DEVELOPING A STRATEGY TO ACCELERATE UTILISATION OF NEW ZEALAND'S SUPERCRITICAL GEOTHERMAL RESOURCES

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ABSTRACT

Renewable energy resources will be an increasing component of New Zealand's 2050 "zero carbon" energy portfolio, but the nation has quite some distance to go to achieve this target, with all the carbon-friendly energy sources needing to significantly increase their contribution. The challenge for the geothermal sector is to sustainably use conventional geothermal systems to the fullest possible extent, *and* to go beyond conventional resources, tapping into deeper supercritical heat resources - expected to offer substantial additional energy potential.

A Government-funded research programme established in 2019, Geothermal: The Next Generation (GNG), is the start of this move toward supercritical resource utilisation. The programme includes development of a supercritical heat strategy (2020-2050), targeting technology deployment by 2040 with sector-wide rollout through the 2040s. The strategy will build on the current scientific understanding of New Zealand's supercritical resources; account for international experiences; and address technological, legal, regulatory, economic and other barriers relevant to the nation's utilisation of supercritical resources. Action Plans will assist in implementation of the supercritical heat strategy, and an Action Group will drive implementation.

This paper introduces the GNG programme, particularly outlining the intended strategy development process and the intended engagement with potential players across the geothermal industry, academia, researchers, business, Māori, development banks and government entities.

The authors are keen to draw on your supercritical experience – visit www.geothermalnextgeneration.com to find out how to get involved.

1. Introduction

New Zealand's 2050 carbon emissions target was identified by the Climate Change Commission in 2020 as ~20 Mt CO_2e (CCC, 2020), moving from a current level of ~80 Mt CO_2e [Figure 1]. This ambitious target will move New Zealand to "zero carbon" by 2050.

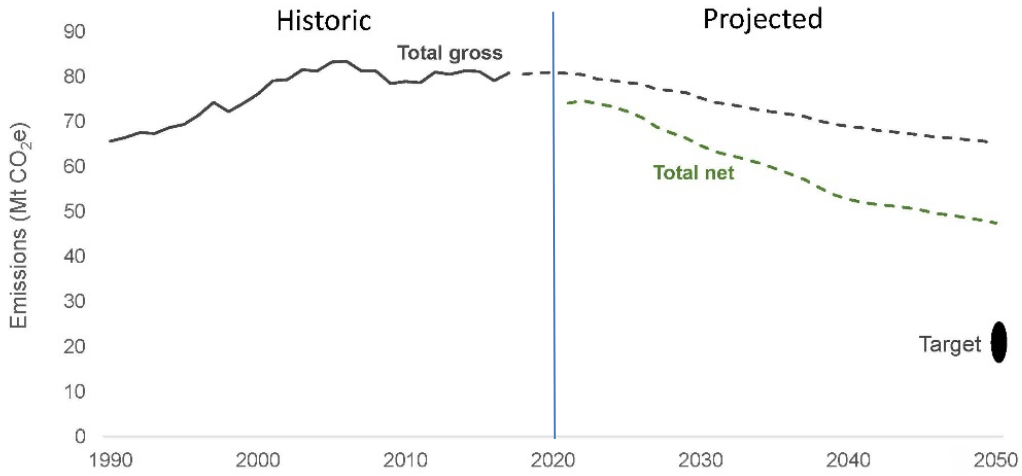

Figure 1: New Zealand's carbon emissions: historical, projected and the 2050 target (CCC, 2020). Net emissions include emissions and removals from land use change and forestry. Greenhouse gas emissions are measured in megatonnes of CO_2 equivalent (Mt CO_2-e).

New Zealand's energy data is reported as primary energy supply and consumed energy, and is recorded and reported by the Ministry of Business, Innovation and Employment (MBIE).

The total primary energy supply in 2018 amounted to ~890 PJ (MBIE, 2018a).

The 2018 electricity generated was ~154 PJ (MBIE, 2018b), with over 80% produced from renewable sources (hydro 60%, geothermal 17%, wind 5% and other renewable 2%) and 16% from carbon-based sources (13% gas, 3% coal and oil) [Figure 2].

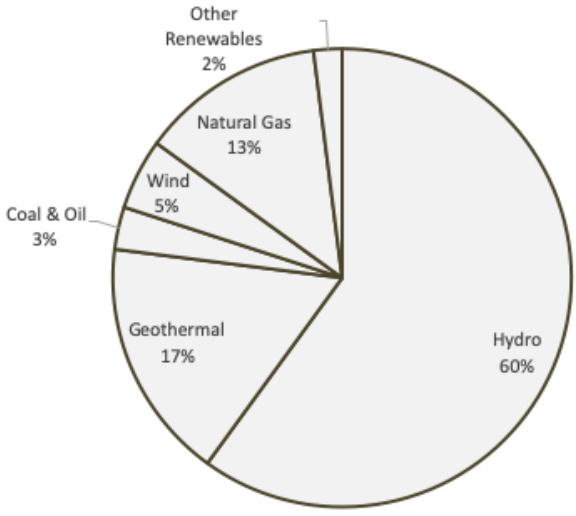

Figure 2: New Zealand's renewable and carbon-based electricity generation for 2018.

In 2018, New Zealand's consumed energy (MBIE, 2018a) was ~590 PJ [Figure 3, Table 1], dominated by 69% carbon-based (oil 48%, natural gas 13%, coal 4% and carbon based electricity 4%), and 31% renewable (electricity 20% and other 11%). The 'Renewable Other' category includes wood, biogas, solar and geothermal direct heat supplies.

In total, based on the 2018 data, geothermal accounts for about 5.5% of the total consumed energy in New Zealand, of which 1.5% is from direct energy use (~ 8PJ). Thus, while geothermal energy has a significant part to play as consumed energy use transitions to more renewable energy, significantly more use of geothermal resources is required to assist in moving the nation to the identified 2050 carbon target.

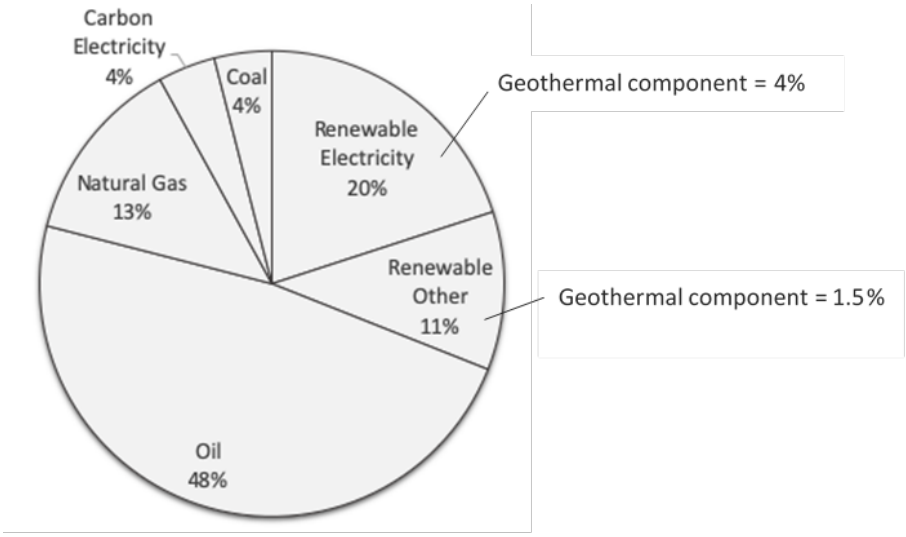

Figure 3: New Zealand's consumed energy by generic fuel type for 2018.

Table 1: Renewables contribution to total consumed energy (for 2018).

Renewable Energy Type	Electricity (PJ)	Other (Non-electric energy) PJ	Total (PJ)	% of total consumed energy
Hydro	86.5		86.5	14.7
Wood	1.0	56.6	57.6	9.8
Geothermal	24.5	8.0	32.6	5.5
Wind	6.8		6.8	1.2
Biogas	0.9	0.3	1.2	0.2
Solar	0.3	0.4	0.7	0.1
Total	**120.0**	**65.3**	**185.4**	**31.5**

2. Geothermal: The Next Generation (GNG)

Geothermal: The Next Generation (GNG) is a research programme established to identify what needs to occur for New Zealand to establish hotter and deeper earth resources as a part of the nation's 2050 energy portfolio (Chambefort et al., 2019). The programme is funded through the MBIE Endeavour Fund (Contract C05X1904), from October 2019 – September 2024. GNG is a

collaborative effort led by GNS Science and involving universities and companies in New Zealand and internationally (Table 2).

Table 2: Research organisations participating in the GNG programme.

EXPLORE	UNDERSTAND	INTEGRATE
GNS Science, Swiss Federal Institute of Technology (ETH Zurich), Victoria University	GNS Science, Auckland University, Victoria University	Upflow, GNS Science, Bridger Consulting, Traverse Environmental

GNG is organised into three research themes: 'Explore' and 'Understand' deliver scientific outputs, whilst 'Integrate' disseminates the knowledge gained and engages with the broader New Zealand and global geothermal communities.

1. EXPLORE for future geothermal resources

Using geological and geophysical data from the Taupo Volcanic Zone (TVZ), the structure of the greywacke basement and the influence and location of magmatic bodies will be analysed to identify areas with prospective, drillable supercritical conditions. The research seeks to test the hypothesis that optimal supercritical conditions in the TVZ are found where magmatic heat encounters buried structures above the ductile region, focusing on depths shallower than 10 km. Modelling of thermomechanical and thermochemical processes in shear zones and heat transfer from magma will identify the most likely locations of any shallower supercritical resources.

2. UNDERSTAND the thermochemistry of supercritical resources

Utilisation of supercritical fluids is dependent on understanding the effects of fluid-rock interaction, as fluid and rock chemistry change as supercritical conditions are reached. The research seeks to define chemical species distribution and fluid-rock interactions, and model behaviour of dissolved and volatile species in the transition from ductile to brittle conditions, and during fluid extraction and injection.

3. INTEGRATE and translate knowledge

A robust understanding of the opportunities and challenges will de-risk future investment and accelerate deployment of supercritical resources in New Zealand. The activities aim to translate supercritical research and inform an engaged stakeholder community for next generation of geothermal. Informed by expertise from within the project and through external engagement with Maori, multigenerational kaitiakitanga (guardianship) philosophy with respect to resource use will assist in providing the necessary thinking, information and insights that will lead to the development of long term sustainable supercritical projects.

3. Supercritical Strategy & Action Plans

GNG has adopted the technology readiness scale used by the European Commission (Figure 4, EC, 2015). The Supercritical Heat Strategy for New Zealand (2020-2050) will be developed to move supercritical to deployable (technology readiness level 9) by 2040. Wider rollout would occur in the period 2040 to 2050, aligning with NZ's aspiration of "zero carbon" energy by 2050.

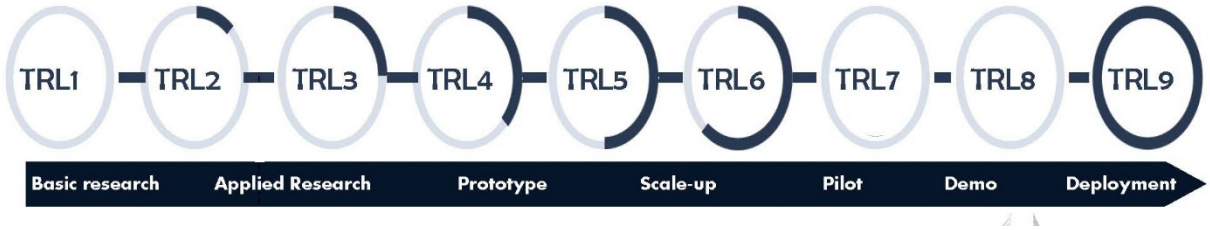

Figure 2: Technology Readiness Scale.

The process to develop the strategy will:

1. identify strategic issues, opportunities and barriers – including planning frameworks, environmental restrictions, competitor analysis/advantages, information gaps, etc;
2. build on the most current scientific understanding of NZ's supercritical resources, and account for international experiences;
3. engage with potential players across NZ and global industry, researchers, business, Māori, and Government; and
4. prioritise actions that leverage strengths to maximise opportunities and reduce barriers to uptake.

The strategy will:

1. respond to barriers to utilisation of supercritical resources in New Zealand;
2. be legitimate, readily understood and marketable;
3. work to unlock the potential of NZ's supercritical resources over the thirty-year timeframe by incrementally moving supercritical heat technology readiness forward (Figure 2), targeting Technology Readiness Level 9 by 2040; and
4. assist industry, iwi, and regional and central Government to coordinate and promote the long-term, sustainable energy utilisation of NZ's supercritical resources, generating significant environmental and economic benefits, including skilled employment.

Short term, sequential Action Plans prepared under the umbrella of the supercritical heat strategy will direct activity in a targeted, flexible and adaptive way, and an Action Group will drive implementation.

4. Stakeholder Engagement

Substantial consultation and engagement is required to progress supercritical resource use in New Zealand. The engagement approach will be based on tiers of effort (Figure 5).

1. INFORM ensures a solid foundation for communication with all stakeholders, focussing on one-way engagement tools, such as disseminating information and resources (e.g. website, fact sheets, newsletters, collateral).
2. CONSULT is for our moderate and high priority stakeholders and includes two-way consultation and feedback (e.g. workshops, lectures, face-to-face meetings).

3. COLLABORATE is for our highest priority stakeholders who are involved in the programme (e.g. co-authoring research, shared delivery of targeted products, advice).

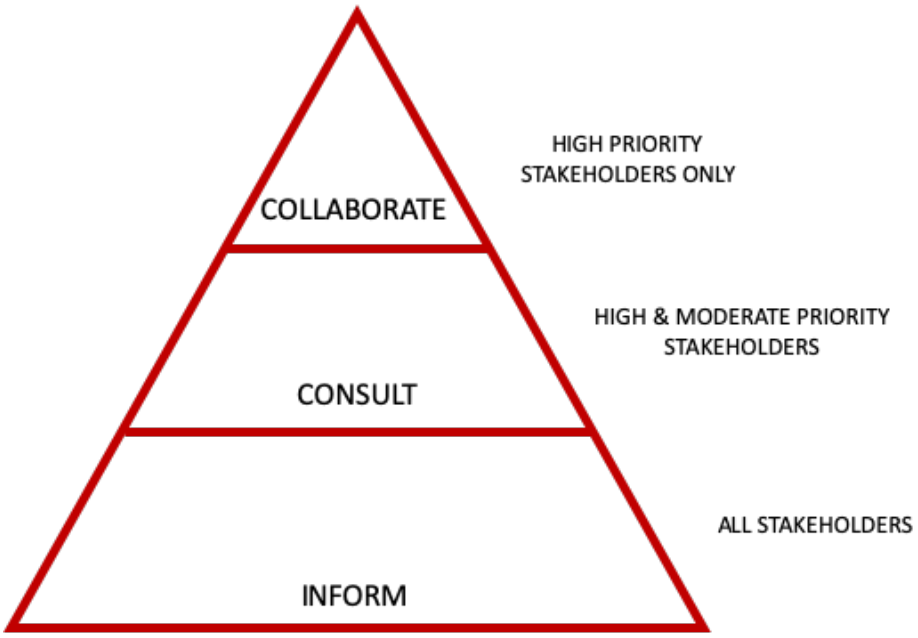

Figure 5: Tiers of stakeholder engagement (modified to suit GNG needs, from IAP, 2018).

The GNG programme has four high-level groups of stakeholders (Figure 6), determined based on their interest and needs from the research, and also the degree to which the programme needs engagement with each group in order to deliver successful outcomes.

- Potential Investors: These stakeholders seek to understand the potential value and relevance of the research, and the developing business case for future New Zealand supercritical energy development(s)
- Governance Pathway: These stakeholders are key to the optimal design of future planning and governance frameworks for the sustainable development of New Zealand's supercritical energy resources
- Science Excellence: These stakeholders (national and international science/geothermal community) value and utilise research outputs, and develop enduring collaborations.
- Community Awareness: These stakeholders require an enhanced understanding and awareness of New Zealand's supercritical research and industry potential.

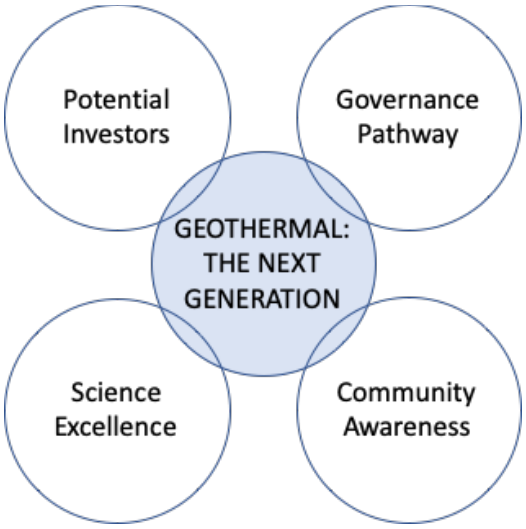

Figure 6: GNG stakeholder groups.

5. Information Dissemination

A broad range of supporting studies and initiatives will occur in GNG in parallel to the science programme (some examples below).

Website: A website will act as the key dashboard to facilitate communication with industry, Māori, land owners, government agencies and others. Visit www.geothermalnextgeneration.com to find out how to get involved.

Inventory: An inventory of New Zealand's supercritical resource potential, assets and infrastructure will focus on potential large-scale projects in prospective geological settings and incorporating international insights.

Market Propositions: Complementary and prioritised market value propositions will be identified for energy suppliers and high energy demand users. This includes data and information needed to build business cases for investment.

Planning Framework: A regulator-industry-Māori geothermal "think-tank" will provide recommendations on the optimal way to regulate the use of supercritical resources. The current planning regime will be considered, along with how this might apply to supercritical resource use. The work will consider how we might optimise the existing (or create a new) planning regime to support sustainable supercritical resource consenting, utilisation and system management.

Publication & Conferences: GNG will publish in peer-reviewed journals, release summary reports, and communicate through proceedings papers and conference presentations. The New Zealand Geothermal Workshop will have an annual update paper on the GNG programme. For WGC 2020, a forum hosted by GNG will be run in Reykjavík Iceland in May 2021. Invitations will be sent out for this event.

6. Summary

The GNG programme commences New Zealand's move towards supercritical geothermal resource utilisation, targeting technology deployment by 2040 with sector-wide rollout through the 2040s and aligned with the Government's 2050 "zero carbon" energy portfolio target.

A key part of this programme is the development of a supercritical heat strategy (2020-2050) and associated action plans. The strategy will bring together current scientific understanding of New Zealand's supercritical resources accounting for international experiences, address technological, legal, regulatory, economic and other barriers and drive targeted and coordinated activity across multiple sectors to unlock our supercritical resource potential.

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