



Traverse
Environmental



Regulatory Planning – Output compilation and brief summary of Critical Steps 1.3.6 and 1.3.7

11 December 2024

Report Overview

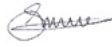
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1 Introduction

The Geothermal: the Next Generation research programme (“GNG”) is focussed on the future potential development and use of hotter, deeper superhot, including supercritical, geothermal resources.

The Ministry for Business Innovation and Employment (“MBIE”) funded the GNG work under Endeavour Contract (C05X1904). GNS Science was the lead agency with the work undertaken through the period October 2019 to March 2025. The regulatory planning activities discussed in this document are the outputs associated with Critical Steps 1.3.6 and 1.3.7.

GNG was designed to address the geological, geochemical, technological and planning challenges for the use and development of superhot geothermal resources in New Zealand.

In the Taupō Volcanic Zone supercritical geothermal fluids are likely to be found at depths greater than 4km where temperatures can exceed 400°C. These resources offer the potential for the availability of significantly more energy than from the conventional geothermal fluids currently utilised in New Zealand. The superhot inventory prepared by Bromley et al (2024), that considers the depth range 3.5 to 6km, identifies a total additional power generation capacity equivalent to about 4.6 GWe. If systems protected under existing regulatory planning regimes are excluded, the assessed capacity reduces to 3.5 GWe, capable of generating ~29 TWh of baseload power annually. For comparison, in 2023 conventional geothermal generated ~8 TWh.

Castalia (2023) identified that there is a market opportunity and that superhot resources can make a substantial contribution to the future renewable electricity requirements in New Zealand contributing between 1.3 and 2 GWe of capacity (**Figure 1**). There may also be potential for direct use of the superhot geothermal resources to provide industrial process heat.

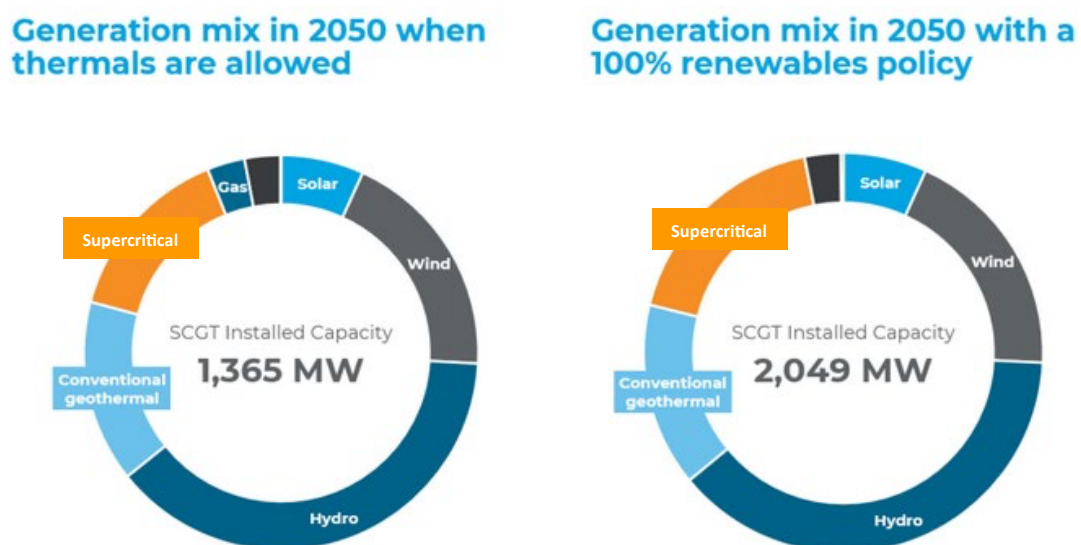


Figure 1 Supercritical in the generation mix in 2050 with and without gas fired thermal generation scenarios (Castalia 2023)

Regulatory planning approvals are a necessary component of successfully realising this superhot geothermal resource potential. This was acknowledged through the programme outline and resulted in the development of two critical steps to consider regulatory planning framework implications and opportunities for optimisation and enhancement.

The two Critical Steps in the GNG programme with a regulatory planning component were:

- Critical Step 1.3.6 "Supercritical resource delineation: legal framework for allocation and consents". This was scheduled in the MBIE contract to commence on 1 October 2020.
- Critical Step 1.3.7 "Supercritical Resource Delineation: Criteria for Resource Boundary Definition and Interconnectivity". This was scheduled in the MBIE contract to commence on 1 October 2022.

This report provides a summary compilation of the work completed under these two critical steps and provides links to the documents prepared to enable easy access for readers.

2 Project Outputs

The following is a summary of the work completed under Critical Steps 1.3.6 and 1.3.7. The material is presented in chronological order.

2020 outputs

Work commenced by preparing background material on New Zealand's geothermal resources, geothermal utilisation and baselining the current statutory planning regime for geothermal resource use in New Zealand.

The following is a summary of outputs from 2020:

- Authored a 2020 New Zealand Geothermal Workshop ("NZGW") [Conference Planning Paper](#) (Kissick et al 2020)
- The poster presented at the 2020 NZGW is included as [Attachment 01](#).
- The associated [Quick Reference Guide](#) of New Zealand's Statutory Framework applicable to geothermal resources is included as [Attachment 02](#).
- Co-authored a 2020 NZGW [Supercritical geothermal strategic opportunity paper](#) (Climo et al 2020)
- Assisted with the facilitation of the strategy workshop session on "*Supercritical Opportunity: Moving from Potential Resource to Deployed Technology*" at the 2020 NZGW alongside other GNG team members. The notes recording the workshop outputs are included as [Attachment 03](#).

In June 2020, Randerson et al (2020) was released by Ministry for the Environment ("MfE") which identified legislative changes proposed to resource management in New Zealand. The proposed Resource Management reform ("RM reform") changed some of the GNG planning work which is discussed below.

2021 outputs

Background material on the existing regulatory planning framework for geothermal was written up through 2020-2021 in a comprehensive report by Kissick et al (2021).

- Kissick, D., Carey, B., Climo, M. 2021, [An Overview of New Zealand's Geothermal Regulatory and Planning Framework for Conventional Geothermal Resource Use](#) Traverse Environmental Ltd ISBN 978-0-473-59132-8 ([Attachment 04](#))

The GNG Planning team continued to engage in the RM Reform process. This engagement sought to support the development of an optimal framework for supercritical geothermal resource use and development in New Zealand. The GNG Planning team worked collaboratively with the New Zealand Geothermal Association ("NZGA") in preparing submissions and presentations.

The following is a summary of outputs from 2021:

- Submission on Natural and Built Environment Act Exposure Draft (3 August 2021) ([Attachment 05](#)) (Also available from the NZGA web site – [URL Link](#))
- Assisted NZGA with the presentation of NZGA's submission on 9 September 2021 to the Parliamentary Environment Select Committee on the Natural and Built Environments Bill ("NBA") Exposure Draft. The video recording of the NZGA presentation starts at 1:12:19 on the [linked video](#).

2022 outputs

The GNG Planning team contributed to a paper for the 2021 NZGW which was presented online by Brian Carey to the workshop (deferred through to early February 2022).

The following is a summary of outputs from 2022:

- 2021 NZGW paper [New Zealand's Pathway to Supercritical Geothermal Energy Use: Moving forward to exploration drilling](#) (Carey et al 2021).
- A PDF of the presentation can be accessed as [Attachment 06](#) and the video of the talk is available through this [URL](#).

2023 outputs

Through 2023, the GNG Planning team continued work on submissions to the ongoing RM reform process, as well as submissions on the proposed revision of the National Policy Statement for Renewable Electricity Generation ("NPSREG") and the NZ Energy Strategy refresh. This was supported by work completed under the GNG programme to date.

The following is a summary of outputs from 2023 in relation to the Resource Management Act ("RMA") reform programme:

- Contributed to the NZGA submissions on the [NBA](#) and [Spatial Planning](#) ("SPA") Bills as part of the RM reform. ([Attachments 07 & 08](#))
- Assisted with the presentation of the NZGA submissions on the NBA and SPA Bills to the Parliamentary Environment Select Committee. NZGA's oral presentation starts at 21:41, the NPA oral presentation commences at 25:54 and the SPA presentation commences at 35:58 on the [linked video](#).
- Contributed to [NZGA's submission on NPSREG](#) to the Ministry of Business, Innovation and Employment ("MBIE"). ([Attachment 09](#))
- Part contribution to the GNS Science submission on the NZ Energy Strategy Refresh.

Preparatory work was also underway on better understanding the likely requirements for deep 6km exploratory drilling activities. Kissick et al (2023a) discusses the drilling processes for superhot resources and then evaluates the likely permitting / consents required for establishing a drill site and for drilling operations.

The following is a summary of outputs from 2023 in relation to the drilling activities:

- Kissick et al (2023a) Deep Geothermal Exploratory Drilling and Testing in the Taupō Volcanic Zone. ([Attachment 10](#))
- Kissick, D., Bendall, S., Carey, B., (2023b), [Planning Preparation for Six Kilometre Deep Geothermal Wells in the Taupō Volcanic Zone](#), New Zealand was paper 64 prepared for the 2023 World Geothermal Congress ("WGC"), Held in Beijing, China 2023
- Chris Bromley's presentation of the planning paper at WGC 2023 is included as [Attachment 11](#).

2024 outputs

Work continued on better understanding the consenting requirements for developing and operating a superhot geothermal power plant with this work reported in Kissick and Carey (2024a) as follows:

- Kissick and Carey (2024a). Consenting a Superhot Geothermal Development in the Taupō Volcanic Zone. ISBN 978-0-473-72335-4. ([Attachment 12](#))
- Contributed to the organisation of the 2024 New Zealand Geothermal Week *Geothermal Energy, What is Our Potential Workshop* run by GNS Science. ([Attachment 13](#)). The workshop identified that across a broad temperature range and using new technologies, geothermal energy has a much more significant role to play in New Zealand's energy future than was earlier considered possible.

Following the initial identification of what regulatory changes might usefully assist the ongoing development of geothermal energy in New Zealand, including the accessing of superhot geothermal, a comprehensive report was prepared (Kissick et al 2024b). This was summarised in Kissick et al (2024c) and in a paper prepared for the 2024 NZGW as referenced below:

- Kissick, D., Bendall, S., Campbell, A., Carey, B., Bromley, C., 2024b. Regulatory considerations for the future of Superhot Geothermal Development in the Taupō Volcanic Zone. ISBN 978-0-473-72336-1 ([Attachment 14](#))
- Kissick, D., Bendall, S., Campbell, A., 2024c. Unlocking our potential: a superhot geothermal future for Aotearoa New Zealand. Proc. 46th New Zealand Geothermal Workshop, University of Auckland, (2024). ([Attachment 15](#))
- Deborah Kissick's presentation to the 2024 NZGW delivering the Kissick et al (2024c) paper can be accessed through [Attachment 16](#).

This summary report concludes the planning work associated with the GNG Research Programme Critical Steps 1.3.6 and 1.3.7 and draws together the outputs from the work into one report.

The next section draws together the essence of the work, summarising at a high level, the key findings.

3 Key Findings

The GNG Planning team has been privileged to be able to spend time analysing and considering aspects of the regulatory planning framework as it applies to geothermal resource protection, use and development. We have had the opportunity to consider the future potential contribution of geothermal to New Zealand's energy future, with a particular focus on the opportunity presented by superhot geothermal.

Work under the GNG programme has demonstrated that geothermal energy has a significant role to play in NZ's energy future. Achieving Government targets for net-zero emissions by 2050, while maintaining affordable, reliable and sustainable electricity supply, will require substantial growth in geothermal energy use.

In 2023, geothermal resources accounted for 18% of our electricity generation; there is potential to more than double this output by tapping into 'superhot' geothermal resources. Other, currently unutilised, geothermal technologies offer yet more potential.

Technical advancements in geothermal practices, including sophisticated modelling and reservoir simulations using advanced three-dimensional software, enable better understanding and management of geothermal fields, reducing drilling risks and enhancing resource management capabilities. Modern practices, such as reinjecting geothermal fluids and returning geothermal gases underground, are becoming standard, supporting sustainable reservoir management.

The GNG planning team have identified a series of recommendations for consideration by developers, policy makers, regulators and others interested in realising NZ's geothermal potential. These recommendations take account of the significant future potential for geothermal energy, the existing regulatory framework, advances in research, modelling and geothermal practice, and the importance of placing geothermal values at the centre of decision-making.

The following provides a summary of the important findings from our work under 1.3.6 and 1.3.7:

- Effective engagement and partnership with mana whenua is fundamental to sustainable geothermal resource use in NZ. Recognising Māori rights and interests, particularly their role as kaitiaki (guardians), should be prioritised in future resource management legislation, moving beyond the current focus of the RMA on consultation with iwi authorities.
- Growing recognition of geothermal energy's role in meeting energy demands and carbon-neutral goals is emerging from the Climate Change Commission and government ministers. However, geothermal has yet to be fully acknowledged in government policy.
- The role of geothermal needs to be championed through the resource management reform process. This is essential to ensure that the values of geothermal resources generally, including superhot, are recognised and appropriately managed. This requires balancing the need for the protection of important geothermal values and enabling resource use and development where appropriate.
- Geothermal system boundary delineation is important to ensure protection of valuable surface features by directing that geothermal development is inappropriate in some areas. This approach may not be necessary for areas with potential for sustainable geothermal resource use. This is because resource consent processes require a thorough assessment of system capacity and environmental impacts as part of any resource consent application for geothermal development. Modern approaches including reinjection, monitoring, advanced modelling and adaptive management are increasingly effective at managing adverse effects.
- There are a range of alternatives for delineating geothermal system boundaries and managing activities within these systems that could achieve a better outcome for the

protection and management of the resources, some of which are outlined in Kissick et al (2024b).

- Enhancing our understanding of the connectivity between deep superhot geothermal resources, shallow systems, aquifers, and surface features is important for future resource use and regulatory approvals. More detailed modelling studies, exploratory drilling and well testing will further develop our understanding and validate / modify connectivity models and understanding.
- High costs and the absence of short-term returns pose challenges for superhot geothermal exploration, with estimates reaching up to \$200 million for a three-well programme. No superhot wells have been drilled in NZ, leaving a data gap for investors. Past geothermal developments in Aotearoa New Zealand benefited from substantial government investment, reducing risk and encouraging private sector involvement. A similar government-backed approach would be a significant driver for superhot geothermal exploration and likely be a precursor to attracting future investment in superhot geothermal development.
- Past geothermal development practices have caused adverse effects. Shaping a positive narrative around future geothermal energy use is crucial. Modern practices, including reinjection, independent oversight from peer review panels and adaptive management, enhance sustainability and reduce environmental risks. Sharing information about the potential benefits of superhot geothermal energy will empower communities to engage meaningfully in future policy discussions and consent processes.
- While NZ has not yet drilled into superhot geothermal conditions, international research into these deep geothermal systems is ongoing. Global collaboration and knowledge sharing can help avoid duplication of effort, facilitate advancements and may assist in attracting international investment in superhot geothermal in Aotearoa New Zealand.
- At developed geothermal sites, existing consents for geothermal drilling including water use, may be able to be utilised for deeper drilling into superhot geothermal resources. Some amendments to the scope of the consent and potentially to consent conditions may be needed to enable this to occur. Modifying existing consents may be a more streamlined pathway to enable superhot geothermal exploratory drilling than seeking new consents for a greenfield site.
- Production from a superhot geothermal operation, outside the boundary of a currently identified 'development' geothermal system (as defined in a regional plan) is a prohibited activity meaning consent cannot be applied for. A formal change to the regional plan is therefore required in order to change the system 'status' which can add significant time, cost and complexity while also needing to be followed by a thorough resource consent application for the production activity. These requirements are likely to hinder the ability of developing superhot resources where they are located outside of known 'development' geothermal systems.
- Freshwater availability is a nationwide challenge. Access to freshwater resources for future deep drilling projects is an important aspect for geothermal drilling operations which require large daily volumes for drilling (Kissick et al 2023a).
- The regulatory planning framework would benefit from:
 - Development of a National Policy Statement (NPS) and accompanying National Environmental Standard (NES) that specifically recognise geothermal resources to streamline regulations and provide consistent national guidance. These tools should also reflect the significance of geothermal resources to Māori.

- Reconsideration of the approach to the delineation and classification of known system boundaries and the subsequent rules that apply. These changes would reduce the need to require a formal change in system status to enable production from a proven resource.
- Ensuring that future regulation accounts for the future potential of the range of potential geothermal technologies including conventional, low temperature and future technologies including superhot as illustrated in Figure 2.

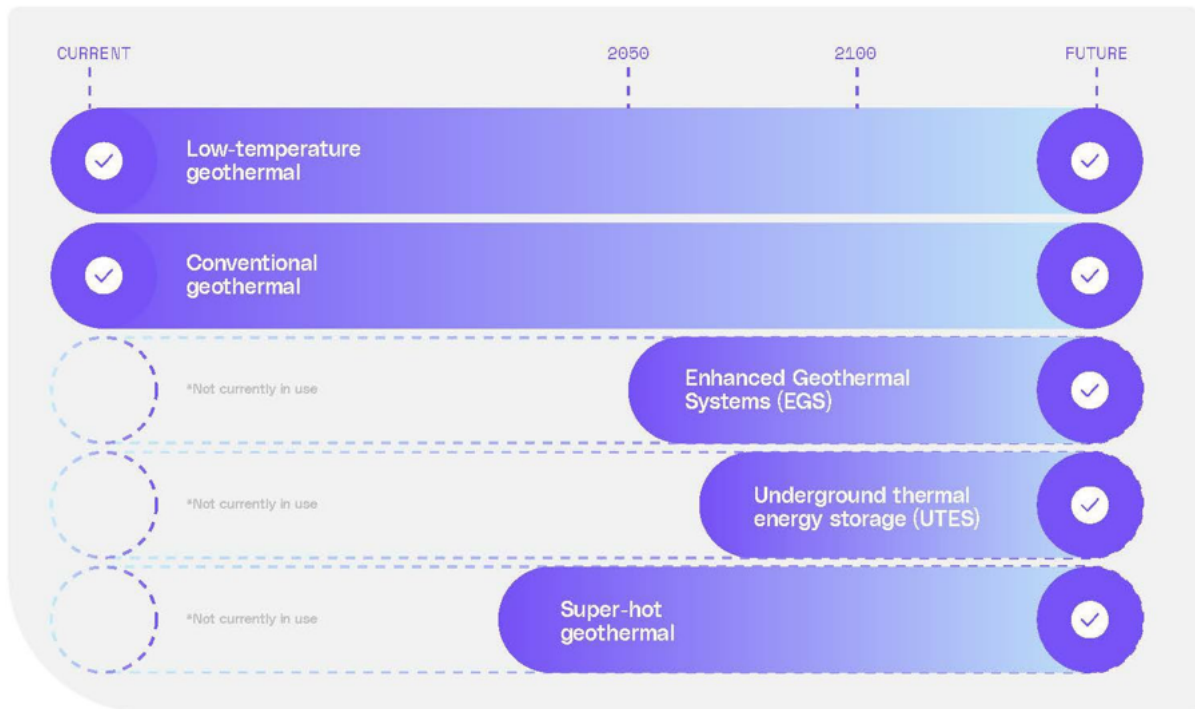
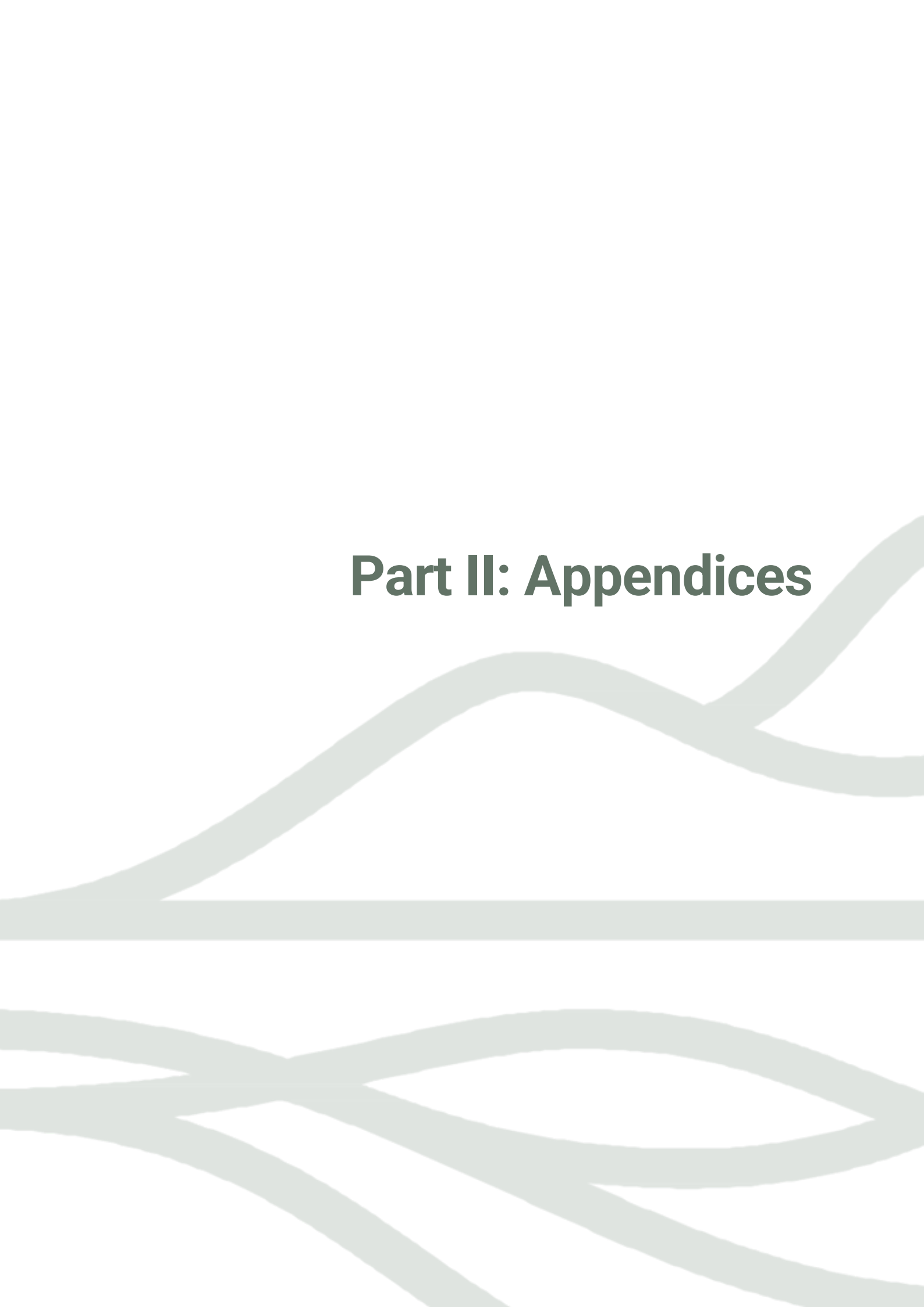


Figure 2 NZ currently employs conventional and low temperature geothermal. In future and with investment and research, there is significant opportunity from additional geothermal technologies to contribute to achieving our net-zero targets in and beyond 2050.

4 References

- Bromley, C.J., Rae, A.J., Alcaraz, S.A., Kissling, W.M., Rivera, J.M. 2024. Inventory of New Zealand supercritical resources. GNS Science report SR2023/50, ISBN: 978-1-99-105857-7. (2024)
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- Randerson, T., Brooking, R., Kimpton, D., Linzey, A., Peart, R., Prime, K., [New Directions for Resource Management in New Zealand](#), Report of the Resource Management Review Panel. June 2020. ISBN: 978-1-98-857998-6. (2020)

Part II: Appendices

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Appendix 1. Scope and Scope Changes for Critical Steps 1.3.6 and 1.3.7.

A.1 Critical Step 1.3.6

Supercritical resource delineation: legal framework for allocation and consents

This Critical Step ("CS") was originally scoped to look at how the regulatory framework under the RMA applies to the use and development of geothermal resources, and to identify how this framework could be optimised to apply to supercritical resources.

The original critical step was defined as:

1.3.6 Supercritical resource delineation: legal framework for allocation and consents

We will initiate a regulator-industry-iwi geothermal "think-tank" and provide recommendations on the optimal way to utilise supercritical resources. The body will consider resource delineation, connectivity between aquifers, environmental and system management, as well as legal frameworks for supercritical resource allocation, consenting, utilisation and sustainable system management.

In early 2021, the New Zealand Government announced its intention to reform the resource management system by repealing and replacing the RMA. As a result of the changing regulatory environment for managing natural and physical resources, it was decided to refocus the deliverables of Critical Step 1.3.6 to take advantage of the opportunities, whilst responding to the risks, presented through this legislative reform.

In mid-2021, the task scope, objectives and deliverables were revised to focus on the new legislation to support the development of an optimal framework for Supercritical geothermal resource use and development.

The task scope was revised to:

We will initiate a regulator-industry-iwi geothermal "think-tank" to acknowledge the current planning regime and how we might optimise the proposed new legislation, replacing the Resource Management Act to support sustainable supercritical resource allocation, consenting, utilisation and system management through making submission(s) on the proposed Acts.

Revised Task Objectives

1. Confirm understanding of current planning framework and its applicability to supercritical resource use.
2. Engage externally, through a co-ordinated Think Tank of regulators (Central and Local Government), industry, Iwi and others, to understand the implications of the current planning framework for supercritical resource use.
3. Identify key regulatory optimisation approaches to support supercritical resource use and provide this through a submission on the legislation proposed to replace the Resource Management Act.
4. Achieve buy-in for a new regulatory framework for supercritical resource use from regulators.

Revised Deliverables

1. Report: Identify the existing planning framework for consenting geothermal resources.
2. Report: Identify an optimised supercritical resource planning framework through a submission on the new legislation proposed to replace the Resource Management Act

A.2 Critical Step 1.3.7

Supercritical Resource Delineation: Criteria for Resource Boundary Definition and Interconnectivity.

This CS was originally scoped to look at criteria to define the extent of supercritical reservoirs, particularly where the 'resource boundary' is ambiguous, or if deep interconnectivity is inferred (e.g. from modelling or drilling) with overlying geothermal and non-thermal aquifers. Issues impacting resource allocation and sustainable management for regulatory agencies and iwi were also in scope.

The original critical step was defined as:

1.3.7 Supercritical resource delineation: criteria for resource boundary definition and interconnectivity

We will initiate a regulator-industry-iwi geothermal "think-tank" and provide recommendations on the optimal way to utilise supercritical resources. The body will consider resource delineation, connectivity between aquifers, environmental and system management, as well as legal frameworks for supercritical resource allocation, consenting, utilisation and sustainable system management.

In early 2020 the task statement was revised to:

We will develop an approach for defining supercritical resource boundaries for planning and regulatory purposes. We will explore the interconnectivity between supercritical resources and conventional geothermal resources / surface geothermal features / groundwater resources to understand how the actual and potential effects of supercritical resource development can be understood, assessed and managed in accordance with the sustainable management imperatives of the Resource Management Act (RMA). We will also consider ideas and concepts around the allocation of rights to supercritical resource utilisation through the RMA regulatory regime including resource consents.

Revised Task Objectives

- 1. Determine how regional policy and plans can define supercritical resource boundaries.*
- 2. Develop recommendations on how the planning and regulatory framework can manage the effects of supercritical resource development on conventional geothermal resources, surface geothermal features and groundwater resources.*
- 3. Advance thinking on whether allocation approaches (through rights established by resource consents) are required for supercritical resources, and if so, what options might be available to be further developed.*

Revised Deliverables

- 1. Report: Defining supercritical resource boundaries in Regional Plans*
- 2. White paper: Supercritical Resource Interconnectivity and Sustainable Management*
- 3. White paper: Possible approaches to allocation of supercritical resource use*

The work was scheduled to use information generated from the EXPLORE theme of the GNG programme, particularly the magnetotelluric, seismic exploration and imaging supercritical resources critical steps. Useful Information from these steps was subject to quite some delay and it became evident that material would not become available in time to usefully inform the outputs from CS 1.3.7 as had been envisaged in 2020.

On the 31 August 2023 rescoping of CS 1.3.7 reset the focus to the following two task objectives:

- 1. Critical assessment of current approach to geothermal resource boundary definition in RMA plans – is it still fit for purpose? What about supercritical?*
- 2. Think piece on regulatory framework considerations for developing / utilising supercritical resources and research needs for developing an effective regulatory framework.*

In February 2024 a report was being drafted with the purpose of informing legislative change, national direction and the development of regional planning frameworks to address regulatory barriers and facilitate consenting pathways for superhot developments.

In April 2024 it became evident that there was an opportunity for broader superhot geothermal discussions with stakeholders through the GNS Science, 2nd July, *Geothermal Energy, What is our potential workshop?* organised as part Geothermal Week 2024.

Report preparation continued through 2024 with publication of Kissick et al (2024b) in November 2024 completing the CS. Kissick et al (2024c) summarised the report in a paper in the proceedings of the 2024 New Zealand Geothermal Workshop.