The Economic Impacts and Benefits and Costs of Geothermal Resources in the Bay of Plenty region

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Cover photo: "Kawerau Geothermal Field" (Bay of Plenty Regional Council)

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Glossary

Economic terms

Allocative efficiency is concerned with spending limited resources in the areas that are best able to maximise public value. In economics it is described as where price equals marginal cost.

Backward linkages are the supply chain costs for an industry sector's production. An industry sector has significant backward linkages when its production requires substantial inputs provided by other sectors.

Direct effects are the activities of an economic sector of the economy (e.g. electricity generation, tourism).

Employment count (EC) measures the number of employees in a sector. Working proprietors are not included (unless they pay themselves a wage or salary).

Employment multipliers determine the direct, indirect and induced effects of the output of one sector on employment in the economy.

Forward linkages are the relationships in the supply chain that move production towards end consumers. For example, consumers of electricity are forward linkages for generators of electricity.

Gross domestic product is New Zealand's official measure of economic growth. The production approach (value-added) measures the total value of goods and services produced in New Zealand, after deducting the cost of intermediate goods and services used in the production process.

Indirect effects are the impacts from one economic sector's output on other sectors (including those supplying goods and services to the sector).

Induced effects are flow-on effects from wages and salaries available in the economy as the result of a sector's economic activities.

Modified employment count (MEC) is a measure of employment based on the EC and including estimates of the numbers of working proprietors for each industry type. Market Economics has modified the EC to calculate the MEC.

Output is a measure of the total flow of goods and services within an economy. This includes intermediate demand, primary inputs and final demand. It is calculated by the quantity of goods supplied multiplied by the price of each unit.

Resource rent is the economic rent of a natural resource. It equals the value of capital services flows rendered by the natural resource, or their share in the gross operating surplus (OECD, 2001).

Value-added multipliers (Type I and Type II) are used to determine the contribution of a sector to the economy (GDP). Type I are used to estimate the value of the direct and indirect effects; Type II are used to estimate the value of the direct, indirect and induced effects.

Energy terms

Base load[1] is that component of the electricity system load which is continuously present over a stated period. For example, fossil fuel generation and geothermal can be called on at any time to provide generation.

Gigawatt One billion watts or 1000 megawatts.

Gigawatt hours (GW h). A unit of energy (see MW h).

Kilowatt One thousand watts.

Load factor is the difference between how much a generator is designed to produce (installed capacity) and how much it actually produces (output).

Megawatt (MW) One million watts.

Megawatt hours (MW.h) A unit of energy. A 1MW generating plant run for one year (24hr x 365) would produce 8760 MW h, or 8.76 GW h.

Petajoules (PJ) A unit of energy used for expressing the energy contents of fuels and other energy sources. 1 PJ = 1,000 TJ.

Terajoule (TJ) A measurement unit of energy that is often used to express the energy content of fuels. 1 TJ = 0.278 GW h.

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[1] Transpower (2021).

Contents

Executive Summary

The Bay of Plenty Regional Council (the Regional Council) is reviewing the geothermal provisions in the Regional Natural Resources Plan and the Rotorua Regional Geothermal Plan. Section 32 of the RMA requires the Regional Council to identify and assess (and quantify if practicable) the benefits and costs of new policies and rules against existing policies, including anticipated economic growth and employment (s32(2)).

The Regional Council manages the geothermal resources in accordance with its functions under the Resource Management Act (RMA), which include:

- Control of the taking or use of geothermal energy (s30(e)(iii)).
- Allocation of the taking or use of heat or energy from the material surrounding geothermal water, if appropriate (s30(a)(iii)).

The purpose of this report is to provide an estimate of the economic impact of geothermal direct use and electricity generation in terms of contribution to regional GDP (value-added) and employment, and to describe, and where practical quantify, the community wellbeing benefits. The report is based on current policy settings.

The Kawerau, Tauranga and Rotorua geothermal systems are three of 12 geothermal systems in the Bay of Plenty region (the region). Each system has different geothermal characteristics and is managed according to the characteristics of the resource. The Kawerau System is used mainly for industrial heat and electricity generation (Table 1). The Tauranga System mainly provides benefits to a large and widespread community through heated pools, and horticultural businesses. The Rotorua System is important to tourism in that area, not just in terms of geothermal attractions, but also for mineral pools, and space and pool heating.

Table 1: Kawerau, Rotorua and Tauranga/Mount Maunganui system uses

Use	Type	Kawerau	Tauranga/ Mt Maunganui	Rotorua
Electricity generation		✓		
Direct use:	Industrial process heat	✓		
	Horticulture		✓	✓
	Municipal	✓	✓	✓
	Residential		✓	✓
Tourism/Recreation		✓	✓	✓

Economic impact

The size and discrete location of the Kawerau System makes it relatively easy to estimate the contribution its economic impact. Kawerau-based businesses using geothermal energy for process heat or electricity generation together provide some 700 jobs on-site, with additional jobs in the wider region and New Zealand. The direct annual contribution to regional GDP from these businesses is estimated to be more than $180 m, with an additional impact through flow-on (indirect and induced) effects.

The main economic direct uses in the Tauranga System are horticulture and tourism. A survey of users undertaken in 2014 suggested that these businesses are likely to employ few people – on average 2-3 per business. The impacts on regional GDP and employment are not significant given the availability of substitutes in both production and energy, but for individual businesses, geothermal energy can be essential.

In the Rotorua System, commercial uses account for 43% of geothermal water takes, including for mineral pools and space and water heating in tourist accommodation. It is unlikely that guests visit Rotorua because of geothermally heated accommodation, but once there they may choose a particular motel because it has a mineral pool. In this way, direct use of geothermal contributes little to the regional economy, although geothermal tourism (not a direct use) is a major contributor, assessed to have directly contributed an estimated $90m-$118m and 2,300 jobs to the Rotorua economy in 2016 (BOPRC, 2017).

While geothermal energy contributes to regional GDP, the extent to which the region benefits, depends on the structure of businesses and where they are based (as opposed to where they operate). For example, Mercury Energy generates in Kawerau (among other locations) and is listed on the New Zealand stock exchange. Profits (value-added) are distributed to national and international shareholders. In contrast, Eastland Generation Ltd is ultimately owned by Trust Tairawhiti, which distributes profits for the benefit of the Gisborne community (a neighbouring region).

Wellbeing indicators (SOLGM Framework)

Environmental wellbeing indicators include sustainability and climate change and can be enhanced by geothermal resources. For example, geothermal process heat can provide significant reductions in greenhouse gases relative to alternatives such as natural gas and coal – Kawerau provides examples. However, greenhouse gases could increase if replacing clean, renewable electricity generation.

Social wellbeing indicators include life satisfaction, and geothermal resources contribute to this through the provision of jobs, community facilities (e.g. swimming pools), and through providing warm homes. In many cases, these benefits would be provided by other energy sources if geothermal was not available. In addition to those direct benefits, some businesses have specific company goals to bring benefits to the local community (e.g. NTGA, Waiu Dairy).

Cultural wellbeing indicators include cultural respect, arts and heritage participation, and inclusiveness. Building an understanding of the geothermal contribution to cultural wellbeing – Māori and European – is outside the scope of this report. Earlier work on the value of tourism to the Rotorua Economy (2017) suggests that geothermal tourism may contribute to respect for Māori culture, and Conroy et al. (2021) provided a contemporary view of Māori regarding geothermal resource availability in the Rotorua area. There may be other publications that assist in filling this information gap.

Suitable information to assess economic impact or wellbeing effects for some aspects of value is not currently available. These included the marginal cost of geothermal for process heat relative to other energy sources, and for geothermal versus other energy sources for heating swimming pools. These topics should be investigated if they are found to be relevant for alternative policy approaches.

1.0 Introduction

Geothermal activity is a distinctive feature of the New Zealand landscape, contributing to the regional economy through GDP (value-added) and jobs, and providing environmental, cultural, social, and economic wellbeing benefits to New Zealanders and international visitors.

The Taupo Volcanic Zone includes nearly 90% of New Zealand's geothermal resource and straddles the Bay of Plenty and Waikato regions, from Whakaari/White Island in the north-east, to Tongariro in the south-west. Of this, 70% is in the Waikato region, including some well-known systems such as Wairakei.

The Bay of Plenty region (the region) has 12 geothermal systems. They are mainly within Rotorua District but also include Kawerau, Whakaari/White Island, and Moutohora, with low temperature systems from Waihi Beach to south-east of Te Puke (the Tauranga system), and some isolated low temperature systems at Tuhua/Mayor Island, Pukehinau and Manaohau. This report focuses on the Kawerau, Tauranga and Rotorua Systems. Conroy and Donald (2014) assessed the economic value of direct and indirect uses for these systems. This report provides an update.

The Bay of Plenty Regional Council (the Regional Council) manages the geothermal resources in accordance with its functions under the Resource Management Act (RMA), which include:

- Controlling the taking or use of geothermal energy (s30(e)(iii)).
- Allocating of the taking or use of heat or energy from the material surrounding geothermal water, if appropriate (s30(a)(iii)).

The Regional Council is currently reviewing the geothermal provisions in the Regional Natural Resources Plan and the Rotorua Regional Geothermal Plan. Section 32 (s32) of the RMA requires the Regional Council to identify and assess (and quantify if practicable) the benefits and costs of new policies and rules against existing policies, including anticipated economic growth and employment (s32(2)).

The purpose of this report is to provide an estimate of the economic impact of geothermal direct use and electricity generation, in terms of contribution to regional GDP and employment, and to describe, and where practical, quantify the community wellbeing benefits. The report is based on current policy settings, and focuses on the Kawerau, Tauranga and Rotorua geothermal systems. These are three of 12 systems in the region.

A s32 evaluation requires that alternative policy options are assessed against the status quo. Policy alternatives have not yet been developed and the effects of those alternatives are likely to require further analysis. The extent of that analysis will depend on the scale and significance of the anticipated implementation effects (s32(1)(c)). An assessment of the risk of acting or not acting if there is uncertain or insufficient information is also a requirement under s32 of the RMA (s32(2)(c)). This assessment is outside the scope of this report.

This report relies in part on Regional Council resource consent records. Not all activities require a resource consent, e.g., energy taken or used in accordance with tikanga Māori for communal benefit of tangata whenua[2].

This report, along with the following reports, is part of the package of economic information to assist in informing regional geothermal policy:

- *Conroy and Donald (2014). Valuing uses of the Bay of Plenty Geothermal Resource.* Conroy and Donald estimated the contribution of geothermal tourism, direct use and electricity generation for the regional economy in terms of GDP and employment.
- *Bay of Plenty Regional Council (2017). Valuing geothermal attributes in the Bay of Plenty region. A survey of visitors to four Rotorua geothermal tourism sites[3].* In this research, domestic and international visitors to Kuirau Park, Te Puia, Waimangu Volcanic Valley and Whakarewarewa were surveyed to elicit willingness-to-pay figures for visiting geothermal attractions. The study was undertaken in collaboration with Waikato Regional Council staff, who surveyed visitors to Waikato regional geothermal attractions. The contribution of geothermal tourism to the Bay of Plenty economy and employment was also estimated.

The report is set out as follows: Section 2 provides an overview of economic impact assessment (EIA) and cost benefit analysis (CBA), and section 3 provides a high-level description of the Kawerau, Tauranga and Rotorua geothermal systems, and a summary of the resource consents for taking and using geothermal water and heat. Section 4 provides context about where the economic impact and wellbeing values fit within an ecosystem services framework. Section 5 describes the economic impact (output, value-added and employment) of the Kawerau, Tauranga and Rotorua geothermal systems. Section 6 identifies community wellbeing benefits for the three systems in the context of the SOLGM Community Well-being Indicator Framework (SOLGM Framework). Section 7 provides a discussion, and section 8 provides the conclusions.

[2] RMA, s14(3)(b).

[3] The executive summary to this report is provided in Appendix 2.

2.0 Overview of economic tools

This analysis uses Economic Impact Analysis (EIA) to identify the effects the current policy approach has on the economy, measured in terms of economic output, value-added and employment.

An alternative economic tool, Benefit-Cost Analysis (BCA) addresses whether society is better off by performing a certain action (such as building a road) versus doing nothing. The New Zealand Treasury (2015) provides detailed guidance on how to use the method, selection of timeframe and discount rate.

Economic Impact Analysis can differ from BCA in terms of geographic scope, when the boundary of the economy is different to the boundary of the area in which people receive the policy benefits (NZ Treasury, 2015). For example, a company may operate in New Zealand, but the profits (value-added) may be distributed to overseas shareholders.

Economic Impact Analysis has a narrower scope of benefits than BCA because it includes only traditional macroeconomic indicators (economic output, GDP, employment) and does not consider opportunity costs. However, EIA takes a wider view of indirect impacts. Economic impacts may be direct (e.g. geothermal generation costs), indirect (e.g. services to generators provided by businesses in other sectors) or induced (occurring due to changes in household spending). Indirect and induced impacts are not included in BCA because the method assumes markets are competitive and projects are small relative to the economy – so overall economic activity will not change.

Economic Impact Analysis can provide contextual information about relative impacts on different sectors, which may be particularly useful for identifying whether a policy could cause significant economy-wide changes in prices. However, it is not a suitable tool for measuring the balance of costs and benefits of a decision; it treats all expenditure as an economic activity with no consideration of the benefits, the disbenefits (e.g. environmental degradation), or the opportunity cost of expenditure (NZ Treasury, 2015).

Economic Impact Analysis is an exercise to determine how a project or policy affects the amount and type of economic activity in a region and can be described in monetary terms. Benefit-Cost Analysis is used to determine a provision's impact on well-being (environmental, social, cultural and economic), and may be able to be described in monetary terms, but is often described quantitatively (e.g. the number of people impacted) or qualitatively (e.g. how those people are impacted).

In this report the SOLGM Framework has been used to identify and assess (qualitatively) the wellbeing benefits relevant to BCA. Wellbeing costs have generally not been assessed.

3.0 Overview of Geothermal Resources in the Bay of Plenty

The geothermal systems of the region result from the tectonic activity within the Taupo Volcanic Zone. The region's geothermal systems extend from Waimangu (south of Rotorua) to Whakaari (White Island) (Figure 1).

Geothermal water[4] is defined in the is defined in the RMA as:

> ***…*** *water heated within the earth by natural phenomena to a temperature of 30 C or more; and includes all steam, water, and water vapour, and every mixture of all or any of them that has been heated by natural phenomena.*

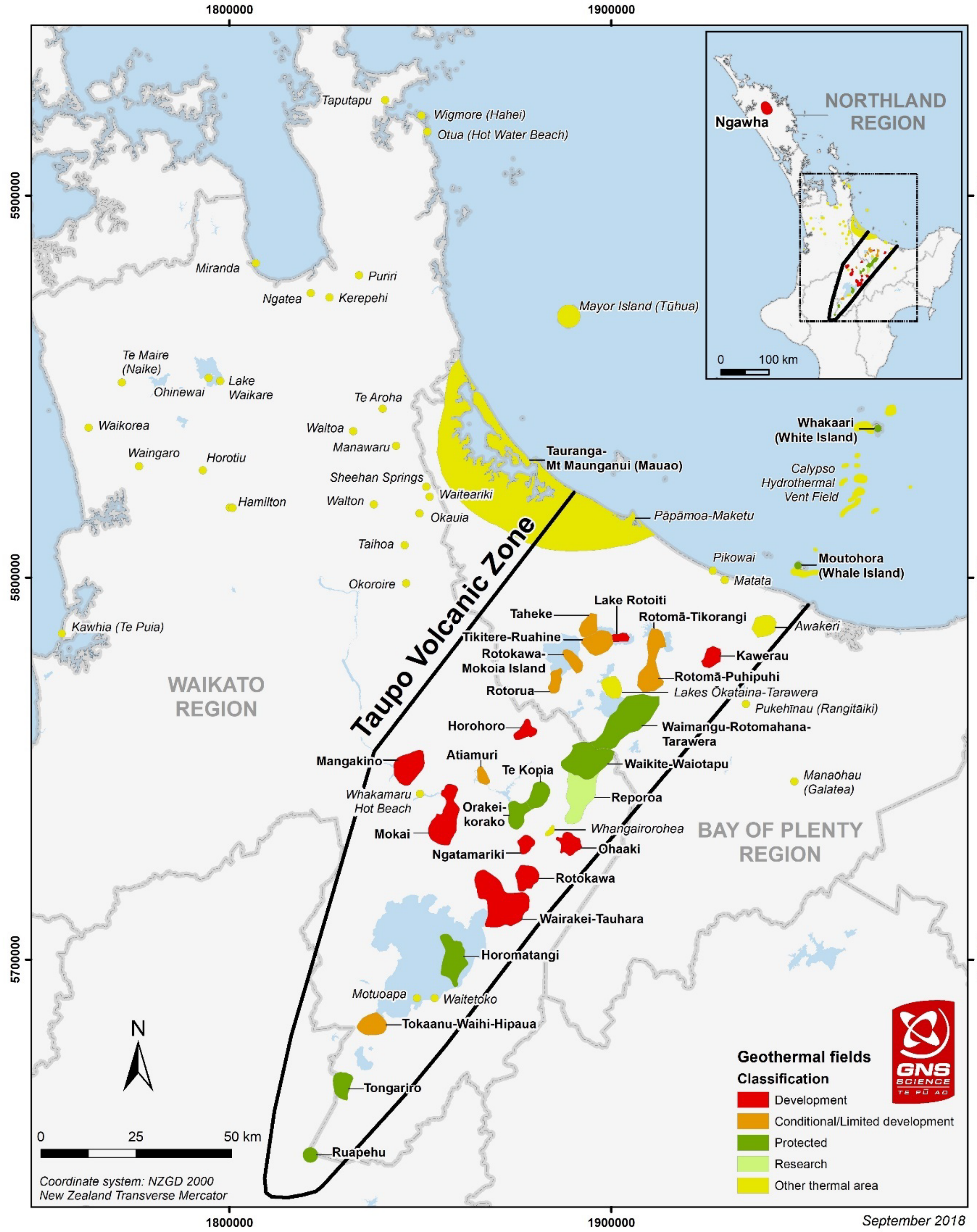
and geothermal energy is defined as:

> *…energy derived or derivable from and produced within the earth by natural heat phenomena; and includes all geothermal water.*

The Regional Council is responsible for the management of geothermal systems, which are classified in the Regional Policy Statement (RPS) in terms of their management and potential for sustainable extractive use. Under those classifications (BOPRC, 2013):

- The Kawerau System is a development system with potential for development of extractive use (heat or fluid).
- The Tauranga-Mt Maunganui System has potential for development of extractive use (heat or fluid).
- The Rotorua System has a significant number of high-value surface features, including a geyser field, and limited potential for further large-scale extractive use.
- Tāheke and Tikitere Systems are examples of conditional development systems, so have potential for further development of extractive uses, with significant constraints.
- Some areas, such as Waimangu, Whakaari and Moutohorā Island, are prohibited from extractive use due to significant geothermal features with outstanding natural, scenic, cultural, heritage and ecological values overriding extractive values.

[4] Geothermal water can be referred to as geothermal fluid. Geothermal water is used in this document for consistency with the RMA definition.



Source: NZ Geothermal Association, GNS (2018)

Figure 1: Geothermal systems in the Taupō Volcanic Zone. Regional boundaries shown

The economic activities associated with geothermal resources depend on the characteristics of the resource and other factors including location, supporting infrastructure and nearby land uses. The Kawerau system provides heat for industrial processing (e.g., wood, pulp and paper, dairy processing) and electricity generation, while the Rotorua system is mainly associated with tourism (e.g. geothermal tourist attractions, space and water heating in motels and bathing in geothermal water). The Tauranga System is a low temperature system and provides agriculture/horticulture (e.g. glass house heat) and tourism (e.g. mineral pools). Table 2 shows the diverse uses of the geothermal systems.

Table 2: Kawerau, Rotorua and Tauranga system uses

Use	Type	Kawerau	Tauranga/ Mt Maunganui	Rotorua
Electricity generation		✓		
Direct use:	Industrial process heat	✓		
	Horticulture		✓	✓
	Municipal[5]	✓	✓	✓
	Residential		✓	✓
Tourism/Recreation		✓	✓	✓

3.1 The Kawerau Geothermal System

The Kawerau System straddles the Kawerau and Whakatāne districts, covering about 35 km^2. Classified as a Development System in the RPS, it is a high temperature system (>70^{O}C) with significant geothermal vegetation sites, though few other significant geothermal features. It has the potential for further development provided significant adverse effects on significant geothermal features are remedied or mitigated (BOPRC, 2013).

In high temperature systems like Kawerau, very hot fluid (over 200^{O}C) can be abstracted at depth to provide energy for industrial scale direct heat or electricity generation. Ngāti Tūwharetoa Geothermal Assets (NTGA) is one of four major resource consent holders for large takes from the Kawerau System (Table 3) and supplies geothermal heat/fluid/water for direct use and electricity generation. The other three major consent holders are associated with electricity generation rather than direct use. Together the four parties are authorised to take almost 175,000 tonnes of geothermal water per day[6], although consents may also be subject to annual volumes that result in lower average daily volumes (BOPRC, 2018). In 2019, the four major consent holders extracted 47.8 m tonnes of geothermal water, equating to a daily average of 131,000 tonnes, which is approximately 75% of the total consented daily take (Table 3) (BOPRC, 2020).

[5] For example, public swimming pools.

[6] This compares to the high temperature system of Rotorua with sensitive surface features where the total consented take per day is less than 10,000 tonnes. The low temperature Tauranga system has a total take of 18,000 tonnes of geothermal water per day, suitable mainly for space and water heating.

Table 3: Resource consents for taking/discharging geothermal water in the Kawerau System

Consent holder	Consent no.	Date granted	Expiry date	Purpose	Max. take volume (tonnes per day)	Take as % of allocated volume	Max. discharge volume (tonnes per day)
Mercury NZ Ltd/KGL	63295	19/09/2006	30/11/2040	Take and discharge	45,000	37%	45,000
	67335	20/06/2013	30/11/2040	Take and discharge	20,000		20,000
Ngāti Tūwharetoa Geothermal Assets Ltd	24598	2/05/2006	30/09/2030	Take and discharge	44,400	51%	24,000
	67151	1/06/2016	31/12/2050	Discharge (to Tarawera River)	-		20,880[7]
	66862	17/02/2014	35 years post commence-ment	Take and discharge	45,000		45,000
Geothermal Developments Ltd (Eastland Generation Ltd)	67161	24/01/2014	35 years post commence-ment	Take and discharge	5,280	3%	5,280
Te Ahi O Māui Partnership (Eastland Generation Ltd and Kawerau A8D Ahu Whenua Trust)	67340	12/09/2016	35 years post commence-ment	Take and discharge	15,000	9%	15,000
Total take and discharge volumes (per day)					**174,680**	**100%**	**175,160**

Source: Bay of Plenty Regional Council (2018; 2020)

Based on the resource consents, and assuming all geothermal energy in the NTGA consent is used in direct use, the split between direct use and generation is about 50:50. However, in practice the type of use is less well-defined. Businesses operating in the Kawerau field have commercial arrangements to buy and/or sell energy/consent volumes to each other. This can occur across use types, and individual businesses may use geothermal water for both direct use and electricity

[7] The consented discharge is 20,880 m^3/day and (ii) 870 m^3/hour to 30 July 2024, reducing to 9,600 m^3/day and (ii) 400 m^3/hour from 30 July 2024 (BOPRC Resource Consent 67151-AP).

generation[8]. The Kawerau System consents are granted for long durations, acknowledging the significant financial investment associated with the economic activities.

There are two minor direct use resource consents including one held by the Kawerau District Council to heat the town's public swimming pool.

The Regional Council has worked in collaboration with the major Kawerau consent holders to develop the Kawerau System Management Plan (SMP) (2018), with the objective of managing the resource in a sustainable manner in accordance with the requirements of the RMA (BOPRC, 2018). The SMP (2018) recognises:

> *The importance of the sustainable management of the Kawerau Geothermal System to the region's economy is substantial and strategic initiatives such as the Bay of Plenty Regional Growth Strategy (Geothermal) seek to support continued use and development of geothermal resources (2018, p.2).*

The SMP (2018) is a non-statutory document and sets out the arrangements for the ongoing administration of consents (including adaptive management protocols), addressing issues between consent parties, reporting to the Regional Council, processing new resource consent applications (including changes to existing consents, new consents and reviews), ensuring efficiency, and the role of the Kawerau Peer Review Panel (BOPRC, 2018). The Regional Council and the four major consent holders are currently reviewing the SMP (BOPRC, 2020).

The overall objectives set out in the SMP (2018) include providing for the geothermal needs of present and future generations, remedying and mitigating significant adverse effects on significant geothermal features, and avoiding, remedying and mitigating significant adverse effects on the surface-built environment. Other objectives are operational flexibility to facilitate adaptive management, integrated management, and cooperation between the consent holders.

Adaptive management is integral to achieving objectives and relies on modelling. The three Kawerau System models are the Conceptual Model (describing the scientific understanding of the system), the Reservoir Model, and the Subsidence Model. The models run current and proposed scenarios (e.g. take and discharge rate and quantity, injection fluid temperature, well location, depths including feed zones) for existing and new consents to predict the effect of resource use on the geothermal reservoir and/or any localised effects. The models are revised where monitoring shows the actual field performance differs significantly from model forecasts and when new scientific information is available (BOPRC, 2018).

The SMP (2018) states that '*…a large part of the resource has already been allocated…'* however, there is no agreed capacity for the Kawerau System and existing and potential users can apply for resource consents. New resource consent applications require modelling of proposed takes and discharges and subsidence modelling in addition to other requirements including an assessment of how the new activity will be consistent with the SMP, a cultural impact assessment, and an assessment of effects on surface features and vegetation. Where the monitoring of a consented activity differs to a 'material degree' from predictions and would be

[8] An example of this was the Norske Skog Tasman (NST) plant, which had an installed capacity of ~7MW and annual production of about 44 GW h. Norske Skog Tasman bought and sold on the electricity market depending on spot prices. Norske Skog Tasman is no longer operating its paper manufacturing plant.

likely to result in a ‘material adverse effect’, the SMP (2018) stipulates a process, which can result in a review of the conceptual model, an adaptive management response, or changes to consented activities.

> *As a system becomes fully allocated, opportunities for adaptive management to address effects becomes less effective or potentially lead to greater consequences for consent holders (i.e. there is less room for flexibility) (SMP, p.36, 2018).*

3.2 The Tauranga Geothermal System

The Tauranga System is a Low Temperature system (>30^{o} C, <70^{o} C), extending over Tauranga/Mount Maunganui and the Western Bay of Plenty. The system has few if any significant geothermal features and is classed as having potential for development of extractive use providing adverse effects can be avoided, remedied or mitigated. Discharge of geothermal water must be managed to avoid significant adverse effects on surface water and storm water (BORPC, 2013).

The Tauranga System is basically heated groundwater; its mineral content is much lower than in other high-temperature systems, and the water is generally suitable for irrigation, stock water and human drinking water, although it can have relatively high-levels of some potentially toxic minerals, like arsenic. In this way the Tauranga System differs from the Kawerau and Rotorua systems, which are high temperature with high levels of minerals, so not suitable for human or stock drinking water in all cases.

The current consented volume (maximum take) of geothermal water from the Tauranga System is 9.5M tonnes, or an average of 26,000 tonnes per day. ‘True geothermal uses’, or uses that depend thermal energy in the water, make up 76% of the consented total. Non-geothermal uses make up the remaining 24%. Non-geothermal uses occur in cases where users do not seek warm water *per se*, but the bore produces warm water because of the nature of the aquifer. Nonetheless, the take is still considered a geothermal take as the main criteria set by the RMA is the water temperature and not the end use.

Two-thirds (67%) of the resource consents use the geothermal water for its energy or mineral proprieties (balneology/mineral pool). Consented activities tend to be small scale and non-industrial, varying by type of use and location, and include heating swimming pools, filling mineral pools, and space heating (e.g. retirement villages, private home, greenhouses). Water and/or space heating is the single biggest purpose category, at 60% of the allocated volume for true geothermal uses (Figure 2).

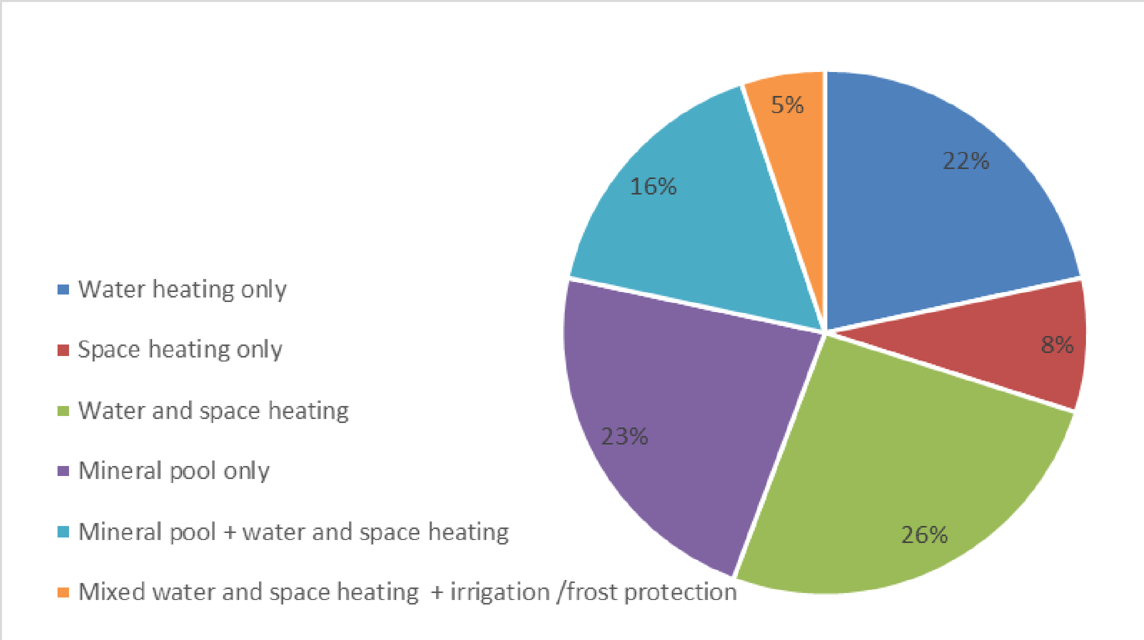


Figure 2: Geothermal water consented for 'true geothermal' direct use activities

Public swimming pools and other community facilities (e.g. schools) account for 44% of the consented volume of direct use (Figure 3). About 29% is allocated to businesses, including retirement villages (e.g. space and water heating), horticulture (e.g. heating greenhouses) and tourism (space and water heating, including mineral pools). About 23% is allocated to private, non-commercial uses, such as home heating, private swimming pools, and spas.

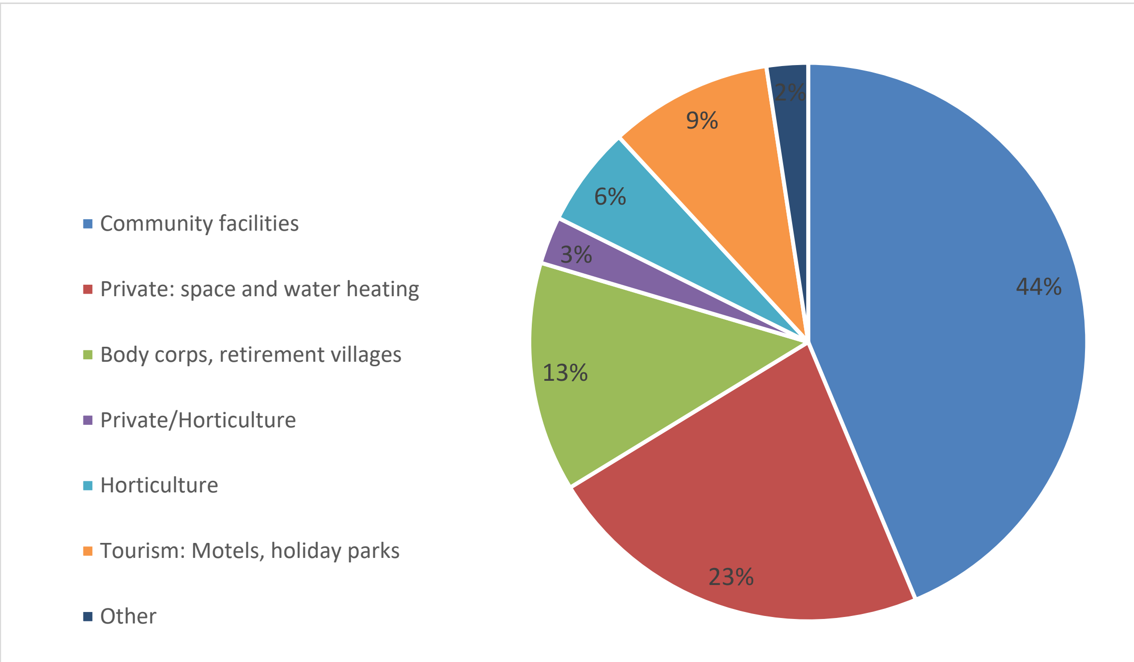


Figure 3: Geothermal water for true geothermal direct use, by sector

When geothermal water allocated to non-geothermal uses is included, about a third of the total allocation is used in community facilities (e.g. public pools, schools), nearly half to businesses including tourism and horticulture, and about 17% for households for space and water heating (Figure 4). About 96% of the geothermal water allocated to non-geothermal activities is for horticulture (irrigation, frost protection).

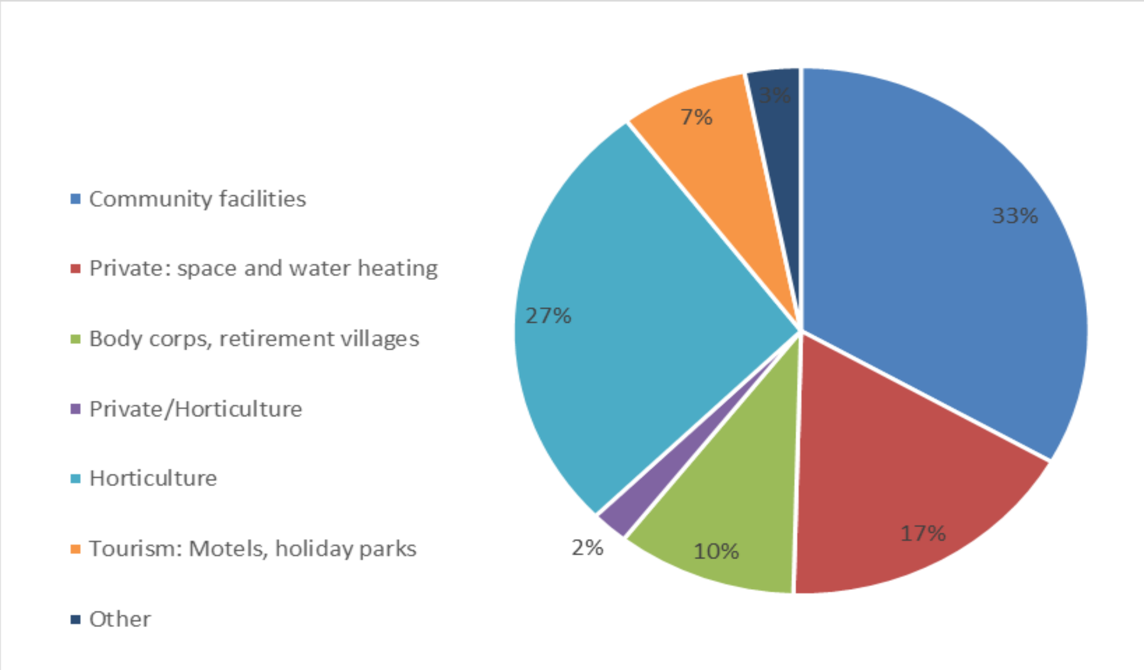


Figure 4: Geothermal water – all activities

Most of the resource consents for the Tauranga System expire within the next 10 years, including pre-RMA consents, which will expire in 2026.

3.3 The Rotorua Geothermal System

The Rotorua System is a high temperature system (>70^{O}C), with many significant geothermal features, some with outstanding characteristics, such as the geysers and mud pools. Surface feature protection is the system objective and limits and overrides extractive use. The significant features are considered vulnerable to extractive uses due to their reliance on pressure and temperature to play (BOPRC, 2013). The system has a unique protective status/class under the RPS, with provisions for both extractive and non-extractive uses (BOPRC, 2013). Under this approach, there is an allocation limit of 4,400 tonnes per day net mass abstraction and limited opportunity for large scale industrial or commercial development.

Commercial direct uses in the Rotorua System tend to be small scale, and in many cases supporting the tourism sector, such as pool, spa and space heating, and mineral pools. The Rotorua System is characterised by a large number of small, consented takes. Resource consents are generally short term (10 years).

Scott (2019) describes the bore closure programme of 1986, which came about because of decline in surface features in the 1970s and 80s. The decline correlated with unregulated growth in bores – by the mid-1980s there were 370 shallow bores extracting 30,000 tonnes of geothermal water daily. A Government-enforced bore closure started in 1986 and the number of bores fell to 140, reducing daily extraction to less than 10,000 tonnes. Since the closures, many of the surface features have again become active. Today the number of bores and consented withdrawal remains at much the same level as the changes brought about by the bore closure programme.

The Rotorua System has approximately 80 resource consents to take geothermal water. The total average daily allocation of geothermal water and energy is ~10,000 tonnes, with 60% of discharges going back into the system, meeting the allowable net mass extraction limit for the system (4,400 tonnes per day) (Scott, 2019). Geothermal water direct use is split between water and space heating, mineral pools, with a very small allocation to horticulture (Figure 5).

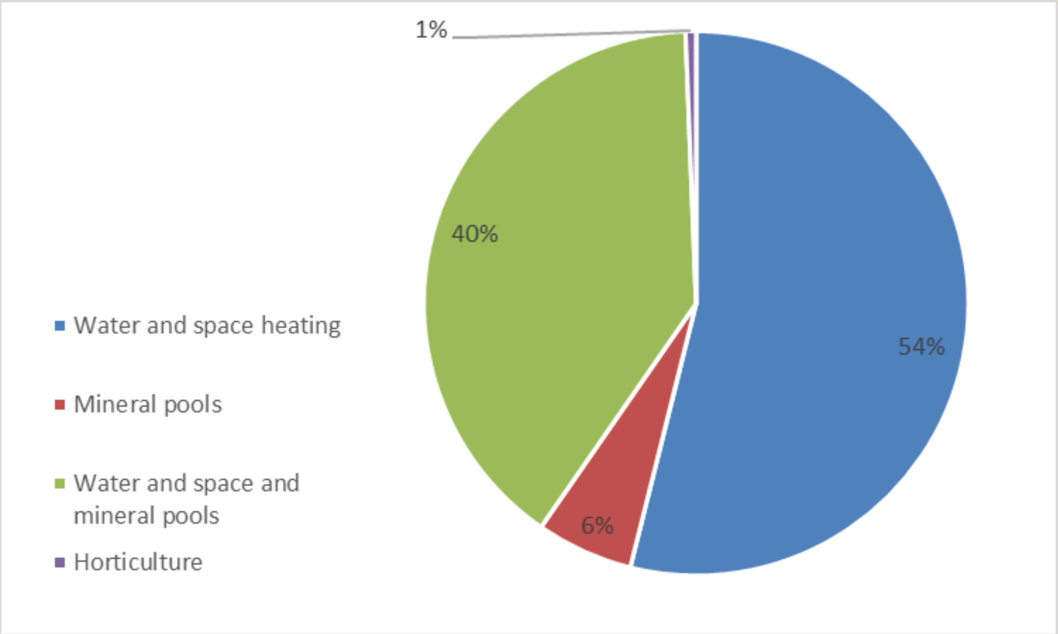


Figure 5: Geothermal water consented for direct use activities

Nearly half the consented geothermal water takes are for commercial uses, with a further 21% to mixed commercial/domestic. The Rotorua Hospital is one of the largest and oldest users of geothermal water (Conroy and Donald, 2014), taking about half the geothermal water allocated to the community sector (Figure 6). The Rotorua Lakes Council holds several consents in the community category, including the Rotorua Aquatic Centre and the Rotorua Community Youth Centre.

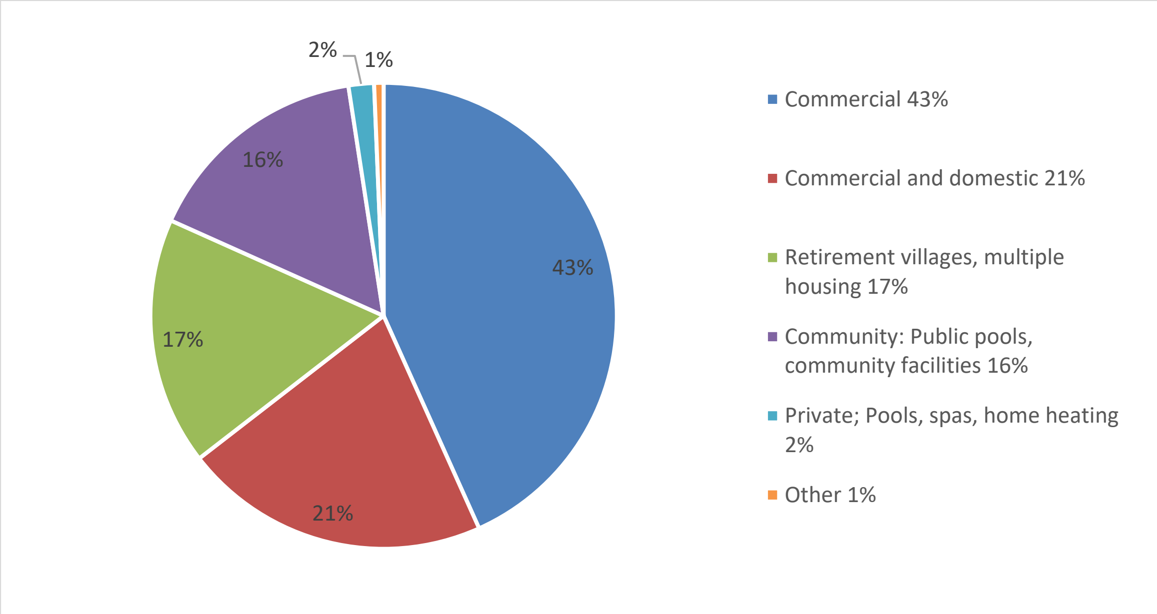


Figure 6: Geothermal water consented by user type

Other than the resource consents to take geothermal water (above) there are 31 consents for geothermal heat through down-hole heat exchange. This method extracts heat from the reservoir without bringing the fluid to the surface. These consents are all for water/space heating.

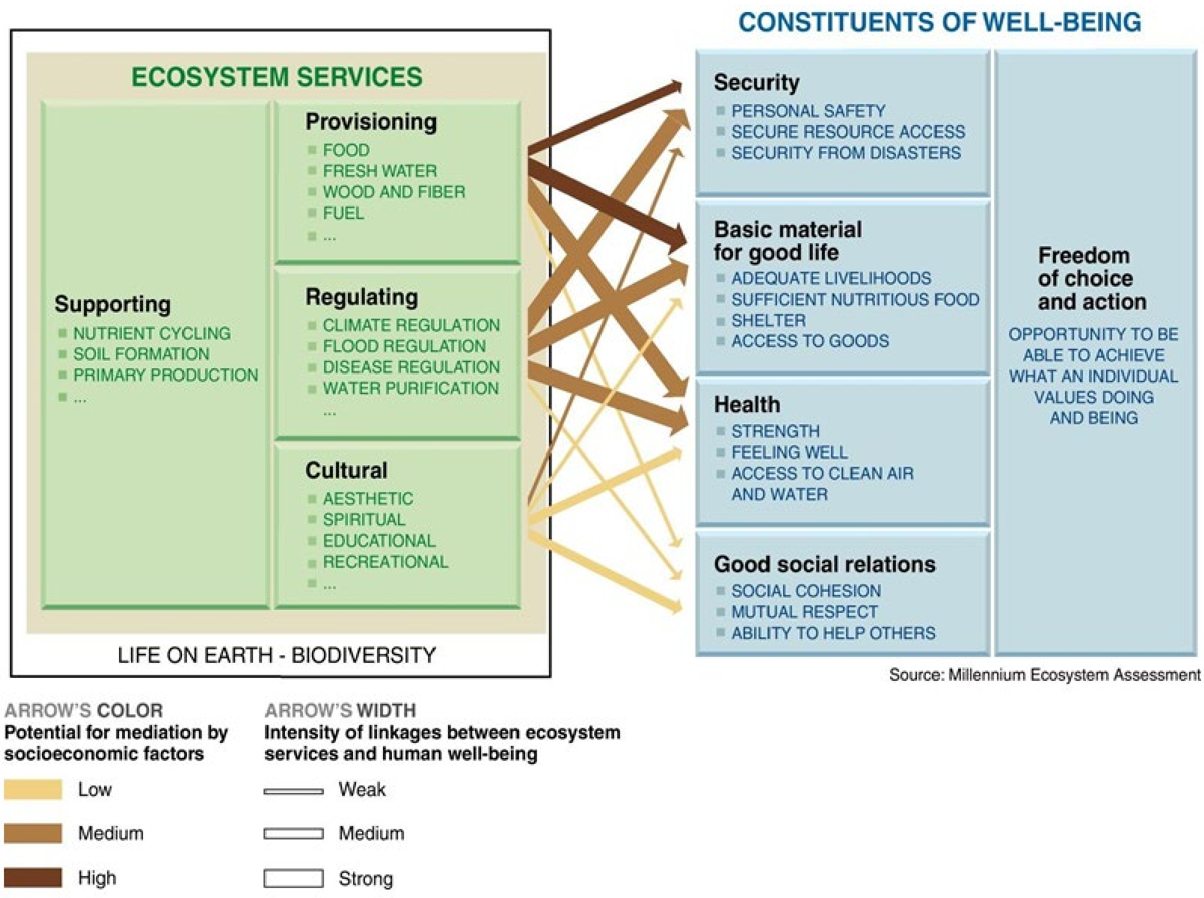
4.0 Ecosystem Services

It is useful to look at the ecosystem framework to provide context for where the economic impacts and wellbeing values identified in this report sit in relation to the wider human benefits of geothermal systems, and to acknowledge that the values in this report are a subset of the system benefits.

Ecosystem services are created by an ecological system, or ecosystem, which is defined as (MEA 2015a, p.28):

> *…a dynamic complex of plant, animal and micro-organism communities and the non-living environment interacting as a functional unit.[9] (p.28)*

The ecosystem services framework helps to conceptualise the values humans derive from ecosystem services, and how they relate to our wellbeing (Figure 6). Provisioning services are frequently measured because they tend to have a market value, but regulating, supporting and cultural values can be overlooked because of the general inability to measure these values.



Source: Millennium Ecosystem Assessment (2005)

Figure 7: Ecosystem services and relationship with wellbeing

[9] Millennium Ecosystem Assessment (2005, p.28). Vol 1: Current state and trends.

Geothermal resources provide a range of ecosystem services. Table 4 provides a high-level generic assessment, based on the work of Luketina (2010), Cook et al (2017), and Wildlands (2018). Conroy and Donald (2014) also reported on ecosystem services relevant to the Bay of Plenty geothermal resource.

Table 4: Summary of ecosystem services that may be provided by geothermal ecosystems

Ecosystem service class	Ecosystem services	Application to geothermal resources
Provisioning	Energy Genetic resources Freshwater supplies Mineral resources Nutrition Plant-based resources	Electricity supply and industrial processes. Firewood produced by trees and shrubs. Genes and genetic material that can function at the high temperatures found in industrial processes, for example: The polymerase chain reaction (PCR), using enzymes found in geothermal bacteria, amplifies a specific target DNA fragment from a pool of DNA so that a sample large enough for testing can be created for e.g. forensic use. Extraction of minerals such as sulphur for use in industrial applications. Geothermal bacteria are used in industrial applications for biodegradation, capturing precious metals from water, and production of biomass fuels. Cultivated crops, wild plants, wild animals and their output (including honey production). Wood produced (planted forest), flaxes.
Regulating	Water purification Waste treatment Air quality regulation Sediment retention	Geothermal microbes reduce the concentration of heavy metals and other chemicals in the geothermal water before that water flows into the wider environment. The minerals are captured by microbes into sinter deposits. The sinter is deposited as terraces that slow the flow of the geothermal water and increase surface contact and residence time in the geothermal ecosystem, cooling the water through evaporation and allowing the microbes a greater opportunity to further cleanse the water so that thermal and chemical shock to receiving environments is reduced.
Social/Cultural	Recreational amenity Spiritual values Aesthetics Inspiration Archaeological heritage Other cultural associations	Geothermal tourism (domestic and international) On-site recreation such as walking, birdwatching, and botanising. Traditional Māori spiritual beliefs and uses, Pakeha historical associations, belief in balneology (bathing for health), bathing for recreation. Geodiversity (landscape diversity).

Sources: Luketina (2010), Cook et al. (2017), Wildlands (2018)

There are many ways that the values associated with ecosystem services can be measured. In a meta-analysis of international studies on ecosystem service measurements, Boerema et al. (2017) found that provisioning ecosystem services were most commonly quantified as benefits and values, while regulatory services are more likely to be quantified as ecosystem properties and functions. Cultural ecosystems tended to be quantified using scores.

Many of the provisioning services (e.g. genetic resources) identified in Table 4 have not been quantified, and nor have the regulating services. The social/cultural services have only been quantified to the extent of their contribution to the economy.

5.0 Economic Impact Assessment

The economic impact assessment of the economic activities in the Kawerau, Tauranga and Rotorua geothermal systems is relevant to s32(2) of the RMA in that it quantifies (monetises) the contribution in terms of output, GDP (value-added) and employment. This report is focused on the current policy approach, although s32 requires that other 'reasonably practicable options for achieving the objectives' are identified (s32(b)(i)), and that they are assessed for efficiency and effectiveness (s32(b)(ii)) with a level of detail corresponding to the scale and significance of the environmental, economic, social and cultural effects (s32(c)). This further analysis will be appropriate when alternative policy options have been developed.

It is useful to note that value-added (contribution to GDP) is estimated at the location where the economic activity occurs (e.g. Kawerau), but profits and induced effects will not necessarily stay in the area.

5.1 Kawerau Geothermal System

The process for obtaining new resource consents to take geothermal water from the Kawerau System is described in the SMP (2018) and summarised in section 3 of this report (p.10)[10]. The costs of implementing a resource consent at Kawerau are significant – well-drilling is complex and expensive. Costs can be $10M-$15M. Wells can be more than a kilometre deep and can be producing a kilometre away from the wellhead on a horizontal plain. Production wells need reinjection wells, which are not so deep but may have a shorter lifetime due to accumulation of silica and carbonate from reinjection fluid. Financial risks associated with well-drilling include equipment breakage, collapse of the well, and not finding a suitable source of geothermal water.

Direct energy use - Economic impact

Ngāti Tūwharetoa Geothermal Assets Limited (NTGA) is a geothermal energy supplier, selling untransformed geothermal energy (fluid and/or steam) for direct use manufacturing processes[11]. Ngāti Tūwharetoa Geothermal Assets Limited contributes to regional GDP through its business activities, including capital investment such as the construction of new pipes and other infrastructure. Industry sectors that NTGA buys goods and services from other sectors including heavy and civil engineering construction, electricity and transport, and others such as mining when exploring and establishing new wells.

Ngāti Tūwharetoa Geothermal Assets Limited is a registered New Zealand company, and Ngāti Tūwharetoa Holdings Limited (NTHL) is the Ultimate Holding Company. NTHL has seven shareholders (trustees) based in and near Kawerau. The structure and location of shareholders suggests that much of the GDP contribution of NTGA is likely to be experienced in the Kawerau district and the wider region.

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[10] Information in this paragraph provided by Jason Laurent, Senior Compliance Officer, Air, Industry and Response Team, BOPRC.

[11] Appendix 1 provides background information on geothermal direct use and electricity generation in New Zealand.

Quantifying NTGA's contribution to regional GDP would require information about the structure of the business in terms of its income and expenses, which has not been sought at the time of writing. The economic impact of NTGA activities in the region relates to the activities on the Kawerau System, and in terms of backward linkages, where NTGA purchase goods and services needed for production. The main well-drilling business used by NTGA is based in the Waikato Region (Taupō), and infrastructure and construction services are based in the Bay of Plenty region[12,13]. In 2019 the heavy and civil engineering construction sector accounted for 2.6% of activity in the Kawerau economy ($10M) and 2.3% of employment (68 jobs) (Table 5). Part of that contribution would be due to the NTGA activities. Ngāti Tūwharetoa Geothermal Assets Limited employs 11 staff based at Kawerau.

The direct contribution to regional GDP of sectors associated with geothermal direct use activities in Bay of Plenty region was $351.7M in 2019. In the Kawerau district the pulp and paper product manufacturing was the largest sector with a value-added of $128.7 (33%), followed by wood product manufacturing at $24.8 (6.3%). These sectors also have flow-on indirect effects on the local and regional economy[14].

Table 5: Contribution to GDP by linked sectors in Kawerau District, $2019 (%)

Sector	Value-added in Kawerau $m (%)
Pulp and paper product manufacturing	$128.7 *(33%)*
Wood product manufacturing	$24.8 *(6.3%)*
Dairy product manufacturing	Not available
Main supplying sectors	
Construction	$18.4 *(4.7%)*
Machinery and equipment	$14.1 *(3.6%)*
Electricity and gas supply	$13.6 *(3.5%)*
Heavy and civil engineering	$9.8 *(2.5%)*
Forestry and logging	$2.1 *(0.1%)*

Source: Infometrics

Industry sectors that supply goods and services to the direct use sectors also contribute to GDP (indirect effects). These sectors include construction, machinery and equipment manufacturing, waste collection, and repairs and maintenance (e.g. electrical). Construction services, machinery and equipment manufacturing, and electricity and gas supply comprise 4.7%, 3.6% and 3.5% of GDP for Kawerau (Table 5). The size of the indirect economic impact depends on what proportion of output from the supplying sectors go to the direct use sectors, which is unknown.

The forestry and logging sector is an important supplier for the direct use activities. In the region this sector contributes $295.4M to GDP, although in Kawerau it is much smaller at Kawerau $2.1M.

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[12] J. Quinao, pers.comm. Email 12 July 2021.

[13] The structure and shareholder location for businesses supplying goods and services has not been investigated.

[14] Not estimated in this report.

Employment

The industry sectors associated with geothermal direct use are the larger employment sectors in the Kawerau district (Table 6). In 2019, direct employment in the pulp and paper product manufacturing sector was estimated at 619 jobs (21.6% of Kawerau jobs), and wood product manufacturing was 270 jobs (9.4%) (Table 6). The construction sector provides goods and services to direct use businesses and accounted for 253 jobs (8.8%), although many of these will not relate to the geothermal sector.

Table 6: Employment effects from geothermal direct use related sectors, 2019 (%)

Sector	Kawerau	Bay of Plenty
Pulp and paper product manufacturing	619 *(21.6%)*	896 *(0.6%)*
Wood product manufacturing	270 *(9.4%)*	2,554 *(1.6%)*
Dairy product manufacturing	Not available	Not available
Main supplying sectors		
Construction services	253 *(8.8%)*	9,273 *(5.9%)*
Machinery and equipment	120 *(4.2%*	1,974 *(1.3%)*
Electricity and gas supply	14 *(0.5%)*	355 *(0.2%)*
Heavy and civil engineering	68 *(2.4%)*	2,777 *(1.8%)*
Forestry and logging	5 *(0.2%)*	812 *(0.5%)*

Source: Infometrics

The local and regional economies benefit from the spending of wages and salaries of ~1,000 people working in the businesses located in and associated with activities in the Kawerau System. Spending by workers of suppliers is an induced economic impact of geothermal direct use.

Direct use – The businesses

Five businesses use process heat in the Kawerau System. All have contracts to purchase geothermal water from NTGA. Each business contributes to local and regional GDP because that is where the economic activity occurs. However, the extent that the value-added benefits the region depends on opportunity costs of inputs, where the business is located, how much businesses spend locally on goods and services (indirect effects), how much employees spend locally (induced effects), how profits are distributed, and where shareholders are located. Of the direct use businesses in Kawerau[15]:

- Essity AustralAsia is a subsidiary of a company listed on the Swedish stock exchange, and most of the profit (value-added) paid out as dividends accrue to foreign shareholders who are mostly based in Europe.

[15]The business ownership, structure and location are summarised in Appendix 2.

- Oji Fibre Solutions NZ Limited is listed with the New Zealand Companies Office, but Oji Holdings Corporation is the ultimate holding company, and is registered on the Tokyo Stock Exchange. Most of the profit paid out as dividends will accrue to Japanese shareholders who own 76.5% of the shares, with the balance to other international shareholders.
- Carter Holt Harvey Woodproducts Limited is registered with the New Zealand Companies Office. More than 99.9% of the company is owned by a single person. The registered office is Auckland. Most profits will accrue to that single person.
- Sequal Lumber Limited is registered with the New Zealand Companies Office and owned by Sequal Holdings Limited. Profits are distributed to the shareholders, who are based mainly in the Bay of Plenty region.
- Waiu Dairy General Partner Limited is registered with the New Zealand Companies Office. It is 67% owned by Bay of Plenty Māori businesses and 33% by a Japanese company. Based on the ownership, we assume two-thirds of the distributed profit will be paid to shareholders of the Māori businesses who are based mainly in the Bay of Plenty, and the balance will be paid to Japanese shareholders.

Geothermal electricity generation – Economic impact

The estimated direct contribution of geothermal electricity to regional GDP in 2019 was $33.0M (Table 7), with much of the economic impact in the Kawerau district[16]. The indirect effects (sectors suppling the electricity sector) increased the contribution to $63.4M, and induced effects (spending of salaries and wages) to $76.7M.

Indirect effects come from the supplying of goods and services to the generation sector (e.g. transport, repairs and maintenance). Maintenance of wells accounts for a significant part of the indirect effects. For example, in 2020 Eastland Group Limited incurred operating costs of $5.4M on revenue of $22.9M for the electricity generation segment of their business, not including personnel and administration expenses (Eastland Group, 2020). The Eastland Group, through their subsidiary companies, owns 56 MW of installed geothermal generation capacity in Kawerau, 5 MW of hydro in the Hawkes Bay region and 6 MW of diesel generation throughout the Eastland Network region.

[16] Refer Appendix 4 for multiplier calculations. The economic multipliers used in this study are based on the wider electricity generation sector, which relies on the assumption that cost structures are similar across the sector.

Table 7: Contribution to regional GDP by geothermal electricity generation

Parameter	Value	
Year (April-March)	2014 ($2019)	2019 ($2019)
Annual energy supplied MWh ('000)[17]	1,133	1,277
Average price per MWh [18]	$76.59	$95.59
Total output	$86.8M	$122.1M
Direct value-added	$24.30M	$34.4M
Direct and indirect	$70.71M	$66.0M
Direct, indirect and induced	$71.68M	$79.9M

Capital expenditure associated with establishing new businesses and growing existing businesses contributes to the economy in addition to the impacts above. For example, Contact Energy expects to spend $30M drilling four appraisal wells on the Tauhara geothermal field, with most of that spending in New Zealand (Contact Energy, 2019). In another example, the earthworks for Te Ahi O Māui began in June 2016, and construction of the plant continued throughout 2017, becoming operational in 2018 (Eastland Group, 2017). The forecast cost of development was $116M.

Employment

Geothermal generation at Kawerau results in about 35 jobs onsite, increasing to an estimated 44 jobs for the region and 53 nationally (Table 8). Total jobs in the region are 54 including indirect effects and 73 including induced effects.

Table 8: Employment effects from geothermal generation

	Direct employment*	Direct and indirect effects	Direct, indirect and induced effects
Kawerau	35	36	38
Bay of Plenty	44	54	73
New Zealand	53	84	173

*Direct employment figure based on actual jobs, not modelled jobs.

There are five operational geothermal power plants on the Kawerau system (Table 8). The largest is owned by Mercury Energy, re-rated at 107 MW in 2017 (Table 8). Eastland Group Limited, through its subsidiaries and partnerships, is responsible for 56 MW of installed capacity, and about 460 GWh of annual generation. In total, the Kawerau System has 170 MW of installed capacity and produces 1,404 GW.h per year, which is about 18-19% of New Zealand's total installed capacity.

[17] Reconciled generation published by the Electricity Authority

[18] Electricity Authority (2019). Weighted average wholesale price per MWh for KAW1101. https://www.emi.ea.govt.nz/Wholesale/Reports/

The most recently built plant, Te Ahi O Māui, was commissioned in 2018 and is a partnership of Eastland Generation Limited and the Kawerau A8D Ahu Whenua Trust. The 24 MW plant produces sufficient electricity to supply about 25,000 homes (Eastland Group Limited, 2020).

Two generation plants have been decommissioned in recent years. The Kawerau Binary (TG1) was installed in 1989 and was the first geothermal electricity generating plant in the region. It had an installed capacity of 2.4 MW and produced 8 GW.h of electricity annually. It was decommissioned in 2014 (BOPRC, 2018). The Kawerau Binary (TG2) was decommissioned in 2020[19].

Electricity generation – The businesses

Mercury Energy owns the largest generation plant on the Kawerau field, with 107 MW of installed capacity. Eastland Group Limited, through Geothermal Developments Limited and Eastland Generation Limited, own two plants totalling 32 MW of installed capacity, and have a partial ownership in a third plant with the Kawerau A8D Ahu Whenua Trust, with an installed capacity of 24 MW. Norske Skog Tasman Limited have a small generating plant formerly used for manufacturing paper. Of the electricity generating businesses in Kawerau[20]:

- Eastland Generation Limited and Geothermal Developments Limited are subsidiaries of Eastland Group Ltd, a registered NZ company owned by Trust Tairawhiti – a community trust. The Trust income is spent in the Tairawhiti region on community projects.
- Kawerau A8D Ahu Whenua Trust is a Māori Trust and owned by the Ngāti Tuwharetoa ki Kawerau iwi. Shareholder income is distributed in the Kawerau area.
- Norske Skog Tasman Limited is a registered NZ company ultimately owned by Oceanwood Master fund, based in Malta.
- Mercury NZ Limited is a public company listed on the New Zealand Stock Exchange. The New Zealand government retains a 51% share in the company, and the balance of the shares are owned by domestic and international shareholders.

5.2 Tauranga Geothermal System

The groundwater in the Tauranga area is currently managed as two layers – an upper (shallow) and a lower (deeper) layer (Figure 8)[21]. Each of the layers has management zones. In the upper layer there are multiple management zones which are surface water catchment based and have a likely connection with surface water. In the lower layer there are three management zones. The boundaries for these management zones are based on some surface water catchment boundaries. The lower layer is less likely to have a direct connection with surface water bodies. Within the management zones the dark green indicates that no allocation has been made in an area, the lighter green indicates that an area is between 0-50% allocated, the yellow that it is between 50-90% allocated, orange (none displayed)

[19] TG2 was struck by lightning, leading to its decommissioning. The reason for decommissioning TG1 is not known by the author.

[20] Refer Appendix 3 for a summary of the business structure.

[21] This differs from the rest of the region where groundwater is currently managed as a single layer with management zones.

that it is 90-100% allocated, the red is over-allocated, and the grey that there is no allocation available. The blue dots represent existing groundwater resource consents, with the size of the allowable take indicated by the dot size.

The management approach recognises that the Tauranga groundwater is different from other groundwater and geothermal water resources in the region.

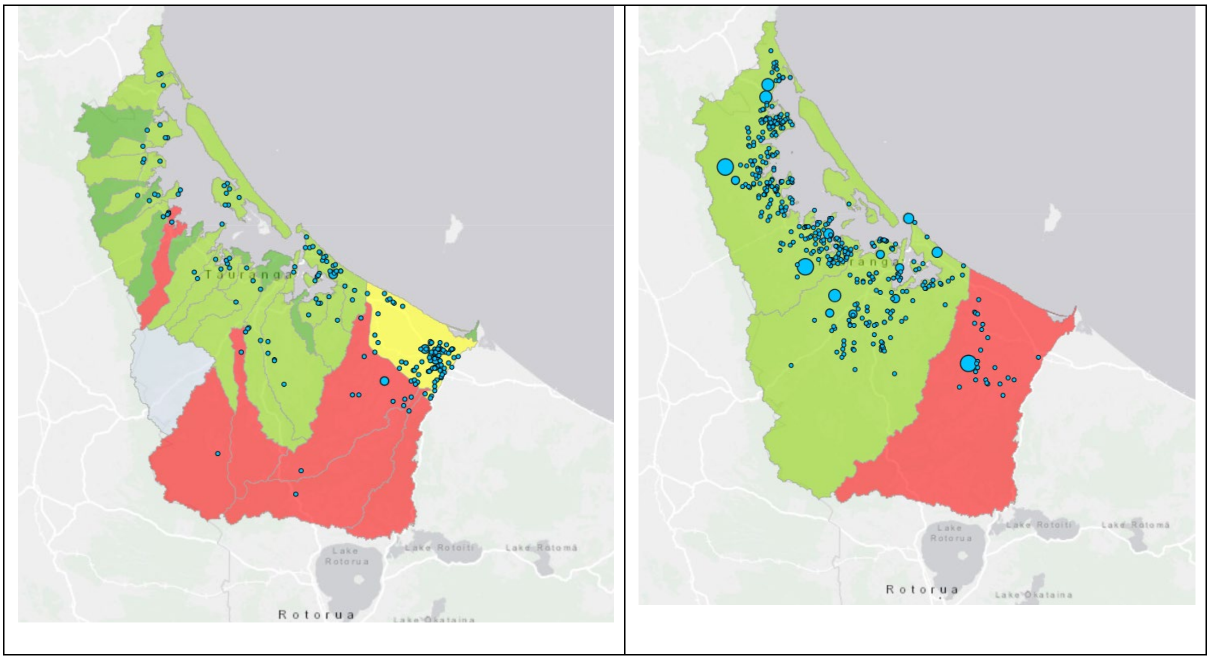

Figure 8: Upper and lower management layers in the Tauranga groundwater system

In general, the presence of warm water is a function of the location and depth of a bore. The construction and integrity of a bore can also play a role – when integrity is lost the temperature of the water from the production bore may be reduced. The characteristics of the water from existing bores can provide a good indication of the likely location and depth of warm water in an area.

Wells for geothermal water from the Tauranga System are typically at least 100 m deep. The well-depth for geothermal water depends on location and heat required, for example in Katikati a geothermal well could be expected to be about 250 m, and in Pukehina about 150 m. Well-drilling costs are about $1,300/m, so a 100 m well would cost about $130,000. Wells for non-geothermal water can be less than 100 m, but again it depends on location and availability of groundwater at different depths.

Horticultural activities

Horticulture is a mainstay of the Western Bay of Plenty economy, contributing 5.4% and 9.2% of regional GDP and employment respectively (Table 9). In Tauranga and the wider region, horticulture is much less significant.

Table 9: Horticulture in the Bay of Plenty 2019

	Bay of Plenty		Tauranga		Western Bay of Plenty	
GDP	$188.1	1.2%	$22.4	0.3%	$124.9	5.4%
Employment	3,312	2.1%	396	0.5%	2,199	9.2%

Source: Infometrics

Despite the high level of horticultural activity, just 13 of 74 consents for geothermal water are for direct use horticultural activities. In the Conroy and Donald (2014) surveyed horticultural businesses about the importance of the geothermal resource to their business. Out of seven responses, four said geothermal was 'essential' and three said 'useful'. The number of staff employed by businesses depending on geothermal water is small. In 2014, Conroy and Donald reported that of the seven horticultural businesses responding to a survey about their use of geothermal energy, most employed 2-3 staff, and larger operations employed 5-17 staff.

Although horticulture is an important part of the Western Bay of Plenty economy, the contribution of geothermal energy to that sector is small, with most consent holders seeking groundwater rather than geothermal water.

Tourism

Six tourist accommodation businesses in the Tauranga and Western Bay of Plenty are hold consents for geothermal water for space and/or water heating, and mineral pools. It is unlikely that domestic or international visitors target the Tauranga area for the purpose of staying in geothermally heated accommodation, although on arrival their choice of accommodation may be influenced by the presence of mineral pools. In general, the economic benefits associated with geothermal resources in tourism facilities is captured by the business owners through lower operating costs and/or a greater ability to attract more guests, with little or no additional benefit in the regional economy.

For some accommodation providers mineral pools may be an important or necessary part of their business, providing income through the off-season. Similarly, in businesses built around geothermal resources, such as the Oropi Hot Pools and Café, geothermal resources are essential. Conroy and Donald (2014) noted that respondents to a survey on pay bathing in the Bay of Plenty reported that geothermal resources were 'essential' to their business.

Public pools

In 2014 staffing the region's public heated pools provided 131 jobs, making up 69 full-time-equivalent positions, with total pool visits of 806,609 (Conroy and Donald, 2014). Assuming the number of jobs is correlated to the number of visitors, the estimated jobs in Tauranga and the Western Bay in 2019-20 would be 105, making up 55 full-time equivalent positions. The presence of geothermal increases the number of jobs - without geothermal the region would have fewer heated pools. Nevertheless, on a district or regional scale this is a very small impact.

Table 10: Public pools – visitor numbers and entry prices

Location	Swimming pool	Pools 25+m	Visitors 2020-21	Entry prices			Opening months
				Child	Adult	Senior	
Mount Maunganui	Baywave TECT Aquatic	1	230,001	$5.30	$8.00	$5.30	All year
	Mount Hot Pools		242,914	$11.50	$18	$11.50	All year
Tauranga	Greerton Aquatic and Leisure Centre	1	76,285	$2.50	$5.10	$2.50	All year
	Memorial Pools	1	31,804	$2.50	$4.90	$2.50	All year
	Otumoetai Swimming Pool	1	42,666	$2.50	$4.90	$2.50	All year
Katikati	Dave Hume Pools	1	19,784*	$3.50	$5.00	$3.80	Sep-Mar
TOTAL		**5**	**643,454**				

Sources: Bay Venues Limited (2020); Dave Hume Swimming Pool Trust (2020)

5.3 Rotorua Geothermal System

Despite the availability of geothermal resources, the likelihood of being granted a resource consent, and economic benefits (Peng and Moore, 2021) the Regional Council receives few consent applications for the Rotorua System; in the past 12 months the single application has been made by an existing user seeking to increase their consented take. Barriers to entry include cost, unwillingness to share supply (shared supplies reduced individual costs), risk in health and safety perspectives, relatively mild climate, and issues around ownership and management (Peng and Moore, 2021).

Establishing geothermal bores can be expensive - $50,000-$100,000 in the Rotorua System, where bores are relatively shallow (up to 180 m) [22]. A bore might be expected to last 50 years and will require maintenance throughout its life. Where reinjection is required a second bore in needed.

Commercial/Commercial and domestic

Of the approximately 120 resource consents for geothermal energy from the Rotorua System, 70% are for geothermal water and 30% are for down-hole heat exchangers. Of the water takes, 50 have a commercial component, and together these consents account for 62% of the total consented water take.

[22] Estimate provided by Jason Laurent, Senior Compliance Officer, Compliance Air Industry and Response Team, BOPRC.

InfraCore[23] in central Rotorua, uses geothermal energy to support plant nursery operations through the winter months. With six greenhouses, the organisation grows and supplies plants for Rotorua's gardens, parks, reserves and cemeteries. InfraCore also supplies other councils including New Plymouth, Tauranga, Ōpōtiki, Kawerau and Whakatāne, and sells direct to the public. Eight staff are employed directly in the nursery, with 150 jobs across Infracore, although some of the 150 jobs would occur regardless of the nursery. Without geothermal energy to heat the greenhouses through winter, the nursery would operate quite differently.

The Rotorua Lakes Council uses geothermal energy for water and space heating for their offices, the Rotorua Aquatic Centre, the Southern Trust Sportsdrome, and the Community Youth Centre.

The Rotorua Hospital is one of the oldest and largest water takes in the Rotorua System (Conroy and Donald, 2014). If geothermal energy was not available, the Lakes District Health Board would be dependent on another and potentially more expensive energy source.

The volume of geothermal water consented is not necessarily actual use, in that some consent holders may not exercise their consents or may not use the entire allocation. Peng and Moore (2021, p.12) note that in the Rotorua System there is 'incomplete or out-of-date information on actual energy take'.

The commercial use of down-hole heat exchanges is relatively small, with nine of 37 (24%) consents for commercial uses. Most down-hole heat exchangers are for domestic use – of 27 consents, 24 are for individual dwellings and 3are for multiple dwellings.

Tourism

Most of the commercial consents in Rotorua are for tourism. Tourism businesses use geothermal for space and water heating, and mineral pools. In a survey of holiday accommodation across the Bay of Plenty, Conroy and Donald (2014) found that 55%-100% of guests used mineral pools if available at accommodation. Hotels/resorts rated geothermal resources as useful to their business, while other forms of accommodation (hostels, holiday parks, motels) rated geothermal as essential.

While tourism businesses can differentiate by providing mineral pools, the ability to differentiate a business based on geothermal space or water heating is limited. There is no reason to expect that geothermally heated accommodation would attract additional visitors to Rotorua, or would result in additional spending by visitors, and therefore the presence of geothermally heated accommodation would not increase local or regional GDP.

It seems likely that mineral pools provide businesses with a competitive advantage over rival businesses either by charging a higher price or attracting more customers, but it is unlikely that mineral pools in accommodation would bring additional visitors to Rotorua. The lack of new resource consent applications suggest that the premium is not sufficient to drive new investment currently.

[23] A Council-controlled organisation (CCO) under Rotorua Lakes Council.

Geothermal water is a central part of the Polynesian Spa business in central Rotorua, which suggests that guests ‘immerse [themselves] in New Zealand’s original geothermal bathing experience’. Businesses like this may attract people to the region for specialist services, and in those cases would make a small but insignificant contribution to GDP and employment.

6.0 Community wellbeing

An assessment of the effects of a policy on community well-being is relevant to s32(2) of the RMA, which requires that the benefits and costs of environmental, economic social and cultural effects anticipated are identified and assessed (s32(2)(a)(i)), and if practicable quantified (s32(2)(b)). Quantification is not necessarily monetisation (MfE, 2017), and can include counting, measuring and calculating (MfE, 2014), for example the number of people affected by a proposal, or a measurement of contaminants in a water body.

Indicators developed for SOLGM Community Well-being Indicator Framework (SOLGM Framework) fit well with a broad approach to assessing values (Figure 9). Some such as GDP (economic impact) can be monetised, while others can be counted (e.g. the number of Te Reo Māori speakers), modelled (e.g. climate change), or measured (e.g. health). Others such as housing affordability could be calculated.

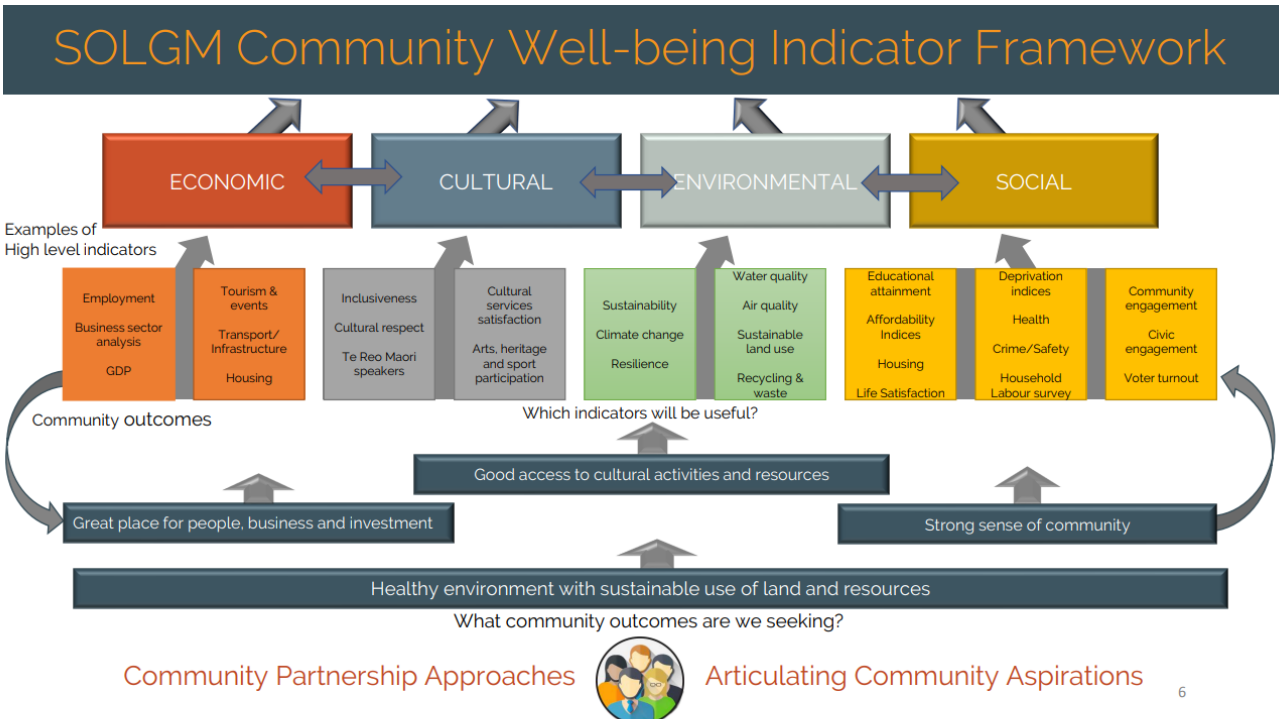

Figure 9: SOLGM Community Well-being Indicator Framework (NZLGM, 2019)

This section does not provide a complete list of wellbeing effects. In particular, negative wellbeing effects of current policy approach have not been considered, such as localised effects on water or air quality. The extent to which gaps should be addressed will depend on whether they are relevant to proposed policy options.

6.1 Kawerau Geothermal System

Environmental wellbeing

Climate change is one of the environmental wellbeing indicators in the SOLGM Framework. Geothermal electricity generation can produce significantly fewer greenhouse gases than fossil-fuel generation. The release of greenhouse gases is a natural occurrence in geothermal resources, released through surface features, steaming ground, and discharge through the soil (McLean, 2019), however, production induce additional emissions which is estimated to be counterbalanced by a reduction in the thermal activity at surface, although this is still a research field. Nonetheless, geothermal is a low-carbon energy alternative, with lifecycle emissions slightly higher than other renewables (e.g. PV and wind), but significantly less than fossil fuels (e.g. natural gas, coal) (Sullivan, Clark, Han and Wang, 2010).

Gases are also released when geothermal water is flashed in the electricity generation process (McLean, 2019). McLean (2019) estimated that the median and weighted average emissions intensity of CO_2-e across 12 geothermal generation plants (NZ) to be 12 g/kWh and 76 g/kWh respectively, compared with 390 g/kWh for combined cycle gas turbine plants and 525 for open cycle gas turbine plants.

The reduced CO_2-e benefit is also relevant to direct use of geothermal where fossil fuels are the practical alternative to direct use geothermal. For example, Essity Australasia, based in Kawerau, initially used natural gas in their manufacturing processes. In 2011 the company shifted part of its processing to geothermal energy, reducing its annual CO2-e emissions by 50%, from 46,000 tonnes to 23,000 (Table 11). A recently announced grant through the Government Investment and Decarbonising Industry Initiative (GIDI) will contribute to funding the next stage of emissions reduction (EECA, 2021).

Table 11: Changes in annual CO2-e emissions (tonnes) from Essity Australasia moving from natural gas to geothermal energy direct use

GHG Emissions (tonnes)	2009	2020	Next stage
CO2-e	46,000	23,000	18,000
Cumulative avoided emissions		23,000	28,000
Avoided annual cost reduction for cumulative emissions[24]		$959,100	$1,167,600

Source: Pers. Comm Ian Shepherd, Technical Manager, Essity Australasia

Economic wellbeing

A reduction in greenhouse gases for individual businesses can flow through to reductions in operational costs, as in the Essity AustralAsia example (Table 10), and can contribute to the regional economy through costs associated with installing new equipment (EECA, 2021).

[24] The avoided cost calculation was made by the author of the report based on NZ ETS Carbon Auction 23 June 2021 Clearing price $41.70 NZX Managed Auction Service (etsauctions.govt.nz)

Geothermal water supply, generation and direct use contribute to the economy through providing jobs, both directly – through work for the electricity sector, and indirectly - through businesses that supply goods and services to the sector (e.g. maintenance, transport). The economic impact is felt through the effects of spending wages and salaries[25]. The number of people directly employed by businesses using the Kawerau Geothermal resources is more than 800[26], with many of these jobs based onsite at Kawerau. Businesses supplying goods and services to the Kawerau-based businesses also provide jobs (indirect effects).

Social wellbeing

Deprivation indices are included as an indicator of social wellbeing in the SOLGM Framework. The southern and eastern areas of the Bay of Plenty, including Kawerau, are some of the most deprived in New Zealand (University of Auckland, 2020). The businesses supplying and using geothermal water provide a significant number of on-site jobs at Kawerau.

Some of the businesses based in Kawerau have specific social goals. The extent to which this occurs depends in part on the business structure. Examples of Kawerau-based businesses with specific social goals include:

- NTGA, as a business belonging to a Māori Trust, describe their business as providing:

    > *… long-term socio-economic benefits for Ngati Tuwharetoa ki Kawerau, the wider Kawerau community, and the Bay of Plenty region of New Zealand*.[27]

    NTGA contributes to the local economy through the distribution of profits to the people of Ngāti Tūwharetoa (Bay of Plenty) to support educational, health and marae development initiatives (BOPRC, 2016).

- Waiu Dairy, processing dairy products, a collaborative effort by 12 businesses, 11 of those Māori businesses, aims to create opportunities for local people and their community, and exports its products, reputation, and story to the world.
- Sequal Lumbar, locally owned, sees itself as having a role in contributing to local initiatives, having a community profile, and helping young people. One of the social initiatives is partnering with Tarawera High School, which includes bringing two students a year to work on-site, supporting the careers expo, and providing prizes for student endeavours.
- Eastland Group Ltd funds projects in the Gisborne community though its shareholder, Trust Tairawhiti.

25 Referred to in section 4 of this report as the ‘induced economic impacts’.

26 Refer Appendix 3 for estimates for individual businesses.

27 www.tuwharetoageothermal.co.nz/

Swimming pools provide social wellbeing benefits. The Maurie Kjar Memorial Pool Complex includes a 25 m and a 5 m pool, and two smaller pools for children (Table 12). The complex also has a spa of 8 m by 10 m, which has steps, supporting handrails, and a hoist to enable disabled people to use the pool. The pool is built within recreation area with barbeques and a picnic area.

In terms of community wellbeing, the Kawerau District Council describes the pool complex as providing opportunities for creative, cultural and recreational activities, and the facilities being accessible – being age and disability friendly, and affordable for all residents (KDC, 2020)[28]. These social well-being benefits would be available regardless of whether the pool was heated or not, but the winter heating extends the benefits.

The original pool was built by volunteer labour in the 1950s and was a cold pool. In the 1960s it was connected to a bore for heat exchange. The pool is open year-round, and admission is free (Table 12). The history of the pool suggests the community would have a swimming pool regardless of geothermal resources. However, geothermal heating enables year-round use of the Kawerau pool. Recent Council decisions about the future of the pool are clear that without geothermal heating operation would be restricted to November to April, with a $5,000 cost to decommission the existing well (KDC, 2021a), and that the swimming period could potentially be extended to September to May with solar at an unknown cost (KDC, 2021a). The Council decided to replace the existing well, budgeting $75,000 for replacement and connection to existing infrastructure and decommissioning the existing well (KDC, 2021b). The new well is expected to have a lifetime of 25 years (KDC, 2021a). The costs of heating by natural gas and electricity were not provided in the staff report to Council, although expert[29] information provided regarding a Tauranga facility suggested that even with initial high capital costs of geothermal construction, the lower operational costs of geothermal make it a financially more attractive option than other heating options.

The community pays for building, maintenance, and operations of the swimming pool through rates. Calculating the marginal benefit of geothermal in the case of the swimming pool would require calculations of the capital and operating costs for alternative methods of construction and operations. These costs are not readily available for the Kawerau pool.

28 The satisfaction of the community with the swimming pool (and other Council initiatives) is measured in a 3-yearly survey. In 2020 93% of residents responding to the survey said they were either very satisfied or fairly satisfied with the public pool facility (KDC, 2020). There are no questions in the survey regarding additional satisfaction in relation to geothermal heating.

29 Refer Yannikis Pers Comm. Section 5.2 of this report.

Table 12: Kawerau heated pool complex

Location	Swimming pool	Pools =>25 m	Visitors (2020-21)	Entry prices			Opening months
				Child	Adult	Senior	
Kawerau	Maurie Kjar Memorial Pool Complex	1	Not available	FREE	FREE	FREE	All year

Source: Kawerau District Council

Cultural wellbeing

The SOLGM Framework indicators of cultural wellbeing include cultural respect, inclusiveness, cultural services satisfaction, te reo Māori speakers, and arts, heritage, and sport participation. Businesses contributing to cultural wellbeing in Kawerau include NTGA and Waiu Dairy through specific company goals (see above under social wellbeing).

The public swimming pool contributes to opportunities for cultural activities (KDC, 2020), to inclusiveness within the community (being affordable, and age and disability-friendly), and is a heritage asset, originally built by the community for the community and still owned by the community (through the Council).

The environmental benefits associated with geothermal energy as a renewable energy with low carbon emissions can also bring benefits to businesses in terms of reputation and product stewardship. For example, Waiu Dairy sees geothermal energy as part of a sustainable approach to business, aligned with the role of kaitiakitanga, or guardianship of the land. Geothermal energy sits alongside low impact, high value production, and sustainable farming.

6.2 Tauranga Geothermal System

Economic wellbeing

Horticulture (‘true geothermal use) and tourism are relatively small users of geothermal water in the Tauranga System (Figure 4) and make a small contribution to economic wellbeing of the community through GDP and employment.

Heating privately owned pools, spas and homes account for 18% of direct use and multi home complexes used another 10% (Figure 4). The value to homeowners could be assessed in terms of the capital and operational costs of establishing a geothermal heating system versus electricity. This may be a moderately easy assessment, but it has not been undertaken for this report. The small number of people taking advantage of geothermal for this activity, and the continued availability make it questionable whether such an assessment is necessary or useful.

Social wellbeing

Community facilities including public swimming pools account for 32% of consented volume of geothermal water in the Tauranga System (Figure 4). In terms of social wellbeing (SOLGM, 2019), public swimming pools potentially contribute to life satisfaction, health, and community engagement. In most cases the pool water is geothermally heated, although electricity (or other energy) is generally still required to pump the geothermal water, run heat exchange equipment, circulate pool water, manage humidity and temperature in the pool complex, and for heating, lighting, air conditioning. Swimming pools are substantial energy consumers.

The Bay of Plenty region is particularly well-endowed with heated public swimming pools – all heated by geothermal energy. Tauranga City (for example) has five heated public pool complexes, compared with neighbouring Hamilton which is reliant on other energy sources for its two complexes (Table 13). This gives Tauranga one heated pool complex per 28,400 people, while for neighbouring Hamilton (without the advantage of geothermal heating) the rate is one per 84,300 people (Gallagher Aquatic Centre and Water World). The excess of heated public swimming pools relative to population in the Tauranga area may be the result of relatively cheap geothermal heating or could be due to differing council priorities.

Table 13: Geothermally heated public swimming pools in the Bay of Plenty region

City/district	Heated pool complexes	Population*	Population per heated pool complex	Heating source
Tauranga City	5	142,000	28,400	Geothermal
Tauranga and Western Bay	6	195,400	32,567	Geothermal
Katikati**	1	5,010	5,010	Geothermal

**StatsNZ sub-national population data by district (2018). **Katikati pool is also included in the Western Bay group.*

Swimming pool complexes are extraordinarily energy intensive; water heating is a significant part of the operational costs. Nick Yannakis[30], Technical Director, Mechanical and Pool Water Engineer at Powel Fenwick, states:

> *A typical indoor aquatic facility in the Tauranga CBD area would be likely to require a bore of ~500 m to get sufficient heat capacity (400-500 kW) and the required yield. Assuming a capital cost of $1M-$1.3M to develop and establish the heating source, the expected simple payback period would be in the order of three to five years relative to an alternative energy source, and the bore would have an expected lifetime of some 50 years, although would require repairs and maintenance throughout its life. However, while the geothermal energy stacks up particularly well on medium to large facilities, establishing a capital cost prior to construction can be very uncertain because it is location specific, and the amount of energy able to be extracted from a bore can vary significantly.*

While it seems unlikely that pool visitors place additional value on the geothermal heating (it is not geothermal water), the economic and social benefits of having heated pools which enable swimming throughout the year including:

- Year-round swimming, providing health and amenity benefits, and life skills through swim training.

[30] Nick Yannakis, Technical Director, Mechanical and Pool Water Engineer, Powell Fenwick. Pers. Comm. Emails 21 July 2021 and 30 July 2021.

- Comfortable pool temperatures.
- Low electricity costs.
- Environmentally sustainable heating with no or low emissions and a relatively low carbon footprint.

Many of the pool complexes are used by schools. The high availability and spread of pools suggest that the region's geothermal resources have enabled more children to have access to the pools through their schools, and lower costs for schools (in time and money) to travel to pools, and year-round use. Other groups such as St John's ambulance services and fire service volunteers use pools for training (Dave Hume Swimming Pool Trust, 2020).

In 2019-20, 643,454 visits were made to Tauranga and Western Bay geothermally heated pools (Table 7). Bay Venues Limited, which manages the Tauranga public pools note that due to Covid-19 restrictions, the number of pool visits was nearly 20% below the 2018-19 visitors, and revenue was similarly down (Bay Venues Limited, 2020).

Working out the wellbeing benefit of geothermally heating public swimming pools would require an assessment of the capital and operational costs of each method. Despite extensive efforts these costs have not been able to be sourced for this project beyond the information provided by Yannakis (above).

Cultural wellbeing

The SOLGM Framework cultural wellbeing indicators include inclusiveness and sports participation. On the assumption that the presence of geothermal resources has brought about the relatively high number of heated pools in the Tauranga area, then geothermal resources contribute to cultural wellbeing by providing for inclusiveness and participation.

6.3 Rotorua Geothermal System

In its natural state, the Rotorua System provides high natural, intrinsic, scenic, cultural, heritage and ecological values, which are enjoyed and highly valued by the local, national and international individuals and communities (BOPRC, 2017).

Environmental wellbeing

The SOLGM Framework environmental wellbeing indicators include sustainable land use, sustainability and resilience. The current policy approach is aligned with these values. The geothermal habitats in the Rotorua System make up about 30% of the geothermal vegetation in the region (Scott, 2019). 'Stream sides, heated ground, and hydrothermally altered ground, which are all found in the Rotorua system, are classified as 'Critically Endangered' ecosystem types' (Scott, 2019).

Economic wellbeing

Tourism

Geothermal is the key part of the Rotorua tourism experience. Ensuring that the attractions remain viable is vital. Visitors to Rotorua value the range of attractions available in the area, but geothermal is the primary attraction, including the geothermal features and wellness/bathing experiences (BOPRC, 2017).

In 2016, New Zealanders and international visitors made roughly 1.44M visits to Rotorua to see the spectacular and iconic geothermal features[31] . These visits directly contributed $90M-$118M to Rotorua GDP, increasing to $142M-$185M with indirect effects. In addition, geothermal tourism directly provides about 2,300 jobs, increasing to around 3,000 jobs with indirect effects (BOPRC, 2017).

At a regional level, the economic contribution is higher. In 2015/16, geothermal tourism in the Rotorua area directly contributed an estimated $118M-$138M to the regional economy. The willingness-to-pay to visit geothermal attractions in the Rotorua area was estimated to be $55/adult (domestic tourists) and $75/adult (international visitors) (BOPRC, 2017). These values imply total annual recreation values for domestic and international visitors of $62M and $33M respectively (BOPRC, 2017).

The wellbeing benefits associated with tourism and recreation extend across the social and cultural wellbeing boundaries.

Social wellbeing

Recreation, in the form of local, national and international tourism, is an important feature of the Rotorua System. Visitors to attractions in the Rotorua area have described geothermal sites they visited in terms of (BOPRC, 2017):

- Sharing an experience with family and friends.
- Appreciating the uniqueness of geothermal.
- Relaxing.
- Enjoying the natural setting.
- Finding geothermal educational and interesting.

Community

Rotorua Aquatic Centre

The Rotorua Aquatic Centre heated pools comprise a 50 m outdoor pool, a 25 m indoor pool and an indoor learner pool, plus spas. The pools are open year-round, with relatively low admission charges (Table 14). In 2020-21 visitors numbered 380,000+. Although the history of the pool suggests the community would have a swimming pool regardless of geothermal resources, heated pools encourage year-round use (relative to unheated pools), providing social and economic benefits to the Rotorua community of 74,800 residents (Statistics NZ, 2018), and visitors to the city. Leah Burgess, Facility Manager at the Rotorua Aquatic Centre says[32]:

> *The Rotorua complex includes a 50m outside pool, open all year round. This pool reopened from upgrades in March 2021 and is the only 50 m outside heated pool in New Zealand. Most of the visitors to the pool complex are Rotorua residents, although international visitors and domestic tourists do use the facilities. The 50 m pool is used by clubs from around New Zealand for swim training – the availability of tourism attractions is a bonus for visiting clubs. Competitions, such as water polo and underwater hockey also take*

[31] Which include those at Tikitere, Waimangu and Rotorua.

[32] Leah Burgess, Facility Manager, Rotorua Aquatic Centre. Pers. Comm Email 26 January 2022.

place at the pools, although this has been restricted with Covid. Local school groups use the pools through the year, including throughout the winter months.

Admission figures show visitor numbers to be about 30,000 per month, with no drop off through winter. Children are the most frequent visitor, at 44% of all visits through the 2020-21 year (Rotorua Aquatic Centre, 2021).

Table 14: Rotorua heated public pools – visitor numbers and entry prices

Location	Swimming pool	Pools =>25 m	Visitors (2020-21)	Entry prices			Opening months
				Child	Adult	Senior	
Rotorua	Rotorua Aquatic Centre	2	380,000+	$3.00	$5.50	$4.00	All year

Source: Rotorua Lakes Council

Like most cities, Rotorua would probably have a swimming pool complex regardless of geothermal resources, but it may not be heated or may have higher admission charges to pay for fuel, making it less accessible. Heating pools increases the number of visitors throughout the year, contributing to income to support the pool.

Southern Trust Sportsdrome and the Rotorua Community Youth Centre

The Sportsdrome, owned by the Rotorua Lakes Council, is a 1,450 m^2 space, heated by geothermal energy. It provides a venue for local and national sporting events, including school sports, performing arts and exhibitions. Although a commercial venture, the Sportsdrome contributes to social wellbeing in bringing people together and providing a facility to support people in achieving life satisfaction.

The Rotorua Community Youth Centre provides for social wellbeing of Rotorua youth.

The contribution of geothermal in these facilities is in space heating, which would otherwise be heated through other, potentially more expensive, heating sources.

Cultural wellbeing

The Rotorua System provides cultural well-being values of cultural respect, inclusiveness, arts and heritage (NZLGM, 2019). In Rotorua, visitors to geothermal attractions cite the ability to experience Māori culture as part of the reason for visiting (BOPRC, 2017). Visitors also referred to spending time with family and friends (inclusiveness), and geothermal as uniquely New Zealand (BOPRC, 2017).

- Cultural values – spiritual, aesthetic, inspirational and other cultural associations. Ongoing customary Māori uses of geothermal include cooking, preserving, healing, ceremonial uses and bathing (Stewart, 2006).

There are no resource consents recorded for marae or other uses specific to Māori in the Rotorua area, however, under s14(3)(c) of the RMA 1991:

> *A person is not prohibited…from taking, using, damming, or diverting any water, heat, or energy is – in the case of geothermal water, the water, heat, or energy is taken or used in* accordance *with tikanga Māori for the communal benefit of the tangata whenua of the area and does not have an adverse effect on the environment; …*

Although resource consents are not required, a recent report (Conroy and Te Rotorua Wai Ariki Ahi Kaa Roa, 2021) sets out the historical legislation designed to manage and/or protect geothermal resources. These, along with the 'development' of the Rotorua area have influenced Māori access to geothermal resources. Arguably one of the most far-reaching in recent times was the bore closure programme in the 1980s. Conroy et al. (2021) reported:

> *While the focus of this programme was the protection and restoration of geothermal taonga, there* were *significant and long-lasting impacts to hau kāinga across Rotorua who lost prized geothermal resources for bathing, home heating, healing and cooking. It also saw the loss of access to geothermal wells for home heating for entire central city suburbs.*
>
> *The process and cost of* licensing*, constructing a reinjection bore, and paying a royalty fee, meant that domestic well owners could not afford to keep their wells open.*

While resource consents can be obtained for geothermal water or geothermal heat in the Rotorua system, the costs of drilling wells (estimated cost) may be a barrier to uptake. Conroy et al., (2019, p.43) report that:

> *Although the bore closure programme was in place to restore the health of geothermal taonga, the* restrictions [from the bore closure] *disproportionately affected domestic well owners who could not afford the cost of licensing; reinjection bore construction and paying the high royalty fee*

and that consequently a range of cultural wellbeing benefits were lost, for example (Conroy et al. 2019, p.43):

- Whānau lost their sole source of heating, particularly at Ōhinemutu and Tārewa Pounamu.
- Communal bathing pools remained unused for decades.
- Marae lost access for heating and cooking (i.e. steamboxes).

7.0 Discussion

Kawerau Geothermal System

The Kawerau System is a high temperature, deep resource. Capital costs for development are high and therefore resource consents have long timeframes. The energy from the Kawerau System provides process heat and electricity and has a role in helping New Zealand reduce its greenhouse gases.

The Climate Change Response (Zero Carbon) Amendment Act sets out New Zealand's domestic greenhouse gas emissions reductions targets:

- Net zero emissions on all greenhouse gases other than biogenic methane by 2050.
- 24-47% reduction below 2017 biogenic methane emissions by 2050, including 10% reduction below 2017 biogenic methane emissions by 2030.

And New Zealand's Nationally Determined Contribution target under the Paris Agreement is (MfE, 2018):

- A 50% reduction of net emissions below gross 2005 emissions by 2030.

As New Zealand moves towards its greenhouse gas emissions targets, the benefits of geothermal resources become increasingly relevant. The $70M Decarbonising Industry fund was created to incentivise shifting to fossil fuels for process heat to clean energy sources. Reductions in greenhouse gas emissions such as those described by Essity Australasia (refer Section 5), a recipient of government funding, can bring reputational and financial benefits to businesses, and help to edge New Zealand closer to targets.

Geothermal has increased in importance in electricity generation. In the 10 years to 2020, geothermal generation has increased from 13% to 18% of net generation in New Zealand. About one-fifth of New Zealand's geothermal generation comes from Kawerau. An important characteristic of geothermal is that it can provide baseload generation, which is not common to other renewables currently used in New Zealand.

While the presence of geothermal resources may contribute to a decision to locate in Kawerau, that is not always the case. Kawerau-based business Essity Australasia originally established in Kawerau in 1955 because of proximity to pulp mills and forestry[33]. At that time the company didn't have access to geothermal energy and relied on reticulated natural gas to generate steam for drying. In 2011 Essity shifted from natural gas to geothermal energy, although it still relied on natural gas for some of its processes. The switch resulted in lower production costs and lower CO_2 emissions[34]. The lower costs associated with reduced emissions may increase the attractiveness of Kawerau for businesses, increasing the economic impact associated with the resource.

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[33] Kawerau also has a good rail connection to the Port of Tauranga, although that is not used by the company at this time.

[34] Essity Australasia https://environmentalchoice.org.nz/our-news/case-studies/asaleo-care/

The presence of the industrial activities in the Kawerau System increase business activity in the area, such as the industrial area sited adjacent to the Kawerau direct use businesses. These industry clusters bring benefits, as described by MBIE (2019, p.28):

> *Regional specialisations create complex ecosystem or clusters of upstream and downstream industries, supporting services including professional and technical services, skills and training, and transport and other infrastructure configured to the needs of the industry.*

The search for improving transport efficiency of export goods from Kawerau to the Port of Tauranga has resulted in the development of the Kawerau Container Terminal, bringing $20M of development funding from the Provincial Growth Fund (NZ Govt, 2020b), making the Kawerau area more attractive for business growth, including in demand for its geothermal resources. The investment will bring an estimated 150 jobs to Kawerau in its construction phase[35], and some longer-term jobs. While this will be good news for Kawerau, it may come at the expense of income and jobs elsewhere in the region, so the net regional effects are not clear at this time. Wider economic and social benefits include a reduction in heavy vehicle return trips by 70,000 per year (~200 trucks a day) and reduce annual CO_2 emissions by 25,000 tonnes (Scion, 2018).

The role of business structure and location is particularly relevant to activities in the Kawerau System, which is characterised by large, consented takes, and high investment and returns. While GDP is a measure of economic activity at a particular location, in many cases the distribution of profits occurs outside that area. For example, Mercury Energy generates electricity in Kawerau, employs about 17 people on-site, and a larger number of supporting, administration and managerial staff elsewhere in the region and NZ. Mercury Energy shareholders, located in New Zealand and around the world, receive distributed profits. The GDP benefit to the Kawerau district and wider region is likely to be very small. In this case, the local jobs are the major benefit to the region. The return to the region and neighbouring regions is likely to be greater when the profits are distributed or reinvested locally.

Tauranga Geothermal System

The Tauranga System is characterised by a shallow low temperature (40-70^{o}C) system, interconnecting with the groundwater aquifer. The prime beneficiary of the geothermal system in the Tauranga area is the community through geothermal water in swimming pools throughout the region.

Resource consent data indicates that 77% of the consented geothermal water in the Tauranga System is used for its geothermal properties. Whether a well produces cool or warm water depends on the location and depth of the well, although this is not always the case. In some cases, cool water is sought but a well produces warm water. When that occurs a resource consent to take geothermal water is required. There is no permitted activity level for warm water, so all warm water takes are recorded in the consenting system (except energy taken or used in accordance with tikanga Māori for communal benefit of tangata whenua[36]).

[35] Provincial Growth Fund invests $20M in Kawerau's future | RNZ News

[36] RMA, s14(3)(c).

In the Tauranga System geothermal water is allocated on a first-come-first-served basis, that is, a person applies for a consent and if there is sufficient water available the consent is granted, ideally an efficient amount for the proposed activity.

A large area of the Tauranga System is less than 50% allocated, and in those areas most applicants for geothermal could expect to obtain a resource consent suitable to their proposed activity. In 2020, two consents were granted for geothermal water – one for community use and one for domestic use. In 2021 four consents were granted for geothermal water of which three were for domestic use and one for commercial use. It is not clear why demand is low, except the costs of establishing a geothermal water take are relatively high (>$130,000) and can be uncertain.

Allocative efficiency requires that any resource should be allocated in a way that maximises total value. Determining allocative efficiency is complex. Information is asymmetric – users know more about the value of their business than government agencies, which typically do not have sufficient information to identify the most efficient uses for resources. In any case, returns from economic activities can change over time, altering allocative efficiency. In cases where warm water is used where cold water is desired, there may be potential higher value uses, but if the resource is under-allocated, then any productive use is likely to be a higher value than no use. A downside of allocating the geothermal water now to non-geothermal uses is that it will not be available in the future to potentially higher value geothermal uses.

Requiring unused allocation be relinquished for redistribution would assist in moving the resource to higher value uses. That process is assisted by s125 of the RMA, which enables a regional council to cancel consents that have not been given effect to within five years. Some unused consents have been voluntarily surrendered to avoid the annual costs associated with having a consent, including charges under s136 of the RMA. The incentive to surrender unused consents early may be increased if consent holders knew an unused consent would be unlikely to be renewed.

Potentially allocative efficiency could be achieved through an efficient trading scheme. Under a trading scheme the consent holder would sell if someone offered a price higher than the seller's value for the consent. Requirements for an efficient trading scheme include a fully allocated resource, and enforcement of rules and limits (i.e. no one can cheat), low transaction costs (e.g. a simple and transparent transfer system) and many buyers and sellers. The latter is typically not the case in environmental markets (Greenhalgh et al. 2010).

Other than the obvious impediment to market efficient of a small number of buyers and sellers, there are practical problems, for example, the geothermal field may be localised and not present where the buyer has access to it.

Not all geothermal water consents are metered. Currently there are 147 abstraction points for geothermal water in the Tauranga system. Of those, 75 (51%) are metered. The lack of metering is a legacy problem – early consents did not have metering conditions, but consents issued more recently recognise the need for managing the increasingly scarce and valuable resource[37]. Consent renewals will

[37] The Resource Management (Measurement and Reporting of Water Takes) Regulations 2010 and National Environmental Standards for Freshwater have metering and reporting requirements which only apply to fresh water, not geothermal water.

solve the metering problem over time - by 2026 when pre-RMA consents have been renewed or surrendered just seven consents will not have metering conditions.

A potential drawback of a trading scheme is that all resource consents would be used to allowable limits, which evidence suggests is unlikely to currently be the case (Kroon, 2021). Until all consents are used to allocated limits the Regional Council will not know the full extent of the effects of current allocation on the resource.

The surrender system provides a means of adaptive management – giving the Regional Council greater ability to manage the system, for example, to choose not reallocate surrendered allocation if monitoring shows the resource use has reached sustainable limits. In a trading scheme Council would have to work through a process to wrest allocation from people who hold legitimate and valuable rights.

Rotorua Geothermal System

The Rotorua System is characterised by a very high temperatures at shallow depths, with many significant natural features. The geothermal water has a high mineral content, and the system has high social and cultural benefits. A primary value of the resource is in providing tourism experiences.

There is currently allocated water available in the Rotorua system. A limiting requirement is that the take must be a distance of at least 1.5 km from Pohutu Geyser (i.e. taking geothermal water within this zone is a prohibited activity – rule 13.5.3(b)(ii) - Rotorua Geothermal Regional Plan 1999). Despite this, there is a low level of demand (Peng and Moore, 2021).

A high-level estimate of the costs of establishing a geothermal heating scheme for nine motels and one hotel[38] in Rotorua is provided in Peng and Moore (2021). The estimated cost of planning, consenting, construction and installation of the heating systems totalled $2.5M, with a payback period from reduced energy costs (e.g. electricity, gas) of 13 years[39]. Although this appears quite attractive, Peng and Moore (2021) cite cost and unwillingness to share supply (which would enable sharing of costs) as barriers in relation to district heating schemes. They are also relevant for other businesses considering investment. It seems reasonable to conclude that at this time the benefits to businesses of switching to geothermal for heating are outweighed by the costs – which include consenting costs (well drilling, and risks/uncertainty.

Despite the current availability of resource consents in Rotorua, there may be some uncertainty about future allocation. Peng and Moore (2021) states that further research is needed to refine the existing model (Burnell's model) because of limited understanding of deeper areas below the known aquifer, and incomplete or outdated information on actual energy take. This report is publicly available and may influence decisions to invest in geothermal wells.

[38] A multiple property supply such as this is known as a district heating scheme (Peng and Moore, 2021).

[39] The estimates provided by Peng and Moore (2021) were higher than an earlier estimate for the same district heating scheme scenario based on higher estimated construction costs. The earlier estimate resulted in a cost of $1,787,000, with a payback period of nine years based on reduced energy (e.g. electricity, gas) costs.

Swimming pools

Public, heated, swimming pools are a community benefit in the Bay of Plenty, arguably available due to the presence of geothermal resources. In putting together this report, territorial authorities inside and outside the region were contacted in an unsuccessful attempt to locate a cost-benefit analysis or business case for using geothermal heat versus other forms of energy for heating pools. Knowledge of the marginal costs of geothermal relative to other heating methods would enable an assessment of community benefits.

If a proposed policy was to reduce the accessibility to heated pools, then it may be useful to commission a case study to determine the marginal costs. The study could be done as a desk-top exercise. For example, a case study could be developed for the Kawerau pool, which is in need of a new well. Currently the Kawerau District Council has a budget of $75,000 for decommissioning the existing well, establishing a new well, connecting the new well to existing infrastructure, and ongoing maintenance. In this type of analysis, the potential for heat sharing could also be explored – for example, the Rotorua swimming pool complex shares the bore with the nearby backpacker accommodation.

8.0 Conclusions

This project was initially planned as an update of the Conroy and Donald (2014) report and evolved into a project that provides much of the s32 analysis related to the status quo policy option. The evolution has provided a more useful analysis to assist in developing a s32 evaluation in relation to current and alternative policies. Alternative policy proposals will still require similar evaluation.

The Kawerau, Tauranga and Rotorua geothermal systems are the focus of this report. Electricity generation in the Kawerau System, and direct uses in each of the systems contribute to the regional economy in GDP and jobs and provide wellbeing benefits. The systems are diverse, and each provides a different set and level of benefits.

Kawerau Geothermal System

- Geothermal direct use and electricity generation provides more than 700 jobs on-site at Kawerau with additional staff employed elsewhere in the region and New Zealand. Additional jobs arise locally and across New Zealand because of businesses supplying the Kawerau-based businesses.
- Direct use includes pulp and paper manufacturing, wood product manufacturing and dairy product manufacturing which together contribute more than $150M to Kawerau GDP. The impact on the regional GDP includes the Kawerau contribution plus indirect and induced impacts at the regional level.
- Geothermal generation contributed $34M to regional GDP (value-added) in 2019, and $80M with indirect and induced contributions.
- Businesses at the Kawerau site have made substantial capital investments.
- The extent to which the region benefits from the associated economic activity depends on whether profits and wages are spent in the region, and the opportunity cost of all inputs.
- An important environmental wellbeing benefit of the Kawerau resource is the CO_2 reduction that it can bring in relation to other process heat sources. Essity Australasia provides an example for a single business of 28,000 tonnes per annum in the conversion from natural gas to geothermal energy. This benefit is likely to increase, and potentially drive demand for the Kawerau resource.
- There is an opportunity to investigate cultural wellbeing benefits for this resource.

Tauranga Geothermal System

- Community facilities (e.g. public pools, schools) is the biggest single use geothermal water (by volume) followed by private use (pools, spas, space heating). These bring economic and social wellbeing benefits to the regional community.
- Businesses relying on geothermal water comprise horticulture (e.g. greenhouse heating) and tourism (e.g. mineral pools, space heating). The businesses involved are small and diverse, and the likely impact on GDP is minimal, although for individual businesses the impact of changes to allocation may be substantial.

- The system is a shared groundwater resource, and about 23% of the consented geothermal water is used for non-geothermal uses, mostly for horticulture (irrigation and frost protection). Currently there appears to be spare capacity in the system, but that may not always be the case. Allocation to non-geothermal uses now may reduce future allocative efficiency.
- Allocation in the Tauranga system is according to groundwater availability; there is no specific allocation system for geothermal water in the Tauranga system.
- Setting up a system that encourages surrender and/or cancellation unused resource consents would assist in improving allocative efficiency and enable adaptive management of the resource.
- A large part of the system area is less than 50% allocated. Barriers to investment haven't been investigated, although the low demand suggests that for potential users the perceived costs and risks may outweigh benefits.
- There is little information available about cultural well-being benefits. This may be an area for further investigation.

Rotorua Geothermal System

- Commercial takes make up the single largest group in the Rotorua System, at 39 % of the take. Mixed consented takes (e.g. commercial and domestic) lift this percentage.
- The Rotorua Lakes Council holds several consents. Their use of geothermal energy provides the community with commercial benefits from the plant nursery (Infracore) and through water and space heating in council facilities.
- Many diverse businesses use the Rotorua geothermal resource. Estimating the GDP contribution is not possible. However, access to the resource is likely to be important to individual businesses, especially if it a pivotal part of the business.
- Multiple housing heating is a feature of use for this system, and accounts for 17% of the total consented volume, which is similar to the consented volume community facilities.
- Māori rights to geothermal resources are a permitted activity under the RMA. Despite this, the work of Conroy et al (2019) suggests that in Rotorua, cultural benefits haven't recovered since the bore closures in the 1980s. This tends to suggest that reestablishment costs may be the impediment to recovering the cultural uses and restoring those wellbeing values.

Information gaps

Several information gaps have been identified. Their relevance will depend on whether alternative policy options are likely to impact on existing consented uses, and scale and significance of any changes to current policy settings (s32(1(c)). The information gaps identified are:

- The negative impacts resulting from the current policy approach (costs). These may have been identified through the plan change process underway and will be required in the s32 evaluation report. Where practicable they should be quantified (s32(2)(b)), and they may be able to be monetised.

- The marginal cost of geothermal versus other energy sources for direct use has not been calculated due to an absence of information on the cost of geothermal energy at a unit level. This is particularly relevant for the Kawerau System, which has high capital investment and long-term consents. However, getting this type of information may not be possible given the small size of the sector and confidentiality, and if alternative policies do not change the status quo allocation, then it is unlikely to be necessary.
- No information was able to be sourced on the marginal benefit of geothermally heated pools. While this could be done as a desk-based exercise, it is unlikely to be required unless alternative policies reduce the consented volume to pools or prevent further allocation.
- Wellbeing benefits have been identified qualitatively, but some may require quantification, and for some monetisation could be considered. Wellbeing costs in any form are largely lacking from the report. These may become relevant depending on the anticipated effects of alternative policies.
- Ecosystem services pertaining to geothermal resources were listed by Luketina (2010), Cook et al. (2017) and Wildlands (2018). There may be opportunities to quantify and monetise these, although monetising can be controversial because it implies that trade-offs between natural and financial capital are acceptable. If this approach were to be used it would be best to first establish which trade-offs are socially acceptable and monetise only those. However, it may serve no useful purpose in this instance.
- Demand is relatively low for the Rotorua resource, and barriers to investment have been identified (Peng and Moore, 2021). Similar barriers may exist in the Tauranga area, where there appears to be a significant amount of geothermal energy available. The barriers to use could be tested further in each area through a survey.

Next steps

- Identify wellbeing costs related to the current policy approach for the three systems.
- Identify any other economic impact or wellbeing benefits, including filling identified gaps, if necessary.
- Identify economic impacts and wellbeing benefits and costs of alternative approaches, quantify is practicable, and identify where further analysis is required.
- Decisions about the scale and significance of the environmental, economic, social, and cultural effects anticipated (s32(1)(c)) will assist in determining whether information gaps are relevant, whether quantification is necessary, and the level of detail required.

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Appendices

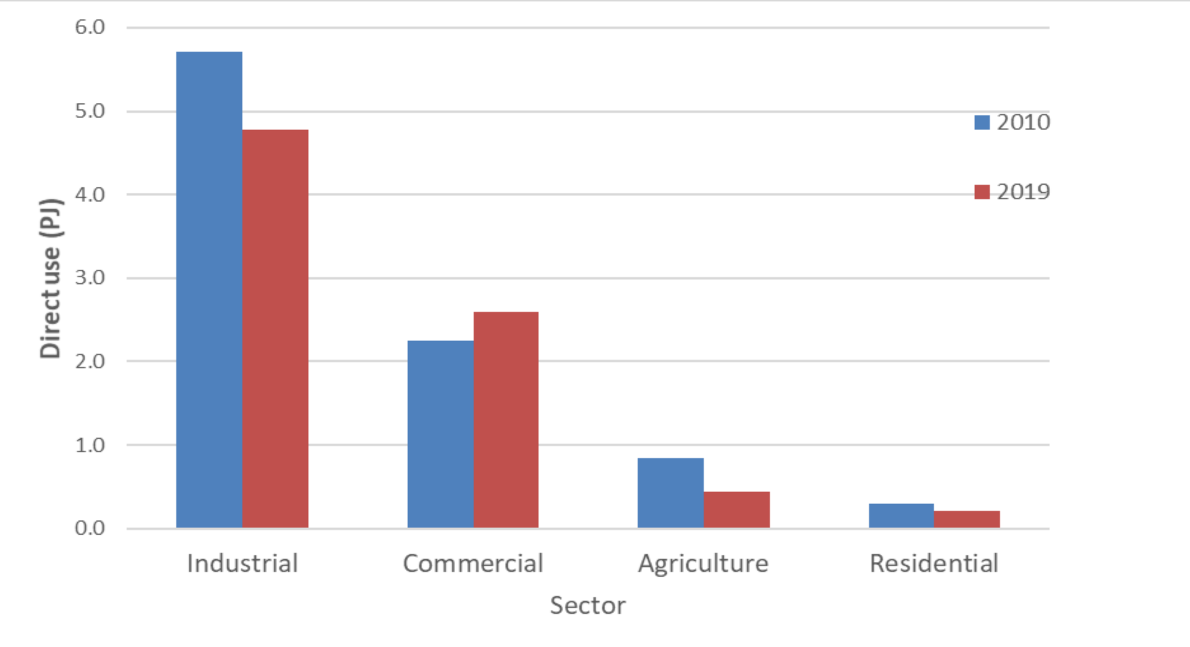
Appendix 1: Background – economic uses of geothermal resources

Direct use

Direct use of geothermal energy refers to a range of applications that use thermal (heat) energy without transformation to electrical, chemical, or mechanical energy (GNZ Science, 2018b). In 2019, total direct use in New Zealand was 8.04 petajoules (PJ) (MBIE, 2020c). The New Zealand Geothermal Association describe direct use as:

> *Direct use involves using geothermal heat directly (without a heat pump or power plant) for such purposes as heating buildings, industrial processes, domestic heating, greenhouses, aquaculture, public baths and pools. Direct use can use high and moderate to low temperature geothermal resources.*

New Zealand has a long history of direct use of geothermal energy, dating back to early Māori use for bathing, healing, cooking, and community life (Climo, Bendall & Carey, 2017). For the past 60 years geothermal energy has been used for industrial applications and electricity generation. The greatest demand for direct use is from the industrial sector, taking 4.78 PJ (60%) in 2019, followed by commercial use (2.6 PJ), agriculture (0.45 PJ) and residential (0.21 PJ) (Figure 2).



Source: MBIE (2020c)

Figure 10: NZ direct use of geothermal energy, by sector, 2010 and 2019

In the past 10 years commercial geothermal direct use has increased by 15%, with most of the increase occurring from 2010 to 2013 (Figure 3). Use by the industrial, residential and agricultural sectors has decreased by 16%, 31% and 47% respectively, although the industrial sector decrease occurred from 2010 to 2013, with no discernible trend over the past 6 to 7 years[40].

[40] Total electricity consumption (GW h) by the industry sector may provide clues about the changes seen in geothermal direct use. For example, electricity use by the wood, pulp, paper and printing subsector decreased by 31%, while electricity use by the food processing subsector increased by 25%. By comparison, electricity use by

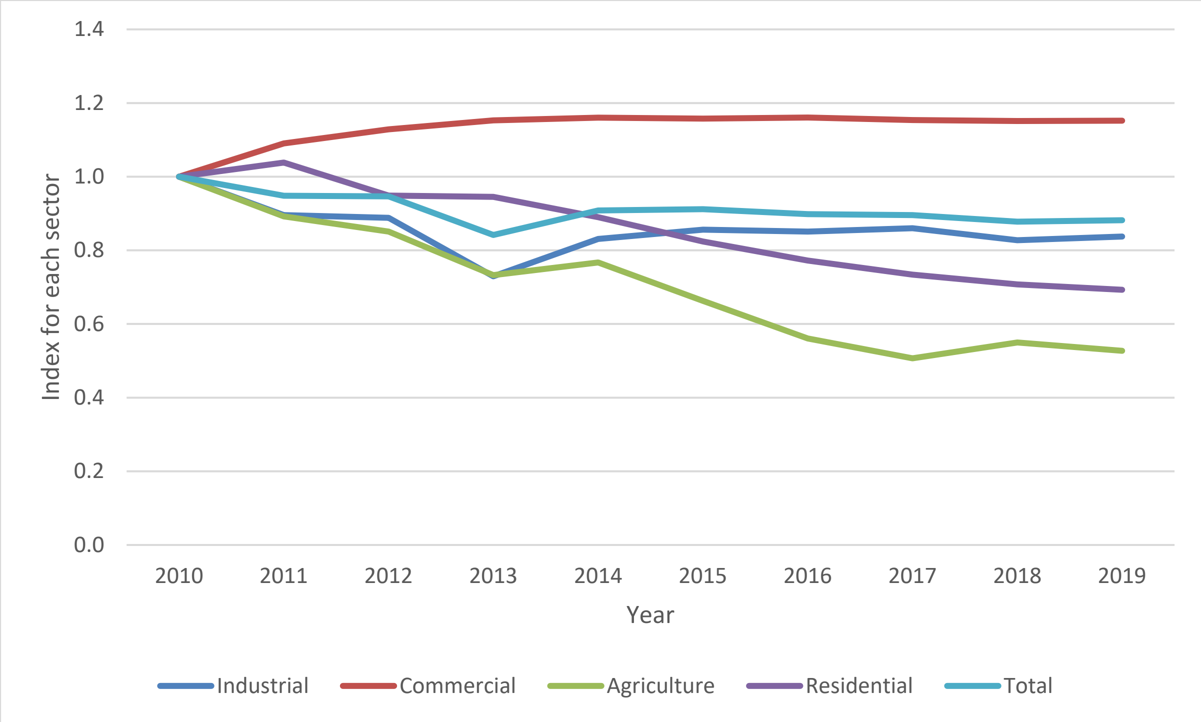


Figure 11: Changes in national geothermal direct use by industry sectors (2010 = 1.0)

Geothermal direct use has the benefit of displacing carbon dioxide emissions. Blair et al. (2018), reports that while 'most geothermal sector operations have greenhouse emissions associated with construction, maintenance and transportation', however geothermal developments can result in significantly fewer emissions relative to coal and gas, which are also used in process heat in New Zealand.

Direct use of geothermal energy is seen as an area for growth by the New Zealand Geothermal Association (NZGA), which aims to increase direct use by 7.5 PJ in new projects across New Zealand. NZGA's strategy is active promotion of direct use through information, advocacy, and incentives (NZGA, 2017).

There is potential for businesses to use lower temperature heat released in the electricity generation process, known as 'cascading' uses (Lawless Geo-Consulting, 2020), although the necessity of locating close to the source can be a limitation (MBIE, 2019). The opportunity to realise this growth will be determined at least in part by system classifications in both the Bay of Plenty and Waikato regions[41].

The Kawerau system is the world's largest direct geothermal heat use at one location (Bloomer, 2015), providing heat for industrial processes for large businesses situated on the Kawerau geothermal field, and for some community uses, such as the local public swimming pool. The consented take from the Rotorua and Tauranga systems is relatively small.

the mining, chemicals, basic metals and other minor sectors has remained fairly constant over the past 10 years, although year-to-year variability does occur.

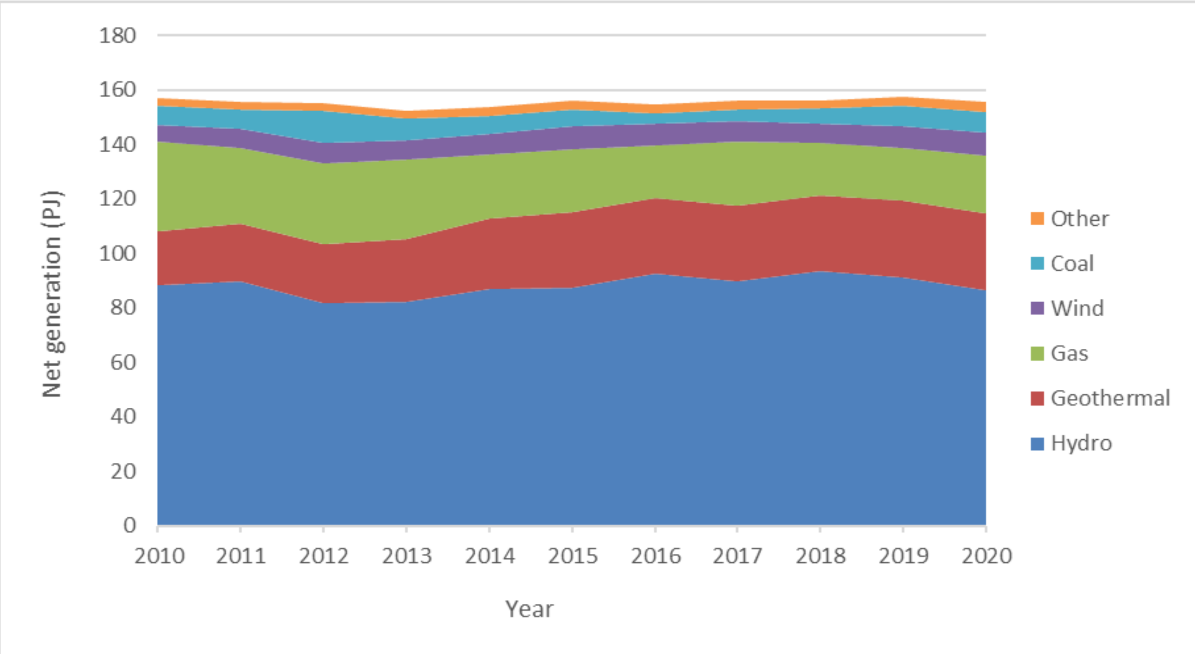
[41] Five of the seven Development Geothermal Systems in the Waikato region are currently developed.

Geothermal electricity generation

Geothermal generation uses the geothermal water to power steam turbine generators to produce electricity (GNS Science, 2018b) or heat a secondary fluid that in turn, drives the turbine generators to produce electricity.[42] Geothermal systems require careful management and monitoring to control water and pressure and prevent land subsidence, limit the rate of depletion, and provide a renewable source of electricity (EECA, 2016). Geothermal water (and sometimes the condensed steam and gases) can be reinjected into the wells in the geothermal system, which helps to recharge the geothermal system, stabilise the ground and minimise emissions.

Net electricity generated by the national grid has remained steady over the 10 years to 2020 (**Source: MBIE (2021 DATA)**

Figure 12). Based on net electricity generated, the share of net generation from renewable sources has increased from 74% of total net generation to 81% and has been as high as 84% (2018), and the share in any year can vary depending on hydro lake inflows (MBIE, 2021). Geothermal generation has increased from 13% of total net generation to 18%. As a renewable share, geothermal has increased from 17% of renewable generation to 22%. About one-fifth of New Zealand's geothermal generation comes from the Kawerau System, which is the sole source of geothermal electricity generation in the Bay of Plenty region.



Source: MBIE (2021 DATA)

Figure 12: Net generation by fuel type, 2010 to 2019 (PJ).

[42] Jaime Quinao (personal communication, Email July 30, 2020).

However, conversion of geothermal energy to electricity is less efficient than other thermal power plants (Figure 13), and depends on factors including power plant design, size, gas content, parasitic load and ambient conditions (Moon and Zarrouk, 2012). In a worldwide review of 94 geothermal powerplants, Moon and Zarrouk (2012) found conversion efficiency ranged from 1% to 21%, with an average of around 12%. In relation to this, MBIE (2021) note that an alternative indicator to net electricity generated (as in **Source: MBIE (2021 DATA)**

Figure 12) is total primary energy supply (TPES), however a drawback to using that is that the conversion efficiency of geothermal energy to electricity is relatively low, and so that indicator would overstate the renewables share (MBIE, 2021).

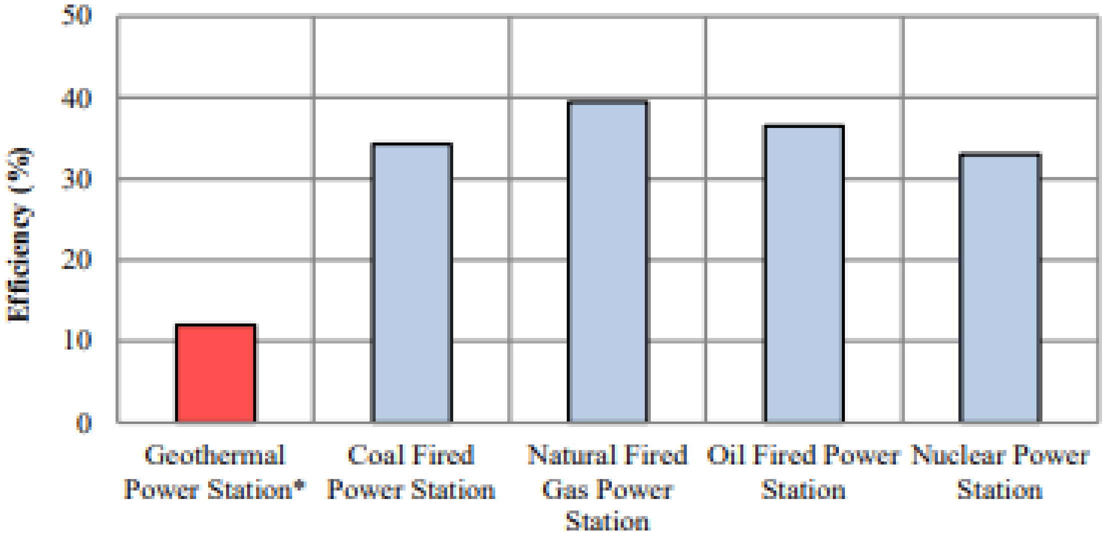


Figure 13: Thermal power plant efficiency (Moon and Zarrouk, 2012)

An important benefit of geothermal generation is that it provides reliable baseload electricity – it is not dependent on favourable weather conditions. Transpower (2018) anticipate that geothermal generation will play an important role in meeting New Zealand's future electricity needs. Geothermal generation is expected to increase by 4% (net) to 10.8 TW h in 2030, and to 15TW h in 2040 (Transpower, 2018). By 2050 geothermal makes up 17.6 TW h (20% of ~88 TW h) of expected electricity generation required, which is about 140% of the current capacity, ignoring any decommissioning of existing generation. The Transpower (2018, p.25) report states:

> *Geothermal is an attractive means of providing baseload generation, and recent innovations are helping to make it climate friendly*.

Electricity generation developments starting in 2020 include applications for resource consents for 35 MW of generation, consented developments for 282 MW, and 31.5 MW of geothermal generation under construction (MBIE, 2021).

Appendix 2: Structure of businesses supplying and using direct heat in the Kawerau System [43]

Business name	Business structure	Ownership	Head office location	Shareholders	Industry sector	Estimated annual production	Employees (est.[44])
Suppliers of geothermal energy for direct use							
Ngāti Tūwharetoa Geothermal Assets Ltd	Registered NZ company	Tūwharetoa Holdings Ltd. Registered NZ company	Kawerau	Ngāti Tūwharetoa ki Kawerau through the shareholders (trustees) of Ngāti Tūwharetoa Holdings Ltd.	Supplier of geothermal energy	Not estimated	11 based in Kawerau
Direct users of geothermal energy							
Carter Holt Harvey Wood-products Ltd	Registered NZ company	Rank Group Limited. Registered NZ company.	Auckland, NZ	Dividends to shareholders. >99.9% owned by a single individual based in NZ; <0.01% to shareholders of overseas companies.	Wood product manufacturing	Log intake 630m^3/year; sawn timber ~350,000m^3	180+
Essity AustralAsia	Subsidiary of public company listed on the Swedish stock exchange	Essity Aktiebolag. Company listed on the Swedish stock exchange.	Sweden	Dividends to shareholders mostly outside New Zealand. Shareholders by country: Sweden (48%), USA (18%), UK (13%), Luxembourg (6%), Belgium (3%), other countries (12%) (Essity, 2020).	Pulp and paper product manufacturing	~50,000 tonnes tissue product	200+ (EECA, 2021)
Oji Fibre Solutions NZ Ltd (Oji Fibre	Registered NZ company	Oji Holdings Corporation, Japan, listed	Tokyo, Japan	Dividends to shareholders 76.5% Japanese investors (Oji Holdings, 2021).	Pulp and paper product manufacturing	~300,000 tonnes/year of kraft market pulp used by	250+

[43] Norske Skog Tasman Ltd closed their newsprint mill in June 2021.

[44] Employee numbers have been sourced from business websites unless otherwise stated.

Business name	Business structure	Ownership	Head office location	Shareholders	Industry sector	Estimated annual production	Employees (est.[44])
Solutions, 2020).		on the Tokyo stock exchange				manufacturers of paper, tissue and building products.	
Sequal Lumber Ltd	Registered NZ company	Sequal Holdings Ltd	Tauranga, NZ	Shareholders largely based in the Bay of Plenty.	Wood product manufacturing	Sawn timber ~75,000m^3	113 in the BOP region, incl. 97 on-site at Kawerau
Waiu Dairy General Partner Ltd[45]	Registered NZ company	67%: 11 BOP-based Māori businesses 33%: Imanaka Ltd Japanese owned company (33%)	Bay of Plenty, NZ Japan	Shareholders of Māori businesses mostly based in Bay of Plenty. Japanese shareholders.	Dairy product manufacturing	~30 million litres of milk processed annually.	44

Additional sources: Carey (2018); Blair et al (2018); NZGA (2019). *Employee counts are those working onsite, excluding suppliers of steam and other contractors

[45] Waiu Dairy received $4.9M from the Provincial Growth Fund in 2020 as a commercial loan to expand its dairy plant at Kawerau. The expansion is expected to provide additional jobs in the Kawerau locality (New Zealand Government).

Appendix 3: Structure of businesses generating electricity in the Kawerau System

Plant[46]	Business name	Business structure	Ownership	Head office location	Shareholders	Year commis-sioned	Installed capacity (MW) [47]	Electricity generated annually (GW h)	Number of employees
TOPP1	Eastland Generation Ltd[48]	Registered NZ company	Eastland Group Ltd, which is owned by Trust Tairawhiti	Gisborne, NZ	Trust Tairawhiti receives the dividend and decides how to distribute. Gisborne community the beneficiary.	2013 2020 re-rating	21.4 23.7	184 220	18 (Kawerau) + general and support staff
Te Ahi O Māui	Partnership between Eastland Generation Ltd Kawerau A8D Ahu Whenua Trust	Registered NZ company Māori Trust	Eastland Group Ltd Part of the Ngāti Tūwharetoa ki Kawerau iwi	Gisborne, NZ Kawerau, NZ	Trust Tairawhiti receives the dividend and decides how to distribute. Gisborne community the beneficiary. Iwi members of Kawerau A8D Ahu whenua, who own the land.	2018	24	210 (Est)[49]	
GDL plant (KA24)	Geothermal Developments Limited[50]	Registered NZ company	Subsidiary of Eastland Group Ltd	Gisborne, NZ	Trust Tairawhiti receives the dividend and decides how to distribute. Gisborne	2008	8.3	30	

[46] Kawerau Binary (TG2) was decommissioned in 2020.

[47] Is the thermal overall power, multiplied by the efficiency of the plant

[48] Sold by NTGA to Eastland Generation Ltd in 2021, with a reported price of $83M (Richter, 2021).

[49] Gisborne Herald (2018).

[50] A wholly owned subsidiary of Eastland Generation Limited, which is owned by Eastland Group Limited, which is owned by the Eastland Community Trust (BOPRC, 2018).

Plant[46]	Business name	Business structure	Ownership	Head office location	Shareholders	Year commis-sioned	Installed capacity (MW) [47]	Electricity generated annually (GW h)	Number of employees
					community the beneficiary.				
Mill turbo-alternator (TA)	Norske Skog Tasman Ltd	Registered NZ company	Oceanwood Special Situations Malta Ltd, a subsidiary of Oceanwood Master Fund.	Malta	Privately owned fund management company	2004	7	44	Unknown
Kawerau	Mercury NZ Ltd	Public company listed on the NZ sharemarket		Auckland, NZ	NZ Crown 51% of shares. Balance owned by international shareholders	2008 2017 re-rating	100 107	800 900	17 (Kawerau) + general and support staff

Sources: NZ Companies Register; GNS database[51]; Eastland Generation (2020); Statistics NZ; MBIE www.mbie.govt.nz/dmsdocument/7040-energy-in-new-zealand-2019

[51] GNS Science (2018b).

Appendix 4: Multiplier effects for geothermal electricity generation

Table 15: Geothermal electricity generation multipliers and estimated value-added contribution to the Kawerau district and regional economies

Energy supplied MW h (000)	Price per MW h	Gross output	Output: Value-added ratio	Value-added multipliers		Contribution to economy		
				Type 1	Type 2	Direct value added	Direct and indirect	Direct, indirect and induced
1,277	$95.59	$122.1m	0.28	0.03 (Kawerau)	0.09 (Kawerau)	$34.4M (Kawerau)	$35.3M (Kawerau)	$37.4(Kawerau)
				0.92 (BOP)	1.33 (BOP)	$34.2M (BOP)	$66.0M (BOP)	$79.9M (BOP)

Table 16: Geothermal electricity generation employment multipliers and estimated contribution to Kawerau and BOP employment

Geothermal generation output	Output : Employment ratio (MEC/$2016)	Employment multipliers		Contribution to employment		
		Type 1	Type 2	Direct value added	Direct and indirect	Direct, indirect and induced
$122.1	2.5	0.03	0.08	35* (Kawerau)	36 (Kawerau)	38 (Kawerau)
		0.27	0.75	44 (BOP)	54 (BOP)	73 (BOP)

Notes:

- Multipliers for value-added and employment provided by Market Economics Limited. They are based on the broad sector of electricity generation, rather than geothermal generation. It is assumed that these are reasonably similar.
- Reconciled generation is from the Electricity Authority
- Wholesale market price for electricity is for the generation weighted average for 2019, sourced from the NZ Electricity Authority www.ea.govt.nz

Appendix 5: Valuing geothermal attributes in the Bay of Plenty region. A survey of visitors to four Rotorua geothermal tourism sites

Executive Summary

The Bay of Plenty Regional Council is currently gathering information to inform a review of the management of geothermal resources, and to develop policy for future management. A gap in the understanding of how the community values geothermal surface features was identified, and a survey of visitors to geothermal sites was designed to address this.

The survey

Staff from the Bay of Plenty and Waikato Regional Councils together developed similar surveys to elicit and estimate geothermal values, and in early 2017 Versus Research interviewed 161 domestic and international visitors at four geothermal sites in the Bay of Plenty region. The Waikato Regional Council carried out their survey at about the same time. The survey included qualitative and quantitative questions, with the purpose of:

1. Identifying the geothermal surface feature attributes people value, eliciting the reasons for those values, understanding why people visit geothermal sites, and why they choose to visit specific sites.
2. Estimating the recreational value (travel cost) for visitors to the Bay of Plenty geothermal resource in 2016.
3. Estimating the contribution of geothermal tourism to the regional economy in 2016.

The Bay of Plenty sites were:

- Kuirau Park - a public park in the middle of Rotorua city.
- Te Puia - a commercial attraction on the edge of Rotorua City offering a variety of tourism experiences in a geothermal setting.
- Waimangu Volcanic Valley - a commercial attraction 25 km south of Rotorua city, featuring geothermal in a natural setting.
- Whakarewarewa – The living Māori Village - a commercial attraction on the edge of Rotorua city offering a variety of tourism experiences in a geothermal setting.

Why people visit and what they value

- About half the domestic visitors and two-thirds of the international visitors said their visit to the area was specifically to see geothermal sites.
- Iconic geothermal features such as geysers and bubbling mud pools were of most interest to the greatest number of visitors across all sites. A small number of respondents expressed a high level of interest in less visible features, such as geothermal vegetation and colourful rocks and minerals.
- Accessibility (e.g. close by) and cost were important reasons for about one-third of visitors' choice of site, confirming the value of Kuirau Park, which is free to visit and in the heart of Rotorua city.

- The uniqueness of geothermal was important to nearly one-third of visitors. People also said they wanted to experience geothermal themselves and/or to share the experience with their family or friends. Verbatim quotes provided in the report confirm a sense of wonder that people feel when visiting these geothermal sites.
- More than half the visitors said that what they most liked about the site they visited was being close to the geothermal activity.
- Many people said that more information or signage would improve their experience. This was particularly the case for visitors to Kuirau Park.

Valuing the recreation experience

Travel cost analysis was used to estimate the individual's value of the experience. To do this the cost of travel to the site, admission costs and spending on the trip was calculated (based on survey questions) and proportioned depending on the purpose of the trip and number of activities undertaken.

Total estimated annual domestic visits to geothermal sites number between 830,000 and 1,800,000, and the average travel cost per visitor is $55. The implied recreation value for domestic visitors is $59.3 to $64.3M/year.

Total estimated annual international visits to geothermal sites are 416,000 to 461,500, and the average travel cost per visitor is $75. The implied recreation value for international visitors is $31.3 to $34.8M/year.

Valuing the contribution to the regional economy

The direct contribution of geothermal recreation to the regional economy was estimated to be between $90.2M and $117.9M in 2016. When indirect value added is included the economic contribution of the sector is $138.0M to $180.3M. With induced effects the annual contribution increases to $141.6M to $185.0M/year.

Based on the output of the geothermal tourism sector, the direct employment is estimated to be 2,052 to 2,681 jobs. Direct and indirect employment is 2,627 to 3,432 jobs, and with induced effects the total is 2,668 to 3,486 jobs.

Limitations and assumptions

The survey sample is assumed to be relatively representative of geothermal visitors to the Bay of Plenty region. The inclusion of visitors to Waikato geothermal sites increased the sample size and improved the robustness of results.

The Domestic Visitor Survey has not been undertaken since 2012, and there is little or no current information about domestic trips. Best efforts have been made to estimate the number of visits, and results have been compared with available information.