Australian Geothermal Implementing Agreement Annual Report – 2008

Innamincka 1 MW Pilot Plant and Visitor Centre, Habanero, Cooper Basin, South Australia. Photo courtesy of Geodynamics

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See: http://www.pir.sa.gov.au/geothermal and http://www.pir.sa.gov.au/geothermal/ageg

AUSTRALIA

1 Introduction

Concern about climate change, rising costs of fossil fuels, and evidence of enormous hot rock resources are key factors stimulating growth in geothermal energy research (exploration), proof-of-concept (appraisal) and demonstration (pilot development) projects in Australia.

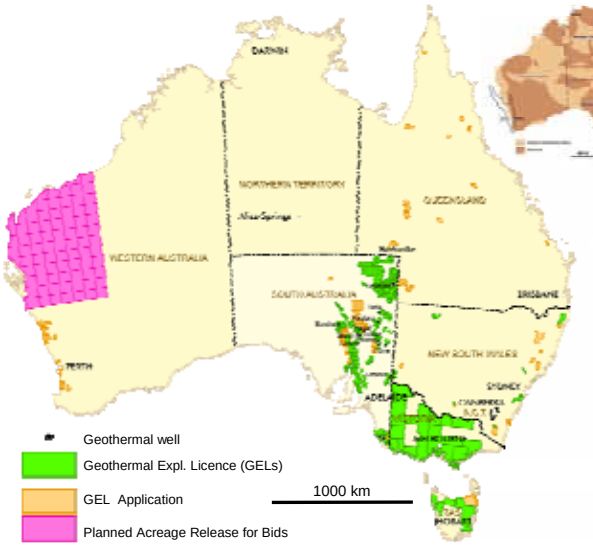

Figure 1a. Geothermal licences, applications and gazettal areas as at 31 December 2008[1]

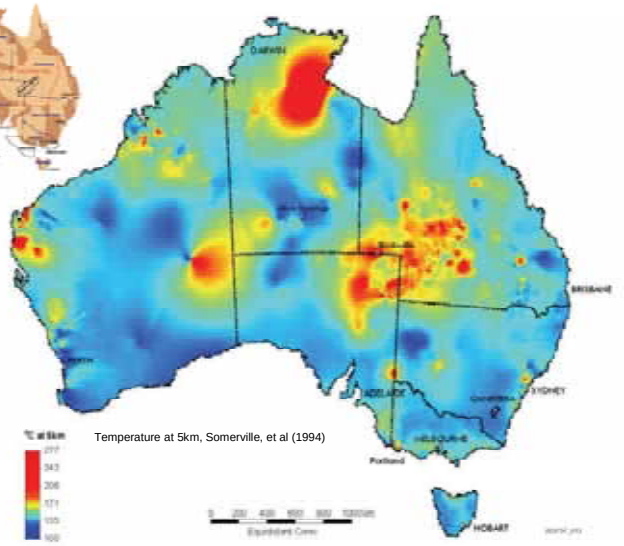

Figure 1b: Extrapolated temperature at 5km This map is based on available, in places sparse, data. See Section 7b for details

Since the grant of the first Geothermal Exploration Licence (GEL) in Australia in 2001 through year-end 2008, 48 companies have joined the hunt for renewable and emissions-free geothermal energy resources in 385 licence application areas covering ~360,000 km^2 in Australia (Figure 1a). This represents a 39% increase in applications in the last year, but leaves vast prospective areas still to be licensed for geothermal exploration energy (Figure 1b). The associated work programs correspond to an estimated investment of AU$1,523 million (US$1,066 million[2]) (79% increase since year end 2007) over the period 2002-2013, and that tally excludes deployment projects assumed in the Energy Supply Association of Australia's scenario for 6.8% (~5.5 GWe) of Australia's baseload power sourced from geothermal resources by 2030. This progress follows encouraging geothermal drilling, temperature logging and flow testing programs in South Australia in the term 2004-2008, the dissemination of information that publicises the vast potential for Australia's geothermal resources, and the implementation of legislation to clarify investment frameworks to explore for and sell geothermal energy in a number of Australian jurisdictions.

Australia's geothermal resources that have considerable potential to fuel power generation fall into two categories: (1) Hot Sedimentary Aquifer (HSA) plays (e.g. hydrothermal groundwater resources); and (2) Hot Rock (HR) plays, including Hot Dry Rocks (HDR) and Hot Fractured Rocks (HFR) which are likely to be fluid saturated. Where geothermal reservoirs are enhanced with fracture and/or chemical stimulation, HR resources constitute EGS. Currently, the only geothermal energy being used in Australia emanates from a 120 kW geothermal energy plant located in Birdsville, Queensland that sources hot hydrothermal waters at relatively shallow depths from the Great Artesian (Eromanga) Basin.

Current investment to explore for, and demonstrate the potential of geothermal energy for power generation in Australia is focused on:

- HR EGS plays in the South Australian Heat Flow Anomaly (SAHFA) and the eastern half of Tasmania; and
- HSA plays in the Otway and Gippsland basins in the states of South Australia and Victoria.

[1] See Appendix B for a map and statistics of Australian geothermal licenses and license application to 30 June 2009.

[2] The exchange rate assumed through this report is 0.7017 as at 31 December 2008.

Licences applied-for (and yet to be granted), and further applications are expected to expand investment in HR EGS and HSA plays across Australia in 2009.

A few companies are also focused on the deployment of direct use applications, including ground-sourced heat pumps.

In 2008, government grants from the Australian Federal, South Australian State and Queensland State Governments for geothermal energy projects totalled AU$64.6 million (US$45.3 million). In the term 1 January 2000 - 31 December 2008, the Australian Federal Government has committed AU$92.2 million (US$64.5 million) to foster progress towards commercialising geothermal energy resources and cognate technologies. Details of these awards are provided in Section 2d. This includes the AU$50 million Geothermal Drilling Program (GDP) for meritorious proof-of-concept deep geothermal drilling and flow test projects. This excludes the AU$300 million of Renewable Energy Demonstration Program (REDP)[3] funding, designed to accelerate commercialisation and deployment of new renewable energy technologies for power generation in Australia. Additionally, the Australian Federal Government's five year funding (AU$58.9 million) for an *Onshore Energy Security Program*[4] will enable the national geoscience and geospatial information agency (Geoscience Australia) to acquire precompetitive data and conduct research in support of geothermal energy exploitation. Geoscience Australia has consulted with industry, State and Territory governments and academic experts in developing its geothermal energy project plan.

Ten Australian geothermal projects have reached a drilling phase in the term 2002 to 31 December 2008. One additional project concluded magneto-telluric (MT) surveys in 2008 to define potential geothermal reservoirs partly intersected in pre-existing petroleum wells. These 11 projects are located in Figure 2. Appendix A provides a summary of the operations of 14 companies with joint venture equity in Australian geothermal drilling and/or geophysical survey and/or power production operations in the term 2002 – 2008.

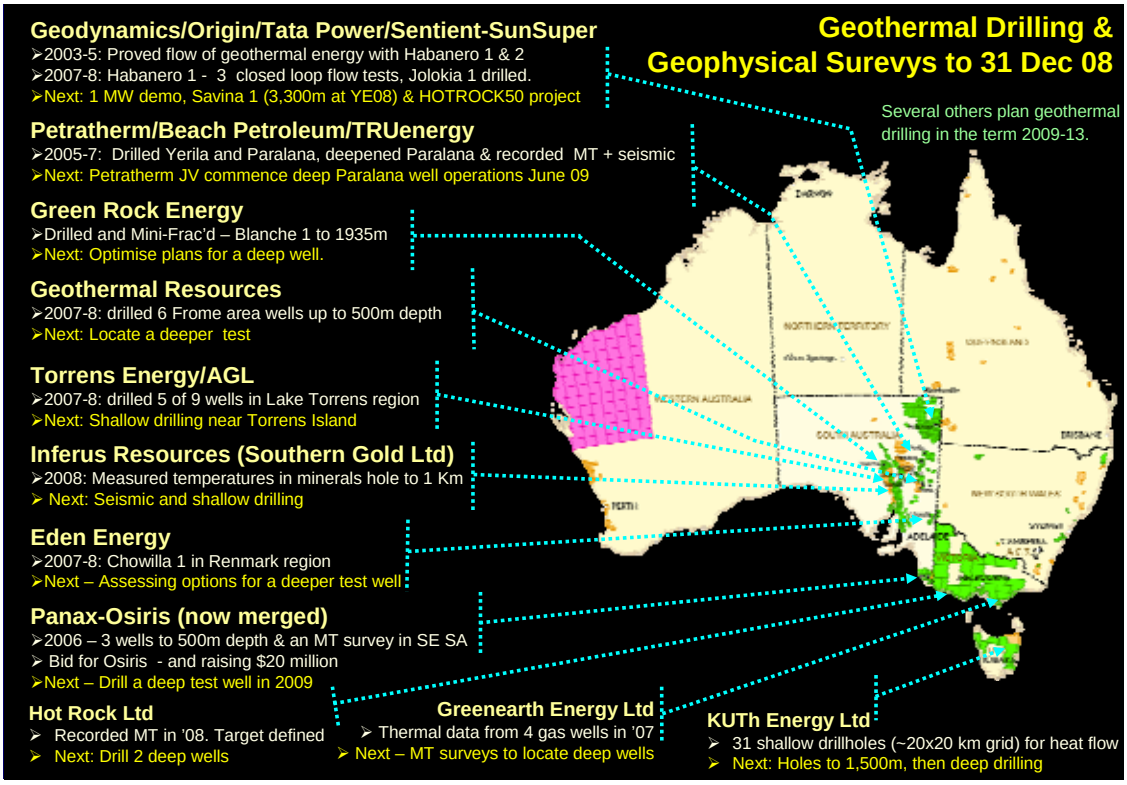

Figure 2. Geothermal drilling and downhole measurements to year-end 2008.

3 See http://www.aph.gov.au/Library/pubs/RP/BudgetReview2009-10/Climate_Energy.htm

4 For more information, visit: http://www.ga.gov.au/minerals/research/national/geothermal/index.jsp or see Budd et al. (2008)

1a Highlights and Achievements

Highlights and achievements to end 2008 are summarised as follows:

- At year-end 2008, 48 companies have joined the hunt for renewable and emissions-free geothermal energy resources in 385 geothermal licence areas covering ~ 358,906 km^2 in Australia. This represents a 39% increase in geothermal licences in the last year. Most (272 or 71%) of the areas applied for are GELs covering 126,866 km^2 in the state of South Australia. The balance include: 27 Geothermal Exploration Permits (GEPs) applied-for in the state of Queensland, 23 Geothermal Exploration Permits (GEPs) awarded in the state of Victoria covering a total area of 162,000 km^2, 21 Exploration Licences (ELs) for geothermal exploration have been applied for in the state New South Wales; 36 Geothermal Licences applied-for in Western Australia and 6 Special Exploration Licence (SEL) have been granted or applied for in the state of Tasmania.
- As at 31 December 2008, AU$1,523 million (US$1,066 million) in work program investment is forecast for the period 2002 – 2013. Approximately AU$325 million (US$227 million) of this forecast was invested in the term 2002 - 2008; 97% of which was spent in South Australia. This current forecast (for the term 2002 – 2013) represents an increase of AU$671 million (US$470 million) over the forecast for the same period stated in the 2007 annual report. These forecasts exclude capital expenditure associated with demonstration power plants.
- Highlights in legislation and acreage release activity in Australia are summarised in Section 2b.
- Drilling to test HR play concepts by geothermal licence holders was undertaken in 2008 by Geodynamics Limited., KUTh Energy Limited., Geothermal Resources Limited, Eden Energy Limited and Torrens Energy Limited.
- The Australian Federal Government's five year AU$58.9 million Onshore Energy Security Program conducted by the national geoscience and geospatial information agency (Geoscience Australia) continued to acquire precompetitive data and conduct research in support of geothermal energy exploitation. Geoscience Australia has consulted with industry, State and Territory governments and academic experts in developing its geothermal energy project plan. A nation-wide resource inventory was calculated from the Austherm temperature at 5 km dataset of Chopra and Holgate (2005). This work suggests a total thermal energy in place between a lower base of 5 km depth and an upper limit of the depth at which 150°C occurs of 1.9 x 10^{25} PJ. A map was produced that categorises outcropping granites by their radiogenic heat production and includes thickness of sedimentary basins. This map works as a first-pass geothermal play map.
- In the term 2000 - 2008, Australian Federal and State grants totalling ~AU$111 million (US$77.7 million) for geothermal research and exploration projects (detailed in Section 2d). Highlights in 2008 are:
    - The Australian Federal Government committed AU$50 million (US$35 million) for its GDP. The GDP will provide up to AU$7 million (US$4.9 million) for proof-of-concept deep drilling projects on a $:$ basis to establish flow rates at a sufficient temperature to support either power generation or an industrial process. Additionally, the Australian Federal Government has committed AU$300 million (US$210 million) from its REDP for meritorious, commercial-in-scale renewable energy demonstration projects. Separate budgets have been committed to support the demonstration of solar and carbon capture and storage technologies.
    - The NSW State Government has offered $10 million in matching funds for proof-of-concept drilling of a HR play in the Hunter Valley, NSW;
    - The West Australian State Government committed AU$2.3 million (US$1.6 million) to establish a West Australian Geothermal Centre of Excellence as a joint venture with the University of WA, Curtin University and the CSIRO.
    - A Federal Government Renewable Energy Demonstration Initiative (REDI) AU$2.3 million (US$1.6 million) grant was provided to KUTh Energy for its Tasmanian Tamar Conductivity Zone project.
    - The South Australian Government's continued support for the geothermal sector as contracting party to the IEA's GIA, secretariat for the AGEG, and providing AU$550,000 (US$385,000) in grants for geothermal research projects.

- The Australian Geothermal Energy Group (AGEG) is the peak Australian whole-of-sector representative body for industry, research and government organisations interested in the use of geothermal energy. The AGEG provides financial and intellectual support for Australia's membership in the IEA's GIA. The AGEG's vision is for *geothermal resources to provide the lowest cost emissions-free renewable base load and direct-use energy for centuries to come*. In the year to 31 December 2008, the AGEG increased from 65 to 92 member organisations including: an increase from 48 to 70 companies (including Australian licence holders and licence applicants and service companies); an increase from 8 to 11 Universities with geothermal research programs; and all Federal, State and Territory government agencies responsible for geoscience information provision, investment attraction and licence regulation for the geothermal sector. The organisational links of the AGEG and its Technical Interest Groups (TIGs) are illustrated in Table 1. The structure is devised to foster national and international sharing of information. The AGEG's membership is provided in Appendix D. For further information , see:
  http://www.pir.sa.gov.au/geothermal/ageg

  The AGEG's TIGs have active links to the International Energy Agency's (IEA's) research annexes, and will attain strong linkages to all other reputable international geothermal research clusters, to ensure that Australia's HR geothermal projects can leveraged on coordinated national and international expertise and geothermal research into improved technologies and techniques.

The Australian Geothermal Energy Group
- AGEG Members (**Industry, Government & Research Organisations**)
- AGEG Associate Members (**People and Organisations**)
- AGEG Student Members (**People**)
- AGEG Distinguished Members (**People**)

Research collaboration with:
- Companies
- Research Organisations
- International Energy Agency, International Partnership for Geothermal Technologies, International Geothermal Association; and other national and international Fora

AGEG Executive Committee (Member Representatives)
1. Chair (Australia's Exec. Comm. Mbr - IEA Geothermal Implementing Agreement)
2. Vice Chair (Australia's Alternate Exec, Comm. Mbr - IEA GIA)
3. Chief Executive Australian Geothermal Energy Association (AGEA)
4. Australia's Representative to the Board of the International Geothermal Association
5. Australia's Industry Representative to the International Partnership for Geothermal Technologies
6. Chair of AGEG-AGEA Code Committee
7. AGEG Technical Committee Leader
8. AGEG Technical Committee Leader
9. AGEG Technical Committee Leader

Linkages designed to foster the sharing of information

Ex. Drill costs

Ex. Reservoir rock catalogue

AGEG Technical Interest Group Sub-committees

Members - Associate Members - Students - Distinguished Members

Best practice protocols and communication				AGEG-AGEA Joint Venture Australian Partnership for Geothermal Technologies						
TIG1	TIG2	TIG3	TIG4	TIG5	TIG6	TIG7	TIG8	TIG9	TIG10	
Land access Legislated & 'best practice' protocols stakeholder engagement (Hazops, etc)	**Reserves and Resources** Joint AGEG' AGEA Code Committee	**Policy** Whole-of-sector forum. AGEA provides industry positions	**Outreach** Foster awareness & share info via presentations, web, FAQ sheets, education etc	**Getting to Markets** Technical aspects of transmission and distribution	**Power Plant** Technologies and Methods	**Direct Use** Technologies and Methods	**Data** Technologies and Methods for QA, Db, management, delivery and accessibility of data	**Reservoirs** Technologies and Methods for characterisation, models, etc	**Geophysical Operations** Technologies and Methods	**Well Operations** Technologies and Methods

Table 1: The organisational structure for the Australian Geothermal Energy Group (AGEG) and its Technical Interest Groups are designed to foster national and international sharing of information.

- Since forming in November 2007 from the AGEG's Technical Interest Group for Policy, Australia's peak geothermal industry association – the Australian Geothermal Energy Association (the AGEA) has grown to have 23 company members. The aim of the AGEA is to realise the potential for geothermal energy to provide both
  - A low-cost, emissions-free baseload of reliable and secure energy for the Australian national market over the next decade; and
  - A reliable, low-cost source of heat to drive energy efficiency and industrial applications.

AGEA and its members work with all Australian Governments, the academic community, relevant scientific organisations and the media to promote information about the progress of the industry and its capabilities. All members of the AGEA are also members of the AGEG.

- The AGEA and the AGEG have agreed to:
  - Coordinate research through the AGEG's 10 Technical Interest Groups (TIGs);
  - Designate TIG 2 as the AGEG-AGEA Reserves and Resource Code Committee. The purpose of this joint committee is develop and sustain an evergreen code for the reporting of geothermal exploration results, geothermal resource estimates and geothermal reserve estimates;
  - Designate AGEG as the Australian affiliate for the International Geothermal Association. and
  - Designate the Chief Executive of AGEA as the Chair of the AGEG's TIG for Policy, to assure industry's leadership in providing advice to government in relation to legislation, policies and programs

- The Australian Federal Government's Geothermal Industry Development Framework (GIDF[5]) was instigated in March 2007, and was published in December 2008. The GIDF sets out to identify the challenges for the Australian geothermal sector and to recommend actions, including high level national and international alliances, to encourage the development of a viable geothermal energy industry. The GIDF has been developed in parallel to a Council of Australian Government (CoAG) Technology Roadmap for the development of Australia's geothermal energy resources and technologies which was also released in December 2008. The Technology Roadmap has identified technology and research needs for the pre-competitive demonstration and subsequent development of geothermal energy resources. These initiatives follow the Australian Government's 2004 White Paper, Securing Australia's Energy Future, which classified hot dry rocks as a technology in which Australia had comparative advantages. Government support for geothermal exploration (research), appraisal (proof-of-concept) and demonstration projects manifest the view that geothermal energy has potential to contribute significantly to Australia's baseload electricity supplies, without generating greenhouse gas emissions. Initial drilling results indicate that Australia's HR resources are amongst the best in the world for the development of EGS.

- Significant opportunities for the direct use of geothermal energy are gaining recognition, in parallel to growth internationally in the deployment of direct use applications. In particular, ground-sourced geothermal heat pumps, circulating hot water for heating and drying applications, and the use of geothermal steam for osmotic desalination are forms of direct use that hold material potential for deployment in Australia.

2a Strategy

When invited to provide advice to the Australian Federal Government in March 2007, the Australian geothermal sector articulated the following vision and milestones, and since that time, strong bi-partisan support has been provided to support the attainment of the milestones at both Federal and State government levels:

Vision: Geothermal power as safe, secure, reliable, competitively priced, emissions-free and renewable base load power for centuries.

Milestones for the Vision – Geothermal Energy Roadmap

- Several successful research (exploration) and proof-of-concept (heat energy is flowed) geothermal projects. **At least 10 by 2010**.
  Status at 31 December 2008: Three locations (Habanero, Jolokia and Savina) have been drilled in the Cooper Basin, and Australian Federal Government GDP grants to be determined in 2009 will provide funding to support proof-of-concept projects at an additional seven locations.
- Several geothermal power generation demonstration projects in distinctively different geologic settings. **At least 3 by 2012.**

5 For more information, see: http://www.ret.gov.au/energy/clean_energy_technologies/energy_technology_framework_and_roadmaps/geothermal_industry_development_framework_and_technology_roadmap/Pages/GeothermalIndustryDevelopmentandTechnologyRoadmap.aspx

Status at 31 December 2008: Proof-of-concept was essentially attained at Habanero. At least 3 companies are expected to apply for support from the Australian Federal Government's REDP program to demonstrate geothermal energy production at commercially significant scales

- Compelling success with geothermal power generation demonstration so the investment community is convinced geothermal energy is real. **By 2012.**
  Status at 31 December 2008: The proponents of the most advanced geothermal projects in Australia have plans to progress to commercial scale deployment by circa 2015+, based on compelling evidence from earlier demonstration scale projects
- Safe, secure, reliable, competitively priced, renewable and emissions-free base load power from geothermal energy for centuries to come. **At least 7% of base-load demand from hot rock power by 2030**.
  Status at 31 December 2008: The proponents of the most advanced geothermal projects in Australia have plans to progress to commercial scale deployment by circa 2015+, based on compelling evidence from earlier demonstration scale projects

A continuing strategy for both the AGEG and AGEA is to foster awareness of the realistic potential benefits that will flow from the widespread use of geothermal energy. In this regard, the AGEA and the AGEG continue to provide advice as participants in the Reference Group for the implementation of the Australian Federal Government's GIDF which incorporates the CoAG Roadmap for Geothermal Technologies. Also, in 2008:

The AGEG made a submission to the Garnaut Climate Change Review. Download from: http://www.pir.sa.gov.au/__data/assets/pdf_file/0010/71389/AGEG_Submission_Garnaut_4April08.pdf

The AGEA made submissions as follows:

Subject of Submission[6]	**Web Reference to Download Submission**
Garnaut Climate Change Review:	http://www.agea.org.au/media/docs/agea_submission_garnautreview.pdf
National Renewable Energy Target scheme	http://www.agea.org.au/media/docs/national_ret_submission.pdf
Review of Energy Market Frameworks in light of Climate Change Policies	http://www.agea.org.au/media/docs/aemc_scoping_paper.pdf http://www.agea.org.au/media/docs/aemc_scoping_paper.pdf

The AGEA also commissioned a report "Installed capacity and generation from geothermal sources by 2020" (AGEA, 2008), to estimate the future electricity generation capacity of geothermal energy in 2020 and the price. The report highlights the potential of the Australian Geothermal Industry to make a significant contribution to Australia's future energy needs, with a forecast of 2200 MW baseload capacity by 2020 under current policy settings.

2b Legislation and Regulation (including acreage releases)

To end 2008, six states (New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia) have legislation in place to regulate geothermal exploration and development. The Northern Territory expects to have legislation in place by mid 2009. Relevant legislation is summarised below.

South Australia: The *Petroleum Act 2000* covers licensing and activity approvals for upstream petroleum, geothermal, gas storage and petroleum pipeline projects. The Petroleum Act has recently undergone a review and amendment process and will be renamed the Petroleum and Geothermal Energy Act 2000. A paper outlining proposed amendments to the *Petroleum Act 2000* closed for public comment on 29 June 2007. The Petroleum (Miscellaneous) Amendment Bill 2008 was released in April 2008 for public consultation. The intended changes will increase the maximum size of geothermal licences to 3,000 km^2 and lower licence fees. It is expected that the *Petroleum and Geothermal Energy*

[6] In the term to 30 June 2009, AGEA has also made submissions in reference to: the Carbon Pollution Reduction Scheme (http://www.agea.org.au/media/docs/senate_economics_inquiry_into_cprs_.pdf); and the Exposure Draft Design Features for the Expanded National Renewable Energy Target scheme (http://www.agea.org.au/media/docs/agea_ret_exposure_draft_submission.pdf)

Act, 2000 will be enacted in 2009[7]. See: http://www.austlii.edu.au/au/legis/sa/consol_act/pa2000137/.

The number (136 to 273) and extent (62,182 km^2 to 126,866 km^2) of Geothermal Exploration Licenses in South Australia increased by more than 100% in 2008.

Victoria: The *Geothermal Energy Resources Act* (GER Act) was passed in April 2005 and the *Regulatory Impact Statement and Geothermal Energy Resources Regulations 2006* came into effect during 2006. See: http://www.austlii.edu.au/au/legis/vic/consol_act/gera2005297/

The GER Act aims to encourage large-scale commercial and sustainable exploration and extraction of Victoria's geothermal energy resources. It does not apply to small-scale extraction operations or to exploration or extraction where the target in situ resource is less than 70 °C temperature or less than 1 kilometre below the surface.

To facilitate the development of these potential resources, the Victorian Department of Primary Industries conducted a public tender process for Geothermal Exploration Permits (GEP). A total of 5 companies accepted offers over 12 separate GEPs in 2007. These permits cover 73,000 square kilometres in southern Victoria with the companies committing over $64 million in expenditure over the five year term of the permits.

The number (12 to 23) and extent (74,000 km^2 to 162,408 km^2) of GEPs in Victoria increased by 92% and 120% respectively in 2008. This followed bidding in April 2008 on 19 permits, covering 154,000 square kilometres. In December 2008, 11 GEPs were awarded over an area of almost 90,000 km² to three companies. A further eight geothermal acreage areas remain unallocated in Victoria. These areas are likely to be offered for tender again at a later date as the geothermal industry in Victoria gains momentum.

New South Wales: The *Mining Act, 1992*, governing geothermal exploration in New South Wales is on its final review stage for a bill amendment. Currently geothermal exploration is considered Group 8 - Geothermal Substances. Application for a Group 8 geothermal exploration licence requires the Minister's consent especially if it is under mineral allocation areas, usually within coal basins. In other areas of the state over the counter applications are still accepted. If successful, a maximum 5-year term is granted based on work program commitments.
See: http://www.austlii.edu.au/au/legis/nsw/consol_act/ma199281/

In the last year, six Group 8 ELAs were received and all were granted titles. Two ELs have been renewed and ten Group 8 EL applications are currently under review.

NSW Department of Primary Industries is continuing its state wide geothermal resource assessment and data compilation. The Sydney Basin Geothermal data package has been completed and the Gunnedah Basin Geothermal package will be released shortly. New South Wales will be introducing a tender process for geothermal exploration licences for Sydney Basin.

Geodynamics received a $10 million grant under the NSW Climate Change Fund Renewable Energy Development Program to accelerate the exploration and development of its resource in the Hunter Valley.

Queensland: The *Geothermal Exploration Act 2004 and Geothermal Exploration Regulation 2005* provides a competitive permit system to encourage and facilitate efficient and responsible exploration for the State's geothermal resources.
See: http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/G/GeoExpA04.pdf

In 2008, the Queensland Government continued work aimed at expanding the scope of the current regime. The development of a proposed Geothermal Energy Bill to facilitate and promote the responsible management of both geothermal exploration and production activities is currently well advanced.

27 Geothermal Exploration Permits (GEP) covering over 15,461 km^2 have been offered to applicants following two highly successful acreage releases in late 2007 and mid 2008. GEP-17 was granted to

[7] The Petroleum (Miscellaneous) Amendment Bill 2009 was introduced into Parliament on 29 April 2009. It is expected that the new Act will be promulgated by the end of September 2009. See: www.pir.sa.gov.au/__data/assets/pdf_file/0010/100018/Petroleum_Miscellaneous_Amendment_Bill_2009.rd.158.pdf

Granite Power Limited on 1 June 2008 for a period of four years. Remaining high-bid applications are progressing through necessary approval processes.

There were no calls for tender in 2008 with planning for a call for tenders in 2009 being well advanced.

Tasmania: Geothermal exploration and development has been covered for over a decade by the *Mineral Resources Development Act* (1995) (MRD Act) and using this tried legislation, exploration has been able to be conducted with little regulatory impediment or uncertainty.
See: http://www.austlii.edu.au/au/legis/tas/consol_act/mrda1995320/

The MRD Act operates an 'over the counter' system, where explorers can apply for those areas wanted to be explored, and these co-exist with existing or future minerals and petroleum exploration titles. Geothermal tenements are granted as 'Special Exploration Licences' (SEL) which have cheap annual rentals and cover large areas. Initial grant is for 5 years, with annual reviews determining work programmes and mandated expenditures. An SEL can be renewed for an additional 5 years at the discretion of the Minister.

The MRD Act in its present form would allow a geothermal play to come into production via a Mining Lease but this is viewed as being impractical, due to the likely large size and exclusion of other resources exploration, and geothermal production aspects of the Act are currently under review.

To the end of 2008, 5 SELs for geothermal substances had been granted, totalling 22,663 km^2 [8]. See http://www.mrt.tas.gov.au

Western Australia: The West Australian (WA) *Petroleum and Geothermal Energy Resources Act 1967* (PGERA67) was proclaimed on 15 January 2008, providing legislative coverage for both conventional (hydrothermal) geothermal energy and hot dry rock geothermal energy. The legislation provides a clear legal framework for companies to pursue large-scale geothermal energy projects in the State. The PGERA67 is under the portfolio of the Minister for Resources and will be administered by the Petroleum and Royalties Division of the Department of Industry and Resources (DoIR)[9].

Western Australia had two open gazettal releases for geothermal exploration acreage during 2008 leading to bids for 46 areas covering some 75,500 km^2. Permits will be offered to 12 different companies during the first half of 2009. Three acreage releases are planned for 2009 including the re-release of the Perth area, the southern/eastern region and late in 2009 the interior/northern region.

Northern Territory: The Northern Territory of Australia Geothermal Energy Act 2009 has been passed and assented to and is expected to come into operation in mid-August 2009. The NT Government is in the process of developing the Regulations, Forms and Guidelines prior to triggering the Act. The intent is to reserve a relatively small region around the Katherine area, for later tendered release, while providing for "over-the-counter" application for geothermal authorities over the remainder of the Territory. To view the legislation, visit:
http://notes.nt.gov.au/dcm/legislat/Acts.nsf/830a91a0fb6c1fed6925649e0009c237/3049cc0938e9139a6925750e000a0a4c/$FILE/Actg013.pdf

2c Progress Towards National Targets for Renewable Energy and Emissions

In 2008, the Australian Government initiated development of a comprehensive set of policies and programs to support the development of renewable energy technologies in Australia which the geothermal sector will also benefit from. In addition, several initiatives were put in place specifically to support the geothermal industry.

Through the expanded Renewable Energy Target (RET), the Australian Government's goal is to have at least 20 per cent of Australia's electricity supply coming from renewable energy sources by 2020. This will provide a cross-subsidy to the renewable energy sector worth many billions of dollars. The Australian Government's modelling shows that by 2020, geothermal projects could take up one fifth of the target, or around 10,000 GWh.

The Government is also moving to meet its long-term national emissions reduction target of 60 per cent below 2000 levels by 2050, through the introduction of the national Carbon Pollution Reduction

8 A 6th Tasmanian SEL was granted in the term to 30 June 2009

9 Note: In January 2009, portfolio responsibilities passed to the Honourable Minister for Mines and Petroleum and is administered by the Department of Mines and Petroleum, through Petroleum and Environment Division.

Scheme (CPRS). Together with the RET, the CPRS will provide a very strong incentive for investment in renewable energy.

These policy initiatives are supported by two new funds: the $500 million Renewable Energy Fund and the $150 million Energy Innovation Fund. These funds should stimulate over $1.5 billion investment in renewable energy generation and are discussed in Sections 2d and 4a.

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

A total of AU$111 million (US$77.7 million) in Australian Federal and State grants have been committed to support Australian geothermal research, exploration and proof-of-concept projects for the period 2000 to end December 2008 (Appendix C). This tally excludes the AU$300 million (US$210 million) committed to support up to one-third of the costs of meritorious, non-solar demonstration projects under the Federal Government's REDP[10]; the Aus$72 million (US$50.4 million) State of Victoria's Energy Technology Innovation Strategy (DPI, 2008); as well as support from Australian Renewable Energy Certificates (ORER, 2008); and Australia's emissions cap and trade scheme (DoCC, 2008), all of which will be described in more detail in the following sections.

Federal Government

The Australian Federal government has committed AU$51.8 million (US$36.3 million) in grants for industry-backed, geothermal exploration and proof-of-concept projects in 2008. The majority (AU$50 million or US$35 million) of that commitment takes the form of the GDP that will be dispersed in 2009. A total AU$82.1 million (US$57.5 million) in Federal Government grants have been committed to underpin meritorious, industry-backed geothermal projects in the term 2000 – 2008. Descriptions of these grant programs are outlined in Section 4 (under Support Initiatives and Market Stimulation Incentives) and in Appendix C.

Renewable Energy Fund (REF)

Details of the REF are provided in Section 4a.

Energy Innovation Fund (EIF)

The $150 million EIF was announced in 2008 to provide $100 million through the Australian Solar Institute to support research and development in solar energy technologies. The Australian Solar Institute was launched in January 2009 and the interim management is developing guidelines for grant programs. The EIF will also provide $50 million for the Clean Energy Program (CEP) to support other clean energy research and development, including energy efficiency, energy storage and hydrogen. The Department of Resources, Energy and Tourism is currently developing guidelines for the CEP.

Geothermal Industry Development Framework and Geothermal Technology Roadmap

On 1 December 2008, the Minister for Resources, Energy and Tourism, Martin Ferguson, released the Geothermal Industry Development Framework (GIDF) and the Geothermal Technology Roadmap, joint efforts between industry, researchers and governments to identify the key challenges facing the geothermal industry in Australia, and actions to overcome these challenges.

The GIDF has been developed jointly by the Australian Department of Resources, Energy and Tourism and the AGEA. The Framework maps out a development path for Australia's geothermal industry and is designed to accelerate the development of geothermal energy in Australia. It contains 10 recommendations, each accompanied by several suggested strategies.

The GIDF recommendations include the following.

- Attracting investment
- Gathering geoscientific data
- Developing networks and international linkages
- Progressing research and development
- Building human capacity in the field of geothermal

The Geothermal Technology Roadmap, which was requested by the Council of Australian Governments, is part of the GIDF and identifies technology requirements for the geothermal sector

[10] The REDP is now part of the Clean Energy Initiative (CEI) announced in 2009, to be administered by the newly created Australian Centre for Renewable Energy (ACRE) for more information see: http://www.ret.gov.au/Department/Documents/CEI_Fact_Sheet.pdf.

throughout the geothermal project development process, from surface exploration to drilling to power plant construction and dealing with environmental issues.

The Roadmap makes recommendations for high priority technology needs, suggesting that key issues are for industry to demonstrate proof of concept by establishing circulation of geothermal fluids between wells in different geological settings, and to establish proof of concept power plants. The GDP (see above) already addresses this issue. Other priority technical needs include improving well technologies including fracture stimulation, geoscience to better understand Australian conditions, and power plant technologies including cooling in hot, arid climates.

The Roadmap proposes a collaborative approach to addressing these technology needs, drawing on expertise existing in the Australian geothermal industry, in other industries, particularly the electricity and oil and gas sectors, internationally, and in research institutions. Government leadership is suggested where agencies have required expertise, particularly pre-competitive geoscience data.

The GIDF and the Geothermal Technology Roadmap can be accessed at the homepage of the Department of Resources, Energy and Tourism, at www.ret.gov.au.

Australia's Onshore Energy Security Program
A part of the Federal Government's AU$58.9 million (US$41.2 million) funding over five years for Australia's Onshore Energy Security Program (OESP) will be directed towards the advancement of geothermal energy projects. This program is discussed in greater detail in Section 7b. Approximately AU$1,000,000 from this program has been spent directly on geothermal projects (including salaries) up until December 2008 and it is expected that a further AU$300,000 will be spent in 2009.

States and Northern Territory Governments
South Australia: A total of AU$1.6 million (US$1.1 million) in South Australian Plan to Accelerate Exploration (PACE) drilling and other research grants has been provided to underpin the advancement of geothermal energy projects since July 2004 (Appendix C). Two grants of AU$100,000 each were awarded to Petratherm Ltd and Torrens Energy Ltd in February 2008. PACE grants assist in addressing critical uncertainties in frontier geothermal exploration regions and include partial funding of shallow drilling, temperature logging and thermal conductivity analyses. The South Australian Government also continues to provide the secretariat for the AGEG and is the Contracting Party to the IEA's GIA for Australia. Research projects supported by the South Australian government are summarised in Section 7 herein.

Western Australia: Leveraging on studies concluded in 2007, the Department of Industry and Resources, Geological Survey has enabled easy access to onshore petroleum well log data and headers, including bottom hole temperatures and data necessary to estimate equilibrium geothermal gradients in the Perth, Canning and Carnarvon Basins. Further temperature data was gathered from water bores in the Perth Basin and more water bore data will be collected for the other sedimentary basins in 2008. These data will provide the basis for further studies.

The Geological Survey has also collected seismic, magnetic and gravity data for the Perth Basin and produced a combined well and geophysical survey data package to assist companies in assessments of the areas offered for work program bids in 2008.

In March 2008, the Western Australian Government committed $2.3 million for a grant to establish the Western Australia Geothermal Centre of Excellence (WAGCOE), a partnership between the University of WA, Curtin University and the CSIRO, to foster geothermal research into low-grade (up to 130°C) heat in permeable sedimentary settings such as the Perth Basin.

New South Wales: In 2007, as part of its New Frontiers initiative programme, the NSW Department of Primary Industries, Petroleum Geoscience Group initiated a project focused on mapping and identification of prospective geothermal energy systems. A suite of scientific data such as: granite geochemistry, potential field data, heat flow units, bottom-hole temperatures from petroleum wells have been compiled and presented as an ArcGIS project and forms the main portion of a comprehensive geological and geophysical database called 'The Sydney Basin Geothermal Data Package'. This is a first geothermal data package prepared by the New South Wales Department of Primary Industries and was released in 2008. A Gunnedah Basin geothermal data package is the next planned similar work to be concluded.

Tasmania: In 2006, Mineral Resources Tasmania launched its four year TasExplore initiative, which incorporates the acquisition of gravity and airborne magnetics and radiometrics, upgrading of the geology on north and northeast Tasmania and upgrading the 3D Geological Model of Tasmania. In focussing on the east and north-east granite terrain of Tasmania, this work will advance the understanding of the state's geothermal province.

Queensland: Under its Renewable Energy Plan[11], The Queensland Government has taken a number of steps that support the wider use of geothermal energy. Included are:

- $4.3 million committed to Ergon Energy for the new Birdsville Geothermal Power Station. The project will replace existing plant that is reaching the end of its design life with more efficient equipment that will use the existing wet geothermal resources more efficiently, producing more energy from these hydrothermal resources
- The Coastal Geothermal Energy Initiative (CGEI) is a $5 million drilling program that will build on existing geological data in Queensland. Its aim is to identify HR resources close to existing electricity transmission lines and population centres.
- The release of legislation covering geothermal energy production in 2009;
- An investigation of steps needed to commence a pilot geothermal project in Queensland by 2014;
- Starting to map geothermal resources in Queensland in 2009; and
- The provision of $15 million to establish the Queensland Geothermal Energy Centre of Excellence (QGECE) at the University of Queensland. The QGECE will establish a critical mass of scientific and engineering expertise providing the potential for development of large scale, zero emission geothermal power generation. The QGECE which will officially launch in 2009.

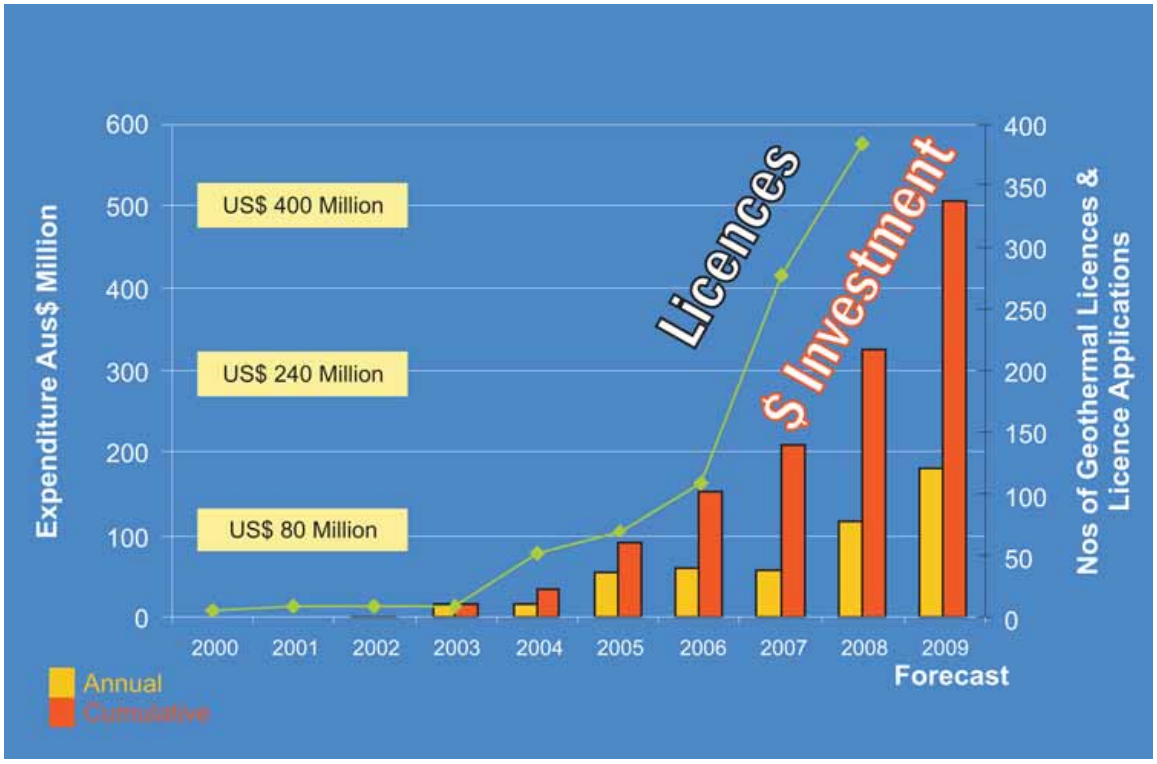

Figure 3: Growth in Australian Hot Rock and Hot Sedimentary Aquifer projects since 2000. Geothermal licence applications and exploration expenditure, 2000 to 2008 actuals and the forecast for 2009. Source: PIRSA

2e Industry Expenditure on Geothermal R&D

Australian geothermal industry field expenditure is classed as research and totalled AU$116 million (US$81.2 million) for the year 2008. This represents a 103% increase of AU$59 million (US$41.3 million) from the previous year. A 156% increase to AU$182 million ($US127.4 million) is forecast to be expended in 2009. Historical, current and projected expenditure for 2009 are highlighted in Figure 3.

[11] For details, see: http://www.cleanenergy.qld.gov.au/zone_files/Renewable_Energy/oce_rep_11_web_final.pdf

3 Current Status of Geothermal Energy Use in 2008

3a 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^{o}C and derives from the Great Artesian Basin (also referred to as the Eromanga Basin) that overlies the Cooper Basin. The water is run through a gas filled Organic Rankine cycle heat exchanger which heats and pressurises the gas which drives a turbine and alternator to produce electricity. The partly cooled water is channelled into a pond for further cooling and reticulation into the town's water supply and the lagoon. The gross capacity of the plant is 120 kW and the plant power consumption is 40kW, which equates to a net output of 80kW.

Total power generation in 2008 was 2,001,757 kWh of which 768,542 522,636 kWh was provided by the geothermal power plant. This equates to 38% of total power output.

In late 2007 Ergon Energy completed a feasibility study into whether it can provide Birdsville's entire power requirements and relegate the existing LPG and diesel-fuelled generators to be used only as a back-up at peak times such as the annual Birdsville races which attract large crowds for several days. The company is reviewing which steps it should take forward as a result of the feasibility study.

In response to Ergon Energy 2008 application for funding to replace the aging plant, the Queensland Government has committed $4.3 million for this purpose. For more information, visit: http://www.ergon.com.au/network_info/isolated_and_remote_power_stations

3b Direct Use

i. Installed Thermal Power

Australia's total installed capacity in direct geothermal applications is estimated to be 130 MW_{th}. This is up from the 2005 estimate of 109.5 MW_{th} (Lund et al. 2005).

ii. Thermal energy used (including capacity factor)

Following Lund et al. (2005) with a capacity factor of 0.9, the thermal energy used is estimated to be 3672 TJ/year, up from the 2005 estimate of 2968 TJ/year.

iii. Category use (space heating, bathing, heat pumps, etc)

District heating (space heating) constitutes the majority with an estimated 98 MW_{th}. Bathing and swimming installations total 8 MW_{th}. Ground Source Heat Pumps (GSHPs) constitute the remaining 24 MW_{th}. The GSHP installations include over 300 residence and several commercial sites. See Chopra (2005) and Appendix E for an abridged list of significant sites.

iv. New developments during 2008

The AGEA was founded late in 2007 to represent Australian Geothermal power generation and direct use industries. For direct use geothermal applications including GSHPs, AGEA is calling for government incentives and rebates. Any progress here will substantially increase uptake of GSHPs. Regional Development Victoria launched the Four Seasons Pilot Program which funds up to 50% of commercial and 100% of public GSHP installations in regional areas without a natural gas supply. Further, Sustainability Victoria is funding 20% of some commercial, innovative Direct Use installations through the Renewable Energy Support Fund (RESF).

New direct use installations include a resort in Warrnambool which uses 45º water drawn from a bore approximately 770 metres deep with a flow rate of up to 50 litres/second to provide domestic hot water, space heating, and pool and spa heating to a 122 room tourist facility. The estimated thermal capacity is 0.2 MWth or 5.6 TJ/yr. This project can abate up to 412 tonne CO_2-e/yr.

GSHPs can be broken into sub-categories: water-loop and refrigerant-loop or Direct Exchange (DX). Over the last two decades, only water-loop district heating and GSHPs have been installed in Australia. Over the last couple of years, DX GSHPs have been introduced to Australia. DX GSHPs are generally more viable for the residential and small-commercial markets: instead of 15-cm wide, 100-metre deep bore holes (as required for water-loop systems), only 5 - 7-cm wide, 15 - 30-metre deep bore holes are required, substantially reducing the drilling cost. There are now ten DX GSHP installations in Victoria with a total capacity of roughly 0.3 MWth. These include seven residences, a factory, council offices, and a ski chalet.

v. Rates and trends in development

In the face of increasing public and political will to act on climate change, rising energy prices, and an emerging GSHP industry, it is expected that the installation of GSHPs will accelerate.

vi. Number of wells drilled (production and reinjection)

Based on the assumption that a 30-metre bore for a DX GSHP has a 3.5 kW_{th} capacity and a 100-metre bore for a water-loop GSHP has of order 10 kW capacity, the estimated number of wells is 13,000.

3c. Energy Savings (Direct Use)

i. Fossil fuel savings/replacement (tonnes of oil equivalent per year)

The estimated fossil fuel savings is 87,440 tonne of oil equivalent (toe, 1 toe = 42 GJ).

ii. Reduced/avoided CO_2 emissions (tonne/year)

Using the DTI/Carbon Trust/DEFRA/Ofgem recommended figure of 0.43kg CO_2 per kWh saved yields avoided emissions of CO_2 of 439 tonne/yr.

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 support and accelerate commercialisation of renewable energy technologies and R&D in general including geothermal energy. For information of earlier programs that are no longer active or have been superseded including the START program, the Greenhouse Gas Abatement Program (GGAP), the Renewable Energy Commercialisation Program (RECP), Low Emissions Technology Demonstration Fund (LETDF), the Low Emissions Technology and Abatement initiative(LETA)[12] and the Renewable Energy Equity Fund (REEF), please see the Australian GIA Annual Report for 2007[13]. The following are current Federal and State government support initiatives:

i. **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 one REC for each MWh of electricity generated from an eligible renewable source.

ii. **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 AU$100 million program commenced in 2003 and will provide individual grants from AU$50 000 to AU$5 million over seven years. The REDI finishes on 28 April 2008, and will be supplanted with a number of new Government programs to support renewable and clean energy development in Australia. The following geothermal companies have been supported so far under the REDI scheme:

- In 2005, Geodynamics received AU$5 million for the construction and operation of a high efficiency Kalina cycle generation plant based on existing geothermal wells near Innamincka, South Australia;
- In 2005, Scopenergy Limited received AU$3.98 million for a proof-of-concept geothermal energy project on the Limestone Coast;
- In 2006, Geothermal Resources Ltd received AU$2.4 million to identify (with geophysical methods and drilling) and map the composition of granites in the Curnamona Craton region of South Australia;
- In 2006, Proactive Energy Developments Limited received AU$1.22 million under REDI for the development of a novel regenerator for adapting supercritical cycles to geothermal power applications;
- In February 2007, Petratherm Ltd received AU$5 million under REDI for its Paralana project to supply electricity to the Beverley mine in South Australia.; and
- In August 2007, Torrens Energy Ltd received AU$3,000,000 under REDI to undertake 3D modelling of HR resources in South Australia.

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12 For details see: http://www.environment.gov.au/settlements/programs/leta/index.html

13 Available from http://www.iea-gia.org/documents/GIA2007AnnReptAust_ECFinal31Dec08.pdf or http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/24979/2007_GIA_Ann_Rept_Australia.pdf

- In April 2008, KUTh Energy Ltd received AU$1,800,000 for drilling in its Tamar Conductivity Zone project area in northeast Tasmania.

iii. Renewable Energy Fund (REF) – The REF objectives include:

- leveraging around $1.5 billion worth of investment in renewable energy technologies through encouraging private investment with government funding;
- supporting a range of technologies across a range of geographic areas in Australia; and
- taking technology from the laboratory to the field to help prove a project's viability on a technical and economic basis.

The REF has three components[14]:

- **Geothermal Drilling Program (GDP).** AU$50 million (US$35 million) of the REF has been allocated for the GDP. The GDP (launched on 20 August 2008) provides up to one-half (on a $:$ basis, capped at AU$7 million or US$4.9 million) of the cost of proof-of-concept projects including drilling, stimulating and flow testing geothermal wells. The GDP is a competitive merit-based grants program Applications to the first round of the GDP closed on 5 January 2009[15].
- **Renewable Energy Demonstration Program (REDP) –**The objective of the REDP is to accelerate the commercialisation and deployment of new renewable energy technologies for power generation in Australia by assisting the demonstration of these technologies on a commercial scale. The REDP provides grants for eligible renewable energy power generation demonstration projects, of up to one third of the eligible expenditure of the project. The size of grants to successful projects is expected to be in the range of $50 million to $100 million. Renewable energy technologies eligible for the REDP are: solar, geothermal, wind, biomass, hydro systems, ocean energy, combinations of these technologies, and energy storage where it is part of one of those technologies. This designed to fill the gap between post-research and commercial uptake for renewable energy technologies. A large part of the REDP (AU$300 million equivalent to US$210 million) is set aside for the commercial scale demonstration of non-solar technologies (e.g. geothermal, ocean and bio-fuel demonstration projects); and
- **Second Generation (Gen2) Biofuels Research and Development Program – This portion of the REF provides** AU$15 million (US$10.5 million) for certain forms of bio-fuel research and development projects.

iv. Energy Innovation Fund (EIF) – The EIF has been established by the Australian Government to provide $150 million over five years to support the development of clean energy technologies. The aspect of the EIF that may become relevant to geothermal technologies includes $50 million for competitive grants for research and development in clean energy technologies. Relevant objectives of the Energy Innovation Fund include:

- accelerate the development of new and innovative clean energy technologies that will lead to medium to long term reductions in emissions from energy production and use;
- increase the level of collaboration within Australia and internationally on clean energy research and development; and
- create clean energy technology development, growth and export opportunities for Australian businesses

v. PACE – the **P**lan for **AC**celerating **E**xploration was launched in April 2004 by the South Australian government and includes funding for collaborative exploration programs that will address critical uncertainties in mineral, petroleum and geothermal exploration. The AU$22.5 million program (of which AU$10 million has been designated for direct drilling initiatives) will be operative until at least 2009. A total of AU$959,000 in South Australian PACE drilling grants has been provided to 7 geothermal explorers as listed in Appendix C. This includes PACE grants in February 2008 to Torrens Energy (AU$100,000) and Petratherm (AU$100,000). For details, see: http://www.pir.sa.gov.au/minerals/pace/theme_2/current_round_of_pace_projects

[14] For more information see: http://www.ret.gov.au/energy/energy%20programs/RenewableEnergyFund/Pages/RenewableEnergyFund.aspx

[15] Petratherm Ltd and Panax Geothermal Ltd were named as recipients of AU$7 million (US$4.9 million) GDP grants in April 2009. Bids for the second round applications (for circa five similar in size grants) close on 4 August 2009, with determinations expected later in 2009.

vi. **Renewable Energy Support Fund –** *Sustainability Victoria* offers a Renewable Energy Support Fund that helps to pay 50% of the capital cost for new operations (such as fish farms, horticulture and swimming pool heating). http://www.sustainability.vic.gov.au

vii. **NSW Climate Change Fund –** The NSW Climate Change Fund was established in July 2007. It includes $40 million Renewable Energy Development Grant (RED). The Climate Change Fund was established under the Energy and Utilities Administration Act 1987. It provides $40 million over five years to support projects which are expected to lead to large scale greenhouse gas emission savings in NSW by demonstrating renewable energy technologies in NSW and supporting the early commercialisation of renewable energy technologies in NSW. The Renewable Energy Development Program was open for Expressions of Interest for any renewable energy project, which will generate electricity or displace grid electricity use in NSW for stationary energy purposes.

4b Development Cost Trends

Drilling costs for high temperature non-sedimentary targets remain a challenge to be managed, especially while there is significant competition for a limited fleet of fit-for-purpose rigs. With each deep geothermal well drilled in Australia, learnings will be applied to foster more efficient operations in hostile, deep and hot hole conditions, including the development of increasingly resilient drilling assemblies. With increasing numbers of companies planning to drill deep wells, the opportunity will arise for one or more companies to commit to long-term arrangements for drilling rigs that can be expeditiously mobilised, commissioned, decommissioned and transported in a relatively low number of truck loads. Substantial increases in the cost of consumables and steel casing are also a challenge to efficiency.

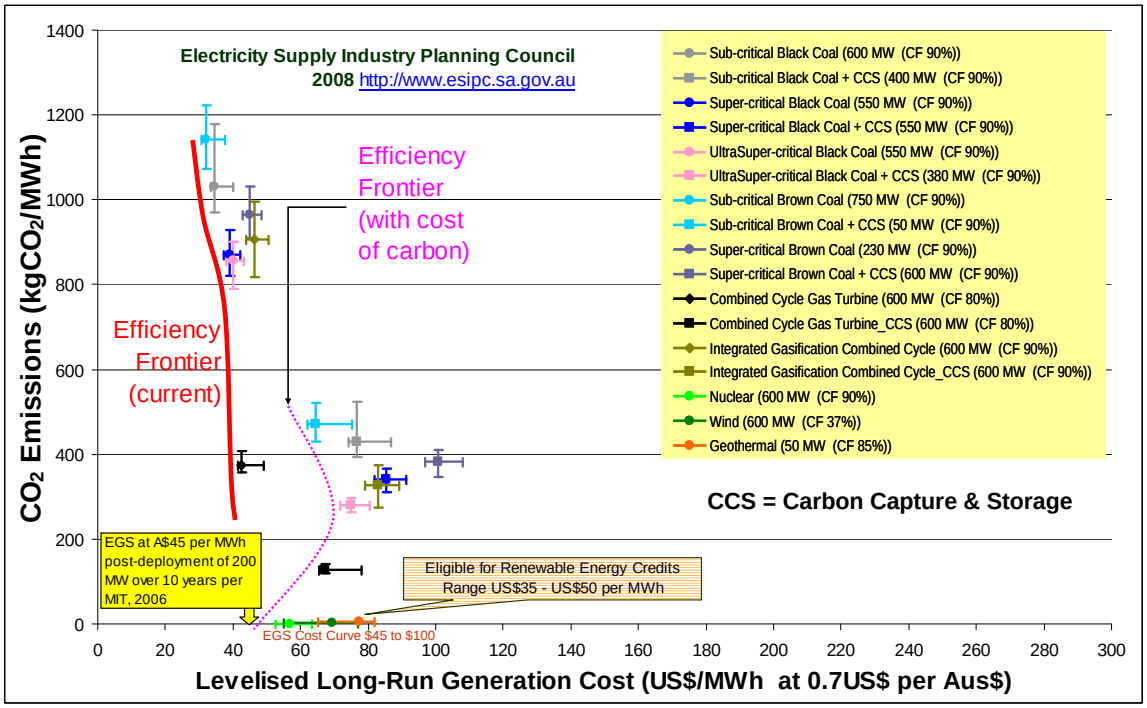

Figure 4: CO_2 emissions (Kg/MWh) on the vertical axis versus A$ costs to generate electricity power in Australia on the horizontal axis to indicate relative costs and CO_2 emissions from various fuels, with and without carbon capture and storage (geosequestration). Source: Electricity Supply Industry Planning Council 2008 Annual Planning Report., *http://www.esipc.sa.gov.au/webdata/resources/files/APR_Final_for_Website.pdf*

5 Development Constraints

Whilst geothermal energy resources in Australia have vast potential, geothermal power generation is not yet price-competitive, and remains to be demonstrated to be economic at price levels that may be realised with the addition of costs to constrain greenhouse gas emissions in the cost of electricity from emissive fuels such as coal and natural gas.

6 Economics

6a Trends in Geothermal Investment

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 by 2030 under a scenario that emissions are reduced to 70% of 2000 levels by 2030. The forecast 6.8% represents 5.5 GW in generating capacity from EGS. At roughly 2% growth, Australia's power demand will grow from approximately 50 GW current generation capacity to approximately 80 GW in 2030.

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

In a global market with carbon pricing, geothermal energy is likely to be a significant growth industry. The anticipated cost of EGS electricity generation in Australia has been estimated at $68-$128 per MWh (ESIPC, 2008). Without carbon pricing, many forms of conventional energy generation such as coal and natural gas are more cost effective.

Investors have continued to support capital requirements for geothermal projects, and funding has continued to increase in 2007, with ten companies now listed on the Australian Stock Exchange. By end October 2008, the market capitalisation of these ten companies amounted to more than AU$315 million.

6b Trends in Cost of Energy

Estimated costs to generate electricity from various fuels and plant-types are indicated on Figure 4. Australia's vast coal and gas reserves and resources are an important factor behind our very competitively priced domestic power supplies. Public opinion polls suggest that a majority of Australians would be willing to pay some price to help reduce greenhouse gas emissions. Certainly, the cost of energy is likely to rise in excess of the underlying rate of inflation if the cost of reducing emissions is factored into the price of power supplies. The precise timing and level of price increase is, however, uncertain.

7 Research Activities

Three states (Queensland, Western Australia and South Australia) have thus far set plans to support Centres of Excellence (CoE) in Geothermal Energy Research in local Universities.

The organisational structure of the AGEG and its TIGs (as illustrated in Table 1) are designed to foster national and international cooperation in planning for complementary, high priority research into advanced geothermal technologies and techniques.

7a Focus Topics

The principal focus topics of Australian research relate to challenges faced by proponents of drilling deep hot geothermal wells for the development of EGS and challenges shared in the development of EGS and HSA resources – including but limited to environmental impacts (such as potential induced seismicity and efficient water use), predictive production modelling, and pre-drill prognostication of geothermal reservoir potential.

Considerable alignment exists between the research priorities for EGS as determined in Australia (DRET, 2008), the USA (DoE, 2008), the EU (ENGINE, 2008) and most recently by the International Partnership for Geothermal Technologies (IPGT, 2008) –as summarised in Table 2. The list includes high priority techniques along with research priorities. Many of the technology targets will also assist the petroleum industry, and successful deployment of the associated services and equipment will also be relevant to HSA projects. These research directions are also aligned with GIA Research Annexes.

Share knowledge & drive complementary research	
Standard geothermal resource & reserve definitions	Improved / revolutionary HTHP hard rock drill equipment
Predictive production modeling	Improved HTHP zonal isolation, e.g. materials, methods and equipment to enable the temporary of permanent isolation of multiple zones in a single well
Predictive reservoir and stress field characterisation	Reliable HTHP submersible pumps for modest hole diameter
Mitigate induced seismicity / other HAZOPS	Enable well longevity (20-30 years), e.g. tubulars that are resilient to HTHP and potentially corrosive conditions.
Condensers for high ambient-surface temperatures	Optimum HTHP fracture stimulation methods
Use of CO_2 as a working fluid for heat exchange	HTHP temperature logging tools and monitoring sensors
Improve power systems	HTHP flow survey tools
Education / training	HTHP fluid flow tracers
Technologies & methods to minimise water use	Mitigation of formation damage, scale and corrosion
Exploration technologies to predict heat flow and reservoirs ahead of the drill bit	Research priorities shared with the petroleum industry

Table 2: International priorities for geothermal research –with a strong focus on unlocking the potential of magmatic resources. Several of these priorities are also targeted by the petroleum industry. Adapted from Goldstein (2009). HTHP: high temperature and high pressure

7b Government funded research

Geoscience Australia

Key activities of Geoscience Australia's geothermal energy project under the auspices of the Federal Government's five year (2006-2011) Onshore Energy Security Program during 2008 included continuing a series of factsheets by producing one on risks posed by induced seismicity, preliminary design work on a heat flow database, refining the geological datasets used in the Austherm05 dataset of Chopra and Holgate (2005), and installing a heat flow measurement capability comprising downhole temperature logging and thermal conductivity measurement equipment. Acquisition of seismic, MT, gravity, magnetics and geochemistry data continued in areas with energy potential. Technical advice was provided on numerous geothermal matters to the relevant Australian Government Minister and Department. A 3D model of the Cooper Basin was made and a new thermal modelling capability was trialled using the model.

South Australia

As detailed in Appendix C, in the term April 2005 through 2008, the South Australian Government has provided AU$1.6million (US$1.12 million) in grants for Australian geothermal projects and research, and additional support is expected[16].

In 2008, Primary Industries and Resources South Australia (PIRSA) made three tied grants to the University of Adelaide to foster competence and capacity in geothermal research in Australia. These include:

[16] The South Australian state government has committed an additional AU$2.24 million (US$1.57 million) for geothermal research and demonstration projects in the 6 months to 30 June 2009,

- As follow-up to Hunt *et al.* (2006)[17]. PIRSA provided AU$50,000 for research by the Australian School of Petroleum at University of Adelaide to extend the findings from a study area in the Cooper Basin to the Adelaide Geosyncline, and to establish generic protocols for managing potential risks posed by induced seismicity associated with the fracture stimulation of EGS wells. Operators of geothermal energy projects in 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 (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. The results of this follow-up research into induced seismicity (Morelli and Malavazos, 2008) was presented at the AGEG-AGEA Geothermal Energy Conference in 2008 with the final report to be released in 2009[18]; and
- To stimulate national cooperation in high priority geothermal research, PIRSA provided an AU$250,000 tied-grant in June 2007 to initiate HR geothermal research in the South Australian context, but open to project proponents from anywhere in Australia. The terms of the tied grant required projects to be endorsed by the geothermal sector – through the AGEG. The framework specified in the relevant Deed between the University of Adelaide and South Australia's Minister for Mineral Resources Development is designed to:
  - Enable and stimulate national and international collaboration in geothermal energy research with up to 80% of the funds for any single project (and up to 80% of the $250,000 tied grant) available to bring to bear expertise from outside the University of Adelaide;
  - 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) were invited to participate in this initiative, and/or complement the initiatives with ; and
  - Ensure that funded projects focused on what industry considered to be high priority research; findings underwent high quality peer review; and final reports of findings are prepared and made freely and openly available.

  All of the associated research remained in progress in 2008. Table 1 summarises the nature of the AGEG endorsed research projects underway under the PIRSA grant to the University of Adelaide. The aggregate budget for these AGEG endorsed research projects is AU$737,538 (including the AU$250,000 from PIRSA). 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. This initiative will be complementary to any/all other proposals from the Federal Government and other jurisdictions to support geothermal research. A further tied grant of AU$250,000 for additional geothermal research was provided to the University of Adelaide[19] in June 2008 on the same terms described above.

Queensland

The Queensland State Government provision of AU$15 million (US$10.5 million) to the Queensland Geothermal Energy Centre of Excellence (QGECE) at the University of Queensland will enable research relevant to the development of deep geothermal resources in South Australia and Queensland. Research priorities for the QGECE were established in 2008 – and key foci for research will include:

- New turbines for supercritical CO_2 cycles
- Natural draft dry cooling towers and efficient heat exchangers
- Electricity transmission and power network modeling
- Geothermal reservoir exploration , characterisation and management

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

[18] The final report by Morelli (2009) is available online at http://www.pir.sa.gov.au/__data/assets/pdf_file/0018/113616/rb2009_11_www.pdf

[19] A further AU$800,000 pa for two years has been granted by the SA Government to establish the Centre for Geothermal Energy Research at the University of Adelaide.

The QGECE will work with other national and international research groups to address all challenges that need to be overcome before deep geothermal energy becomes a proven commercial reality. The QGECE will also work with other Australian universities to introduce undergraduate and post-graduate programs to develop a skill base, and train postgraduate students. For further details of planned QGECE research priorities – see http://www.uq.edu.au/geothermal/docs/2009-QGECE-Research-Mar.pdf

In 2008, the QGCECE made a submission to the Garnaut Review to elaborate the prospectivity of circulating stored supercritical CO_2 in a closed loop through a hot dry rock reservoir both to yield geothermal power and sequester CO_2 as a by-product. For details, see: http://www.uq.edu.au/geothermal/centre-makes-submission-to-garnaut-review-on-climate-change

Western Australia

On the 29th of February 2008, the Western Australian State Government announced AU$2.3 million in funding for the WA Geothermal Centre of Excellence (WAGCOE). The Centre comprises three participants: CSIRO, The University of Western Australia, and Curtin University of Technology. Because of Perth's geological setting, the Centre is initially focussing on direct heat use technologies (e.g. geothermally powered air conditioning and desalination) for use in population centres where there is shallow groundwater of moderate temperature. Geothermal groundwater convection in settings such as the Perth basin provides a natural underground heat exchanger. Owing to the high natural permeability there is no need for artificial hydraulic fracturing. For 3-D modelling of these geothermal systems the Centre will harness the supercomputers now being set up in Perth, and will make it possible to drive geothermal research into computationally intensive directions that had previously been out of reach in Australia. The Centre will also offer geothermal training to students and industry. The research is organised in three interlinked Programs: 1) Assessment of Perth Basin Geothermal Opportunities using presently available data; 2) Optimal use of geothermal resources; 3) Identification of Future Potential by going deeper. For details, see: http://www.geothermal.org.au/

Northern Territory

The Northern Territory government has undertaken pre-competitive geologic studies to determine that the existing physiography and HR potential of an area in the vicinity of Katherine and within the zone covered by the existing major Northern Territory power transmission grid looks promising for geothermal exploration and proof-of-concept projects. Hot Springs in the Daly region 100km north west Katherine and at Mataranka 120km SE of Katherine coincide with an interpreted presence of a major crustal heat source in the region. Good regional magnetic, gravity and particularly radiometric coverage exists to be utilised by explorers to focus their research. The Northern Territory has commissioned an expert review of the geothermal potential of the Territory. The results of this study were presented at Annual Geoscience Exploration Seminar (AGES) at Alice Springs in March 2007 and has been released as a CD containing a summary report and GIS. The GIS is intended to be a toolkit for use by geothermal explorers, containing multiple layers of information relevant to the assessment of geothermal potential.

Victoria

Geological Survey Victoria (GSV) initiated geothermal exploration activities in Victoria by integrating and adding value to assorted petroleum, mineral and water datasets and by commissioning new temperature sampling in boreholes. In addition, GSV is supporting heat flow research work at Melbourne University and is collaborating with Geoscience Australia to acquire thermal conductivity and downhole temperature data.

Additionally, GSV has commenced a series of major studies that will better characterise the potential of Victoria's sedimentary basins and bedrock for geothermal potential. The core of these studies will be the construction, as part of GSV's four-year (to 2012) Rediscover Victoria in 3D initiative, of a fully attributed 3D geological model of Victoria's sedimentary basins and basement terrains. The model will include the key sedimentary horizons and surfaces in basins across the entire state. Basin and crustal architecture, as well as basin thermal structure and subsurface fluid flow, are key science themes of the initiative. The major sedimentary basins, the Gippsland, Otway and Murray basins will be evaluated sequentially. Detailed investigations will be undertaken into factors such as top seal integrity, reservoir and source rock quality and distribution and fault geometries. Integration of these data will allow the development of high-resolution, 3D fluid flow models.

Theme	Project Name	Summary of key project objectives	Research Partners
AGEG TIG 4 Engineering EGS	Geochemistry, Corrosion and Scaling in HDR Energy Extraction Systems	Determine the effect of variations in geochemical composition of circulating water on clogging of fracture networks in reservoir rock. Budget: $110,000 (50% from sector participants)	♦ U Adel (Ngothai & O'Neil) ♦ S.A Museum (Brugger) ♦ Ian Warke Inst. U of SA (Pring) ♦ Geodynamics (Wyborn) ♦ Petratherm (Reid) ♦ Eden Energy (Jeffress) ♦ Greenrock (Larking) ♦ PIRSA (Malavazos)
AGEG TIG 4 Engineering EGS	Full life-cycle water requirements for deep geothermal energy developments in South Australia	Water requirements for each step of geothermal through production will be quantified. An atlas of available water resources; processes for accessing these resources; and (possibly) software for calculating water requirements for specific projects will be developed. The aims are to allow individual project managers to manage water availability, and the industry to counter potential community concerns over water use for geothermal projects. Budget: $33,000 ($12,375 from PIRSA Tied Grant; balance from sponsor participants). Final report completed in 2008 (Cordon and Driscoll, 2008).	♦ Hot Dry Rocks Pty Ltd (HDRPL: Beardsmore, Baria, Cordon, Walsh, Waining & Cooper) ♦ PIRSA (Hill) ♦ Panax (de Graaf)
AGEG TIG 6 Engineering Power Generation	Preliminary assessment of the impact of geo-fluid properties on power cycle design	Study the relationship between the effect of non-condensable gas, fouling and corrosion caused by geofluid properties on surface heat exchangers and the heat transfer efficiency of the exchangers. Budget: $85,729 ($6,784 from PIRSA Tied Grant; balance from sponsor participants). Final report expected in 2009.	♦ U Adel. (Ashman, Gamboa & Nathan) ♦ Petratherm (Reid) ♦ Pac Hydro (Teoh) ♦ Eden Energy (Jefress) ♦ Greenrock (Larking) ♦ PIRSA (Malavazos)
AGEG TIG 6 Engineering Power Generation	Preliminary assessment of the potential for underground cooling on power cycle design	Test the cost-saving potential of using the thermally cool and stable soil layer to cool surface geothermal exchangers, pipework and plant. Compare different underground cooling systems with air cooling systems in Australian conditions. Budget: $44,550 ($22,275 375 from PIRSA Tied Grant; balance from sponsor participants). Final report expected in 2009 (Dally et al., 2009)	♦ U Adel. (Dally, Nathan & Ashman) ♦ Pac Hydro (Teoh) ♦ Petratherm (Reid) ♦ Eden Energy (Jeffress) ♦ Greenrock (Larking) ♦ PIRSA (Malavazos)
AGEG TIG 6 Engineering Power Generation	State of the Art in Power Cycles for geothermal applications and bottoming cycles	Make a detailed comparison of the performance and operating conditions of selected existing geothermal power plants with the range of conditions expected to apply in South Australia. Develop a detailed model of the Kalina cycle using HYSYS and compare with existing models - ORC and SC. Budget: $83,710 ($41,855 from PIRSA Tied Grant; balance from sponsor participants) Final report expected in 2009 (Doroodchi and Moghtaderi, 2009).	♦ U of Newcastle (Doroodchi) ♦ U Adel (Nathan & Ashman) ♦ Pac Hydro (Teoh) ♦ Petratherm (Reid) ♦ Eden Energy (Jeffress) ♦ Greenrock (Larking) ♦ PIRSA (Malavazos)
AGEG TIG 6 Engineering Power Generation	Development of a geothermal power plant cost estimator - Stage 1: basic estimates	Develop a model to estimate costs of geothermal power generation (South Australian conditions). The model will provide input options for key variables such as well depth, ambient conditions, geofluid temperature etc. Budget: $40,979 ($8,610 from PIRSA Tied Grant; balance from sponsor participants)	♦ U Adel.(Nathan) ♦ Petratherm (Reid) ♦ Eden Energy (Jeffress) ♦ Greenrock (Larking) ♦ PIRSA (Malavazos)
AGEG TIG 4 Geology EGS	Adelaidean reservoir characterisation	Characterise Adelaidean rocks for their potential to serve as heat exchange reservoirs within geothermal insulators and potential for geosequestration reservoirs in the vicinity of coal-fired electricity plants in the Port Augusta region Budget: $55,000 ($27,500 from PIRSA Tied Grant; balance from sponsor participants)	♦ U Adel. (Ainsworth) ♦ Petratherm (Reid) ♦ Eden Energy(Jeffress) ♦ Torrens (Matthews) ♦ PIRSA (Hill)
AGEG TIG 9 Geology Data Management	Forward prediction of spatial temperature variation from 3D geology models	Develop model for rapid calculation of spatial variations of temperature from 3D geology. Compare model-derived temperatures with observed to refine model. Demonstrate methodology via a case study of Petratherm's Paralana Project. Budget: $110,000 ($27,500 from PIRSA Tied Grant; balance from sponsor participants). A paper on this project was presented at the 2008 Australian Geothermal Energy Conference (Gibson et al., 2008).	♦ Intrepid (Gibson) ♦ Calcagno (BRGM), ♦ GA (Budd) ♦ Petratherm (Reid)Eden Energy (Jeffress) ♦ PIRSA (Hill)
AGEG TIG 4 Geology EGS	3D reconstruction of the Adelaide Geosyncline	Produce a geologically and geophysically sound 3D model of the Adelaide Geosyncline from studies of outcrop geology (existing geological maps, satellite images analysis, field work) and potential field data (gravity and magnetic data) interpretation and forward modelling. Budget: $248,324 ($27,858 via PIRSA Tied Grant; balance from sponsor participants). Final report by Backé and Giles (2008).	♦ U Adel. (Backe & Giles) ♦ U of Pau (France); ♦ U of Toulouse (France) ♦ HDRPL (Beardsmore) ♦ Torrens (Matthews)
AGEG TIG 2 Geol. / Engin../ Finance Reserve Definitions	Geothermal Reserve and Resource Estimates and Definitions	Establish a trustworthy code and guidelines for estimates of the in-place and extractable geothermal heat energy in hot rock resources. Sustain the draft to international peer review, including comments from the ASX, the JORC Committee, the IEA's GIA, AGEG members, and others. Budget: $27,500 (50% from sector participants) To view the *Code* (AGCC, 2008) please see the website link in the References.	♦ SKM (Lawless) ♦ Geodynamics (Williams); ♦ GA (Holgate); ♦ Petratherm (Reid) ♦ Torrens (Matthews) ♦ Greenrock (Larking); ♦ HDRPL (Beardsmore) ♦ Eden (Graham Jeffress) ♦ Intrepid (Gibson) ♦ PIRSA (Goldstein)

Table 3: AGEG endorsed research projects supported with joint PIRSA and geothermal sector support

8 Geothermal Education & Conferences

Geoscience Australia produced a new factsheets to supplement two previous factsheets, Induced Seismicity and Geothermal Power Development in Australia available at http://www.ga.gov.au/minerals/research/national/geothermal/index.jsp

PIRSA, as Contracting Party to the GIA and the secretariat for the AGEG has developed a geothermal web page that currently serves as a public portal to salient information pertaining to geothermal energy in Australia, including Australia's GIA membership. Members are detailed at the following webpage: http://www.pir.sa.gov.au/geothermal/ageg/membership

The Northern Territory proposes to develop web pages (as part of the Departmental web site) for geothermal education and information and will be seeking assistance from other State Governments and companies as the site develops.

There is a growing awareness of geothermal energy in Australia and this is reflected in the inclusion of geothermal energy within mainstream energy, petroleum and mineral conferences. On 19-22 August 2008, the inaugural Australian Geothermal Energy Conference was held in Melbourne, Victoria. This was attended by over 300 professionals from the geothermal sector, business and government. Forty-eight papers were presented over the 3 day conference. The conference was supported by a grant from the Sir Mark Oliphant International Frontiers of Science and Technology scheme administered by the Australian Academy of Sciences and the Australian Academy of Technological Sciences and Engineering. The Western Pacific Regional Branch of the International Geothermal Agency and the AGEG presented a pre-conference one day seminar on Geothermal Reservoir Management by Cedric Malate, Philippines National Oil Company.

9. International Cooperative Activities

Australia is a member of the IEA Geothermal Implementing Agreement. Geodynamics, Green Rock Energy and Petratherm are corporate members of the IEA Geothermal Implementing Agreement.

Petratherm has entered into an exclusive cooperative agreement with four Chinese government institutions to identify high prospect geothermal energy projects in China. The Asia Pacific Partnership (APP) which is supported by the Chinese and Australian governments will identify the potential for conventional geothermal, EGS, hot water and electricity plays in a number of provinces in China.

Geodynamics Limited and the Australian National University have formal agreements with Japanese researchers in geothermal energy.

PIRSA and Geoscience Australia have co-authored papers for presentation on the behalf of the AGEG at the annual Stanford Geothermal Workshops, annual Geothermal Resource Council Conferences, as well as international conferences of the American Association of Petroleum Geologists, the Society of Petroleum Engineers, and the Society of Exploration Geophysicists.

AGEG representatives held discussions on research directions with the venture capitalists and banks in North America and Europe; USA's Department of Energy (Renewable Energy Group), Lawrence Berkeley National Labs and deep well tubular manufacturers in Japan.

Australia is providing a Coordinating Lead Author for geothermal energy in Working Group III that is developing the Special Report on Renewable Energy scheduled to be published by the Intergovernmental Panel for Climate Change in 2010.

The French Bureau de Recherches Geologiques et Minieres (BRGM) has linkages with Intrepid Geophysics and Petratherm. 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.

International Partnership for Geothermal Technology

In August 2008, Australia became a founding member of the International Partnership for Geothermal Technology (IPGT) with Iceland and the United States. These countries are pursuing a range of activities in EGS, which is the key technology of interest to Australia.

The IPGT provides a forum for government and industry leaders to coordinate their efforts, and collaborate on projects. The IPGT Steering Committee includes both government and industry participants from each country. The IPGT has the advantage that it involves a small group of participants working on a specific subject; it is very focussed, relatively informal and flexible in responding to the needs of members.

The IPGT's approach to technology issues is first to identify the high priority technology needs of the industry (e.g. pumps, drilling, high temperature tools), then to seek to develop projects in each area with government and industry participants.

Further information can be found at the IPGT homepage; http://www.internationalgeothermal.org.

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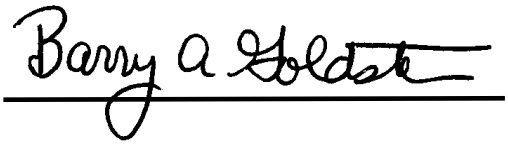

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Appendix A

Summaries follow of the activities of the 14 Australian geothermal licence holders who undertook well and/or geophysical survey operations in the term 2002 – 2008. Drilling has been undertaken by: the Geodynamics-Origin Joint Venture (5 deep holes, maximum depth of 4,911m); Green Rock Energy (1 hole to 1935m); Petratherm (3 holes, maximum depth 1,807m); Geothermal Resources (8 holes, maximum 1,761m); Inferus Resources (2 holes, maximum depth 1,034m); Torrens Energy (7 holes, maximum depth 760m); Panax (Scopenergy) (5 holes; maximum depth 531m); Eden Energy (1 hole, maximum depth 512m) and KUTh Energy (37 holes, maximum depth 300m). Greenearth Energy and Pacific Hydro gained access to boreholes to measure geothermal parameters and Hot Rock Ltd completed an MT survey near pre-existing petroleum wells. Ergon continued to operate the Birdsville geothermal power plant in 2008.

Eden Energy Ltd (ASX Code: EDE) has transferred its geothermal projects into a subsidiary company (Terratherma) that holds 23 geothermal licences covering just under 12,000 km^2. These include 22 GELs in South Australia and 1 Exploration Licence (EL) in New South Wales. EDE's South Australian licences are located in four distinct geothermal areas: (1) targets associated with buried radiogenic iron oxide and granites in the northern Torrens Hinge Zone, including the Witchellina project area northwest of Leigh Creek (GELs 166 – 168) and Coorichina in the Mulgaria basin NW of Lake Torrens (GEL 329-30); (2) an area where anomalously high heat flow has been mapped in the Renmark Project area north of the Murray River (GELs 175-176); (3) deep hot fractured granite targets in the Cooper Basin north of Moomba (GEL 185) and at Bollards Lagoon (GEL 169) and at Mungeranie, on the Birdsville Track (GEL 177); and (4) the Pirie area between Adelaide and Port Augusta (GELs 411-422).
Given success in its proof-of-concept drilling, Eden plans to target electricity markets, direct use applications and hydrogen production opportunities. Eden's first shallow heat exploration well, Chowilla-1, was drilled near Renmark to a depth of 512m in the first half of 2008, with the assistance of $100,000 from the PACE 4 initiative. For more information, visit http://www.edenenergy.com.au

Ergon Energy currently has the only operating utility owned geothermal power station in Australia. The power station uses low temperature bore water at ~ 98°C at a flow rate of 27 l/s and produces ~120kW gross and ~80kW net of energy. Ergon Energy is in the process of reviewing the remaining life of the power station and investigating options and plans to replace the aging equipment with new and more efficient geothermal generation equipment. For more information, visit: http://www.ergon.com.au

Geodynamics Limited (ASX Code: GDY) has the most advanced hot rock geothermal project in Australia. Geodynamics has first mover advantage in Australia with its Habanero-Jolokia-Savina project in granites beneath the Cooper Basin in northeast South Australia and is the only proponent with a proven EGS in its tenements. Geodynamics has drilled four deep wells and is drilling a fifth in this project area, including: Habanero 1 (Total Depth: 4,421 m), Habanero 2 (total depth: 4,357 m; 500m SE of Habanero 1), Habanero 3 (Total depth: 4,221 m; 550m NE of Habanero 1) Jolokia 1 (Total Depth: 4,911 m; 9.5 km WNW from Habanero 3) and Savina (Drilling ahead at 3,244 m on 19 December 2008 with a planned total depth of 4,250 m; 10km WSW of Jolokia 1 and 19km W of Habanero 3.). The granites at both Jolokia and Savina will be hotter at shallower depths than encountered in the Habanero wells. These wells will enable Geodynamics to firm up its reserves estimates and provide a choice for locating its planned 50 MW demonstration project.

The Habanero Project was the first and remains the most advanced Hot Rock 'proof of concept' project in Australia. Flow of geothermally heated formation waters (with 20,000 ppm Total Dissolved Solids) from Habanero 2 was achieved in 2005 at a maximum rate of 25 litres/second to surface at (up to) 210ºC. The geothermal reservoir in the Habanero wells is a water-saturated, naturally fractured basement granite (250ºC at 4,300 m as reported by Geodynamics) with permeability that was effectively enhanced by fracture stimulation. The connected EGS created at Habanero is laterally more extensive than achieved anywhere else in the world. Two fractured reservoir zones are present in the Habanero wells: a shallower, less permeable zone at 4,200 m; and a deeper, 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 4,300 m 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 subsequently drilled Habanero 3 with an 8 ½ inch hole through its Hot Fractured Rock (HFR) reservoirs (compared to 6 inch through reservoirs in Habanero 1 and 2). During testing, Habanero 3 was sustaining production of 208 °C formation water at a rate of 18 kg/second and at a flowing pressure of 27.5 MPa (3,990 psi) through a 12.5 mm fixed choke. The flow is directed to a steam separator designed for up to 25 kg/second input, the rate achieved with an output temperature of 210ºC from Habanero 2 in 2005. Produced fluids from Habanero 3 flow through a variable choke capable of increasing production. In one short experiment lasting 3 minutes the variable choke was opened to 100% and production of 40 kg/second was sustained over that period. Productivity is 400% higher than that obtained from Habanero 2 in 2005, where lost down-hole equipment impeded flow and eventually caused blockage from the main fracture zone. During production and shut-in of Habanero 3, the monitored well head pressure at Habanero 1 responded as expected, indicating good communication between the wells at 4,250 m depth. The high rates of injectivity into the heat exchanger from Habanero 1 and 2 and pressures measured at Habanero 1 and Habanero 3 during flow testing in

March 2008 indicate the presence of a large volume of low impedance, water saturated reservoir where the rock temperature is 250ºC (at 4.3 km). The flow tests of Habanero 1 and 3 are continuing in late 2008 through early 2009. Chemical tracer injection between Habanero 1 (the injection well) and Habanero 3 (the production well) commenced in mid December 2008 and will continue in 2009 as a further step in demonstrating commercial viability. The horizontal extension of stimulated reservoirs at the Cooper Basin site lends itself to multi-well developments. A small (1 MWe) power generation plant is expected to be commissioned in early 2009, and will supply electricity to the local town, Innamincka. That will be the final phase of work to precede Geodynamics' HOTROCK 50 project. That next step entails a proposed 9-well, 50 MW power station. The 9 wells will be drilled 1 km apart at 4 km depth. This will entail 4 injection wells and 5 production wells forecast to yield 10 MW net per well from flows of 120 kg/second/well. This will be an important milestone for the demonstration of EGS from HFR in Australia 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. Geodynamics has three key cornerstone investors, Origin Energy, Sentient/Sunsuper and Tata Power. Origin Energy has extensive upstream petroleum interest and Tata Power has extensive power station development interests. For more information visit http://www.geodynamics.com.au

Geothermal Resources Ltd (ASX Code; GTH) has three hot rock geothermal exploration projects: Frome, Crower and the Otway Basin, all in South Australia. The Frome project lies within the Arrowie Basin, which is underlain by some of the most radiogenic Mesoproterozoic granites in Australia, associated with numerous historic uranium occurrences in the Curnamona Province. In the Frome project area a large body of granite reached in Frome 12 is also 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. With the assistance of a Commonwealth government REDI grant of $2.4 million and a $100,000 PACE 3 grant by the South Australian government, the company completed 4 holes to approximately 500 metres depth on its Frome Project during 2007. Temperature logging indicated abnormally high temperatures within the sediments above the interpreted buried granite body, with geothermal gradients comparable to the Cooper Basin, thus vindicating the buried granite heat source model. Geothermal Resources drilled 3 wells in 2008 (Frome 5A, 10 and 11), providing encouragement to locate Frome 12 to reach up to 1,800 m (drilling at 1761 m in late December 2008. Samples of the granite in Frome 12 are reported as having 'well developed subhorizontal fracturing'. Geothermal Resources will log Frome 12 and then plan to drill at least two additional holes to roughly 1,800m in the Frome area during the first half of 2009. These wells will be tied to existing seismic data to select a deep well location. The Frome project is located some 120 kms away from the extension of the NEM to the township of Broken Hill. A number of active minerals exploration projects that lie between the Frome Project and Broken Hill are additional, potential future power markets.

Owing to current market conditions, Geothermal Resources will defer in the Crower project in favour of more drilling on the Frome project. Crower lies along the northern margin of the onshore Otway Basin where early Palaeozoic granites of the Padthaway Ridge dip beneath onlapping Jurassic to Cretaceous sediments.

Geothermal Resources was also granted 2 GELs in the South Australian Otway Basin in 2008, where pre-existing petroleum wells define a prospective HSA play.

For more information visit: http://www.geothermal-resources.com.au

Greenearth Energy Ltd (ASX Code: GRE) has 3 Geothermal Exploration Permits (GEP 10, 12 and 13) in Victoria covering 18,795 km^2 over prospective HSA and EGS plays in the onshore Gippsland Basin, in the Latrobe Valley and the Geelong areas. Two announcements of inferred geothermal resource estimates have been made by Greenearth, for GEP 10 in December 2008 and GEP 13 in January 2009. The inferred geothermal resource in the GEP 10 area was estimated at 260,000 PJ, covering an area of 462 km^2 and including both EGS and HSA prospects. The inferred resource estimate for the GEP 13 area was 3,600 PJ, over an area of only 27.5 km^2. This inferred resource estimate was confined within the area of a 2008 seismic survey which itself covered an area of 29km^2 – which is only 0.54% of the total GEP 13 area. With reference to this inferred resource estimate, Greenearth estimate that 10MWe could be generated over 30 years by recovering only 2.8% of the stored heat.

The seed capital for Greenearth came from companies that drilled a gas exploration well (within what is now one of Greenearth's GEPs) that flowed 90° C water from 2,200 metres in 2004. In addition to deriving valuable information from three petroleum wells in petroleum permits coincident with its geothermal licences: Hazelwood-1 (PEP 166 - total depth: 2,081m) and Boola Boola-2 (PEP 166 - suspended with a log total depth of 1,715m); Alberton-1 (PEP 158 – total depth: 998m).

In November 2008, Greenearth concluded a magneto-telluric ground resistivity (MT) survey in the Geelong/Bellarine Peninsula area (In GEP 10) to delineate permeable aquifers below 3 km in its licences. A pilot, 18 month trial of micro earthquake monitoring as an exploration tool will be implemented in 2009 in GEP 13 with a sonde to be placed at 1,430m in Loy Yang -2. This aims to help delineate major fracture zones. Shear wave splitting may also define potential permeable zones. For more information visit: http://www.greenearthenergy.com.au/

Green Rock Energy Ltd (ASX Code; GRK) has 16 GELs in South Australia (7 GELs covering 2,899 km^2 in proximity to Olympic Dam, 3 GELs covering 3,834 km^2 in the Cooper Basin and 6 GELs covering 1,938 km^2); 5 geothermal licence applications covering 3,950 km^2 in the West Australian Perth Basin and projects in Hungary.

Greenrock plans to commence drilling the first of two deep evaluation wells in proximity to the Olympic Dam mine in the second half of 2009. This will enable water circulation testing and follows hydraulic testing in the Blanche-1 well in 2008. The two new wells will be drilled a few kilometres to the west of Blanche-1, and approximately 15 kms from BHP Billiton's mining operation. An in-place resource estimate compliant with the AGEG-AGEA Geothermal Reporting Code defines 120,000 PJ of heat in place in a 460 km² area of Greenrock's Olympic Dam area GELs. Greenrock have estimated that the production of 3% of that 460 km² target area is enough heat energy to deliver 400 MWe for 30 years

In 2005 Green Rock drilled Blanche-1, its first exploratory diamond geothermal well, to 1,935 m (718 m of sedimentary rocks and 1,216 m of homogenous hot granite) 8 km from the giant Olympic Dam mine and 5 kms from a high voltage power transmission line connected to the national power grid. The target granite is interpreted to persist to depths of 6,000 m over an area of about 400 km^2 and represents a potential geothermal resource in excess of 1,000 MWe. Cores and wireline logs from Blanche-1 suggested natural fractures exist. In 2008, Green Rock undertook a mini-fracture stimulation program in Blanche-1 to inform the design of a deep well stimulation. Thirteen zones were tested and the well bore was imaged with a slim-hole acoustic televiewer to enable the analysis of fractures, post fracture stimulation. Greenrock was awarded a $68,000 South Australian PACE Grant to advance its Blanche project. Greenrock's project in Hungary targets the production of geothermal water for electricity generation and direct heat for industrial and agricultural uses. For more information, visit http://www.greenrock.com.au

Hot Rock Limited (ASX Code: HRL) holds five Geothermal Exploration Permits (GEPs 6, 7, 8, 9 and 23) in Victoria covering over 27,000 km^2 in the search for commercial hot wet rock targets. The permits are located proximal to transmission infrastructure and power markets. Prospective water temperatures have been measured in petroleum wells in HRL's Otway Basin GEPs, including: 143°C in Windermere 2 at 3,595 m in GEP 7; and 142°C in Ross Creek 1 at 3,659 m in GEP 8. HRL is planning to develop these hot wet rock resources. Future plans for HRL are to drill its first and second deep wells. The well locations are selected on the basis of information from existing well and reflection seismic data, and a magneto-telluric survey completed by HRL in mid 2008. Pending encouragement from its deep tests, HRL plans to commission a small binary power plant. The intended pilot plant will use standard, proven technology. HRL has estimated its GEP-8 Koroit project has power generation potential of some 200 MWe. Hot Rock Limited also holds an Exploration Permit (EPG 19) in Queensland, covering an area of 657 km^2. Hot Rock Limited is also investigating direct use markets for its geothermal energy. For more information visit: http://www.hotrockltd.com

Inferus Resources Pty Ltd is a wholly owned subsidiary of Southern Gold Limited (ASX: SAU). Inferus Resources has four GELs covering 1,990 km^2 in the eastern Gawler Craton (north of Port Augusta and south of Olympic Dam), within the South Australian Heat Flow Anomaly (SAHFA). Southern Gold took up these GELs after drilling two mineral exploration drill holes to depths of 996 m and 1034 m in which heat flows at up to 94.1 mW/m^2. Sedimentary rocks of the Adelaide Geosyncline provide insulation for trapping heat from the older basement rocks and granite in this play-trend. For more information visit: www.southerngold.com.au

KUTh Energy Limited (ASX Code: KEN) has geothermal licenses covering 14,171 km^2 in eastern Tasmania and has been named as the preferred tenderer for 2 geothermal tenements in Queensland. In its eastern Tasmania licenses, high heat producing granites are a recognised source of heat flows up to 159mW/m^2 (measured in shallow boreholes). KUTh completed an in-fill gravity survey in 2007 to delineate those prospective high heat producing granites, and that data indicates the target Hot Rocks below 3 to 5km of a sedimentary sequence (including some coal measures). KUTh has since drilled (in 2008) 37 drill holes to depths of 250-300m in a 20km x 20km grid across its eastern Tasmanian tenements. Measurements from these drillholes (to late November 2008) define a 5,000 km^2 area with heat flows of 92 to 118mW/m^2. From this, KUTh plans to undertake deep drilling and, ultimately, production drilling. The Tasmanian licenses were also applied for to capture 'direct heat' opportunities (industrial heating and drying) in urban and industrial areas. KUTh Energy's strategy is to establish a generation capacity within five years, and to have a commercial Direct Use project within three years. KUTh efforts in Tasmania have been assisted with a $1.8 million REDI Grant. KUTh's subsidiary companies have applied for geothermal exploration licenses in the Pacific Region. For more information visit: www.kuthenergy.com

Origin Energy Ltd (ASX Code: ORG) is a cornerstone investor in Geodynamics. In 2007, Origin purchased a 30% equity position in Geodynamics' South Australian geothermal tenements together with 30% of the Lightning drilling rig. In addition to its 30% share of on-going project expenditure, Origin Energy's forecast expenditure in Geodynamics' Cooper Basin project is expected to be about $150 million. Origin is a diversified energy company with more than 2,400 PJe of proven plus probable petroleum reserves – of which 90% is gas. Origin is significant producer of coal seam gas in Queensland. Origin owns and operates gas and wind fuelled power stations in Australia, and owns 51.4% of Contact Energy – a major electricity generator from geothermal and wind, and a wholesaler and retailer of natural gas and LPG in NZ. For more information see: http://www.originenergy.com.au

Pacific Hydro Ltd is owned by IFM Renewable Energy under the control of Industry Funds Services Pty Ltd. Pacific Hydro holds 18 Geothermal Exploration Licenses covering 9,000 km^2 in the South Australian extent of the Mesozoic Eromanga Basin (also called the Great Artesian Basin). 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 ºC/km, which suggests temperatures of 133 ºC at 2,000m in the Jurassic-aged (Hutton and Poolowanna Formations) hot wet sedimentary rock targets. Laboratory permeability tests of Hutton core samples and thin section analyses provide further verification of high permeability at target reservoir depths. One slim hole is planned to be drilled in 2009, in the gravity low (deepest, so hottest Jurassic targets) in the eastern section of Pacific Hydro's GEL. That drilling program will establish potential upside above the 133 ºC temperature projected from measurements taken at 1,500m. Theses wells will drill in a geological setting with benign fluid chemistry, high permeability and lateral continuity. This drilling aims to establish a very large scale hydrothermal resource that could be developed with existing technologies. For more information, visit: http://www.pacifichydro.com.au/

Panax Geothermal Ltd (ASX Code: PAX) acquired **Scopenergy** in October 2007 and merged with **Osiris Energy Ltd** in December 2008. The combined assets now held by Panax include projects in both the South Australian Otway and Cooper Basins. Panax's Limestone Coast Geothermal Project in the South Australian Otway Basin covers 3,127 km^2 in GELs 170-173, 184, 212 and 223. The Otway Basin in the southeast of South Australia represents an area of anomalously high heat flows proximal to the National Electricity Market transmission grid and with an extensive database of petroleum well and seismic data that define hot wet sedimentary rock targets.

These three sub-basins within the boundaries of Panax's GELs have an estimated generating potential in excess of 1,500 MWe. Scopenergy drilled three slim-hole wells (Heatflow 1A, 3A and 4) in the Limestone Coast Project near Millicent and Beachport in southeast South Australia in 2006. Surveys of those three slimholes added to measurements in 19 petroleum exploration wells and 26 water wells in the vicinity of Panax's tenements. This well data supports interpretations of temperatures of 170ºC or higher at depths between 3,300m and 3,700m and 186ºC to 200 ºC at 4,000m in Lower Cretaceous – Jurassic aged sandstones, and this prospectivity was recognised by the Federal Government through the issue of a $4 million REDI grant (not consummated). Panax is planning to drill a well in GEL 223 in mid 2009. Scopenergy was awarded a $130,000 South Australian PACE grant to advance understanding of the Limestone Coast Geothermal Project area.

Osiris has established an agreement with Protavia Pty Ltd to delineate potential to economically supply approximately 2 Petajoules of geothermal heat per annum for drying the final pulp in Protavia's (to be commissioned) paper pulp plant.

Panax plans to drill a deep test (Salamander 1) in its Otway Basin HSA play in 2009 with Weatherford Drilling International providing a newly constructed WDI Rig # 828, Le Tourneau "Lightning" Rig. For more information visit www.panaxgeothermal.com.au

Petratherm Ltd (ASX Code: PTR) is actively involved in projects in Australia, Spain and China, and is a leader in developing conventional, EGS and direct heat energy projects in Spain. Benefiting from a grant associated with the Asia Pacific Partnership on Clean Development and Technology Petratherm entered into an exclusive agreement with four key Chinese geological/geothermal institutions to undertake a co-operative assessment to identify prospective geothermal projects in China.

Petratherm has four geothermal projects in South Australia, which are the Paralana and Callabonna projects in the northern Flinders Range; and the Ferguson Hill and Stuart Shelf projects near Olympic Dam. Petratherm's most advanced Australian project is the Paralana Geothermal Energy JV Project.

Petratherm drilled two wells to establish thermal gradients down to about 600m above exceptionally high heat producing granites in South Australia. Results from both wells were encouraging, with the Callabonna and Paralana sites respectively exhibiting 68 and 81°C/km thermal gradients. In June 2006, the phase-2 drilling program at Paralana was successfully completed with the geothermal test well being extended to 1,807m. Geologic modeling indicates temperatures of 200°C can be expected at a depth of 3600m within insulating sedimentary overlying high heat producing granites at Paralana. Both the granite and the overlying sedimentary strata are expected to be susceptible to fracture stimulation. This concept of targeting geothermal reservoirs within sedimentary cover over high heat producing granites is referred to (by Petratherm) as its Heat Exchanger Within Insulator (HEWI) model. Petratherm has been successful in obtaining a $5M Renewable Energy Development Initiative (REDI) Grant from the Federal Government to assist in testing the HEWI concept. In addition, the Company has also received two grants worth $240,000 from the South Australian Government funded PACE scheme to underpin developmental components of the project. This funding is complemented by two significant Joint Ventures for the Paralana Project. In early 2007, Beach Petroleum Ltd entered an agreement with Petratherm to contribute up to $30M for a 36% interest in the Paralana project. In August 2008, TRUenergy (a wholly owned subsidiary of China Power and Light) has agreed to pay up to $57M to earn 30% equity in the Paralana Project.

Reflection seismic, magneto-telluric and passive seismic have been integrated to optimise the location of the Paralana 2 deep well. This has provided Petratherm with sufficient confidence to contract with Weatherford Drilling International to import a new 2,000 HP LeTourneau "Lightning" Drilling Rig. Petratherm expects to spud the Paralana 2 well in May 2009 and drill up to 4 kms deep. Given success in its first deep well, Petratherm plans to spud Paralana 3 well in early 2010. The next phase will be to use one well as an injector and a second well as a producer as a sub-surface heat

exchange system. Under the terms of the Paralana Joint Venture agreement, Beach Petroleum will take the lead role in the drilling operations required to create the underground heat exchanger. It is anticipated that the technical challenges to achieve long term heat extraction are lower within the sedimentary layer thereby potentially reducing project risks. The drilling and circulation work will be a precursor to constructing an electricity generation plant (of around 7.5MW) to meet the local power needs at Heathgate Resource's Beverley Uranium Mine, 10kms away. This plan is the subject of a Memorandum of Understanding between Petratherm and Heathgate Resources who own the mine. The Company's longer term development goal is to supply 520MWe into the national electricity grid.

In late November 2008, Petratherm gained title to a prospective HSA play in a 9,000 km^2 Geothermal Exploration Permit (GEP - 24) in Victoria's East Gippsland Basin.

In February 2007, Petratherm began the process of securing geothermal energy sites in Spain. The strategic entry into Spain has provided a first mover advantage for Petratherm which, to date, has eight projects on the mainland and in the Canary Islands spanning conventional geothermal, EGS and direct heating targets. Most advanced of the Spanish projects is the Geo-Madrid 8 MW District Heating project. Construction of the Geo-Madrid DH project could commence by November 2009 with geothermal heat production, and production to markets by July 2010. On the volcanic island of Tenerife, Petratherm is exploring for high temperature, conventional geothermal resources with the view of supplying 50MWe.

Petratherm's agreement with Chinese Government institutions is focused on securing tenure over high value geothermal projects in China. To date, work has focused on analyzing the various datasets provided by the Chinese institutions to identify projects develop project joint ventures. For more information, visit http://www.petratherm.com.au/

Teck Cominco Australia Pty Ltd is a subsidiary of **Teck Cominco (**NYSE Code: TCK and TSX Code: TCK.A and TCK.B) and has been offered South Australian GELs 294 and 295 covering 994 km^2 in the eastern Gawler Craton in proximity to Teck Cominco's Carrapateena Cu-Au discovery. Teck Cominco's exploration for geothermal resources has been implemented in parallel with its exploration and appraisal of the Carrapateena deposit discovery with temperature data collected in three Carrapateena drill holes. For more information see http://www.teckcominco.com.

Torrens Energy Ltd (ASX Code; TEY) has 21 geothermal licences and five licence applications spread across three areas covering 9,500 km^2 in South Australia. These three areas are located: (1) East of Lake Torrens and north of Port Augusta (GELs 230-235, 278, 285 and 407-410 totalling around 6,000 km^2); (2) The northern Adelaide Plains (GELs 227-229 and 263 totalling 1,963 km^2); and (3) Port Adelaide (GELs 226, 260-262 and GELAs 266 and 293 over a total of 1,868 km^2). The company also has one geothermal exploration permit (GEP) in Victoria. All of Torrens' licence and licence application areas are located close to the National Electricity Market transmission grid and markets. Torrens Energy drilled seven wells to depths ranging 501m to 760m in the northern extent of its licences east of Lake Torrens, in its Parachilna Play in 2007 - 2008. Determined heat flows ranged between 70–120 mW/m^2 – with the results calibrating an inferred in place resource for the Parachilna Play of 780,000PJ in August 2008.
Torrens next plans to record 2D seismic and magneto-telluric surveys in its Parachilla Play area and drill at least one shallow well (TKDH-1A) in the central extent of its East of Lake Torrens licences, south of Parachilla and north of Port Augusta, and at least one shallow well (Raitaro – 1) in its Port Adelaide play area in 2009. The information gained from wells to < 1km will be used to locate wells to intermediate depths (to <2km) in the Parachilla, north of Port Augusta and Port Adelaide areas. The aim of shallow (to < 2 km) exploration drilling is to delineate heat flow trends as a precedent to locating deep proof-of-concept wells to pre-heat feed-waters for coal and gas fired power stations and desalination. Torrens was awarded a $3 million REDI grant (in 2007) to develop, demonstrate and refine a 3D modelling method for the prediction of Hot Rock plays, and also a $100,000 South Australian PACE grant (in 2006) for heat flow exploration in the Adelaide Geosyncline.

In 2008, Torrens Energy entered into an agreement with Australian Gas & Light (ASX Code: AGL) to jointly develop geothermal resources for generation into the National Electricity Market (NEM). This agreement resulted in AGL: owning 10% of Torrens shares; having a first right of refusal to earn 50% of any Torrens geothermal project by funding the completion of a deep confirmation well, and act as a joint venture to find new geothermal opportunities through mid 2012 .For more information see: http://www.torrensenergy.com

Appendix B

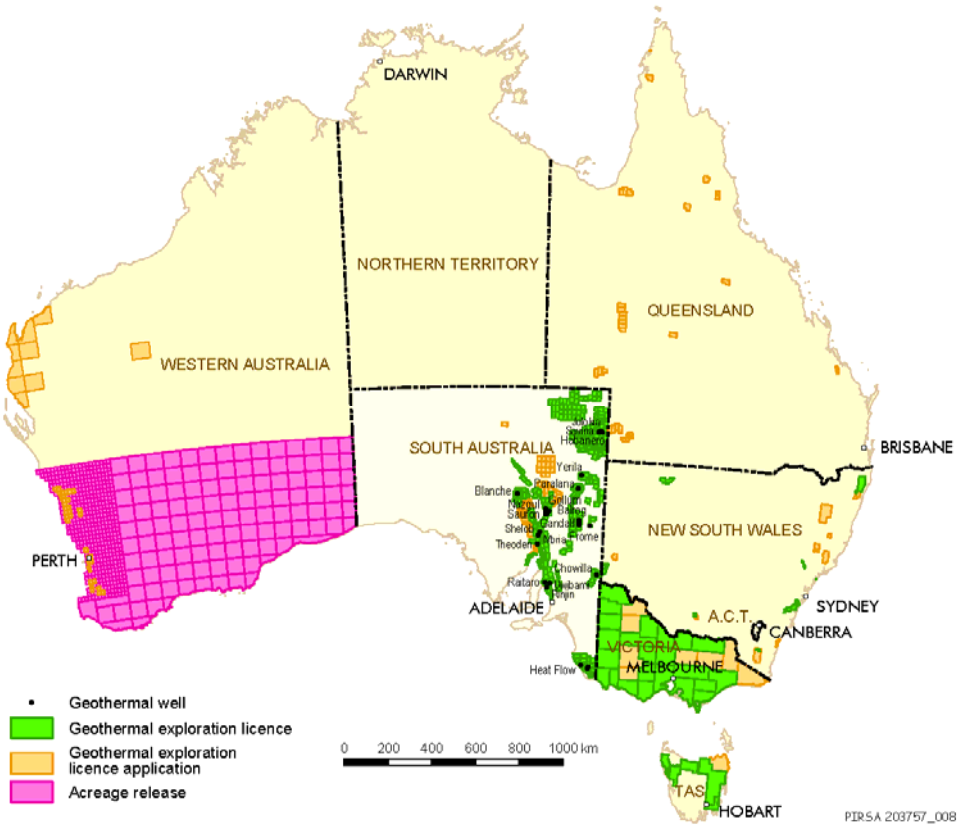

Figure 5: Australian geothermal licenses and license application areas to 30 June 2009.

Australian geothermal licenses and license application statistics at year-end 2007, year-end 2008 and 30 June 2009 are shown in Table 4.

Statistics for Australian Geothermal Leases	31 December 2007	31 December 2008	30 June 2009
Number of companies with geothermal licences and licence applications	33	48	48
Number of geothermal licences and licence applications	277	385	384
Area of licences and licence application	219,000 km^2	359,700 km^2	358,900 km^2
Estimated actual work program investment in geothermal licences (2002-to specified date)	AU$209,093,158	AU$325,148,424	~ AU$375 million
Estimated actual plus forecast work program investment in geothermal licences (2002-13)	AU$852 million	AU$1,523 million	AU$1,519 million

Table 4: Australian geothermal licenses and license application statistics.

Appendix C.

Ratio	Grant	Date	Recipient	Project	AU$ Amount
$:$	Fed. RECP	2000	Pacific Power/ANU	Hunter Valley Geothermal	$790,000
$:$	Fed. START	2002	Geodynamics	Habanero Project	$5,000,000
$:$	Fed. REEF	2002	Geodynamics	Habanero Project	$1,800,000
$:$	Fed. GGAP	Mar-05	Geodynamics	Kalina Cycle to produce 13 MW from waste heat, WA	$2,080,000
$:$	Fed. REDI	Dec-05	Geodynamics	Cooper Basin, SA	$5,000,000
$:$	Fed. REDI	Dec-05	Scopenergy	Limestone Coast, SA	$3,982,855
$:$	PACE 2	Apr-05	Petratherm	Paralana, SA	$140,000
$:$	PACE 2	Apr-05	Scopenergy	Limestone Coast, SA	$130,000
$:$	PACE 2	Apr-05	Eden Energy	Witchellina Project, SA	$21,000
100% of cost	SA Grant	Jun-05	U of Adelaide	Induced seismicity, Cooper Basin	$50,000
100% of cost	SA Grant	Dec-05	Geodynamics	Cost: benefit eval. of hot rocks to reduce national emissions	$40,000
$:$	SA PACE 3	Dec-05	Geothermal Resources	Curnamona Project, SA	$100,000
$:$	SA PACE 3	Dec-05	Green Rock	Olympic Dam Project, SA	$68,000
$:$	Fed. REDI	Jul-06	Geothermal Resources	Frome Geothermal Project	$2,400,000
$:$	Fed. REDI	Dec-06	Proactive Energy	Supercritical cycles to geothermal power	$1,224,250
$:$	SA PACE 4	Dec-06	Torrens Energy	Heatflow expl., Adelaide Geosyncline	$100,000
$:$	SA PACE 4	Dec-06	Eden Energy	Renmark Project, SA	$100,000
$:$	SA PACE 4	Dec-06	Geodynamics	High Temp. borehole imaging, Cooper Basin, SA	$100,000
$:$	Fed. REDI	Feb-07	Petratherm Ltd	Paralana Project, SA	$5,000,000
$:$	SA Grant	May-07	U of Adelaide	Induced seismicity protocols – SA	$50,000
$:$	SA Grant	Jun-07	U of Adelaide	AGEG Research	$250,000
$:$	Fed. REDI	Aug-07	Torrens Energy	3D modelling, hot rocks,, SA	$3,000,000
$:$	Qld Grant	Oct-07	U of Queensland	Qld Geothermal Energy Research Centre of Excellence	$15,000,000
$:$	SA PACE	Feb-08	Petratherm	Shear wave splitting for Hot Rock exploration	$100,000
$:$	SA PACE	Feb-08	Torrens Energy	2D seismic, Adelaide Plains	$100,000
$:$	REDI	Feb-08	KUTh	Tamar Conductivity Zone	$1,800,000
$:$	WA Grant	Mar-08	U of WA	WA Geothermal Energy Research Centre of Excellence	$2,300,000
$:$	SA Grant	Jun-08	U of Adelaide	AGEG Research	$250,000
$:$	NSW	Dec-08	Geodynamics	Drilling in Hunter Valley	$10,000,000
				Sub-tally in 2008 (Includes AU$50 Million GDP)	$64,550,000
				Sub-tally 2000 – 2008 (Includes AU$50 Million GDP)	$110,976,105
100% of cost	SA Grant	2Q-09	U of Adelaide	Innovative use of Hot Rock power, remote locations	$10,000
$:$	SA Grant	Apr-09	Geodynamics	50% of transmission line from Habanero to Innamincka from SA Regional Development Infrastructure Fund	$630,000
$:$	GDP	Apr-09	Petratherm Ltd	Fed Geothermal Drilling Fund - Paralana, SA	$7,000,000
$:$	GDP	Apr-09	PANAX Geothermal	Fed Geothermal Drilling Fund - Penola, SA	$7,000,000
$:$	GDP	In 3-4Q/09	TBD	Fed Geothermal Drilling Fund	$36,000,000
80% of $1m	SA REF	Jul-09	U of Adelaide	South Australian Geothermal Energy Research Centre of Excellence; $800 000 pa from State and $200 000 pa from the University for 2 years	$2,000,000
Excludes $300 million REDP available for meritorious, commercial-in-scale geothermal, ocean and bio-fuel energy demonstration projects				Total Government Grants (Includes AU$50 Million GDP)	$113,616,105

Abbreviations:

- RECP (Federal Government's Renewable Energy Commercialisation Program);
- REEF (Federal Government's Renewable Energy Equity Fund);
- GGAP (Federal Government's Greenhouse Gas Abatement Program);
- REDI (Federal Government's Renewable Energy Development Initiative);
- PACE (South Australia's Plan to ACelerate Exploration);

Table 5: Australian Federal and State Government grants awarded for geothermal research, proof-of-concept (including exploration geophysical surveys, drilling and well surveys/tests), and demonstration projects in Australia 2000 – June 2009 (sub-tallies for 2008 and 2000-2008 also provided).

Appendix D. Australian Geothermal Energy Group Membership

Australian Geothermal Energy Group (AGEG) Members

17 July 09

http://www.pir.sa.gov.au/geothermal/ageg

ASX-Listed (Code)

AGEG'S VISION: Geothermal resources to provide the lowest cost emissions- free renewable base load and direct-use energy for centuries to come.

Company Members

1. AGEA (Industry Group)
2. AAA Energy
3. ACILTasman
4. Activated Logic
5. AGL (AGL)
6. Balance Energy
7. Beach Petroleum (BPT)
8. BurnVoir Corporate Finance
9. Callabonna Energy
10. Clean Energy Australasia
11. Deep Energy
12. Earth Heat
13. Earthinsite
14. Earth Solar Power
15. E-Connect
16. Eden Energy (EDE) (Terratherma is a subsid.)
17. Electranet
18. Encom Technology
19. Energycore
20. Ergon Energy - owned by the Qld G'ment
21. Finlayson
22. FrogTech
23. Geodynamics (GDY)
24. Geogen
25. Geopower
26. GHD
27. Google (NASDAQ) - RE<C Team
28. Gradient Energy - Planet Gas subsid (PGS)
29. Granite Power
30. Greenearth Energy (GER)
31. Greenrock Energy (GRK)
32. Geothermal Resources (GHT)
33. Geothermal Advisory Pty Ltd
34. Halliburton (NYSE listed)
35. Hitech HIPPO
36. Hot Dry Rocks Pty Ltd
37. Hot Rock Ltd (HRL)
38. Hot Rocks Tasmania
39. Hydro Aluminium
40. Icon Energy (ICN)
41. Inferus Resources (Southern Gold subsid. (SAU)
42. Intrepid Geophysics
43. KUTh Energy (KEN)
44. KPMG
45. KTM Capital
46. Monaro
47. Macquarie Capital Products Limited (MQG)
48. Marubeni-Itochu Tubulars (Japan)
49. Mitsubishi Heavy Industries (Japan)
50. Near Surface Geothermal Energy
51. New Energy Finance
52. New World Energy
53. Origin Energy (ORG)
54. Osiris Energy (merged with PAX)
55. Panax/ Scopenergy (PAX)
56. Petratherm (PTR)
57. Pacific Sensor Technologies
58. Pacific Hydro
59. Red Hot Rocks
60. RPS Energy
61. Schlumberger (NYSE)
62. Senergy
63. Sinclair, Knight, Merz
64. Snowy Mountain Engineering
65. Strategic Chemistry
66. Stuart Petroleum (STU)
67. Sumitomo (Japan)
68. Syncline Energy
69. Teck Cominco (Toronto Exch)
70. ThermaSource
71. 3D-Geo
72. Terra Therm
73. Torrens Energy (TEY)
74. Tri-Star Energy
75. TRUenergy (Owned by China Light & Power, HK)
76. VEMTEC
77. Weatherford (NYSE)
78. Worley Parsons (WOR)

Research Institution Members

1. Curtin
2. Monash
3. University of Melbourne
4. University of Adelaide
5. University of Newcastle
6. University of NSW
7. University of Queensland
8. University of South Australia
9. University of Sydney
10. University of West Australia
11. University of Tasmania

Government Members

1. Fed. Government (RET, GA, CSIRO, EWH&A, CC)
2. South Australia (Chair)
3. Victoria
4. Western Australia
5. Queensland
6. Tasmania
7. Northern Territories
8. New South Wales

97 Members & Growing

Appendix E

A list of current commercial, water-loop GSHP installations in Australia are listed in Table 6.

New South Wales	Lithgow Hospital, Lithgow	Cowra Shire Council Offices, Cowra
	NPWS Tourist and Information Centre, Jindabyne	Wagga Wagga Civic Centre, Wagga Wagga
	Macquarie University, North Ryde	Surry Hills Community Facility, Surry Hills
	Detention Centre, Dubbo	
Australian Capital Territory	ACTEW Corporation, Canberra	Airport Caltex, Pialligo
	Geoscience Australia, Canberra	ANU Research Laboratory, Canberra
	Duntroon Headquarters, Canberra	
Tasmania	Grand Chancellor Concert Hall, Hobart	Antarctic Centre, Hobart
	Queen Victoria Museum and Art Gallery, Launceston	Westpac Call Centre, Launceston
	Southern Cross Homes/Aged Care, Moonah	Hobart Aquatic Centre, Hobart
Victoria	Victoria University of Technology, Werribee	Station Pier, Port Melbourne
	Paynesville Pool, Paynesville	
South Australia	Royal Adelaide Hospital, North Terrace	Coober Pedy Police Station, Coober Pedy
	Bureau of Meteorology, Kent Town	Mt Barker TAFE, Mt Barker
	Garden East Apartments, Adelaide	
Queensland	University of Southern Queensland swimming pool, Toowoomba	Logan Institute of TAFE, Logan
Northern Territory	Bureau of Meteorology, Darwin	

Table 6: Commercial water-loop GSHP installations