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The Rebirth of Geothermal Exploration for New Zealand: A Superhot Government Initiative

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ABSTRACT

Late 2024, the New Zealand Government ring-fenced up to NZ$60 million to progress a staged superhot geothermal exploration programme, beginning with detailed design and delivery readiness for the first of three deep exploratory wells in the Taupō Volcanic Zone. The programme, GeoShot NZ, is a Government-led engineering and drilling initiative that translates New Zealand's next-generation geothermal research into delivery, building directly on the science and subsurface targeting insights from Geothermal: The Next Generation and related research programmes. It is positioned within From the Ground Up: A Strategy to Unlock New Zealand's Geothermal Potential, which sets an ambition to double geothermal energy use by 2040 and includes long-term actions on exploration and innovation. Independent technical assurance is provided through an International Peer Review Panel, established to guide and challenge the technical workstreams and provide confidence in well design, subsurface assumptions, and overall approach. This paper outlines the national approach, governance and assurance settings, and the current status of the first exploratory well at Rotokawa.

1 INTRODUCTION - DEVELOPMENT OF SUPERCRITICAL, DEEP GEOTHERMAL ENERGY: A 20-YEAR GLOBAL AND NEW ZEALAND PERSPECTIVE

Supercritical geothermal energy refers to the extraction of heat from fluids at temperatures and pressures beyond the critical point of water (374°C and 22.1 MPa), offering significantly higher enthalpy and energy density than conventional geothermal systems. Over the past two decades, this frontier of geothermal science has gained momentum globally and in New Zealand, driven by the need for low-carbon, baseload renewable energy.

Globally, supercritical geothermal systems have been explored in volcanic regions. Countries like Iceland, Japan, Italy, USA, Mexico, and Kenya have drilled into supercritical zones, with some encountering magma (e.g., IDDP-1 in Iceland). International projects (e.g., DEEPEGS, DESCRAMBLE, GEMex) have focused on drilling technologies, fluid chemistry, and well integrity under extreme conditions.

These projects in Iceland, Japan, USA, Mexico and Kenya have highlighted key challenges: Maintaining permeability at depth, managing corrosive and abrasive fluid chemistry, developing high-temperature drilling and completion technologies. Despite these hurdles, international collaboration and technological innovation have advanced the feasibility of supercritical geothermal as a scalable energy source.

New Zealand's geothermal sector has evolved from conventional systems to exploring supercritical resources, particularly in the Taupō Volcanic Zone (TVZ). Geothermal: The Next Generation (GNG)(2019–2024) Ministry of Business Innovation and Employment funded programme mapped supercritical zones, developed experimental geochemistry, and modelled heat transfer from magma to surface (Figure 1). We estimated up to 2,000 MW of supercritical geothermal potential, capable of supplying 35% of New Zealand's electricity by 2050.

The New Zealand initiative is notable for integration of Māori landowners and values, strategic alignment with net-zero carbon goals and emphasis on industrial applications beyond electricity, such as dairy processing and potentially green hydrogen.

Supercritical geothermal development faces several challenges: Drilling to 5–6 km depths in brittle to possibly ductile environments, materials able to sustain high-temperature, and potentially corrosive environments,

regulatory frameworks for novel energy systems and economic modelling to ensure viability and commercial scalability. But despite these challenges, supercritical geothermal energy represents a transformative opportunity for clean, firm, and scalable energy. Continued research, innovation, and collaboration will be essential to unlock its full potential. In this presentation we summarize the development of the new phase of deep geothermal exploration in New Zealand.

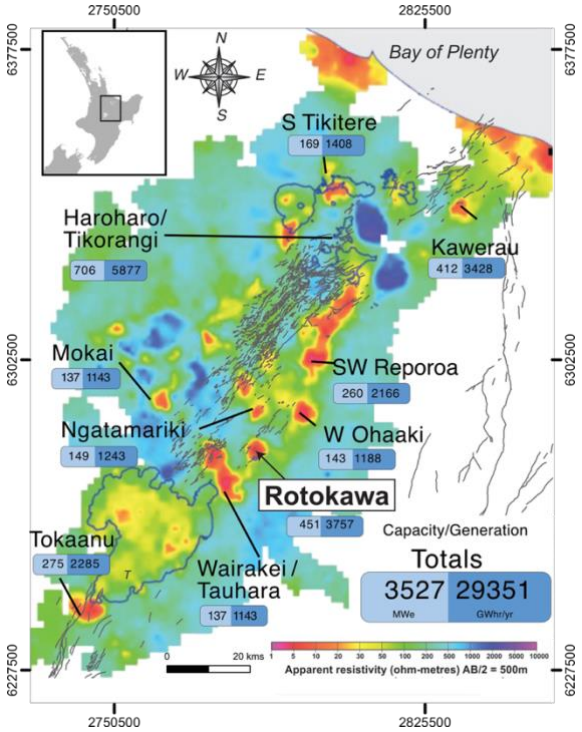


Figure 1: Taupo Volcanic Zone map with the DC resistivity indicating the location of the geothermal fields. In blue are calculated estimated of energetic outputs from depth (from Bromley et al. 2024).

2 PREVIOUS RESEARCH:

Buried beneath the Taupō Volcanic Zone (TVZ) is the huge potential of superhot geothermal 'supercritical' energy (Figure 1) and which could be available 24/7, 365 days a year as a source of baseload electricity generation. In the past 5 years Geothermal: The Next Generation programme www.geothermalnextgeneration.com has been exploring the potential of supercritical or superhot geothermal. The TVZ has one of the largest heat output in the world allowing us to access this heat/energy on a large scale at shallower depths.

Driven by the now accepted need to decarbonise the energy sector, important new engineering technologies and the need to provide baseload to weather-dependent renewable energy sources, all the major economies are looking at geothermal in a new light.

Based on the science delivered, we were able to demonstrate that supercritical geothermal energy is a long-term economic opportunity for Aotearoa New Zealand. The electric grid modelling suggests that over 2000 MW of carbon-neutral supercritical geothermal electricity could be economically viable for the grid by 2050 (Castallia Limited 2023, Bromley et al., 2024). The programme aimed to identify the locations of future supercritical resources, understand the fundamentals of geochemistry associated with reservoir utilization, and integrate science for communities (including Iwi groups), regulators, and policy developers.

Our research has refined our understanding of the deep connectivity and heat potential of the southern TVZ, which led to an inventory of New Zealand's supercritical geothermal resources.

Superhot geothermal energy is a potential solution for New Zealand to double its renewable electricity generation within the next 25 years and provide baseload electricity to the system. The Taupō Volcanic Zone (TVZ) is the best location to start the exploratory drilling. Superhot refers to conditions above 400 °C, above the critical temperature of water – hence the term *supercritical*.

Globally, several international projects are underway to push the boundary of knowledge and solve technological challenges that are associated with the drilling and utilisation of deep superhot geothermal resources. New Zealand is a major player in only a very few fields of human endeavour – geothermal is one of

them. Just as our predecessors took the calculated risk in the 1950s of funding an exploratory drilling programme and initiating the first large scale geothermal electricity plant using wet steam technology (Wairakei), there is a strong case for leading this next stage of geothermal power development.

We accumulated scientific evidence and interpretations to support a national strategy for a new phase of government supported exploration campaign for deep geothermal.

3 SUPPORT OF A NEW ZEALAND'S GOVERNMENT DECISION:

Following the geoscientific findings, the New Zealand Government via Kanoa Regional Infrastructure Fund under the Ministry of Business Innovation and Employment, ringfenced NZ$60M in November 2024 for exploration of supercritical resources in New Zealand. Under the guidance of a governance group, NZ$5M have been allocated for engagement, project design, well design and development of business case. The Rotokawa site was selected as the preferred location of the new exploration well. Here, we summarize the selection criteria:

3.1 Selection criteria

We have identified several criteria based on data, interpretation , and modelling:

- Geophysics data, modelling and interpretation,
- Permeability assessment (basement type and faulting),
- Geology, and
- Geochemistry.

The weighting on the criteria at various locations in the Taupo Volcanic Zone was provided for each fields (not presented here). The highest score points to the best-known reservoir to target for the next phase(s) of supercritical geothermal exploration. Also considered is the presence of existing geothermal infrastructure and fluid utilisation to ensure that there is a large amount of data and knowledge from the conventional reservoir. The existing operators have consents as well as know-how to drill at least in the less than 3000m depth range.

Each science-based knowledge was weighted: - no data, 0 no evidence, 1 evidence, -1 negative effect. We applied a weight of "2" for operating fields. Rotokawa ranking is presented below. More detailed explanations for each criterion are below the Table 1.

Table 1: Geoscientific selection criteria for Rotokawa geothermal field.

Geoscientific criteria		Rotokawa
Operation	operator	RJV
	Operated	2
	if operated 0 - no Go	
Regional Geophysical	Deep Seismic analyses	1
	Deep MT converage	1
	Interpretation of partial melt at depth >6 km	1
	Interpretation of a shallow intrusion in field <5km	2
	Revised local gravity model	1
	Evidence of deep permeability / caldera fault	1
Geology	3D geological model	1
	3D alteration model	1
	High T BDT - deep intermediate composition rocks	1
	Numerical simulation scenario	1
Geochemistry	T°C>300	1
	High NCG gas system (CO2)	-1
Rank	Total	13

Note: Higher weight was put on shallow intrusion based on the theoretical modelling and operated field.

3.2 Parallel research

IN 2025, a new research programme entitled DeepHeat: unlocking superhot geothermal and national energy security through advanced permeability modelling. No country has fully commercialised superhot geothermal

energy. The main challenge to unlock superhot resources lies in understanding fluid movement above and within the brittle-ductile transition (BDT) zone where these fluids circulate, compounded by extreme study conditions and the limitations of conventional analytical methods. Supported by one of the world's largest heat sources, the Taupo Volcanic Zone promises long-term thermal stability and reduced operational risks. The DeepHeat Programme supports the drilling opportunity and the interpretations of data created, by leveraging recent global advancements. We will integrate geomechanical experiments, advanced geophysical interpretation, and AI-enhanced dynamic 3-D modelling to accelerate NZ's adoption of superhot geothermal energy by: a) Developing novel methods to model reservoir permeability and fluid flow at the brittle ductile transition; b) Estimating the central TVZ's superhot geothermal commercial potential and informing the location and design of future deep exploration wells; c) Investigating engineering performance for fluid extraction and reinjection conditions; andDeveloping strategies, if necessary, for hydrofracturing and borehole stability to enable commercial-scale energy production.

We are bringing together a multidisciplinary research team of geologists, geophysicists, geochemists, geothermal modellers, engineers, AI experts, and Māori advisors, supported by an end-user-focused international advisory group and collaborations with countries leading geothermal development—USA, Japan, and Iceland—to cover the full breath of expertise required for successful delivery. Māori-led development of a Māori Trust business model will promote indigenous wealth creation, and collaboration with environmental agencies will establish regulatory and monitoring frameworks for resource use. The knowledge, tools, and strategies developed through this research have the potential to unlock NZ's vast superhot geothermal resources, driving a transformative shift in national energy resilience, accelerating decarbonisation, creating new export markets, strengthening regional economies, generating jobs, attracting foreign investment in energy-intensive emerging sectors, and positioning NZ at the forefront of sustainable energy innovation.

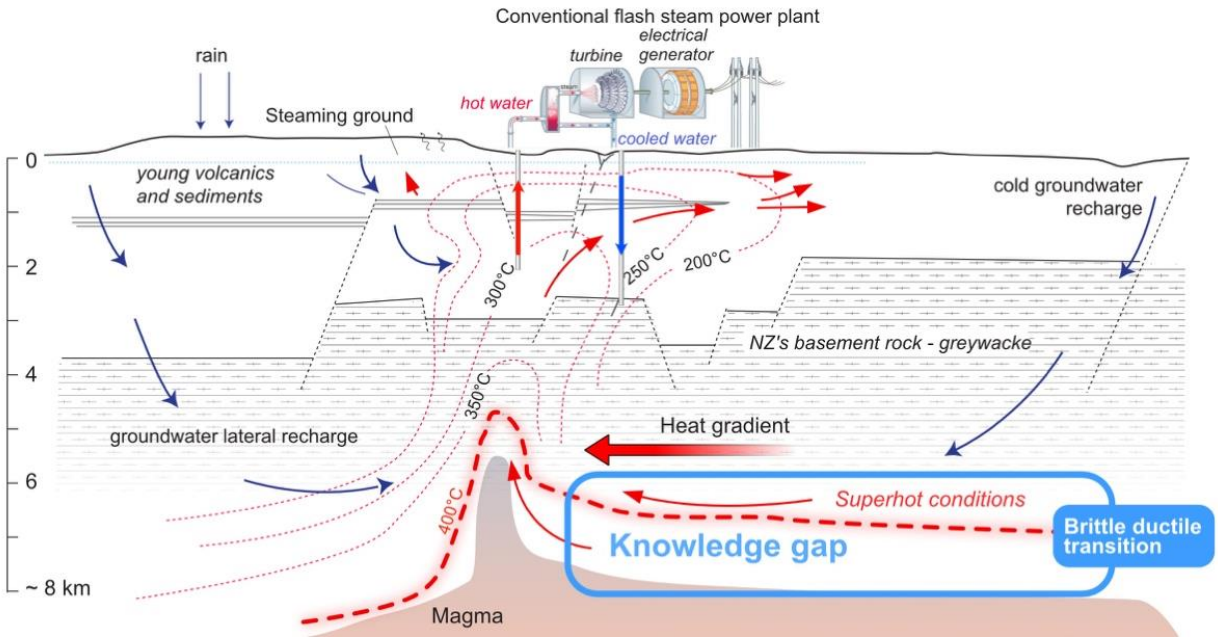


Figure 10. Schematic diagram of a conventional geothermal system with the superhot potential reservoir illustrating the brittle ductile transition zone (blue box) above a magma intrusion where superhot fluid exists.

4 A NATIONAL APPROACH

The new exploration drilling for supercritical resources in New Zealand represents a national opportunity. Such government supported exploration has not been happening for more than 40 years in New Zealand and the approach must be collaborative and inclusive.

The government is partnering with the geothermal generators, scientific institutes and indigenous Māori entities and Trusts to deliver in once in a generation a rebirth of geothermal exploration for New Zealand.

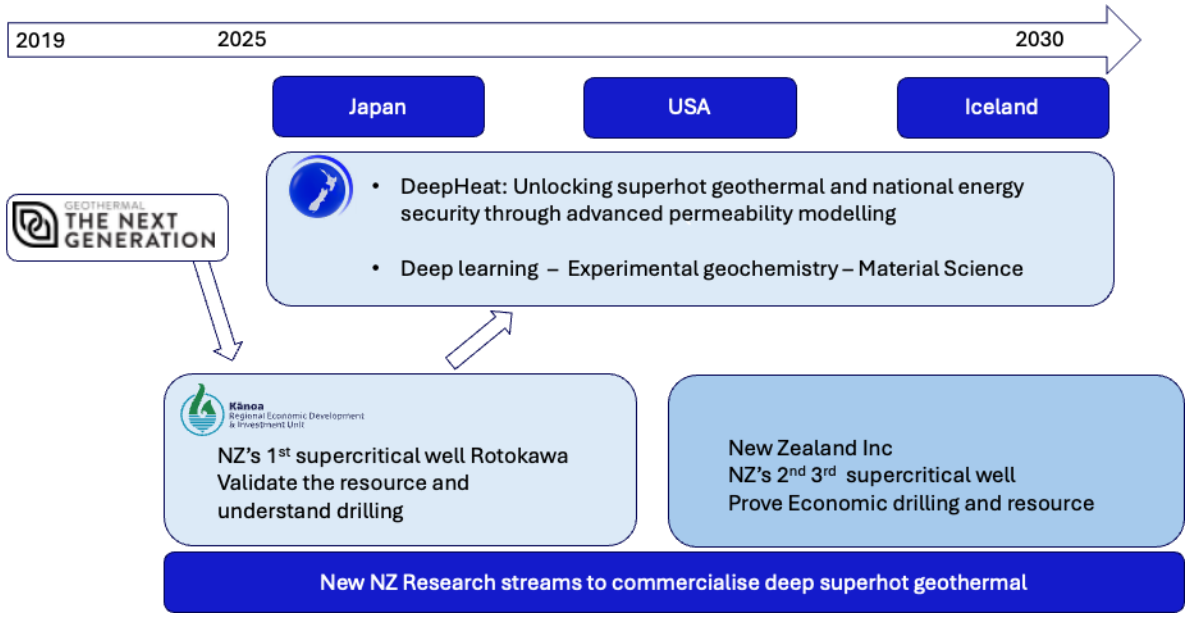


Figure 2: Project timeline, international relationships and parallel activities.

In this talk, we will present an update of the exploration drilling programme and the scientific advancement.

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