the cost of a constructing either a large-scale hot rock geothermal project or ocean tidal system.

Impact of the Kyoto Protocol

Australia as a signatory to the Kyoto Protocol has an undertaking to limit greenhouse gas emissions growth to an eight per cent increase on a 1990 base level. A number of industry and government stakeholders have suggested that the 2 per cent measure will result in annual savings of six to seven million tonnes a year in savings of greenhouse gas emissions. Whilst this is not a large contribution in terms of absolute savings when one considers Australia's total emissions in 1998 were 455.9 million tonnes, it will be an important contributor. However, in addition to the contribution to reducing greenhouse gas emissions, the 2 per cent measure is expected to greatly assist the development of an important and growing worldwide sustainable energy industry. In association with the provision of important domestic renewable energy infrastructure, there is considerable potential to develop renewable energy exports to Asian countries where there is high demand for power systems, especially for smaller scale embedded RAPS.

Coal-fired power stations are the major contributors in creating greenhouse gases. In Australia, fossil-fuelled power stations emit an estimated 55 per cent of our annual carbon dioxide emissions, well ahead of vehicles, which emit an estimated 17 per cent.

Overseas Developments

At present, the largest potential renewable energy markets in developed countries are in Europe. The European Commission has set a target of doubling to nearly 24 per cent the contribution of renewable energy to Europe's electricity needs by 2010. Europe is a large market for wind generation. The European market is expected to grow from 4 780 MW in 1997 to 10 000 MW by 2000, at an average growth rate of 22 per cent. Major wind farms are located in Germany, Denmark, Spain, the Netherlands and the United Kingdom. Denmark is the dominant exporter of wind generating equipment. There is also a large potential for wind power in the United States, for new, large machines to replace older, smaller units dating from the 1980s. However, a number of commentators believe the overall potential for market growth in the United States is low.

Developments have also occurred in the solar PV market. Governments around the world have announced programs to achieve more than 10 000 MW of PV power by 2010. As far back as 1996, the Japanese Government proclaimed guidelines to achieve more than 400 MW of PV power by 2000 and to increase this further to 4 600 MW by 2010. The United States Government announced its 'million solar roof initiative' in 1997. Germany and Switzerland have announced both programs to a lesser extent.[17]

The International Energy Agency (IEA) predicts global electricity generation will grow by an average of 3 per cent per year between 1995 and 2020. By 2010 the IEA projects total electricity generation capacity will have increased to 4 556 GW, an increase of almost 48 per cent from 1995. Renewables (other than hydro) is expected to increase to 43 GW (or 43 000 MW) in 2010 compared to 13 GW in 1995 (an increase of over 230 per cent).

The French Prime Minister announced in May 2000, that France would invest the equivalent of almost US $300 million of Government funds in renewable energy. However, European Commission forecasts indicate that France will lag behind the rest of the EU in the use of renewables by 2010—reaching nine per cent of generation output against an EU average of 12.5 per cent and Denmark's proposed 29 per cent. France has rejected suggestions that it should follow Germany and end its substantial reliance on nuclear power, which is around 80 per cent.

The European Energy Commissioner, Loyola de Palacio, is promoting a plan that will see the overall share of renewable electricity in the EU rise to 23.5 per cent from the present 14.5 per cent. This includes the contribution from hydro-electric schemes.[18]

Conclusions

Renewable energy presently supplies 10.7 per cent of Australian electricity generation capacity. The Federal Government has introduced mandatory legislation to increase the use of renewable energy by some 2 per cent (9 500 GWh of electricity annually) in increments to around 12.7 per cent of total generation capacity by 2010.

The bulk of renewable energy in electricity generation comes from large-scale hydro schemes located in the Snowy Mountains in southern New South Wales and in Tasmania. Presently, only small contributions to electricity generation come from other renewable energy sources such as mini-hydro, biomass, wind and solar energy systems. Solar hot water systems result in considerable savings in electricity generation. However, their market penetration has remained relatively small because of their high initial cost and perceived ongoing maintenance requirements.

Industry commentators estimate the mandatory requirement for the increase in renewable energy will require $3 billion in capital outlays and will add $300 million (plus GST) to electricity charges annually. Of the order of 3 000 MW of new renewable electricity generation capacity will need to be constructed to generate this electrical output. At present, installed renewable electricty generating capacity stands around 8 390 MW in comparison to total electricity gnerating capacity as at the end of 1999 of 39 383 MW.

The commentators expect biomass projects (including waste-to-energy) to account for about half of the new generation capacity, with wind providing around 20 per cent, efficiency gains in large-scale hydro and mini-hydro systems 10–20 per cent and solar PV and solar thermal the rest. With such a breakdown, there is an expectation that additional renewable capacities will be biomass 1 500 MW, wind 600 MW, hydro systems 450 MW and solar 450 MW. There are a number of substantial developments in biomass, wind and solar PV in Australia. Solar PV is one of the fastest growing businesses, with solar cell PV manufacturing increasing in the order of 30 per cent per annum. The concept of plug-and-power solar panelling on roof-tops which both generate electricity for internal use and excess generation available for export back to the grid is very appealing.

Further Information

Detailed information on all forms of renewable energy in Australia is outlined in a recently published Department of Industry Science and Resources Energy Action Agenda[19] and the Australian Greenhouse Office has a dedicated Internet renewable energy site at http://renewable.greenhouse.gov.au/.

Endnotes

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