PROCEEDINGS, Thirty-Eighth Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 11-13, 2013
SGP-TR-198

THE CURRENT STATUS OF GEOTHERMAL PROJECTS IN AUSTRALIA - A NATIONAL REVIEW

Betina BENDALL[1], Cameron HUDDLESTONE-HOLMES[2] & Barry GOLDSTEIN[1]

[1]Department for Manufacturing, Innovation, Trade, Resources & Energy-South Australia (DMITRE)
GPO Box 1264,
Adelaide, SA, 5001, Australia

[2]Commonwealth Scientific & Industrial Research Organisation (CSIRO)
PO Box 883, Kenmore QLD 4069 Australia
e-mail: betina.bendall@sa.gov.au

ABSTRACT

Australia has large geothermal energy potential; however the use of geothermal energy is a relatively new technology to Australia and requires successful technical and commercial demonstration before gaining widespread acceptance. Australia's current geothermal projects are focused on developing both Engineered Geothermal System (EGS) and Hot Sedimentary Aquifer (HSA) plays to generate electricity, power large scale air conditioning and industrial-scale direct use applications. At this point the Australian geothermal industry remains largely at a pre-competitive exploration stage.

The high expectations of the sector have been tempered in the last 18 - 24 months by the impact of the Global Financial Crisis (GFC) broadly reducing equity investment in projects that have multiple, technical risks. Difficulty in accessing capital for projects in the current market has slowed the sectors' anticipated progress and hampered access to more than Au $296 million (~US$311 million) in allocated Australian Commonwealth and State government grants, which include a matching funding component, although equity markets continued their support of the geothermal sector by participating in individual companies' capital raisings.

Rather than a large-scale retraction however, the trend has been for the companies to re-negotiate their work programs and try to minimise their capital outlay while continuing to hold onto their licences, plan for future work activities, and vigorously seek additional funding for this future work. Currently 56 companies hold 361 exploration licences distributed across the nation covering over 441,000 square kilometres. In the 9 year term 2002 - 2011, more than Au$750 million (~US$787 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 license areas.

The Australian Government has been working with companies to assist the progress of projects and has recently implemented substantial changes to Commonwealth policy on renewable energy and climate change over the last 12 months culminating in the introduction of a comprehensive series of policy initiatives. These include the introduction of a carbon price, expansion of the National Renewable Energy Target, promoting innovation and investment in renewable energy, encouraging energy efficiency and the establishment of two new funding bodies which will be key to the emergence of the Renewable Energy Sector generally and geothermal energy specifically.

This paper summarises: (1) policies and programs put in place to support the development of the geothermal sector; and (2) a synopsis of progress of key geothermal projects in Australia.

NATIONAL POLICY FRAMEWORK

There have been substantial changes to the Australian Commonwealth Government's policy on Renewable Energy and Climate Change in the 2011 – 2012 term, culminating in the introduction of the Government's Clean Energy Future Plan in July 2011, which is designed to complement the existing National Renewable Energy Target (RET).

The RET was initiated by the Australian Government as a primary mechanism for stimulating investment in renewable energy in 2009. To help provide greater certainty to developers of large-scale renewable energy generation projects, the Government implemented a number of changes to the RET in January 2011, whereby the RET was split into two parts - the Small-scale Renewable Energy Scheme (SRES) and the Large-scale Renewable Energy Target (LRET) (Commonwealth of Australia, 2012; Clean Energy Regulator, 2012). The LRET, covering large-scale renewable energy projects, is intended to deliver the vast majority of the National Renewable Energy Target of 20% by 2020 which represents an

additional 41,000GWh of renewable energy generation by 2020. The SRES, covering small-scale technologies such as solar panels and solar hot water systems, will deliver the remainder of the target through the establishment of a market system of fixed price Small-scale Technology certificates at $40 per megawatt hour of electricity produced by small scale generation (Commonwealth of Australia, 2012; Clean Energy Regulator, 2012).

The overall objectives of the Clean Energy Future Plan are to increase the use of Renewable Technologies and decrease carbon pollution through the implementation of a range of new policy instruments and strategies including;

- the introduction of a carbon price,
- active promotion of innovation and investment in renewable energy technologies,
- encouraging energy efficiency, and
- creating opportunities in the heavy land use sectors such as farming, and forestry to assist in transitioning to a low carbon production footing and improve biodiversity (Commonwealth of Australia, 2011).

As an outcome of the Plan, the Government has committed to moving the Australian energy sector away from traditional high polluting sources such as coal, which currently account for about 75% of electricity generated, toward the deployment of large scale renewable electricity generation (BREE, 2012). The Plan is expected to deliver a reduction in greenhouse gas pollution by at least 5% compared with 2000 levels by 2020, which equates to cutting the net expected greenhouse gas pollution by about 23% in 2020 (Commonwealth of Australia, 2011).

Carbon Price:

A price on Carbon Emissions provides a significant incentive for private investment in low-emissions technologies, including geothermal by levelling the playing field. It will not only provide incentive for the largest polluters to cut their emissions, but will encourage the investment, development and innovation in clean renewable energy technologies.

The carbon price started at Au$23 a tonne in 2012-13. In each of the next two years it will rise in line with inflation to Au$24.15 in 2013-14 and Au$25.40 a tonne in 2014-15. From 1 July 2015 the carbon price will no longer be fixed by the Government but will be set by the market with transition to a market-based emissions trading scheme in 2015 (Commonwealth of Australia, 2011).

ARENA:

In the short term, the Australian Geothermal Industry will be most directly affected by the establishment of two new funding bodies which will be key to the emergence of the Renewable Energy Sector generally and geothermal energy specifically. These agencies are the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC).

ARENA commenced operations on 1st July 2012 as an independent body with a focus on providing funding assistance for research, development, deployment and early stage commercialisation of renewable energy technologies. Its objectives are to improve the competitiveness of renewable energy technologies and increase the supply of renewable energy.

ARENA consolidates the administration of Au$3.2 billion (US$3.36 billion) in Government support for renewable energy technology which had been previously administered by a number of different agencies. This funding is to be invested in renewable energy and enabling technology projects through to 2020, and currently Au$1.7 billion (US$1.78 billion) of the $3.2 billion in funding remains uncommitted. As such ARENA will oversight all existing and future funding initiatives to the geothermal sector including Au$14 million (US$14.7 million) previously allocated under the Geothermal Drilling Fund and Au$153 million (US$160 million) under the Renewable Energy Demonstration Program.

In addition to a number of new initiatives, ARENA will continue the Emerging Renewables Program which commenced in August 2011. This Program commits Au$126 million US$132 million) in funding toward Australian renewable energy and enabling technology projects to move them along the innovation chain. Under the Program, at least Au$40 million (US$42 million) will be available for developing technologies with potential to contribute to large-scale base load power generation, such as ocean, solar and geothermal. Although the Program is technology-neutral, a further Au$26.6 million (US$27.9 million) has been allocated to assist the geothermal energy sector specifically (ARENA, 2012).

To date, two geothermal energy related projects have been awarded grants through the Emerging Renewables Program. The first is an Au$1.9 million (US$2 million) grant to the National ICT Australia Ltd data fusion and machine learning projects which aims to collate existing geothermal data from a variety of sources and through the application of statistical machine learning and data fusion methods, improve the process of exploration, discovery and characterisation of potential geothermal resources. The second is an Au $1.25 million (US$1.31 million) grant to the South Australian Centre for Geothermal Energy Research (SACGER) for a research project investigating aspects of reservoir characterisation and quality of Hot Sedimentary Aquifer resources.

Clean Energy Finance Corporation:

The second body established under the Clean Energy Plan is the Au $10 billion (US$10.5 billion) commercially-oriented Clean Energy Finance Corporation. This organisation's purpose is to directly invest in businesses seeking funds to get innovative clean energy proposals and technologies off the ground. It will not provide grants or compete with the private sector in financing renewable and clean energy technologies, but will seek to bridge current commercial investment barriers that inhibit deployment of these technologies. A variety of funding tools will be used to support projects, including loans on commercial or concessional terms and equity investments (Commonwealth of Australia, 2011; CEFC Expert Review Panel, 2012). An Expert Panel review, established to advise on the design of the CEFC has tabled its recommendations and a Governing Board appointed. The CEFC will begin investment operations from July 1st 2013 (CEFC Expert Review Panel, 2012).

PROJECT ACTIVITIES

The Bureau of Resources and Energy Economics (BREE) released a report on Australia's long term energy production (to 2034-35) in December 2011 (BREE, 2011) in which Australia's large geothermal energy potential was acknowledged. The report notes however that these resources are currently considered sub-economic as the commercial viability of geothermal technologies is yet to be demonstrated in Australia. BREE suggest that the commercial development of the industry is dependent on the demonstration of the technical and commercial viability of harnessing geothermal energy in Australia to show an acceptable investment risk, including grid connection.

Consistent with this view, the geothermal sector is having difficulty in accessing private capital for their projects in the current market. No additional companies listed on the Australian Securities Exchange (ASX) in the 2011 – 2012 term, although equity markets continued their support of the geothermal sector by participating in individual companies' capital raisings. The issues in relation to access to private sector capital have been reasoned as the:

- previous lack of investor certainty on a price on carbon;
- high risk nature of these particular early-stage proof-of concept projects;
- some sub-optimal results from early geothermal projects;
- need for high amounts of capital for projects; and
- the overall increasing cost for these projects in particular the drilling component (BREE, 2011).

Geodynamics-Cooper Basin

Geodynamics Ltd has been one of the few companies able to substantially move forward with major activities at their Habanero EGS project near Innamincka in the Cooper Basin, north eastern South Australia.

Geodynamics have three EGS fields under investigation in this area and have drilled a total of six deep EGS wells so far. At the Habanero field, Geodynamics have drilled and stimulated four wells into the reservoir zone, and have demonstrated connection between atleast 2 wells through the fractured reservoir via tracer and pressure transient testing. Additionally they have drilled one deep well at each of the Jolokia and Savina fields (Jolokia-1 4911m; Savina-1 3700m). Aside from their EGS targets in this area, Geodynamics and Joint Venture partner Origin

Energy have also investigated Hot Sedimentary Aquifer targets within the Hutton Sandstone, a formation which forms part of the Great Artesian Basin system within the wider Eromanga Basin, stratigraphically overlying the Cooper Basin.

Importantly, Geodynamics have been recently successful in drilling and completing the Habanero 4 well which was drilled as a replacement to the Habanero 3 well which experienced casing failure on April 24th 2009. Located about 120m east of Habanero 3 in order to intersect the existing fracture network already developed via stimulation of the Habanero 1 and 3 wells, Habanero 4 was drilled to a total depth of 4204 metres (about 489 m within the Carboniferous Big Lake Suite granite) and achieved a number of critical outcomes (Geodynamics Ltd, 2012a). Of particular note is its achievement as the first reverse circulation cementing operation in Australia, the highest pressure and temperature reverse circulation cementing operation performed in Australasia, and one of the deepest and longest of these operations ever undertaken (Geodynamics Ltd, 2012a; Geodynamics Ltd, 2012b). Geodynamics' decision to implement reverse circulation cementing of the 9 7/8" section was in response to investigations of the causes of the Habanero 3 casing failure. Findings from Habanero 3 implicated caustic cracking from high pH annular fluids remnant from normal cementing operations conducted at the top of the well (Geodynamics Ltd, 2011; Geodynamics Ltd, 2012a).

A significant technical challenge for Geodynamics in drilling their Cooper Basin resource has been the substantial fluid overpressures encountered in the naturally occurring fractures present within the target Big Lake Suite granite. Pressures within these

fractures are 34.47 MPA (5000 psi) above hydrostatic pressure which complicates drilling operations and the management of mud systems to ensure well control, while minimising formation damage through mud losses (Wyborn, 2012; Fernandez-Ibanez et al, 2009). These overpressures have been encountered in each of the Cooper Basin EGS wells drilled by Geodynamics, and a number of different strategies have been trialled by Geodynamics to improve drilling rates and reliability (Wyborn, 2012; Fernandez-Ibanez et al, 2009).

An initial open flow test at Habanero 4 was conducted on November 10th 2012 as part of the well cleanout process subsequent to drilling. During this test a maximum flow rate of 35 kg/s at 27.7 MPa (4020 psi) was achieved through a variable choke. The temperature of the produced fluid measured at surface was increasing with time and reached 191°C prior to shut in. The temperature measured in the well at 4130m depth was 241°C (Geodynamics Ltd, 2012b).

A restricted local stimulation program was then performed over a 2 day period from November 13th during which 2.5 ML of water was pumped into the well up to a maximum pump rate of 52.5L/s at a maximum surface pressure of 44.2 MPa (6400 psi). Microseismic monitoring detected 1900 events clustered around the well in a 400 metre radius with a maximum event magnitude recorded being 1.9 M_L. A second open flow test program conducted on November 15th 2012, resulted in an average flow rate of 38 kg/s at 29 MPa (4200 psi), believed to be the highest thermal energy output recorded from an EGS well (Geodynamics Ltd, 2012c). These results suggest that Habanero 4 has successfully intersected the targeted fracture zone which has demonstrated hydraulic connectivity between Habanero 1, 2 and 3.

A major hydraulic stimulation of the Habanero 4 well was conducted over 14 days from November 17 to 30th 2012, with over 34 million litres of water being injected through the course of the operation. As of 10th December 2011, over 24,000 microseismic events associated with the stimulation operations were detected extending up to 1500 metres from the well and oriented in a predominantly NNE to SSW oriented ellipsoid shape. The maximum event magnitude recorded was 3.0 M_L (Geodynamics Ltd, 2012c). Results of the stimulation operation are currently being assessed and have yet to be announced. Further open flow testing is scheduled for February 2013 following a period of inactivity to enable the reservoir to approach equilibrium.

The interim strategy for Geodynamics over the coming year, is to complete flow testing and demonstrate sub-surface circulation between Habanero 1 and Habanero 4 through the reservoir zone. Successful demonstration of the reservoir connectivity will enable completion of the Habanero1 and 4 doublet closed loop and commissioning of the existing 1MW Habanero Pilot Plant, followed by extended operational trials (approximately 3 - 6 months) to demonstrate technical 'proof of concept'.

CSIRO Geothermal Project

The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia's national science agency, is developing a geothermal demonstration and exploration project at the Australian Resources Research Centre (ARRC) in Kensington, Perth. The goals of the project are to demonstrate direct use geothermal energy as a means of cooling the Pawsey Centre Supercomputer and to evaluate the deeper geothermal resources of the Perth Basin. The project has two phases:

Phase one

The first step in the project is to meet the cooling requirements of the Pawsey Centre Supercomputer by establishing a geothermal cooling system known as groundwater cooling (GWC). The system works by extracting cool groundwater from a semi-confined aquifer located beneath the ARRC site, and circulating this groundwater through an above-ground heat exchanger to remove heat from a separate water loop that is used to cool the supercomputer. The heated groundwater is then reinjected back into the same aquifer, resulting in no net consumption of water. The system has been designed to reject a heat load of approximately 2 MW_{th}.

The system is novel, efficient all-year round, and environmentally friendly saving significant quantities of water compared with conventional cooling towers. This will be the first time groundwater cooling has been used on this scale in Australia. The technology concept, if deployed more widely, also has the potential to replace cooling towers in commercial and residential buildings. Drilling for the GWC system is scheduled to commence in early 2013, and be completed in time for the opening of the Pawsey Centre in mid-to-late 2013.

Phase two

The second phase involves drilling a 3km deep exploration well to assess the geothermal resource contained in the hot sedimentary aquifers beneath the ARRC facility. The Perth Basin is known to contain thick aquifers with high permeabilities, combined with moderate heat flows that could provide a potential direct use geothermal resource. The planned well will evaluate these formations at depth to ascertain their potential qualities as a geothermal reservoir, and to confirm the thermal gradient in the Perth metropolitan area. The drilling is scheduled to commence in the third quarter of 2013.

The CSIRO Geothermal Project is a component of the Sustainable Energy for the Square Kilometre Array (SKA) project supported by the Department of Industry, Innovation, Science, Research and Tertiary

Education through the Federal Government's Education Investment Fund initiative.

CONCLUSION

Widespread recent changes to Commonwealth Government legislation and well considered government policy frameworks aimed at supporting and promoting the deployment of large-scale, renewable energy technologies generally will also significantly benefit the Australian geothermal industry directly. While the tightening of private equity funding in response to the Global Financial Crisis has impacted on the sector, and generally led to a slowing of on-ground project activities, overall community support, interest and goodwill for the sector remains high. Importantly, a number of projects continue to make noteworthy progress and hold out the promise that the geothermal industry's goal of achieving commercial production of large scale, base load geothermal energy in Australia will come to fruition.

REFERENCES

ARENA (Australian Renewable Energy Agency), (2012). "Consultation Draft of the General Funding Strategy." Accessible online at: http://www.arena.gov.au/_documents/funding-strategy/consultation-draft-general-funding-stratetgy.pdf

BREE (Bureau of Resources and Energy Economics), (2011). "Australian energy projections to 2034–35." Accessible online at: http://www.bree.gov.au/documents/publications/aep/Australian-Energy-Projections-report.pdf

BREE (Bureau of Resources and Energy Economics), (2012). "Energy in Australia 2012." Accessible online at: http://www.bree.gov.au/documents/publications/energy-in-aust/energy-in-australia-2012.pdf

CEFC Expert Review Panel, (2012). "Clean Energy Finance Corporation Expert Review Report to Government March 2012". Available online: http://www.cefcexpertreview.gov.au/content/report/downloads/CEFC_report.pdf

Clean Energy Regulator, (2012). "About the Renewable Energy Target". Available online: http://ret.cleanenergyregulator.gov.au/About-the-Schemes/Large-scale-Renewable-Energy-Target--LRET-/about-lret

Commonwealth of Australia, (2011). "Securing a clean energy future: the Australian Government's climate change plan." Department of Climate Change and Energy Efficiency: Canberra. Accessible online: http://www.cleanenergyfuture.gov.au/clean-energy-future/securing-a-clean-energy-future/

Commonwealth of Australia, (2012). "Fact Sheet: Enhanced Renewable Energy Target". Available online: http://www.climatechange.gov.au/en/government/initiatives/renewable-target/fs-enhanced-ret.aspx

Fernandez-Ibanez, F., Castillo, D., Wyborn, D. And Hindle, D., (2009). Benefits of HT-hostile environments on wellbore stability: a case study from geothermal fields in central Australia. In: Proceedings of the Indonesian Petroleum Association 33rd Annual Convention and Exhibition, May 2009.

Geodynamics Ltd, (2011). "Annual Report 2010 - 2011 Ann Rpt." Accessible online: http://www.geodynamics.com.au/Investor-Centre/Reports/Annual-Reports.aspx

Geodynamics Ltd, (2012a). "Annual Report 2011 - 2012 Ann Rpt." Accessible online: http://www.geodynamics.com.au/home.aspx

Geodynamics Ltd, (2012b). CEO presentation to Annual General Meeting. Accessible online: http://www.geodynamics.com.au/home.aspx

Geodynamics Ltd, (2012c). "Quarterly Report Period ending 31 December 2012." Accessible online: http://www.geodynamics.com.au/home.aspx

Wyborn, D. (2012). The Innamincka Enhanced Geothermal System (EGS) – Dealing with the Overpressures. In: Proceedings of the 2012 Australian Geothermal Energy Conference p 251. Accessible online: https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=74874