Submission No: 136

THE AUSTRALIAN GEOTHERMAL ENERGY GROUP'S SUBMISSION TO THE HOUSE OF REPRESENTATIVES' INQUIRY INTO THE DEVELOPMENT OF THE NON-FOSSIL FUEL ENERGY IN AUSTRALIA

INTRODUCTION

The Australian Geothermal Energy Group's submission covers one of the seven non-fossil fuels (geothermal) listed in the inquiry announcement issued on the 8 May 2007

GEOTHERMAL – A NATIONAL OVERVIEW

Australia's vast hydrothermal and Hot Rock energy resources have the potential to become a very significant source of safe, secure, competitively-priced, emission free, renewable baseload power for centuries to come. This potential combined with the evidence of risks posed by climate change is stimulating growth in geothermal energy exploration (drilling) and proof-of-concept (flow tests) and demonstration power generation projects in Australia.

Nationally, 27 companies have applied for 166 licences (Figure 1) with 5 year work program investment totaling $686 million, including 13 geothermal exploration licences recently offered in Victoria, and excluding up-scaling and deployment projects assumed in the Energy Supply Association of Australia's scenario for 6.8% (about 5.5 GWe) of Australia's base-load power coming from geothermal resources by 2030.

The vast natural endowment in hot rock resources and supportive investment frameworks are deemed to be the key factors that have enabled South Australia to attract more than 80% of the national tallies for licence applications and investment. This has been achieved in the six years since the grant of the first Geothermal Exploration Licence (GEL) in South Australia in 2001. To end June 2007, 17 companies have applied for 142 geothermal licence applications areas covering more than 60,000 km^2 in South Australia. The guaranteed and non guaranteed work programs associated with those 142 areas corresponds to an estimated investment of $556 million.

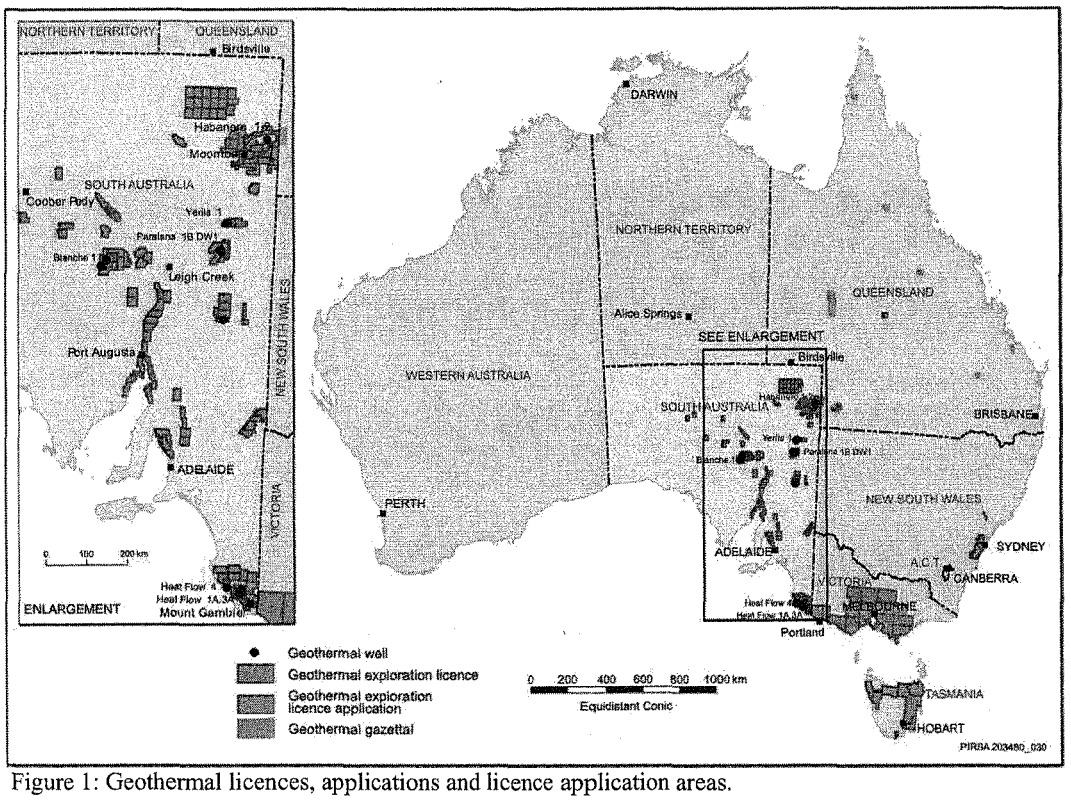

Figure 1: Geothermal licences, applications and licence application areas.

The majority of current and forecast investment to explore for, and demonstrate the potential of, geothermal energy in Australia focused on hot rock enhanced geothermal

systems (EGS), but some companies are also exploring for hydrothermal resources in the Great Artesian, Gippsland and Otway Basins. Most holders of rights to explore-for, demonstrate, develop, deploy and produce geothermal energy are focused on the use of Hot Rock energy to fuel power plants to meet base-load electricity demand. However, other possible applications include niche markets such as pre-heating water for coal- and gas-fired power plants, desalinisation and local direct-use for heating.

Many forms of conventional energy generation such as coal and natural gas are currently more cost effective than any renewable energy sources. However, modelling undertaken by MMA[1] concludes that electricity generated from Hot Rock EGS will be lower cost than any other form of renewable energy and, within decades has the potential to be comparable in cost to coal-fired power without the pricing of greenhouse gas emissions factored into the cost of electricity generation.

Geoscience Australia's preliminary work suggests Australia's Hot Rock energy between the shallowest depth corresponding to a minimum temperature of 150°C and a maximum depth of 5,000 m is roughly 1.2 billion PJ (roughly 20,000 years of Australia's primary energy use in 2005), without taking account of the renewable characteristics of geothermal energy. Even if only a fraction of this energy is recoverable, it still far exceeds the amount of energy provided by fossil fuels.

Key advances scheduled for conclusion in 2008 include:

(1) a national geothermal resource assessment by Geoscience Australia;

(2) a roadmap for the deployment of geothermal energy projects through a joint effort by Australian State and Federal governments; and

(3) an Australian Federal Government's Geothermal Industry Development Framework.

Current use in Australia

The only electricity derived from geothermal energy in Australia emanates from a small binary power station located in Birdsville, Queensland. It is sourced from hot (98°C) hydrothermal waters at relatively shallow depths from the Great Artesian (Eromanga) Basin. The gross capacity of the plant is 120 kW, and the plant has 40kW of parasitic losses. Total power generation at Birdsville in 2006 was 2,034,615 kWh of which 715,182 kWh was provided by the geothermal power plant with the remainder provided by auxiliary diesel powered generators. Ergon Energy, the owner of the plant, has commenced a feasibility study into whether it can provide Birdsville's entire power requirements and relegate the existing LPG and diesel-fuelled generators to peaking.

Industry Exploration and Expenditure on Geothermal Energy Projects

More than 80% of geothermal licence applications and forecast national expenditures attracted to geothermal projects located in the state of South Australia. Supportive investment frameworks and quality geothermal resources are the key factors behind this trend

Since the drilling of Habanero 1 by Geodynamics Limited in 2003 through to end April 2007, 12 geothermal wells have been drilled in Australia by five companies: Geodynamics Limited, Petratherm Limited, Green Rock Energy Limited, Scopenergy Limited and Geothermal Resources Limited, all within the state of South Australia. In addition, Pacific Hydro undertook temperature surveys of water bores to further geothermal exploration drilling is expected to be undertaken by at least Torrens Energy and Eden Energy over the period 2007 – 2008.

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[1] Refer to McLennan Magasanik Associates Report, Renewable Energy – A contribution to Australia's Environmental and Economic Sustainability, June 2006 available from:

.http://www.rega.com.au/Documents/Publications/J1281%20Final%20Report%20V3%20Exec%20Summary.pdf

A précis of progress achieved by the five companies that have already commenced drilling to delineate and prove geothermal resources follows:

EGS Projects

Geodynamics Limited: The most significant advancement in terms of demonstrating the potential of Hot Rock geothermal energy in Australia is Geodynamics' drilling, fracture stimulation and flow testing of two wells that are 500 m apart near Innamincka in the Cooper Basin in northeast South Australia: Habanero 1 (total depth: 4,421m) and Habanero 2 (total depth: 4,357m – see Figure. 1). The Habanero Project was the first and remains the most advanced Hot Rock 'proof of concept' project in Australia. Flow of geothermally heated, saline formation waters at a maximum rate of 25 litres/second to surface at (up to) 210°C was achieved in 2005. The geothermal reservoir is a water-saturated, naturally fractured basement granite (250°C at 4,300 m as reported by Geodynamics) with permeability that was effectively enhanced by fracture stimulation.

Two fractured reservoir zones are present in the Habanero wells: an upper less permeable zone at 4,200 m; and a lower more permeable zone below 4,300 m. An obstruction in Habanero 2 (the intended production well) interfered with a planned flow test of the main fractured reservoir below 4,300m while the less-productive upper fractured reservoir zone at 4,200 m remained accessible. To conclude a circulation test of the main fracture zone, Geodynamics drilled a sidetrack borehole around the blockage in Habanero 2. The sidetrack progressed to a depth 100 m above the target reservoir when the drill bit became stuck. Attempts to conclude drilling operations in the Habanero 2 sidetrack were abandoned in June 2006. Geodynamics plans to drill Habanero 3 in 2007. Habanero 3 will be a larger 8½ inch hole through its reservoirs... Following the drilling of Habanero 3, a flow test with tracer injection between Habanero 1 (the intended injection well) and Habanero 3 (the intended production well) is planned as a further step towards demonstrating commercial viability.

The horizontal extension of stimulated reservoirs at the Cooper Basin site lends itself to multi-well developments. Geodynamics' HOTROCK40 project entails a proposed seven-well, 40 MWe power station. The seven wells will include three injection wells and four production wells up to 1km apart. This will be an important milestone for the demonstration of Hot Rock geothermal resources and a stepping stone towards commercialising vast renewable and emissions-free geothermal energy supplies to meet Australia's future baseload energy requirements. Geodynamics believes that a successful flow test between Habanero 1 and 3 will lead to large-scale development of an extensive area of more than 1,000 km^2 where rock temperatures, stress conditions and rock properties are extensive and favourable for geothermal energy production. Two Australian Stock Exchange (ASX) listed companies with extensive upstream petroleum interests (Origin Energy and Woodside Limited) are cornerstone investors in Geodynamics.

Petratherm Limited: Petratherm has drilled two wells to establish thermal gradients down to about 600 m above exceptionally high heat producing granites in South Australia. Results from both wells were encouraging, with the Callabonna and Paralana sites (Figure 1) respectively exhibiting 68 and 81°C/km thermal gradients. In June 2006, the phase-2 drilling program at Paralana was successfully completed with the well being extended to 1,807 m. Temperature logging of the well suggests a world class thermal resource is located at Paralana, with extrapolations indicating 200°C can be expected at a depth of 3, 600 m within insulating sedimentary rocks that are susceptible to fracture stimulation. Petratherm refers to this play concept as Heat Exchange Within Insulator (HEWI). High heat producing basement rocks are a prerequisite for high quality HEWI plays.

Petratherm next plans to drill and fracture stimulate its first injection well at Paralana to approximately 4,000 m depth and then drill and fracture stimulate a second well. The company then plans to create an underground HEWI system with the circulation of water between the two Paralana project wells to demonstrate Hot Rock geothermal energy production from an initial small scale power plant that will supply up to 7.5 MW to a growing electricity market 10 km away at the Beverley uranium mine. This plan is the subject of a Memorandum of

Understanding between Petratherm and Heathgate Resources. An ASX-listed upstream oil and gas company (Beach Petroleum) has taken an equity position in the Paralana project.

Green Rock Energy: Green Rock drilled Blanche 1 (Figure 1) to 1,935 m (718 m of sedimentary rocks and 1,216 m of homogenous hot granite) eight km from the giant Olympic Dam mine in South Australia in 2005. The target granite is interpreted to persist to depths of 6,000 m over an area of about 400 km2 and represents a potential geothermal resource in excess of 1,000 MWe. Cores and wireline logs from Blanche No 1 suggested natural fractures exist. Green Rock plans to undertake a mini-fracture stimulation program in Blanche 1 to optimize the design of a deep well stimulation. Greenrock quotes a CSIRO study[2] of the stress regime encountered in Blanche 1 as "is an ideal situation for generating an optimal heat exchange reservoir that would allow a maximum distance between injection and production wells."

Geothermal Resources: Geothermal Resources has commenced an 8-well program in the Lake Frome region of South Australia. At the time of preparation of this submission, the Geothermal Resources had drilled four wells and is expected to complete its drilling program in 2007.

Hydrothermal Projects

Scopenergy: In the first quarter of 2006, Scopenergy drilled three slim-hole wells near Millicent and Beachport in southeast South Australia (Figure. 1) to determine geothermal gradients and confirm several large scale heat flow anomalies previously measured in 19 petroleum exploration wells and 26 water wells in the vicinity of its tenements. In mid 2006 the company completed temperature logging of its three wells: Heatflow 1A, 3A and 4. Poor recovery of core samples from unconsolidated sediments and highly variable lithology affected the reliability of thermal conductivity measurements and hence, estimates of heat flow. Scopenergy is now considering whether to undertake a 3D seismic program to better define drilling targets prior to drilling its first production scale hole to reservoir depth. Scopenergy is targeting hot aquifers in Cretaceous – Jurassic sedimentary rocks. If reservoir enhancement is required to achieve commercial flows, this too may become an EGS project.

Pacific Hydro: In the second quarter of 2006, Pacific Hydro conducted downhole temperature measurements on three water bores to a depth of 1,500m to confirm 56.1 °C /km, or 133 °C at 2,000m in the target Jurassic-aged Hutton and Poolawana Formations. Laboratory permeability tests of Hutton core samples and thin section analyses provide further verification of high permeability. Two slim holes are planned to be drilled, targeted over the gravity low in the eastern section of Pacific Hydro's GEL, which may unlock further upside above the 133 °C temperature already confirmed by measurement in a geological setting with benign fluid chemistry, high permeability and lateral continuity. This gives rise to a very large scale hydrothermal resource that could be developed with existing technologies.

Australia's 2006 Annual Report to the International Energy Agency under the auspices of the Geothermal Implementing Agreement is provided as Enclosure 1. This document

A précis of progress made by Australian geothermal licence holders to 1 March 2007 is provided in Enclosure 1 (as Attachment 1 to that enclosure). Enclosure 1 is Australia's 2006 Annual Report to the International Energy Agency (IEA) pursuant to the Geothermal Implementing Agreement (GIA). An interim update of geothermal energy projects undertaken in Australian geothermal licences will be submitted to the IEA in October 2007, and Australia's 2007 Annual Report under the GIA is due in April 2008.

Trends in Geothermal Investment

In 2006, the total (estimated) $29 million spent on surveys and well operations in Geothermal Licences in Australia targeted geothermal resources in South Australia. This represents an 11% increase ($3 million) from the previous year. A 97% increase (to $45 million) is forecast for 2007

[2] The CSIRO's findings are quoted in a document on Greenrock's website at: http://www.greenrock.com.au/media/CSIRO%20Stress%20regime%20release%202%20July%2007_V2.pdf

– and 96% of this is associated with Geothermal Licences in South Australia. Historical, current and projected expenditures for the term 2000-2007 are highlighted in Figure 2.

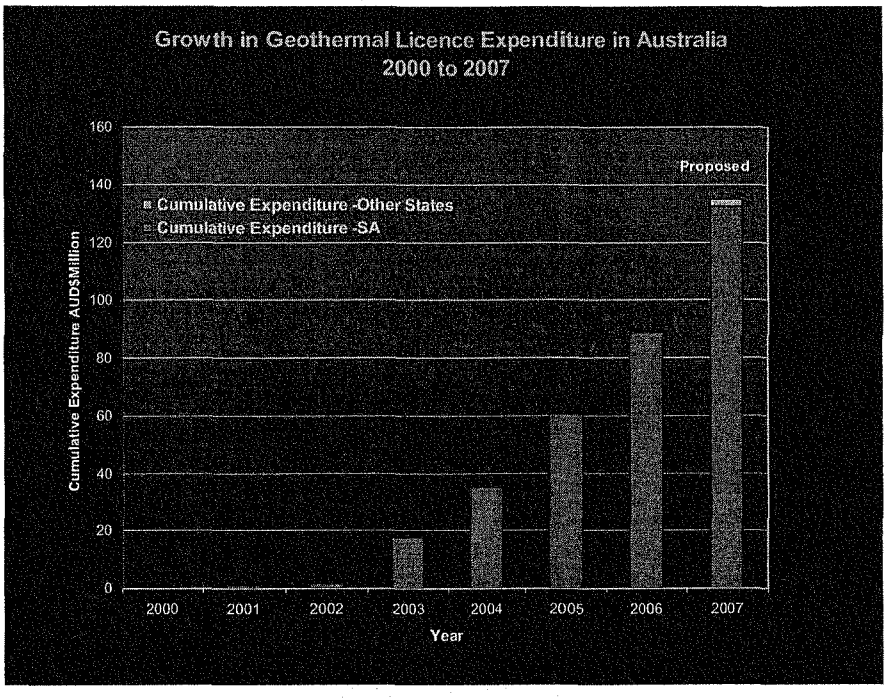
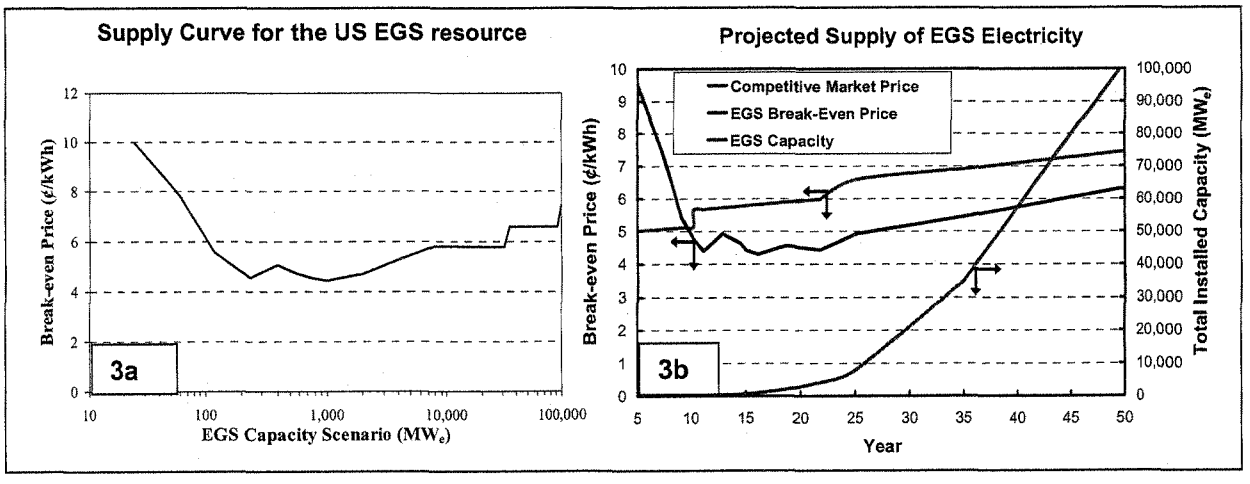


Figure 2: Geothermal Licence applications and exploration expenditure, 2000 to 2007.



Figures 3a and 3b – US¢ cost reductions forecast for ESG through its development and deployment to 2050. Costs are expected to fall to levels competitive with coal- and gas-fired electricity without the cost of carbon in the price of coal- and gas-fired power. From Tester, et al (2006) *Future of Geothermal Energy* available from htpp://www.geothermal.inel.gov

Future Cost of Hot Rock Geothermal Electricity

Assuming success in demonstration and proof of concept projects, the Electricity Supply Association of Australia concluded that 6.8% of all Australia's power could come from geothermal energy by 2030 under a "scenario that assumes no nuclear power and (CO2) emissions reduced to 70% of 2000 levels by 2030". The forecast 6.8% represents 5.5 GW in generating capacity from Hot Rock geothermal resources. At roughly 2% growth, Australia's power generation capacity will need to grow from its current level of (approximately) 50 GW to approximately 80 GW to meet forecast demand in 2030.

These views are consistent with conclusions reached by the Massachusetts Institute of Technology (MIT, December 2006) in its US Department of Energy commissioned assessment of the potential for Hot Rock geothermal resources to supply competitive electricity supplies into the US energy markets through 2050. Figure 3a and 3b illustrate conclusions drawn by MIT in relation to the development of Hot Rock geothermal resources (in the form of EGS) in the USA.

According to South Australia's Electricity Supply Industry Planning Council's 2007 Annual Report, Australia's initial 7.5 to 250 MWe geothermal power plants are forecast to have power generation costs between $70 and $130 per MWh with a 90% capacity factor. Proponents of geothermal power supplies (including Geodynamics, Petratherm, and others), industry lobby groups (including REGA and the ESSA) and respected energy sector consultants (including MMA) forecast that the costs of generation from Hot Rock resources will fall to a range of $60–$100 per MWh. Figure 4 illustrates the current costs of power generation from alternative fuels, including geothermal. At this point in time, coal and gas are the most competitively priced fuels for electricity generation.

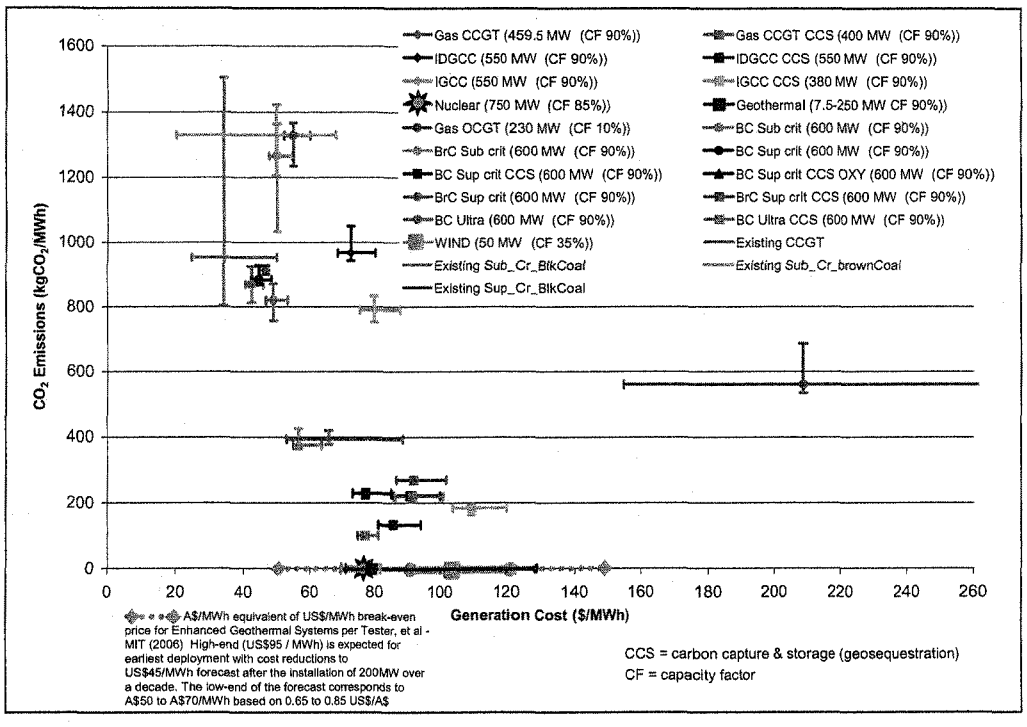


Figure 4. ESIPC's 2007 Annual Report assessment of CO_2 emissions (Kg/MWh) versus costs to generate electricity (AUS$/MWh) from various power plants (www.esipc.sa.gov.au). Also displayed is MIT's (Tester, 2006) expected range of break-even price per MWh for power from enhanced geothermal systems (EGS a.k.a Hot Rocks) in the USA over a decade of learning-while-doing through the deployment of 200 MWe of Hot Rock EGS. This indicates relative costs and CO_2 emissions from various fuels, with and without carbon capture and storage (CCS). Capacity factors (CF) are the proportion of annual hours online generating electricity.

Progress towards Commercialisation of Geothermal Energy

There have been a number of Federal and State Government initiatives to foster investment in geothermal energy exploration, and proof-of-concept, and demonstration projects, on the road to the commercialisation of geothermal energy resources. These initiatives include:

- Stimulating significant exploration and proof-of-concept investment with attractive legislation, policies, programs and incentives. To date, the Australian Federal Government has allocated grants totalling $27 million, and South Australian Government has allocated $1.3 million in grants for geothermal exploration and proof-of-concept projects;

- The direction of part of the $59 million Federal Government's Onshore Energy Security Program in 2006-2011 towards the provision of precompetitive geoscience data for the advancement of geothermal energy;
- Membership in the International Energy Agency's Geothermal Implementing Agreement (GIA) Research Cluster. The geothermal sector, in consultation with the Federal Department of Industry, Tourism and Resources, elected South Australia's Director of the Petroleum & Geothermal Group (Primary Industries & Resources - SA) to be Australia's Executive Committee representative to the International Energy Agency's (IEA's) geothermal energy research cluster under the Geothermal Implementing Agreement (GIA). PIRSA is Australia's contracting party to the GIA;
- A whole-of-sector, nation-wide interest group, the Australian Geothermal Energy Group (AGEG) has been established to position the Australian geothermal sector to reap maximum benefits from domestic and international geothermal research, demonstration, development and deployment projects. The AGEG now provides the intellectual support for Australia's membership in GIA and is engaged with the international geothermal community;
- The Australian Federal Government's Geothermal Industry Development Framework announced in March 2007, which will result in the development of a roadmap for the commercialisation of Australia's geothermal resources (including the COaG Geothermal Technology Roadmap); and
- In May 2007, corporate members of the AGEG have agreed to create a geothermal industry directorate under the auspices of the Renewable Energy Generators of Australia (REGA).

Australian Geothermal Energy Group (AGEG)

The AGEG formed in late 2006. Membership is in growth mode with 46 organisations already committed, including every company, all State, NT and Federal government agencies focused on geothermal resources, and six universities. The AGEG is actively seeking out additional University-based experts with skills that can be of help. Federal agencies represented in the AGEG include the AGO, DITR, Geoscience Australia, the CSIRO, and advisors to both the MCE and the MCMPR. Table 1 lists the AGEG's membership to end June 2007.

The AGEG'S vision is for geothermal resources to provide the lowest cost emissions-free renewable base load energy for centuries to come. The AGEG's Terms of Reference are:

1. Provide support for Australia's membership in the IEA's Geothermal Implementing Agreement (GIA) and facilitate engagement with the international geothermal community.
2. Foster the commercialisation of Australia's geothermal energy resources. Collectively:
    - Cooperate in research and studies to advance geothermal exploration, proof-of-concept, demonstration and development projects;
    - Cooperate to develop, collect, improve and disseminate geothermal-related information;
    - Identify opportunities to advance geothermal energy projects at maximum pace and minimum cost; and
    - Disseminate information on geothermal energy to decision makers, financiers, researchers and the general public (outreach).

Australian Geothermal Energy Group (AGEG)

Organisation	Representative and Contacts
1. SA Government (PIRSA)	Barry Goldstein (Chair), Tony Hill, Mike Malavazos Craig Oakeshott (ESIPC)
2. Australian Fed. Government	Ralf Ernst (DITR, Roadmap)
	Anthony Budd (GA, Onshore Energy Security)
	AGO: John Jende, Tas Sakellaris (AGO)
	Frank Horowitz, Klaus Regeauer-Lieb, Paul Roberts, Rob Jeffrey, Dave Dewhurst CSIRO
	Clinton Foster, John Schneider, Mark Leonard GA
	John Söderbaum DITR
	Drew Clark (MCE, DITR)
	Bob Pegler (MCMPR, DITR)
3. Clean Energy Australasia	Joe Reichman, Cam Selin
4. Deep Energy	John Risinger
5. Digirock	Alexandra Papadakis, John Libby
6. Earthinsite	Prame Chopra
7. *Eden Energy*	*Graham Jeffress*
8. Geodynamics	Adrian Williams, Doone Wyborn
9. Geogen	Bob Kitch
10. Geopower	Frank Rogers
11. Granite Power	Stephen de Belle, Catherine Stafford
12. Greenearth Energy	Robert Annells, Robert King
13. *Greenrock Energy*	*Adrian Larking, Alan Knights*
14. Geothermal Resources	Bob Johnson
15. Hot Dry Rocks	Graeme Beardsmore
16. Hot Rocks Ltd	Mark Elliott, Sharif Oussa, Norm Zillman
17. Hot Rocks Tasmania	Lindsay Newnham
18. Inferus	Russell Hetherington, Mark Baluan
19. *Intrepid Geophysical*	*Des Fitzgerald*
20. KUTh Energy	Malcolm Ward

Organisation	Representative and Contacts
21. Monash University	Jim Cull
22. Near Surface Geoth'l Energy	Colin Randall
23. *NSW Government*	*Brad Mullard, Steve Cozens*
24. NT Government	Steve Tatzenko, Tony Waite
25. Osiris Energy Pty Ltd	Ian Reid, Ron Palmer
26. Pacific Hydro	Terry Teoh
27. Panax	Bertus de Graaf
28. Petratherm	Terry Kallis, Peter Reid, Betina Bendall
29. *Queensland Government*	*Malcolm Cremer, J. Draper, R. D'Arcy*
30. Red Hot Rocks	John Shirley
31. REGA	Susan Jeanes
32. Scopenergy	Roger Massey-Greene
33. Sinclair, Knight, Merz	Jim Lawless
34. Syncline Energy	Phil Galloway
35. *Tasmanian Government*	*Carol Bacon*
36. Teck Cominco	Ian Sandl
37. Torrens Energy	Chris Matthews
38. Touchstone	Peter Bull
39. Tri-Star Energy	Vic Suchocki
40. University of Adelaide	Martin Hand, Richard Hillis, Gus Nathan Cameron Morelli, Mark Jacksa
41. University of Newcastle	Behdad Moghtaderi
42. University of Queensland	Victor Rudolph, Hal Gurgenei
43. University of NSW	Sheik Rahman
44. University of SA	Wasim Saman, John Ralston
45. Victorian Government	Jim Driscoll, Kathy Hill
46. WA Government	Bill Tinnapple, Maryie Platt

Table 1. AGEG Membership

AGEG Technical Interest Group (TIG)		Purpose
1	Land Access Protocols (induced seismicity, emissions, native title, etc)	Mirrors IEA Geothermal Implementing Agreement research annex 1. Management of environmental concerns and potential impacts of geothermal energy and devises protocols to avoid or minimize impacts.
2	Reserves and Resource (Definitions)	Align with similar International forums
3	Policy Issues * Industry Forum * Whole-of-Sector Forum	Advice to Governments.
4	Enhanced Geothermal Systems	Mirrors IEA Geothermal Implementing Agreement research annex III Investigate technologies for enhancing geothermal reservoirs for commercial heat extraction.
5	Interconnection with Markets	Transmission, distribution, network, National Electricity Market issues.
6	Geothermal Power Generation	Mirrors IEA Geothermal Implementing Agreement research annex VI (Ormat, Italy, Australia). Develop scenarios as a basis for comparison of cycles, plant performance and availability, economics and environmental impact and mitigation. The output would be a database and guidelines of best practice.
7	Direct Use of Geothermal Energy (including geothermal heat pumps)	Mirrors IEA Geothermal Implementing Agreement research annex VIII. This annex address all aspects of the technology related to geothermal energy being used directly as heat, with emphasis on improving implementation, reducing costs and enhancing use
8	Outreach (Including Website)	Create informed public through accessible information. Provide educational kits for media, all levels of schooling and university education.
9	Data management	Database design, contents and ongoing enhancements.
10	Wellbore operations	In part Mirrors IEA Geothermal Implementing Agreement research Annex VII. Cover drilling, casing, logging, fracture stimulation, testing, etc

Table 2. The AGEG's Technical Interest Groups.

AGEG Technical Interest Groups (TIGs)

To foster the achievement of these objectives, the AGEG has established 10 Technical Interest Groups (TIGs). These TIGs will enable Australian companies, research experts and government regulators to convey and take note of international best practices for the full-cycle of below-ground and above-ground geothermal energy operations and stewardship. The AGEG's TIGs will have active links to the International Energy Agency's (IEA's) research annexes, and all other reputable international geothermal research clusters, to ensure that Australia's comparative advantages in Hot Rock geothermal resources can be leveraged into international leadership in geothermal technologies, methods and development. The AGEG's TIGs are summarised in Table 2.

Current Research Activities

The principal focus topics of current Australian research relate to:

- Identification and targeting of locations with high potential for the development of Hot Rock geothermal;;
- Reserve and resource definitions;
- Assessment of technologies (including numerical simulation techniques) with high potential to minimise costs and maximize efficiencies in the development of Hot Rock geothermal resources;
- Environmental impacts of developing Hot Rock geothermal resources, including potential induced seismicity that can be associated with the fracture stimulation of EGS reservoirs; and
- Modeling future energy supply: demand scenarios.

Government support (in the form of grants for exploration and proof-of-concept projects) has been instrumental in progressing geothermal research... Federal and State grants provided to underpin geothermal projects are listed in Table 1 in Enclosure 1.

In 2005, the Primary Industries and Resources South Australia (PIRSA) commissioned the Australian School of Petroleum at University of Adelaide to undertake a research study of potential induced seismicity associated with the fracture stimulation of ESG wells in the Cooper Basin. The results of this study are detailed in Hunt *et al.* (2006)[3]. Key conclusions are:

- The Cooper Basin in South Australia is ideally suited to Hot Rock EGS activities in terms of natural background seismicity levels;
- Reactivation of any basement faults in the region is unlikely in the vicinity of the Habanero Site; and
- Seismic events induced by reservoir stimulation at the Habanero well site in the Cooper Basin were of low magnitude (intensity) and fell below the background level that the government's current building design standards allow-for. The petroleum industry operating in the same area have been using similar reservoir fracture stimulation methods safely for decades.

The static stress damage zone would not be expected to have any impact on identified local structural features. This is due to the nearby faults being beyond the reach of the induced seismicity associated with reservoir stimulation activity. PIRSA is funding a regional study of the Adelaide Geosyncline, which is prospective for Hot Rock geothermal resources to foster the development of trustworthy protocols for assessing the potential risks of induced seismicity.

Operators of geothermal energy projects in South Australia will then have a credible foundation to develop or their own hazard management strategies to avoid negative impacts from induced seismicity. PIRSA's regulatory aim is two-fold: (1) foster robust risk-management frameworks and

[3] Hunt, et al (2006) can be found at www.iea-gia.org/publications.asp

(2) sustain widespread, multiple-use land access for geothermal energy projects by attaining stakeholders' confidence that regulated activities undertaken by companies will deliver safe and sustainable operations.

In May - July 2007, PIRSA made three tied grants to the University of Adelaide to foster the emergence of South Australian universities to become the world's hub for excellence in innovative Hot Rock geothermal energy research, demonstration and development projects. These include:

- A $50,000 tied grant to extend the findings from *Hunt, et al.* (2006) to the Adelaide Geosyncline. This will enable an analysis of induced seismicity risks associated with geothermal reservoir stimulation operations. This will result in the establishment of peer-reviewed protocols for assessing and managing potential induced seismicity risks arising from these activities. The resulting protocols will also have relevance to induced seismicity risk management for geosequestration operations. The protocols will have direct application to regions identified to be of high Hot Rock potential in South Australia.
- A $50,000 tied grant to characterise Proterozoic-aged rocks that have potential to be geothermal reservoirs in 'Heat Exchange Within Insulators (HEWI) projects in the Adelaide Geosyncline in the mid-northeast of South Australia. This research will include potential Adelaide Geosyncline reservoirs in the vicinity of the only coal-fired power stations in South Australia, near Port Augusta. Hence, this research has potential benefits for future Hot Rock and geosequestration development projects.
- A $250,000 tied-grant to initiate Hot Rock geothermal research in the South Australian context. The tied grant requires project plans to be agreed by the geothermal sector – through the Australian Geothermal Energy Group (AGEG). The framework specified in the relevant Deed between the University of Adelaide and the Minister for Mineral Resources Development is designed to:
    - Enable and stimulate national and international collaboration in geothermal energy research;
    - Attract in-kind and financial inputs from non-SA Government sources that are a multiple of the SA Government inputs. The Australian geothermal industry, the Federal Government (through Geoscience Australia and the CSIRO) and capable universities both in and outside South Australia (in addition to the University of Adelaide) are expected to welcome and participate strongly in this initiative, and/or complementary initiatives to follow; and
    - Ensure that funded projects are focused on what Industry considers to be high priority research, findings undergo high quality peer review, and final reports of findings are prepared and made freely and openly available.

  The quality and impact of reports on findings and scope of inputs from non-SA Government sources are key performance indicators for this initiative.

  The findings of these research projects will be made freely available, and the experience gained will inevitably be leveraged into further valuable research and the development of a service sector for the geothermal industry.

Key Steps that will Drive the Development of Geothermal Energy in Australia

- Geothermal exploration, proof-of-concept and demonstration projects (fostered with government grants);
- Attractive, appropriate investment frameworks in all Australian jurisdictions;
- Research and sharing lessons learnt to reduce critical uncertainties (nationally and internationally);
- A national roadmap for geothermal energy to guide the path for Hot Rock geothermal energy to meet a significant part of Australia's power demand by 2030; and

- Geoscience Australia's Onshore Energy Security Project which will provide salient national maps, enabling data management tools, and a readily assessable national database for geothermal energy information.

Geothermal Industry Development Framework

The Australian Federal Government instigated a Geothermal Industry Development Framework in March 2007. Work will be completed in 2008, and eight distinct outputs are planned as follow:

1. Geothermal Technology Roadmap
2. Assessment of the training and skills development infrastructure of the geothermal sector
3. Assessment of the legislative and regulatory framework governing the geothermal sector
4. Analysis of private sector and government financing structures supporting the geothermal sector
5. Geothermal resource assessment and definitions
6. Geothermal industry communication strategy
7. Geothermal Industry Map
8. Synthesis – Geothermal Industry Development Framework

Drafts will be the subject of national and international peer review prior to publication of outputs.

Geoscience Australia Onshore Energy Security Program

A part of the Australian Federal Government 2006–11, $58.9 million Onshore Energy Security Program will enable Geoscience Australia to acquire precompetitive data and conduct research in support of geothermal energy exploitation. Key activities will include:

- consolidation of existing geothermal data acquisition of additional, infill (precompetitive) geothermal and cognate data (including new thermal conductivity and heat flow measurements);
- assessments leading to a new detailed Hot Rock model (map) with refined gridding techniques, and constructing an information system for the dissemination of geothermal and associated data;
- acquisition of 140 000 line km of new radiometric data; and
- develop play maps that will characterise the key geologic factors that determine the extent of Hot Rock plays, as part of a national geothermal resource assessment, expected to be published in 2008.

Forecast Milestones on the Road to Commercialise Hot Rock Energy

About $100 million has been invested in Hot Rock projects in Australia in the term January 2002-June 2007. The results to date lead the Australian Geothermal Energy Group (AGEG) to forecast:

- At least 10 successful research (exploration drilling) and proof-of-concept (heat energy is flowed) geothermal projects by 2010. This will be enabled with government grants and frameworks that stimulate pre-competitive, 'learn-while-doing' investment to pull low emissions and renewable energy technologies through costs-curves, towards market-competitive energy supplies;
- Several geothermal power generation demonstration projects in distinctively different geologic settings in the coming years, and at least three by 2012, if governments provide sufficient 'pull' for pre-competitive, 'learn-while-doing' investment in the demonstration of low emission and renewable technologies, and Hot Rock geothermal, in particular;
- Compelling success with geothermal power generation demonstration so the investment community is convinced geothermal energy supplies are real by 2012, again, if governments

provide sufficient 'pull' for pre-competitive, 'learn-while-doing' investment in the demonstration of low emission and renewable energy technologies, and Hot Rock geothermal, in particular;

- Realising the vision of safe, secure, reliable, and the lowest-priced renewable and emissions-free base load power from geothermal energy for centuries to come, with at least 7% of base-load demand from Hot Rock power by 2030;
- Enhanced energy security with vast reliable, competitively priced, emissions-free and renewable base load power from geothermal energy for centuries to come; and
- Mitigation of expected negative impacts of greenhouse gas emissions and associated climate change.

Measures to Achieve the Vision for Geothermal Energy

Coherent policies can constructively influence private sector strategies to commercialise vast geothermal plays at maximum pace and minimum cost. Policies that underpin the learn-while-doing phases of Hot Rock resource delineation, demonstration, development and deployment have been, and will remain particularly influential in attracting multiples of private funds into the pre-competitive phase of developing Australia's geothermal resources. Key policy measures that will support efficient investment to develop Australia's vast geothermal resources include:

- Market-based mechanisms that account for the cost of CO_2 gas emissions;
- Sufficient incentives to pull diverse low emission fuels and technologies into markets during the pre-competitive, 'learn-while-doing' phase of bringing costs down to competitive levels; i.e. MRET, MLET, Feed-in, etc); and
- Frameworks to entice early, material and meritorious investment in geothermal exploration, proof-of-concept and demonstration (pre-competitive development) projects, with emphasis on Hot Rock EGS i.e. Start, REDI, PACE-type and LETDF grants that recognise exploration is research, demonstration is necessary in a number of different geologic settings, and that conditional offers will facilitate funding for pioneer geothermal projects.

The Australian Geothermal Energy Group (AGEG) thanks the House of Representatives Standing Committee on Industry & Resources for the opportunity to make this submission to its Inquiry into the development of non-fossil fuel energy in Australia.

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