

## **Geothermal energy, decarbonisation and the just transition: developments in governance and regulation**

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### **ABSTRACT**

This review article pursues this special issue's theme of renewable energy and just transition into the field of geothermal energy, an energy source which has a special role in Aotearoa New Zealand, and which raises clear questions of justice in the energy transition. It evaluates the track record, and examines the legal, regulatory and institutional challenges and opportunities for a just transition for geothermal in New Zealand. It particularly considers the role of Māori, and the challenges presented by emerging technological change. It considers the problems of renewability and sustainability that are special to geothermal resources. It evaluates the just transition issues that have particularly affected Māori landowners and holders of mana whenua. It finds that what constitutes a just transition must be seen against a longer historical time frame than many observers might assume. It shows that the distinctive regulatory framework for geothermal has been considerably affected by addressing these problems but may need to adapt further in the future. It considers the technical features that have shaped geothermal regulation and are likely to shape it in the future as new technological options emerge.

Keywords: geothermal resources; indigenous; Māori; sustainability; renewability; decarbonisation; Resource Management Act 1991; regulation; law; governance.

### **The special place of geothermal energy in Aotearoa New Zealand**

Geothermal energy is an essential part of any discussion of renewable energy and enabling a just transition in Aotearoa New Zealand. Geothermal resources have a special role in the country, a role that raises clear questions of justice in the energy transition. Our objective in this article is to examine the track record and to consider the legal, regulatory and governance challenges and opportunities for a just transition in the use of New Zealand's geothermal resources, having regard particularly to the role of Māori and the pressures of technical change. We evaluate the just transition issues that have

particularly affected Māori landowners and others who hold mana whenua. What constitutes a just transition must be seen against a longer historical time frame than many observers might assume. We then consider problems of renewability and sustainability that are special to geothermal resources and require careful resource management for the long term. The regulatory framework for geothermal resources has been considerably affected by addressing these problems but may need to adapt further in the future. The key institutions in regulation and governance are the regional councils, mainly Waikato Regional Council (WRC) and Bay of Plenty Regional Council (BOPRC). This review article helps fill a gap in the literature about the regulation of geothermal resources (Parson 2022) under the Resource Management Act 1991 (the RMA) (NZ Govt 1991a).

We identify new technology options that affect geothermal resource management or may do so in the future. We conclude by discussing future research possibilities and future challenges arising from changing law and policy.

### ***The physical context***

Geothermal energy comes from within the earth. In tectonically active places such as New Zealand, geothermal resources are found in greater abundance than elsewhere. Large, high-temperature geothermal systems producing fluid greater than 100 °C at the surface are found only in Northland Region and in the Taupō Volcanic Zone (TVZ), a narrow zone extending from Mount Ruapehu (Waikato Region) to Whakaari-White Island (Bay of Plenty Region). Smaller, isolated sets of warm (30 to 100 °C) springs are scattered throughout most parts of the country. Depending on the temperature and pressure in the subsurface, geothermal fluid can be found in the phases of water, steam, or supercritical fluid. Geothermal surface features include geysers, fumaroles, sinter-forming springs, mud pools, warm springs, geothermal lakes, hydrothermal eruption craters, spectacular crystal formations, and unique geothermal ecosystems with specially adapted plants, invertebrates, and microorganisms.

Key to most large-scale geothermal energy development projects is a *geothermal system*,<sup>1</sup> an individual body of geothermal water not hydrologically connected to any other in the upper few kilometres of the Earth's crust (Waikato Regional Council 2011). Generally, to utilise geothermal energy, three things are needed in a geothermal system: 1) a near-surface body of hot rock; 2) permeability within the rock matrix to enable water circulation in one or more interconnected aquifers, which together make up a geothermal *reservoir*; and 3) enough water to bring the heat energy to the surface, where it can be either used directly or converted to electricity. A geothermal *system* may have one or more interconnected *fields* of separate geothermal upflow and surface expression.

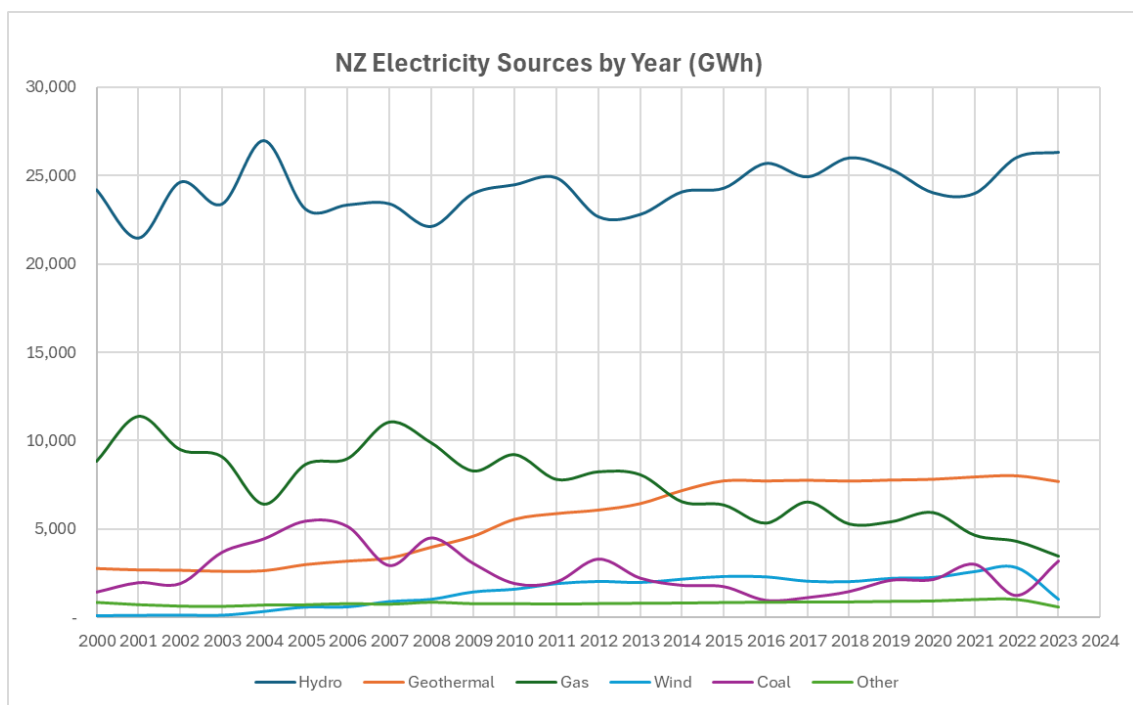
Lower-temperature geothermal springs generally rise through faults that transport upwellings of water from greater depths to the surface. As discussed below in ***Regional council governance under the RMA***, regional regulation of geothermal resources classifies different types of geothermal systems into different usage categories, where some geothermal systems are protected from extractive uses to preserve rare, vulnerable and valued surface features and their dependant ecosystems, some may be utilised for energy developments, and others developed to an extent that does adversely affect surface features (Bay of Plenty Regional Council 2008, 2014, Waikato Regional Council 2011, 2016).

## Energy contribution

A key advantage of geothermal energy is that it provides consistent baseload energy. Geothermal power stations have the highest output capacity factor (the percent of time that generation occurs in a year) of all electricity producers in New Zealand, running 95% of the time, with output usually only ceasing for annual maintenance. In contrast, hydropower runs at 50%, wind at 40% and solar at 20% (Concept Consulting 2024). Since 1998 the total installed capacity of geothermal power stations has risen sharply from 263 MWe (Montague et al. 2024) to 1281 MWe (Transpower 2024), with twenty developments and extensions occurring on seven high-temperature geothermal systems. A further 208 MWe is planned or under construction (Montague et al. 2024).

Based on New Zealand's latest figures, electricity generated in 2023 consisted of hydroelectric (62%), geothermal (18%), gas (8%), coal (8%), wind (2%), and other (including solar and biomass) (1%) (See Figure 1) (MBIE 2024). The mix varies because hydro contributes less when the weather is dry. The mix is expected to transition away from fossil fuels to meet zero carbon emissions by 2050 (NZ Govt 2002, Ministry for the Environment 2022) with an increase in geothermal, wind, and solar, with many such generation facilities being planned, consented or built (Transpower 2020). Since 2005, there has been an increasing trend of renewable generation (mostly geothermal and wind) and a corresponding decreasing trend in fossil fuel generation (particularly natural gas and coal).

Today, New Zealand is the fifth largest geothermal energy producer in the world after the USA, Indonesia, Philippines, and Turkey (Cariaga 2024).



**Figure 1:** Sources of NZ Electricity Production (data from MBIE 2024). NB to editors: This figure and its data are available in an Excel spreadsheet.

### **Other energy values**

As well as for electricity generation geothermal energy can be used for direct heat applications; it accounts for 1.4% of the country's total primary and industrial direct heat applications (MBIE 2024). Most of this is utilised at several Kawerau paper mills (Laurent and Doorman 2021). Other direct uses include wood processing, flower and vegetable growing, prawn farming, milk drying, extraction of commercial-grade silica, and hydrogen fuel generation (Montague et al. 2024).

Geothermal bathing and nature experiences have long played a significant role in New Zealand's tourism industry, with the towns of Rotorua, Taupō and Te Aroha originally built for geothermal tourism and bathing (White and Chambeft 2016). Today, although geothermal tourism contributes less to Gross Regional Product than geothermal electricity generation (\$74 million versus \$106 million) it employs ten times more people and caters to ca. 16% of domestic tourists, and the international tourist trade (Luketina et al. 2017).

While energy security continues to occupy government attention, now concerns include climate mitigation and adaptation (NZ Govt 2000, 2002, 2004, 2008a, 2019) and increasing emphasis to ensure society's just transition to a zero-carbon energy future (Ministry for the Environment 2022, MBIE 2020, 2022).

### **Justice in the just transition**

For geothermal energy, the just transition concept directs attention to how its benefits are distributed through society, and to the avoidance of adverse effects it may have on communities, and indigenous communities in particular. Just transition thinking had its origins in the advocacy of labour unions in the coal and petroleum sectors, to protect workers while not impeding environmental action, but it broadens out to connect to environmental justice, climate justice and energy justice (del Guayo et al. 2020). Pathways for a just transition, or multiple transitions, have been an important part of international climate change negotiations (International Institute for Sustainable Development 2023). The concept of the just transition calls for equity in the distribution of the costs and benefits of the transition to a low emissions or net zero future; while there will be many benefits in the economic and societal shifts entailed, they may not accrue to all groups of people, whether nationally or internationally, and there are many costs and risks that may fall on particular sectors or marginalised communities (Wang and Lo 2021). The free-market environmentalism that New Zealand has relied on in recent decades is an increasingly unconvincing solution to a just transition. For example, the wide dispersal of the shareholding of Mercury (and Contact Energy), the country's largest geothermal electricity producers, means that most of the profit from geothermal electricity generation goes outside the TVZ regions where it is produced.

The status quo for managing access to geothermal resource data by regulators under the RMA and Local Government Official Information and Meetings Act 1987 (NZ Govt 1987b) has also been questioned for favouring commercial interests to the detriment of public and tāngata whenua (Māori who have a particular guardianship role over an area or resource) interests (Boast 1989, Waikato Regional Council 1992, Parson 2022). The government's ability to charge royalties for the use of geothermal energy, a provision that lies dormant in the RMA and associated regulations, also warrants attention as an avenue

to provide energy justice (Ministry of Economic Development 1989, Ministry for the Environment 1992, Malafeh and Sharp 2015).

Many energy-related activities affect the self-determination of Māori (MacArthur and Stephenson 2022, Taute et al. 2023) and their relationship with the wider aspects and uses of resources. This is of special and ongoing significance given the constitutional relationship between the Crown and Māori.

### ***Geothermal energy development history and Māori***

This section summarises the effect of historical government actions and policies on the rights and interests of Māori in geothermal resources. It shows that despite the country's world-leading status in geothermal energy development, historical development occurred at a cost to Māori who have struggled to maintain rights to manage and control their geothermal resources. While today there are success stories of Māori involvement in geothermal energy development, in part due to localised Treaty Settlements, nationally outstanding geothermal claims by Māori remain to be resolved (NZ Govt Waitangi Tribunal 2012, 2024).

Geothermal resources are regarded by Māori as taonga (treasures) and are among the resources the Crown guaranteed to protect in The Treaty of Waitangi Te Tiriti o Waitangi (1840) (NZ Govt 1975). From the start of Aotearoa's human habitation, Māori have coexisted with and used geothermal water, steam, minerals, mud and hydrothermal activity for practical, economic and spiritual purposes. Place-based mātauranga (Māori knowledge) and tikanga (customary law) govern tāngata whenua interactions with their geothermal resources (Tutua-Nathan 1992, Boast 1989, Stokes 2000).

However, in breach of Te Tiriti, the New Zealand Wars (1845–1872) (Belich 1988) and Native Lands Act 1865 (NZ Govt 1865) systematically dispossessed Māori of large areas of land and geothermal resources. The Crown also conferred on itself a statutory monopoly over Māori land acquisition in Thermal Springs districts under the Thermal Springs Districts Act 1881 (NZ Govt 1881, Boast 1989, 1995; Severne et al. 2020). Many geothermal springs were given English names, erasing their historical significance. Later, when the energy-generating value of geothermal resources was realised, a new phase of legislative control over geothermal resources occurred with the Geothermal Energy Act 1953 (NZ Govt 1953). Here the Crown assumed exclusive rights to use geothermal energy. Geothermal energy areas were proclaimed, where the Crown took land (by various means) to access the resource for development (Boast 1995).

Between 1926 and 1930 geothermal surveys of the TVZ were spurred by a rapidly increasing national demand for electricity. In the 1950s much of the Wairākei area (Waikato Region) was acquired by the Crown for New Zealand's first geothermal power station, commissioned in 1959. Thus, New Zealand became the second nation worldwide to harness geothermal energy for electricity generation, after Italy (White and Chambefort 2016).

A dry year restricting hydroelectricity generation in 1972, followed by the global oil crisis, led to a 1974 Government policy of developing national resources. The Crown's land acquisition and Crown-developed geothermal resources for energy developments from the 1950s to mid-1980s, at Kawerau (Bay of Plenty), Wairakei and Ōhaaki (Waikato Region), all had detrimental effects on tāngata whenua, and many irreversible adverse environmental effects (Keam 1965). In Kawerau, Ngāti Tūwharetoa ki Kawerau, who had settled there to take advantage of the geothermal springs, suffered deprivation of much of their land by various means from the time of the Land Wars onwards. In the 1950s the

town of Kawerau was built on land acquired from tāngata whenua under threat of compulsory acquisition through the Public Works Act 1928 to develop a geothermal industry processing timber into various products (NZ Govt 1928, Adlam and King 2015, White and Chambeft 2016). Geothermal steam supply to the Kawerau mills producing newsprint, wood pulp and sawn timber started in 1957 and electricity production started in 1966 (Martin 1991). Tāngata whenua were not consulted or involved in the Kawerau development (NZ Govt 2005).

By the 1990s, at Wairākei and the connected Tauhara geothermal field all geysers and sinter-depositing springs were extinct, and many other geothermal features adversely affected, mainly as result of extraction by Wairākei power station. Local hapū (subtribes of Ngāti Tūwharetoa) lost not only access to their traditional uses and customs but also the ability to exercise their kaitiakitanga (guardianship) over these taonga (Cody et al. 2021).

Following Ngāti Tahu's forced eviction from the Ōrākeikōrako geothermal area and their adjacent marae (meeting place) in 1960 by the Crown for the construction of the hydro-electric lake Ohakuri (Lloyd 1972), they resettled on their land at Ōhaaki. The Ōhaaki ngāwhā, a large boiling pool close to their marae, was used for cooking and its outflow channelled for bathing. However, in 1982 the Crown, wishing to build a geothermal power station, forced a lease agreement upon Te Ōhaaki Marae and Ngawha Trust (Stokes 2004). The agreement contained provisions intended to protect the marae hot springs, urupā (burial grounds), and other significant sites from adverse effects of the operation of the power station. Despite this, and as a result of changes in the reservoir due to the operation of the power station, the Ōhaaki ngāwhā stopped flowing in 1989 and is now fed artificially by bore water (Glover et al. 1996). Other adverse environmental effects in the area included inundation of low-lying land and infrastructure (Nishar et al. 2021).

In Rotorua (Bay of Plenty Region), increasing use for bathing and domestic heating partially depleted the geothermal aquifer. Between 1969 and 1985 the number of boiling springs at Whakarewarewa, where most tourist activities were concentrated, dropped from 63 to 38, leading in 1987 to a forced closure of all bores within a 1.5 km radius of Pōhutu Geyser. Resource royalties were imposed by central government until the early 1990s for wells outside that radius, which led to a reduction in use and some voluntary well closures (Ministry for the Environment 1992, Bay of Plenty Regional Council 1999).

In 1987 the state's near-monopoly on producing electricity ended, and the Electricity Corporation of New Zealand was established as a state-owned enterprise (Barton 1998). Further loosening of the electricity market, including privatisation of some assets, and the development of new power companies, ensued. Geothermal energy operators now include a mix of publicly listed companies, Māori entities, and partnerships between Māori and other companies (Climo et al. 2022).

### ***Māori and geothermal energy development today***

With the advent of the Waitangi Tribunal to hear claims by Māori against the Crown in breach of Te Tiriti (NZ Govt 1975), some claims concerning geothermal resources have resulted in Treaty Settlements with settlement legislation describing these and the return of geothermal resources for some claimants (NZ Govt 2005, 2006, 2008b, 2014, 2018).

The Waitangi Tribunal has consistently reported that the Crown's legislation for geothermal resources, including the RMA, is in breach of Te Tiriti. In 2012[1] the Crown acknowledged that Māori have rights and interests in geothermal resources (and

freshwater), however the Crown has not comprehensively acknowledged their extent in respect to all geothermal resources nationally. The contemporary Treaty claim on the national geothermal resource, *The National Fresh Water and Geothermal Resource Inquiry* (Waitangi Tribunal, Wai 2358 Stage 3, geothermal resources) is enquiring into to what extent the current regulatory framework is consistent with the principles of Te Tiriti. The Tribunal's report (forthcoming) will provide an opportunity for the Crown to comprehensively address Māori rights and interests in geothermal resources.

Commercial geothermal utilisation by Māori as indigenous people is world leading and Māori resource management experience is shared internationally with indigenous peoples (Bargh 2012, MacArthur and Matthewman 2018). Today many Māori iwi (tribe) and hapū (sub-tribe) play a leading role in geothermal energy developments (Climo et al. 2022), some assisted by settled claims and private joint-venture partnerships, and others independently. For example, the Tūaropaki Power Station at Mōkai (Waikato Region) was developed independently by the collective Māori landowners of the Tūaropaki Trust, with Mercury Energy (then known as Mighty River Power) initially engaged to run the facility, eventually becoming a minority stakeholder in the Tūaropaki Power Company.

The Rotokawa, Ngā Awa Purua and Ngā Tamariki geothermal power stations (Waikato Region) are all joint ventures between Mercury Energy and tāngata whenua (Climo et al. 2022). Following a Treaty Settlement, Ngāti Tūwharetoa ki Kawerau gained ownership of the Crown's Kawerau geothermal interests and assets, and Ngāti Tūwharetoa Geothermal Assets (NTGA) was formed. This led NTGA to a complex but mutually beneficial cooperation agreement between Pūtauaki Trust, Treasury, Mercury, and Norske Skog, who had acquired the Tasman mill. NTGA is now one of the world's largest suppliers of geothermal heat for industrial processes (Adlam and King 2015).

Today, the role of Māori in geothermal energy developments is not simply the result of handouts or transfers of power stations; it has been prudent use by Māori of their own lands and resources, especially as landowners where geothermal systems exist. This is increasingly coupled with recognition by businesses that they need Māori support (indeed, participation) to continue to operate under the legal, regulatory and governance framework of the RMA and post-Settlement landscape.

## **The legal, regulatory and governance framework for geothermal energy**

New Zealand's open energy market economy and decentralised environmental regulatory regime provide an interesting contrast to the political situation in other countries. The RMA allocates geothermal energy and geothermal water resources, manages the effects of activities on the environment<sup>2</sup> and the sustainable management of resources. Matters of national importance, including "the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga" must be recognised and provided for, within an overarching requirement for decision-makers to take into account Te Tiriti principles (section 8) By international standards, policymaking and governance for geothermal resources are strikingly concentrated in the hands of regional government, and the national or central government only plays a minor policy or regulatory role.

Central government has a light-handed role in energy policy, leaving key decisions to businesses and market forces. For example, a recent policy initiative 'Electrify NZ' aiming to double electricity production is mainly directed at faster environmental

permitting (Bishop and Brown 2024). New power stations do not require approval by an energy regulator, and there is no preference or subsidy for renewable energy. Climate change policy is strongly reliant on price signals generated by the New Zealand Emissions Trading Scheme, and there are few other climate change policies in place, none aimed at geothermal. In lawmaking, Parliament plays a larger role, putting high-level governance settings in place; statutes such as the Treaty of Waitangi Act 1975, the RMA and related ‘national direction’ instruments, and Treaty Settlement legislation, are particularly important in geothermal matters. Changing political direction after the 2023 general election is also relevant and presents some possible challenges, considered below.

### ***Regional council governance under the RMA***

The regional councils’ governance of the resource is subject to the legal directions in the RMA to pursue the purpose of sustainable management (section 5), and to recognise and provide for outstanding natural features (section 6). They must also have particular regard to the efficient use and development of natural and physical resources, any finite characteristics of resources, and the benefits to be derived from the use and development of renewable energy (section 7). The councils’ choices of policy objectives must meet RMA requirements. Policy objectives to sustainably manage the regional geothermal resource are stated in integrated management and classification of geothermal system types (Waikato Regional Policy Statement 2016, Bay of Plenty Regional Natural Resources Plan 2008). To ensure that the resource is managed sustainably, regional policy provides for a range of uses including energy extraction, low impact use, research and protection. For example, WRC’s policy documents set out objectives, policies and rules for each of Development, Limited Development, Research, Protected and Small Geothermal Systems (Waikato Regional Council 2011, 2016). BOPRC has a broadly similar regime, adapted to apply to the region’s unique geothermal resource (Bay of Plenty Regional Natural Resources Plan 2008).

RMA national direction for geothermal resources occurs in two National Policy Statements (NPS): The NPS for Renewable Electricity Generation (2011) and the NPS for Indigenous Biodiversity (2023). Nonetheless, it has been regional rather than central government that has led geothermal policy development; in particular, WRC and BOPRC (Parson 2022).

RMA section 5 is particularly relevant to geothermal energy; it calls for the managing of resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while sustaining the potential of resources to meet the reasonably foreseeable needs of future generations, safeguarding the life-supporting capacity of air, water, soil, and ecosystems, and avoiding, remedying, or mitigating adverse effects on the environment. The Act identifies a number of matters that councils must provide for or take into account; several that relate to Māori and sustainable management are discussed shortly.

Due to the importance of geothermal resources to the Waikato Region (it embraces approximately 70 per cent of the national geothermal resource) its Regional Policy Statement (RPS) and Plan both contain chapters dedicated to geothermal resource management (Waikato Regional Council 2011, 2016). The Bay of Plenty RPS applies to a further 20 per cent of the national resource and similarly contains dedicated sections for geothermal resource management. Also in force are the Regional Natural Resources Plan, and a separate Rotorua Geothermal Regional Plan (currently under review) (Bay of Plenty Regional Council 1999, 2008, 2014, 2023). As required by their RPSs, the Kawerau and

Rotorua geothermal systems have management plans (Bay of Plenty Regional Council 2018, 2023), as do all the developed large geothermal systems in the Waikato Region (Waikato Regional Council 2011 and 2016; Doorman and McLeod 2018).

Through regional plans, the take, use and discharge of geothermal water and geothermal energy usually require the granting of a resource consent. Exceptions apply, including for reasonable domestic needs and use in accordance with tikanga Māori (section 14). (Geothermal resources on public conservation lands and reserves are managed by the Department of Conservation (NZ Govt., Conservation Act 1987a, Reserves Act 1977).)

A resource consent application to develop the resource must include an assessment of environmental effects and comply with relevant policy and plan rules (RMA sections 88, 104 and schedule 4). Preparation of a resource consent application for a large geothermal energy project also requires a thorough project description and a draft geothermal system management (or operational) plan. The processing time of geothermal resource consents for an energy project by regional councils is short by international standards and can be completed within 4 to 12 months. Potential adverse environmental effects of geothermal energy development include, but are not limited to, premature depletion of a geothermal energy source, land subsidence, depletion or extinction of geothermal surface features, and contamination of fresh ground or surface water by discharged geothermal water.

Resource consents for most geothermal projects are issued for 25 to 35 years, the latter being the maximum duration allowed under the RMA. This gives a developer greater certainty of long-term operation, for a return on capital investment, and a useful timeframe for resource monitoring data to be accumulated to assess long-term environmental effects.

The Waikato and Bay of Plenty approaches to managing geothermal resources and regulating geothermal energy developments are similar, due to a concerted effort between the Councils to integrate cross-boundary geothermal resource management policy and technical monitoring of resource consents (Doorman et al. 2021, Parson 2022).

### ***Renewability and sustainability***

The rate of large-scale geothermal fluid extraction from a geothermal aquifer is far greater than natural recharge and without reinjection leads to depletion of the reservoir fluid. Additionally, with or without reinjection, the heat content of the reservoir is depleted over decades, with natural heat recharge by conduction from below being much slower (Luketina 2012). Pre-RMA, at Ōhaaki (Waikato Region), early geothermal electricity production fell from an initial 108 megawatts of electricity (MWe) to the current 53 MWe due to sub-optimal reservoir and system management. Other adverse effects included subsidence (and subsequent inundation of land by the Waikato River) and the extinction of geothermal springs (Bromley et al. 1993).

Since the enactment of the RMA in 1991, regional councils are obliged to give effect to the RMA's purpose and principles with respect to sustainable management, noted above and which we discuss now.

*Renewability* is a characteristic of an energy source, and each source has its own timeframe for renewability. For solar, this is diurnal, and the sun is not affected by the amount of energy we convert to electricity. In contrast, for a geothermal system that has been depleted by large-scale industrial extraction, the timeframe for recovery is more like tens or hundreds of years (O'Sullivan and Mannington 2005, Axelsson 2010). Thus, although geothermal energy is considered renewable, and defined as such in the RMA,

the amount of energy accessible using current technology is finite. Furthermore, while depletable in human timeframes, geothermal systems themselves are also ephemeral on a geological timeframe, lasting on average hundreds of thousands of years before the heat pulse that created them dissipates (Kissling et al. 2023).

In contrast to renewability, *sustainability* is a characteristic of how a resource is managed and used. It relates to the effects of use on not only the resource itself but on the wider environment and society. Sustainable management and use of a geothermal energy source can be undertaken in a way that minimises energy depletion and adverse environmental effects and maximises efficient use. From the time of European colonisation to the enactment of the RMA, significant degradation of the geothermal resource occurred because of geothermal exploitation and hydro-electricity developments that adversely affected adjacent geothermal fields through inundation or other hydrological effects, and to a lesser extent because of surface activities such as farming, forestry and urbanisation (Keam 1982, Luketina 2012). On a system- and region-wide scale, sustainability is enhanced by the classification of some geothermal systems for protection, research and low impact uses.

As it is difficult to make predictions about system dynamics and sustainability prior to development, initial resource consents allocate geothermal water conservatively. Once a new power station is operating, much can be learned about the nature of the geothermal resource through its response to the take and reinjection of geothermal water/fluid. Then, in stepped production, larger consents can be granted more confidently, providing certainty for a resource developer, the regional council as regulator, and for the wider community. This avoids expensive overshoot and adverse or irreversible environmental effects (Bay of Plenty Regional Council 2008, 2014, Waikato Regional Council 2011, 2016).

### ***Geothermal governance and Māori***

Regional councils' governance of the geothermal resource must conform to RMA part 2. Broadly, decision makers must take into account Tiriti principles (section 8); and, in particular, recognise and provide for the relationship of Māori and their culture and traditions with their ancestral lands, waters, waahi tapu, and other taonga (section 6). Though more particular, the latter is a generally phrased requirement that is often difficult for regional councils to apply, but which has a cogent message in relation to geothermal resource management.

Both WRC and BOPRC have in their Regional Policy Statements and Regional Plans, objectives, policies, rules and other implementation methods that acknowledge mana whenua (territorial rights) and provide for their kaitiaki (guardian) role in managing the geothermal resource (Environment Court 2018[2], (Waikato Regional Council 2011, 2016, Bay of Plenty Regional Council 1999, 2008, 2014, 2023). Both councils engage Māori in regional energy planning and active protection of customary access and mauri (life force) of the resource. BOPRC is updating the Rotorua Geothermal Regional Plan (1999) in partnership with local hapū (Mutu and Doorman, 2023), and WRC intends to update its Regional Energy Strategy (Waikato Regional Energy Forum et al. 2009, Waikato Regional Council 2024) and the geothermal module of the Waikato Regional Plan (Waikato Regional Council 2008).

Treaty Settlement instruments relate specifically to geothermal resources (NZ Govt 2005, 2008b, 2010, 2012, 2014, 2016, 2018, 2021a, 2021b), and among their consequences are: the return of geothermal areas and the transfer of Crown assets (e.g.

geothermal energy infrastructure) to mana whenua; co-management arrangements for geothermal resources between mana whenua and the Department of Conservation; formation of joint committees between regional authorities and mana whenua; and RMA planning authority requirements to incorporate Statutory Acknowledgments and Statutory Areas into planning instruments and for consent authorities (and other decision makers) to have regard to them.

Geothermal policy and regulation fine-tuning and strengthened decision-making roles by Māori and the wider community in geothermal resource management are key to continued sustainable management of geothermal uses (Doorman et al. 2021).

### ***UNFC Waikato geothermal assessment***

The United Nations Framework Classification for Resources (UNFC) enables different energy projects to be assessed against each other. UNFC can be applied to all energy resources, (UNECE 2024a). Each energy project is assessed against resource characteristics and technological, social, and ecological considerations, to determine its viability. It can then be compared against other energy projects, and the output used to provide greater certainty to environmental and infrastructure planners, stakeholders and investors (UNECE 2024a).

In 2023 large geothermal resource users cooperated with the WRC to apply the UNFC assessment method to geothermal energy projects in the Region's high-temperature development geothermal systems (Jacobs 2023). The results will inform the Waikato Regional Energy Strategy 2025 (Waikato Regional Council 2024), the WRC's geothermal policy review, and its submissions on central government policies affecting geothermal resources.

As New Zealand transitions to a zero-carbon future, the UNFC is a sophisticated tool to inform energy planning (Parliamentary Commissioner for the Environment 2023), as an innovative tool to compare various offshore wind, hydro, solar, and other energy projects.

### **The challenges of new technology**

Select technological developments linked to or supporting geothermal energy developments are discussed here, particularly with respect to just transition, and corresponding potential regulatory gaps are noted.

### ***Mineral extraction from geothermal fluids***

Geothermal water contains various minerals such as silica, lithium, boron, and caesium. Boast noted historical mining of geothermal areas by both Māori and Europeans (Boast 1995). Since 2014, Geo40 Ltd has been extracting silica from geothermal water, mainly at Ōhaaki (McGrail 2021) for commercial use in a range of industrial processes. Barton (2015) assessed the law for mineral extraction from geothermal fluid and found that, although the RMA is the most relevant statute, as to water, it would be desirable to clarify what role the Crown Minerals Act 1991 (NZ Govt 1991b) might play. Waitangi Tribunal claimants in Stage 3 of *The National Fresh Water and Geothermal Inquiry* have argued that those who hold ownership or mana whenua over the land from which the geothermal water/fluid is sourced should have control over or receive benefit from this and other additional uses of taken geothermal fluid; however, mineral extraction from taken fluid

does not typically require additional resource consents beyond the existing take consent so is not subject to such legal scrutiny as would allow for this through a regional council process.

### ***Trialling of carbon capture and storage in geothermal systems***

Geothermal water contains dissolved gases including carbon dioxide and methane, which are released during use of the fluid in a power station. The Climate Change Response Act 2002 (NZ Govt 2002) requires emitters of such greenhouse gases to obtain and surrender units in the New Zealand Emissions Trading Scheme (NZ Govt 2009) for the amount emitted (McLean et al. 2020). To reduce this expense, trials are underway at several geothermal power stations to reinject the gases back into the ground, entrained in the reinjected geothermal fluid (Altar et al. 2024). Northland, Bay of Plenty, and Waikato regional councils with the help of academia and geothermal power companies are beginning to assess the environmental effects on the reservoir and on the rate of CO<sub>2</sub> discharge to the air, if any.

Carbon capture and storage (CCS) is somewhat different in requiring permanent sequestration of carbon dioxide. Research is under way to determine how fluid chemistry can be changed to ensure that carbon dioxide is permanently bound to the rock matrix in the aquifer (Altar et al. 2024). New Zealand does not have legislation in place to manage CCS but would benefit from having that option available (Barton, Jordan and Severinsen 2013, Severinsen 2017). There is a certain amount of room under the present law to proceed with CCS, with only minor alterations of legislation and policy, and new legislation would open up more substantial possibilities that could involve geothermal operations (Barton 2023). While the world in general is expected to benefit from any carbon mitigation, the specific issues for mana whenua have not been traversed in any great detail.

### ***Using timber residue and geothermal energy together***

There is potential for forestry waste such as prunings, stumps and treetops to be gathered and efficiently burned to provide direct process heat, either with or without the addition of geothermal heat. When geothermal water at 250 °C is topped up to 300 °C by burning woody material, far greater thermodynamic efficiency in an industrial process such as milk drying, or in a geothermal power station, can be obtained (Dempsey et al. 2024).

Research is under way on Geothermal Bio-energy Carbon Capture and Storage (Geo-BECCS), which involves increasing the temperature of geothermal water by burning forestry waste, generating electricity from the hot water, and collecting and reinjecting the carbon dioxide produced, to create a carbon-negative energy source. (Dempsey et al. 2024). These carbon-neutral and carbon-negative potential new uses for geothermal energy have the potential to lead to lower energy prices, reduced carbon emissions, and greater employment opportunities, particularly in high-unemployment, rural parts of the TVZ with relatively high Māori populations but also in any industrial site that uses electricity or heat. As with mineral extraction, this can largely be done under the existing regulatory regime, however, there may be changes needed to the Emissions Trading Scheme to accommodate its benefits.

### ***Geothermal resource delineation and extraction***

Technological advances in geothermal exploration, drilling and energy extraction can enable further sustainable management of the known resource and the discovery and utilisation of new resource (Luketina 2012, Bertrand et al. 2022). For example, the recent TVZ-wide magneto-telluric survey by Geological and Nuclear Sciences Ltd (GNS) has enabled a far greater understanding of the extent and nature of the geothermal resource at depths of up to 10 kilometres (Pearson-Grant et al, 2023).

### ***Supercritical geothermal resource***

Supercritical geothermal fluid is water substance found above 374 °C and pressure of 22 MPa. At these conditions, it is in a phase that is neither liquid nor gas and carries up to ten times more energy than steam does. The MBIE-funded GNS Geothermal Next Generation research programme investigated the geological, geochemical and technological challenges in accessing and harnessing such a resource (Chambefort et al. 2024). In November 2024 the NZ Government announced a further \$60 million research grant for GNS including drilling a deep well of perhaps 5 km depth where supercritical fluid may be accessed (Collins 2024).

Even if they are successful, technologies to exploit the supercritical geothermal resource are likely to be several decades in the future (Chambefort et al. 2024), and environmental, social, and financial derisking will require consultation with mana whenua and participation from the entire community.

## **Discussion**

### ***Changes in law and government policy***

Several new policies proposed by the government elected at the 2023 general election may be significant for geothermal energy. A Fast-track Approvals Act 2024 (NZ Govt, 2024a) has been enacted by Parliament, intending to speed up environmental permitting and give priority to national and regional economic development. The initial list of projects to be eligible for the new procedure includes several renewable energy projects, but none in the geothermal sector. It presents a real possibility that environmental sustainability and Māori rights and interests in, and relationships with, the environment will be subordinated to short-term economic benefits. The Government has also announced its intention to replace the RMA with new legislation (NZ Govt 2024b) which could significantly alter the important high-level governance settings embodied in law that steer the work of regional councils in geothermal resource management. While the government has stated its plans in only general terms it says that red tape must be reduced to make it easier to carry out development, including power generation; the new system of environmental regulation is to have a limited scope (Bishop and Court 2024). The Government has also proposed a review of provisions in all statutes that require consideration of the principles of the Treaty of Waitangi (NZ Govt 2024c, Walters 2024); among other things, this could disrupt progress in ensuring that the special relationship of Māori with natural resources is taken into account.

### **Further research**

Further research on the issues canvassed here is desirable in several respects. The government proposals noted above will require a reconsideration of the governance framework provided by the RMA. Similarly, the Emissions Trading Scheme needs reappraisal for its suitability for emerging methods of injecting or reinjecting carbon dioxide. More research is required for those methods, for the extraction of minerals from geothermal fluids, and for the legal and technological challenges surrounding supercritical geothermal use. As the UNFC geothermal assessment methodology grows in acceptance and adaptation in Europe, Africa and Latin America, a simplified assessment tool is being considered by the UNFC Geothermal Working Group (2024 email from G. Ussher to K. Luketina, unreferenced). Matters raised by Waitangi Tribunal claimants in contemporary claims such as the *National Freshwater Geothermal Resource Inquiry* (Wai 2358), and the Tribunal's forthcoming reports, will also be noteworthy for research into the just transition.

### **Conclusions**

The geothermal resources of Aotearoa New Zealand are distinctive in many ways. They play a prominent role in the country's energy system, especially providing baseload electricity generation and process heat, without using fossil fuels whether domestic or imported. Geothermal resources have long played an important role in Māori identity and culture. In this context, this article has examined the concepts of just transition, renewability and sustainability. We have examined the unique role that Māori iwi, hapū and land trusts play in geothermal resource management and the New Zealand energy picture generally. There is a history of Māori loss and deprivation in relation to geothermal resources, which requires recognition of a long timeframe for an understanding of justice in a just energy transition. There continue to be shortcomings in the relationship between the Crown and Māori, but there is growing respect for rangatiratanga (chieftainship) and mātauranga Māori, and, partly as a result of ongoing Treaty claims redress, some Māori exercise roles as co-venturers, owners and developers to an extent that is unrivalled in the broader energy sector.

Although the central government led the commercial development of geothermal resources, it is the regional councils who manage the resource, under the RMA. It is striking how completely it is regional government that develops and implements policy for geothermal resources. Over time the regional councils of the central North Island have developed the policy framework significantly, classifying geothermal systems and requiring detailed system management plans for systems subject to large-scale extraction. A particular challenge is to manage large-scale extraction rates. Compared to other renewable energy sources, geothermal has a much greater timeframe for recovery of the accessible energy source when subject to excessive industrial extraction: tens or hundreds of years. Fluid reinjection, data collection and stepped development have become imperative.

Another challenge, driven by the price imperatives of the national Emissions Trading Scheme, is to return carbon dioxide to the subsurface as part of the reinjection process. Other new ways to utilise the resource are also the subject of research and development, often with a particular focus on climate change mitigation. Such developments, along

with changing political imperatives, show that governance and regulation for geothermal resources will continue to adapt.

## Notes

1. Regional planning instruments under the RMA define other geothermal terms used in this paper, such as *geothermal field*, and *geothermal fluid*. See for example, NZ Govt 1991a. Waikato Regional Plan *Glossary* (Waikato Regional Council 2011); Rotorua Geothermal Regional Plan *Glossary* (Bay of Plenty Regional Council 2023).
2. Note, the RMA only defines *geothermal water* and *geothermal energy*. National direction and regional planning instruments define other aspects of the geothermal resource. See for example, above n 1.

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## Disclosure statement

The authors report there are no competing interests to declare.

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