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International Partnership for Geothermal Technology

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ABSTRACT

The International Partnership for Geothermal Technology (IPGT) was established in 2007 and facilitates the development of cost-effective geothermal energy technology between its five-member countries. The current membership includes New Zealand, Switzerland, Australia, Iceland and the USA. Although these five countries have very varied geothermal resources, they are working together on governmental, and research and development levels toward efficient development and advancements to encourage geothermal development.

Representatives from Australia, Iceland and the United States signed the Charter Agreement for the International Partnership for Geothermal Technology on August 28, 2008 in Keflavik, Iceland. In 2009 Switzerland submitted an application to the Steering Committee and was invited to join IPGT. Switzerland signed IPGT Charter on October 6, 2010 in Reykjavik, Iceland. In 2011, New Zealand submitted their own application to join IPGT steering Committee and were accepted. New Zealand signed IPGT Charter on November 16, 2011 in Melbourne, Australia.

1. INTRODUCTION

The purpose of IPGT is to facilitate the development of advanced, cost-effective geothermal energy technologies, to accelerate the availability of these technologies internationally, to share and leverage each other's technical capabilities, and to identify and address wider issues relating to geothermal energy.

The key driver of IPGT is to strengthen the global response to the utilization of geothermal resources. Many countries have promoted affordable, scalable geothermal solutions to enable them to leapfrog to cleaner, more resilient economies and have measurable energy targets. In addition to IPGT, international organizations such as the International Energy Agency – Geothermal, the International Geothermal Association; and the Global Geothermal Alliance are also working on initiatives to promote and support the uptake of geothermal resource.

IPGT activities include promoting the appropriate technical, political, financial and regulatory environments for the development and deployment of geothermal technology. The primary focus of IPGT collaborations is enhanced geothermal systems (EGS), deep drilling technologies for EGS, and supercritical hydrothermal sources. We facilitate collaborative discussion between industries and researchers with interests in reservoir/numerical modelling, zonal isolation and stimulation technologies, induced seismicity processes and mitigations, development of high temperature tool and advancements in exploration technologies. We also provide a forum for governmental representatives to discuss and share policies, frameworks and incentives to encourage the uptake of geothermal technologies.

IPGT seeks to

- Identify key obstacles to achieving improved technological capacity
- Identify and recommend potential areas of multilateral collaborations on geothermal technologies, which may include drilling, reservoir characterisation, reservoir fracturing, power conversion, modelling, education and training, environmental impact assessment and monitoring, and resource assessments;
- Exchange best practices on accelerated geothermal deployment, for example, policies, financing, and loan guarantees
- Foster and promote collaborative research, development and deployment projects
- Establish guidelines for collaborations and reporting of results
- Prioritise and evaluate collaborative technology development and make recommendations on the direction of such projects
- Promote collaboration with all sectors of the international research community, including industry, academia, government and non-government organisations
- Develop a framework for sharing best technology applications, policies and financing schemes
- Identify interoperable codes and standards and work toward international standards where appropriate
- Foster education and training programme to grow human capital in the geothermal industry and work toward international standards where possible
- Exchange best practices on social and environmental issues, including community consultation and environmental assessment and monitoring and
- Conduct such activities to advance achievement of IPGT's purpose as the Members may determine.

In this way, IPGT serves as complementary multilateral agreement to the long-established IEA Geothermal Technology Collaboration Program that has significantly broader remit.

2. ORGANISATION OF IPGT

The Steering Committee comprises one government and one industry representative from each partner country. The Steering Committee is chaired by a government representative from a member country and a Secretary from a member country. Both the current Chair and the Secretary are held by New Zealand, and is due to rotate through the member countries every three years. The Steering Committee fosters collaboration and knowledge sharing to promote collaborative research, development and deployment projects. Bi-monthly telephone conferences and annual in-person meetings result in close familiarity of each member countries advances and experiences in the field of policy, research and innovation – a platform from which governmental officials, researcher and developers can delve into specific topics with considerable speed and ease. The Steering Committee oversees the work of 'working groups', which comprise networks of researchers and developers from our member countries working towards on common objectives.

There are currently six active working groups, focusing on issues that are common and of interest to each member country. The areas of interest are:

2.1 Induced seismicity

The Induced Seismicity working group (IS-WG) aims at facilitating the development and advancement of cost-effective and safe geothermal energy technologies. The research undertaken under this umbrella includes work on understanding the cause, behaviour and effects of induced seismicity associated with geothermal extraction of fluids, or stimulation of fluid flow (e.g. Meier et al 2019). There is an increasing interest by government to foster appropriate technical, political and regulatory environments that enable progress in identifying outstanding challenges in managing induced seismicity to acceptable levels. Consequently, there is a strong need to accelerate piloting and demonstration of novel approaches to managing risks associated with induced seismicity. The IS-WG has thus identified the need for risk-based measures that should be implemented before and during development and production phases of geothermal resources, and particularly so when reservoir enhancement by way of stimulation is called for. These risk-based measures need to be proven to be an effective tool to safely asses the risk and translate scientific observations and methodologies to government and non-government organizations.

A case in point is the recent international oversight committee investigation of the Mw 5.5 Pohang earthquake in connection with an Engineered Geothermal Reservoir that has provided considerable insight and recommended similar risk management strategies. Their report, formulated by an international panel of experts [Ge et al., 2019], recommended that continuously evolving risk studies, and not only hazard studies, are needed to better mitigate induced seismicity and reduce risk in regions neighbouring EGS facilities. The study also concluded that the Mw 5.5 seismic event in Pohang was induced – a reminder that there remains room for improvements in all aspects of enhanced geothermal resource extraction.

The methodology identified by the IS-WG promotes research into developing a `dynamic risk' landscape. Initial risk studies appear to be a necessary tool for permitting and demonstrating compliance, as well as enabling structured communication with other partners, insurance companies, the general population and government agencies. Moreover, it has been observed that misinformation can lead to severe negative socioeconomic impact (Rubinstein and Mahani, 2015). We have noted correct and well-designed communication campaigns are strongly necessary such that communication breakdown does not occur.

The IS-WG is currently in the implementation phase focusing on the applicability, feasibility and robustness of the Adaptive Traffic Light Systems (ATLS) (Wiemer et al., 2014; Grigoli et al., 2017). ATLS benefits from the use and flow of large amounts of geophysical, geomechanical, hydraulic, and socioeconomic data to perform real-time and risk-based decisions that, in theory, will outperform classical traffic light systems and better mitigate induced seismicity.

To tests the efficaciousness of ATLS, a large-scale in situ experiments in Iceland is currently underway through the COSEISMIQ project funded through Geothermica. Moreover, a small- to medium-scale experiment is scheduled to begin in the first part of 2020 in the Bedretto Underground Laboratory for Geoenergies (BULG) funded primarily through the Swiss Competency Center for Energy Research Supply of Electricity (SCCER-SOE). BULG will focus on more fundamental scientific questions surrounding induced seismicity associated with EGS projects. Both demonstration sites together will help to better understand any scale-dependent behaviours in the ATLS concept.

2.2 Stimulation procedures

Reservoir stimulation is the single most critical research area for enabling the development of commercial EGS technology. Stimulation also provides a method to increase production in conventional geothermal wells and low permeability regions of otherwise productive geothermal systems. Effective stimulation should produce a permeable reservoir volume through which the injected water can be circulated to extract heat energy from the rock mass. At this point, the member countries of IPGT have not only identified the need to inform each other of relevant research and innovation activities, but also to create opportunities for the respective research and innovation communities to engage in international research and innovation projects.

2.3 Reservoir modelling

Numerical simulation has played a pivotal role in elucidating the dynamic behaviour of hydrothermal systems and for testing competing hypotheses in complex, typically data poor environments. Though our ability to rigorously describe key hydrothermal processes is still imperfect, there have been substantial advances over the past several decades. These advances owe mainly to the steady growth of computational power and the concomitant development of numerical models that have gradually minimized various simplifying assumptions. They include incorporation of more accurate equations of state for the fluid system, an increased ability to represent geometric complexity and heterogeneity, and faster and more accurate computational schemes. In some instances, these advances have revealed dynamic behaviors that were entirely obscured in previous generations of models.

Through a series of member country working group meetings and a detailed road mapping effort (Ketilsson et al., 2012), in 2011/2012 the Reservoir Modeling working group (RM-WG) developed a vision for advancing numerical modeling capabilities that centers on the development of fully coupled thermo-hydro-mechanical-chemical (THMC) reservoir simulation codes by the Year 2020. The codes will require capabilities to describe the complex non-linear interactions and feedbacks associated with multiphase fluid flow, energy transport, regional- and local-scale geomechanical deformation (and fracturing), and geochemical interactions between the working fluid and host reservoir rock—all at highly variable timescales

The key of the identified strategy was a tiered approach, consisting of the development or identification of laboratory and field datasets, which in turn support a series of model-component development exercises focused on sub-grid scale processes. These exercises were designed to focus on subsets of the full coupling that were identified as most relevant to geothermal reservoir creation and operation. Advancing continuum and hybrid field scale models followed, with the envisioned development culminating with fully coupled THMC simulation codes. Much progress has been made since setting the 2020 vision.

Currently, the RM-WG is in the process of critically assessing the advances in reservoir modeling capabilities since setting our vision in 2012, and developing a revised roadmap focused on 2025 and beyond.

2.4 Zonal isolation/packing

The Zonal Isolation/packing working group was borne out of recognition that development of EGS resources will require hydraulic isolation of specific zones within an injection wellbore in order to first maximize the extent of and create a more uniformly distributed fracture network, and second, to improve the economics of EGS development by increasing well productivity and creating larger reservoirs using fewer wells (McClure et al, 2014, Meier et al, 2015). The Zonal Isolation/Packing working group was led by representatives from Australia, Iceland and the United States and produced a White Paper in 2012 outlining the challenges associated with zonal isolation in high temperature EGS wells, an inventory of existing tools developed for Oil and Gas that could be adapted for EGS environments, and specific considerations for advancement of isolation technologies.

The current Zonal Isolation Working Group, re-established in 2018 and led by Switzerland and the US, seeks to build upon this important early work and advance the state-of-the-art in this critical technology area through collaborative testing of isolation devices in intermediate and full-scale environments. The US has a small portfolio of projects focused on retrievable isolation in 8 ½ inch diameter boreholes and, for example, Switzerland-led ZoDrEx, a European research and innovation project funded under the auspices of the European Research Area Network GEOTHERMICA, aims to demonstrate zonal isolation products that are effective in EGS environments and test them side-by-side in situ. As the technologies under development by these two complimentary programs advance, the Zonal Isolation/Packing Working Group leads plan to host a roundtable discussion with the geothermal community to communicate results, discuss remaining technology gaps, and identify opportunities for future field testing.

2.5 Exploration technologies

Effective exploration tools and methodologies for hydrothermal (high, moderate or low temperature resources) and enhanced geothermal systems are fundamental to realistic resource / capacity assessment, prioritisation and development decision-making, and best utilisation of the geothermal resource – i.e. mitigation of financial and development risk. Exploration technology and the synthesis of exploration data are of critical importance for all stages of a geothermal project, from the successful targeting and drilling of the first exploration well(s), as part of a flexible drilling strategy (e.g. slimhole or conventional drillhole design), to appraisal and production drilling, and later field management and plant operation.

As an example of international cooperation in this space, Australian and New Zealand IPGT colleagues are collaborating to trial new Australian exploration technology within the Taupo Volcanic Zone. The technology (‘Heat Needle’; Beardsmore, 2020) has previously shown promise as an exploration tool for hydrothermal reservoirs (e.g. Gutiérrez-Negrín et al., 2020), and two surveys in the Taupo Volcanic Zone are planned for early 2020 to test the Heat Needle’s ability to discriminate between ‘hot’ and ‘cold’ electromagnetic drilling targets prior to drilling.

2.6 High temperature tools

There are two main applications for high temperature tools: 1) For exploration of enhanced geothermal wells, obtained as part of an Enhanced Geothermal System (EGS) and 2) For exploration of wells drilled into high temperature (or ‘volcanic’ geothermal systems), some of which can be expected to reach supercritical fluid temperatures within the next few years (supercritical means beyond 374°C for pure water and pressure greater than 22 MPa). The need for new EGS technology evolves around formation characterization to determine the generation and placement of the reservoir, the stimulation (even creation) of the reservoir itself and the maintenance of the reservoir once production is started. In high temperature geothermal fields, the need is primarily for higher temperature and pressure readout tolerance and secondly for improved temperature tolerance of existing formation evaluation tools. For both EGS and volcanic systems, casing inspection during cementing and later monitoring is becoming more relevant at elevated temperatures.

Working groups on reservoir modelling and induced seismicity have provided valuable input to the formulation of research topics suitable for international collaboration, such as code comparison workshops for dynamic reservoir simulators.

3. ACHIEVEMENTS

Our membership enabled closer working relationships, with increasing sharing of expertise and experience adding value to all partners of IPGT. For example, one outcome of IPGT’s relationship building is the U.S. Department of Energy and New Zealand’s Ministry of Business, Innovation and Employment (MBIE) decision to intensify their collaboration on the advancement of geothermal technologies. In 2018, representatives from the NZ MBIE (Dr. Prue Williams) and the US-DOE (Lauren Boyd) signed a Statement of Principal for cooperation of Geothermal research and development (see Figure 1).

As a result of this official collaboration, the U.S. Department of Energy (US DOE) announced two new partnerships with New Zealand based companies who are utilizing advanced technologies to improve the economics of geothermal development.

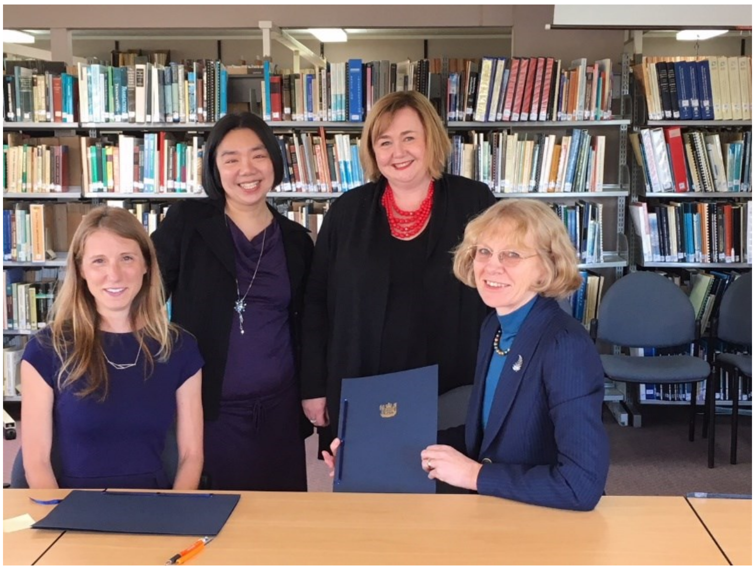

Figure 1: Signing of the Statement of Principals between the NZ-MBIE and US-DOE, witnessed by Minister Wood at GNS Wairakei research centre June 2018. Photo right to left: Lauren Boyd (US-DOES), Kennie Tsui (Chair of IPGT; MBIE), the Hon Dr. Megan Wood (Minister of Energy and Resources and Research, Science and Innovation , NZ) and Dr. Prue Williams (General manager Science Systems, Investment and Performance, MBIE)

Selected for award under a 2019 Funding Opportunity Announcement (FOA) entitled "Machine Learning for Geothermal Energy," Upflow Limited is using data from established NZ and US geothermal fields to model, train and verify machine learning algorithms to produce a plant/field monitoring system for geothermal operators to use to manage and optimize their fields. Their project goal is increasing the capacity factor of geothermal plants by > 1%.

Another partnership between a US National Laboratory and a NZ company was funded by the US DOE in 2019 via the DOE's Technology Commercialization Fund (TCF), which was created to advance promising commercial energy technologies and strengthen partnerships between DOE's national labs and private sector companies to deploy energy technologies to the marketplace. The DOE's Geothermal Technologies Office selected a project partnership between the Pacific Northwest National Laboratory (PNNL), who developed a cost-effective means for extraction of rare earth elements (REEs) from geothermal brine solutions using nanofluids and Geo40, established in 2010 to develop technologies for the extraction of minerals from geothermal fluid used to generate electricity. In the coming years, PNNL will work with Geo40 to develop technology to extract two elements, Cesium and Antimony, that are present in brines in NZ power plants at ppm level amounts and could be sold internationally if produced at attractive prices.

Similarly, IPGT has facilitated research collaborations between 1) Iceland and Switzerland (COTHERM and COTHERM2), 2) Iceland and the United States (Zhang et al., 2012), and 3) Australia, the United States, and Switzerland. It has opened direct communications between the funding bodies in the countries and created new contacts between geothermal scientists across the Atlantic Ocean. In the case of the Switzerland – Iceland cooperation it has led to the on-going COSEISMIQ project and direct scientific cooperation between the two countries. Bilateral geothermal cooperation between Iceland and USA has also increased since IPGT was established. This applies for example to participation of US scientists in the Iceland Deep Drilling Project (IDDP) and a new collaboration project is about to start that deals with improved drilling technology for high temperature geothermal wells in order to prevent well damages. Additionally, an Australia, United States, and Switzerland collaboration has emerged where researchers from the Commonwealth Scientific and Industrial Research Organization (CSIRO), the Idaho National Laboratory (INL), and the Swiss Federal Institute of Technology in Zurich (ETH-Zurich) are collaboratively developing an open-source reservoir simulation software code using INL's MOOSE framework (Gaston et al., 2012a,b; Adhikary et al., 2016).

IPGT has ongoing commitments to strongly support the member countries' geothermal communities, which are enthusiastic about engaging with IPGT via the working groups.

4. NEXT STEPS

At the 2019 IPGT annual meeting, the group agreed to develop targeted funding mechanisms via international funding communities (e.g. GEOTHERMICA) to strengthen our research and development collaborations and to extend our working groups to target high priorities topics, such as minerals recovery and hot rocks and cascaded use of geothermal energy.

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