

COVER SHEET

Australian Geothermal Implementing Agreement Group - Annual Report – 2005

Prepared by: Tony Hill, Principal Geologist, PIRSA (7th March 2006)

Members of the Australian Geothermal Implementing Agreement Group

Name	Title .Organisation
Barry Goldstein - Contracting Party GIA Ex Com Representative	Director - Petroleum & Geothermal Primary Industries & Resources – South Australia (PIRSA)
John Soderbaum Australian GIA Member Representative	Science & Technology Advisor - Energy & Environment Division Australian Federal Government Dept. of Industry, Tourism & Resources
Clinton Foster Australian GIA Member Representative	Chief of Petroleum & Marine Division, Geoscience Australia, Australian Federal Government
Graham Jeffress Australian GIA Member Representative	Senior Geologist, Eden Energy,
Bertus de Graaf Australian GIA Member Representative	Managing Director, Geodynamics Ltd
Adrian Larking Australian GIA Member Representative	Managing Director, Greenrock Energy Ltd
Bob Johnson Australian GIA Member Representative	Chairman, Geothermal Resources Ltd
Des Fitzgerald Australian GIA Member Representative	Managing Director, Intrepid Geophysical
Graeme Beardsmore Australian GIA Member Representative	Senior Research Fellow, School of Geoscience, Monash University
Tony Galligan Australian GIA Member Representative	Director Sustainable Development, Department of Primary Industries, New South Wales
Steve Tatzenko Australian GIA Member Representative	Deputy Director, Resource Development & Policy, Minerals & Energy, Northern Territory Department of Primary Industry, Fisheries & Mines
Geoff Geary Australian GIA Member Representative	Director, Osiris Energy Pty Ltd
Terry Teoh Australian GIA Member Representative	Development Manager – South Australia, Pacific Hydro Ltd
Peter Reid Australian GIA Member Representative	Chief Executive Officer, Petratherm Ltd
David Hawley Australian GIA Member Representative	Director, Proactive Energy Developments
Malcolm Cremer Australian GIA Member Representative	Deputy Director General - Mining & Petroleum, Queensland Department of Natural Resources & Mines
Roger Massy-Greene Australian GIA Member Representative	Managing Director, Scopenegy Ltd
Carol Bacon Australian GIA Member Representative	Managing Geologist, Tasmanian Department of Infrastructure, Energy & Resources
Sheik Rahman Australian GIA Member Representative	Associate Professor, School of Petroleum Engineering, University of New South Wales
Kathy Hill Australian GIA Member Representative	Director Geoscience, Victorian Department of Primary Industries
Bill Tinapple Australian GIA Member Representative	Director Petroleum & Royalties, West Australian Department of Industry and Resources

AUSTRALIA

1. Introduction

The only geothermal energy being used in Australia currently emanates from a 120 kW geothermal energy plant located in Birdsville, Queensland. Investment to explore for, and demonstrate the potential of geothermal energy in Australia is, however, on the rise. Although still to be commercialised, significant progress in the geothermal energy has been achieved by the Australian sector during 2005. There has been a dramatic increase in the number of investors, geothermal licences and licence applications in 2005 (Figure 1). This progress is founded on major advancements in realising the geothermal potential through drilling and flow testing programs primarily in South Australia in the term 2004-2005.

The strength of the Australian geothermal sector can be gauged by the increased number (11 at year-end 2005) of companies targeting at least 3 types of geothermal resource: Hot Rock (HR) radiogenic granites targets below sedimentary basins (e.g. Geodynamics, Petrathern, Greenrock, Geothermal Resources, Eden Energy, Proactive Energy, Osiris, KUTH Exploration, Hot Rock Energy); hydrothermally heated water in sedimentary reservoirs in proximity to recent (4000 to 5000 years bp) volcanic centres (e.g. Scopenergy, Geothermal Resources, Osiris Energy); and the extraction of heat from waters within proven aquifers in the Great Artesian Basin (Pacific Hydro).

This increase in interest is largely in response to the encouraging results emerging from the implementation of legislation providing clear entitlements to investors to explore for and sell geothermal energy in a number of the states; and the recognition of geothermal resource potential from pre-existing borehole data.

A summary of exploration and proof-of-concept projects that have reached the drilling phase by year-end 2005 are summarised below. These include Geodynamics Limited “proof of concept” project in the Cooper Basin. Others including Petrathern, Greenrock Energy and Scopenergy also entered the drilling phase of demonstrating the prevalence of geothermal energy in 2005.

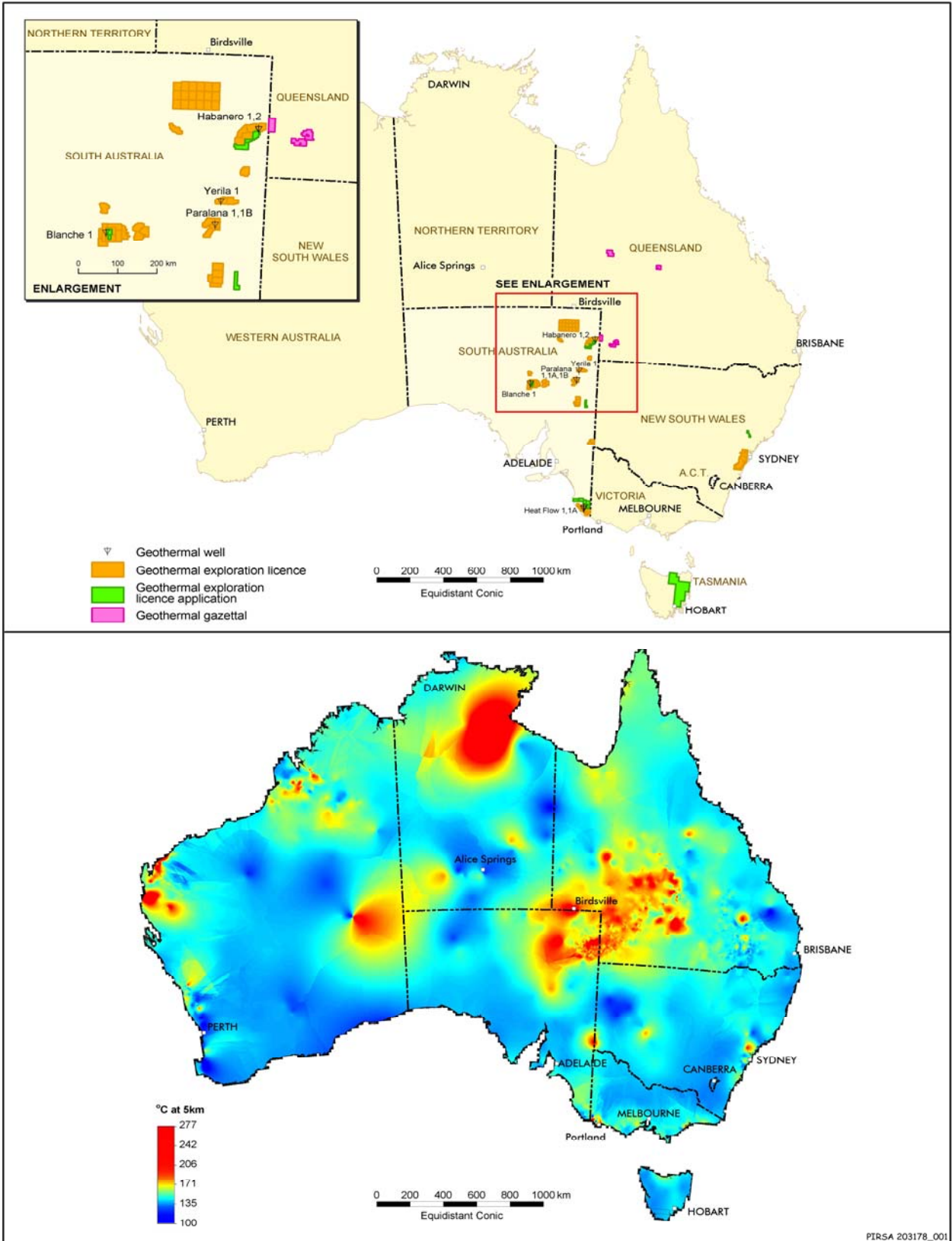
GEODYNAMICS

The most significant advancement in terms of realising the potential for HDR energy is Geodynamics’ fracture stimulation and flow testing at its Habanero Project in the Cooper Basin. Indeed, the Habanero Project was the first and remains the most advanced Hot Rock ‘proof of concept’ development in Australia.

Geodynamics has achieved first mover advantages through its extensive Hot Rock energy exploration and appraisal programs and is the only proponent with a proven to be productive geothermal resource in its tenements, having successfully drilled 2 wells to depths of 4 358m and intersecting naturally fractured granites with the proven capacity to sustain flows of very hot waters to surface without appreciable pressure depletion. Geodynamics has successfully hydraulically fracture stimulated the natural fracture system within these granites.

In May 2005 Geodynamics announced that Habanero 2 well flowed at a rate in excess of 25 L/sec (13,586 barrels of water per day) from reservoirs at 4,300 meters below ground level at 0.896 Kbars (13,000 pounds per square inch) and 250 degrees Celsius. Geothermal brines flowed to surface at temperatures of approximately 210 degrees Celsius, equivalent to 15MW thermal power (just one well’s flow). In October 2005 the hydraulic stimulation through Habanero resulted in a 52% enlargement of the Bottom Zone reservoir and a further significant improvement of the already high permeability in this zone. This test represents the first Hot Fractured Rock (HFR) flow in Australia

To facilitate the conduct of a circulation test through the Bottom Zone reservoir, Geodynamics plan to drill a new sidetrack as the current connection between Habanero 2 and the reservoir is essentially blocked off. This sidetrack will commence in March 2006. A flow test between the two wells is planned as a further step towards demonstrating commercial viability.



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Figure 1 (a): Geothermal licences, applications and gazetted areas as at December 2005
 Figure 1 (b): Heatflow map of Australia. *Courtesy of Prame Chopra, ANU.*

Geodynamics has also secured exclusive regional rights to the Kalina power cycle technology, which is a more efficient technology for converting the geothermal heat to electricity and has the potential to lower power generating costs by 25%. The development of the fluid filled fracture network has exceeded expectations and securing the Kalina Cycle technology should allow Geodynamics' proof-of-concept pilot project to progress to supply power to Moomba from a 2-3 MW demonstration plant via a low voltage power line from Habanero, subject to successful flow testing between Habanero 1 and 2 wells.

This will be an important milestone for the commercialisation of Hot Dry Rock derived geothermal energy in Australia and the stepping stone to realising significant renewable energy reserves to meet Australia's future energy requirements.

PETRATHERM

Petratherm has drilled two wells to establish thermal gradients down to about 600 metres above exceptionally high heat producing granites in Southern Australia.. Results from both wells were encouraging, with the Callabonna and Paralana sites respectively exhibiting 68 and 81 degrees Celsius per kilometre thermal gradients. Petratherm next plans to drill its first injection well at Paralana to approximately 3.5 kilometres depth where temperatures are expected to exceed 220 degrees Celsius.

GREEN ROCK ENERGY

Green Rock drilled Blanche No 1 to 1,935 metres (718 metres of sediments and 1,216 metres of homogenous hot granite).in 2005. The target granite is interpreted to persist to depths of 6,000 metres over an area of about 400 square kms and represents a potential geothermal resource in excess of 1,000 MWe. Cores and wireline logs from Blanche No 1 suggested natural fracture exist. Greenrock plans to drill at least one deep well in 2006 to establish the basis for flow tests.

A summary of the activities of the twelve Australian geothermal explorers at year-end 2005 is provided as Attachment 1.

1.a. Highlights and Achievements

Highlights and achievements to end 2005 are summarised as follows:

- At year-end 2005, eleven companies had applied for a total of 70 geothermal licence areas in Australia; 64 or 91% of the areas applied for are located in South Australia. A further 5 geothermal applications have been lodged in New South Wales and 1 in Tasmania. Of these 70 applications, to year-end 2005, 58 Geothermal Exploration Licences (GELs) have been granted in South Australia and 4 Exploration Licences for geothermal exploration (ELs) have been granted in New South Wales;
- Over AUS\$410 million (US\$307 million) in work program investment has been committed for the period 2002 – 2009. This figure excludes capital expenditure associated with demonstration power plants. Strong interest expressed by yet more new entrants into the geothermal sector bodes well for continued growth and competition. Passage of legislation in other Australia jurisdictions will also stoke the sectors' growth;
- 6 tenements were released for tender in Queensland in October 2005;
- 31 bid areas are forecast to be released over the entire state of Victoria in 2006;
- At year-end 2005, 3 geothermal explorers were listed on the Australian Stock Exchange (ASX)– Geodynamics, Petratherm and Green Rock Energy. Market capitalisation for these 3 geothermal explorers as at 31 December was about AUS\$172 million (US\$129 million). At least four geothermal energy companies plan ASX listings in 2006;
- Encouraging results were achieved in well (drilling and/or flow testing) programs in a variety of geological settings by Geodynamics, Petratherm, Greenrock Energy and Scopenergy;
- Geodynamics was very successful in its fracture stimulation of wells in the Cooper Basin, making considerable progress in the proof of concept phase of their Habanero project;

- Following South Australia’s lead, Queensland, Victoria, Western Australia and the Northern Territory implemented reviews of geothermal legislation (ahead of gazettal of prospective geothermal acreage);
- Australian Federal and State grants totalling ~AUS\$9.5 million (US\$7.1 million) were awarded to 6 geothermal companies in 2005 (to progress geothermal exploration and development projects);
- Strong public interest and investment was sustained in ASX-listed hot rock companies, with the majority of geothermal capital raisings oversubscribed; and
- Revitalisation of Australia’s GIA membership with 21 participating organisations including representatives from, industry, academia and State and Federal governments (Attachment 2).



Figure 2: Habanero 2 Steam Separator. The well flowed at 25 L/sec with a wellhead temperature of 210°C during testing in May 2005. *Photo courtesy of Geodynamics.*

2. National Policy

2.a. Strategy

There has been a steady increase in all forms of renewable energy over the period 2000-2005 largely due to government activities. In 2000 the Australian federal parliament passed the Renewable Energy (Electricity) Act. This Act saw the introduction of the Mandatory Renewable Energy Target (MRET) Scheme that requires an additional 9,500 GW of renewable electricity by the year 2010 and which includes geothermal energy. This equates to approximately 2% of Australia’s annual electricity consumption being sourced from renewable technologies. The MRET Scheme operates through a system of tradable Renewable Energy Certificates (RECs) that are created by renewable energy generators at the rate of 1 REC for each MWh of electricity generated from an eligible renewable source.

In 2004 the Australian Federal government reaffirmed the 2% MRET target and released a new energy policy “Securing Australia’s Energy Future”. Included in this policy was the introduction of the “Low

Emissions Technology Development Fund” (LETDF) that will provide AUS\$500 million (US\$375 million) to companies that can demonstrate new technologies that will significantly reduce long term green house gases. Geothermal energy and in particular, HDR, has been identified by the federal government as a technology suitably placed to benefit from this fund. A number of additional renewable energy grants are outlined in Section 4. The energy White Paper, released in 2004, included a statement that Australia should seek to be a ‘Market Leader’ (highest category of involvement) in hot dry rocks technology. www.pmc.gov.au/energy_future

2.b. Legislation and Regulation

Four states (South Australia, New South Wales, Queensland and Tasmania) have legislation in place to control geothermal exploration and development. Geothermal energy exploration in South Australia falls under the *Petroleum Act, 2000* whilst in New South Wales and Tasmania it is governed by the *Mining Act, 1992* and *Mineral Resources Development Act, 1995* respectively.

Legislation for the production of geothermal energy in Queensland will be progressed in 2006. Queensland is (thus far) the only state to have developed stand-alone legislation for geothermal energy exploration under the *Geothermal Exploration Act, 2004*. The remaining onshore Australia jurisdictions (Western Australia, Victoria and the Northern Territory) plan to follow Queensland’s lead, and are in the process of developing stand-alone legislation and regulations. Of these, the *Geothermal Energy Resources Act, 2005* has been passed in Victoria and the Regulations are in preparation with both pieces of legislation expected to come into operation by April 2006. The geothermal legislation and regulations are intended to apply to high-end scale geothermal operations. Under the new *GE* regulations, exploration permits are not required where the geothermal resource is less than 70 degrees or less than 1000 metres depth. Low-end operations operate under existing environmental, water and planning laws.

The Western Australian Department of Premier and Cabinet, Greenhouse Policy Unit, together with Petroleum and Royalties Division, of the Department of Industry and Resources is preparing legislative drafting instructions to enable geothermal energy and geothermal energy resources to be explored and produced in Western Australia. It is contemplated that the *Petroleum Act 1967* (Western Australia) will be amended to enable the regulation of geothermal resources, in a similar manner to the approach taken by Primary Industry and Resources, South Australia.

The Northern Territory expects to develop stand alone legislation for both geothermal exploration and development tenure that will be administered by the Titles section within the NT Department of Primary Industry, Fisheries and Mines and is expected to be operative in 2007

2.c. Progress Towards National Targets for Renewable Energy and Emissions

There has been no shift in the Federal Government’s MRET of 9,500 GW of new renewable electricity by the year 2010.

2.d. Government Expenditure on Geothermal Research and Development (R&D)

Federal and state government expenditure on geothermal research and development, including grants to industry, totalled just over AUS\$9.5 million in 2005 (Table 1). Detailed descriptions of these grants are outlined in Section 4 under Support Initiatives and Market Stimulation Incentives.

Federal government grants

Geodynamics Ltd was awarded a AUS\$5 million Renewable Energy Development Initiative (REDI) grant from the Federal government in December 2005 for the demonstration HFR power plant to be constructed near Innamincka in the Cooper Basin, South Australia.

Scopenegy Ltd also secured a AUS\$4 million REDI grant for its Limestone Coast Geothermal Project in the southeast of South Australia. This project, which has the potential to reduce ~40 million tonnes of carbon dioxide will focus on proving and commercialising its potentially large scale, geothermal power project using conventional geothermal methods for the production of baseload renewable electricity. The grant will assist in financing 3-D seismic and drilling that are critical to proof of concept. Scopenegy and

Snowy Hydro Limited have entered into a long-term Power Purchase Agreement for 40MW of electricity to be generated from the project.

Grant	Recipient	Project	Amount (\$AUS)
REDI	Geodynamics Ltd	Habanero Project, Cooper Basin, SA	\$5,000,000
REDI	Scopenergy Ltd	Limestone Coast Geothermal Project, SA	\$3,982,855
PACE	Petratherm Ltd	Paralana Geothermal Project, SA	\$ 140,000
PACE	Scopenergy Ltd	Limestone Coast Geothermal Project, SA	\$ 130,000
PACE	Geothermal Resources Ltd	Curnamona Geothermal Project, SA	\$ 100,000
PACE	Green Rock Energy Ltd	Olympic Dam Geothermal Project, SA	\$ 68,000
PACE	Eden Energy Ltd	Witchellina Project, SA	\$ 21,000

Table 1. Recipients of Federal and State funded grants for geothermal R&D.

State Government Grants

South Australia

A total of AUS\$459,000 in South Australian PACE drilling grants has been provided to five companies exploring for geothermal energy (Table 1). These grants assist in addressing critical uncertainties in frontier geothermal exploration regions and include partial funding of drilling, temperature logging and thermal conductivity analyses.

The South Australia Department of Primary Industries and Resources (PIRSA) also allocated AUS\$50 000 to the Australian School of Petroleum at University of Adelaide to undertake a research study exploring the likelihood of enhanced seismic hazard in Australia's Cooper Basin petroleum province as a result of geothermal energy production in the region. The collaborative study, led by Dr Suzanne Hunt, will assess anthropogenic seismic hazard assessment through predictive modelling of local stress change resulting from Hot Fractured Rock (HFR) geothermal energy operations. The one year study will be completed in June 2006.

Victoria

The Victorian Department of Primary Industries (Vic DPI) spent AUS\$35 000 on validation and analysis of existing borehole temperature database by Geoscience Victoria in preparation for a geothermal acreage release in April 2006 that will cover the entire state of Victoria and comprises 31 blocks (up to 10,000 km²). Sustainability Victoria commissioned a review of information on geothermal resources in Victoria that was undertaken by Sinclair Knights Mertz (SKM) in conjunction with Monash University. The final report is dated February 2005 although the report has not been released to the public.

Western Australia

A report on the energy needed for minerals development in the South West of Western Australia (Sleeman and Goodall, 2005) included a recommendation that the Geological Survey of Western Australia investigate the potential of geothermal energy from hot dry rocks. It is planned to conduct a preliminary study in 2006.

2.e. Industry Expenditure on Geothermal R&D

All industry field expenditure is classed as R&D and is estimated at AUS\$26.1 million for the calendar year 2005. This represents an increase of AUS\$8.5 million (up 48%) from the previous year. Historical, current and projected expenditure for 2006 are highlighted in Figure 3.

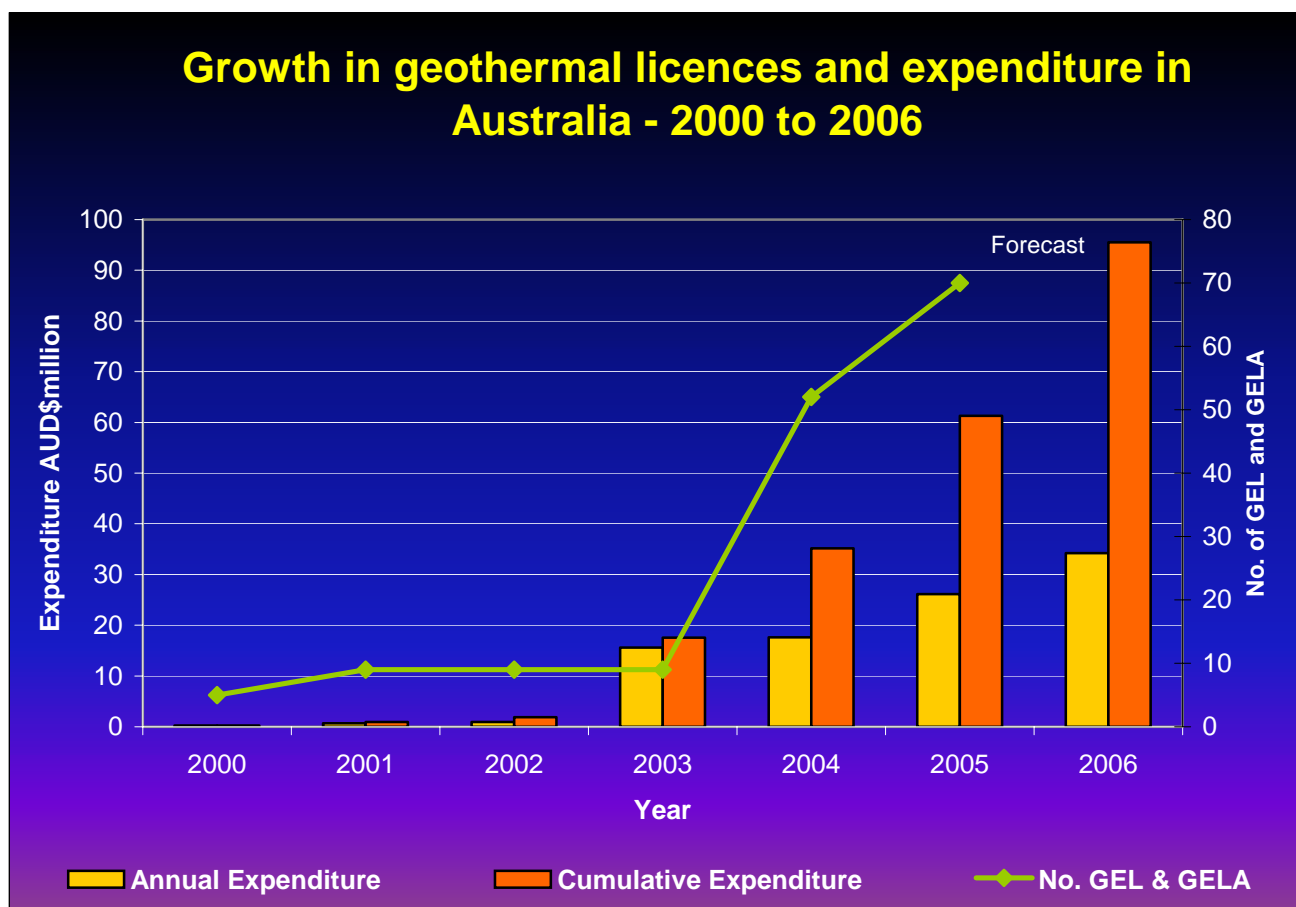


Figure 3. Geothermal Licence applications and exploration expenditure, 2000 to 2006. Source PIRSA

3. Current Status of Geothermal Energy Use in 2005

3.a. Electricity Generation

Geothermal energy is currently produced at one small binary power station at Birdsville in western Queensland, which is supplemented by diesel powered generators. The fluid is 98°C and derives from the Great Artesian Basin that overlies the Cooper Basin. The gross capacity of the plant is 120 kW and has 40kW parasitic losses, which equates to a net output of 80kW. The plant was shutdown from December 2004 to December 2005 for upgrading to meet compliance of Australian Standards regarding handling of isopentane but is now operating. Total power generation in 2004 was 1,756,009 kWh of which 520,116 kWh was provided by the geothermal power plant. There were no new developments in 2005.

3b. Direct Use

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 degrees Celsius at rates of approximately 60 Litres per second with a nominal capacity of 3600 kW and 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. There are no available estimates of the amount of energy being produced at these locations. There is a plan for development of another (unrelated) spa resort in Gippsland, Victoria.

Ground source heat pumps are also finding increased use in Australia in both commercial and residential applications.

4. Market Development and Stimulation

4a Support Initiatives and Market Stimulation Incentives

There are a number of Federal and State government support initiatives designed to accelerate commercialisation of renewable energy technologies, including geothermal energy. For more information on the following support programs visit the site: www.ausindustry.gov.au

i. Start Program – The R&D Start program was introduced in 2002 by the Federal government to assist Australian industry to undertake research and development and commercialisation. Geodynamics was granted AUS\$5,000,000 from this fund in 2002.

ii. Renewable Energy Certificates (RECs) – The MRET Scheme operates through a system of tradable RECs that are created by renewable energy generators at the rate of 1 REC for each MWh of electricity generated from an eligible renewable source.

iii. Renewable Energy Development Initiative (REDI) Program – This Federal government initiative is a competitive, merit based grants program supporting renewable energy innovation and its early stage commercialisation. The AUS\$100 million program commenced in 2003 and will provide individual grants from AUS \$50 000 to AUS \$5 million over seven years. Geodynamics Ltd and Scopenergy Ltd were awarded REDI grants of AUS \$5million and AUS \$4 million respectively in December 2005.

iv. Low Emissions Technology Demonstration Fund (LETDF) – The AUS \$500 million LETDF is a merit based programme designed to demonstrate break-through technologies with significant long term greenhouse gas reduction potential in the energy sector. Key criteria for award is the potential to reduce Australia's total carbon dioxide emissions by at least 2%. The Fund was announced by the Federal government in June 2004 and will leverage at least AUS \$1 billion in additional private investment in new low emission technologies. The Fund will operate over the period 2005-06 to 2019-20. Geodynamics has announced that it will submit an application for the March 2006 funding round to assist with financing of an initial large-scale commercial HFR power plant in the Cooper Basin.

v. Renewable Energy Equity Fund (REEF) – The REEF program was introduced by the Federal government in 1997 and is a specialist renewable energy technology research fund.

vi. PACE – the Plan for Accelerating Exploration was launched in April 2004 by the South Australian government to fund collaborative exploration drilling programs that will address critical uncertainties in the resources sector including the mineral, petroleum and geothermal industries. The AUS \$22.5 million program (of which AUS \$10 million has been designated for direct drilling initiatives) will be operative until 2009. A total of AUS \$459,000 in South Australian PACE drilling grants has been provided to 5 geothermal explorers: Scopenergy (AUS \$130,000), Petratherm (AUS \$140,000), Green Rock (AUS \$68,000), Geothermal Resources (AUS \$100,000) and Eden Energy (AUS \$21,000).

<http://www.pir.sa.gov.au/sector5.shtml>

Renewable Energy Support Fund – Sustainability Victoria offer a Renewable Energy Support Fund that helps to pay 50% of the capital cost for new operations (such as fish farms, horticulture & swimming pool heating). <http://www.sustainability.vic.gov.au/www/html/1155-home-page.asp>

4.b. Development Cost Trends

Drilling costs remain high due to difficult drilling conditions associated with overpressured granites and equipment failures. The vast distances between geological provinces, coupled with a critical shortage of drilling rigs, has seen high costs for mobilisation and lengthy delays in securing a rig. Substantial increases in the cost of diesel fuel and steel casing has also contributed to elevated development costs.

5. Development Constraints (e.g. low cost of petroleum/gas, environmental issues, etc)

Figure 4 illustrates the current costs of power generation from alternative fuels, including geothermal energy. At this point in time, coal and gas are the most competitively priced fuels for electricity generation.

Whilst geothermal energy resources in Australia have vast potential, it is not yet price-competitive, and remains to be demonstrated to be economic at price levels that could be realised with the addition of costs to constrain greenhouse gas emissions in the cost of electricity from fossil fuels.

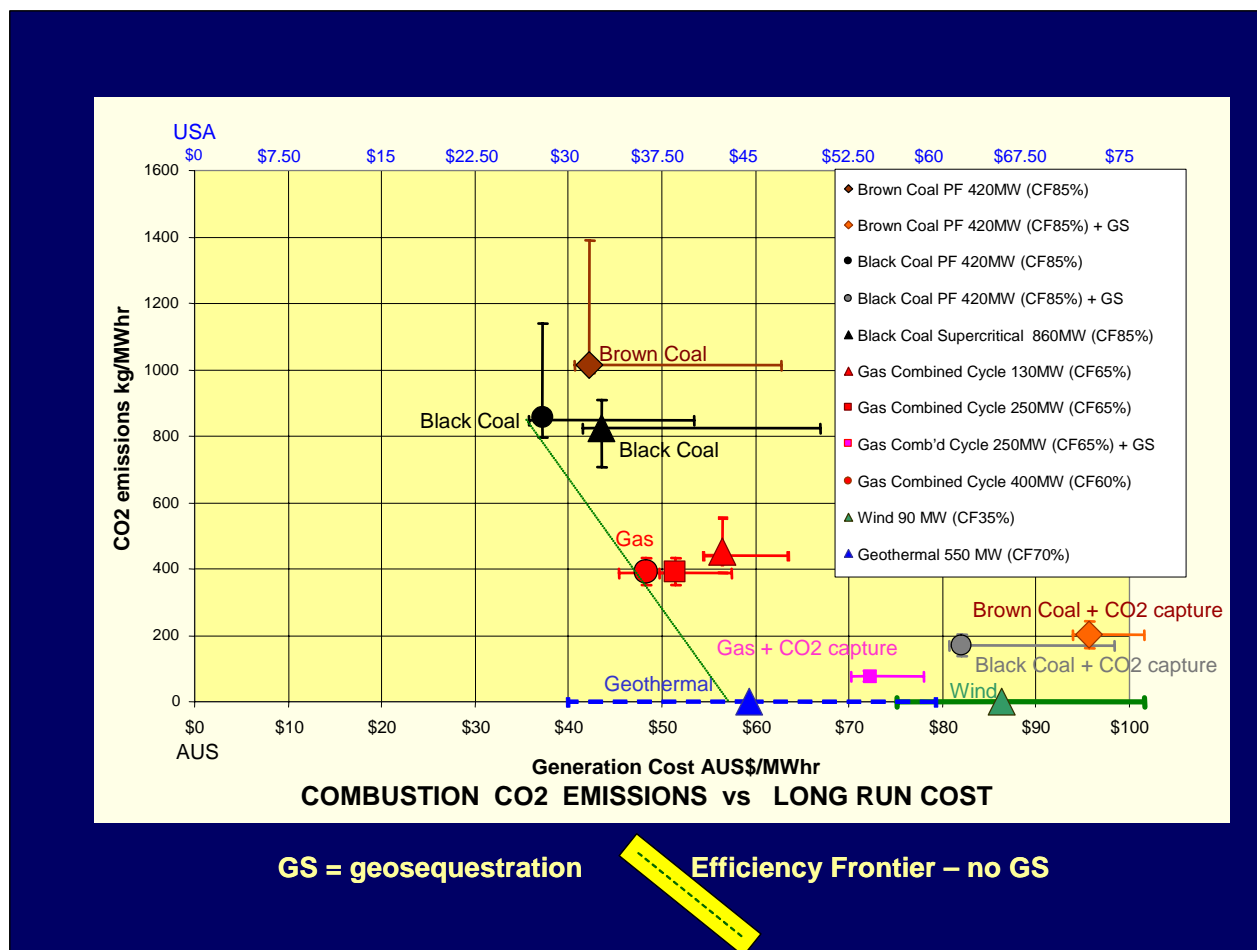


Figure 4. Electricity generation sources and technologies – CO₂ emissions vs. long run marginal costs. All costs are in AUS\$. Source: PIRSA, 2005

6. Economics

6.a. Trends in Geothermal Investment

Funding from the general public has continued to increase in 2005, with Geodynamics, Petrathern and Green Rock Energy raising AUS\$20.78 million from public share subscriptions during the year. As at 31 December 2005, the market capitalisation of these three companies amounted to about AUS \$172 million (US\$129 million). There are strong indications that several geothermal explorers will list on the Australian Stock Exchange in 2006.

6.b. Trends in the Cost of Energy

Coal-fired electricity costs remain one of the lowest in the world so new renewable technologies find it difficult to compete. However, if we assume geosequestration costs of AUS \$66/tonne CO₂ (US\$50/tonne), geothermal energy becomes competitive in the energy market. A comparison of power generation costs per MWh versus CO₂ emissions kg/MWh in Australia places geothermal power favourably ahead of nuclear, wind, gas, brown and black coal (assuming you include geosequestration costs) at AUS \$58/MWh (Figure 4).

7. Research Activities

7.a. Focus areas

The principal focus area of research in Australia relate to Enhanced Geothermal Systems (Annex III) associated with the fracture stimulation of granitic basement rocks in the Cooper Basin and related research into ‘anthropomorphic seismicity’ associated with these high energy fracture stimulation. There is also a key focus in establishing more accurate heatflow maps of Australia through acquisition of thermal conductivity data and refined gridding techniques.

7.b. Government Funded

Australian National University – Australian Capital Territory

Research has focused on development of a new database of temperature measurements made in 5722 wells across Australia that has been used to construct improved maps of the spatial distribution of temperature in the Australian crust. This work has been undertaken by Dr Prame Chopra and Fiona Holdgate. The new database, Austherm04, builds upon the earlier work of Somerville et al. (1994) by greatly improving data quality control and by including temperature data from a further 1430 wells. Whilst there has been some enhancement of the overall spatial coverage when compared with the earlier work, the bulk of the new data are still largely clustered within the same provinces that dominate the Somerville *et. al.* dataset. As a result, data distribution across the continent still tends to be rather patchy and irregular with some regions well represented and others not. An Arc/Info GIS coverage has been built from the Austherm04 database.

The crustal temperature maps produced in this study reveal large spatial variations in temperature across continental Australia. Lowest temperatures occur where basement is exposed at the surface such as in the Yilgarn Block, Gawler Craton and Lachlan Fold Belt. High temperatures are associated with thick sedimentary basin cover and the inferred presence of high heat production granites under the sedimentary sequences. Particular examples include the Cooper-Eromanga, Macarthur and Canning Basin regions.

Other smaller areas of relatively elevated crustal temperature that may represent future hot dry rock targets include parts of the Sydney, Perth and Murray Basins. Whilst representing significant improvements over the previous Somerville et al. map, the new crustal temperature maps continue to be influenced by artefacts caused by the strongly heterogeneous spatial distribution of the subsurface temperature data across continental Australia. More sophisticated geostatistical methods and analysis on a province by province basis may offer some improvements but further temperature exploration data will probably be required to significantly improve the resource analysis.

University of New South Wales

The School of Petroleum Engineering at the University of New South Wales (UNSW) has made a strong commitment to the development of renewable energy and has been actively participating in developing technology for the exploitation of geothermal energy in Australia since the 1st HDR Conference held in Canberra in 1992. Together with Geoscience Australia, it actively participated in collecting geophysical and temperature data from different parts of Australia and prepared a heat map of Australia in 1994.

Following this it carried out a major study to characterise temperature, stress and natural fracture system of the basement in the Cooper Basin. As part of this study the School also developed an innovative fracturing technology for the development of geothermal reservoir. This study was primarily funded by ERDC and industry. To commercialise the technology it formed a geothermal company, Scopenergy Ltd, in January 2001 (currently owned by Eureka Capital Partners) who hold the major geothermal licences in Mount Gambier region of South Australia. The School of Petroleum Engineering is working together with Scopenergy on a number of issues: (1) characterisation of geothermal reservoirs in particular in sedimentary rocks, (2) geothermal reservoir development by hydraulic fracturing and (3) fluid flow and production estimation in fractured reservoirs. The program is being funded by UNSW, Australian Greenhouse Office (AGO) and industry.

In 2005, the School developed a numerical simulation technique for characterisation of fracture system in geothermal reservoirs adopting a geostatistical approach that incorporated field data. Initial results are very encouraging and the School is currently working to advance this work. The School has also developed a numerical geothermal reservoir simulator to estimate hot water recovery. An important feature of this model is that it simulates fracture system with spatial distribution and considers fluid flow between fracture and matrix.

Australian School of Petroleum, Adelaide University – South Australia

The South Australia Department of Primary Industries and Resources (PIRSA) allocated AUS \$50 000 in June 2005 to the Australian School of Petroleum at University of Adelaide to undertake a research study

exploring the likelihood of enhanced seismic hazard in Australia's Cooper Basin petroleum province as a result of geothermal energy production in the region. The collaborative study, led by Dr Suzanne Hunt, will assess anthropogenic seismic hazard assessment through predictive modelling of local stress change resulting from Hot Fractured Rock (HFR) geothermal energy operations. This work will be pursued in collaboration with the International Energy Agency (IEA) who has officially stated that as part of a cooperative effort in addressing induced seismicity associated with enhancing output of geothermal systems;

"Participants will pursue a collaborative effort to address an issue of significant concern to the acceptance of geothermal energy in general but Enhanced Geothermal Systems (EGS) in particular. The issue is the occurrence of significant seismic events in conjunction with EGS reservoir development or subsequent heat extraction. "

Outputs from the project will include the development of numerical models to assess permanent impact of the developed HFR reservoir structure on the local in-situ stress field and also the development of finite difference models of wellbore and completion to assess the likelihood of damage caused by a seismic wave hitting a wellbore at various depths. The one year study will be completed in June 2006.

Monash University –Victoria

Geothermal research has focussed on measuring and mapping heat flow and temperature distribution in the crust across SE Australia during 2005.

8. Geothermal Education

Dr Graeme Beardsmore (Monash University, Victoria) ran a 5-day "Introduction to Geothermal Energy" course in 2005 through the VIEPS coursework program, and will do so again in June 2006.

9. International Cooperative Activities

Australia is a member of the IEA Geothermal Implementing Agreement. In addition, Geodynamics Limited and the Australian National University have formal agreements with Japanese researchers in geothermal energy. There are also linkages with the French Bureau de Recherches Geologiques et Minieres (BRGM) through Intrepid Geophysics who are a member of Australia's GIA. BRGM have expertise in the integration of state of the art rapid 3D geological modelling with geothermal temperature and thermal capacity latent in radiogenic granites. Petrathern is currently engaged in Hot Rock energy research with BRGM.

Author: Barry Goldstein, Minerals and Energy Resources, South Australian Department of Primary Industries and Resources, GPO Box 1671, Adelaide, South Australia, Australia 5001
Email: Goldstein.barry@saugov.sa.gov.au

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Attachment 1 — Australian Geothermal Licence Holders (Alphabetical Order)

Eden Energy Ltd is a new diversified clean energy company seeking listing on the Australian Stock Exchange in early 2006. Eden has interests in hydrogen storage and transport fuel systems, including the low emission Hythane® hydrogen-methane blend, a revolutionary cryogenic storage and superconducting magnetic electrical storage device, coal seam and abandoned mine methane, conventional gas, low temperature pyrolysis research into hydrogen production and geothermal energy production. All these aspects of Eden's business are part of an integrated strategy to become a major global participant in the alternate energy market, particularly focussing on the clean energy transport market, producing hydrogen without any carbon emissions, transporting the hydrogen to markets and providing the engines to power hydrogen-based transport and energy solutions. Eden is exploring for geothermal resources in a number of target areas:

- 1 At Witchellina, northwest of Leigh Creek;
- 2 North of Renmark, on the Murray River;
- 3 Around Moomba in the Cooper Basin, adjacent to Geodynamics and at Bollards Lagoon; and,
- 4 At Mungeranie, in the southwest Eromanga Basin region on the Birdsville Track.

The company is pursuing a prospecting-style strategy, aiming to test a number of different geothermal target types, ranging from the deep hot fractured granite model near Moomba and at Mungeranie, relatively shallow (2-3km) heat sources associated with buried radiogenic iron oxide and granite at Witchellina and enhanced permeability zones in the Renmark Trough associated with elevated heat flows. If successful, Eden will target electricity markets and clean hydrogen production. Eden Energy was the recipient of a \$21,000 PACE 2 grant in July 2005. For more information, visit <http://www.edenenergy.com.au>

Green Rock Energy Ltd is a public company listed on the Australian Stock Exchange which is undertaking the evaluation and development of a hot dry rock ("HDR") geothermal power plant on its geothermal exploration licences in central South Australia in preparation for the construction of power plants with a base load electricity capacity of no less than 100 MW. Green Rock Energy holds 7 SA GELs. The Olympic Dam HDR Geothermal Energy Project is located within 10 kms of BHP Billiton's world class Olympic Dam copper and uranium mine and only 5 kms from a high voltage power transmission line connected to the national power grid which supplies electricity to eastern Australia's major cities. Green Rock drilled Blanche No 1, its first exploratory diamond geothermal well, in the second half of 2005. The well was drilled to a depth of 1,935 metres through 718 metres of sediments and 1,216 metres of homogenous hot granite. The temperature measured was 85 degrees C at 1.9 km depth. This granite body is interpreted to persist to depths of 6,000 metres near Blanche No. 1 and cover an area of about 400 square kms of the GELs and represents a potential geothermal resource in excess of 1,000 MWe. Studies are underway into the key factors that determine the quantity of heat that can be recovered via water circulating through the hot rocks, and thus the amount of electricity that can be generated. This water circulation requires the forcing open of a network of fractures in the hot granites by injecting water under pressure. Cores from Blanche No 1 exhibited horizontal fracturing and logging suggested other natural fracture orientations are present. The Company hopes to commence the drilling of the first of two deep wells in the second half of 2006 to enable a water circulation system to be established. Green Rock is the recipient of a \$68,000 Round 3 PACE grant for the Olympic Dam Geothermal Energy Project and the Blanche Prospect. For more information, visit <http://www.greenrock.com.au>

Geodynamics Ltd has first mover advantage in Australia with its Habanero project in the Cooper Basin in NE South Australia and is the only proponent with a proven resource in its tenements. All other proponents in Australia still have to prove geothermal resources exist in their tenements. Geodynamics "Proof of Concept" project (Habanero) is located where rocks are hottest in the Cooper Basin (approximately 300°C at 5 km depth). The company has created the world's largest underground heat exchanger by high pressure water injection in two stages in 2003 and 2005. High rates of injectivity into the heat exchanger indicate the presence of large areas of low impedance reservoir where the rock temperature is 250°C (4.3 km). After successful completion of the Habanero 2 well, flows of up to 20l/sec and output temperatures of 210°C in 2005, a 6 week circulation test will complete "Proof of Concept" in 2006. The potential area of accessible hot rocks extends for more than 1000 km². The great distances from electricity markets are not considered a problem since external consultants reports indicate transmission costs of less than 0.8 cents per kilowatt hour to the national grid. Geodynamics was the recipient of a \$6.5 million START grant in 2003-4 and a \$5 million REDI grant in 2005. The company aims to build a 2-3 MW demonstration plant using Kalina Cycle technology to supply electricity via a 60 km power line from its Habanero project site to Moomba. For more information visit <http://www.geodynamics.com.au>

Geothermal Resources Ltd holds two hot dry rock geothermal exploration projects located within high heat flow areas of South Australia. In both cases the model is based on "hot" radiogenic granites that are buried by a sufficient thickness of insulating sediments. The Frome project lies within the Mesoproterozoic Curnamona Craton, which is characterized by some of the most radiogenic granites in Australia, associated with numerous historic uranium occurrences. In the project area a large body of granite, evidenced by a regional gravity low and non-reflective seismic responses, is interpreted to lie beneath 2-4 kilometres thickness of younger sedimentary cover rocks. Geothermal Resources has been awarded a \$100,000 PACE 3 grant by the South Australian government to assist with deep drilling for the purposes of obtaining reliable heat flow measurements over the interpreted buried granite complex. The Crower project situated in the South East lies along the northern onshore margin of the Otway basin where early Palaeozoic granites of the Padthaway Ridge dip beneath onlapping Jurassic to Cretaceous sediments. Rapid changes in thickness of the sediments caused by basement faulting and rifting at the time of continental break up provide the opportunity for locally elevated geothermal gradients and optimal depths of burial. Both projects are well located with respect to existing power grids and even

modest geothermal fields could be quickly brought into production to meet the rising demand for clean renewable energy. Geothermal Resources is currently in process of raising capital for exploration of its projects by way of an IPO that will close on 24 February 2006. For more information please visit: http://www.havilah-resources.com.au/geothermal_energy.html <http://www.geothermal-resources.com.au>

Hot Rock Energy Pty is operator of Exploration Licence (EL) 6212 in the Sydney Basin, New South Wales. This licence area covers approximately 5,500 sq. kms and was granted in 2004 to Longreach Oil Ltd (50%) and Hot Rock Energy Pty Ltd (50%). A company is currently undertaking a technical review of the Sydney Basin, incorporating petroleum, coal and water well data with the aim of identifying areas of high heatflow. The outcome of the study will lead to the isolation of certain areas of abnormally high geothermal gradients to provide the focus for shallow drilling in 2006. Acquisition of prospective petroleum exploration acreage, drilling and development of such areas, whether in Australia or overseas, is a vital part of the company's strategy.

KUTH Exploration Pty Ltd has applied for a Class 6 (Geothermal Substances) Special Exploration Licence (SEL) over an area of some 13,000km² in eastern Tasmania.

The company is exploring the eastern portion of the state in SEL 26/2005 where several large radiogenic granite masses have demonstrated high heat fluxes. The first stage of the project is to locate the most favourable areas in the overlying Tasmania Basin where it is associated with the eastern batholith.

For more information visit: <http://www.kuthenergy.com>

Osiris Energy Pty Ltd is a privately held Australian company and a new entrant to Australian geothermal exploration and development. The company was formed to locate, define and exploit geothermal resources suitable for power generation and other ancillary uses requiring energy in the form of heat. It has already submitted two geothermal exploration licence applications in South Australia adjacent to existing geothermal exploration licences in the Cooper Basin in the northeast of the State and one in the Otway Basin area in the State's southeast. Osiris perceives an opportunity in combining the expertise and methods available in the petroleum, mineral and energy sectors. It has engaged consultancy group Hot Dry Rocks Pty Ltd to provide it with the necessary technical expertise to achieve its aim of being in the forefront of geothermal exploration and development using state-of-the-art techniques. Hot Dry Rocks (www.hotdryrocks.com) provides a very experienced and multidisciplinary team of geoscience professionals with extensive experience in the utilisation of geological, geophysical and remote sensing techniques, analysis of well bore data, expertise in basin modelling and experience in cross-disciplinary approaches to minerals and petroleum exploration. It offers specialist services in locating and defining geothermal resources by applying leading edge exploration methodologies and three dimension (3D) modelling and resource estimation.

Osiris believes that its approach to exploration and development is unique in the emerging renewable hydrothermal energy industry, and will result in successful and cost-effective exploration and development of geothermal resources. Osiris Energy Pty Ltd is currently an unlisted company, but plans to list on the Australian Stock Exchange towards the end of 2006 or the beginning of 2007.

Pacific Hydro Ltd is exploring for sediment-hosted geothermal heat in the Great Artesian Basin for a 400MW conventional geothermal project. Pacific Hydro holds 18 Geothermal Exploration Licenses covering 9,000km² and has successfully completed year 1 of its GEL work program to delineate the resource and define exploration targets. During 2006 drilling is planned as the next phase of development.

Petratherm Ltd listed on the Australian Stock Exchange in July 2004 after a highly successfully public offering based on a commercial rationale of locating high quality geothermal resources close to market. The Company has developed predictive exploration methods to locate Hot Dry Rock Resources through collaborative research with the University of Adelaide. It has since drilled gradient test wells to approximately 600m at two sites associated with exceptionally high heat producing granites in Southern Australia. Results from both wells were outstanding, with the Callabonna site returning an average temperature gradient of 68^oC per kilometre and at the Paralana Site an average gradient of 81^oC per kilometre. Plans are now underway for the company to drill its first injection well at Paralana to approximately 3.5 kilometres depth where temperatures are expected to exceed 220 degrees Celsius. Having an up front exploration focus, Petratherm are also actively looking to develop new projects elsewhere in Australia and overseas. Petratherm successfully secured a PACE 2 grant of \$140 000 to partially fund its Paralana Project drilling programme. For further information, visit <http://www.petratherm.com.au>

Proactive Energy Development Ltd is a privately held company that plans to explore for hot rocks at intermediate depths in proximity to the existing high voltage grid to connection to Olympic Dam. Proactive has commenced geotechnical model building in GEL207 Roxby Downs in SA, and a field inspection is planned over the coming month with an ex- WMC project manager to guide on past exploration drilling activity. The company has also commenced geotechnical model research for the Felton EPM in SE Qld, but await the passing of Geothermal legislation, copied from NSW & SA. Proactive has completed a geotechnical model on the Bulli EL6360 in NSW, and is currently seeking funding plus a research grant to drill a 3,000+m well later this year. The Ulan ELA for Geothermal Energy in NSW is awaiting a decision on grant by the Minister. The company plans to list with the ASX in the first half of 2006.

Scopenegy Ltd is focused on searching for water in hot sedimentary rocks in proximity to recent volcanic activity in the South East of South Australia, around Millicent. The company holds contiguous Geothermal Exploration Licences totalling 2,634 km² covering substantially all of Australia's most recently active volcanic province (5,000 yrs BP). Scopenegy commenced a slim hole (100 mm) drilling program in January 2006, seeking to confirm several large scale heat flow anomalies previously measured in 19 petroleum exploration wells and 26 water wells in the vicinity of its tenements. If this program is successful the company plans a 3D seismic program to better define drilling targets, and to drill 3 production scale test wells later in 2006. Scopenegy's areas are well served by 275kV and 132kV transmission lines. Scopenegy's business model seeks to generate conventional geothermal power from water at or above 170°C hosted in a known deep aquifer of the Otway Basin, in proximity to recent volcanic activity and the existing electricity grid. The company is the recipient of a \$4 million Australian Government REDI grant to fund an extensive drilling and 3D seismic program and also successfully secured a PACE 2 grant of \$130 000 to partially fund its South East drilling program that commenced in January 2006. Scopenegy is currently a privately owned company but may seek a listing on the ASX later in 2006. For further information, visit <http://www.scopenegy.com.au>

Attachment 2. Australia's GIA Membership

Company/Organisation	Name	Title	Address	Email	Phone
Department of Industry, Tourism and Resources	John Soderbaum	Science & Technology Advisor - Energy & Environment Division	GPO Box 9839, Canberra ACT 2601 PO Box Z5360 St Georges Tce Perth WA 6831	john.soderbaum@industry.gov.au	02 6213 7865
Eden Energy	Graham Jeffress	Senior Geologist	Suite 6, Level 1, 19 Lang Parade, Milton QLD 4064	gjeffress@tasmanresources.com.au	08 9221 5323
Geodynamics Ltd	Bertus de Graaf	Managing Director	GPO Box 378, Canberra ACT 2601	bdegraaf@geodynamics.com.au	07 3721 7500
Geoscience Australia	Clinton Foster	Chief of Petroleum & Marine Division		clinton.foster@ga.gov.au	02 6249 9447
Greenrock Energy Ltd	Adrian Larking	Managing Director	PO Box 1177, West Perth WA 6872 63 Conyngham Street, Glenside SA 5065	alarking@greenrock.com.au	08 9482 0482
Havilah/Geothermal Resources Ltd	Bob Johnson	Chairman		geo@havilah-resources.com.au	08 8338 9292
Intrepid Geophysical	Des Fitzgerald	Managing Director	2/1 Male Street, Brighton, VIC 3186	des@dfa.com.au	03 9593 1077
Minerals & Energy, NT Department of Primary Industry, Fisheries & Mines	Steve Tatzenko	Deputy Director, Resource Development & Policy	GPO Box 3000, Darwin NT 0801	steve.tatzenko@nt.gov.au	08 8999 5372
Monash University - School of Geoscience	Graeme Beardsmore	Senior Research Fellow	Monash University, VIC 3800 Level 6, 201 Elizabeth Street Sydney NSW 2000	graeme.beardsmore@sci.monash.edu.au	03 9905 1169
NSW DPI	Tony Galligan	Director Sustainable Development		tony.galligan@dpi.nsw.gov.au	02 8289 3918
Osiris Energy Pty Ltd	Geoff Geary	Director	PO Box 871, South Yarra VIC 3141 30 Kensington Road, Rose Park SA 5067	geoff.geary@hotdryrocks.com	038610 4706
Pacific Hydro Ltd	Terry Teoh	Development Manager - SA	247 Greenhill Road, Dulwich SA 5065	tteoh@pacifichydro.com.au	08 8333 2833
Petratherm Ltd	Peter Reid	Chief Executive Officer		preid@petratherm.com.au	08 8304 8200
PIRSA	Barry Goldstein	Director - Petroleum & Geothermal	Level 6, 101 Grenfell Street, Adelaide SA 5000 Level 21, 201 Miller Street, North Sydney NSW 2060	goldstein.barry@saugov.sa.gov.au	08 8463 3200
Proactive Energy Developments	David Hawley	Director		dhawley@proenergy.com.au	02 9959 2348
Qld Department of Natural Resources & Mines	Malcolm Cremer	Deputy Director General - Mining & Petroleum	GPO Box 2454, Brisbane Qld 4001 Level 9, 1 York Street, Sydney NSW 2000	malcolm.cremer@nrm.qld.gov.au	07 3224 2250
Scopenergy Ltd	Roger Massy-Greene	Managing Director		RogerMG@scopenergy.com.au	02 9250 0121
Tas Department of Infrastructure, Energy & Resources	Carol Bacon	Managing Geologist	GPO Box 936, Hobart Tasmania 7001	carol.bacon@dier.tas.gov.au	03 6233 8326
UNSW - School of Petroleum Engineering	Sheik Rahman	Associate Professor	University of NSW, NSW 2052 GPO Box 4440, Melbourne VIC 3001	sheik.rahman@unsw.edu.au	02 9385 5659
VIC DPI	Kathy Hill	Director Geoscience Victoria		kathy.hill@dpi.vic.gov.au	03 9658 4562
WA DOIR	Bill Tinapple	Director Petroleum & Royalties	Level 11, 100 Plain Street, East Perth WA 6004	bill.tinapple@doir.wa.gov.au	08 9222 3291