1. MEASURES FOR TRANSITION TO AN EXPANDED AND HIGHLY RENEWABLE ELECTRICITY SYSTEM

Part 1: Growing Renewable Generation	
1.	Are any extra measures needed to support new renewable generation during the transition? Please keep in mind existing investment incentives through the energy-only market and the ETS, and also available risk management products. Any new measures should add to (and not undermine or distort) investment that could occur without the measures.
	An additional measure MBIE should consider with respect to geothermal exploration and development is a risk guarantee scheme. The French government run incentive and insurance scheme was based on a risk guarantee, drilling projects received 30% subsidy towards their project and the remaining 70% was provided as a loan. If a project was unsuccessful, developers were only accountable for 10% of their loan. The scheme is self-sufficient because successful drilling projects loan repayments paid for any drilling failures the government encountered (Boissavy, 2017). Thanks to the very low rate of failure in well-resourced regions (like the Paris Basin), wells entailing higher risks can be drilled in regions where little exploration has been conducted (Bezelgues-Courtade and Jaudin, 2008). The scheme has since evolved but the principles have been applied in many other European countries, with the model being so successful in some cases that private insurance have replicated the scheme. Risk mitigation schemes and insurance programmes is one of the main policy instruments designed to attract investment to and facilitate the development of the geothermal direct-use projects, no such schemes exist in New Zealand and if included with heat tariffs or subsidy mechanisms, accelerated uptake in primary industries could be expected. The French geothermal risk guarantee scheme is an established, successful model for dealing with risk associated with investing in geothermal. It has been adopted by the Dutch for horticulture and other sectors, by other countries in Europe, and is one of the recommended priority actions in the International Renewable Energy Agency (IRENA)'s 'Powering agri-food value chains with geothermal heat. A guidebook for policymakers' (IRENA, 2022). The scheme has existed since the 1970s and was developed to address the geothermal risk quandary, that being a successful drilling project depends on the properties of the geothermal resource, but these are only known at the end of drilling work. Traditional insurance policies do not offer any specific solutions for this type of risk, and with no insurance for large capex projects, financial organisations are unlikely to invest (Bezelgues-Courtade and Jaudin, 2008). Bezelgues-Courtage and Jaudin (2008) The French geothermal risk guarantee system. tagungsband.geofund.pmd (geothermal-energy.org) Boissavy (2017) The successful geothermal risk mitigation system in France from 1980 to 2015 - Eurogeologists

	IRENA (2022) - [Powering agri-food value chains with geothermal heat: A guidebook for policy makers (irena.org)]()
5.	Are any measures needed to support storage (such as battery energy storage systems or BESS) during the transition? If yes, what types of measures do you think should be considered and why?
	GNS Science has conducted analysis exploring the social issues in relation to subsurface energy storage in New Zealand. Findings suggest: • There are several overarching policy drivers supporting action around large-scale energy storage options in the country and policy action around addressing intermittency issues in relation to renewable energy sources that are intended to replace fossil fuel reliance. However, subsurface energy storage options are not clearly demarcated (or focused upon) within these policy drivers. • Current regulatory and consenting norms for subsurface operations operate under a process that was designed to address the discharge of contaminants into the environment. Analysts also point to other factors that make the current regulatory framework ill-suited to address the complexities, long-term uncertainties and long-term monitoring and oversight challenges that are likely to be relevant to subsurface energy storage options. Electrothermal batteries suffer from a limited lifespan and high environmental impact due to extensive need of rare elements and high capex cost when upscaled to large numbers. New types of electrothermal batteries (excluding lithum) are being developed that use more abundant elements (iron, zinc, vanaduim) and should be prioritised. (Rendell 2022). Rendell, 2022/14. Energy Storage and Technical Review, pg. 3
Part 2: Competitive Markets	
19.	Aside from increased market concentration of flexible generation, what other competition issues should be considered and why?
	GNS Science recommends a trusted body completes a review of international models, they are scrutinized and their applicability to New Zealand is evaluated.
25.	What extra measures around electricity market competition, if any, do you think the government should explore or develop?
	Prioritisation of wind, solar and geothermal development including low temperature and hotter resources is essential.
Part 3: Networks for the Future	
27.	Do you consider that the balance of risks between investing too late and too early in electricity transmission may have changed, compared to historically? If so, why?
	Infrastructure is exposed to multiple natural and climate induced hazards in New Zealand, so the balance we must strike is making investment decisions based on the best available science. Transpower should engage with GNS Science and other Crown Research Institute’s on natural hazard information, including increasing of

	weather event frequency and intensity from climate change, to build resilience into investment in future infrastructure investment.
28.	Are there any additional actions needed to ensure enough focus and investment on maintaining a resilient national grid?
	GNS Science recommends continuing investment in: • Building collaborative linkages with research and development across the earth sciences, engineering, and materials disciplines to build knowledge base, and data and tools to make informed decisions. • Understanding the impacts of natural hazard events on the national grid including socio-economic loss modelling, refined hazard modelling, multi-hazard risk modelling, combined with the impacts of ground subsidence. • Extreme weather and natural hazard event analysis GNS Science has proven record of hazard and risk modelling capability for infrastructure; refined hazard modelling; exposure; vulnerability work with infrastructure providers & society; probabilistic risk (e.g., Riskscape tool); and socio-economic modelling. GNS Science can support this work by providing further understandings of risks and opportunities within building a resilient national electricity grid. GNS Science has conducted analysis exploring the social issues in relation to subsurface energy storage in New Zealand. There are several overarching policy drivers supporting action around large-scale energy storage options in the country (for example the New Zealand Battery Project) and policy action around addressing intermittency issues in relation to renewable energy sources that are intended to replace fossil fuel reliance. However, subsurface energy storage options are not clearly demarcated (or focused upon) within these policy drivers currently.
32.	Are there other regulatory or practical barriers to efficient network investment by electricity distributors that should be thought about for the future?
	The recently proposed National Policy Statement for Renewable Energy Generation (NPS-REG) appears to favour wind and solar electricity generation over geothermal. However, to achieve the stated objectives of the NPS-REG and achieve policies relating to recognising the national significance of REG activities, the significant potential future contribution of geothermal to electricity generation in New Zealand needs to be included.
Part 4: Responsive Demand and Smarter Systems	
45.	Would government setting out the future structure of a common digital energy infrastructure (to allow trading of distributed flexibility) support co-ordinated action to increase use of distributed flexibility?
	Yes, any Government signals for trading of distributed energy are welcomed as it will increase investment.
47.	Aside from work already underway, are there other areas where government should support collaboration to help grow and develop flexibility markets and improve outcomes? If yes, what areas and actions are a priority?
	Exploration for deeper and more extensive geothermal resources could be favoured. As demonstrated in Castalia report 2023 regarding the economic opportunity in renewable electricity generation from supercritical in New Zealand,

	this geothermal energy resource could potentially generate 30 GWh of energy annually. Until now, government agencies have not included the potential benefits of supercritical geothermal electricity generation or other energy use in their policy analysis and advice. National collaborative effort is essential to grow this resource and limit individual industry risk. Collaborative approach could support the development of geothermal direct use. As an example, in the Netherlands this type of system is one of the reasons that they have had an increase investment into geothermal direct use, especially in the covered crop horticulture sector. Castelia, 2023. Supercritical Geothermal in New Zealand: Economic opportunity in renewable electricity generation and for off-grid energy. 43 p.
48.	Could co-funding for procurement of non-network services help address barriers to uptake of non-network solutions (NNS) by electricity distributors?
	GNS Science recommends facilitating the development of distributed decentralised energy solution via thermal network systems and utilisation of ground source geothermal heat pump. In response to global demands towards electrification, high-temperature heat pump technology, tailored for industrial applications, is progressing at an accelerated pace. Although the initial capital outlay remains relatively high, ongoing technological innovations indicate a trajectory towards greater cost competitiveness, alongside advancements that are poised to enable even higher industrial process temperatures in the near future.
Part 5: Whole-of-system considerations	
57.	What measures do you consider the government should prioritise to support the transition?
	Continue Government Investment in Decarbonising Industry (GIDI) Fund and the transition of high abatement industry, however, GIDI seems to be valued by government dollar spend vs carbon abatement outcome, which is arguably narrow. Energy Efficiency and Conservation Authority's Regional Energy Transition Accelerator project is starting to consider regional coordination, so learnings from this work hopefully feed into revised versions of GIDI.
58.	Are there gaps in terms of information co-ordination or direction for decision-making as we transition towards an expanded and more highly renewable electricity system and meeting our emissions goals? Please provide examples of what you'd like to see in this area.
	Distributed geothermal resources Recently completed analysis by GNS Science for Energy Efficiency and Conservation Authority's Regional Energy Transition Accelerator (RETA) in the Bay of Plenty highlights the efficiency of ground source heat pump (GSHP) technology in comparison to air source heat pump (ASHP), especially GSHP accessing geothermally enhanced groundwater (between 20-45°C). The GNS Science analysis includes a case study for a hospital and industrial facility and demonstrates the opportunity that thermal/ground source energy can play in New Zealand's decarbonisation pathway. The report will be made public at the end of this year, but GNS Science would welcome an opportunity to discuss the report with MBIE earlier if interested.

Deep drilling for geothermal resources represents a substantial capital investment, and the inherent risks associated with drilling for resource stand as an obstacle to direct use. This is not unique to New Zealand; numerous European nations have successfully embraced an insurance scheme to address the risks linked to drilling operations. This scheme has directly contributed to the growth of geothermal direct use investments, and adopting an almost identical scheme in New Zealand holds significant promise.

Obtaining consent for a high-temperature installation constitutes a substantial investment, both in terms of time and financial resources. The process of obtaining consent for such installations is intricate and can vary between regional authorities, each bearing unique associated risks. Proactive and early engagement with iwi is strongly encouraged. Māori-owned development of high-temperature resources has proven to be a successful and sustainable model, and it is advisable for local and national governments to provide support for such initiatives.

In contrast, GSHP and low-temperature geothermal projects, while not exempt from due process, do not encounter the same complexities in the consenting phase. That being said, it is not a straightforward process and discrepancies in process and outcome exist between regional authorities. Crucially, the potential for these technologies extends nationwide. Therefore, it is recommended that national guidance on the opportunity and potential consenting process that include best practices for subsurface and groundwater management be established to facilitate and standardize the development of these technologies.

Critical Minerals

The role of critical minerals in our transition needs greater consideration in the overall direction of New Zealand's low carbon transition. Minerals are increasingly being used for low-emissions, renewable energy technologies such as solar, wind and batteries, as part of a global clean-energy transition to combat climate change (International Energy Authority 2021). Meeting New Zealand's 2050 Net Zero Carbon target relies on significant increases in the use of clean-tech energy such as wind, solar and batteries. New Zealand will be reliant on the supply of these technologies from other countries.

The role of critical minerals will become more important as New Zealand transitions to a low emission future. The government should continue to support further research into the complexities associated with meeting critical minerals demand, societal attitudes and values.

As for fossil fuels, New Zealand is dependent on international markets for renewable generation that employs critical minerals (e.g. for solar and wind). As international demand grows, New Zealand will have less security in supply. Ongoing research into our own sources of critical minerals and renewable generation less dependent on critical minerals (such as geothermal) should be supported.

International Energy Agency [IEA] (2021). The Role of Critical Minerals in Clean Energy Transitions. The Role of Critical Minerals in Clean Energy Transitions (windows.net)

General Comments:

Aquifer Thermal Energy Storage (ATES) has largely been overlooked in the future of New Zealand's energy mix. ATES seeks to provide cooling in summer and heating in winter by using an aquifer to hold cool or warm water, respectively. ATES is a new concept, and a new technology, for most New Zealanders, and will requires social, environmental and economic impact research to support its uptake. GNS Science does not advocate that aquifer energy is a silver bullet for New Zealand's energy future, instead it is highlighting that it is currently overlooked and should be a feature of our future energy mix, thus adding to the variety of investment options the market currently has. An energy eco-system that integrates aquifer heat is an opportunity for Aotearoa, New Zealand to enhance its sustainable future.

Supercritical geothermal

There is much more that geothermal resources can contribute to New Zealand's renewable energy and carbon goals, with further exploration and development of existing resources and the potential for deeper superhot supercritical resources, particularly within the Taupō Volcanic Zone.

Research from GNS Science led Geothermal: The Next Generation research programme suggests that the electricity generation from geothermal energy use can more than double our national electricity generation by accessing deeper superhot / supercritical resources. Direct heat use applications can also be increased. (Castallia 2023).

Castelia, 2023. Supercritical Geothermal in New Zealand: Economic opportunity in renewable electricity generation and for off-grid energy. 43 p.