Summary of AGEG Technical Interest Groups Research Projects

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The Australian Geothermal Energy Group (AGEG) has the vision that geothermal resources will provide the lowest cost emissions free renewable base load energy for centuries to come. The AGEG is working towards this vision through its Technical Interest Groups (TIGs) which focus on topics that have been prioritised by the Australian geothermal industry. The priorities are thus aligned with those of the International Energy Agency Geothermal Implementing Agreement (GIA) and the International Partnership for Geothermal Technologies (IPGT). Increasingly, priorities are also coming into line with the oil and gas industry with opportunities to drive innovation.

This paper will provide an update and overview of the scope and research findings of projects completed for the AGEG by members since the last Australian Geothermal Energy Conference. Many of the projects focus on topics relevant to the advancement of Enhanced Geothermal Systems (EGS) in Australia, including reservoir characterisation, research and development into power cycle design for the Australian conditions and other studies to reduce the uncertainties surrounding EGS and ensure responsible management of projects.

It is expected that detailed presentations will be given on many of these projects by the project investigators, so this paper intends to provide a brief introduction of each project's aims and to demonstrate the range of research that is covered by the AGEG TIGs.

Keywords: Australia, EGS, Hot Rock geothermal

The Australian Geothermal Energy Group

The AGEG was formed to bring together all parties involved in geothermal development in Australia, in order to work together and cooperatively advance the industry as a whole.

The method of this advancement is through the work of the Technical Interest Groups which are broadly separated into the stages of a geothermal project and so encompass land access and exploration through to power systems and transmission or connectivity to the National Electricity Market. The 12 AGEG TIGs are briefly described in Table 1.

The TIGs have transformed somewhat since their conception in 2007. In particular TIG 2 has formed the joint AGEG and AGEA Resource and Reserves Code Committee, who released and now administers the first uniform geothermal reserves and resources reporting code. The TIG for policy advice has led to the creation of the Australian Geothermal Energy Association (AGEA), the national industry body representing the Australian geothermal industry. TIG 5 has held some informative workshops and has become the AGEA working group on issues relating to the national electricity market which also reports back to the AGEG. The order of the groups has been re-organised such that the first four groups cover best practice protocols and communication and TIGs 5 to 12 cover geothermal technology development (Outlined in red).

TIG 1	Land Access
TIG 2	Reserves & Resources
TIG 3	Policy
TIG 4	Outreach
TIG 5	Getting to Markets
TIG 6	Power Plants
TIG 7	Direct Use
TIG 8	Information & Data
TIG 9	Reservoir Development & Engineering
TIG 10	Exploration & Well Log Technologies
TIG 11	Drilling & Well Construction
TIG 12	Education

Table 1 - The AGEG's Technical Interest Groups

The AGEG and the AGEA have agreed to coordinate research efforts through the AGEG's Technical Interest Groups. This will facilitate Australian companies, research experts and government agencies (including regulators) to convey and take note of international best practices for the full-cycle of below-ground and above-ground geothermal energy operations and stewardship.

The structure of the AGEG and the TIGs is shown in Figure 1. The AGEG's TIGs will have active links to the International Energy Agency's (IEA) geothermal research annexes, the IPGT, and will aim to attain strong linkages to all other reputable international geothermal research clusters, to ensure that Australia's comparative advantages in Hot Fractured Rock (HFR) geothermal resources can be leveraged into accelerated development of high priority geothermal technologies, methods and the sharing of lessons learnt. On this basis, the AGEG and the AGEA have agreed that the AGEG should become the Australian affiliate for the International Geothermal Association.

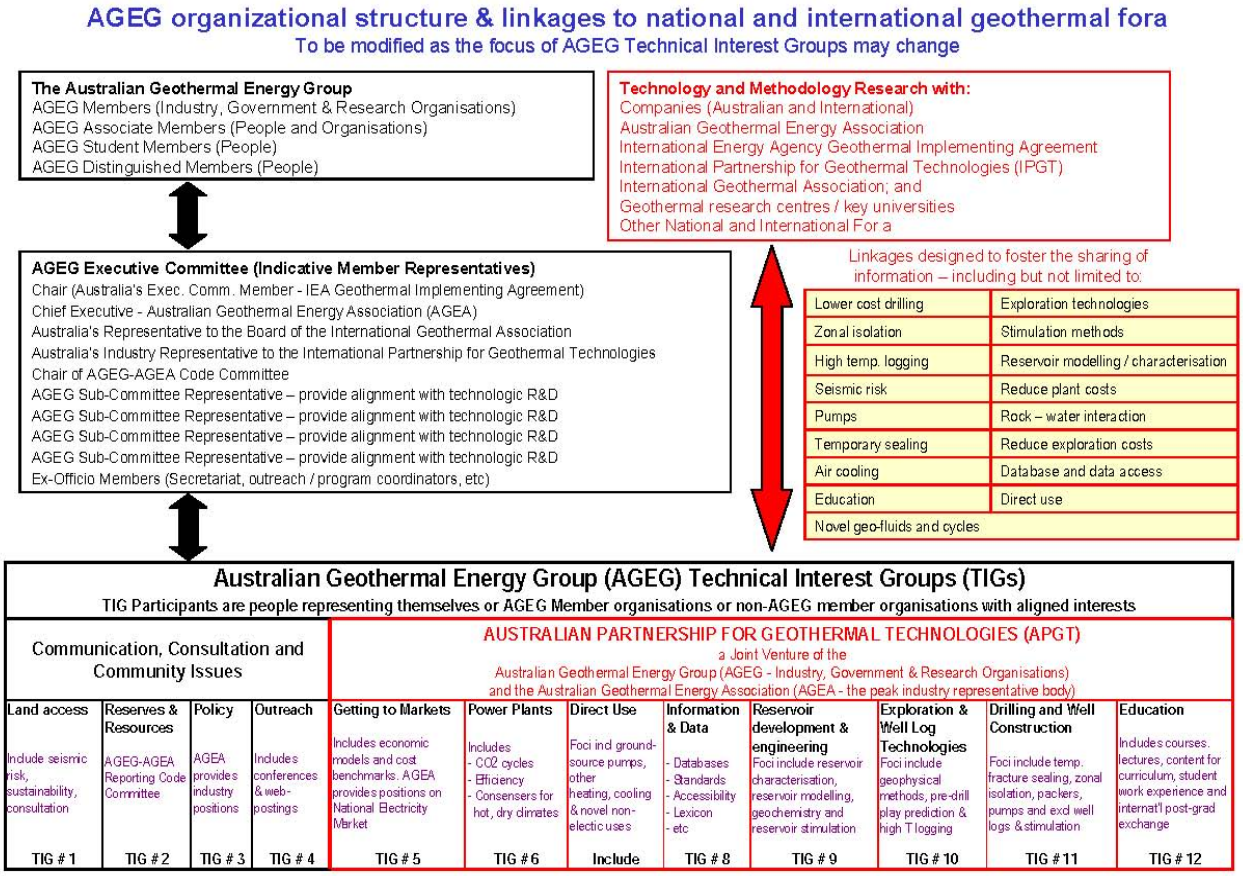

Figure 1: Diagram showing the structure of the AGEG, including the Technical Interest Groups and linkages to national and international geothermal groups.

Further information on the AGEG and its TIGs can be found on the AGEG website at http://www.pir.sa.gov.au/geothermal/ageg

Geothermal Research Projects

Already some significant projects have been completed within the AGEG TIGs with support from the Department of Primary Industries and Resources, SA (PIRSA) tied grants, geothermal company contributions and in-kind contributions from members providing their valuable time.

Completed projects of note include the first uniform code to guide the reporting of geothermal data to the market, The Geothermal Reporting Code and the accompanying Lexicon, which were developed by the Australian Geothermal Code Committee (AGCC) and released in 2008. Since the Code's release a number of operating companies have reported their geothermal exploration results according to the Code. The Code is intended to be a living document and as such a second version is expected to be released in 2009.

Under the TIG for land access and environmental issues, PIRSA commissioned research studies on the potential for induced seismicity associated with the fracture stimulation of EGS wells in the Cooper Basin (Hunt and Morelli, 2006), followed by a report on the analysis and management of seismic risks (Morelli and Malavazos, 2008 and Morelli, 2009). These studies were completed at the Australian School of Petroleum at the University of Adelaide and have been reported on previously.

Further to these research projects, 6 more projects have been completed in the last year and another 5 are expected to be completed by the end of 2009. These projects are described in more detail below and the reports will be made freely available from the AGEG website.

An assessment of radiological hazards in HR geothermal systems

Battye and Ashman (2008) were commissioned by PIRSA to conduct a literature review and some modelling to assess the risk of radiological hazards for HR geothermal systems. The study found that isotopes of Uranium, Radium, Thorium, Radon and Lead will be likely to be present in the circulating ground waters.

The main risks of exposure to these Naturally Occurring Radioactive Materials (NORMs) for a HR geothermal system would be through exposure to radon gas if the geo-fluid and steam are emitted to atmosphere, or exposure to the scales and sludge that may form in the above ground system.

If the HR geothermal power plant is operated in an entirely closed loop configuration then there would be little to no risk of radon exposure. For an open loop situation the levels are probably still below the action levels for workplaces in Australia (1000Bq/m3) but are very dependent on wind speed and the residence time of the geo-fluid in the reservoir, so thorough monitoring should take place to ensure that the exposure is known and there is no risk, or else the risk is managed appropriately.

The other way there could be exposure is from the scales or sludge that may be deposited in the above ground equipment, depending on the geochemistry and the plant conditions. Experience from conventional geothermal systems and from the oil and gas industry shows that these scales and sludge can contain radio-nuclides that have been carried with solid particles suspended in the solution and then deposited, or from particles that precipitate out at surface. Only the Radium isotopes can emit gamma radiation that could penetrate the pipe work. Radium isotopes are less likely to be found in waters with low concentrations of barium and strontium sulphates, and the report states that as the radium concentrations will be expected to be lower than for the oil and gas industry the gamma radiation from these residues would be expected to be at insignificant levels.

The other isotopes that may be present could be hazardous if inhaled as a fine dust, so precautions should be taken during all cleaning operations.

Geochemistry, corrosion and scaling in Hot Dry Rock energy extraction systems

This project investigates an important element of the Hot Rock geothermal energy system. The first objective is to study geo-fluid chemistry and its contribution to the corrosion and scaling in pipes in the above ground equipment of a geothermal power plant. Understanding the fluid chemistry is also vital to maintain open pores within the underground reservoir, by avoiding clogging of the fracture network caused by mineral precipitation.

The project has involved sampling the geo-fluid from a Hot Rock EGS system and also the rock itself to determine the mineralogy and composition of each. The researchers at the University of Adelaide and the Museum of South Australia then intend to re-create the above ground and below ground conditions experimentally. Using a specially designed experimental apparatus they first study the interaction between the geo-fluid and the rock at temperatures and pressures equivalent to those in the geothermal reservoir. The results of these experiments will be used to calibrate and further develop geothermal modelling tools to determine potential scaling and pore blockage issues and consequently possible solutions

Characterisation of Adelaidean rocks as potential geothermal reservoirs (Heat Exchange Within Insulator)

The main objectives of this project are to determine the extent of pre-competitive data available to characterise the reservoir parameters of the Adelaidean formations within the Adelaide Geosyncline. This will involve reviewing and compiling all available data and publications. Further to this, maps would be compiled to show the areas in the region possibly suitable for both geothermal development and geosequestration, with the intention to provide a temperature gradient for the region.

Three dimensional reconstruction of the Adelaide geosyncline – application to geothermal exploration

Backé and Giles (2008) developed a robust integrated methodology to construct a 3D model of the Lake Torrens – Central Flinders zone in South Australia. Using Gocad, they incorporated various tectonic structures (including faults, folds and mini-basins) without geomorphic expression at the surface.

The Gocad model was then exported into 3D thermal modelling software to provide an inferred geothermal resource over the Parachilna area of the southern Flinders Ranges, South Australia.

Full life-cycle water requirements for deep geothermal energy developments in South Australia

Cordon and Driscoll (2008) documented the likely water usage for each stage of geothermal exploration and development, including issues of water loss, and compiled an atlas of water resources for South Australia to assist explorers in understanding the quality, availability and legislative requirements associated with these resources. Although the atlas of this report is for South Australia, the full life-cycle water requirements for deep geothermal energy developments that are outlined in this report are applicable world-wide.

Preliminary assessment of the impact of geo-fluid properties on power cycle design

While the effects of geo-fluids in terms of corrosion and scaling are known, there has not been a thorough assessment of the scope of these issues for Australian geothermal projects, and in particular with reference to the power cycle design to accommodate the Australian conditions. Information on the composition of the water that can be expected for geothermal projects is difficult to find, which causes great difficulty in forward planning for power plant design as these elements greatly affect the choice of systems and materials.

The first project aim was to compile a database of available water composition and quality from a consortium of AGEG members. This aim was revised, for at the time the researchers were completing this section the only available data was from the Geodynamics wells. From this data set, the most difficult set of conditions have been selected and a preliminary design will be completed using these conditions in order to provide guidance for how to manage them. The preliminary design will also allow further investigation of where opportunities lie for geothermal companies to achieve cost savings through better design and highlight areas of further research. This project is expected to be completed in 2009.

Preliminary assessment of the potential for underground cooling on power cycle design

Dally et al. (2009) have reported on a novel concept of using a large underground network of pipes instead of large cooling towers or large air coolers. Large cooling towers are unlikely to be feasible due to their water requirements which previously left large air coolers as the only option. Underground cooling offers the possibility to provide increases in efficiency for power cycles for geothermal plants operating in locations where the ambient temperatures are very high. The concept and initial results of this study have been reported (Dally et al., 2008) and the final report provides further insights.

A thermodynamic model of the underground pipe was used to determine the required length of pipe and depth of burial for a set of harsh conditions and a 5 MW power plant output. The model results were then used to determine the feasibility of such a design. The authors found that a pipe length of 25 km was needed but this would only need to be placed 10 cm deep to be beneficial – this requires a total area of approximately 5 km^2. While this is a large area it was estimated that the cost for the system would be lower than for an air cooled system and provide more constant output including greater power output than a fan/air cooler system during peak daytime temperatures.

State-of-the-art in power cycles for geothermal applications and bottoming cycles

Researchers from Newcastle University and the University of Adelaide are working jointly on this study to compile a detailed comparison of existing geothermal power plants, their performance and operating conditions, compared with the conditions expected for the Australian geothermal industry. Using models of the Kalina, Super critical, flash and Organic Rankine cycles the research aims to estimate modifications that would be required to adapt those existing power plants to Australian conditions.

The development of a geothermal power plant preliminary cost estimator – Stage 1: basic estimates

Stage 1 of this project aims to develop a cost estimator for power generation by a geothermal power plant in Australian conditions. The estimator will initially be designed around a set of assumptions which define the geothermal system, providing the ability for the user to specify the values of certain variables such as the geo-fluid temperature, the ambient conditions, well depth, reservoir porosity and surface pressure. The cost estimator will calculate the average cost of power generation for a specified period and the predicted net power under a range of conditions.

This model will be designed to be used in conjunction with the MIT cost calculator (Herzog et al., 1997), and to include some factors important for the Australian geothermal industry. Important factors include the effect of ambient conditions on the cooling cycle, the water quality and level of treatment required, and the pressure required for reinjection. The model will also be designed to be able to expand over time and include more options for power cycle design, a range of options for working fluids and different cooling systems and corrosion mitigation methods.

Forward prediction modelling of spatial temperature variation from 3D models

This report was prepared by Intrepid Geophysics (2008) and involved the development of a software module in 3D GeoModeller to calculate 3D temperature directly from a 3D geology model. The method for 3D temperature prediction incorporated heat flow contributions from conductive and in situ heat production sources and honoured known boundary conditions.

During the module testing, a simple case of heat advection, honouring a known internal boundary condition was proven. Furthermore, the capacity to compare outcomes of model-generated temperatures, with observed temperatures and heat flows was demonstrated using real–world 3D geology models in the Mount Painter and Cooper Basin regions of South Australia.

The ability to commence a forward 3D temperature run, starting with a non-GeoModeller 3D geology model was demonstrated for the Cooper Basin, South Australia. This project was completed in 2008 and included the provision of an informative workshop.

Alternative carriers for geothermal energy in SA - an investigation of the systems needed to generate hydrogen and methane from a 50 MW geothermal demonstration.

Dickinson et al. (2009) were commissioned jointly by the Electricity Supply Industry Planning Council and PIRSA to assess the system requirements for hydrogen production as a potential primary electricity load for a geothermal demonstration power plant output.

The objective of this study was to assess the possibility that hydrogen, methanol or synthetic methane production facilities co-located with geothermal energy production could have an attractive benefit to cost ratio. This study concluded that the costs to design and construct a 45MW electrolysis plant and an associated 5 MW refrigeration plant with all of the required pumps and ancillary equipment, could be economically more attractive than using the same geothermal energy to fuel a 50MW capacity power plant to reach distantly located markets via high voltage transmission lines. Locating the electrolysis plant near to existing gas transmission (pipeline) infrastructure suggests that synthetic methane could have the lowest transport costs.

Geothermal Centres of Excellence

Australian geothermal research will now be further strengthened through the work of three geothermal Centres of Excellence. The Queensland Geothermal Energy Centre of Excellence (QGECE) was established in 2008 with support from the Queensland government and the University of Queensland. The Western Australia Geothermal Centre of Excellence (WAGCoE), announced in 2008, is a joint venture between the CSIRO, Curtin University, the University of Western Australia and the government of Western Australia. Given the good results attained with its earlier grants, the South Australian Government announced the first project to be funded from a South Australian (state-based) Renewable Energy Fund will be the South Australian Centre of Excellence (CoE) for Geothermal Research at the University of Adelaide.

Each centre will have areas of expertise which complement the research and expertise of the other centres.

Industry Support for Geothermal Research

The geothermal research projects to date have been completed with support from federal and state governments and co-contributions or in kind support from geothermal companies and research institutes such as universities, Geoscience Australia and the CSIRO. Moving forward geothermal companies will be expected to make contributions to collaborative research in order to continue to progress geothermal technology.

Geodynamics has taken the lead in this endeavor with an announcement this year that the company has committed $5 million over a five year period for their Geothermal Technology Plan (GTP) (Geodynamics, 2009). This significant contribution will leverage private and public sector co-funding to develop geothermal technology which will benefit Geodynamics' Cooper Basin project and the geothermal industry both nationally and internationally.

Conclusion

The Australian geothermal industry has advanced significantly since 2005 and is assisted by supportive government initiatives, the efforts of the Australian Geothermal Energy Association and the collaborative determination of industry priorities and research work through the Australian Geothermal Energy Group.

A number of interesting research projects are underway and have already been completed relating to topics that will aid the Australian geothermal industry, with some projects focussed in the area of EGS or HR geothermal systems and more specifically to adapting to the Australian conditions. All of the outcomes of these research projects and their final reports will be made available through the AGEG website.

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