Australian Geothermal Implementing Agreement Annual Report – 2010

Flow test at Panax Geothermal's Salamander 1 well, the first deep well drilled at the Penola Hot Sedimentary Aquifer Project in the south east of South Australia. ***Photo courtesy of Panax Geothermal.***

Prepared for the Australian Geothermal Energy Group (AGEG) by:

Barry A Goldstein – Executive Committee Member for Australia – IEA GIA
Barry.Goldstein@sa.gov.au

Betina Bendall – Alternate Executive Committee Member for Australia – IEA GIA
Betina.Bendall@sa.gov.au

25th August 2011

Australian Geothermal Implementing Agreement Annual Report – 2010

1. Introduction

The use of geothermal energy for electricity generation and direct use applications is new technology to Australia and requires successful technical and commercial demonstration before gaining widespread acceptance. Nonetheless interest and activity in the geothermal sector continues to gather momentum.

Nationally, to the end of 2010, 57 companies have applied for 414 licence areas (covering 472,000 km^2) to progress proof-of-concept amagmatic Enhanced Geothermal Systems (EGS) and Hot Sedimentary Aquifer (HSA) projects (see Figure 1). From 2002 to 2010, more than AU$679 million (US$708 million) has been spent on studies, geophysical surveys, drilling, reservoir stimulation and flow tests which comprise the work programs required to sustain tenure in geothermal licence areas (see Figure 3).

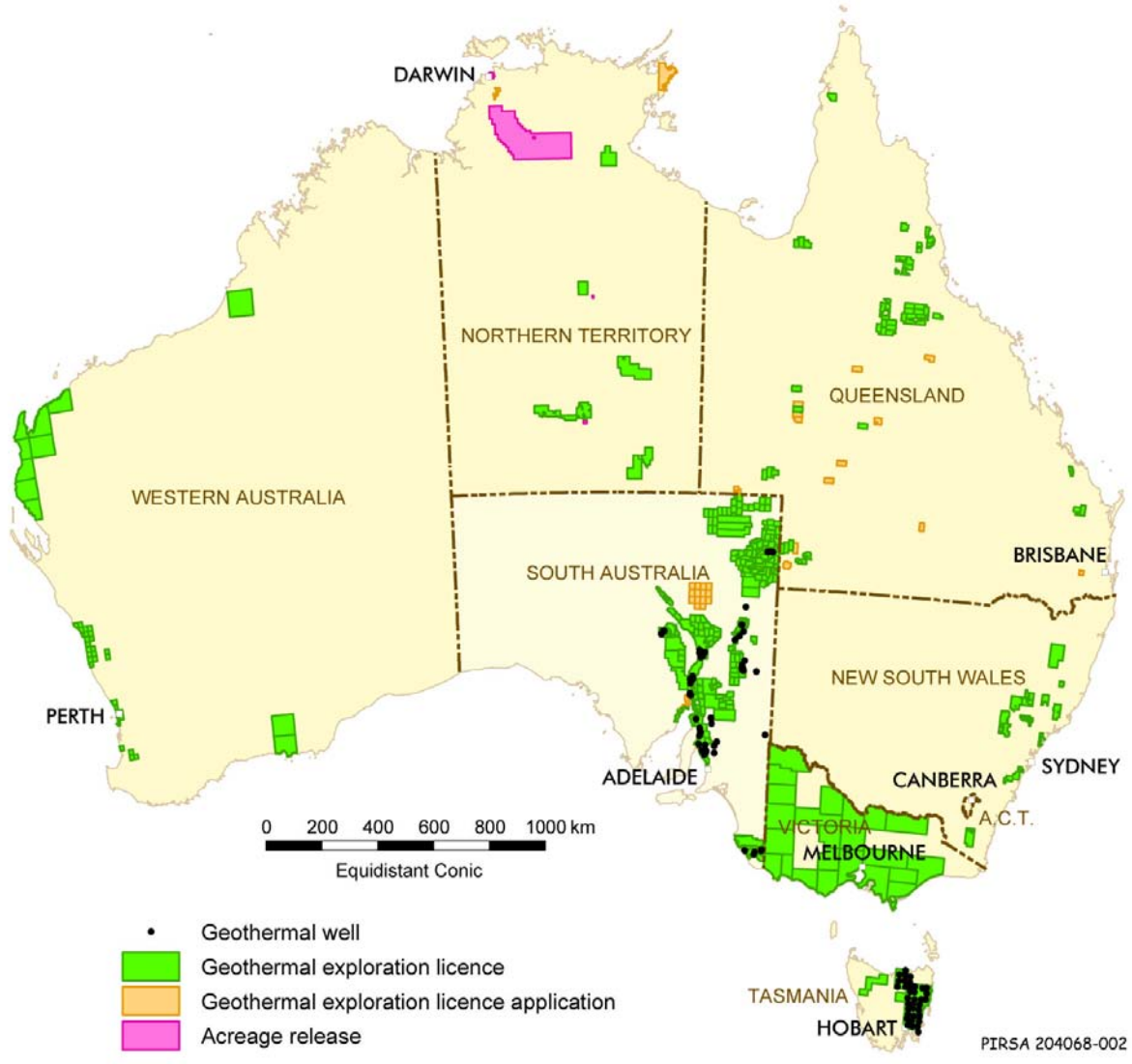


Figure 1. *Geothermal licences, applications and gazettal areas as at 31 December 2010.*

1a. Highlights and Achievements for 2010

- Panax Geothermal Ltd drilled its first well Salamander 1 to reservoir depths (~4000m) to test their Hot Sedimentary Aquifer (HSA) resource within the Pretty Hill Formation of the Otway Basin in south-eastern South Australia.
- Geodynamics Ltd undertook hydraulic stimulation of the Jolokia 1 well (at ~ 4400 – 4700 metres depth) in South Australia's Cooper Basin near the town of Innamincka.
- At 31 December 2010, a total of AU$3,073 million (US$3207 million) in work program investment is forecast for the period 2002 to 2015. An estimated AU$679 million (US$708 million) of this forecast was invested in the term 2002 to 2010. These forecasts are based upon current proposed exploration work programs and exclude capital expenditure associated with demonstration power plants. However, not all projects may continue to the completion of their tenure
- A total of over AU$187 million (US$195 million) in Commonwealth geothermal grant contracts were executed during 2010 under the Geothermal Drilling Program (GDP) and the Renewable Energy Demonstration Program (REDP).
- The Australian Government's primary mechanism for stimulating investment in renewable energy is the expanded Renewable Energy Target (RET). To help provide greater certainty to developers of large-scale renewable energy generation projects the Government introduced a number of changes to the RET in June 2010. As of 1 January 2011, the RET will be split into two parts - the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET). The LRET, covering large-scale renewable energy projects, will deliver the vast majority of the 2020 target (41,000 GWh). The SRES, covering small-scale technologies such as solar panels and solar hot water systems, will deliver the remainder of the target and provide a fixed price of $40 per megawatt hour of electricity produced.
- Synopses of operating Australian geothermal companies and their activities for 2010 are provided in Appendix A.

2. National Policy

2a. Strategy

In 2010, changes were made to the Australian Government's existing set of policies and programs aimed at supporting the development of affordable and efficient low-emission and renewable energy technologies and reducing Australia's greenhouse gas emissions.

The Government's primary mechanism for stimulating investment in renewable energy is the expanded Renewable Energy Target (RET) which is designed to ensure that the equivalent of at least 20 per cent of Australia's electricity is generated by renewable sources by 2020. The RET is a mandatory market-based mechanism that will provide a cross subsidy to the renewable energy sector worth billions of dollars.

In addition to the RET, the AU$5 billion (US$5.2 billion) Clean Energy Initiative (CEI) provides a comprehensive range of measures to support the development, demonstration and introduction of low emission technologies that are not yet commercially competitive in Australia's electricity sector. The CEI includes the AU$1.5 billion (US$1.6 billion) Solar Flagships Program, which aims to construct and demonstrate large-scale solar power stations and the AU$1.68 billion (US$1.75 billion) Carbon Capture and Storage (CCS) Flagships Program designed to accelerate the development and demonstration of CCS technologies.

The CEI also includes the Australian Centre for Renewable Energy (ACRE), which is administering over AU$690 million (US$720 million) to be allocated to a range of renewable energy programs and initiatives to demonstrate and commercialise emerging renewable energy technologies, and the AU$150 million (US$160 million) Australian Solar Institute, which will advance and accelerate innovation in solar thermal and solar photovoltaic technologies in Australia.

The Australian Government has adopted a multifaceted approach to policies and programs to transition to a lower carbon economy and address climate change, including investigating options around market based mechanisms, support for low emission and renewable technologies and support for energy efficiency initiatives across multiple sectors of the economy. The Government's emissions reduction target is to reduce emissions by 5 to 15 percent or 25 percent below 2000 levels by 2020, with greater reductions where major economies agree to substantially restrain carbon emissions or to stabilise greenhouse gases at 450 parts per million or lower.

2b. Legislation and Regulation (including acreage releases)

In Australia, legislation and regulation of geothermal exploration and development is state and territory government responsibility. Each of the six states (New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia) and one territory (Northern Territory) has legislation in place to regulate geothermal exploration and development. Relevant legislation is summarised in Table 1. In 2010, Queensland had one acreage release with 11 areas being gazetted with three tenders being received.

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

The Australian Government has expanded the Renewable Energy Target to ensure that 20 per cent of Australia's projected electricity supply comes from renewable sources by 2020. Geothermal energy is a major resource and potential source of low emissions renewable energy suitable for base load electricity generation and direct use applications.

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

The expanded Renewable Energy Target (RET) provides a strong incentive to accelerate the uptake of Australia's abundant renewable energy resources (discussed in section 4a). However, significant increases in renewable energy technologies and various commercial challenges facing the renewable energy industry cannot solely be addressed by implementation of the RET. Resolving these challenges requires supporting legislation and funding structures to encourage research, development and demonstration of these renewable energy technologies.

The Australian Government is investing over AU$5 billion (US$5.2 billion in the Clean Energy Initiative (CEI), which complements the proposed carbon price and existing Renewable Energy Target (RET) by supporting the research, development and demonstration of low emission energy technologies. Key elements of the CEI are:

- the AU$1.68 billion (US$1.75 billion) Carbon Capture and Storage (CCS) Flagships Program;
- the AU$370 million (US$386 million) National Low Emissions Coal Initiative (NLECI);
- the AU$1.5 billion (US$1.6 billion) Solar Flagships Program;
- the AU$150 million (US$160 million) Australian Solar Institute (ASI); and

- the Australian Centre for Renewable Energy (ACRE) drawing together over AU$690 million (US$720 million).

***Table 1**. Summation of the applicable legislation currently governing geothermal exploration activities in the various Australian states.*

State or Territory Government	Applicable legislation for geothermal exploration	Description
South Australia	*Petroleum and Geothermal Energy Act 2000*	Regulates licensing and activity approvals for upstream petroleum, geothermal, gas storage and petroleum pipeline projects. An 'over the counter' system, where explorers can apply for those areas desired. Licences can co-exist with existing or future minerals and petroleum exploration titles.
Victoria	*Geothermal Energy Resources Act 2005*	Regulates large-scale commercial and sustainable exploration and extraction of geothermal energy resources.
New South Wales	*Mining Act 1992*	Governs geothermal exploration, which is considered as Group 8 - Geothermal Substances. Application for a Group 8 geothermal exploration licence requires the Minister's consent.
Queensland	*Geothermal Exploration Act 2004* *Geothermal Energy Act 2010*	Applies a competitive permit system to encourage and facilitate efficient and responsible exploration. Will replace the *Geothermal Exploration Act 2009* upon commencement in 2011. The Act includes comprehensive legislation covering exploration and production and provides for over-the-counter applications for exploration tenure. The Act has received royal assent and the regulations are due to commence in mid 2012.
Tasmania	*Mineral Resources Development Act 1995*	Geothermal tenements are granted as a Category 6 mineral 'Special Exploration Licence' (SEL). An 'over the counter' system, where explorers can apply for those areas wanted for exploration. Licences can co-exist with existing or future minerals and petroleum exploration titles.
Western Australia	*Petroleum and Geothermal Energy Resources Act 1967*	Provides legislative coverage for the exploration and recovery of both conventional (hydrothermal) geothermal energy and EGS (hot dry rock) geothermal energy. Does not cover non-commercial uses or heat pumps.
Northern Territory	*Geothermal Energy Act 2009*	Provides for "over-the-counter" application for geothermal authorities over most of the Territory. Intent is to reserve a relatively small region around the Katherine area for later tendered release.

The Australian geothermal sector benefits most directly from targeted programs administered under ACRE. ACRE's objectives are to promote the development, commercialisation and deployment of renewable energy and enabling technologies to a point where they can be on a competitive footing with existing energy technologies. ACRE therefore acts as a central agency for Australian renewable energy businesses, consolidating various new and legacy programs including:

- AU$235 million (US$245 million) Renewable Energy Demonstration Program
- AU$100 million (US$104 million) Renewable Energy Venture Capital Fund
- AU$92 million (US$96 million) ACRE Solar projects
- AU$40 million (US$41.8 million) Emerging Renewables Program
- AU$15 million (US$15.7 million) Second Generation Biofuels Research and Development Program
- AU$50 million (US$52 million) Geothermal Drilling Program

- AU$20 million (US$20.9 million) Advanced Electricity Storage Technologies Program
- AU$14 million (US$14.6 million) Wind Energy Forecasting Capability Program
- AU$18 million (US$18.8 million) Renewable Energy Equity Fund.

Programs under ACRE that have direct relevance to the Australian geothermal sector are:

- Geothermal Drilling Program (GDP) – The GDP supports companies with the cost of drilling for proof-of-concept geothermal projects. In 2009, seven recipients were awarded grants of AU$7 million each (US$7.3 million) with five contracts executed with the Commonwealth in 2010, including: Hot Rock Ltd –Otway Basin, Victoria; Geodynamics – Hunter Valley, New South Wales; GRE Geothermal WA1 Pty Ltd – Perth, Western Australia; Greenearth Energy Ltd – Geelong, Victoria; and Torrens Energy Ltd – Parachilna, South Australia.
- Renewable Energy Demonstration Program (REDP) – REDP accelerates 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 by providing grants on a 2:1 matched funding basis for eligible demonstration projects. Two geothermal projects were awarded REDP grants with contracts executed with the Commonwealth in 2010: Geodynamics Ltd (AU$90 million / US$94 million) for its Cooper Basin project and Petratherm Ltd (AU$62.7 million / US$65.5 million) for its Paralana project.

In addition, the AusIndustry REDI program grant (AU$1.25 million/ (US$1.3 million) for the development of improved heat conversion technology (now called GRANEX™) reached a successful conclusion, under the stewardship of the University of Newcastle and Granite Power Limited, with an ~50% uplift in heat conversion relative to conventional ORC technology. Commercial roll-out is now under way, focussed on recovered waste heat applications.

Australia's Onshore Energy Security Program

In addition to the CEI, the Australian Government's AU$58.9 million (US$61.6 million) funding over five years for the Onshore Energy Security Program (OESP) provides new precompetitive geoscience data and interpretation in support of various earth resource industries including geothermal (see section 7b).

State and Territory Government Initiatives

Growth and activity in the Australian geothermal sector has benefited from targeted policy and legislative frameworks and generous grant funding from the Australian state and territory governments. Current government programs supporting geothermal energy research and development are summarised in Table 2.

South Australia (SA)

Launched in 2004 by the South Australian Government, the Plan for Accelerating Exploration (PACE) initiative includes funding for collaborative exploration programs that address critical uncertainties in mineral, petroleum and geothermal exploration. In 2010, AU$120,000 in PACE funding was awarded to two geothermal companies in support of innovative research or greenfields drilling projects. To end 2010, a total of AU$3.9 million (US$4.1 million) in South Australian Government funding including AU$1.1 million (US$1.15 million) has been provided to underpin the advancement of geothermal energy

projects in South Australia. In addition, the South Australian Government continues to provide the secretariat for the AGEG and is the Contracting Party to the IEA GIA for Australia. For details of successful projects supported by PACE funding, see: http://www.pir.sa.gov.au/minerals/pace/theme_2. South Australian Government support for other research organisations and programs is discussed further in Section 7b and Appendix B.

Western Australia (WA)

In 2010, the Geological Survey of Western Australia (GSWA), within the Department of Mines and Petroleum, commissioned the geothermal studies for the onshore Bonaparte, Browse, Carnarvon, Officer, and Perth Basins amounting to a total cost of AU$150,000 (US$160,000). The Department of Mines and Petroleum, the Department of Water and the Western Australian Geothermal Centre of Excellence participated in the preliminary organisation and sponsorship of the inaugural West Australian Geothermal Energy Symposium, which is planned for March 2011 with the aim to promote geothermal energy in the state. Two grants, to a sum of AU$300,000 (US$314,000), were made to geothermal drilling activities by Green Rock Energy Limited under the Exploration Incentive Scheme administered by the Geological Survey of Western Australia. For more information, see section 7b and Appendix B.

Queensland (Qld)

The Queensland Government's AUD$5 million (US$5.2 million) Coastal Geothermal Energy Initiative (CGEI) aims to investigate additional sources of hot rocks for geothermal energy close to existing transmission lines. A 12 hole fully-cored shallow-drilling program commenced in November 2010 to assess the geothermal potential of a range of geological settings in Queensland. By the end of the year, two holes were completed. Temperature logging will be undertaken after the temperature has stabilised. Thermal conductivity measurements on core samples will be undertaken to enable calculation of the heat flow at each site.

New South Wales (NSW)

As part of its New Frontiers Initiative, the NSW Government 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 are being compiled and will be presented as geothermal data packages. Under this program, the Darling-Murray and Oaklands Basin Geothermal Energy Potential study by Hot Dry Rock Pty Ltd was completed in October 2010.

Victoria (Vic)

In 2010, the Victorian Department of Primary Industries (DPI) completed an AU$500,000 (US$520,000) study to collect and compile datasets on heat flow and thermal conductivity across the state. This fundamental geothermal data was compiled into a state-wide heat flow map and database. Further work increasing geothermal data density across the state is planned for the next three years from July 2011. The Energy Technology Innovation Strategy group within DPI granted Greenearth Energy AU$5 million (US$5.2 million) for deep appraisal drilling, to be followed by AU$20 million (US$20.9 million) for a demonstration power plant if the drilling is successful. In addition, the four year 3D Victoria project building a full crustal 3D model of Victoria is now complete. This AU$2.5 million (US$2.6 million) project incorporates and reconciles potential field data such as gravity, magnetics

and seismic into the model. Open file geothermal data has been incorporated into this model and will facilitate regional scale modelling of geothermal potential across the state.

Table 2. *An overview of grants currently available to the Australian geothermal sector and their relationship to the stages of individual project development. All currency values in Australian Dollars (AU$) and million expressed as 'M' throughout the document AU$1 = US$1.0455 at August 2011.*

Agency	Research & pre-drill	Shallow drilling & early exploration	Deep drilling to resource depth	Proof of Concept	Pre-competitive Production demonstration	Production
Australian Government (federal)	Geoscience Australia (GA) data		GDP~ AU$50M total available at AU$7M per project		REDP~ AU$435M total available at $50 – 100M per proposal	Renewable Energy Credits (RECs)
South Australian Government	SA PACE ~ AU$1.6M total at up to $100,000 per proposal	SA PACE ~ AU$1.6M total at up to $100,000 per well			Regional Development Infrastructure Fund	
Victorian Government			Energy Technology Innovation Strategy AU$5	Energy Technology Innovation Strategy	Renewable Energy Support Fund AU$20	
Western Australian Government	Exploration Incentive Scheme ~AU$81M total available at up to AU$200,000 per proposal	Exploration Incentive Scheme ~AU$81M total available at up to AU$200,000 per proposal				
New South Wales Government				NSW Climate Change Fund ~AU$40M total	NSW Climate Change Fund ~AU$40M total	
Queensland Government		QLD Collaborative Drilling Initiative				QLD Renewable Energy Plan ~AU$4.3M

2e. Industry Expenditure on Geothermal R&D

Australian geothermal sector field expenditure is considered as research and totalled AU$208 million (US$217 million) in 2010. A 167% increase to AU$348 million ($US363 million) is forecast to be expended in 2011. Historical and current expenditure are highlighted in Figure 2.

3. Current Status of Geothermal Energy Use in 2010

3a. Electricity Generation

Geothermal energy is currently produced at one small binary power station at Birdsville, 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) which overlies the Cooper Basin. The water is run through a gas-filled Organic Rankine Cycle heat exchanger and the partly cooled water is channelled into a pond for further cooling and reticulation into the town's water supply and lagoon. The gross capacity of the plant is

120kW and the plant power consumption is approximately 40kW, equating to a net output of 80kW. Total exported power generation in 2010 was 1,824,538kWh, of which 681,090kWh was provided by the geothermal power plant. This equates to 37% of total exported power output, which reduced diesel consumption by about 170,000 litres and saved about 457 tonnes of greenhouse gas emissions through the year.

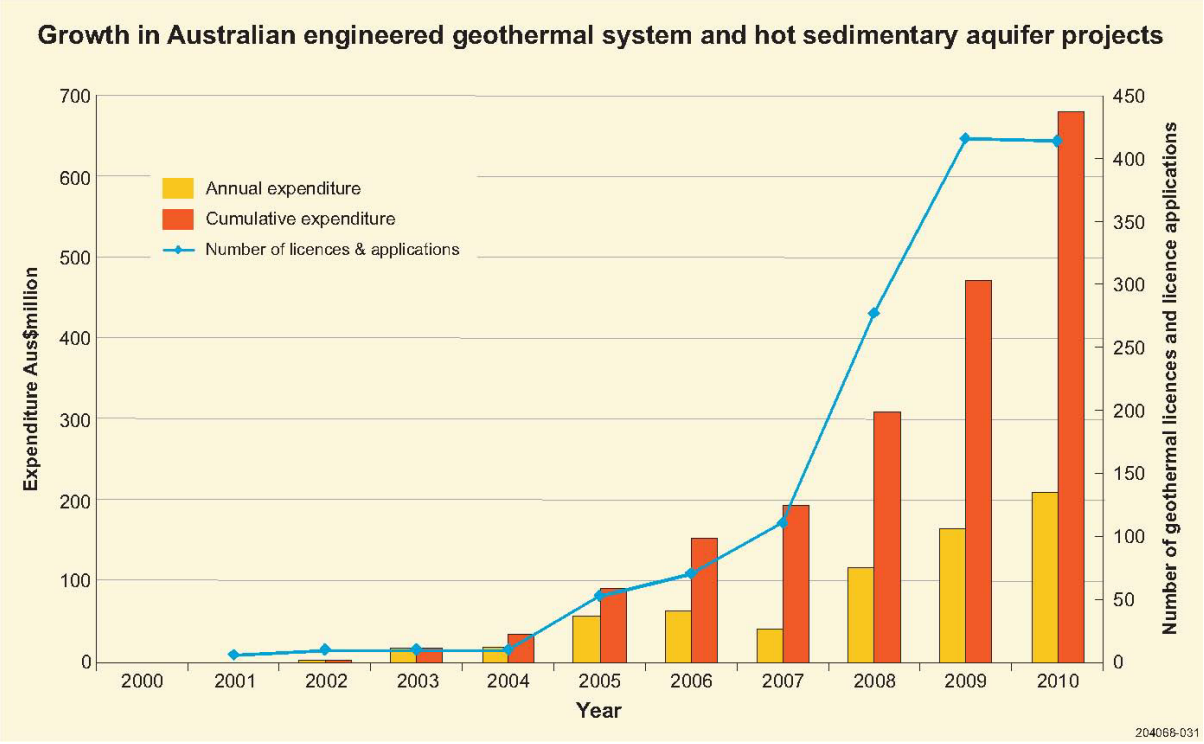


Figure 2: *Growth in Australian EGS and Hot Sedimentary Aquifer projects since 2000, indicating the cumulative increases in exploration expenditure and geothermal licence applications actuals 2000 to 2010 and the forecast for 2011. Source: PIRSA.*

3b. Direct Use

i) Installed Thermal Power

Australia's total installed capacity in direct geothermal applications is estimated to be 134MWth. This is up from the 2005 estimate of 109.5MWth (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 3802TJ/year, up from the 2005 estimate of 2968TJ/year.

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

District heating (space heating) constitutes the majority with an estimated 98MWth. Bathing and swimming installations total 8MWth. Ground Source Heat Pumps (GSHPs) constitute the remaining 28MWth.

3c. Energy Savings (Direct Use)

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

The estimated fossil fuel saving is 90,553 tonnes of oil equivalent (toe, 1 toe = 42GJ).

ii. Reduced/avoided CO2 emissions (tonne/year)

Using the DTI/Carbon Trust/DEFRA/Ofgem recommended figure of 0.43kg CO2 per kWh saved yields avoided emissions of CO_2 of 454 tonnes per year.

4. Market Development and Stimulation

4a. Development Constraints

Whilst geothermal energy resources in Australia have vast potential, geothermal power generation is not yet price-competitive, particularly in the absence of a carbon price and has not yet been demonstrated at a significant scale in Australia.

4b. Support Initiatives and Market Stimulation Incentives

The Australian Government's Renewable Energy Target (RET) scheme was initiated to stimulate investment and growth in Australia's renewable energy industry, including the geothermal sector. Key goals of the RET scheme are:

- to promote additional generation of electricity from renewable energy sources with a declared target of 20% of national electricity supply from renewables by 2020
- to achieve reductions in greenhouse gas emissions in the electricity sector.

RET is implemented via the *Renewable Energy (Electricity) Act 2000* and the *Renewable Energy (Electricity) (Charge) Act 2000*. This legislation facilitates the achievement of RET objectives by;

1) placing a liability on wholesale electricity purchasers to proportionally contribute an additional 45,000GWh of renewable energy per year by 2020; and

2) setting the framework for both the supply and demand of Renewable Energy Certificates (RECs) via a REC market.

RECs are an electronic form of currency created on the REC Registry and able to be transferred between eligible parties (recognised renewable energy generators) and liable parties (wholesale purchasers of electricity) for a negotiated price. Compliance with the RET is encouraged by a shortfall charge being levied against liable parties who do not meet obligations to purchase RECs.

To help provide greater certainty to developers of large-scale renewable energy generation projects the Government introduced a number of changes to the RET in 2010. As of 1 January 2011, the RET will be split into two parts - the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET). The LRET, covering large-scale renewable energy projects, will deliver the vast majority of the 2020 target (41,000 GWh). The SRES, covering small-scale technologies such as solar panels and solar hot water systems, will deliver the remainder of the target and provide a fixed price of AU$40 per megawatt hour of electricity produced.

RET does not provide a rebate or feed-in tariff.

4b. Development Cost Trends

There are no data available as yet to assess development cost trends.

5. Status of Geothermal Industry

At this point the Australian Geothermal Industry remains largely at a pre-competitive exploration stage, aside from a small production from the Ergon Energy Birdsville plant discussed in Section 3a. At 31 December 2010, a total of AU$3,073 million (US$3207 million) in work program investment is forecast for the period 2002 to 2015. An estimated AU$679 million (US$708 million) of this forecast was invested in the term 2002 to 2010. These forecasts are based upon current proposed exploration work programs and exclude capital expenditure associated with demonstration power plants. However, not all projects may continue to the completion of their tenure

6. Economics

6a. Trends in Geothermal Investment

Over the past three years, the Australian Government has committed AU$203 million (US$212 million) to the geothermal energy sector with the approval of seven applications under the Geothermal Drilling Program (GDP) and AU$153 million (US$160 million) with the approval of two grants under the Renewable Energy Demonstration Program (REDP). Approximately AU$12 million (US$12.6 million) of these funds have been released to companies thus far, as recipients are required to achieve certain milestones prior to payment.

No additional companies listed on the Australian Securities Exchange (ASX) in 2010, although equity markets continued their support of the geothermal sector by participating in individual companies' capital raisings.

6b. Trends in Cost of Energy

Other than the Ergon Energy Birdsville Plant discussed in Section 3a, commercial scale Engineered Geothermal Systems (EGS) and Hot Sedimentary Aquifer (HSA) units have not yet been commissioned in Australia. Due to the more speculative nature of EGS and HSA technology at this time, cost discussions have focussed on a discussion of the technology status and cost trends as opposed to more detailed cost and performance estimates.

Modelling on Australian electricity generation costs completed by the Electric Power Research Institute (EPRI, 2009) suggested that the cost of geothermal per megawatt hour could be between AU$100 - $200 for Engineered Geothermal Systems and AU$90 - $150 for Hot Sedimentary Aquifer geothermal energy in 2030.

7. Research Activities

7a. Focus Topics

Considerable alignment exists between identified Australian research priorities (DRET, 2008a & 2008b) and international research imperatives (e.g. DoE, 2008; ENGINE, 2008; IPGT, 2008) including the GIA Research Annexes (see http://www.iea-gia.org/research_tasks.asp). The Australian geothermal sector recognises that coordinating local research efforts with those of the wider international geothermal community is important, and to this end supported the creation of the Australian Geothermal Energy Group

(AGEG), comprised of members from industry, government and academia, including key research institutions. The role and structure of AGEG is further discussed in section 9.1.

In addition to the AGEG, the Geothermal Research Initiative (GRI) was established in August 2010. The GRI is a group of university, CSIRO and Geoscience Australia researchers who have agreed to collaborate on the research and development of geothermal energy resources across a broad range of technologies and geographical locations in Australia. The GRI's aim is to perform research that supports the development of commercial and sustainable large scale geothermal power generation (electricity and heat) in Australia. The GRI has developed a collegiate and collaborative working style and the definition of the science questions that need to be addressed is well advanced.

GRI's members are the CSIRO, Geoscience Australia, The Queensland Geothermal Energy Centre of Excellence, The Western Australian Geothermal Energy Centre of Excellence, The South Australian Centre for Geothermal Energy Research, The Melbourne Energy Institute, The Priority Research Centre for Energy (University of Newcastle), and the Institute for Earth Sciences and Engineering (University of Auckland). All have made substantial commitments to Geothermal Energy research. The NSW and Victorian members are actively pursuing state funding for centres of excellence.

This group of institutions represents an effort equivalent to 77 full time staff and over 40 post graduate students. The GRI's aim is to have a network of state based research centres and national research organisations (CSIRO and GA) with the GRI acting in a national coordinating role. Research topics include, but are not limited to: drilling technologies for deep, high pressure and temperature environments; environmental impacts (such as induced seismicity and efficient water use); pre-drill prediction and characterisation of geothermal reservoir potential; and innovative power generation solutions.

7b. Government funded research

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

CSIRO's research capabilities in the geothermal arena are broad, due to the organisation's research diversity and ability to integrate multidisciplinary skills. CSIRO's activities in geothermal are through its contribution to WAGCOE's research (see below) for HSA resources and in reservoir stimulation for EGS resources as well as directly into the areas of hydraulic fracturing, reservoir engineering, well bore stability, rock petrophysics and microseismic monitoring. For more information, visit www.csiro.au/org/geothermal.

CSIRO is also building the ARRC/Pawsey Geothermal Demonstration Project component of the Education Infrastructure Fund grant "Sustainable Energy for the Square Kilometre Array". This large scale direct use project will provide heating and cooling for a research precinct using geothermal energy and adsorption or absorption chillers, targeting hot sedimentary aquifers in the Perth Basin.

Geoscience Australia (GA)

In 2010, as part of the Australian Government's five year (2006-2011) Onshore Energy Security Program, key activities of Geoscience Australia's geothermal energy project included release of new heat flow determinations as the first results generated by a new data acquisition capability, and release of an updated image and underlying bore hole database of

interpreted temperature at 5 km depth (figure 3). Acquisition of seismic, MT, gravity, magnetics and geochemistry data continued in areas with energy potential.

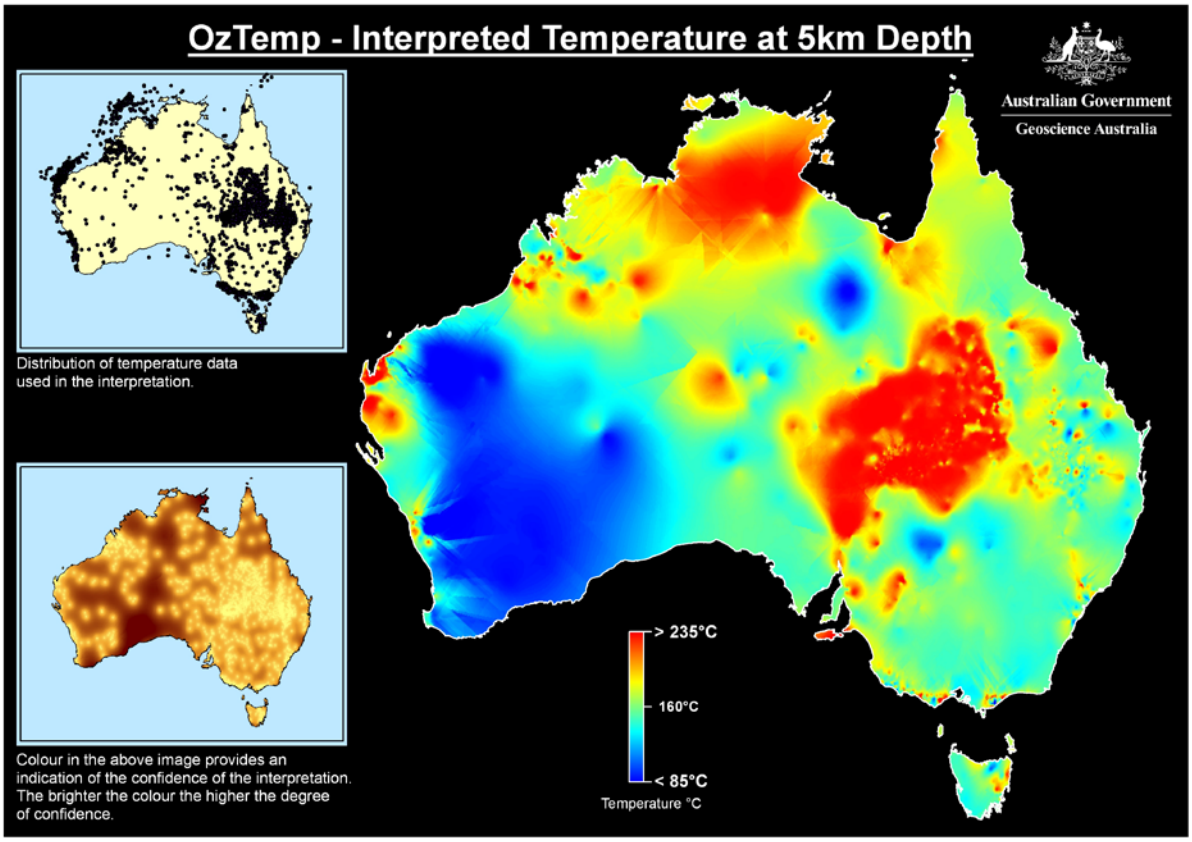


Figure 3. *An interpretation of the crustal temperature at 5km depth, based on the OzTemp bottom hole temperature database and additional confidential company data. A simple two layer model has been used for the extrapolation of the temperature to 5km depth; where the data quality and availability has allowed a slightly more complex three layer model using heat flow and thermal conductivity data was used for the extrapolation. Note: map is 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. Available at: http://www.ga.gov.au/energy/geothermal-energy-resources.html*

South Australia (SA)

The South Australian Centre for Geothermal Energy Research (SACGER) was established via an AU$1.6 million (US$1.67 million) grant over two years from July 2009. Based at the University of Adelaide, the Centre is also supported by a grant of AU$400,000 from the university over the same period. The SACGER research program focuses on investigating subsurface factors in EGS and HSA resources such as reservoir characterisation and modelling, geomechanics, geophysical imaging, and geochemical processes within reservoirs, and complements research programs of other national centres. For more information see: www.adelaide.edu.au/geothermal/ and Appendix B**.**

Western Australia (WA)

The Western Australian Geothermal Centre of Excellence (WAGCOE) is a collaborative venture between three of Western Australia's leading research institutions: CSIRO, The University of Western Australia, and Curtin University of Technology. The Centre was

established in February 2009, with an AU$2.3 million (US$2.4 million) grant over three years from the WA Government and substantial in-kind and cash contributions from the Centre's members. WAGCOE is charged with leading the exploration and exploitation of geothermal energy in Western Australia, and is focussing initially on direct heat use technologies (e.g. geothermal powered air conditioning and desalination) for use in population centres where there is shallow groundwater of moderate temperature. For more information, visit: http://www.geothermal.org.au/ and Appendix B.

Queensland (Qld)

The Queensland Geothermal Energy Centre of Excellence (QGECE) is based at the University of Queensland and was established with a AUD$15 million (US$16.1 million) grant from the Queensland Government and AUD$3.3 million (US$3.5 million) of in-kind support from the university. The Centre commenced operations in January 2009 with a five year program designed to fill gaps in the national and international geothermal research effort. The Centre's focus is on new tools for precompetitive exploration of high heat producing granites and above ground technologies, with the aim of accelerating large-scale utilisation of geothermal energy in Australia in collaboration with other national and international research groups and the industry. The collaborative projects include development of a fully-instrumented portable test plant and high pressure power cycle and expander test laboratory in Brisbane with the power plant equipment manufacturer Verdicorp; hybrid (dry and wet) cooling technology test tower for air-cooled condensers in Chinchilla with the Solar Dawn Consortium; developing options for connecting the geothermal electricity to the Queensland grid with the Queensland transmission authority, PowerLink. For more information, visit: www.uq.edu.au/geothermal and Appendix B.

New South Wales (NSW)

Geothermal research at the University of Newcastle focuses on novel power generation cycles and the concept of CO_2 thermosiphon concept for Engineered Geothermal Systems (EGS). The study of power cycles is regarded as a key area for major technological improvements since many of the problems associated with power generation from geothermal sources are underpinned by inefficient, and often unsuitable, heat exchange processes within power cycles. This is partly due to the fact that most power cycles currently in use were originally designed for large-scale power production from fossil fuels, where higher temperature sources are available for heat exchange. For more information see Appendix B.

In June 2010 the Newcastle Institute for Geothermal Energy (NIER) based in the University of Newcastle, was established with AU$30 million (US$31 million) funds from the Education Investment Fund (EIF). In September 2010 an AU $460,000 research grant was awarded by the Australian Research Council (ARC) to University of Newcastle and Near Surface Geothermal Energy to investigate extraction of geothermal energy from coals burning underground.

Victoria (Vic)

The Melbourne Energy Institute, located at the University of Melbourne, has a number of geothermal projects including the Victorian Geothermal Assessment Report, which intends to address critical issues for the successful development of geothermal power capability in Victoria. For more information, visit: http://www.energy.unimelb.edu.au. DPI and the University of Melbourne are contributors to programs to undertake subsurface borehole

measurements including temperature as part of the AuScope Australian Geophysical Observing System as of mid 2010.

8. Geothermal Education and Conferences

Postgraduate education

A Master's level course in Advanced Energy Systems was introduced in 2009 at the University of Newcastle to cover a range of topics including geothermal power generation.

Australian Geothermal Energy Conference (AGEC)

The 3rd Australian Geothermal Energy Conference (AGEC) was held in Adelaide, South Australia from 16-19 November 2010. This annual conference is the premier national forum dedicated to geothermal energy, and is jointly presented by the Australian Geothermal Energy Association (AGEA - the industry representative body for Australian geothermal companies) and the Australian Geothermal Energy Group (AGEG - representing the wider Australian geothermal energy community including industry, government and academia). The 2010 conference was well supported, with over 60 papers presented on a range of key technical and commercial topics.

WGC2015

Australia and New Zealand will jointly host the 2015 IGA World Geothermal Congress in Melbourne, Australia. The Congress will be organised and supported by the Australian Geothermal Energy Association (AGEA), the Australian Geothermal Energy Group (AGEG) and the New Zealand Geothermal Association (NZGA). For more information, visit: http://www.pir.sa.gov.au/__data/assets/pdf_file/0005/90590/WGC_2015_screen.pdf

9. International Cooperative Activities

Australia is a member of the IEA Geothermal Implementing Agreement, and participates in Annexes I (Environmental Impacts), III (Enhanced Geothermal Systems), VII (Drilling Techniques), VIII (Direct Use), X (Data) and XI (Induced Seismicity). Annex III (Enhanced Geothermal Systems) is led by Australian-based company Geodynamics Ltd, who along with Green Rock Energy (both listed on the Australian Securities Exchange) are corporate sponsors of the IEA Geothermal Implementing Agreement.

Australia is also a member of the International Partnership for Geothermal Technology (IPGT) with Iceland, Switzerland and the United States. For more information, visit: http://www.internationalgeothermal.org

Australian Geothermal Energy Group (AGEG)

The Australian Geothermal Energy Group (AGEG) is the Australian whole-of-sector 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 GIA. In 2010, the AGEG increased to 104 member organisations including: Australian geothermal licence holders, licence applicants and service companies; 13 Australian universities with geothermal research programs; and all Australian Commonwealth, state and territory government agencies responsible for providing geoscientific information, attracting investment, and regulating licences for the geothermal sector.

The organisational structure of the AGEG and its 12 Technical Interest Groups (TIGs) (Table 3) are designed to facilitate coordination of Australia's research effort, and foster national and international sharing of information, expertise and research into improved technologies and techniques. The TIGs have active organisational links to the IEA GIA's research annexes, and to the IPGT's working groups and have also been active in coordinating technical workshops and short courses on topics associated with their individual Terms of Reference. For more information, visit http://www.pir.sa.gov.au/geothermal/ageg and see Appendix B.

Table 3. *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.*

Australian Geothermal Energy Group (AGEG) Technical Interest groups (TIGs)											
Communication & Community Issues				Geothermal Technologies							
TIG 1 Sustainability	TIG 2 Reserves and Resources	TIG 3 Induced Seismicity	TIG 4 Outreach	TIG 5 Economic Modelling/ Novel Use	TIG 6 Power Plants	TIG 7 Direct Use	TIG 8 Information and Data	TIG 9 Reservoir Development and Engineering	TIG 10 Exploration and Logging Technologies	TIG 11 Drilling and Well Construction	TIG 12 Direct Use
Licensing requirements; emission; water and effluent management; environmental impacts	Forum for contributions and discussion on the Australian Geothermal Reporting Code	Focussing on the need for technical research and informed public communication on induced seismicity	Included conferences and web-content	Includes economic models, cost benchmarks and novel uses	Improving geothermal power plant efficiency e.g. Cycle type and fluids, heat exchanger efficiencies and cooling processes	Investigate direct use geothermal application including both circulating hot water and geothermal heat pumps	Data availability usefulness and exchange via standards, database design, content and development of interpretive tools	Reservoir characteris-ation, reservoir modelling, geochemistry and reservoir stimulation	Foci include geophysical methods, pre-drill resource prediction and logging	Foci include; lower cost drilling, zonal isolation and packers, temporary sealing of fractures, reducing exploration drilling costs	Industry short courses, Tertiary curricula and International post-grad exchange
Related Linked IEA GIA Research Annexes and IPGT Working Groups											
IEA GIA: Annex I		IEA GIA: Annex I & III		IEA GIA: Annex III	IEA GIA: Annex VI (Proposed)	IEA GIA: Annex VIII	IEA GIA: Annex III	IEA GIA: Annex III IPGT: Stimulation procedures and modelling	IPGT: Exploration Technologies	IEA GIA: Annex VII IPGT: lower cost drilling and zonal isolation	

10. Future Outlook

Key activities scheduled for 2011 include hydraulic stimulation of Petratherm's Paralana 2 well at the Paralana EGS Project in the northern Flinders Ranges area of South Australia, and the drilling of two exploratory wells into a Hot Sedimentary Aquifer target in the Cooper Basin by Joint Venture partners Origin Energy and Geodynamics Ltd.

Acknowledgements

AGEG and AGEA Members are thanked for their input to this report.

Barry Goldstein
Executive Committee Member for Australia
IEA's Geothermal Implementing Agreement
C/o Petroleum and Geothermal Group, PIRSA
GPO Box 1671, Adelaide SA, AUSTRALIA 5001
Email: Barry.Goldstein@sa.gov.au

11. References

Chopra, P.N. & Holgate, F., 2005. 'A GIS analysis of temperature in the Australian crust.' In *Proceedings of the World Geothermal Congress 2005*', Turkey, 24-29 April.

Department of Energy (DOE), 2008, 'An evaluation of enhanced geothermal systems technology - Geothermal Technologies Program'. Accessible online at: http://www1.eere.energy.gov/geothermal/pdfs/evaluation_egs_tech_2008.pdf.

Department of Resources, Energy and Tourism (DRET), 2008a. 'Australian Geothermal sector Development Framework.' Commonwealth of Australia, Canberra. Accessible online at: http://www.ret.gov.au/energy/clean_energy_technologies/energy_technology_framework_and_roadmaps/geothermal_industry_development_framework_and_technology_roadmap/Pages/GeothermalIndustryDevelopmentandTechnologyRoadmap.aspx.

Department of Resources Energy and Tourism (DRET), 2008b. 'Australian Geothermal sector Technology Roadmap.' Commonwealth of Australia, Canberra. Accessible online at: http://www.ret.gov.au/energy/clean_energy_technologies/energy_technology_framework_and_roadmaps/hydrogen_technology_roadmap/Documents/GEOTHERMAL%20ROADMAP.pdf.

Electric Power Research Institute (EPRI), 2009. 'Australian Electricity Generation Technology Costs – Reference Case 2010' Accessible online at: http://ret.gov.au/energy/Documents/facts-stats-pubs/AEGTC%202010.pdf
International Partnership for Geothermal Technologies (IPGT), 2008. 'Description of the International Partnership for Geothermal Technologies'. Accessible online at: http://internationalgeothermal.org/

Lund, J. W., Freeston, D. H. & Boyd, T. L., 2005. 'Direct application of geothermal energy: 2005 worldwide review', *Geothermics*, Vol. 34, Issue 6, pp. 691-727.

ENGINE, 2008. 'Propositions for the definition of research areas on enhanced geothermal systems.' ENGINE, No. 11 – June, pp. 4-7. Accessible online at: http://engine.brgm.fr/bulletins/ENGINE_Newsletter11_062008.pdf

Appendix A: Company Status Updates.

Introduction

To the end of 2010, there were 57 Australian geothermal companies actively engaged in the exploration for, and development of, geothermal energy. An overview of these companies and their activities is provided below in alphabetical order. Company synopses are for information purposes only and are neither intended, nor suitable, as investment advice.

Australian Geothermal Exploration and Development Companies

AAA Energy is an unlisted company with nine (9) licences (GELs 340–348) in the Great Artesian Basin in South Australia. For more information, visit: www.cgi.net.au

AGL (ASX code: AGK) is one of Australia's leading integrated energy companies and is taking action toward creating a sustainable energy future for our investors, communities and customers. Drawing on over 170 years of experience, AGL operates retail and merchant energy businesses, power generation assets and an upstream gas portfolio. AGL has Australia's largest retail energy and dual fuel customer base. AGL has a diverse power generation portfolio including base, peaking and intermediate generation plants, spread across traditional thermal generation as well as renewable sources including hydro, wind, landfill gas and biomass. AGL is Australia's largest private owner and operator of renewable energy assets and is looking to further expand their renewable energy portfolio by exploring a suite of low emission and renewable energy generation development opportunities.

To date, AGL has made two investments in the Australian geothermal industry. AGL acquired a 9.9% stake in Torrens Energy Limited (ASX code: TEY) in July 2008 and entered into a Geothermal Alliance Agreement (GAA) with the company. In December 2008, AGL acquired 100% of Geogen Victoria Pty Limited (Geogen).

AGL's GAA with Torrens provides for the joint development and commercialisation of base-load geothermal projects close to the National Electricity Market (NEM) in Australia. AGL will have a direct investment of between 50-75% of any joint venture after funding and successfully completing a confirmation well. Torrens' primary target is enhanced geothermal system (EGS) plays. AGL is currently sole funding the Torrens operated exploration program known as the Barossa project, for the right to earn up to 75% participating interest in any geothermal resource discovered at this project, through to the successful completion of a confirmation well to the target reservoir.

AGL's Geogen project targets geothermal magmatic plays in Victoria, Queensland and NSW. During 2010, AGL continued to explore the Victorian tenements GEP1, 2 and 3. In NSW, AGL holds 100% of the tenements EL7384 (Walcha), EL7385 (Barrington), EL7386 (Cooma) and EL7387 (Armidale). The work undertaken during 2010 in NSW was focused on desktop studies such a geological mapping and geophysical modelling to locate drilling targets In Queensland, AGL was offered 29 tenements in May 2010. The first permit year will be to complete desktop studies to locate exploration wells to be drilled in subsequent permit years.

Callabonna Energy is an unlisted company with six (6) licences (GELs 296, 304–307 and 350) adjacent to Petratherm's Callabonna Geothermal Project in the Mount Painter area in South Australia. For more information, visit: www.planetgas.com

Clean Energy Australasia Pty Ltd (CEA) is a privately owned company**,** with the goal of commercial generation of clean, sustainable base-load geothermal electricity using the natural heat flow from hot rocks and hot sedimentary aquifers. CEA comprises a strong team of geoscientists, engineers and business professionals with over 250 years experience in managing the exploration and development of oil and gas projects, power generation and geothermal projects.

CEA have secured 21 tenements in South Australia and 12 in Queensland, in areas where hot rocks and hot sedimentary aquifers are located relatively close to the Earth's surface. This tenement acquisition philosophy is predicated on minimising technical risk, maximising adaptation of conventional petroleum technology; and enhancing the prospects for competitive base-load geothermal power generation.

CEA's is pursuing development of price competitive base-load geothermal electricity for regional and remote communities, mines and petroleum facilities at off-grid and end-of-grid locations. Local base-load geothermal power at these locations potentially is highly competitive compared to existing fossil fuel based local generation such as diesel, and remote coal based generation that carries the burden of transmission costs and losses.

The South Australian tenements and one Queensland tenement are located in the Cooper Basin, where petroleum and geothermal well data confirms temperature gradients of 50°C/km depth. The tenements are also located close to local and regional electricity markets, with the nearest connection points to the national grid at Olympic Dam and Broken Hill, approximately 400km away. The Queensland tenements are located in the Great Artesian Basin which overlies and insulates high temperature rocks in this area: Tenements are located proximal to regional centres at Longreach / Barcaldine, Winton, Jundah, Windorah and Charters Towers/ Hughenden and five tenements are located south of the North West Queensland Minerals Province, which include major copper, lead/zinc and silver mines at Mt Isa and Cannington. CEA is currently progressing towards proof-of-concept commercial power generation projects in the Moomba, Longreach and NWQ regions. For more information, visit: http://www.cleanenergyaus.com.au

Deep Energy is an unlisted company with six (6) licences (GELs 308 and 311–315) over the western and southern margins of Lake Frome in South Australia. For more information, visit: www.adavaleresources.com.au

Earth Heat is an unlisted company with three (3) licences (GELs 337-339) over the Adelaide Geosyncline in South Australia.

Earth Solar Pty Ltd (ESP) is a privately owned company**,** with the goal of commercial generation of clean, sustainable base-load geothermal electricity using the natural heat flow from hot rocks and hot sedimentary aquifers.

ESP has secured 14 geothermal exploration tenements: 9 tenements in the Murray Basin, Victoria and 5 tenements in the Great Artesian Basin, Queensland. The tenements are in areas where hot rocks and hot sedimentary aquifers are located relatively close to the Earth's surface. This tenement acquisition philosophy is predicated on minimising technical risk, maximising adaptation of conventional petroleum technology; and enhancing the prospects for competitive base-load geothermal power generation.

ESP is pursuing development of price competitive base-load geothermal electricity for regional and remote communities, mines and petroleum facilities at off-grid and end-of-grid locations. Local base-load geothermal power at these locations potentially is highly competitive compared to

existing fossil fuel based local generation such as diesel, and remote coal based generation that carries the burden of transmission costs and losses.

ESP holds large geothermal acreage in northern Victoria (Murray Basin), representing significant under explored geothermal resources, located close to major regional centres, agriculture, industry and energy infrastructure at Mildura, Echuca, Wangaratta, Shepparton / Cobram, etc. In addition, ESP holds premium geothermal acreage in Queensland (Great Artesian Basin), located close to Charleville, on grid to supply Brisbane and in the Birdsville area, where Australia's only proven geothermal plant is located. ESP is currently progressing towards proof-of-concept commercial power generation projects in the Mildura, Wangaratta Shepparton/Cobram, Charleville and Birdsville regions For more information, contact: howard.bass@earthsolarpower.com.au

Eden Energy Ltd listed on the Australian Stock Exchange in May 2006 (ASX Code: EDE) and is focused on clean energy technologies, including hydrogen technologies, transport fuel systems, natural gas and geothermal projects. Eden has transferred its geothermal projects into its 100% owned, dedicated geothermal subsidiary company, Terratherma, which holds a total of 23 geothermal exploration licences covering just under 12,000 km^2. These include 22 GELs in South Australia and 1 Exploration Licence (EL) in New South Wales. Eden'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; (2) an area where anomalously high heat flow has been mapped in the Renmark Project area north of the Murray River; (3) deep hot fractured granite targets in the Cooper Basin; and (4) the Pirie area between Adelaide and Port Augusta. For more information, visit http://www.edenenergy.com.au

Geodynamics Limited (ASX Code: GDY) has first mover advantage in Australia with its Habanero-Jolokia-Savina project in granites beneath the Cooper Basin in northeast South Australia. Geodynamics has drilled five deep wells 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 1 (total depth: 3,700 m; 10km WSW of Jolokia 1 and 19km W of Habanero 3).

The Habanero Project is the first Australian geothermal project thus far to achieve 'proof of concept', by demonstrating the following key elements:

- Resource definition
- Drilling and completion of wells
- Hydraulic stimulation of a fractured reservoir
- Development of a substantial reservoir volume
- Achievement of well productivity and injectivity
- Confirmation of fluid circulation between production and injection wells
- Forecasting resource degradation
- Mitigation of currently identified operational constraints

The closed loop test was the culmination of six years of work by Geodynamics in demonstrating all of the above elements.

Flow of geothermal formation waters from Habanero 2 was achieved in 2005 at a maximum rate of 25 litres/second to surface at (up to) 210ºC. The geothermal reservoir at Habanero is a water-saturated, naturally fractured 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. In one short experiment lasting three minutes, the variable choke was opened to 100% and production of 40 kg/second was sustained over that period. 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 indicated the presence of a large volume of low impedance, water saturated reservoir where the rock temperature is 250ºC (at 4.3 km).

Closed loop flow testing of Habanero 1 and 3 including chemical tracer injection between Habanero 1 (the injection well) and Habanero 3 (the production well) was completed in February 2009. The results of the closed loop test were successful, confirming the previously established large size of the Habanero stimulated reservoir. Modelling of wells theoretically located at the extremities of the Habanero stimulated zone showed that the wells would be capable of extracting more than 40 MWth for over 20 years with only a 5°C temperature draw-down for circulation rates higher than 70 kg per second. Circulation rates during closed loop testing between Habanero 1 and 3 reached a maximum of 15.5 kg per second from a single stimulated zone. Production rates of 25 kg per second have been achieved from Habanero 3. Although these flow rates have not approached 70 kg per second at this time, the results are an indication of the heat capacity of the reservoir.

In April 2009, the Habanero 3 well suffered cracking of the casing material which was caused by hydrogen embrittlement. A combination of the fluid chemistry conditions experienced at Habanero 3, the high strength steel used for the two barrier casing strings and temperature fluctuations between flowing and shut-in conditions, led to hydrogen embrittlement conditions that made the casing steel more prone to cracking when stressed. Hydrogen embrittlement occurred due to dissolved gases, principally carbon dioxide as well as hydrogen sulphide in the reservoir fluid, reacting with the high strength steel casing material thereby releasing free hydrogen, which in turn was absorbed by the steel casing materials in the low temperature zone of the well under shut-in conditions. In May 2009, the Habanero 3 well was secured with two cement plugs in the well bore.

During 2010 Geodynamics prepared for and carried out the stimulation of the Jolokia 1 well, a well located approximately 10 km west of the Habanero field. The main concern about the well was that it was cased with the same material as the failed well Habanero 3. Consequently the well was designed with multiple completion tubings to adhere to a double barrier policy. The bottom 600 m of the well was left barefoot from 4,320 m to 4,911 m. Initial temperature logging resulted in a measured temperature of 263.5°C at 4,600m depth. This temperature projects to 277°C at 5,000 m but the well had not fully equilibrated. Over a 13 day injection period from 23 October to 5 November 2010 a total volume of 550 m^3 of NaCl brine was injected into Jolokia 1 at surface pumping pressures below 10,000 psi (68.9 MPa). During the stimulation 130 microseismic events were recorded at two levels at approximately 4,400 m and 4,700 m. The hydraulic and seismic data

indicates that the enhanced fractures at Jolokia are initially steeply dipping and as a result, required higher pressures to achieve stimulation than at Habanero. Fracture conductivity increased threefold during stimulation but from a low base.

It is not clear yet how the Jolokia reservoir will be developed, but the company will re-focus its efforts on the Habanero reservoir in 2011 with the drilling of a replacement well for Habanero 3, called Habanero 4, so that the 1 megawatt Habanero power station, built to supply electricity to the local township of Innamincka, can be brought into production. The commissioning of the power station, delayed as a result of the Habanero 3 casing failure, is expected to be early 2012, an approximate 3 year delay.

Geodynamics has three key cornerstone investors, Origin Energy, Sentient/Sunsuper and Tata Power. Origin Energy has upstream petroleum interest and Tata Power has power station development interests. For more information, visit: http://www.geodynamics.com.au

Geothermal Resources Ltd (ASX Code: GHT) has two geothermal exploration projects, both within South Australia; the Frome Project is an EGS play, whereas the Penola–Robe project is targeting a Hot Sedimentary Aquifer. 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, intersected in Frome 12, and 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.

In 2010 Geothermal Resources focussed on detailed interpretation of our own seismic data and all other seismic data from the Arrowie Basin. This work was assisted by an Australian Government Renewable Energy Development Initiative (REDI) grant of $2.4 million. The high geothermal gradient (>40ºC km^{-1}), proven sub-horizontally fractured basement granite and excellent tie-in to the seismic line have encouraged Geothermal Resources to design and cost Frome 15 and 16 as two 'proof of concept' wells. These wells are planned to reach a depth of 3250 m, with the bottom 200 m of granite to be multi-zone hydraulically stimulated. The Frome project is located approximately 150 km from the National Electricity Market (NEM) grid at Broken Hill; however, between the Frome Project and Broken Hill there are a number of active mineral development projects that could offer closer, long-term markets.

The Penola-Robe Project encompasses approximately 3,500 km^2 of GELs in the northern half of the Otway Basin. Porous, permeable sandstones of the Pretty Hill Formation (PHF) are targeted in the Penola, St. Clair and Robe Troughs at depths of 3 to 4 km. In 2009, stratigraphic and temperature data from more than 25 well completion reports were used to calculate the potential thermal reservoir volume within the GELs. A volume of 886 km^3 was calculated for the PHF slice between 3.5 and 4 km depth, where temperatures are likely to be ideal for an Organic Rankine Cycle power plant (ASX 27th October 2009). In 2010 the focus was on reinterpretation of all available seismic data for the GEL area. The resulting 3-D model that is being developed will enable Geothermal Resources to define the best HSA target considering the variables of geothermal gradient, rock type, porosity, faults, and interpreted porosity and transmissivity (from seismic attributes). For more information visit: http://www.geothermal-resources.com.au

Gradient Energy is an unlisted company with 13 licences (GELs 354–365, 377) over the northern Eromanga (Great Artesian) Basin in South Australia. The northernmost licence areas are located 30km to the south of the Birdsville geothermal power plant which operates from ~90°C waters from the Great Artesian Basin. In New South Wales, Gradient Energy has two (2) geothermal applications over sedimentary basin settings in proximity to power markets and the national power

grid. The company will explore both hot fractured rock basement and hot aquifers in sedimentary settings for power generation and direct heat applications, including desalination. For more information please visit: www.globalorediscovery.com

Granite Power Limited - International patents for the company's GRANEX™ heat conversion technology have been received and recent work has resulted in a further improvement in relative performance to up to ~65% (relative to conventional ORC technology). The company remains focused on sales into the industrial recovered waste heat (RWH) sector, due to the greater ease with which that market can be accessed and due to the virtual absence of investor interest in geothermal energy developments in Australia. Granite Power achieved its first sale of GRANEX™ in May 2011. The company's development alliance with the University of Newcastle is continuing, and step-our R&D that is currently in train offers the prospect of further improvements in GRANEX™'s performance. The key business target is, however, to accumulate a number for formal reference sites.

On the exploration and pre-development front, the company's activities have focused on improved understanding of its existing delineated resources (near Melbourne (Vic) and Gladstone Qld) and generating a formal resource estimate for its tenements at Eneabba (WA). All three are robust platforms for moving to deep drilling, confirmation of reserves status and development of base load power stations when funding becomes available. It is planned that one of the sites will be used for a commercial demonstration project, as the necessary precursor to making GRANEX™ technology commercially available on a license basis – where the prospect is for a levelised unit cost of EGS power of $60 – 70 per MWh.

Green Rock Energy Ltd (ASX Code; GRK) has 16 GELs in South Australia (3 GELs covering 2,157 km^2 in proximity to Olympic Dam, 3 GELs covering 1,483 km^2 in the Patchawarra Trough of the Cooper Basin; six (6) GELs in the upper Spencer Gulf covering 1,938 km^2 and 11 GELs in the Great Artesian Basin covering 5,028 km^2; and in the Perth Basin, in Western Australia it holds five (5) GEPs covering 1,022 km^2 in the Perth Metropolitan area, 9 GEPs in the North Perth Basin covering 2,637 km^2 3 GEPs covering 879 km^2 in and around the Collie Basin in joint venture with BHP Billiton Worsley Alumina and geothermal projects in Hungary via its 50% holding of joint venture company Central European Geothermal Energy.

Work carried out to date at its Olympic Dam project and in place geothermal heat resources was summarised in the 2009 Annual Report. In the Spencer Gulf GELs temperatures and thermo-conductivities were measured on historical drill holes in the area. In both the Perth and Collie Basins activities were aimed at mapping temperature anomalies and permeability distributions.

Green Rock's project in Hungary targets the production of geothermal water for electricity generation and direct heat for industrial, district heating and agricultural uses.

In September 2010 a wholly owned subsidiary of Green Rock Energy signed a funding agreement with the Commonwealth Governments for a $7 million grant under the Government's Geothermal Drilling Program (GDP). This funding is on a 1:1 basis – each dollar from the fund must be matched by dollar from other sources – and is subject to Green Rock achieving agreed milestones. The funds were to drill two wells to around 3km deep each for its Perth Urban Geothermal Energy Project, to replace the electricity powered air-conditioning at the University of Western Australia with geothermal powered air-conditioning. Also in September 2010 the Company was awarded an additional grant of $5.4 million for the same project from the Western Australian Government's Low Emissions Energy Development fund (LEED). Every dollar of LEED funding is required to be matched by three dollars provided from other sources including the funding from the Commonwealth Government for the project.

In June 2010 Green Rock Energy was notified that both of its applications for the Co-Funded Drilling Grant under the WA Government's Exploration Incentive Scheme have been successful. Under this Program Green Rock was awarded grants for geothermal drilling in the Perth Basin, being $145,000 for the Alkimos direct heat project in Green Rock's 100% owned Permit GEP 2 in the Perth metropolitan area and $150,000 for the Urella Fault electricity project in Green Rock's 100% owned Permits GEP 3 and GEP 4 in the North Perth Basin.

On 6th August 2010 Green Rock also reported Geothermal Resource estimate amounting to 61,000 PJ of stored heat (equivalent to 1.9 million MWth.yrs) for its Alkimos Permits GEP2 and GEP39 north of Perth covering 340 km^2. This estimate was determined specifically for the purpose of a potential district cooling project, however production of the stored heat could be used for other direct use purposes including district heating, sea-water desalination and purification of waste water by distillation.

On 28 October 2010, Green Rock reported an estimate of in place Geothermal Resources for its seven North Perth Basin Permits GEP 23, 24, 25, 26, 27, 28 and GEP41 (Permits) covering 2,100 square kilometres, amounting to total just over 1,000,000 petajoules thermal (PJt) contained in Hot Sedimentary Aquifer (HSA) and Engineered Geothermal System (EGS; also known as 'hot rock') reservoirs. HDR's estimate was determined specifically for the purpose of electricity generation by industry-standard binary cycle technology.

Green Rock announced that its 50% owned Hungarian geothermal developer CEGE had acquired a comprehensive data set from a former petroleum well close to existing power infrastructure. MOL holds the other 50% in CEGE. CEGE has exercised an option to purchase the well from MOL. The newly-acquired well data was being assessed for the purpose of determining if the reservoir is technically and economically viable for the production of geothermal energy with the aim of commencing power production in 2012, subject to CEGE obtaining the geothermal concession for the area under legislation being introduced by the Government of Hungary.
For more information, visit http://www.greenrock.com.au

Greenearth Energy Ltd (ASX Code: GER) has three (3) Geothermal Exploration Permits (GEP 10, 12 and 13) in Victoria, covering 18,795km^2 in the greater Geelong region, onshore Gippsland and the Latrobe Valley. These permits straddle the prospective Otway and Gippsland Basins and are proximate to existing grid infrastructure (with capacity), high CO^2 emitting industries and urban growth corridors.

Greenearth Energy's focus has largely been its flagship project, Australia's most awarded Hot Sedimentary Aquifer (HSA) geothermal project, the Geelong Geothermal Power project (GGPP) situated in the region northwest of Anglesea within GEP10. The GGPP was established following the release of an Inferred Geothermal Resource of 17,000PJ. This resource estimate produced for Greenearth Energy by consultants Sinclair Knight Merz (SKM), is for a HSA geothermal resource and is postulated to have the potential to deliver up to 140MWe for a project life of 30 years.

The GGPP has been a recipient of both Federal and State Government grants. The Victorian Government under its Energy Technology Innovation Strategy (ETIS) program, awarded Greenearth Energy $25 million to assist in the first two stages of the GGPP. The Stage 1, Proof of Resource stage has been awarded $5 million to assist in the drilling of a deep geothermal production well and flow testing. Upon the successful completion of Stage 1, an additional $20 million has been awarded towards the development of the Stage 2, 12MWe geothermal energy demonstration plant. The GGPP was also awarded $7 million in funding through Round 2 of the Commonwealth

Government's Geothermal Drilling Program (GDP). This funding is for Stage 1 Proof of Concept exploration drilling and flow testing.

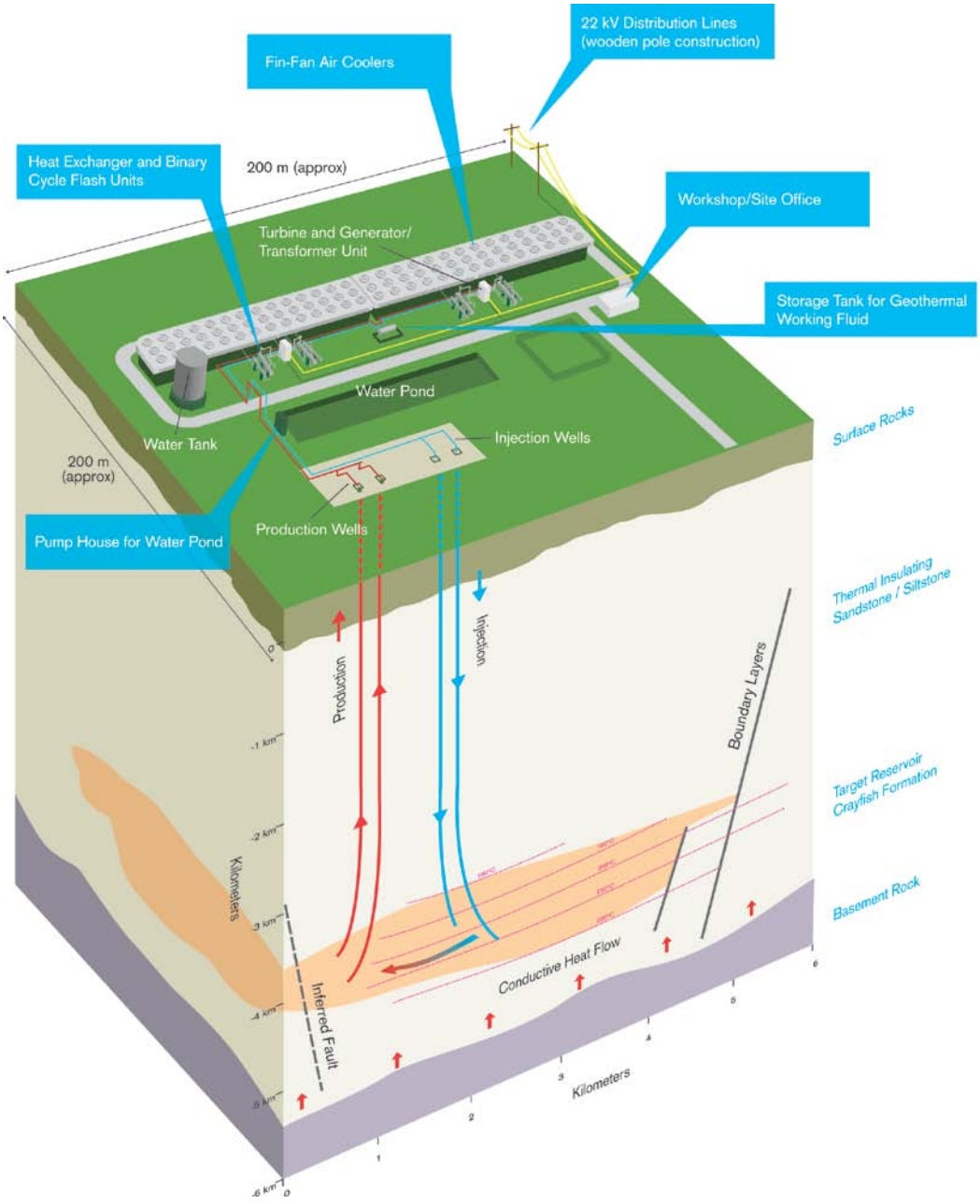


Figure 1. 3D Model of the 12MW Demonstration Stage - Geelong Geothermal Power Project.

Over the last 12 months Greenearth Energy has actively pursued capital investment both domestically and internationally, established a landmark MOI with Alcoa of Australia potentially affording the project a site for exploration and demonstration stages, grid access and a PPA covering green and Renewable Energy Certificate (REC) offtake. In addition the company has continued to undertake substantial engagement with the local GGPP community and stakeholders. Exploration work continues within Greenearth Energy's Gippsland permits.

Greenearth Energy have undertaken a variety of geophysical and geological surveys designed to allow for the interpretation of the depth and location of areas prospective for HSA geothermal reservoirs. Temperature logging of bores and wells and the measurement of thermal conductivity

from core samples have indicated that a trend of high heat flow values exists within the Latrobe Valley with heat flow estimates as high as 101±26 mW/m^2. Further geophysical surveys are planned for 2011/12.

Greenearth Energy in 2010 made several significant strategic investments into other aligned renewable and energy efficient technology categories, including Pacific Heat and Power Pty Ltd, a 100% owned subsidiary company of Greenearth Energy, which is a distributor and integrator of low-emission power supply technologies including Organic Rankine Cycle (ORC) turbines, Micro steam turbines, Microturbines (gas fired) and Redox flow batteries. The company provides full engineering, project and after sales support and will commission Australia's largest operating ORC plant in the second half of 2011.

GT Power Pty Ltd hold four (4) exploration licences (GEP 7, 8 and 9, and GEP 42), which cover a large portion of the Perth metropolitan area. GT Power's exploration focus is on use of hot sedimentary aquifers for a range of applications from heating swimming pools to potential electricity production, as well as use of ground source heat pumps for heating and cooling applications.

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 Sedimentary Aquifer 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. Future plans for HRL are to drill its first and second deep wells. The well locations will be 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. HRL 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

KUTh Energy Limited (ASX Code: KEN) has geothermal licenses covering 14020km^2 in eastern Tasmania and one geothermal tenements totalling 660km^2 in North Queensland. Through its subsidiaries the company also holds three (3) licences in Vanuatu as well as applications in Papua New Guinea and Fiji.

Since 2007, KEN has undertaken an active exploration program across its eastern Tasmania licenses where high heat producing granites are a recognised source of heat flows up to 159mW/m^2 (measured in shallow boreholes). In 2007, the company completed an in-fill gravity survey to delineate prospective high heat producing granites. These data indicate that target granite lies below 3 to 5km of a sedimentary sequence (including some coal measures). In 2008-2009, KEN drilled 37 drill holes to depths of 250-300m on a 20km x 20km grid across its eastern Tasmanian tenements. Heat flow data recorded from these drill holes define an area of ~5,000 km^2 with heat flows >90mW/m^2. Within this zone are a number of smaller areas of very high heat flow (>100mWm^{-2}) with the highest value, 118mWm^{-2} recorded at Lemont in the central Midlands area. By application of 3D geological and geothermal modelling, the company in 2009 - 2010 identified two high priority targets at Lemont (inferred resource estimate 260,000PJ) and Fingal (inferred resource estimate 101,000PJ). Successive geophysical surveys including airborne aero-magnetics (2009), magnetotellurics (2008 – 2010) and further gravity infill (2010) have since revealed the presence of a potential fracture permeable zone at depth within the vicinity of Lemont. The target at Fingal is expected to be an EGS Granite. KEN is currently in the process of planning ahead for deeper

exploratory drilling and, ultimately, production drilling on its Tasmanian targets. KEN's efforts in Tasmania have been assisted by a $1.8 million Australian Government Renewable Energy Development Initiative (REDI) Grant.

Exploration on KEN's Queensland tenements commenced in 2010. Existing borehole data from tenement EPG 7 at Jackin Creek (south of Weipa in far North Queensland) imply heat flows of >110mWm^{-2} may be present in this area. Interpretation of legacy geophysical data points to the presence of subsurface granite bodies in this region. Granite is obscured by younger insulating sedimentary basin layers. Further investigation of these areas is planned for 2011.

Geochemical work on tenement EPG 9 (at Georgetown in North-Central Queensland) produced disappointing results. A decision was made in late 2010 to discontinue the exploration program and relinquish this tenement.

In 2010 KUTh applied for a 605.2km^2 licence at Epsilon in far southwest Queensland. Part of the broader Cooper Basin region, this area is expected to host a Hot Rock EGS play within known granite. Extrapolation of temperature data from existing petroleum wells, many of which reached total depth in granite, infer that temperatures of >200°C may be present at depths around 5000m. There is considerable geothermal development taking place in the Cooper Basin region and the decision to apply for this tenement is a strategic positioning of the company to take advantage of its skill base and any developments that should eventuate in this part of the country.

In addition, the company hopes to accelerate its pathway to electricity production through the development of conventional high-temperature volcanic resources in the Pacific Region with its project in Vanuatu well advanced. For more information, visit: www.kuthenergy.com

Near Surface Geothermal Energy is an unlisted company that has one (1) geothermal licence (GEL 321) in the vicinity of the Leigh Creek Coal Field. For more information, contact: colin@colinrandall.com.au

New World Energy Solutions is a privately-owned company based in Western Australia. The company currently holds two (2) Geothermal Exploration Licences in South Australia (GEL 353, north of Renmark, and GEL 352 south of Moomba). It plans to aggressively progress exploration on these licences upon granting. While the company plans to be involved in all major electricity markets in Australia, NWES' focus at this stage is on Western Australia where it has primarily worked for the past 12 months. For more information, visit: http://www.newworldenergy.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 sedimentary aquifer targets. Laboratory permeability tests of Hutton core samples and thin section analyses provide further verification of high permeability at target reservoir depths. 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 (NEM) 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. Scopenergy was awarded a $130,000 South Australian Government Plan for Accelerating Exploration (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 paper pulp plant (to be commissioned).

Panax drilled a deep test (Salamander 1) in its Otway Basin HSA play in 2010, 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. The company has signed an agreement with leading European company Enel Green Power to jointly develop its electricity projects on mainland Spain, the Canary Islands and Portugal. Petratherm has several projects in Australia with its most advanced being the Paralana Geothermal Energy JV Project being developed adjacent to the Mt Painter region of South Australia's northern Flinders Ranges.

In the first quarter of 2010, Petratherm and joint venture (JV) partners Beach Energy and TRUenergy, completed the first of two deep wells required to begin creating a low-impact, fully operational geothermal energy pilot plant. The Paralana 2 deep injector well was successfully drilled, cased and cemented to 3,725 metres in mid December 2009 and temperatures were taken in January 2010. The bottom hole temperature was measured to be 176ºC at 3672m and the extrapolated bottom hole temperature at 4000m - 190ºC ± 1 degree. This is significantly higher than the minimum temperature of 170°C that the company targeted for economic development of the resource. An older rock sequence than initially prognosed was intersected at target depth, which contains numerous fractures and faults hosting high pressure geothermal brines. A multizone hydraulic stimulation is planned to commence in 2011, designed to link the well with this over pressured, fluid-filled fracture zone to create an underground heat exchange reservoir.

The drilling program has targeted geothermal reservoirs within sedimentary cover over high heat producing granites, referred to (by Petratherm) as its Heat Exchanger Within Insulator (HEWI) model. Petratherm has been successful in obtaining a $5 million Renewable Energy Development Initiative (REDI) Grant from the Australian 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's Plan for Accelerating Exploration (PACE) scheme to underpin developmental components of the project. This funding is complemented by two significant JVs for the Paralana Project. In early 2007, Beach Petroleum Ltd entered an agreement with Petratherm to contribute up to $30 million 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 $57 million to earn 30% equity in the Paralana Project.

The next phase will be to drill Paralana 3 (planned for the final quarter of 2011), followed by circulation testing between the two wells and proof of concept. In 2012, Petratherm aims to commence plant construction, and was recently awarded a $62.8 million Australian Government grant toward building a 30MW commercial demonstration project under the Renewable Energy Demonstration Program (REDP). The first 7.5MW plant will meet the local power needs at Heathgate Resource's Beverley Uranium Mine, 10km away. 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 five projects on the mainland and in the Canary Islands spanning conventional geothermal, EGS and direct heating targets. This includes the Geo-Madrid 8 MW District Heating project. On the volcanic island of Tenerife, Petratherm is exploring for high temperature, conventional geothermal resources with the view of supplying 50MWe.

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 and undertook a co-operative assessment to identify prospective geothermal projects in China. For more information, visit http://www.petratherm.com.au/

Roxby Geothermal Pty Ltd 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).

Stuart Petroleum is a petroleum exploration and production company listed on the Australian Stock Exchange (ASX code: STU)**.** The company has 12 licences (GELs 378–389) over petroleum producing areas of the Cooper and Eromanga Basins in South Australia. For information, visit: http://www.stuartpetroleum.com.au/

Teck Australia Pty Ltd is a subsidiary of Teck Resources Limited **(**NYSE Code: TCK and TSX Code: TCK.A and TCK.B) and has been granted South Australian GELs 294 and 295, covering 994 km^2 in the eastern Gawler Craton in proximity to the Teck / RMG Services Carrapateena Cu-Au discovery. Teck's exploration for geothermal resources has been implemented in parallel with its exploration and appraisal of the Carrapateena deposit discovery which is currently on hold, as Teck assesses its future involvement in Carrapateena. For more information, visit http://www.teck.com

Torrens Energy Ltd (ASX Code: TEY) was listed on the Australian Stock Exchange in March 2007. Torrens has 26 geothermal licences and one (1) licence application spread across three project areas covering 12,500 km^2 in South Australia, plus one (1) permit in Victoria covering 9,644 km^2. The three South Australian projects are: (1) Torrens (GELs 230-235, 278, 285, 501, 407-410, 425 and 481-483, totalling around 10,500 km^2); (2) Barossa-Clare (GELs 227-229 and 263 totalling 1,963 km^2); and (3) Adelaide (GELs 226, 260-262 and GELAs 266 and 293, over a total of 1,868 km^2). All of Torrens' licence and licence application areas are located close to the National Electricity Market (NEM) transmission grid and markets.

Torrens discovered its flagship EGS Parachilna Geothermal Play in late 2007 and early 2008. In total, eight (8) wells have been drilled to a maximum depth of 1807m. Torrens published Australia's first inferred resource at the Parachilna Play of 780,000PJ in August 2008. The aim of shallow well exploration heat flow drilling is to delineate heat flow trends as a precedent to locating

deep proof-of-concept wells. Torrens was awarded a $3 million Renewable Energy Development Initiative (REDI) grant from the Australian Government 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 Government Plan for Accelerating Exploration (PACE) grant in 2006, for heat flow exploration in the Adelaide Geosyncline.

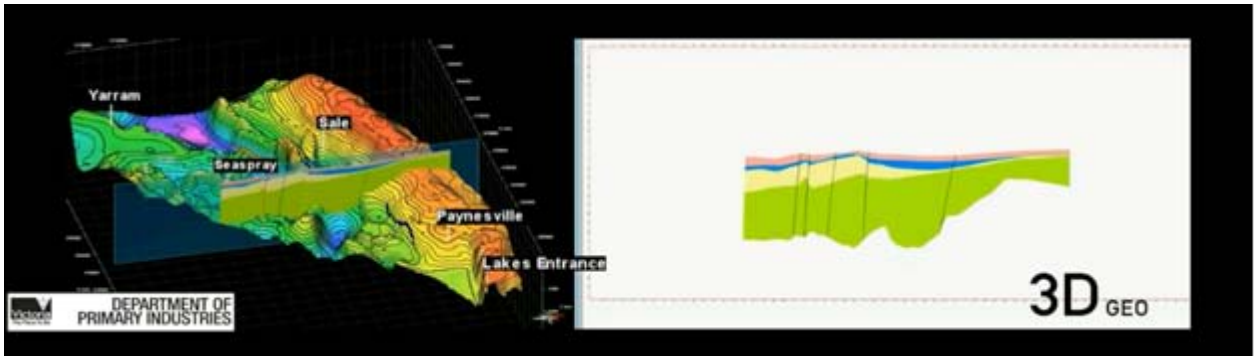
Torrens entered into a binding Geothermal Alliance Agreement (GAA) with AGL Energy Ltd in July 2008, which included AGL acquiring a 9.99% cornerstone position in Torrens Energy. AGL is Australia's largest integrated renewable energy company and largest private owner, operator and developer of renewable generation. The GAA provides for the joint development and commercialisation of base-load geothermal projects close to the NEM in Australia. Under the arrangement, Torrens Energy, as the upstream explorer, will continue to initiate geothermal projects through exploration activities, including the systematic application of its 3D-Temperature Field Model (3D-TFM) exploration methodology across its geothermal landholdings in South Australia.
In December 2009, Torrens was awarded $7 million under the Australian Government's Geothermal Drilling Program (GDP). For more information, visit: http://www.torrensenergy.com

Tri-Star Energy Company is a privately held company with petroleum production and exploration projects in Queensland, and a primary focus on the development of coal seam methane. Tri-Star has two geothermal licences west of Marree in the western Great Artesian Basin of South Australia (GELs 264 and 265 covering 994 km²) and two geothermal licences in the Cooper Basin of northeast South Australia (GELs 309 and 310 covering 955 km²). For more information, visit: http://www.tri-starpetroleum.com.au/

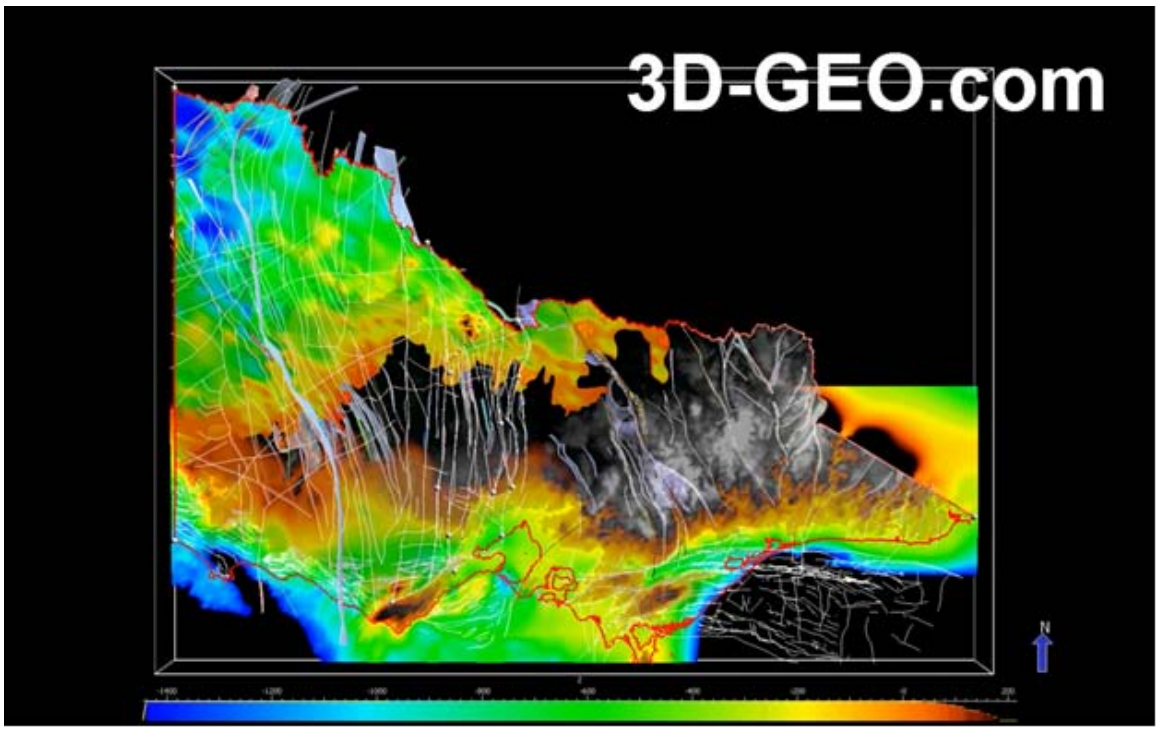
Service Providers and Investment Companies

3D-GEO offers 150 years of combined geological experience, during which geothermal modelling and thermal maturity models for a range of geothermal systems have been completed. The correct application of reservoir modelling and analysis techniques is critical to understanding past, current and future geothermal potential and ultimately performance. 3D-GEO's unique approach incorporates traditional thermal modelling with recent technical advances in heat flow (conductivity and advection), facies mapping , porosity, permeability and fracture modelling. This allows for a complete assessment of the geothermal potential in any given study area. www.3D-GEO.com

Coal, Geothermal. Petroleum, and CCS 3D-Geo Onshore Gippsland Model
http://youtu.be/nNcS_Ig09qs

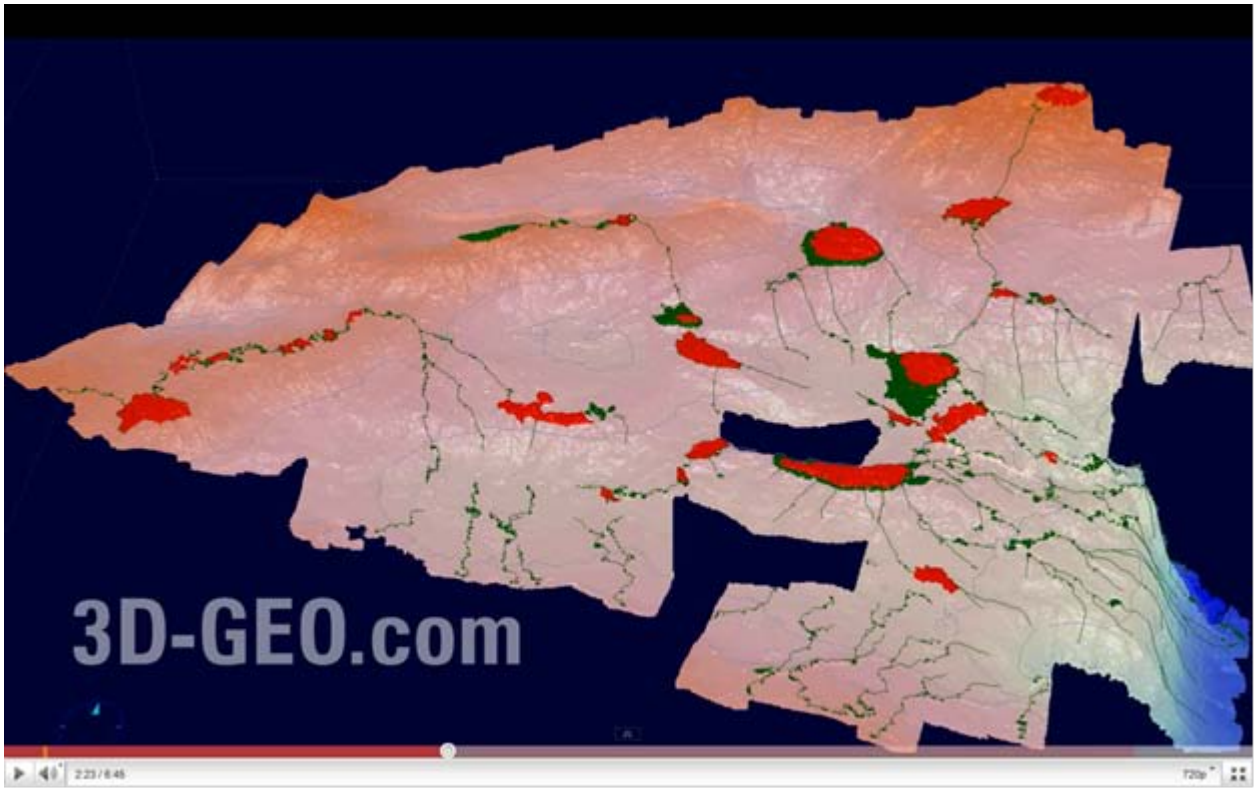


Regional Base Tertiary Aquifer for Victoria Australia
http://youtu.be/tP3fYPjd92c



http://youtu.be/jyRX6eEE-U8

3D-GEO Carbon Capture and Storage Project: Simplified 3D Gippsland Regional Reservoir Basin Model



ACIL Tasman is an Australian consultancy providing economic, policy and strategic analysis and advice to clients in business and government, and internationally. For more information, visit: http://www.aciltasman.com.au/

Activated Logic is the leading provider of strategic and innovative geothermal project development and commercialisation solutions in the Asia Pacific region. Activated Logic has significant expertise in corporate research, strategy, investment, finance and communication capabilities which is able to be applied to the emerging Australian geothermal sector. In December 2009, AGEA commissioned Activated Logic to conduct a report on the forecast development of the Australian geothermal industry. The report focused specifically on the funding requirements (challenges), and is available for download at: www.agea.org.au/media/docs/activated_logic.pdf. For more information, visit: http://www.activatedlogic.com

Balance Energy Pty Ltd is an engineering services provider. Founded in 2002, Balance Energy has been identifying and implementing significant energy efficiency measures on the sites of some of Australia's leading companies. Recently, Balance Energy purchased a 4 MW, gas turbine driven cogeneration plant (producing high voltage electricity and steam), it is currently developing for deployment on a new site. Balance Energy sees its experience in energy flow, heat transfer, fluid mechanics, thermodynamics, HV power generation and practical application as an ideal fit as an engineering services provider to operators in the developing field of geothermal energy. Balance Energy is based in Adelaide, with an office in Melbourne. For more information see http://www.balanceenergy.com.au

Earthinsite are an internet based provider of earth and environmental data and associated products such as thematic maps. For more information, visit: http://www.earthinsite.com

Electranet is a regulated Transmission Network Service Provider (TNSP) in the National Electricity Market (NEM). Their role is to provide the high voltage large capacity network for generators to transport electricity to end users. For more information, visit: http://electranet.com.au

Energycore are a geothermal heating and cooling company supplying a range of heating and cooling services for domestic, commercial or industrial use. For more information, visit: http://www.energycore.com.au

FrOG Tech Pty Ltd – From Oil to Groundwater - is an Australian-based natural resources consultancy with worldwide experience, providing a range of high quality, cost-effective geological services to the petroleum, minerals, coal, groundwater and geothermal industries. FrOG Tech specializes in basin scale studies supported by integrated ArcGIS products that include schematic models for basement composition, prediction of subsurface heat sources, geothermal plays, estimates of depth for the main targets and the heat in-place, integrated well databases, mapping of potential fluid reservoirs and their rock properties and insulating sedimentary cover using regional seismic and well datasets, predictions of areas with enhanced fracturing, fluid focusing, and identification of exploration risks. For more information, visit: http://www.frogtech.com.au

Geothermal Advisory Pty Ltd provides corporate, project and technical services to the geothermal industry in Australia and offshore. For more information, visit: http://www.geothermaladvisory.com

GHD is an international professional consulting services company of architects, engineers, drafters, planners, scientists, management consultants and economists. GHD serves the global markets of infrastructure, mining and industry, defence, property and buildings, and the environment. For more information, visit: http://www.ghd.com.au

Halliburton was founded in 1919, and is one of the world's largest providers of products and services to the energy industry. The company adds value through the entire lifecycle of geothermal reservoirs and provides and integrates products and services, starting with exploration and

development, moving through production, operations, maintenance and abandonment. For more information, visit: http://www.halliburton.com

Hot Dry Rocks Pty Ltd (HDRPL) is Australia's leading geothermal exploration, research and development consultancy specialising in defining geothermal resources suitable to exploit for energy generation. The company combines expertise in 1D, 2D and 3D crustal heat flow measurement and modelling, temperature field prediction, hydro-geomechanical modelling, stress and fracture modelling, seismic interpretation and dynamic reservoir modelling (TOUGH2) for both hot sedimentary aquifer (HSA) and engineered geothermal systems (EGS) resource definition for code compliant reporting. With offices in Melbourne and Hobart and a staff of 10 geoscientists, HDRPL offers services and advice covering initial ground selection; exploration and resource assessment; drilling, reservoir stimulation and appraisal; physical rock property measurements; economic resource modelling; to full scale development. In addition, HDRPL has an active internal R&D program to develop hardware and software tools and procedures to facilitate the rapid uptake of geothermal energy. For more information, visit: http://www.hotdryrocks.com

Intrepid Geophysics has provided innovative software development and services for potential field geophysics applications, as well as practical geophysics knowledge, to the mining and oil and gas industries since 1992. In 2009, Intrepid Geophysics received a software development grant of $20,000 for stochastic thermal modelling under a Geoscience Australia Agreement, with the goal of developing software able to produce 3D temperature probability maps of a given region, based on the measured or estimated variability of thermal conductivity and heat production rate of stratigraphic units within a 3D geology model. This work represents an extension of 3D GeoModeller's current capacity to calculate in-situ 3D temperature directly from a 3D geology model and will continue to expand on the test-bed 3D geology model of the Cooper Basin. For more information, visit: http://www.intrepid-geophysics.com

KPMG is a professional services firm, offering a range of audit, tax and advisory services. For more information, visit: http://www.kpmg.com.au

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'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 New Zealand. For more information, visit: http://www.originenergy.com.au

Schlumberger is the world's leading oilfield services company supplying technology, information solutions and integrated project management to optimise reservoir performance for customers working in the oil and gas industry. Leveraging the company's expertise in subsurface exploration and proprietary instrumentation, Schlumberger Geothermal Services provides leading-edge solutions to the geothermal industry worldwide. Schlumberger has pioneered many technologies that have now become the industry standard and continue to work on new subsurface advancements, including: fracture detection from surface, prolonged exposure of downhole electronics to high temperatures, stimulation and fracture control, cost-effective drilling of deep and large diameter wells in hard/fractured rocks, thermal recovery of heavy oil, and tools for HTHP environments. For more information, visit: www.slb.com

Senergy is an independently-owned energy consultancy, with its roots originally in the oil and gas industry in the UK. The company was formed in 2005 when the subsurface consultancy, RML (Reservoir Management Ltd.) merged with Xcavo, a well engineering and operations consultancy. Since that date the group has grown rapidly through a combination of organic growth and acquisition. The group now has 15 offices in eight different countries, including offices in Perth and Melbourne, Australia and Wellington, New Zealand. The staff base is currently just under 400 people (approximately three-quarters staff, one-quarter associates), and the group is expected to turnover in the region of AU$120 million in the current financial year.
Although the company's roots lie in the oil and gas industry, Senergy has been increasing its activities in the alternative energy market, providing intellectual and project management input to a range of energy projects. Skills within Senergy that are particularly relevant to the geothermal industry include; geomechanics, well engineering and project management, advanced drilling techniques including underbalance and pressure controlled drilling. In 2008, Senergy acquired Econnect, which forms an important part of Senergy Alternatives, having extensive experience in connecting renewable energy projects to the grid, in Australia and New Zealand.
For more information, visit: http://www.senergyworld.com

Sinclair Knight Merz (SKM) is an engineering, environmental, sciences and project delivery firm. The company is a fully integrated multi-discipline international consultancy with a world recognised geothermal sector capability. SKM is able to progress a geothermal project from early exploration right through to project development and long-term resource management, covering: geothermal exploration, geophysics and geochemistry interpretation, reservoir evaluation and modelling, reservoir engineering, well design and supervision, above ground plant development (power and steamfield), network connection studies, environmental approvals and community consultation support, on-going operational support, project management, and funders technical due diligence advisory services. SKM's geothermal energy specialisation covers both hydrothermal (magmatic and hot sedimentary aquifer systems) and hot rock or engineered geothermal systems globally. For more information, visit: http://www.skmconsulting.com or contact: Dr Stephen Hinchliffe, Geothermal Development Manager - Australia, shinchliffe@skm.com.au.

SMEC is a large, multi-disciplined engineering consultancy with over three decades of experience in planning, design, construction, procurement, operation and maintenance in the power industry. SMEC's engineering expertise in geothermal power generation extends from the ground up, including environmental, geotechnical, civil, structural, mechanical and electrical capabilities. Examples of SMEC's ability to deliver large complex design projects can be seen in the Lihir Geothermal Power projects, in Papua New Guinea. For these projects, SMEC was responsible for the engineering design, procurement and construction management along with commissioning of three single flash hydrothermal power plants with a total installed capacity of 56MW. SMECs capabilities in power plant engineering extend beyond geothermal, with experience in design of plants ranging from wind, biomass and biogas, cogeneration, combined cycle, waste heat recovery and solar thermal systems. This broad range of experience allows SMEC to provide tailored solutions to meet a variety of client needs.
Specific services offered by SMEC include:

- Project development and feasibility studies
- Process design and technology selection
- Detailed design, including 2D and 3D drafting
- Piping flexibility analysis
- Specification and contract preparation
- Procurement
- Project management
- Construction supervision
- Commissioning

For further information, visit: http://www.smec.com.au

Strategic Chemistry is a global network of energy industry professionals providing a range of advice, reviews and problem solving capabilities to the petroleum and geothermal industries. They can provide specific advice in corrosion and mineral scale modelling and material selection. For more information, visit: http://www.strategic-chemistry.com

VEMTEC is an independent and integrated design and project management business, specialising in electrical distribution design. For more information, visit: http://www.vemco.com.au

Worley Parsons is a global provider of technical, project and operational support services to the energy, resource and complex process industries.
For more information, visit: http://www.worleyparsons.com

Appendix B: Research Status Updates.

Introduction

The Australian Geothermal Industry Development Framework (GIDF) and Geothermal Technology Roadmap identify technology requirements for the geothermal sector throughout the geothermal project development process, from surface exploration and drilling through 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. Other priority technical needs include; improving understanding of local Australian geological conditions, well drilling and completion technologies, fracture stimulation, and power plant technologies particularly cooling technologies for hot, arid climates.

Promoted in the Roadmap is the need for a collaborative approach to addressing these technology challenges, drawing on expertise from the Australian and international geothermal and other industries, particularly the electricity and oil and gas sectors, and research institutions. Government leadership is suggested where such agencies have required expertise, particularly in the area of 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. An introductory discussion of Government supported research initiatives is presented in the 2009 Annual Report section 7.

Australian Geothermal Energy Group (AGEG)

A continuing strategy for the AGEG is to foster awareness of the realistic potential benefits that will flow from the widespread use of geothermal energy, and to assist in coordinating and communicating research needs and outcomes through its 12 Technical Interest Groups (TIGs). All Research Centres of Excellence, Universities and other government supported research institutions currently active in undertaking geothermal energy focused research, are members of the AGEG, including the organisations discussed below in further detail.

Through linkages to the AGEG and its TIGs, Australia is a member of, and contributes to, the work of both the International Energy Agency Geothermal Implementing Agreement (IEA-GIA) and the International Partnership for Geothermal Technologies (IPGT). Members of the AGEG have nominated research topics of high priority to the industry, which are closely aligned with research priorities of both the GIA and the IPGT.

The 12 AGEG TIGs are summarised in Table 1 below, and more information can be accessed via the AGEG TIG webpages at:

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

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.*

AGEG Technical Interest Group	**Areas of Interest**	**Links**
TIG 1 - Water management & Environmental Sustainability	Licensing requirements; emissions; water & effluent management; environmental impacts	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_1
TIG 2 -Reserves & Resources	Forum for contributions and discussion on the Australian Geothermal Reporting Code	Report: "The Australian Geothermal Reporting Code"

		http://www.pir.sa.gov.au/__data/assets/pdf_file/0012/78798/Australian_Code_for_Reporting_Exploration_Results,_Geothermal_Resources_and_Geothermal_Reserves.pdf Report: "The Geothermal Lexicon" http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/78799/Geothermal_Reserves_and_Resources_Reporting_Lexicon_Edition_1_2008.pdf
TIG 3 - Induced Seismicity	Focussing on the need for technical research and informed public communication on induced seismicity.	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_3_-_induced_seismicity
TIG 4 -Outreach	Improving communication within the geothermal sector & with the wider public	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_4_-_outreach
TIG 5 - Economic modelling & novel use	Covers economic modelling as well as novel use applications for geothermal energy including hybrid systems	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_6_
TIG 6 - Power Plant	Improvements in geothermal power plant efficiency through improvements in, for example, the cycle type, cycle fluids, heat exchanger efficiencies and more efficient cooling processes.	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_6_
TIG 7 - Direct Use	Investigate direct use geothermal applications including both circulating hot water & geothermal heat pumps.	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_7_-_direct_use_of_geothermal_energy
TIG 8 - Information & Data	Assist the sector by simplifying data availability, usefulness and exchange through standards, database design, content and development of interpretive tools.	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_9_-_data_management
TIG 9 -Reservoir Development & Engineering	Investigate technologies for enhancing geothermal reservoirs for commercial heat extraction.	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/group_4_-_enhanced_geothermal_systems
TIG10 - Exploration & Well Log Technologies	To advance geothermal methods and technologies, including the indirect detection of subsurface properties to delineate prospective trends;	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/tig_10b_geophysical_operations
TIG 11 - Drilling & Well Construction	Topics in scope for the TIG include; Lower Cost Drilling: Zonal Isolation and Packers: Temporary Sealing of Fractures: Cutting Exploration Drilling Costs.	http://www.pir.sa.gov.au/geothermal/ageg/technical_interest_groups/tig_10a_wellbore_operations
TIG 12 - Education	Education for the geothermal sector, including; Defining education needs of the industry, Developing courses at tertiary & postgraduate level & short courses for industry.	

Geothermal Research Initiative

Established in August 2010, the Geothermal Research Initiative (GRI) is a consortium of university, CSIRO and Geoscience Australia researchers who have agreed to collaborate on the research and development of geothermal energy resources across a broad range of technologies and geographical locations in Australia. The GRI's aim is to perform research that supports the development of commercial and sustainable large scale geothermal power generation (electricity and heat) in Australia. The GRI has developed a collegiate and collaborative working style and the definition of the science questions that need to be addressed is well advanced.

GRI's members are the CSIRO, Geoscience Australia, The Queensland Geothermal Energy Centre of Excellence, The Western Australian Geothermal Energy Centre of Excellence, The South Australian Centre

for Geothermal Energy Research, The Melbourne Energy Institute, The Priority Research Centre for Energy (University of Newcastle), and the Institute for Earth Sciences and Engineering (University of Auckland). All have made substantial commitments to Geothermal Energy research. The NSW and Victorian members are actively pursuing state funding for centres of excellence.

This group of institutions represents an effort equivalent to 77 full time staff and over 40 post graduate students. Our aim is to have a network of state based research centres and national research organisations (CSIRO and GA) with the GRI acting in a national coordinating role.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

CSIRO has broad research capabilities able to be applied to geothermal technology needs, including expertise in drilling and well technology, hydraulic stimulation, reservoir characterisation, co-generation technologies, rock mechanics, hydrogeology and community engagement. CSIRO is actively engaged in the AGEG TIGs and is also a partner in the Western Australian Geothermal Centre of Excellence.

Excluding CSIRO's involvement in WAGCOE, Current projects include:

- The ARRC/Pawsey Geothermal Demonstration Project component of the Education Infrastructure Fund grant "Sustainable Energy for the Square Kilometre Array". This project will provide heating and cooling for a research precinct using geothermal energy and adsorption or absorption chillers. This system targets hot sedimentary aquifers of the Perth Basin. Drilling is expected to commence in late 2011 or early 2012.
- Development of numerical modelling tools that couple thermal and poro-elastic processes for the assessment of well stability.
- Development of numerical modelling tools and procedures for hydraulic stimulation at high pressures and temperatures.
- Development of numerical modelling tools for fluid flow in fractures.
- Evaluating the application of petrophysical logging techniques to the assessment of thermal conductivity;
- Assessment of waveform characterisation techniques for the interpretation of microseismic monitoring data through laboratory based studies (high pressure high temperature triaxial cell with acoustic emissions monitoring) and the analysis of field data.

For more information see: www.csiro.au/org/geothermal

South Australian Centre for Geothermal Energy Research (SACGER)

SACGER at the University of Adelaide brings together cross-disciplinary research and expertise from the Australian School of Petroleum, Chemical Engineering, Civil, Environmental and Mining Engineering, Geology and Geophysics, and Computer Science, and facilitates research into enhanced geothermal systems and power systems that provide an economically and environmentally viable delivery of geothermal energy. SACGER is part of the Geothermal Research Initiative which is a nationwide sharing of geothermal expertise designed to bring Australia to the forefront of non conventional geothermal energy research.

In the context of national R&D focus and capabilities in Geothermal Energy research, SACGER has principle strengths in;

1) Physical science of Enhanced Geothermal Systems, namely;

- geothermal exploration,
- geophysical imaging of reservoirs
- modelling of stress regimes,
- simulation of fracture and fluid flow networks,

- geochemical processes within reservoirs and circulation systems
- the use of tracers to track fluid flow.

2) Power Systems and Integrated Thermal Cycles, particularly;

- Incorporation of geothermal energy with, solar, biomass and/or fossil fuels to increase the thermal efficiency of the system.
- Enhanced Cooling Systems.

Research Areas include:

- Development of geophysical tools: novel approaches for understanding the distribution of subsurface permeability including using 3D seismic data and the development of magnetotelluric tools that are sensitive to the presence of fluid-filled fracture systems.
- Fluid rock interaction: the geochemistry of geothermal fluids using flow-through and batch hydrothermal reactors to evaluate the dissolution of reservoirs rocks and resultant precipitation and scaling within the reservoir and infrastructure.
- Fracture modelling: development of reservoir fracture models for enhanced geothermal systems and improved understanding of fluid flow and heat transfer in rock fractures.
- Crustal Stress characterisation: modelling contemporary crustal stresses in a number of regions around the world including areas of known geothermal potential such as the Cooper Basin, understanding the stress and fluid-pressure state in non-conventional geothermal systems.

For more information see www.adelaide.edu.au/geothermal/

Western Australia Geothermal Centre of Excellence (WAGCOE)

WAGCOE is a research consortium based at the Australian Resources Research Centre (ARRC), which draws on the capabilities and experience of three of Western Australia's principle research organisations; CSIRO, The University of Western Australia, and Curtin University of Technology

Key research initiatives are:

- Perth Basin Assessment: Develop a rigorous scientific understanding of the geothermal resource in the Perth Basin, incorporating geological and hydrogeological modelling, geophysical heat estimation and convection modelling.
- Above Ground Technologies: Identify and demonstrate innovative applications of HSA geothermal energy; with particular focus on geothermal engineering solutions (desalination, cooling and dehumidifying) and coupling geology with engineering.
- Deep Resources: Provide a scientific framework for the potential exploitation of deep geothermal resources, through the identification and extraction (geochemical and geotechnical permeability management) of deep heat resources.

Current major projects include:

- Research and development activities associated with the CSIRO's ARRC/Pawsey Geothermal Demonstration Project component of the Education Infrastructure Fund grant "Sustainable Energy for the Square Kilometre Array".
- Design of an additional sensor equipped deep research and monitoring well at the same site for research, education, training and long term monitoring.
- Research and development activities associated with the direct geothermally driven MWth scale campus cooling project at UWA run by the leaseholders Green Rock Energy and UWA.
- Development of a novel desalination technology with 30% yield boost from low grade geothermal waters of 65°C and less. A containerised m3/day first generation prototype is sponsored by the

Australian Government National Centre of Excellence in Desalination located at Murdoch University.

For further details, see: http://www.geothermal.org.au/

Queensland Geothermal Energy Centre of Excellence (QGECE)

The QGECE has strong research capabilities in the areas of energy systems engineering, transmission and distribution, and will focus its research activities on above ground technologies in conjunction with key collaborators from the Massachusetts Institute of Technology (MIT) and the University of Adelaide. Principle research areas for the Centre are:

- Power Conversion: developing technologies to enable production of 50% more electricity from binary plants using the same subsurface investment;
- Heat Exchangers: development of natural draft dry cooling towers and other cooling solutions to increase by up to 15% the net output of geothermal plants that use air-cooled condensers;
- Reservoir Geology: establish a geochemical/isotopic and geochronological database and improve understanding of geothermal resources in Queensland and develop routine exploration tools for hot rock geothermal systems; and,
- Transmission: research in to electricity grid interaction with an emphasis on remote generation infrastructure.

Current major projects underway at QGECE include;

- Design and development of small (5-kWe) supercritical turbines for laboratory testing.
- Construction of a 100-kWe mobile geothermal test plant with high-pressure capability to trial supercritical turbines.
- Characterisation of the heat-producing granites in Queensland.
- The effect of ambient dust on air-cooled condenser performance and design against dust.
- Investigation of options for connecting remote geothermal power generation to Queensland grid

For further details, visit: www.uq.edu.au/geothermal

University of Newcastle

Geothermal research at the University of Newcastle focuses on innovative power generation cycles and the application of the CO2 thermosiphon concept in Engineered Geothermal Systems (EGS), in order to increase efficiencies in heat exchange processes from lower temperature sources.

In 2006, Granite Power Limited (GPL) and the University of Newcastle initiated a joint R&D program to investigate alternative and potentially more efficient ways of generating power from geothermal and other low-grade heat sources, such as industrial waste heat. The result was the creation of GRANEX Regenerative Supercritical Power Cycle.

In conjunction with a program of fundamental studies (supported by the University) an applied program of work was undertaken for proof-of-concept and prototype development with the assistance of an AU$2.4 million (US$2 million) grant from AusIndustry (2007-2009) through the Renewable Energy Development Initiative (REDI) scheme. Further research support was provided by the Australian Research Council in the form of two ARC-Linkage grants (AU$428,000).

The R&D phase of the project was completed in 2009 and the technology is now in the early commercialisation stage.