Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Status of the Geothermal Industry in Australia, 2000-2005

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Keywords: Australia, electric power generation, hot dry rock, ground source heat pumps, district heating, renewable energy legislation

ABSTRACT

Australia continues to make modest use of its geothermal energy resources. The only electric power generation from geothermal energy currently in operation in Australia is the 150 kW binary cycle plant at Birdsville in SW Queensland. This plant uses 98°C artesian water from the Great Artesian Basin to generate much of the town's annual power requirements.

Direct use of geothermal waters continues to be an important source of energy in the city of Portland in western Victoria. Water pumped from a 1400 metre deep bore at a temperature of 58°C is used to heat many of the municipal buildings and public facilities. Geothermal waters are also used for spas at Moree, near Barradine and at Lightning Ridge in New South Wales and at two developments in Victoria on the Mornington Peninsula, south of Melbourne. Ground source heat pumps are also finding increased use in Australia in both commercial and residential applications.

Significant research and development of Hot Dry Rock (HDR) energy is underway and a number of companies have been formed to explore for and develop this form of geothermal energy. Most advanced is an HDR project in the Cooper Basin region of north east South Australia. Here a 4.4 km deep borehole has been drilled as part of an extensive commercial project. An extensive underground heat exchanger has been created in granite at this depth with in-situ temperatures >250°C. The drilling of a second deep borehole in 2004 is to be followed by a planned circulation test in early 2005. The known scale of this resource is so large that it could meet all of Australia's electricity generation requirements for centuries. The main purpose of the current work is to evaluate the likely economics of such a development. Other HDR projects, including one in the Hunter Valley of New South Wales, have also been active in the period 2000-2005.

1. INTRODUCTION

Interest in all forms of renewable energy has continued to increase in Australia in recent years. This has been particularly so in the period 2000-2005 due largely to government activities. In 2000 the Australian federal parliament passed the Renewable Energy (Electricity) Act. This Act saw the government's Mandatory Renewable Electricity Target (MRET) Scheme introduced on 1 April 2001. The MRET Scheme requires that by 2010 an extra annual 9,500 GWh of Australia's electricity must be sourced from renewable energy technologies when compared with a 1997 baseline. This will result in approximately 2% of the Australia's annual electricity consumption being sourced from renewable technologies. The onus in meeting the MRET target falls on Australia's power distribution utilities - both companies and state government owned corporations.

In practice, the MRET Scheme operates through a system of tradable Renewable Energy Certificates (RECs). These RECs are created by renewable energy generators at a rate of 1 REC for each MWh of electricity generated from an eligible renewable source (ORER, 2004). Power distribution utilities purchase RECs each year and surrender an agreed number to the federal government. As a tradable commodity, the value of each REC is determined by supply and demand but it has an effective price ceiling since the MRET Scheme will see fines of A$40 levied by the government for each MWh that a power utility falls short of their target in 2010.

In 2004 the Australian federal government re-affirmed the ~2% MRET target and released a new energy policy "Securing Australia's Energy Future". This policy introduced a new Low Emissions Technology Development Fund to provide A$500 million for demonstrating new low emissions technologies with significant long term greenhouse gas abatement potential. Geothermal energy and in particular, Hot Dry Rock, has been identified by the government as a technology that is well placed to benefit from the fund in future.

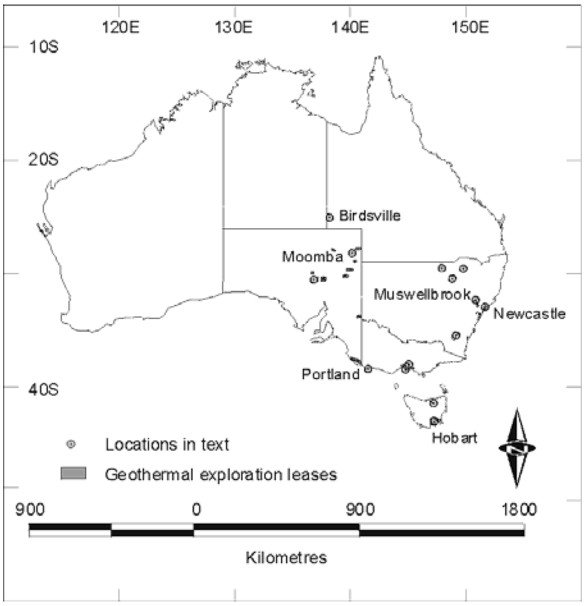

Figure 1: Map of Australian geothermal sites discussed in the text.

2. ELECTRIC POWER GENERATION

2.1 Birdsville

The small town of Birdsville (139°53'E 25°21'S) is situated in arid south west Queensland (see Figure 1). Its needs for electric power follow a familiar seasonal pattern with highest demand in the hot summer months when air-conditioning is used extensively and relatively low demand in winter. This demand cycle from the town's population of around 100 sees less than 120 kW of power required in winter and upwards of 250kW needed in summer. The one exception is during the town's once yearly "races weekend" when the population can swell to more than 5000.

To cope with the annual variations in the demand for electricity an integrated mix of generation systems are used:

- A geothermal power station with a nominal power rating of 150kW,
- A liquefied petroleum gas (LPG) generator set with a rating of 300 kW, and
- Two 150 kW diesel generator sets

The geothermal power system is installed on a free flowing artesian bore that was drilled to a depth of 1230 m to provide the town's water supply approximately 50 years ago. The water flows through a 6" casing to surface at a temperature of 98°C and a rate of 27 l/s. The source of this water is an aquifer in the underlying Great Artesian Basin which underlies approximately 1.7 million km^2 of central and eastern Australia (Habermehl, 1980). A geothermal power station was originally installed on the bore in 1989 and commenced operation in 1992 (Burns et al, 2000). However the original system suffered from a number of technical problems centred on the use of R114 chlorofluorohydrocarbon as the working fluid. In 1999 the plant was upgraded with a grant of A$95,300 from the Queensland Sustainable Energy Innovation Fund and support from Ergon Energy Corporation Ltd.

The upgrade shown schematically in Figure 2 involved:

- Conversion from the R114 chloro-fluorohydrocarbon working fluid previously used to isopentane which is more volatile and produces a larger volume of vapour.
- Installation of a new plate heat exchanger, a new multi-stage liquid pump and larger diameter pipes and fittings to handle the larger volumes of the new working fluid.

The Birdsville geothermal power plant now provides 120kW of net power output after parasitic losses of 30kW. The latter are principally associated with the operation of the plant's pumps. With a capacity factor of >95%, the geothermal power system is so reliable that it provides all of the town's electricity needs at night and during the cooler winter months when air-conditioning is not required (Queensland EPA, 2002). An automatic control system and radio telemetry links the geothermal system with the town's power house 2 km away. The power house is shut down when the geothermal system is able to satisfy the town's demand for electricity.

In the 2002/2003 financial year the geothermal system provided 529,326 kWh to the town of a total power generation of 1,630,985 kWh. This saved 160,000 litres of diesel fuel annually at a saving of A$135,000 and 430 tonnes of CO_2 emitted.

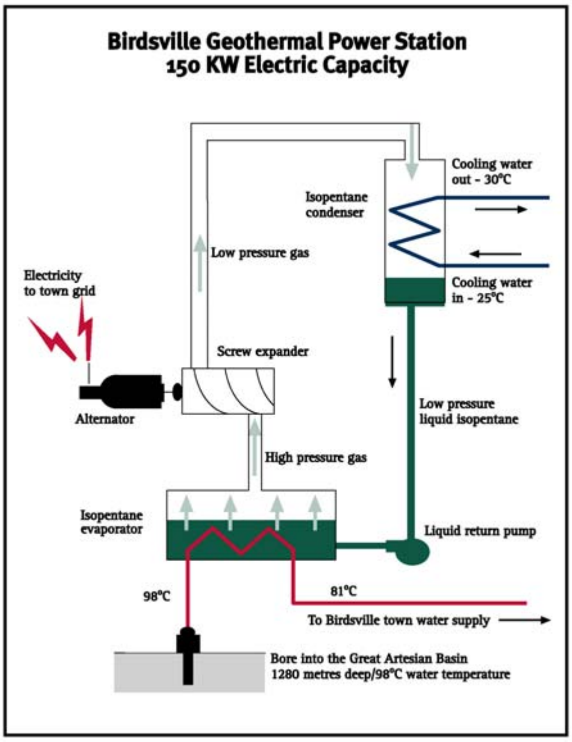

Figure 2: Schematic diagram of the Birdsville Geothermal Power Station (courtesy of the Queensland Environmental Protection Agency

2.2 HYDROTHERMAL HOT WATER SYSTEMS

2.1 Portland, Victoria

The city of Portland (141°36' E 38°20' S) in western Victoria has operated a district heating system since 1983. The city water supply has been drawn from four deep bores with total depths of between 1250 and 1420 metre (see Figure 3). These bores intersect aquifers in the Dilwyn Formation near total depth and deliver water with well-head temperatures between 56 and 59°C (Portland Coast Water Authority, 2004).

Water from one of these bores, the Henty Park Bore, is passed through a district heating system as described by Burns et al (1995). The system services a total building area of 18,990 m^2 (anon, 1997). This includes supplying heating to the Municipal Offices, the Civic Hall, Arts Centre, Senior Citizens Centre, Aquatic Centre, Library, Tourist Information Office, History House and a Multi-Purpose building. More recently the system was extended to also include the Portland Hospital, Richmond Henty Hotel Motel, Police Station and the Maritime Discovery Centre. The annual energy savings achieved by the system were estimated by Burns et al (1995) to be 8,857,014 MJ per annum. A similar amount of energy provided by natural gas space heating would cost at least A$570,000, assuming an average price per MJ of A$0.0639 for Victorian commercial customers (based on Table 2 of Roarty, 1998). At a rate of 0.06 kg CO_2 emitted for each MJ of gas space heating (AGO, 2003), this would correspond to an annual saving of 530,000 kg of CO_2.

Because the district heating system only removes ~25% of the available heat from the geothermal water (anon,

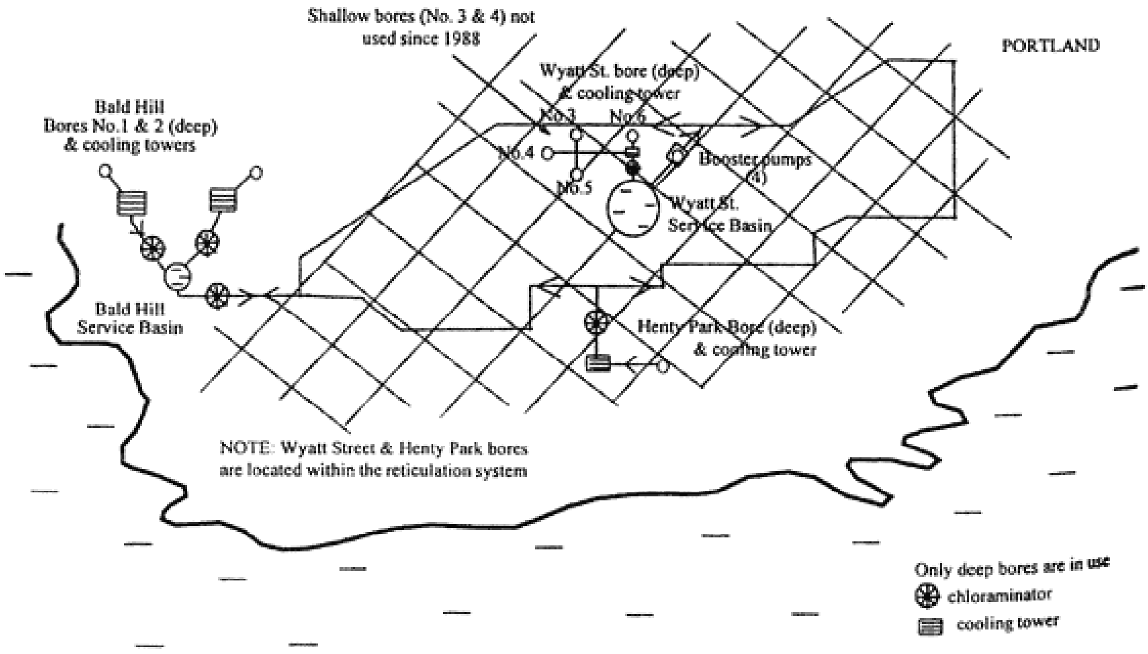

Figure 3 Schematic diagram of the water supply and geothermal district heating system in Portand, Victoria (diagram courtesy of Portland Coast Water Authority).

2004a), the water has to be directed to a cooling tower before it can be placed in the city water reticulation system. At the cooling tower, trace amounts of H_2S and some iron are also removed from the water (ibid).

More recently, changes to local government arrangements in Victoria have resulted in a greater splitting of responsibilities for municipal functions and water supply between the Glenelg Shire Council and the Portland Coast Water Authority (PCWA). The result has seen the latter organisation concerned principally with water supply with no responsibility for the geothermal heating function. On this basis, the PCWA has elected to source all of the city's water from the 2 bores at Bald Hill since these bores produce water of a higher quality for drinking. The geothermal heat in this water is removed in the cooling tower before the water is reticulated. The Henty Park Bore continues to be used by the Glenelg Shire Council to source geothermal waters for the district heating system but it no longer has a role in the water supply. This has meant that the warm water exiting the district heating circuit does not now go into the city reticulation system. Instead it is discarded into a canal and from there into the sea. Re-injection of this water into the deep aquifers is not currently an economic prospect because of the near artesian character of all the boreholes which would necessitate expensive high-pressure pumps. Nevertheless, it is clear from a technical standpoint that Portland has a very effective geothermal heating system and considerable additional capacity.

In 2004 the Council reviewed the operation of the geothermal heating system, assessed its need for additional capital expenditure and evaluated alternative heating arrangements. The review included an assessment of the likely remaining serviceable life of the Henty Park Bore's steel casing and the anticipated replacement costs of the system's pump and ancillary equipment. The outcome of the Council's review appears to be that the system will be refurbished and that it will continue to be operated as Australia's only geothermal district heating system.

2.2 Mornington Peninsula, Victoria

Geothermal spa developments are occurring near the town of Rye (144°50' E 38°22' S) on the Mornington Peninsula south of Melbourne (Figure 1). Mizu Spa opened in November 2000 and incorporates 10 outdoor geothermally heated baths. The 50°C geothermal water is sourced from an aquifer at 630 metre depth. A second geothermal spa development called Bathe Peninsula Hot Springs is under construction on an adjoining property. A$30 million complex is eventually planned on this site using geothermal water from the same aquifer at 637 metre depth (anon., 2004b).

The source of the geothermal system may be deep groundwaters rising up through a high permeability zone along the Selwyn fault that crosses the Mornington Peninsula in the area (Sinclair Knight Mertz, 2002).

2.3 New South Wales Artesian Baths

At a number of locations in inland New South Wales, geothermally heated artesian waters are used for bathing (see Figure 1). Included among these are:

- The Pilliga Hot Artesian Bore (148°53'E 30°20'S) 70km north of Barradine, NSW was drilled in 1902 to a depth of 564 metre. It supplies 37°C water for bathing at a typical rate of 650 litre/second (NST, 2003).

- The Moree Artesian Baths (149°50'E 29°27'S) were established on a bore drilled in 1895 which delivers 41°C mineralised water from an aquifer in the Great Artesian Basin. Annual visitors to the baths exceed 300,000 annually (MPSC, 2004).

- Lightning Ridge Artesian Baths (147°58'E 29°26'S) are sourced from a 1024 metre deep bore that penetrates a Great Artesian Basin aquifer and delivers water at 41.5°C (NSW IP&NR, 2003). The baths are used by an estimated 50,000 people each year and water from the bore is reticulated over distances of up to 170 km for agricultural use.

3. GROUND SOURCE HEAT PUMPS

Specific data on the use of ground source heat pumps (GSHP) in Australia is hard to come by because their use is not regulated or comprehensively monitored by government. Nevertheless it would seem that GSHP are finding increasing use in both commercial and residential applications, particularly in the cooler southern parts of Australia.

The largest single GSHP installation remains the Geoscience Australia (formerly AGSO) Building in Symonston (149°12'E 35°21'S), a suburb of Canberra. This system uses a system of 350 bores drilled to a depth of 100 metre to temperature control a building with a total floor area of 40,000 m^2. Inside the building 210 water to air heat pumps can be independently controlled to deliver heating or cooling as required. In operation the GSHP system provides reduced annual energy consumption over more conventional air-conditioning systems. The ~340MJ per m^2 per annum for the GSHP system compares with an estimated ~400 MJ per m^2 per annum for a variable air volume (VAV) system and ~415MJ per m^2 per annum for a VAV system with chilled water storage (Williams, 1997).

In Tasmania, a number of commercial GSHP installations are now operating including the Integrated Energy Management Centre, Rosary Gardens Nursing Home, Hobart Aquatic Centre and the Antarctic Centre in Hobart (147°17'E 42°53'S) . The Elisabeth Street Pier building uses an immersed fluid circulation system suspended below the wharf and tied to the harbour bed. Elsewhere in Tasmania the former Ansett Call Centre and Aurora Energy Offices in Launceston (147°15'E 41°21'S) and the Vodafone Call Centre in Kingston (147°19'E 42°58'S) also use GSHP. In Victoria, the Monash Science Centre in the Melbourne suburb of Clayton (145°07'E 37°55'S) uses a circulating water system connected to an adjacent artificial lake. In New South Wales, the School of Nursing building and associated 450 seat lecture theatre at the University of Newcastle (151°41'E 32°52'S) are climate controlled with a GSHP system.

4. HOT DRY ROCK

Government legislation to regulate the exploration for hot dry rock (HDR) geothermal energy and to provide secure title to the resource was enacted in the states of New South Wales in 1998 and South Australia in 2000. This legislation has stimulated the commercial exploration for, and development of, hot dry rock geothermal energy in both states so that in 2004 there were 2 exploration leases in New South Wales and 24 in South Australia. The state of Queensland has now also enacted similar legislation and this is expected to further stimulate commercial interest.

4.1 South Australia

The most advanced of the Australian projects to date is the development by Geodynamics Limited in geothermal exploration leases (GELs) GEL97 and GEL98 in the Cooper Basin of north east South Australia (see Figure 4).

In 2003 a borehole called Habanero 1 was drilled to a depth of 4421 metre in GEL98 at a location 10 km south of the small town of Innamincka, South Australia. Habanero 1 intersected 3670 metre of sediments of the Eromanga and Cooper Basins and then 751 metre of a Carboniferous age granite (see Figure 5).

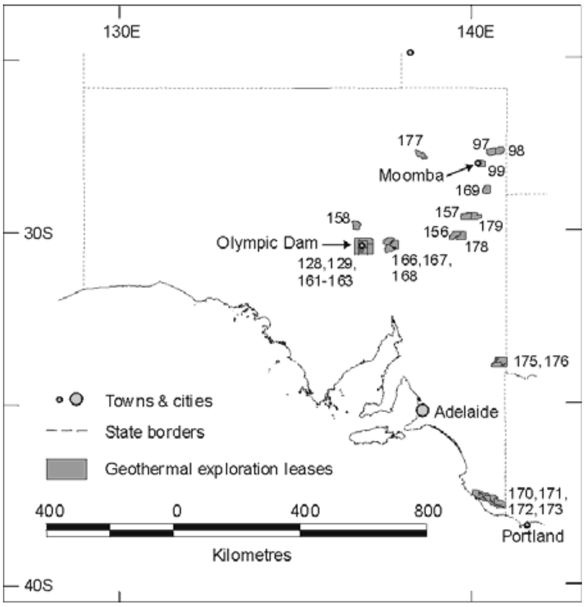

Figure 4 South Australian geothermal exploration leases for Hot Dry Rock (see text).

The Habanero 1 well had a bottom hole temperature after drilling of >250°C. This relatively high temperature at 4421 metre is due both to the chemical composition of the granite and the predominance of low thermal conductivity sediments such as coals and shales in the overlying sedimentary sequence.

In November and December 2003 approximately 23 million litres of water was pumped down Habanero 1 at well-head pressures of up to 63 MPa. The resultant microseismicity was recorded and mapped a very extensive horizontally trending volume of granite containing permeability enhanced fractures (Wyborn et al, this volume). Drilling of a second well, Habanero 2, to intersect this "underground heat exchanger" commenced in July 2004 and was completed in October. An inter-well circulation test between Habanero 1 and Habanero 2 is scheduled for late 2004 and early 2005 and if this is successful, plans are in place to build a 2-5 MWe binary power station. A potential market for this electricity exists at the Moomba natural gas processing facility (140°12'E 28°06'S) approximately 80 km to the south west.

A number of other exploration programs for HDR in South Australia have also been announced. These include programs by Scope Energy Pty Ltd in GEL96 near Moomba and in GELs 170-173 in the south east (see Figure 4), Petratherm Pty Ltd/MNGI in GELs 156-158 and 178-179, and Eden Energy Pty Ltd in GELs 166-169 and 175-177 at several locations in the state. Perilya Resources Ltd/Green Rock Energy Pty Ltd have GELs 128,129 & 161-163 in the vicinity of the Olympic Dam copper-uranium mine (136°54'E 30°27'S). All these exploration programs are only at an early stage in 2004 with no deep drilling yet undertaken.

4.2 New South Wales

Administration of geothermal R&D in the state of New South Wales (NSW) takes place under the Mining Act

(1998). The state government grants exploration leases (ELs) to companies for agreed programs of geothermal exploration and development and monitors progress. In 2004, three ELs are currently active in NSW. These include adjoining leases, EL5560 and EL5886, located south of Muswellbrook (150°53'E 32°15'S, see Figure 1) which are being explored by Geodynamics Limited, and EL2114 which has been applied for by Longreach Oil.

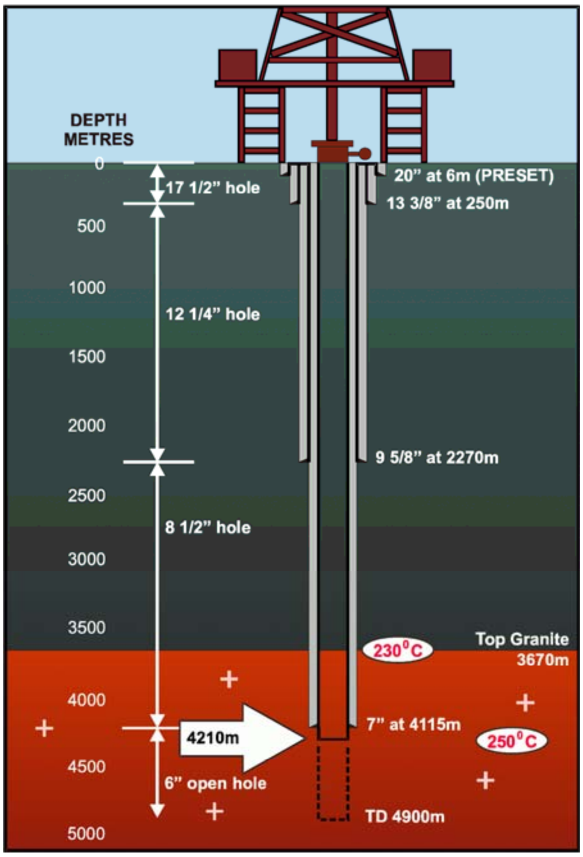

Figure 3 Schematic diagram of the Habanero 1 well in GEL98, South Australia (diagram courtesy of Geodynamics Ltd.)

The EL5560 lease was previously awarded to Pacific Power Corporation and was the subject of a joint Pacific Power – Australian National University project to evaluate its geothermal potential. That project saw the drilling of 11 temperature exploration wells to depths of between 300 and 920 metre and the deepening of the Randwick Park 1 (RP-1) well by 151 metre to a total depth of 851 metre. The project aimed to better map the Hunter Geothermal Anomaly (Somerville et al, 1994). A 19km long vibroseis seismic reflection survey and a coincident high resolution gravity survey were also completed over the anomaly area to investigate subsurface structure. A 1946 metre deep well, PPHR1, was drilled on the survey line to further evaluate the temperature resource and to provide well-control for the seismic analysis. Temperature logging of PPHR1 five months after drilling was completed yielded a bottom hole temperature of 90°C and an estimated equilibrium geothermal gradient of ≥38°C/km. The results for the RP-1 borehole, which is ~2 km SSE of PPHR1 and closer to a pronounced gravity low that may indicate a buried granite, suggest a geothermal gradient of around 65°C/km. Both these geothermal gradient estimates are significantly higher than typical gradients recorded elsewhere in most of Australia of ~20-30°C/km. The presence of a deep geothermal resource therefore appears to be confirmed though deeper drilling is required to better quantify its magnitude and economic potential.

A vibroseis seismic reflection survey and a coincident gravity survey were carried out on the EL 5886 lease by Geodynamics in 2001. The results of these surveys suggest that approximately 2000 metres of low thermal conductivity coal measures sediments exist under the survey line and that the minimum depth to a possible basement granite on this lease is at least 4000 metre (Geodynamics, 2004).

CONCLUSIONS

There has been a significant increase in the level of interest in geothermal energy in Australia in the period 2000-2005. Given Australia's modest resource base for conventional geothermal energy, it is not surprising that most of this interest has been in Hot Dry Rock geothermal energy.

Government legislation in the states of New South Wales and South Australia to regulate the exploration for, and ultimately the production, of HDR geothermal energy has provided a strong stimulus for commercial activity in those states. Comparable legislation recently enacted in Queensland can be expected to provide a similar stimulus in that state.

The Australian federal government's Mandatory Renewable Energy Target that requires ~2% of Australia's electricity production to be generated from new renewable sources by 2010 has provided a further stimulus for geothermal energy development. A market for renewable energy that is effectively quarantined from competition from fossil fuel generated electricity has been created.

By 2004 there were 27 exploration leases/lease applications for HDR geothermal R&D in Australia from six companies set up specifically for geothermal exploration and development.

ACKNOWLEDGEMENTS

Information on the Birdsville geothermal power station was kindly provided by David Smythe of Ergon Energy Corporation Ltd. Thanks are also due to John Keller of Glenelg Shire Council and Owen Phyllis of the Portland Coast Water Authority for useful discussions regarding the Portland district heating system.

REFERENCES

AGO (2003). Selling Energy Efficient Appliances - Workbook for Retail Sales Staff, Australian Greenhouse Office, http://www.energyrating.gov.au/stars/pubs/rfts-workbookv4.pdf

AGO (2004a). Fossil fuel power stations, http://www.ga.gov.au/fossil_fuel/

AGO (2004b). Maps of renewable energy generators in Australia, http://www.ga.gov.au/renewable/

Akmal, M., S. Thorpe, A. Dickson, G. Burg and N. Klijn (2004), Australian Energy: National and State Projection to 2019-20, Australian Bureau of Agriculture and Resource Economics, eReport 04.11, http://abareonlineshop.com/product.asp?prodid=12776

DISR (1997). Hot dry rocks – an easy prospect, Australian Energy News, 5, Department of Industry, Science & Resources, Australia, http://www1.industry.gov.au/archive/pubs/aen/aen5/5rocks.html

Anon. (2004a). Geothermal energy, Glenelg Shire Council, http://www.glenelg.vic.gov.au/energy.htm

Anon (2004b). Bathe Peninsula Hot Springs, http://www.bathe.com.au/Pages/index.html

Burns, K.L., C. Weber, J. Perry and H.J. Harrington (2000). Status of the geothermal industry in Australia. In: *Proceedings of the World Geothermal Congress 2000 Kyushu-Tohoku Japan, May 28-June 10, 2000*, 99-108.

Energy Strategies (2004). *A Clean Energy Future for Australia*, Chapter 8, http://www.enerstrat.com.au/pages/publications.html

Geodynamics (2004). Geodynamics' geothermal HDR tenements, http://www.geodynamics.com.au/IRM/content/02_hotdryrock/02.3.3.html

Habermehl, M.A. (1980). The Great Artesian Basin. Australia. BMR Journal of Geology and Geophysics, 5, 3-38.

MPSC (2004). Moree hot mineral baths, Moree Plains Shire Council, http://www.mpsc.nsw.gov.au

NST (2003). Pilliga Artesian Bore, Narrabri Shire Tourism, December 2003, http://www.narrabri.nsw.gov.au/about/files/Pilliga_Artesian_Bore151203.pdf

NSW IP&NR (2003). Saving the planet while you soak, NSW Department of Infrastructure, Planning & Natural Resources, Media Release, October 2003, http://www.waterweek.nsw.gov.au/media/kit/mediarel/lightning-ridge.doc

ORER (2004).Renewable Energy Certificates, Office of the Renewable Energy Regulator, http://www.orer.gov.au/factsheets/certificates.html

Portland Coast Water Authority (2004). About Portland Coast Water, http://www.portlandwater.net.au/about_pcw/index.html

Queensland EPA (200). Birdsville geothermal power station, Queensland Sustainable Energy Innovation Fund fact sheet, Queensland Environmental Protection Agency. http://www.epa.qld.gov.au/publications/p00834aa.pdf/Birdsville_geothermal_power_station.pdf

Roarty, M. (1998). Natural gas: energy for the new millennium, Parliamentary Library, Parliament of Australia, Research paper 5, 1998-1999. http://www.aph.gov.au/library/pubs/rp/1998-99/99rp05.htm

Sinclair Knight Mertz (2002). Geothermal water under Victoria, News Releases, 2002, Sinclair Knight Mertz Pty. Ltd., http://www.skmconsulting.com/index.cfm?id=1239

Somerville, M., D. Wyborn, P. Chopra, S. Rahman, D. Estrella and T. van der Muelen (1994). *Hot dry rock feasibility study*, Energy Research and Development Corporation (ERDC), Report 94/243, Canberra, ACT, Australia. 133p.

Tedesco, L., A. Dickson, T Johnston and C. Short (2004). Energy in Australia, 2004, Australian Bureau of Agriculture and Resource Economics, eReport, http://abareonlineshop.com/product.asp?prodid=12814

Williams, N. (1997). Mother Earth – a source of sustainable energy?, In: Energy for Ever: Technological Challenges of Sustainable Growth, Symposium, 1997, Australian Academy of Technological Sciences and Engineering, http://www.atse.org.au/index.php?sectionid=542

WA Office of Energy (2003). Electricity, http://www.energy.wa.gov.au/html/publications.html

Wyborn, D., L de Graaf, S Davidson, and S Hann (2005). Development of Australia's First Hot Fractured Rock (HFR) Underground Heat Exchanger, Cooper Basin, South Australia, *Proceedings of the World Geothermal Congress, 2005, Antalya, Turkey*, this volume.

APPENDIX

The following tables are a standard form prescribed for Country Updates. Table 4 is omitted, as comprehensive data on the use of Ground Source Heat Pumps are not available for Australia.

TABLE 1 PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

		In Operation 2001/02	Projected 2005/06
Geothermal	Capacity MWe	150 kWe	150kW
	Gross Prod. GWh/yr	0.082	0.529
Fossil Fuels	Capacity MWe	37,358	42,492
	Gross Prod. GWh/yr	206,861	225,194
Hydro & Pump Storage	Capacity MWe	7,667	7,705
	Gross Prod. GWh/yr	15,861	16,389
Nuclear	Capacity MWe	0	0
	Gross Prod. GWh/yr	0	0
Other Renewables	Capacity MWe	464	1,207
	Gross Prod. GWh/yr	1,333	5,333
TOTAL	Capacity MWe	45,489	51,404
	Gross Prod. GWh/yr	224,083	246,917

Numbers in this Table 1 are from Tedesco et al. (2004), Akmal et al (2004) and collated information from many websites. The current level of electricity production from geothermal sources is very small (see Table 2). Projected fossil fuel generation for 2005/06 is based on the 2001/02 figure in Tedesco et al. (2004), AGO (2004a) and WWW information on fossil fuel power stations commissioned in the period 2000-2004, or projected in 2005, as collected in the following Table. Data for Other Renewables is from AGO (2004b).

Power Station	Fossil Fuel Type	State	Year	Capacity (MWe)
Redbank 1	Coal washery waste	NSW	2001	128
Wilga Park	Gas CC	NSW	2004	10
Bulwer Is.	Gas CC	Qld	2001	32
Callide C	Coal	Qld	2001	840
Milmerran	Coal	Qld	2003	840
Oakey	Gas	Qld	2000	282
Swanbank E	Gas CC	Qld	2002	385
Tarong North	Coal	Qld	2003	450
Yabulu	Gas CC	Qld	2005*	60 MWe upgrade
Ladbroke Grove	Gas	SA	2000	80
Hallett	Gas	SA	2002	180
Pelican Point	Gas CC	SA	2000	485
Quarantine	Gas	SA	2002	96
Bairnsdale	Gas	Vic	2002	43
Somerton	Gas	Vic	2003	150
Valley Power	Gas	Vic	2002	300
Collie 2	Coal	WA	2005*	240
Cockburn 1	Gas CC	WA	2003	240
Esperance	Gas	WA	2004	33
Kemerton	Gas	WA	2005*	260

* projected commissioning date

TABLE 2 UTILISATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION

The only geothermal power plant currently operating in Australia is the small plant at Birdsville in south-western Queensland. The type of plant is B = Binary (Rankine Cycle). It draws its heat from an artesian bore flowing water at 98°C and a rate of 27 l/s. The plant is proving very reliable with a capacity factor of >95%.

A new plant is planned by Geodynamics Ltd. south of the town of Innamincka in north-eastern South Australia. This plant is expected to be 2-3 MWe and will be based on a 2-well hot dry rock system involving 2 deep boreholes accessing granite at 4.4 – 4.7 km depth. By late 2004, the boreholes had been drilled and the underground heat exchanger created. Construction of the binary (Kalina Cycle) power plant is expected in 2005.

Locality	Birdsville
Operator	Ergon Energy
Year Commissioned	1992
Year Refurbished	1999
Status	Operational
Type of Unit	B
Unit Rating (MWe)	0.15
Net Capacity (MWe)	0.12
Annual Energy Produced 2002/2003 (MWh)	529.326
Total under Construction or Planned (MWe)	2.0 – 3.0

TABLE 3. UTILISATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT

Locality			Portland
Type			B & H
Maximum Utilisation	Flow Rate (kg/s)		90
	Temperature (°C)	Inlet	56-59°C
		Outlet	
Capacity (MWt)			10.4
Annual Utilisation	Average Flow (kg/s)		81
	Energy (TJ/yr)		293.8
	Capacity Factor		89.6

The Portland district heating system remains Australia's only geothermal space heating system. It is operated by Glenelg Shire Council and services a total building area of 18,990 m^2 from bores delivering water at 56 and 59°C. The system also heats 2000 m^3 of water in the swimming pool at the city's Aquatic Centre. The type is H = Space heating & district heating (other than heat pumps) and B = Bathing and swimming. The system has continued to operate at the same level for the last 12 years (J. Keller, Manager Infrastructure, Glenelg Shire Council; pers. Comm.. 2004). Accordingly the figures in Table 3 are the same as those of Burns et al (2000).

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT USES

While Portland in Victoria is Australia's only significant geothermal direct use application, there are numerous locations in Australia where geothermal waters flow to the surface. A number of these locations have been developed for bathing, including the Mornington Peninsula in Victoria and the Moree, Pilliga and Lightning Ridge Artesian Baths in New South Wales. Water temperatures at the surface at these locations are reported to be between 37°C (at Pilliga) and 50°C (on the Mornington Peninsula). However, no information on heat production is available. The numbers in the following table therefore only reflect Portland and are the same as those reported by Burns et al. (2000).

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/yr)	Capacity Factor
Space Heating	96	2712	0.9
Bathing and Swimming	8	226	0.9
TOTAL (Portland)	104	2938	0.9

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES

This table applies to the period from 1 January 2000 to 30 October 2004 and does not include drilling for ground source heat pump installations. The latter information is not collated by government agencies and is not available.

The only significant geothermal resource drilling to occur in the period was for hot dry rock research and development. In the Hunter Valley of New South Wales, south of the town of Muswelbrook, a joint Pacific Power/ Australian National University project saw the completion of a 1946 metre deep geothermal exploration well in January 2001. In north eastern South Australia, a large hot dry rock R&D program by Geodynamics Limited has seen the drilling of two deep geothermal wells. The Habanero 1 injection well was drilled to 4421 metre in 2003. By October 2004, the Habanero 2 production well had reached 4340 metre.

Purpose	Wellhead Temperature	Number of Wells Drilled (electrical power)	Total Depth (m)
Exploration	>90°C	1	1946
HDR Injection	>250°C	1	4421
HDR Production	>250°C	1	≥4340*

* this well had not been completed at the time of writing

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES

Categories are (1) Government, (2) Public Utilities, (3) Universities, (4) Paid Foreign Consultants, (6) Private Industry. Category (5)) Contributed by Foreign Aid Programs is not relevant to Australia.

Year	Professional Person-Years of Effort				
	(1)	(2)	(3)	(4)	(6)
2000	0	1	3	0	0
2001	0	1	4	0	0
2002	0	0	3	0	2
2003	0	0	4	0	5
2004	0	0	4	1	10
Total	0	2	18	1	17

The effective date for this table is October 2004. The increasing interest in hot dry rock geothermal energy by private industry during the period is reflected in the rapid increase in the number of personnel in category (6). The proliferation of geothermal lease applications in South Australia during 2004 is likely to see considerable further growth in professional personnel in coming months and during 2005.

TABLE 8. TOTAL GEOTHERMAL EXPENDITURE IN (2004) US$

All documented expenditure for the period 2000-2004 on geothermal energy in Australia has been for hot dry rock geothermal energy. Upgrading of the Birdsville geothermal power station took place in the preceding period. Upgrading of the Portland district heating system has been flagged for the future but at this stage no expenditure has taken place. With regard to hot dry rock, the Hunter Valley project is classified as Exploration. The Cooper Basin project of Geodynamics Limited is classified as Field Development. Financial details for the Geodynamics Ltd. Project are from the company's audited accounts at http://www.geodynamics.com.au

Period	Research & Development Incl. Surface Exploration and Exploration Drilling Million US$	Field Development Incl. Production Drilling and Surface Equipment Million US$	Utilisation		Funding Type	
			Direct Million US$	Electrical Million US$	Private %	Public %
2000-2004	1.5	22.0	0	0	70	30