Platform 1 – Geological Resources

Sustainably utilising geothermal energy

GNS Science's New Zealand's Geothermal Future (NGF) Strategic Science Investment Fund programme is focused on identifying geothermal systems, developing understanding of the processes that influence heat and mass flow and preparing robust predictive models to assess the impacts of extracting energy on the long-term sustainability of these systems and the surrounding environment. The challenge with progressing these activities is that the systems can only be observed at scattered points where data can be collected. Consequently, a major focus of the programme, in conjunction with the Empowering Geothermal Energy (EGE) MBIE Endeavour funded research programme, is developing new methodologies and capability that can extract robust understandings of geothermal systems from disparate data sets.

This work allows New Zealand to target geothermal resources and enhance efficiency and sustainability of energy extraction, resulting in increased renewable, low-Carbon electricity generation, and widespread direct use of geothermal energy. Growing uptake by geothermal companies of this research will result in a more secure and sustainable renewable energy supply to meet New Zealand's energy needs.

Cooling of reservoirs is one of the biggest challenges for developers of geothermal systems. This can result from the injection of cool fluids used for energy extraction into the reservoir that travel back towards the production wells. To assist in understanding of the potential for this to occur in a specific reservoir, tracer tests are used to identify pathways between production and reinjection wells. These are conducted by mixing selected chemicals, the tracers, with the reinjection fluids and injecting them into the reservoir. Production fluids are then sampled to detect returns of these tracers. Information from these tests is used to estimate the potential for cooling of the production wells by providing calibration data for numerical reservoir models.

A tracer test conducted at the Rotokawa geothermal system by Mighty River Power (MRP, now Mercury) in 2011 saw no returns of the tracers at the production wells. This result was inconsistent with previous understanding of the reservoir characteristics. Consequently, MRP commissioned GNS Science to undertake tests on the tracer compounds to confirm assumed non-reactivity. Preliminary testing suggested this assumption might not be correct. As a result, GNS designed a research project originally funded by the Core-funded Geothermal Resources of New Zealand programme, and now the SSIF NGF programme, to develop the appropriate experimental techniques and undertake experiments to build a database of tracer reactivity under different reservoir conditions.

Early results from this research indicated that the commonly used naphthalene sulfonate tracers break down at temperatures greater than 200 °C, with reaction rates depending on the temperature. Therefore, a new research project was incorporated into the EGE programme, designed to make use of this behaviour to estimate temperatures that the tracer encountered while travelling from the reinjection well to a production well through new modelling methods. The research in EGE has developed alongside the SSIF NGF programme experimental work.

Further research this year funded by SSIF NGF confirmed that the original tracer tests were invalid, which has resulted in ongoing reevaluation of old tracer test data. These findings are important for all countries using geothermal energy and have generated great interest worldwide. A milestone in this SSIF funded research this year was a journal paper published in *Geothermics* in 2021 (https://doi.org/10.1016/j.geothermics.2020.102038) offering the sector important peer-reviewed evidence that previous assumptions about tracer reactivity are likely to be invalid.

This year, GNS has presented the new findings to stakeholders in New Zealand and overseas, including a series of seminars on the learnings given to the Energy Development Corporation (Philippines) and the National Institute of Advanced Industrial Science and Technology (AIST Japan). Geothermal generation companies in New Zealand have shown interest in applying the methodologies developed in the programme when they are completed. In early 2021, GNS presented the current state of the tracer work to a Japanese research and development company (GERD). As a result, GERD have contracted GNS to extend the work on modelling tracer breakdown, funded by the Japanese government, incorporating it into a case study on how to rejuvenate a depleted producing geothermal system in Japan.

Collaborators and Funding

Our collaborators on this research are Mercury, Flow State Solutions and GERD. The research has been funded in the 2020-21 year by the SSIF NGF programme (40%) and the Endeavour Research Programme EGE (60%). Previously co-funding has been provided by Mercury and VUW, and the commercial contract with GERD will provide further funding of ~$128K in FY21-22 for this research.