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HOT ROCK GEOTHERMAL ENERGY PLAYS IN AUSTRALIA

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ABSTRACT

Hot Rocks have potential to fuel competitive, emission free and renewable electricity for centuries to come. This potential is stimulating Enhanced (Engineered) Geothermal Systems projects worldwide, calling upon integrated expertise from the petroleum, minerals and power industries.

Converting just 1% of Australia's estimated Hot Rock crustal energy to electricity, from temperatures above 150°C and depths below 5 km (190 million PJ) would supply 26,000 years of Australia's primary power use, and that neither takes into account the renewable characteristics of hot rocks, nor resources below 5,000m.

Factors that distinguish Australian Hot Rock resources are: (1) Very radioactive granites are abundant, as in South Australia where the mean heat flow is 92μWm-2 compared to a global continental average of 51μWm-2[1]; and (2) Australia is converging with Indonesia on a plate scale – giving rise to common, naturally occurring sub-horizontally fractured basement rocks that are susceptible to hydraulic fracture stimulation.

Australia's geothermal projects are focused on both Hot Rocks to develop Enhanced (Engineered) Geothermal Systems and associated Hot Sedimentary Aquifer plays to fuel binary power plants. In addition to meeting demand for base load power, mining, desalinisation and drying processes are also markets for geothermal energy.

In the term January 2000 through December 2008, companies have applied for 385 licence areas (covering 359,723 km^2) to progress proof-of-concept amagmatic Hot Rock and Hot Sedimentary Aquifer projects in Australia. In the term 2002 through 2008, more than Aus$325 million (US$228 million) has been spent on studies, geophysical surveys, drilling, reservoir stimulation and flow tests that comprise the work programs required to sustain tenure in geothermal licences areas. In the term 2002-2013, investment for Australian proof-of-concept geothermal projects is expected to exceed Aus$1,523 million (US$1,066 million).

This rapidly rising level of investment is driving sector-wide cooperation to support high priority and complementary research that can speed the pace and lower the cost of commercialising Australia's vast Hot Rock (HR) and Hot Sedimentary Aquifer (HSA) geothermal plays. That cooperation is underpinned with more than Aus$110 million (US$77 million) in Australian Federal and State government grants to meet up to half of the cost of the private sector's field efforts. This includes Aus$60 million (US$42 million) available to support new deep drilling for the proof-of-concept HR and HSA projects, but excludes Aus$507 million (US$355 million) for all forms of meritorious, commercial-scale demonstration of renewable energy technologies, including geothermal projects.

This paper summarises: (1) proof-of-concept amagmatic HR and HSA geothermal projects co-funded by investors and governments in Australia; (2) policies, programs and alliances put in place to support the development of geothermal plays; (3) research priorities and studies undertaken in support of geothermal projects and (4) emerging protocols to build trust with stakeholders, including a reporting code for geothermal resource and reserve estimates and best practice procedures for the management of potential risks associated with induced seismicity.

These collateral efforts are all directed at having at least 10 successful research and proof-of-concept geothermal projects by YE 2012/13, and at least 3 power generation demonstration projects in distinctly different geologic settings by 2012/13, with the results providing compelling evidence to justify

[1] In comparison to the heat generated from typical granites (2.65 mWm-^{3}), the granites that are the source of geothermal energy for projects in the South Australian Cooper Basin and Flinders Range produce heat respectively at rates of 11 μWm^{-3} and 62 μWm^{-3}. (Hillis, 2008).

investment in the development of Australia's vast Hot Rock and Hot Sedimentary Aquifer plays.

Success in Australia will have positive implications for similar projects elsewhere.

INTRODUCTION

Energy from amagmatic Hot Rocks is a source of inexhaustible, 24/7, free fuel for zero-emission power generation. These characteristics make Hot Rocks and associated Hot Sedimentary Aquifer resources desirable additions to the world's portfolio of safe, secure and competitive energy supplies.

Prospective Hot Rock plays are defined where heat energy source rocks are: within drillable depths; either naturally permeable, or susceptible to fracture stimulation; and overlain with insulating (usually sedimentary) rocks.

The subsurface in Australia is relatively hot at modest depths (Figure 1). This vast store of radiogenic geothermal energy relates to extensive, anomalously radioactive Proterozoic granitoids, the best known examples being those associated with the South Australian Heat Flow Anomaly (Figure 2) where the mean heat flow is estimated to be 92±10 μWm^{-2} compared to 51–54 μWm^{-2} for continental crust.

Australia's convergence with Indonesia on a plate scale gives rise to common, naturally occurring sub-horizontally fractured basement rocks that are susceptible to hydraulic fracture stimulation. This geologic endowment is now recognised as a comparative advantage for the development of Enhanced (Engineered) Geothermal Systems and is a driver for both private investment and government support for several amagmatic geothermal proof-of-concept projects. Australia's long history of shared investment in mining and energy operations is also a key factor in Australia being recognised as leading the world in 'exploiting subterranean heat' (The Economist, 2008)

In 2008 Geoscience Australia (the Australian Federal Government geoscience agency) estimated that converting just 1% of the total contained energy shallower than 5km and hotter than 150°C in the Australian continental crust (190 million PJ) is equivalent to roughly 26,000 years of Australia's primary power usage (Budd, et al, 2008).

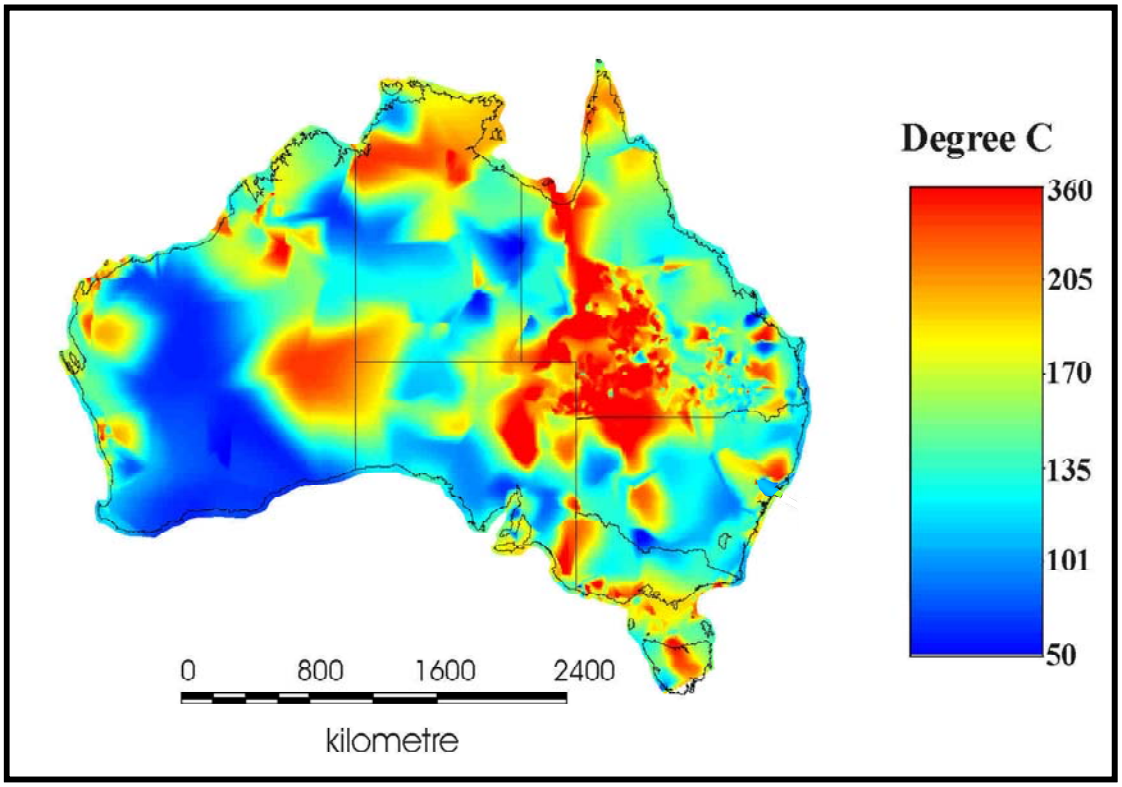

Figure 1: Estimated temperatures at 5 km in Australia (Sommerville et al., 1994). An alternative estimate of crustal temperature at 5 km has been derived from the Austherm database by Chopra & Holgate (2005). Both interpretations are based on available (in places sparse) data and it is likely additional areas of relatively high temperature (> 200° Celsius above 5 km) will be identified in areas not yet depicted.

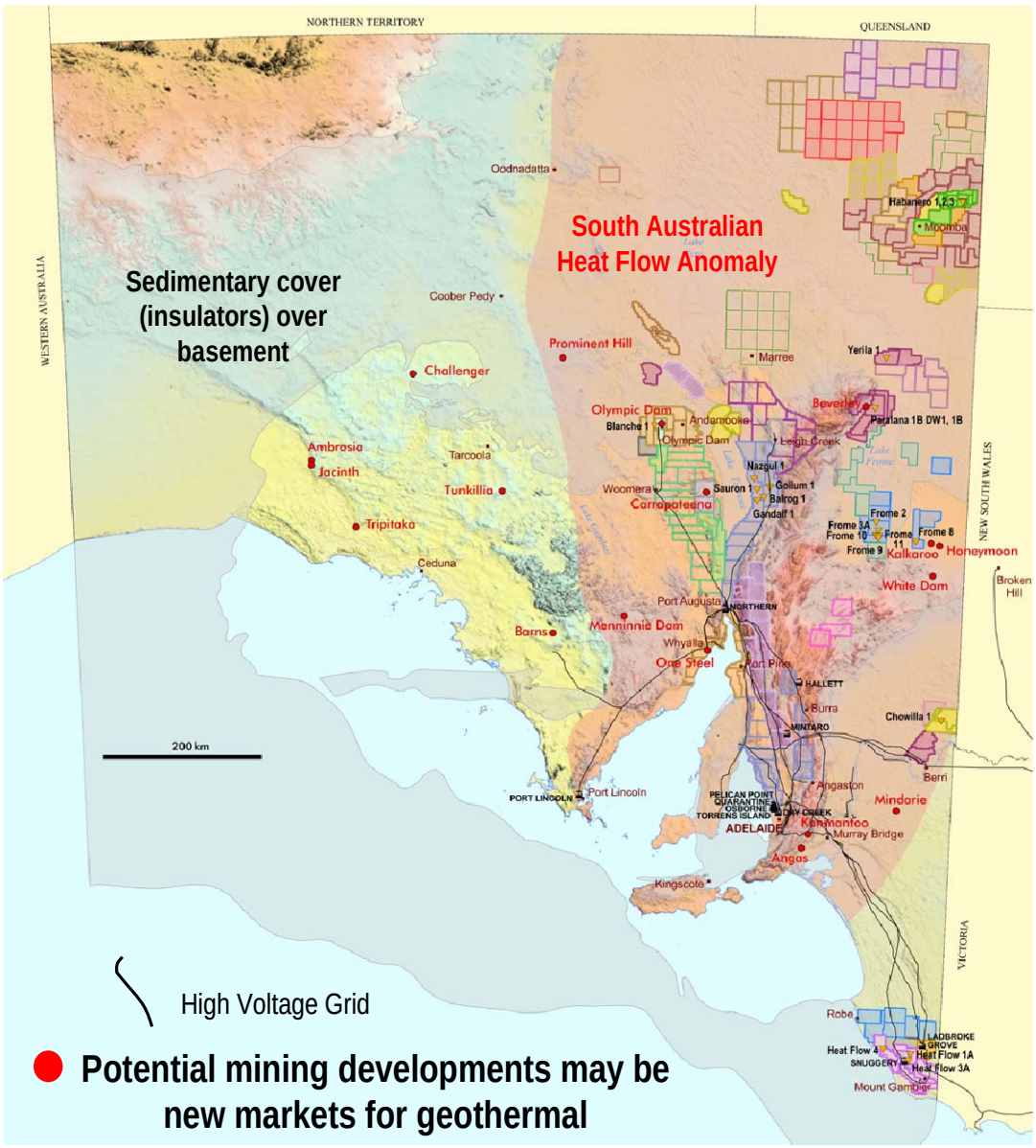

Figure 2: Hot rock play delineation in South Australia. The juxtaposition of the insulating sedimentary cover and the South Australian Heat Flow Anomaly has attracted Geothermal Licence applications. Prospective hot rock plays have also been identified outside these areas, including trends in the Otway Basin in SE South Australia

CURRENT USE

Geothermal energy is currently produced at one small binary Organic Rankine cycle power station at Birdsville in western Queensland (Figure 3). 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 gross capacity of the plant is 120 kWe and the plant power consumption is 40 kWe, which equates to a net output of 80 kWe. Total power generation in 2007 was 1,787,458 kWh of which 522,636 kWh was provided by the geothermal power plant, which is supplemented by diesel powered generators. Options to relegate the existing LPG and diesel-fuelled generators to peaking and back-up roles are now under consideration.

Geodynamics Limited is on track to commission a 1MW power plant at Innamincka in the Cooper Basin in early 2009. This will meet local demand and be the first electricity generated from a Hot Rock (HR) Engineered Geothermal System (EGS) in Australia

GEOTHERMAL PROJECTS IN AUSTRALIA

Since the grant of the first Geothermal Exploration Licence (GEL) in Australia in 2001 through to end December 2008, forty-seven companies have joined the hunt for renewable and emissions-free geothermal

energy resources in 385 onshore licence application areas (an increase of 34% since year-end 2007– as displayed in Figure 4) covering 359,723 km^2 (an increase of 64% since year-end 2007).

Since the drilling of Habanero 1 by Geodynamics Limited in 2003, through to end December 2008, ten companies have drilled a total of 70 wells to establish the extent of hot rock resources in Australia, including: Geodynamics Limited, Petratherm Limited, Green Rock Energy Limited, Geothermal Resources Limited, Panax Geothermal Limited, Torrens Energy Limited, KUTh Limited, Teck Cominco Limited, Inferus Proprietary Limited (a subsidiary of Southern Gold Limited) and Eden Energy Limited. Most were shallow drillholes; only 9 drillholes reached > 1,000m. Only Geodynamics' 5 deep wells in the Cooper Basin have reached reservoir target depths. An additional four companies have undertaken geophysical surveys and/or logged thermal properties in wells. A summary of the geophysical and well operations of the 14 companies are summarised in Appendix 1.

PROSPECTIVITY, FEAR OF CLIMATE CHANGE, DESIRE FOR SUSTAINABLE ENERGY SECURITY, SUPPORTIVE INVESTMENT FRAMEWORKS AND INVESTORS WILLING TO TAKE RISKS ARE DRIVING GEOTHERMAL EXPLORATION

The suite of catalysts leading up to a rush for geothermal licences in Australia from mid 2005 (Figure 4) were:

- Legislation for geothermal licenses in the State of New South Wales in 1992;
- Legislation for geothermal licences in Tasmania in 1995;
- The recognition of the South Australian Heat Flow Anomaly (Neumann, et al, 2000);
- Legislation for geothermal licenses in South Australia in 2000;
- Easily accessible pre-competitive data from government agencies;
- Grant of Geothermal Exploration Licences (GELs) in 2001 to Geodynamics (and predecessors);
- Opening up South Australia to over-the-counter applications for geothermal licences – in effect – debottlenecking the process leading to the grant of licences;
- Stunning exploration success in Geodynamics' first deep test (Habanero 1) in 2005 (with proof of 25 litres/second flow to surface from water-saturated, naturally fractured high heat producing granites at 250ºC at 4,300 m);
- Long sustained propensity for risk-taking amongst Australian Stock Exchange investors in minerals and energy projects – manifested with successful capital raisings by geothermal licence holders;
- The attraction of financially strong cornerstone investors (Origin Energy and Tata Power) by Geodynamics Limited for its Cooper Basin project;
- The attraction of financially strong joint venture partners (Beach Petroleum and TruEnergy) by Petratherm Limited;
- Popular aspirations to attain sustainable energy security;
- Geodynamics drilling its fifth deep well and proving an EGS system with flow from Habanero 3 and injection from Habanero 1 in the Cooper Basin;
- Expectations now realised that Australia would legislate a national greenhouse gas emissions cap and trade scheme that will make low emissions fuels more competitive in energy markets (DoCC, 2008);
- Expectations now realised that Australia's national renewable energy target would be 60,000 GWh or 20% of electricity consumption fueled by renewable energy supplies by 2020;
- Supportive Federal and State Government grant programs that exceed Aus$110 million (US$77 million – See Appendix 2) including the Aus$50 million (US$35 million) Geothermal Drilling Fund (DRET, 2008a);
- Aus$507 million (US$355 million) in grants available on the basis of competitive applications to support the demonstration of all forms of meritorious, renewable, commercial-scale energy technologies, including geothermal projects. This amount includes the Federal Government's Aus$435 million (US$305 million) Renewable Energy Demonstration Program (DRET 2008b) and the State of Victoria's Aus$72 million (US$50.4 million) Energy Technology Innovation Strategy (DPI, 2008);
- Supportive national initiatives including the roll-out of the Australian Onshore Energy Security Program (Budd, et al, 2008) and the Australian Geothermal Industry Development Framework (DRET, 2008c); and
- New, supportive local legislation and calls for geothermal licence applications in the Northern Territory (planned in 2009) and in the States of Victoria (in 2005), Queensland (in 2004) and Western Australia (in 2008).

All the above will continue to attract considerable additional investment in geothermal projects in all Australian jurisdictions.

The geology and investment frameworks in South Australia are the factors that have attracted 70% of all geothermal licence applications and 96% of

investment to date in Australia to projects in the state of South Australia. Predictably, new pre-competitive information and new legislation for geothermal projects in other Australian jurisdictions has reduced South Australia's share of the Australian national tally of actual plus forecast investment in geothermal projects (in the term 2002-13) from more than 70% at year-end 2007 to 54% (of the $1,357 million national tally) at year-end 2008.

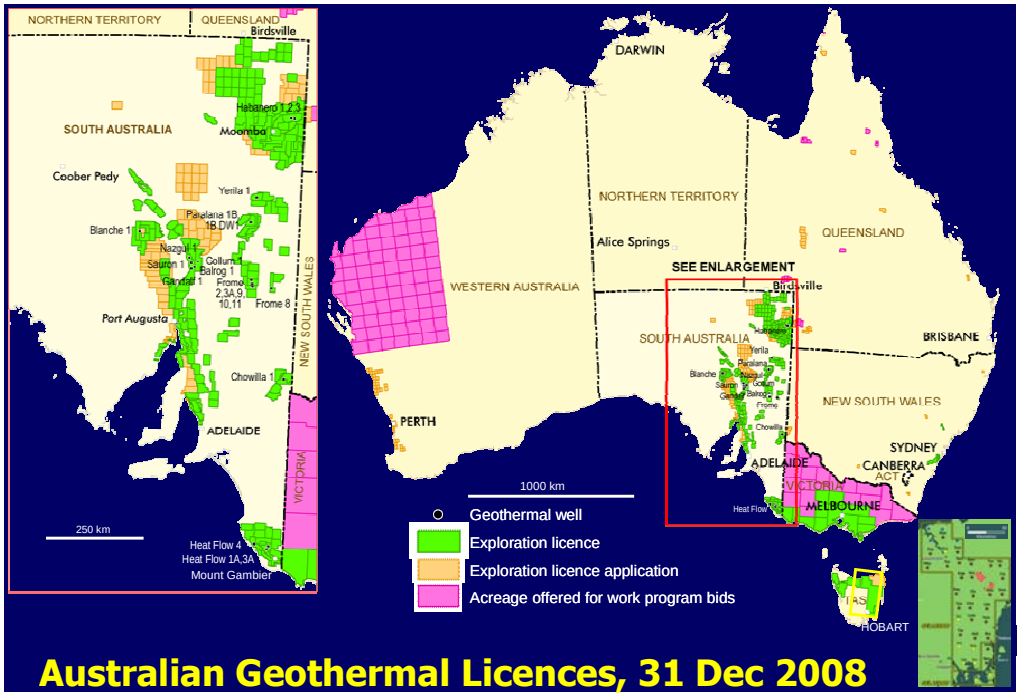

Figure 3: Geothermal licences, applications and bid blocks. Insets to locate geothermal wells drilled 2000 – 2008

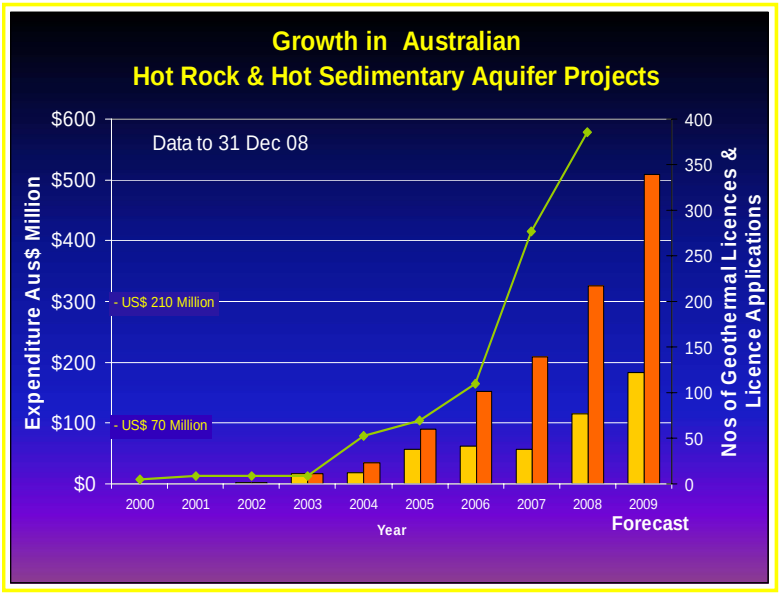

Figure 4: Geothermal Licence applications and exploration expenditure, 2000 to 2008. Source PIRSA

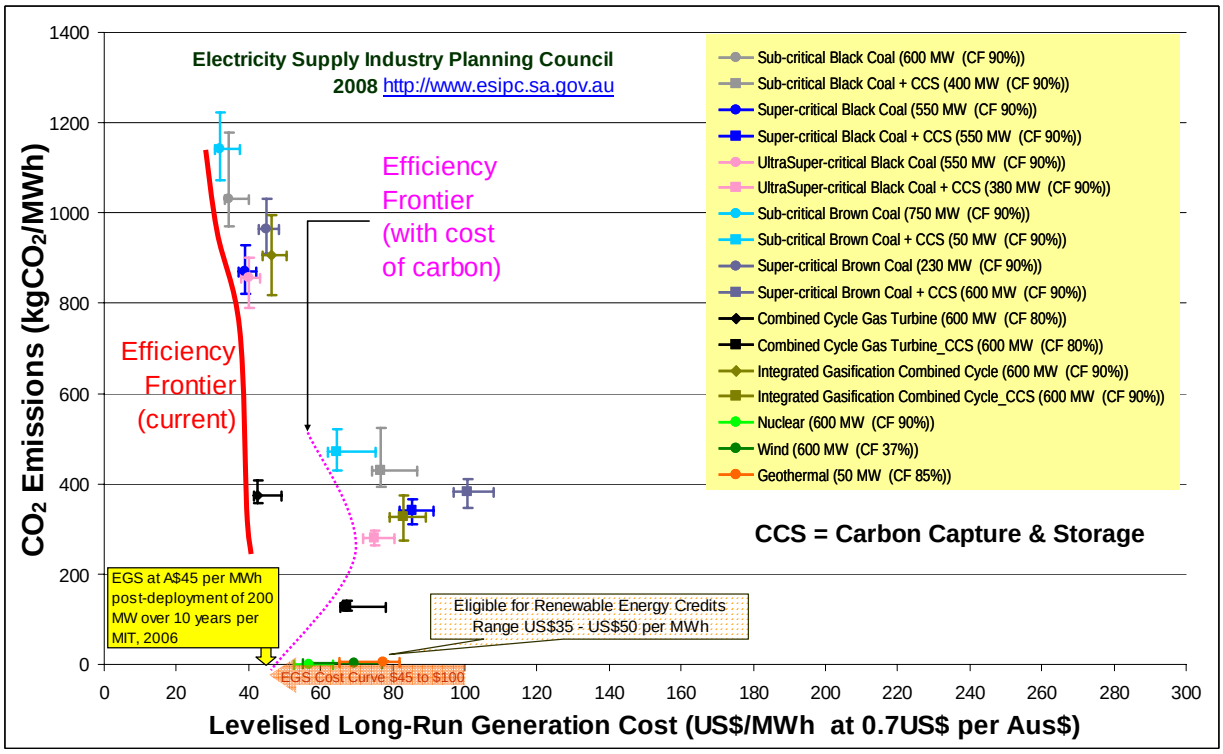

Figure 5: CO_2 emissions (Kg/MWh) on the vertical axis versus costs to generate electricity power in Australia (converted to US$/MWh at US$0.88/A$ - an exchange rate corresponding to the date of the analysis) on the horizontal axis to indicate relative costs and CO_2 emissions from various fuels, with and without carbon capture and storage (geosequestration). Source: Electricity Supply Industry Planning Council 2008 Annual

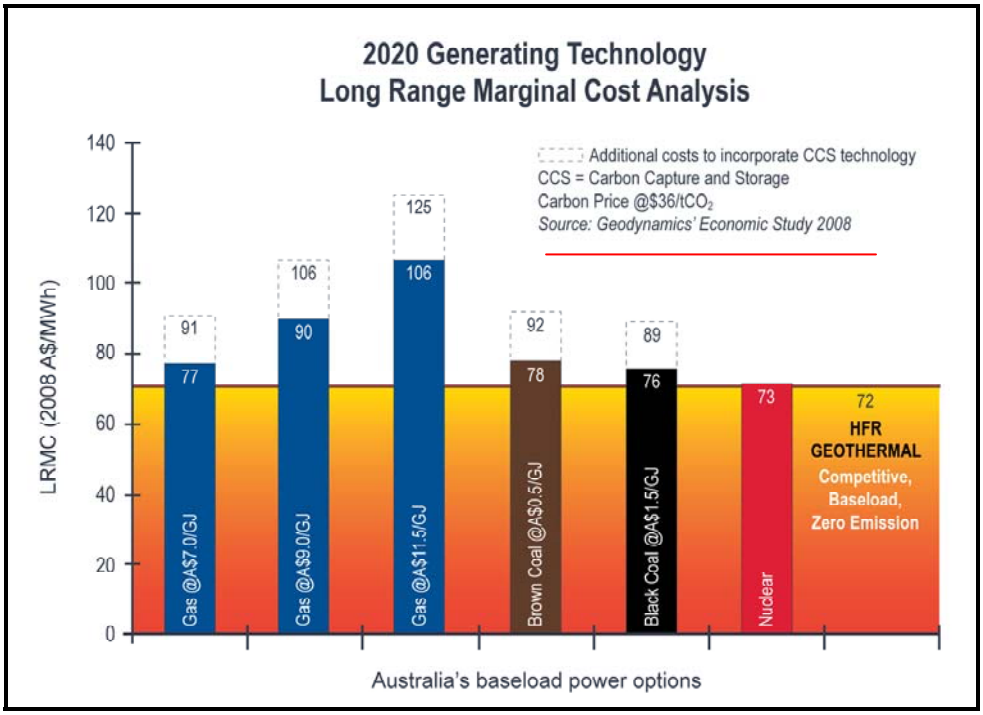

Figure 6: Estimated long run (range) marginal costs of power generation from gas, coal, nuclear and geothermal fuel in 2020, with and without the cost of carbon capture and storage at Aus$ 36 per tonne CO_2.(Geodynamics, 2008b).

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EXPENDITURES

All Australian geothermal industry field expenditure to date is classed as research and is estimated at AUS$116 million (US$81.2 million) for the calendar year 2008. This represents a 104% increase of AUS$57 million (US$40 million) from the previous year. A 37% increase (to AUS$183 million or US$128 million) is forecast for 2009, and this excludes demonstration and development investment (such as Geodynamics' HotRock 50 project). The turmoil in financial markets will be a factor in this forecast being achieved. To date, two companies have contracted to import into Australia rigs capable of drilling to at least 4,000m. Geodynamics has purchased two deep drilling rigs for its Cooper Basin project and Petratherm is importing a deep drilling rig for its Paralana project. Historical, current and projected expenditure for 2009 are highlighted in Figure 4.

Several companies plan to drill deep geothermal exploration wells in 2009-10, with Geodynamics and Petratherm having already raised the necessary capital and contracted rigs capable of deep (at least 4km) drilling henceforth.

The Australian Federal Government's Geothermal Drilling Program (GDP) will be particularly helpful in supporting proof-of-concept deep drilling, fracture stimulation and flow testing. The GDP, provides for grants of up to Aus$3.5 million (US$2.45 million) per well and up to two such grants per project (total of Aus$7 million or US$ 4.9 million) to support at least 7 proof-of-concept deep well projects with grant recipient companies at least matching the GDP grant monies. This should underpin capital raisings, consistent with the Federal Government's Geothermal Industry Development Framework.

COMPETITIVENESS OF FUTURE HOT ROCK GEOTHERMAL DEVELOPMENT

Figure 5 illustrates the estimated long run (range) marginal costs and CO_2 emissions for 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. This is not expected to continue with: Renewable Energy Credits providing subsidies for wind, hydro, solar and geothermal energy supplies; emissions cap and trading schemes increasing the cost of emissive energy supplies; and competition for coal and gas supplies potentially putting upward pressure on the price of power based on fossil fuels.

The Australian Federal Government released the design of its Carbon Pollution Reduction Scheme on 15 December 2008 – intending to reduce greenhouse gas emissions by at least 5% of below 2000 levels by 2020 on a unilateral basis or up to 15% below 2000 levels by 2020 if also agreed by the other major emitters. The indicative trajectory for Australia's emissions reductions is to attain 107% of 2000 levels in 2012-13.

In a global market with carbon pricing, geothermal energy is likely to be a significant growth industry. MIT (2006) forecast the anticipated cost of generating EGS energy in the USA to reduce from uncompetitive levels to US$45 MWh as experience is gained by deploying 200 MW over 10 years. In Australia, Geodynamics expects the cost of commercial scale EGS generation to be very competitive in markets by 2020 (Figure 6).

MATERIALITY OF FUTURE HOT ROCK GEOTHERMAL DEVELOPMENT

Estimates of the prospective materiality of developing Hot Rock and Hot Sedimentary Aquifer resources follow. All assume success in demonstration and proof of concept projects is followed by economic development.

- The Electricity Supply Association of Australia concluded that 6.8% of all of Australia's power could come from geothermal energy by 2030 under a "scenario that assumes no nuclear power and (CO_2) emissions reduced to 70% of 2000 levels by 2030" (ESSA, 2006). 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.
- Geoscience Australia estimates that reaping just 1% of the geothermal energy stored from 150°C to 5 km in the Australia crust corresponds to 190 million PJ, equivalent to ~26,000 yrs of Australia's power use (Budd, et al, 2008)
- Geodynamics Limited estimate the hot, wet, fractured rocks in its Cooper Basin licences in South Australia can fuel more than 10,000 MW of electricity power generation capacity (Geodynamics, 2008)
- Petratherm Limited estimate its 'Heat Exchange Within Insulator' (HEWI) targets in its Paralana geothermal project area in the South Australian Flinders Range will exceed 1 km thickness over 20km and average at least 200°C, and this would suffice to fuel 520 MW over 25 years (Petratherm, 2008);
- Panax Resources Limited estimate the Hot Sedimentary Aquifer play in its Limestone Coast Geothermal Project (covering 2,674 km^2) in its

Otway Basin geothermal licences in South Australia have has potential to fuel more than 1,500 MW of electricity generation capacity (Panax 2008)

- The Australian Geothermal Energy Association forecast up to 2,200 MW of Australia's base-load capacity can come from geothermal energy by 2020 (AGEA, 2008)
- Assuming: (1) a lognormal resource distribution for the global endowment of extractable geothermal energy;, (2) an estimate of 10 MWe as the 99% probability level (of certainty) for the world's Hot Rocks to fuel electricity; and (3) Geodynamics' estimate of capacity to fuel 10,000 MWe from its South Australian Cooper Basin licences as the estimate for the 50% probability level (of certainty) for the world's Hot Rocks to fuel electricity, then the global Hot Rock resource is enormous – as displayed in Figure 7.

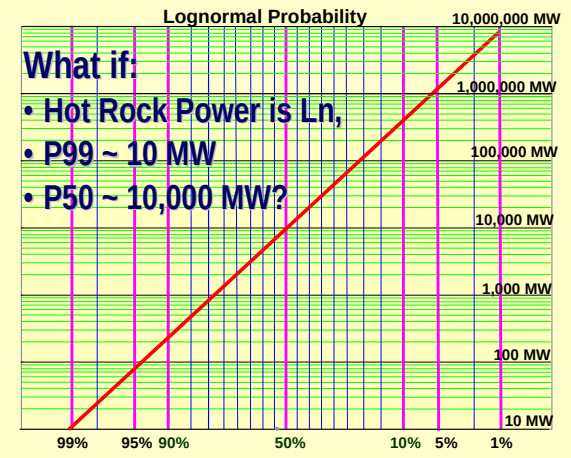

Figure 7: Estimate of potential capacity to generate electricity from Hot Rock energy. Both the P99 (10 MW) and P50 (10,000 MW) estimates are relatively conservative assumptions for world's Hot Rock endowment.

STEPS TAKEN TO FOSTER THE COMMERCIALISATION OF AMAGMATIC GEOTHERMAL RESOURCES AT MINIMUM COST AND MAXIMUM PACE

Australian Federal and State Government programs have committed more than Aus$110 million (US$77 million) to co-fund (with industry) Australian geothermal exploration, proof-of-concept and demonstration projects (Appendix 2). In addition, several steps have been taken to bolster cooperation that can minimise impediments to the economic development of geothermal resources, including:

- the Australian Federal Government's Geothermal Drilling Program (DRET, 2008a) and Geothermal Industry Development Framework (DRET, 2008c) will underpin efforts to make fast progress towards the commercialisation of Australia's vast geothermal resources;
- Australia will sustain its membership in the International Energy Agency's Geothermal Implementing Agreement (GIA) Research Cluster;
- In 2006 a national, whole-of-sector alliance was formed, the Australian Geothermal Energy Group (AGEG) which has grown to have 88 organisation members at year-end 2008;
- In 2008, corporate members of the AGEG created a new peak geothermal industry directorate – the Australian Geothermal Energy Association (AGEA), to provide a unified voice on matters affecting the geothermal industry; and
- In August 2008, the inaugural AGEG-AGEA Geothermal Energy Conference attracted 300 registrants. This will be an annual event with annual published proceedings – the first of which is available for free download from http://www.ga.gov.au/servlet/BigObjFileManager?bigobjid=GA11825.

AUSTRALIAN GEOTHERMAL ENERGY GROUP (AGEG)

The AGEG is Australia's whole-of-sector alliance of companies, government agencies and research organisations with an interest in the advancement of the use of geothermal energy. AGEG members share information and undertake high priority studies to foster efficiency on the road to commercialising Australia's geothermal resources. 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 November 2008, the AGEG refined its terms of reference to be as follows:

1. Provide intellectual support for Australia's membership in the IEA's Geothermal Implementing Agreement (GIA), the International Partnership for Geothermal Technology (IPGT), the International Geothermal Association (IGA), and generally facilitate engagement with the international geothermal community, especially with the Geothermal Resource Council (GRC) and successors to the ENhanced Geothermal Innovative Network for Europe (ENGINE).
2. Foster the commercialisation of Australia's geothermal energy resources. Collectively:
   - Cooperate in research and studies to advance geothermal exploration, proof-of-concept, demo & development projects;
   - Cooperate to develop, collect, improve and disseminate geothermal-related information;

- Identify opportunities to advance geothermal energy projects at maximum pace and minimum cost; and
- Disseminate information on geothermal energy to decision makers, financiers, researchers and the general public (Outreach).

The AGEG has 10 Technical Interest Groups (TIGs – see Table 1) to act as national networks to reduce critical, shared uncertainties that if left unsolved, may act as impediments to geothermal energy development.

AGEG Technical Interest Groups		Purpose
1	Land Access Protocols (induced seismicity, emissions, native title, etc)	Mirrors IEA Geothermal Implementing Agreement (GIA) research annex 1. Management of environmental concerns and potential impacts of geothermal energy and devise protocols to avoid or minimize impacts.
2	Reserves & Resource (Definitions)	Align with similar International forums Now a joint AGEG-AGEA Committee
3	Policy Issues	Split into forums for Industry to lead: • Industry advice to Governments now form the AGEA • Whole of sector forums via AGEG
4	Enhanced Geothermal Systems	Mirrors IEA GIA research annex III. Investigate technologies for enhancing geothermal reservoirs for commercial heat extraction.
5	Interconnection with Markets	Transmission, distribution, network, NEM issues split into**:** • Industry forums (AGEA) for local and national market issues • AGEG forums for grid technologies
6	Power Generation	Mirrors IEA GIA research annex VI.
7	Direct Use of Geothermal Energy (including geothermal heat pumps)	Mirrors IEA GIA research annex VIII. This annex addresses all aspects of the technology related to geothermal energy being used directly as heat, with emphasis on improving implementation, reducing costs and enhancing use. TIG 7 covers: • Industry forum (AGEA) for local and national market issues • Whole-of-Sector Forum (AGEG) for technologies
8	Outreach (Including Website)	Create informed public through accessible information. Provide educational kits for media, all levels of schooling and university education. Run annual AGEG-AGEA Conference
9	Data management	Database design, contents and ongoing enhancements.
10	Field Operations	Split into two sub-groups to cover: • Geophysical surveys, data processing & interpretation • Drilling, casing, stimulation, logging, testing, etc. This mirrors IEA GIA research Annex VII

Table 1: The AGEG's Technical Interest Groups. These 10 TIGs are likely to be modified in 2009, with a TIG for Exploration Technologies formed, and probably refining the focus of the TIG for EGS into reservoir characterisation.

The AGEG's TIG for policy, in effect, became the Australian Geothermal Energy Association (AGEA) in 2008 and all AGEA member companies remain members of the AGEG. The AGEG TIG for policy has been sustained as a useful network for the AGEA to canvass whole-of-sector views.

RESEARCH ACTIVITIES

Considerable alignment exists between the research priorities for EGS as determined in Australia (DRET, 2008c), the USA (DoE, 2008), the EEU (ENGINE, 2008) and most recently by the International Partnership for Geothermal Technologies (IPGT) – as summarised in Table 2.

• Share knowledge & drive complementary research	
• Standard geothermal resource & reserve definitions	• Improved / revolutionary HTHP hard rock drill equipment
• Predictive production modeling	• Improved HTHP zonal isolation
• Predictive reservoir and stress field characterisation	• Reliable HTHP pumps for modest hole diameter
• Mitigate induced seismicity / other HAZOPS	• Enable well longevity (20-30 years)
• 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 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 amagmatic resources. Several of these priorities are also targeted by the petroleum industry. HTHP: high temperature and high pressure

The foci of Australian research are aligned with the research priorities listed above. :

- Identification and targeting of locations with high potential for the development of Hot Rock (EGS) and Hot Sedimentary Aquifer (HSA) plays;
- Reserve and resource definitions. Notably, a joint AGEG-AGEA committee (TIG 2) has developed an Australian code for reporting geothermal exploration results, resource estimates and reserve estimates (AGCC, 2008) to guide consistent reporting of the technical attributes of geothermal

projects and to foster understanding of Australian geothermal projects.

A lexicon for geothermal exploration, resources and reserves has also been published to foster understanding of geothermal energy concepts and the methods used to determine geothermal resources and reserves. This AGEG-AGEA Geothermal Reporting Code (AGCC, 2008) covers all forms of geothermal energy projects that may be expected to be subject to standards for reporting resource and reserve estimates to markets. It is applicable to:

- Amagmatic HR (including EGS), hydrothermal (including HSA) and conventional volcanic based geothermal energy projects;
- All uses of geothermal energy, including geothermal thermal energy for electricity generation, direct use in industrial processes or space heating, or as supplemental energy; and
- Minimum and mandatory requirements for public reports

The AGEA requires its members to comply with the AGEG-AGEA Geothermal Reporting Code. This Code is intended to eventually become a standard for Australian financial markets and regulators – and workshops to elucidate experience gained in 'road tests' will be held with Australian market regulators and the Australian Stock Exchange, starting in 2009.

This Code and its associated Lexicon have sustained considerable international peer review, and remain open for comment via the AGEG's website: http://www.pir.sa.gov.au/geothermal/ageg/geothermal_reporting_code

- Environmental impacts of developing EGS, including potential induced seismicity that can be associated with the fracture stimulation of geothermal reservoirs; and
- Assessment of technologies with high potential to minimize costs and maximize efficiencies in the development of EGS.

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

- The Cooper Basin in South Australia is ideally suited to EGS activities in terms of natural background seismicity levels;
- Reactivation of any basement faults in the region is unlikely in the vicinity of the Habanero Site; and
- Induced seismic events at the Habanero well site in the Cooper Basin fall below the background coefficient of ground acceleration (0.5 g) thereby not exceeding the government's current building design standards for peak ground acceleration.

Further work has recommended protocols for the risk management of induced seismicity (Morelli and Malavazos, 2008). These protocols take into account previously developed protocols (IEA-GIA Annex 1-Subtask D Working Group 2008) and risk evaluation 'traffic light' concepts (Geothermal Explorers Ltd 2007 and Bommer et al. 2006) into accounts. The recommendations are to:

- Use trusted national standards consistent with international best practice for all seismic risk analysis and management processes;
- Government seismic monitoring networks ought to be set to sustain detection of seismic events less than a magnitude of 3 (on the Richter Scale);
- Seismic risk management including deployment of appropriate seismic monitoring of natural background and induced seismicity is to be a regulatory requirement development;
- At least one deep (as is practical and below regolith if possible) seismic monitoring station to be deployed prior to hydraulic stimulation or large scale injections;
- Strong motion accelerometers to be deployed with the seismic monitoring stations, downhole and near surface, to record events that 'clip' the seismometer, and determine regolith amplification; and
- Project operators must demonstrate to the regulatory authority that it has adequately assessed and can effectively manage any seismic risk before commencing any hydraulic stimulation or large scale injection. The objectives are to mitigate risk and build trust with stakeholders that induced seismicity is a potential risk that can be safely managed.

The static stress damage zone would not be expected to have any impact on identified local structural features. This is due to the nearby faults being beyond the reach of the induced seismicity associated with EGS activity. PIRSA will fund similar studies in other prospective EGS provinces (in the State of South Australia) to develop trustworthy protocols for assessing the potential risks of induced seismicity.

Operators of geothermal energy projects in South Australia will then have a credible foundation to develop 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.

In September 2007, the Queensland State Government committed AU$15 million (US$ 13.2 million) to the Queensland Geothermal Energy Centre of Excellence at the University of Queensland (UQ) for research towards exploitation of the deep geothermal reserves of South Australia and Queensland. Studies to be undertaken at UQ include: (1) resource management and optimization; (2) optimum power conversion; (3) power plant cooling systems; and (4) long-distance electricity transmission. The Centre plans to work collaboratively 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 Centre will also work with other Australian universities to introduce undergraduate and post-graduate programs to develop a local skill base.

MILESTONES AHEAD ON THE ROAD TO THE VISION OF COMMERCIALISED GEOTHERMAL ENERGY

The Australian Geothermal Energy Group (AGEG) has considered the future of EGS play exploration and demonstration projects in Australia and suggests it is reasonable to expect:

- At least 10 successful research (exploration) and proof-of-concept (i.e. heat energy is flowed) geothermal projects completed by 2010/11;
- At least 3 geothermal power generation demonstration projects in distinctively different geologic settings are achieved by 2012/13;
- Compelling success with geothermal power generation demonstration so the investment community is convinced that geothermal energy is reliable by 2012/13; and
- Safe, secure, reliable, competitively priced, renewable and emissions-free base-load power from geothermal energy for centuries to come, with at least 7% of base-load demand from hot rock power by 2030.

CONCLUSIONS

Australia's vast Hot Rock and Hot Sedimentary Aquifer plays have the potential to become a very significant source of safe, secure, competitively-priced, emission free, renewable baseload power and direct use supplies for centuries to come. This potential combined with the evidence of risks posed by climate change and aspirations to attain sustainable energy security is stimulating growth in geothermal energy exploration, and proof-of-concept and demonstration power generation projects in Australia.

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APPENDIX 1 – 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 Geothermal Exploration Licences (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 Enhanced (Engineered) Geothermal System (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 favorable 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 favor 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 Hot Sedimentary Aquifer play.

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

Greenearth Energy Limited (ASX Code: GRE) has 3 Geothermal Exploration Permits (GEP 10, 12 and 13) in Victoria covering 18,795 km^2 over prospective Hot Sedimentary Aquifer 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. Greenearth is one of a few companies now exploring for both petroleum and geothermal resources under separate but coincident licences, in addition to deriving valuable information from four 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); and Napier High-1 (in an application area for a Petroleum Retention Licence – will be drilled after the grant of the relevant PRL). Greenearth has retained rights to deepen, core and log Boola Boola-2 from depths below 1,715m.

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. HRL plans to drill its first and second deep wells in 2009 at locations northwest of Koroit in GEP-8. 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 by the end of 2009. 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 licences 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 licences, 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 licences 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 licences 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 fueled 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 9,000km^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 3,127km^2 in 7 Geothermal Exploration Licences (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 Hot Sedimentary Aquifer 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 Hot Sedimentary Aquifer play in a 9,000km^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 two geothermal permits (GEPs) 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 2. Australian Federal and State grants for Australian geothermal projects since 2000.

Grant	Date	Recipient	Project	Aus$ Amount	US$ Amount
Fed. RECP	2000	Pacific Power/ANU	Hunter Valley Geothermal Project	$790,000	$553,000
Fed. START	2002	Geodynamics	Habanero Project	$5,000,000	$3,500,000
Fed. REEF	2002	Geodynamics	Habanero Project	$1,800,000	$1,260,000
Fed. GGAP	Mar-05	Geodynamics	Kalina Cycle to produce 13 MW from waste heat at the Mt Keith Nickel Mine in WA	$2,080,000	$1,456,000
Fed. REDI	Dec-05	Geodynamics	Habanero Project, Cooper Basin, SA	$5,000,000	$3,500,000
Fed. REDI	Dec-05	Scopenergy	Limestone Coast Geothermal Project, SA	$3,982,855	$2,787,999
SA PACE	Apr-05	Petratherm	Paralana Geothermal Project, SA	$140,000	$98,000
SA PACE	Apr-05	Scopenergy	Limestone Coast Geothermal Project, SA	$130,000	$91,000
SA PACE	Apr-05	Eden Energy	Witchellina Project, SA	$21,000	$14,700
SA Grant	Jun-05	U of Adelaide	Induced seismicity – Cooper Basin	$50,000	$35,000
SA Grant	Dec-05	Geodynamics	Cost: benefit evaluation of developing Australia's hot rocks	$40,000	$28,000
SA PACE	Dec-05	Geothermal Resources	Curnamona Geothermal Project, SA	$100,000	$70,000
SA PACE	Dec-05	Green Rock	Olympic Dam Geothermal Project, SA	$68,000	$47,600
Fed. REDI	Jul-06	Geothermal Resources	Frome Geothermal Project	$2,400,000	$1,680,000
Fed. REDI	Dec-06	Proactive Energy	Adapting supercritical cycles to geothermal power application	$1,224,250	$856,975
SA PACE	Dec-06	Torrens Energy	Heatflow Exploration in Adelaide Geosyncline	$100,000	$70,000
SA PACE	Dec-06	Eden Energy	Renmark Geothermal Project, SA	$100,000	$70,000
SA PACE	Dec-06	Geodynamics	High temperature borehole image logging, Habanero 3, Cooper Basin, SA	$100,000	$70,000
Fed. REDI	Feb-07	Petratherm Ltd	Paralana Geothermal Project, SA	$5,000,000	$3,500,000
SA Grant	May-07	U of Adelaide	Induced seismicity protocols – SA	$50,000	$35,000
SA Grant	Jun-07	U of Adelaide	Research posed by the AGEG	$250,000	$175,000
Fed. REDI	Aug-07	Torrens Energy	3D modelling of hot rock resources, SA	$3,000,000	$2,100,000
Qld Grant	Oct-07	U of Queensland	Geothermal energy research	$15,000,000	$10,500,000
SA PACE	Feb-08	Petratherm	Shear wave splitting for exploration	$100,000	$70,000
SA PACE	Feb-08	Torrens Energy	2D seismic, Adelaide Plains, SA	$100,000	$70,000
REDI	2008	KUTh	Tamar Conductivity Zone (TCZ)	$1,800,000	$1,260,000
WA Grant	Mar-08	U of WA	WA Geothermal Centre of Excellence	$2,300,000	$1,610,000
SA Grant	Jun-07	U of Adelaide	Research posed by the AGEG	$250,000	$175,000
REF	Announced	TBD	Fed Geothermal Drilling Fund	$50,000,000	$35,000,000
SA Grant	Jun-08	U of Adelaide	Research posed by the AGEG	$250,000	$175,000
Vic Grant	Bids close 12 Feb 09		Direct Use Geothermal Support Pilot	$100,000	$70,000
NSW Grant	Announced	Geodynamics	Deep drilling in the Hunter Valley, NSW	$10,000,000	$7,000,000
				$111,326,105	$77,928,274

This tabulation excludes funds that may be provided to co-fund geothermal projects from: the Aus$435 million (US$305 million) Federal Government's Renewable Energy Demonstration Program; 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)

Abbreviations:

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