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GEODYNAMICS
LIMITED

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GEODYNAMICS LIMITED
Submission to the

House of Representatives Standing Committee on Industry and Resources
June 2007

Abstract:

Geothermal energy satisfies the critical objectives of materiality, cost competitiveness, timeliness, reliability of supply and does it not introduce any collateral problems.

Australia has very large hot rock geothermal energy resources, with high graded resources being sufficient to meet Australia's power needs for centuries. Within its tenements in South Australia Geodynamics has delineated high quality resources that are estimated to support a generating capacity of more than 10,000 MW, with an annual output the equivalent of 15 Snowy schemes. Most of Australia's geothermal resources appear to be in the Cooper Basin and the South Australian heat anomaly, but other targets are being identified. It is estimated that the opportunity exists for geothermal energy to supply 7% to 10% of Australia's power needs by 2030. First power may be generated by 2010 with 500 MW by 2015.

All of the core technologies required to develop hot rock resources are available from the oil and gas industry or the established geothermal energy industry.

Work to date by Geodynamics has reduced the resources risks significantly. It has proven that the hot granites are naturally fractured, that the fractures contain water under high pressure, so that heat can be produced through a completely closed system that does not require an external supply of water. Temperatures have been measured that show the Cooper Basin rocks to be the hottest of their kind on Earth. Reservoir stimulation has been demonstrated and an initial production test has been run. However, there is still much to be learned about the hot rock resources in Australia and this will happen through project experience.

Pre-feasibility studies suggest that power from hot rocks may be a very cost competitive option. Geodynamics anticipates that generating costs will fall quickly to around $45/MWh.

Hot rock geothermal energy is a reliable source of "base load" power with anticipated capacity factors similar to other geothermal developments being typically over 0.9 and often over 0.95.

Geothermal energy does not introduce any undesirable collateral issues: it does not produce emissions, consume water or leave any legacy.

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It is timely that the Standing Committee is undertaking the comparative study of the renewable energy sector and we are please to contribute to it. We understand that the driver for the study is the need to cut greenhouse gas emissions, especially from the power generation sector, in the most effective way.

We believe that some of the parameters that are important in such a study include:

- Materiality. It is desirable for options to have the potential to make a significant contribution to the reduction of emissions.
- Cost competitiveness. Cost matters if we are to maintain a competitive economy.
- Timeliness is important if we are going to cut emissions in a reasonable timeframe.
- Reliability of supply.
- And we do not want to introduce other problems.

Our submission argues that geothermal energy meets all of these criteria.

1. Australia's potential for large scale geothermal power generation

Australia has a geothermal (hot rock) energy resource that may be comparable to its coal resources.

A report by Somerville et al (1994) assessed Australia's potential hot rock geothermal energy resources on the basis of temperature measurements in thousands of wells and geological knowledge. They estimate a thermal energy resource of around 22m PJ, with around 2.5m PJ having economic value. Most of this resource is in the Cooper-Eromanga Basin. Note that these numbers are for thermal energy in place and do not allow for recovery factors or conversion into electricity. See Table 1.

Table 1 Informal nomenclature for HFR geothermal resources and reserves

<table>
<tr><th colspan="3">Reserves</th></tr>
<tr><td>Proven HFR Geothermal Reserves</td><td>Probable HFR Geothermal Reserves</td><td>Based on reservoir tests and signed off by independent third parties.</td></tr>
<tr><th colspan="3">Resources</th></tr>
<tr><td colspan="2">Delineated HFR Resources
390,000 PJ
(GEL's 97 , 98 & 99)</td><td>As defined by drill holes combined with supporting geophysical evidence.</td></tr>
<tr><td colspan="2">Inferred HFR Geothermal Resources
Low estimate 2.5 million PJ
High estimate 22.7 million PJ
Somerville et al, 1994.</td><td>As defined by shallow geothermal gradients measurements in combination with geophysical evidence.</td></tr>
</table>

Geodynamics has tenements in the Cooper Basin where it has delineated 390,000 PJ of thermal energy in place through geophysics and drilling (Table 1 and Figure 1). Additional resources have been inferred from temperature measurements. Geodynamics has completed pre-feasibility studies that suggest that the delineated resource has the potential to support a generating capacity of over 10,000 MW, with an annual power output equal to the normal output of 15 Snowy schemes.

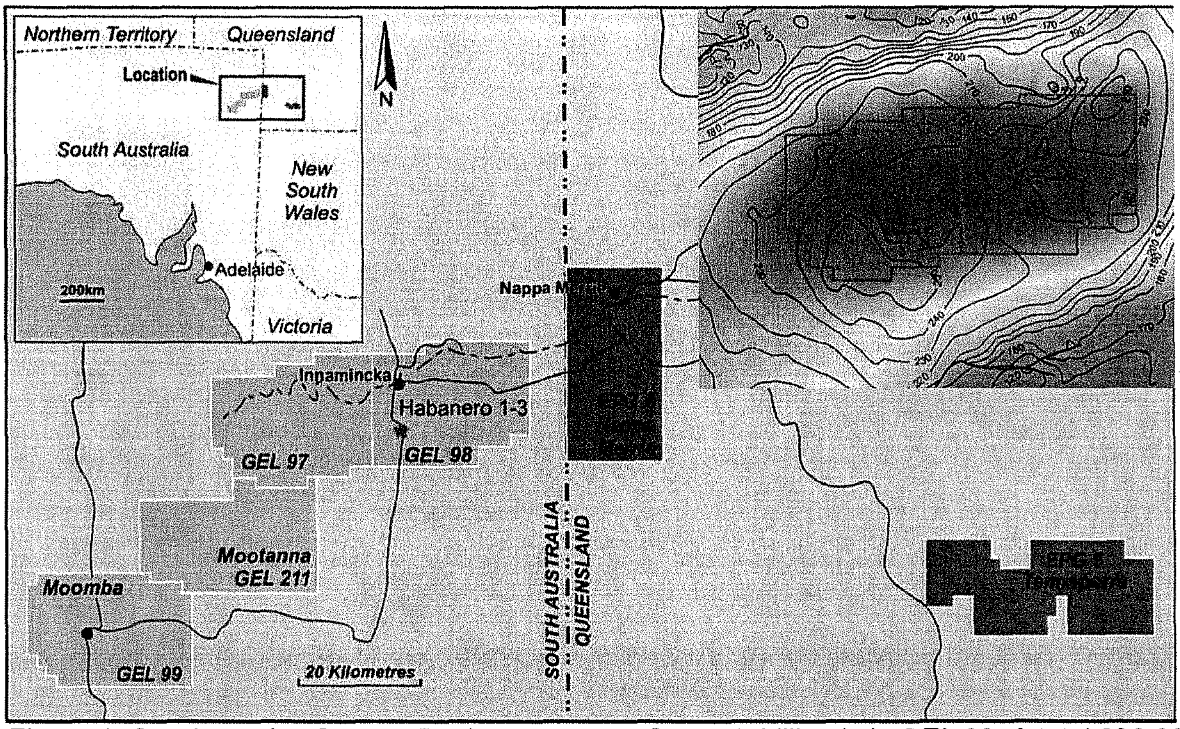


Figure 1. Geodynamics Cooper Basin tenements. Current drilling is in GEL 98. A total 390,000 PJ of thermal energy in place and the potential for 10,000 MW of generating capacity has been delineated in GEL's 97, 98 and 99. Temperature contours at top of granite and gravity image of GEL's 97 and 98 shown in top right.

The Federal Government has recognised the importance of Australia's geothermal resources and has recently provided funding to Geoscience Australia to better define these resources. This work will update the Somerville et al assessments.

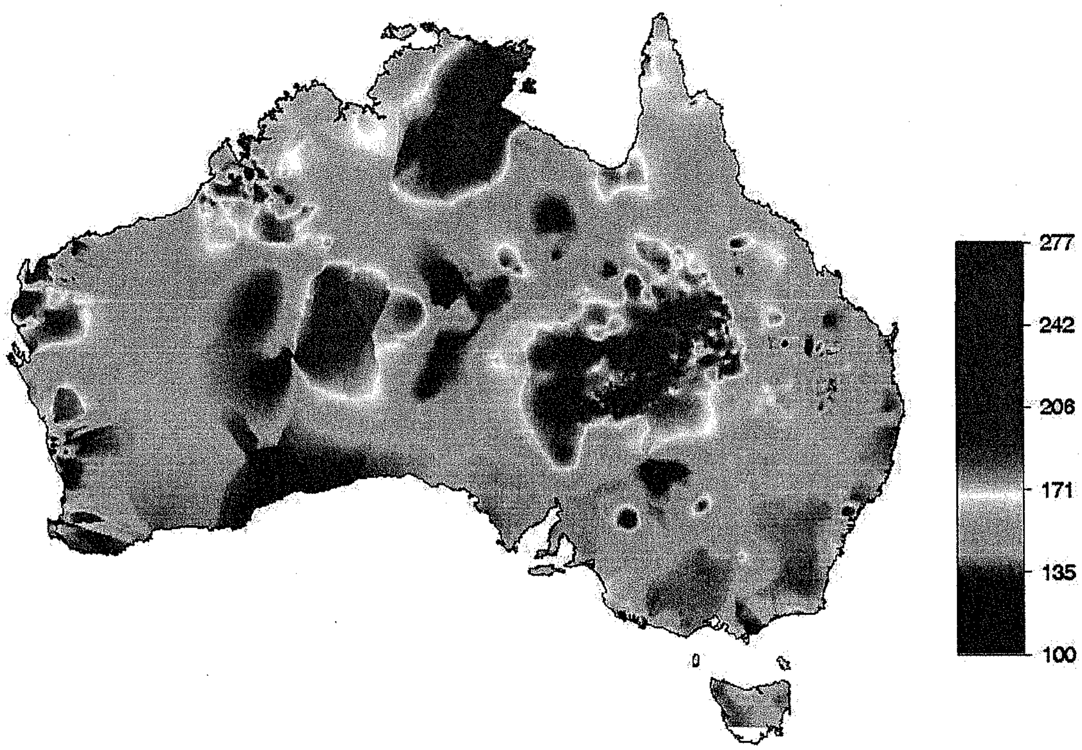


Figure 2. Temperature map at a depth of 5 km. There are several versions of this map and it will again be updated by Geoscience Australia.

Work by the Electricity Supply Industry Planning Council (South Australia) suggests that geothermal energy could supply 7% of Australia's power needs by 2030. Geodynamics agrees with this assessment and notes that it would equate to around 20% of new generating capacity. Some scenarios run by Geodynamics suggest the opportunity for around 10% of total capacity or 25 % of new capacity by 2030.

The above are believed to be reasonable outlooks, because all of the core technology to develop geothermal energy exists. The drilling and reservoir stimulation technology is available through the oil and gas industry. Power station technology is available from the conventional geothermal energy industry and new technologies such as the Kaljna cycle are emerging.

2. The concept of hot rock geothermal energy

Hot rock geothermal energy differs from the "conventional" geothermal energy found, for example, in New Zealand. Conventional geothermal energy is usually derived by producing water that is associated with volcanic heat sources.

Hot rock geothermal energy is based on extracting heat from granites. The granites are hot because of the natural decay of the radiogenic minerals in the granites and that heat has been trapped in the granites by several thousand meters of sedimentary rocks that act as an insulating layer.

The heat extraction process involves circulating water through fractures in the granite to the surface. This heat is then the basis for driving power generating turbines (Figure 3).

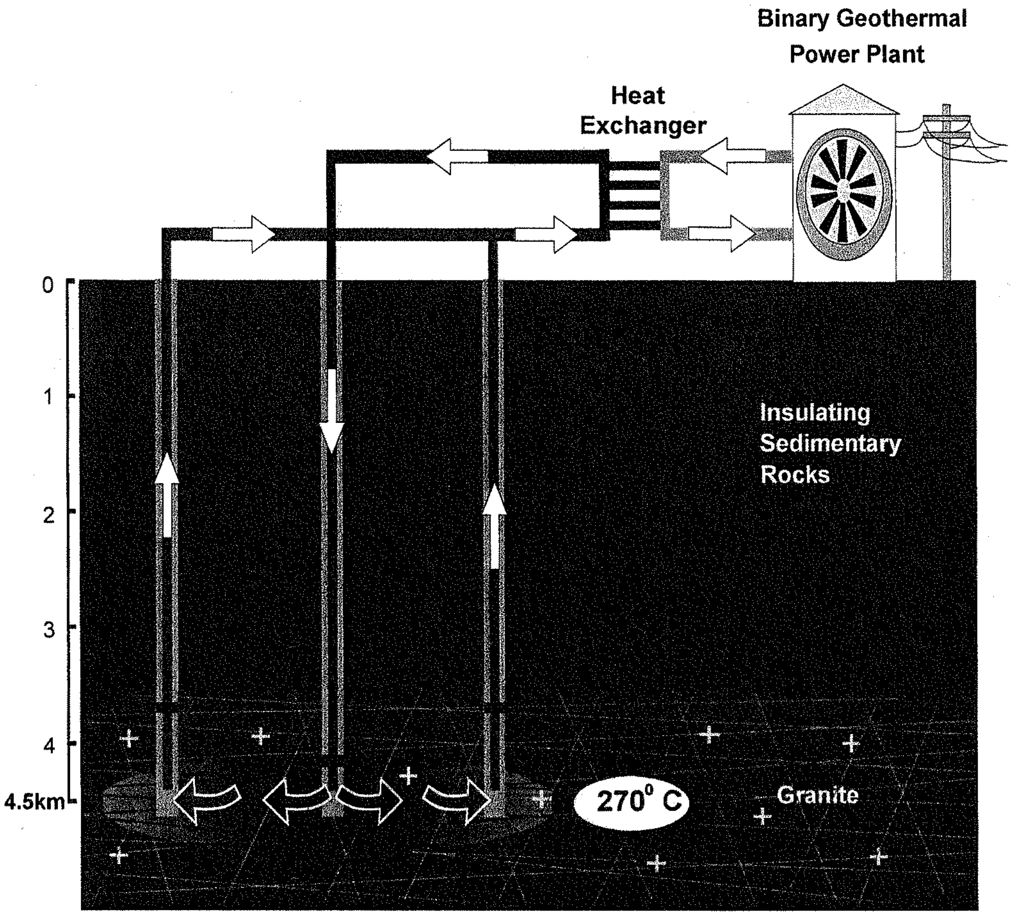


Figure 3. The concept of generating power from hot fractured rocks. The granites in the Cooper Basin are naturally fractured and the fractures are full of water under high pressure. It is thus possible to circulate natural water in a closed loop to extract the heat. No external supply of water is needed.

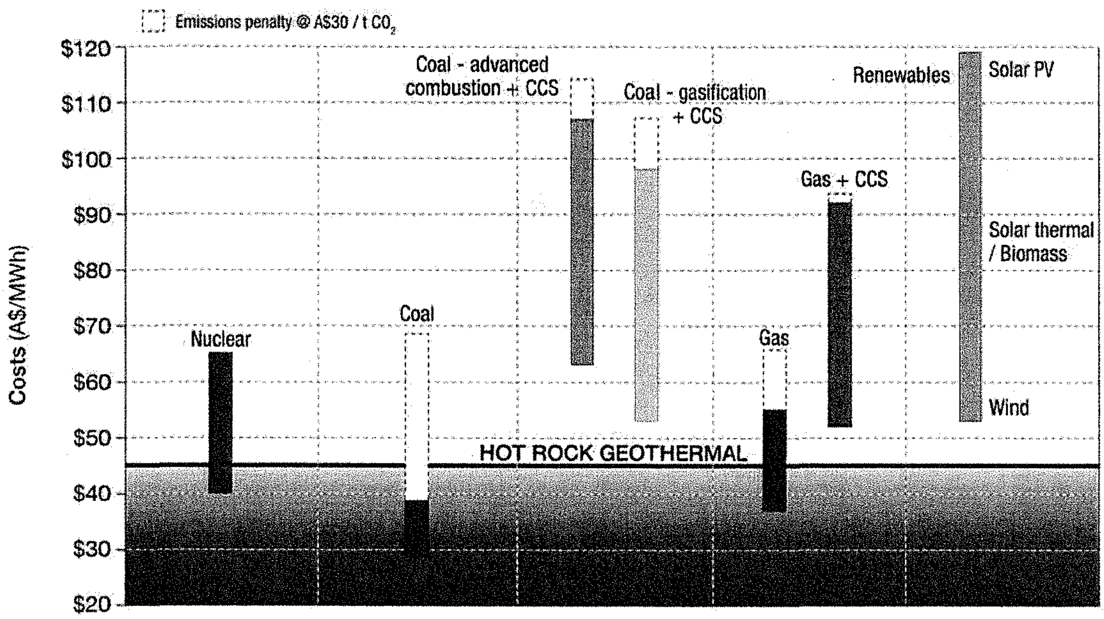
3. Geothermal power may be Australia's most cost competitive option

Geodynamics has completed pre-feasibility economic sensitivity studies which indicate:

- That temperature is the key economic driver for large scale hot rock geothermal development.
- The cost of generating power from hot rocks in the Cooper Basin is anticipated to reduce to around \$45/MWhr with moderate scale-up (hundreds of megawatts production). (Figure 4)

Other independent studies also indicate the cost competitiveness of hot rock geothermal energy. A study by McLennan Magasanik Associates (MMA) of Australian power generation options suggests that geothermal energy will be the cheapest option as soon as there is a reasonable cost on greenhouse gas emissions. A copy of an MMA presentation that summarises this work is contained as Appendix A (by permission of MMA)

Industries that are heavy users of electricity, such as the aluminium industry, are also looking closely at geothermal energy.



CCS = carbon capture and sequestration (75%); MWh = megawatt hours; PV = photovoltaic

(Based on data from Final report: Uranium Mining, Processing and Nuclear Energy – Opportunities for Australia? Chapters 1-10, pg59. *Source: EPRI study[74]* and Geodynamics Limited)

Figure 4. *Estimates of the costs of generating large amounts of power.*

4. The present position and timeliness

(a) Australian Geothermal Energy Industry

The Australian Geothermal energy industry now comprises 19 companies that hold geothermal exploration tenements, including seven listed companies. (Figure 5). Total exploration budgets to 2012 exceed \$0.5 billion. These companies are supported by a service industry, academic institutions and government departments who work together in the Australian Geothermal Energy Association, AGEG. (AGEG is affiliated with the International Energy Agency).

All States now have geothermal energy exploration arrangements in place or are advanced with their legislation.

The Companies involved in the sector are:

- Geodynamics Ltd (listed)
- Petratherm Ltd (listed)
- Pacific Hydro Ltd (previously listed; purchased by IFS in July 2005)
- Green Rock Energy Ltd (listed)
- Geothermal Resources Ltd (listed)
- Eden Energy Ltd (listed)
- Origin Energy Ltd (listed)
- Torrens Energy Ltd (listed)
- Kuth Energy Pty Ltd (IPO planned)
- Scopenergy Ltd
- Proactive Energy Developments Ltd
- Osiris Energy Pty Ltd
- Hot Rock Energy Pty Ltd
- Tri-Star Energy Ltd
- Red Hot Rocks Pty Ltd
- Clean Energy Australia

More than half a billion dollars worth of exploration and proof-of-concept investment is forecast through 2011, not including possible expenditure to install demonstration power plants fuelled with geothermal energy (Industry Fact Sheet, p. 3).

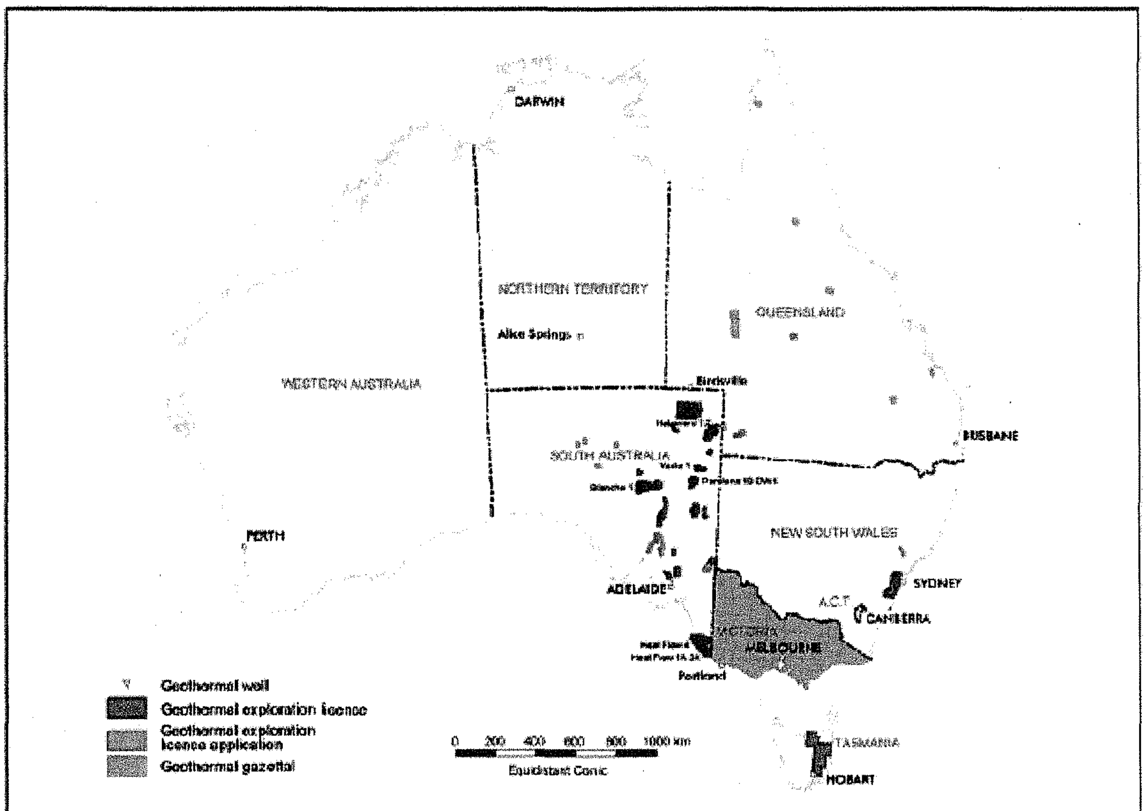


Figure 5. *Geothermal exploration tenements, emphasizing the Cooper Basin and South Australian heat anomaly. Note that additional targets are continuing to be identified.*

(b) Geodynamics Limited

Geodynamics is a recognized leader in Australia and internationally. The company listed in 2002 with the assistance of a $6.5m R&D Start grant from the Federal Government. Today it has a market capitalization around $300m and very strong market support.

Geodynamics has geothermal exploration tenements in the Cooper Basin in South Australia and Queensland, and in New South Wales. Its focus has been in the Cooper Basin, where progress to date has:

- Drilled two wells into the hot granites. These wells, Habanero 1 and 2 intersected the granite at 3,670m and were drilled to 4,421m and 4,358m respectively.

- Habanero 1 made some very important discoveries. It:

    - Proved that the granites in the Cooper Basin are naturally fractured
    - Found that the fractures are full of water, and that;
    - This water is very highly pressured.

These three discoveries mean that it is possible to circulate water through the fractures to the surface, extract the heat and to return that water in a completely closed system. There will be no net consumption or production of water.

- Directly measured the temperatures in granite. That has:

    - Proven the existence of the resource,
    - Shown the existence of temperatures of 220°C at 3500 m and 250°C at 4,300m, implying around 275°C at 5000m. These temperatures make the Cooper Basin the hottest rocks of their type on Earth at this depth. This is important given that temperature is the most important driver of project economics.

- Proven the concept of stimulating the hydraulic properties of fractures in the granite by:

    - Applying the hydraulic stimulation technologies used by the oil and gas industries
    - Demonstrating the ability to stimulate natural fractures over an area of 3km by 2km from the one well. This is the world's largest artificial enhanced underground heat exchanger. See Figure 6

- Proven that hydraulic connectivity can be achieved between wells
- Initial production has been achieved through a short production test from Habanero 2. See Figure 7

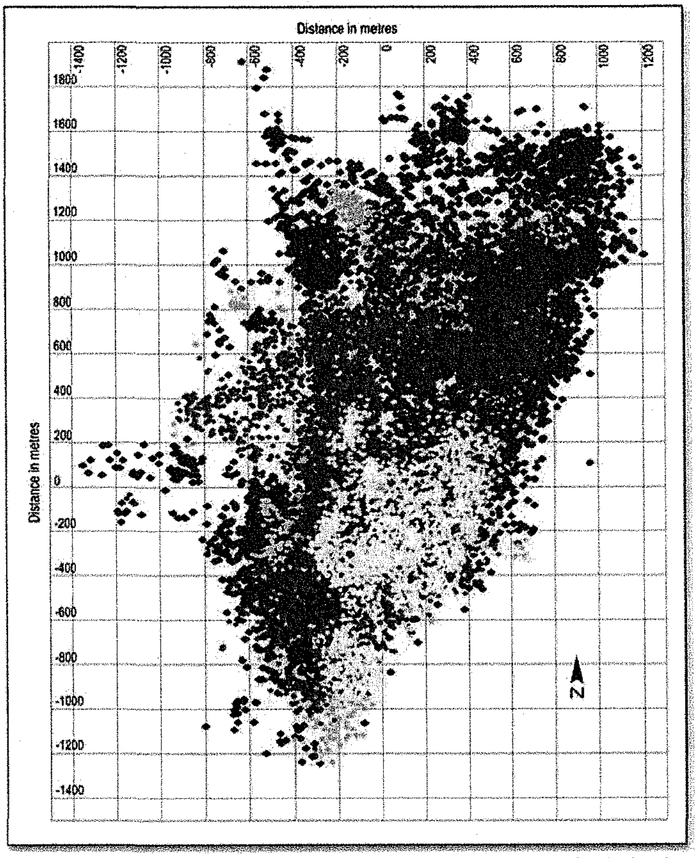


Figure 6. *Plan of microseismic events recorded during reservoir stimulation. Colours denote progressive activity over time. This result is the largest recorded in the world.*

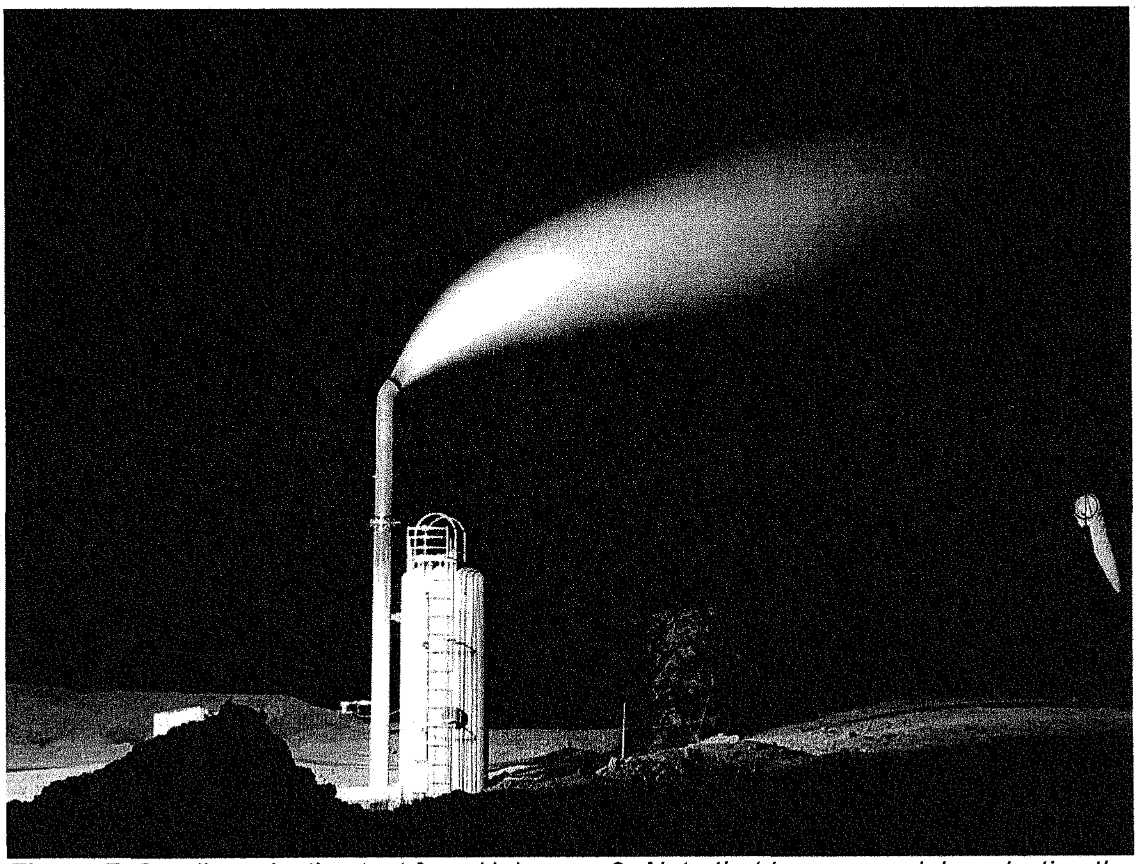


Figure 7. *Small production test from Habanero 2. Note that in commercial production the geo-fluid will always remain as super heated water in a closed system, and never become steam.*

The progress outlined above has significantly reduced the risks. Remaining work needs to demonstrate that:

- fractures exist and can be stimulated to the target depth of around 5000m. This will need drilling to advance another 600m from the current 4400m and the repeating of the reservoir stimulation that has been achieved so far.
- the productivity of fractures meets expectations. The first work in this regard will be carried out through a circulation test between Habanero 1 and a new well, Habanero 3 later this year.

The deep geothermal wells require drilling rigs with a capability greater than any on-shore rigs currently in Australia. Geodynamics has recently announced its purchase of an advanced oil and gas rig that is ideally suited for drilling its deep geothermal wells. This $32m rig was built in Houston and arrived into Brisbane Port on 30 June. It is the most advanced and capable on-shore rig ever to come into the country. It is now on its way to the Cooper Basin to complete its commissioning and drill Habanero 3.

Geodynamics is planning to drill Habanero 3 to intersect the fracture systems it has already stimulated and to carry out a circulation test between Habanero 1 and 3. This test will complete its "proof of concept" plan and provide data to enable the first assessment of reserves. All of this work is planned to be completed by the end of the year.

The company is planning for a 500 MW power development in the Cooper Basin to be operating by the end of 2015. The first part of this development is designed to be a 40 MW module which is planned to be operating by the end of 2010.

(c) Transmission

The location of the hot rock resources held by Geodynamics and other companies suggests the emergence of a new energy province centered around the Cooper Basin. Geodynamics has had concept studies carried out to define some of the options for transmitting power from the Cooper Basin to major load centers such as Brisbane, Adelaide or Sydney.

This work has shown that high voltage transmission lines are appropriate. This is established technology. Transmission to Adelaide or Brisbane would experience energy losses of 5% to 8% respectively. Such lines are clearly major pieces of infrastructure that impact on state and national development. They also offer the opportunity to connect the Queensland transmission region to the South Australian region, with such interconnection providing significant benefits to the national grid.

5. Reliability of supply

Geothermal energy is a characteristically reliable source of electricity supply. It is delivered 24 hours a day every day of the year, with typical capacity factors above 0.9 and often around 0.95.

Geothermal power developments typically have several wells and several turbines, so that each development is not vulnerable to shut down of individual elements.

6. No collateral problems

Hot rock geothermal energy does not introduce other undesirable issues:

- No demand for extra water
- No emissions or waste
- Small footprint
- No legacies

7. National Benefit

An assessment of the national benefits from a Cooper Basin geothermal energy industry has been undertaken by The Center for International Economics. This study was supported by The South Australian Government (PIRSA) and demonstrated a very attractive net benefit of over $5bn to Australia (above the normal commercial returns).

BACKGROUND INFORMATION

Profile of Dr Adrian Williams

Dr Adrian Williams has been appointed as Geodynamics Limited's Chief Executive Officer through to the successful completion of Stage One of the company's business plan. Dr Williams is an engineer with a broad experience concerning energy and technology. As a consultant based in London, and then as Chief Engineer Geomechanics for the Snowy Mountains Engineering Corporation, he has worked on large energy and infrastructure projects in Algeria, throughout Asia and Australia. In every case, he led the commercial resolution of technical challenges. He led the development of the Australian Petroleum Cooperative Research Centre, one of Australia's first CRCs, and with CSIRO, was the foundation chief of its Petroleum Resources Division and then Chief of its Energy Technology Division.

Dr Williams has been committed to the development of Australia's hot rock geothermal energy for over eight years.

He is 62 and holds civil engineering degrees from the University of Melbourne, a PhD in rock mechanics from Monash University and an MBA from Melbourne University.

REFERENCES

Geodynamics Limited, Industry Fact Sheet (2007) available online
http://www.geodynamics.com.au/IRM/Company/ShowPage.aspx?CPID=1219

Somerville, M., Wyborn, D., Chopra, P., Rahman, S., Estrella, D., & Van der Meulen, T., 1994 - Hot Dry Rock feasibility study. Energy Research & Development Corporation, ERDC Report 243, 133pp.