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Australian Governments' Support for Geothermal Development

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ABSTRACT

Security of energy supply and pricing in addition to a desire for low-emission energy sources are driving interest in the development of a geothermal energy industry in Australia. Traditionally Australia has been regarded as having very limited geothermal potential. It is only relatively recently that the potential for Hot Rock and Hot Sedimentary Aquifer systems has started to be quantified. The realization that parts of the Australian crust are anomalously hot at accessible depths came via compilations of bottom-hole temperatures from petroleum drilling produced by the Bureau of Mineral Resources, Geology and Geophysics (now Geoscience Australia) in the late 1980-90s. This work was followed up at the Australian National University and directly resulted in development work at Innamincka (Cooper Basin, South Australia) by Geodynamics Limited.

Various Governments in Australia are supporting the rapid growth of a new geothermal industry through development grants, research and development programs, and provision of precompetitive geoscience information, amongst other activities.

1. INTRODUCTION

Australia has a Federated system of government and the ownership of onshore earth resources is vested in each State and Territory. All States have legislation that regulates exploration and exploitation of geothermal resources. Legislation was introduced to the Northern Territory Parliament in November 2008. In addition to enabling legislation, several States support the geothermal industry through various grant schemes, as detailed below.

The Australian Federal Government has several initiatives in place to support exploration and development of Australia's geothermal resources. Geoscience Australia provides precompetitive geoscience data in support of earth resource industries, and is conducting a data acquisition program to make new heat flow measurements throughout the continent as part of the AUD$58.9M five year Onshore Energy Security Program. During 2000–2008 the Australian Government has awarded AUD$32M in grants to geothermal companies through programs such as the Renewable Energy Development Initiative. The Department of Resources, Energy and Tourism (RET) conducted and published a Geothermal Industry Development Framework and Technology Roadmap. Launched in December 2008, the Framework contains a list of ten key recommendations and actions designed to encourage the development of a viable geothermal energy industry. Several of the recommendations are being addressed by the AUD$50M Geothermal Drilling Program administered by RET. This program provides matching grants of up to AUD$7M per proof-of-concept project via a multi-round competitive application process and aims to assist the growth of a sustainable industry by supporting the development of a number of proof-of-concept projects in a variety of settings. This will demonstrate the robustness of the technology and lower investors' risk leading to increased investment. Geothermal energy companies are also eligible to apply for funding from the AUD$435M Renewable Energy Demonstration Program.

2. GEOTHERMAL SYSTEMS IN AUSTRALIA

Without 'active' volcanism, the heat source for geothermal systems in Australia is dominantly radiogenic high-heat-producing granites, although recent volcanism (~20,000 ya) in the Otway and Gippsland Basins in south-eastern Australia may be contributing to elevated crustal heat flow. In the Australian geothermal community the term "Hot Rock (HR)" has been generally accepted to embrace those systems comprising a deeply buried heat source with an overlying (sedimentary) thermal insulator where the desired temperatures are found at depths of >3.5 km and that require fracture stimulation. These systems may comprise elements of "Hot Dry Rock", "Hot Fractured Rock" and 'Enhanced/Engineered Geothermal Systems".

The term "Hot Sedimentary Aquifer (HSA)" is used to describe geothermal systems in shallower, permeable, water-filled basins that may or may not require permeability enhancement. These are quite conventional in nature, except for the non-volcanic heat source.

3. GEOSCIENCE AUSTRALIA

Geoscience Australia (GA) provides first class geoscientific information and knowledge which enables Australian governments and communities to make informed decisions about the exploitation of resources, the management of the environment, the safety of critical infrastructure, and the resultant wellbeing of all Australians. GA examines key issues such as the global attractiveness of Australia's offshore and onshore exploration, and improving resource management and environmental protection. GA plays a key role in developing a sustainable energy supply for Australia's future.

3.1 Onshore Energy Security Program

The Onshore Energy Security Program (OESP), implemented by the Australian Government as part of a broader package of energy initiatives in 2006, is a five-year program designed to deliver reliable, precompetitive geoscience data and scientifically based assessments of the potential for onshore energy resources, including oil, gas, geothermal energy, uranium and thorium.

The mission of the OESP is to significantly boost investment in exploration for onshore energy resources to assist in securing a sustainable energy supply for Australia's future. The OESP complements GA's program to encourage offshore exploration for hydrocarbons in frontier regions.

The OESP is being implemented by the Onshore Energy and Minerals Division in consultation with the State and Northern Territory geological surveys and peak industry bodies, including the Australian Petroleum Production and Exploration Association, the Association of Mining and Exploration Companies and the Australian Geothermal Energy Association.

Data acquired as part of the OESP has included several long seismic reflection transects, Australia-wide airborne radiometrics and magnetics, regional gravity, magnetic and AEM surveys, and a continent-wide low-density geochemical survey. More information can be found at: http://www.ga.gov.au/minerals/research/oesp/index.jsp.

3.2 Geothermal Energy Project

Geoscience Australia has established a geothermal energy project as part of the OESP. The project aims to improve the existing knowledge about the type and location of geothermal resources in Australia on national and regional scales. It also aims to encourage investment, exploration and exploitation of this energy source through provision of pre-competitive geoscience datasets relevant to geothermal energy. More information on the Project can be found at: http://www.ga.gov.au/minerals/research/national/geothermal/index.jsp.

To achieve these objectives, the geothermal project aims to:

- collect and compile new heat flow data across Australia to better define and locate geothermal resources;
- complete source and trap modelling to identify potential hot rock systems;
- compile national datasets which may be useful to the geothermal industry including groundwater temperatures, borehole temperatures and gradients, rock thermal conductivities, locations of recent volcanic activity and hot springs, and granite and sediment chemistry;
- build a geothermal information system to effectively store new and existing heat flow data and make this data easily accessible to the public, industry and academia; and
- use these new datasets to produce a revised estimates of Australia's total contained geothermal resource.

The current understanding of Australia's geothermal resources is based on limited data such as temperature measurements taken in 5,722 petroleum and mineral boreholes across the country (Figure 1) which were used to generate a map of estimated crustal temperatures at a depth of five kilometers (Figure 2; Chopra and Holgate, 2005).

Heat flow data are rarer, with the most recently published compilation containing less than 200 heat flow data-points for Australia (Cull 1991). These temperature and heat flow measurements are unevenly distributed and, where no temperature or heat flow data exist, the available information has been interpolated over large areas to generate national-scale maps.

Compilations of other national-scale datasets relevant to exploration for geothermal energy are incomplete, non-existent or not publicly accessible. Datasets such as the 3D distribution of high-heat producing granites overlain by insulating low thermal conductivity sediments will be useful for identifying locations with potential for high temperatures. Geothermal energy is an emerging industry in Australia and access to targeted geoscience information will lower the risk to explorers and investors as well as facilitate the exploitation of this low-emission energy source.

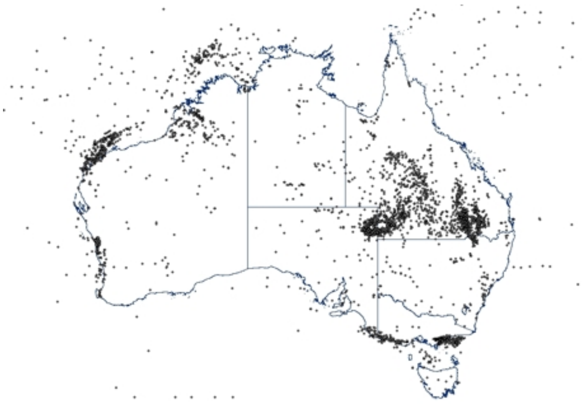

Figure 1: Location of bottom-hole temperatures used in the Austherm dataset.

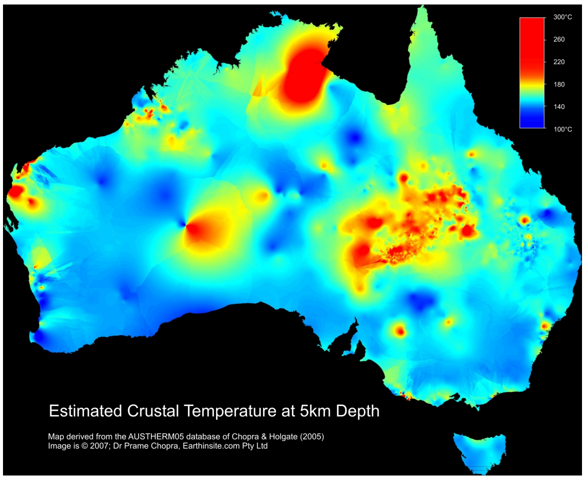

Figure 2: Modelled crustal temperature at 5 km depth using data from the AUSTHERM05 database (Chopra and Holgate 2005). The temperature data contained in this image has been derived from proprietary information owned by Earth Energy Pty Ltd ABN 078 964 735.

3.3 Data Acquisition - Heat flow

Heat flow is the preferred method for quantifying the amount of thermal energy that is available at a particular geographic location. Heat flow is the product of thermal gradient and thermal conductivity, and may be measured in the crust via drill holes. There are approximately 200 heat flow measurements throughout Australia, a coverage that is far too sparse to provide a meaningful map of heat flow on a continental scale (Figure 3). Geoscience Australia has acquired a thermal conductivity meter and downhole logging equipment in order to acquire new heat flow measurements to improve the definition of heat flow provinces throughout the continent. The project will operate a field crew full-time to measure the temperature gradient in selected holes across the continent, and will also sample drill core from State and Territory core libraries to make new thermal conductivity measurements.

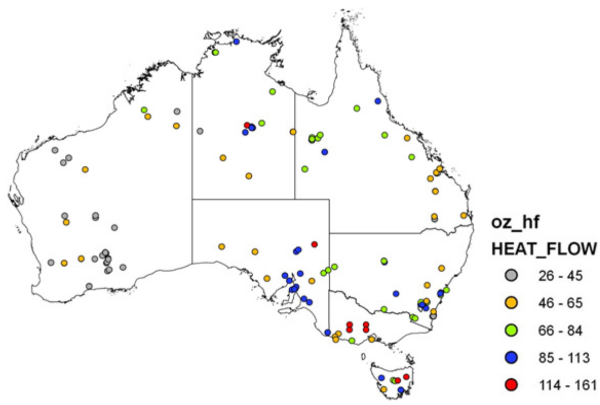

Figure 3: Location of publicly-available heat flow data points (after Cull 1991).

3.4 Mapping

3.4.1 Predicted Map of Temperature at 5 Km

When bore holes are drilled, temperature measurements are often taken downhole including at the bottom of the hole. This is particularly true in petroleum exploration, as temperature is important information for understanding the maturity and therefore the grade of oil or gas that may be expected. Temperature measurements, combined with other information such as thermal gradient, allow the temperature expected at 5 km depth to be vertically extrapolated. This extrapolated temperature can be horizontally interpolated between drillholes, and then contoured to produce a continuous map of temperature at 5 km depth across the entire continent. This technique was pioneered by Somerville et al. (1994 - Geotherm94 database) at the Bureau of Minerals Resources (now Geoscience Australia) and the Energy Research and Development Corporation. Additions and refinements were subsequently made to the database by Chopra and Holgate (2005 - Austherm05 database) (Figure 1). Geoscience Australia has purchased the Austherm05 database from Dr Chopra (Earth Energy Pty Ltd), and has started making further improvements. These include utilizing the OZ SEEBASE™ sediment thickness data to better constrain the depth at which geothermal gradients change from those typical of sedimentary basins to the lower gradients typical of crystalline basement rocks, and dividing the continent into areas of different temperature gradient based on recognized heat flow provinces.

The Austherm05 database has also been used in a new way to estimate the geothermal energy contained within the Australian crust. The 5 km economic drilling depth was used as a lower depth extent: in the USA a similar estimation was based on a depth of 10 km. The database was interrogated to provide the depth at which 150°C would be predicted to form an upper depth layer. Grids with 5 km x 5 km cells were made, and the average temperature, volume and an estimation of the contained heat was calculated for each cell (Figure 4). This provides an estimate of 1.9 x 10^{25} Joules of energy contained in the upper 5 km of Australia's crust. Not all of this energy will be accessible for extraction: if a low estimate of 1% were taken, geothermal sources could provide 26,000 years of energy supply [the ABARE reported gross energy consumption of 7258.1 PJ in 2004-2005]. Renewability, and future drilling and extraction technologies will undoubtedly allow extraction of heat at depths greater than 5 km, meaning that the above figure is conservative.

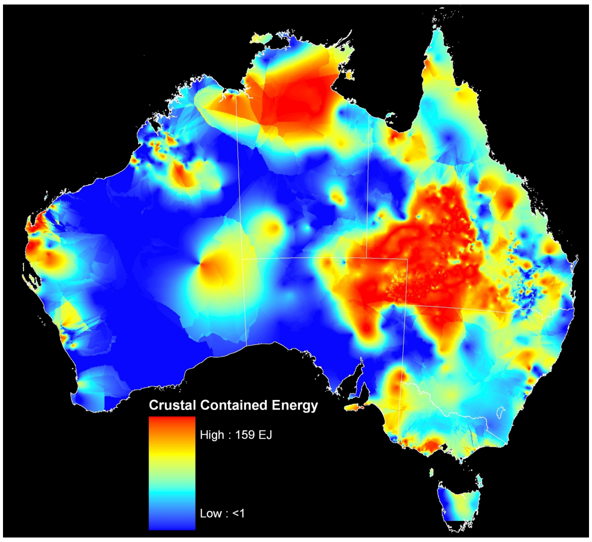

Figure 4: Map of distribution of contained crustal energy. See text for calculation method. The total resource is 1.9 x 10^{25} J, 1% of which is equivalent to 26,000 years of gross energy consumption in Australia during 2004-2005. The temperature data used in this image has been derived from proprietary information owned by Earth Energy Pty Ltd ABN 078 964 735.

3.4.2 Granite-Sediment (Heat Source-Insulator) Map

The key geological components of the Hot Rock geothermal system are high-heat-producing granites overlain by thick accumulations of low-thermal-conductivity sediments. The decay of low concentrations of radiogenic elements (mostly uranium, thorium and potassium) over millions of years produces heat in the granite. This heat may be trapped at depth within the crust by the sedimentary cover which, lying above the granite, acts like a blanket. By mapping out deeply buried granites and having knowledge of both their chemistry and the thermal conductivity of any overlying sediment, it will be possible to make predictions about crustal temperature. Unfortunately most of the available granite chemistry comes from samples at surface, rather than from those that are buried. It is possible however to identify buried granites using remote sensing methods such as gravity and magnetics. By mapping granite outcrops it is also possible to make predictions of the composition of buried granites as they trend from outcrop areas to beneath sediments. In this way the heat production beneath sedimentary basins may be estimated. With information about the thicknesses and thermal conductivity of the overlying sedimentary strata, the heat production of the buried granites, and estimation of heat flow upwards from the mantle, local temperature profiles of the crust in that location may be estimated.

Initial stages of this work have been undertaken with the compilation of information about outcropping granites and their chemistry. The heat production of the granites has been calculated, and combined in a GIS with maps of basin thickness (Figure 5). This provides a first-pass map of prospective areas, but also highlights where more granite geochemical data is needed.

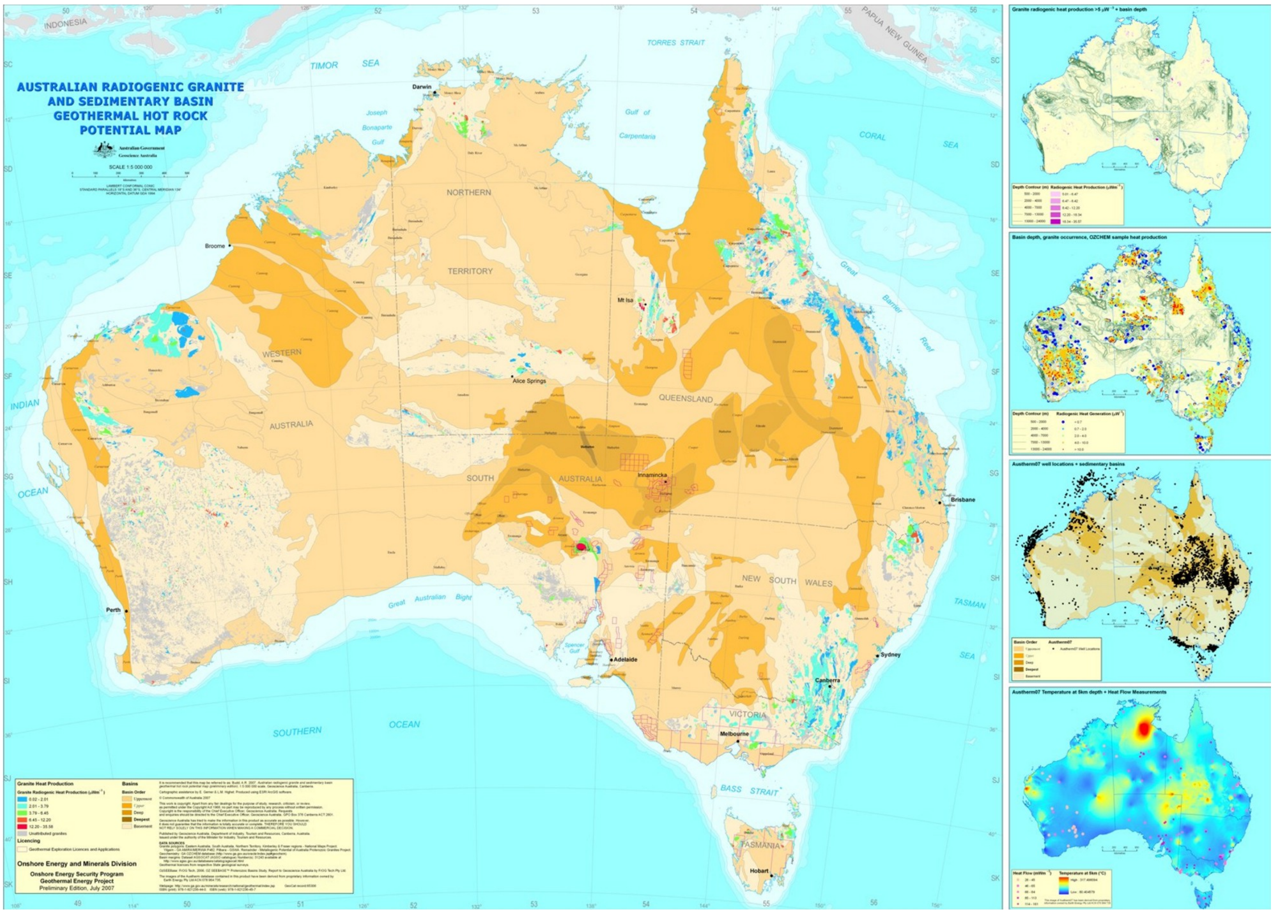

Figure 5: Map showing distribution of granites and their radiogenic heat production, combined with location and depth of sedimentary basins (main panel). Right-hand panels include information on distribution of geochemical samples and their U-Th-K contents, distribution of downhole temperature measurements, depth of sedimentary basins, and temperature at 5 km depth. The map can be downloaded at http://www.ga.gov.au/minerals/research/national/geothermal/index.jsp.

3.4.3 Regional 3D Maps and Thermal Modeling

The Cooper Basin area is host to Australia's most advanced Hot Rock development at Innamincka by Geodynamics Limited in South Australia. Significant volumes of the high-heat producing Big Lake Suite granodiorite intrude basement in this area and thick sedimentary sequences in the Cooper and overlying Eromanga Basins provide a thermal blanketing effect resulting in elevated temperatures at depth. A 3D geological map of a portion of the Cooper Basin region has been produced using geologically constrained 3D inversions of gravity data for an area of 300 by 450 km to a depth of 20 km (Meixner and Holgate, 2009a;b). The inverted density models delineate regions of low density within the basement that are inferred to be granitic bodies. The 3D maps include potential heat sources and thermally insulating cover, the key elements in generating an EGS play.

A region was extracted from the Cooper Basin 3D map and used as a test region for modelling the temperature, heat flow and geothermal gradients. The test region was populated with thermal properties and boundary conditions were approximated. Temperatures were generated on a discretized version of the model within GeoModeller and were solved by explicit finite difference approximation using a Gauss-Seidel iterative scheme. This work is described in detail by Meixner et al. (this volume).

3.4.4 Geothermal Play Systems

Although Australia has relatively few and poorly distributed temperature or heat flow data points, there exists a wealth of geoscience information that may be applied to HR and HSA exploration. Exploration for HR geothermal plays is in its infancy, with relatively little practical experience available to facilitate efficient predictive modelling and exploration. GA is working in two ways to contribute to advancing HR exploration: through synthetic modelling to determine the minimum required geometries and characteristics of granite heat sources and sedimentary insulators; and by creating an understanding of how extensive publicly-available non-temperature geoscience datasets can be used as "mappable practical proxies" to better inform exploration and other data acquisition programs.

3.5 Advice

A key impediment to the development of a geothermal industry in Australia has been the wide-spread lack of understanding of Australia's geothermal energy potential. GA has undertaken numerous activities to address this, including providing information via a web site and public speaking.

3.5.1 Advice to Government

Geoscience Australia is an agency within the Department of Resources, Energy and Tourism. GA provides advice to the Department and it's Minister on technical aspects of geothermal energy. GA has also provided input to the development of the Geothermal Industry Development Framework and continues to work on the Implementation Committee. GA was involved in establishing the Geothermal Drilling Program and continues to serve as Technical Assessor. GA assists DRET to contribute to the Steering Committee of the International Partnership for Geothermal Technology, and also provides information sessions to visiting international governmental delegations.

3.5.2 Australian Geothermal Energy Group

GA provides input to several of the Technical Interest Groups of the Australian Geothermal Energy Group (see below). Two significant activities have included the establishment of the world's first public code for reporting Geothermal Resources and Reserves (see Lawless et al., this volume), and the establishment and running of the Australian Geothermal Energy Conference (Gurgenci & Budd, 2008). For more information on AGEG see: http://www.pir.sa.gov.au/geothermal/ageg.

4. AUSTRALIAN GOVERNMENT – DEPARTMENT OF RESOURCES, ENERGY & TOURISM

The Department of Resources, Energy and Tourism (DRET) is responsible for several programs to support the Australia geothermal industry.

4.1 Geothermal Industry Development Framework and Technology Roadmap

The Geothermal Industry Development Framework works to accelerate the development of geothermal energy in Australia. The Framework is a comprehensive approach to industry development and incorporates the technology roadmap which was produced for the Council of Australian Governments (COAG). The vision presented for geothermal energy is "to make a substantial contribution to Australia's long term energy supply and reduce national greenhouse gas emissions by developing a sustainable, safe, and secure, socially and environmentally responsible geothermal energy industry". The Geothermal Technology Roadmap examines in detail the research and technology development needs of the geothermal industry in Australia.

Both documents were prepared by DRET in collaboration with the Australian geothermal industry. The Minister for Resources and Energy launched the Framework and the Roadmap on 1 December 2008.

The framework recommendations include:

1. Increase investment
2. Geoscience data
3. Industry networks
4. International linkages and partnerships
5. Research and development
6. Human capital development
7. Communication and community consultation
8. Policy environment and development
9. Legislation and regulatory framework
10. Ongoing implementation committee

The Framework and Technology Roadmaps are available for download from: http://www.ret.gov.au/energy/clean_energy_technologies/energy_technology_framework_and_roadmaps/geothermal_industry_development_framework_and_technology_roadmap/Pages/GeothermalIndustryDevelopmentandTechnologyRoadmap.aspx.

4.2 Renewable Energy Demonstration Program

The AUD$435M Renewable Energy Demonstration Program (REDP) is part of the AUD$500M Renewable Energy Fund (REF), which is an Australian Government commitment to maintaining a strong and internationally competitive economy with a lower greenhouse gas signature. REDP aims to stimulate over $1 billion worth of investment in renewable energy technology, with the private sector contributing at least $2 for every $1 provided by the Program. Funding for REDP is available for the 2008/09 and 2009/2010 financial years subject to the availability of suitable demonstration projects. The objective of the REDP is to accelerate the commercialization and deployment of new renewable energy technologies for power generation in Australia by assisting the demonstration of these technologies on a commercial scale, and thereby to contribute to the achievement of the 20 per cent renewable energy target by 2020 and global efforts for climate change mitigation.

The program provides grants for eligible renewable energy power generation demonstration projects, of up to one third of the eligible expenditure on the project. The size of grants to successful projects is expected to be in the range of AUD$50—100M. The program is designed to fill the gap between post-research and commercial uptake, targeted at project proposals that are relatively mature and are at the stage of commercial demonstration. Demonstration is taken to be the final step to address remaining technology risks around integration and scale-up, once the technology has been proven at pilot plant scale. Geothermal is one of six renewable energy technologies eligible for the REDP.

Further information on REDP can be found at: http://www.ret.gov.au/energy/energy%20programs/RenewableEnergyFund/renewable_energy_demonstration_program/Pages/RenewableEnergyDemonstrationProgram.aspx.

4.3 Geothermal Drilling Program

Launched on 20 August 2008 by Minister Ferguson, the AUD$50M Geothermal Drilling Program (GDP) provides assistance to companies seeking to develop geothermal energy with the cost of proof-of-concept projects including drilling geothermal wells. The GDP is part of the AUD$500M REF, and is a competitive merit-based grants program provided as a dollar for dollar matched funding and is capped at AUD$7M per proof-of-concept project. The GDP works towards several of the recommendations of the GIDF (above).

A proof-of-concept project involves drilling an initial deep well to the required depth to reach the desired temperature, usually between three to five kilometers. If necessary, fracturing of the rock at this depth is undertaken to allow fluid passage and create an effective underground heat exchanger. A second well is then drilled to intersect the reservoir hundreds of meters away from the first hole, and testing is undertaken to provide information on how much fluid can be circulated through the underground heat exchanger and at what temperature. Once a suitable geothermal resource is "proven" to exist, a commercial viability study is undertaken, and then development is begun. Whereas the proof-of-concept phase involves as few as two wells, development of a large scale resource may involve the drilling of more than 100 wells.

This program will help get the industry over the short-term hurdle of high drilling costs, which is delaying the ability of companies to demonstrate proof-of-concept in a variety of locations and, thereby, demonstrate the robustness of the technology to private sector investors. It is possible that the first small-scale geothermal power plants could be in place in the next four to five years.

Round 1 completed in early 2009, resulting in grants being awarded to Petratherm Limited's Paralana project and Panax Geothermal Limited's Penola project, both in South Australia. Round 2 will be completed during the second half of 2009.

5. STATE GOVERNMENTS

5.1 Queensland

In September 2007, the Queensland State Government committed AUD$15M to the Queensland Geothermal Energy Centre of Excellence (QGCoE) at the University of Queensland UQ), Brisbane. This grant is being met by a AUD$3.3M contribution of expertise and other resources from UQ, making this the largest investment in geothermal energy research in Australia. The work being conducted by the QGCoE is research towards exploitation of the geothermal reserves through: (1) resource management and optimization; (2) optimum power conversion; (3) power plant cooling systems; and (4) long-distance electricity transmission. The Centre will work with other national and international research groups to address challenges that need to be overcome to make geothermal energy a proven commercial reality. The centre will also work with other Australian universities to introduce undergraduate and post-graduate programs to develop a skill base, and train postgraduate students.

5.2 Western Australia

In February 2008, the Western Australian State Government announced AUD$2.3M funding for a Geothermal Centre of Excellence comprising collaboration between CSIRO, The University of Western Australia, and Curtin University of Technology. The Perth Basin provides a natural underground heat exchanger as it has high natural permeability allowing geothermal groundwater convection with no need for artificial hydraulic fracturing. Because of Perth's geological setting, the Centre focuses on direct heat use technologies (e.g. geothermally-powered air conditioning and desalination) for use in population centers where there is shallow groundwater of low- to moderate-temperature. The Centre will harness new supercomputers being established in Perth to make it possible to drive geothermal research into 3D computationally intensive directions that had previously been out of reach in Australia. The Centre will also offer geothermal training to students and industry. The research is organized in three interlinked Programs: 1) assessment of Perth Basin geothermal resources using presently available data; 2) optimal use of geothermal resources; and 3) identification of future potential by going deeper.

5.3 South Australia

The South Australian Government has been an early-mover in enabling geothermal exploration and exploitation, and this combined with a high perceived resource potential has lead to the state hosting the majority of activity and expenditure in Australia. The State department Primary Industries and Resources South Australia (PIRSA) acts as Australia's Contracting Party to the IEA's GIA, provides the Secretariat for the Australian Geothermal Energy Group (AGEG) including meeting venues and web-page management, and has provided $2.5 million (US$1.9 million) in grants for Australian geothermal projects and research over the period April 2005- April 2009 including:

- AUD$1M to support exploration geophysical surveys and drilling for ten geothermal projects under the State's Plan to ACcelerate Exploration (PACE) program;

- AUD$500,000 to pay for half the cost of transmission lines from Geodynamics' Habanero project to the nearby town of Innamincka;

- Support to the Australian School of Petroleum at the University of Adelaide for a study of potential induced seismicity associated with the fracture stimulation of HR wells in the Cooper Basin. The results underpin PIRSA's approach to the regulation of fracture stimulation during HR project development. The results of this study are detailed in Hunt and Morelli (2006) and Morelli and Malavazos (2008); and

- AUD$500,000 via three tied grants to the University of Adelaide to initiate research with a bearing on South Australian HR geothermal projects. The tied grants require project plans to be agreed by the geothermal sector through the AGEG and involved research organizations. Ten key projects addressing a diverse range of critical uncertainties and issues have been initiated including: scaling and corrosion in HR energy extraction systems; reserve and resource definitions; reservoir characterization; life cycle of water in HR operations; forward prediction of spatial temperature variation from 3D modeling; and assessment of the impact of geo-fluid properties on power cycle design and a comparison of the performance of state of the art power cycle design.

6. INTERNATIONAL COLLABORATIONS

6.1 International Partnership for Geothermal Technology

Australia is a founding member of the International Partnership for Geothermal Technology (IPGT) alongside the United States and Iceland. The Charter Agreement for the IPGT was signed on August 28, 2008 in Keflavik, Iceland. The purpose of the IPGT is to accelerate the development of EGS technology through international cooperation. EGS is in an early stage of development and groups throughout the world are working to develop effective methodologies and practices. Each of the member countries is pursuing a range of activities in EGS. The IPGT provides a forum for government and industry leaders to coordinate their efforts, and collaborate on projects. The IPGT Steering Committee includes both government and industry participants from each country. The Partnership's approach to technology issues is first to identify the high priority technology needs of the industry (e.g. pumps, drilling, high temperature tools), then to seek to develop projects in each area with government and industry participants. DRET's contribution to the IPGT works towards several of the recommendations of the GIDF (above).

6.2 International Energy Agency – Geothermal Implementing Agreement

Australia's membership in the International Energy Agency's Geothermal Implementing Agreement (GIA) and its associated geothermal research annexes is provided by PIRSA. In November 2006, the Australian Geothermal Energy Group (AGEG) whole-of-sector interest group was established to provide support for this membership in the GIA and to facilitate engagement with the international geothermal community. The AGEG is a geothermal sector cluster for industry, government and research organizations. The AGEG's vision is for geothermal resources to provide the lowest cost emissions-free renewable base load energy for centuries to come. As at 30 April 2009, 92 organizations have named representatives to the AGEG including representatives from 48 companies (including all Geothermal Exploration Licence holders in Australia), service companies, the Australian Federal Government, the governments of all six Australian States and the Northern Territory, the CEO of the AGEA, and well-respected researchers from 11 academic institutions, with more likely to join. Ten Technical Interest Groups are run by AGEG, and several of these mirror research Annexes of the GIA.

7. CONCLUSION

Governments around Australia are recognizing the potential of geothermal energy to provide vast amounts of safe, cost-competitive, base-load low-emission power for electricity and direct use. Numerous programs are in place to support all stages of development of the industry from upstream exploration through proof-of-concept and demonstration phase to early commercialization. These activities, along with enabling legislation, a large energy market and Mandatory Renewable Energy Target with Renewable Energy Certificates (see http://www.orer.gov.au/), serve to make Australia an attractive investment environment that will be further enhanced with the introduction of carbon pricing.

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