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Geoheat – Geothermal Heat Energy Powering Industrial and Commercial Processes in Aotearoa New Zealand

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ABSTRACT

Today in Aotearoa New Zealand, geothermal energy is an important energy source which is poised to play an even greater role in the transition to the renewable low carbon energy future. The paper discusses the New Zealand Geothermal Association's Geoheat initiative which is focused on raising awareness and support for commercial and industrial process heat users, whether fuel switching to a renewable or establishing a new operation, to use renewable geothermal heat energy (Geoheat) in their venture.

Geoheat can deliver temperatures from chilled (4˚C) to around 220˚C, and offers a number of advantages to industrial users, being:

- Renewable
- Low carbon
- Cost effective
- Available
- Proven at scale
- Low risk

Fostering Geoheat uptake is primarily associated with existing geothermal operations in the Taupō Volcanic Zone in the Kawerau, Taupō and Rotorua Districts. A diverse range of operations in these districts already use Geoheat, including timber processing, pulp & paper products, dairy product manufacturing, large-scale hothouses and aquaculture. The Geoheat initiative aims to increase the primary energy supplied for process use by 7.5PJ by 2030. Amplify, the economic development agency for the Taupō District, and Bay of Connections, the regional economic development arm of the Bay of Plenty Regional Council, are actively involved, as are a range of Māori-owned entities, consultants, commercial businesses, research organisations and government agencies.

Collectively, the Geoheat initiative priorities are intended to better position Geoheat to deliver new projects, by focusing on six areas:

- Communicate
- Showcase
- Partner
- Represent
- Advocate
- Advance

These themes are detailed in the New Zealand Geothermal Association's 2022-2023 Geoheat Action Plan, released in February 2022.

With the New Zealand government actively driving the decarbonisation of New Zealand industry, and as part of its goals to shift towards a renewable low carbon energy future, geothermal energy is well placed to provide an attractive process heat option for New Zealand industry in districts with developed geothermal resources.

1. INTRODUCTION

Geoheat is the use of geothermal energy as heat in industrial processes. New Zealand is already a world leader in the sector, but much more can be achieved through increasing Geoheat utilisation, particularly as part of the nation's climate change response and in further pursuing of regional economic development opportunities.

To meet the 2030 Nationally Determined Contribution carbon target, and the 2050 net zero carbon target, Aotearoa New Zealand must transition away from fossil fuels, and a range of renewable energy sources will be needed to decarbonise. About 60% of process heat demand in Aotearoa New Zealand is supplied from fossil fuels, mainly coal or natural gas (MBIE 2019). Opportunities exist to decrease carbon emissions in some existing process industries by conversion to or the adoption of Geoheat.

To accelerate this, the New Zealand government is investing significantly in schemes to support existing industry to transition away from fossil fuels, notably the Government Investment in Decarbonisation of Industry (GIDI) fund, which co-invests with industry in major decarbonisation projects. After initially investing NZ$69 million alongside NZ$117 million of private investment from

industry during 2021 and 2022, the government recently announced an increase in this investment to NZ$650 million over 4 years from 2022.

The New Zealand government is also supporting economic growth in the regions through the Regional Strategic Partnership Fund (RSPF), a NZ$200 million fund which looks to achieve improved outcomes of Productivity, Resilience, Inclusivity, Sustainability and opportunities for Māori (PRISM). This is relevant to Geoheat, in that New Zealand's significant developed geothermal resources are located in the regions, notably the Bay of Plenty, Waikato and Northland regions (Figure 1 and insert), rather than the urban centres.

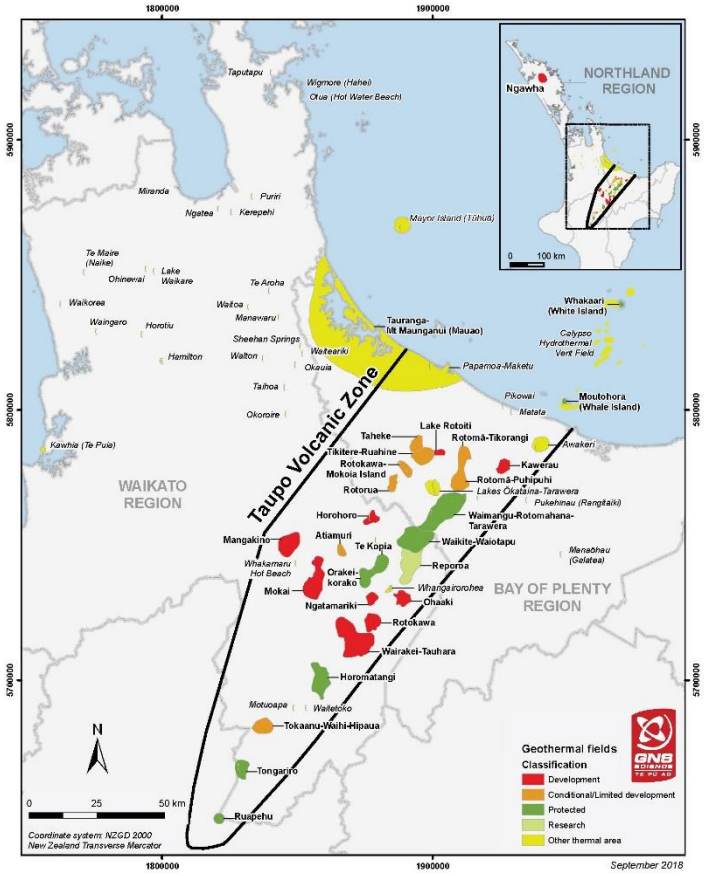

Figure 1: Taupō Volcanic Zone geothermal fields.

Geoheat is also found in districts looking to elevate workforce incomes, skills and resilience, co-located with primary industries seeking to add-value through processing, and where Māori are a significant economic force. Illustrating this point, existing Kawerau-based businesses using Geoheat provide over 650 jobs on-site (Barns (2022) minus 45 for the KGL power plant), with direct annual contributions to regional GDP estimated to be more than NZ$134 million annually (2019 figures from Barns 2022). Sections 2 to 4 of the paper discuss delivered energy to industrial processes from a variety of fuels, in a manner that enables comparisons between fuel types. The analysis includes base pricing, associated carbon charges and the conversion efficiency to deliver energy to the process for each of the base fuel types. Section 4 identifies Geoheat as the lowest cost of any fuel type in delivering energy to an industrial process in New Zealand, with the caveat that it is available at specific locations.

The New Zealand Geothermal Association (NZGA) launched the Geoheat Strategy in June 2017 (Climo et al 2017) and has subsequently published three Action Plans (Climo et al 2018, Climo et al 2020, Climo et al 2022). The NZGA is proud to be taking a leading role in delivering the Geoheat Strategy (Refer Section 5 of the paper). The Strategy seeks implementation of fuel-switching projects and new ventures in the short to medium term, by raising awareness of this energy option, assisting businesses to integrate or switch to Geoheat, whilst supporting progress towards local, regional, and national targets for decarbonisation, delivering infrastructure development, providing support of Māori economic prosperity, and growing the workforce in industries using Geoheat. Geoheat activities were on the global stage at the World Geothermal Congress 2020+1 in Iceland both by way of presentation and in the proceedings (Climo et al 2021).

The economic development arms of the Bay of Plenty Regional Council and the Taupō District have embraced Geoheat as an enabler for their region and districts. Sections 6 and 7 discuss the focus of the economic development agencies (EDAs) Bay of Connections and Amplify (Taupō District EDA).

The material immediately below is the discussion on the cost of energy delivered to industrial processes.

2. DELIVERED ENERGY PRICING

The cost of delivered energy in New Zealand for a given fuel is influenced by the base fuel price, the carbon charge for using that fuel type, particularly the increasing unit price for carbon, and the efficiency of conversion to produce the process energy delivered.

The sub sections below consider the base fuel price for electricity (section 2.1), natural gas (section 2.2) and unit carbon pricing (section 3). Electricity includes the cost of carbon in the base price, for bio-mass there is no carbon charge applicable, whilst for other energy sources; gas, coal and geothermal there are applicable carbon charges which can be determined from information in the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009.

2.1. Base Fuel Pricing – Electricity

The cost of electricity over the last 20 years from Ministry for Business, Innovation and Employment (MBIE) in NZD per Giga-Joule data is plotted in Figure 2.

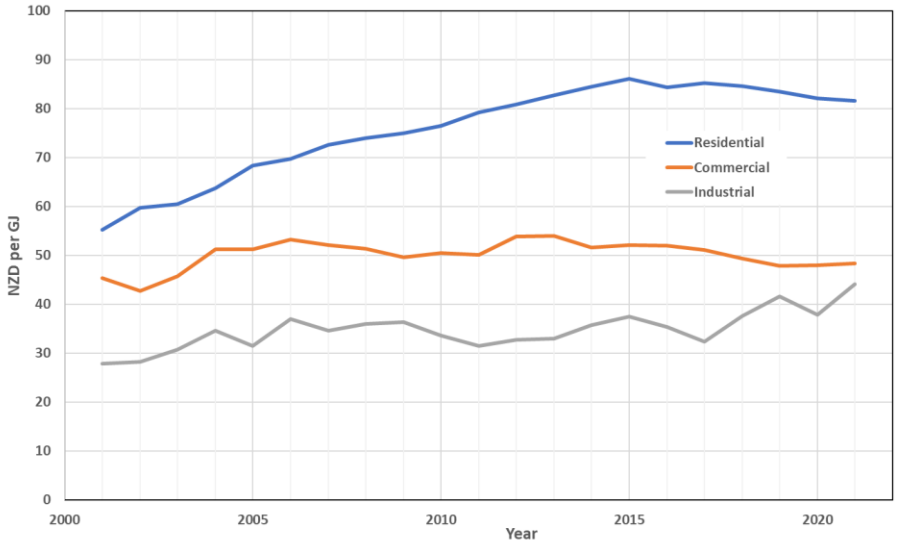

Figure 2: Electricity - NZD per Giga-Joule data 2001 to 2021.

Shown are residential (blue), commercial (orange) and industrial (grey) rates. The industrial rates are relevant to the Geoheat discussion in this paper and in 2021 for which data is available this is taken as $45 / GJ.

2.2. Base Fuel Pricing – Natural Gas

The cost of natural gas over the last 20 years from Ministry for Business, Innovation and Employment (MBIE) in NZD per Giga-Joule data is plotted in Figure 3.

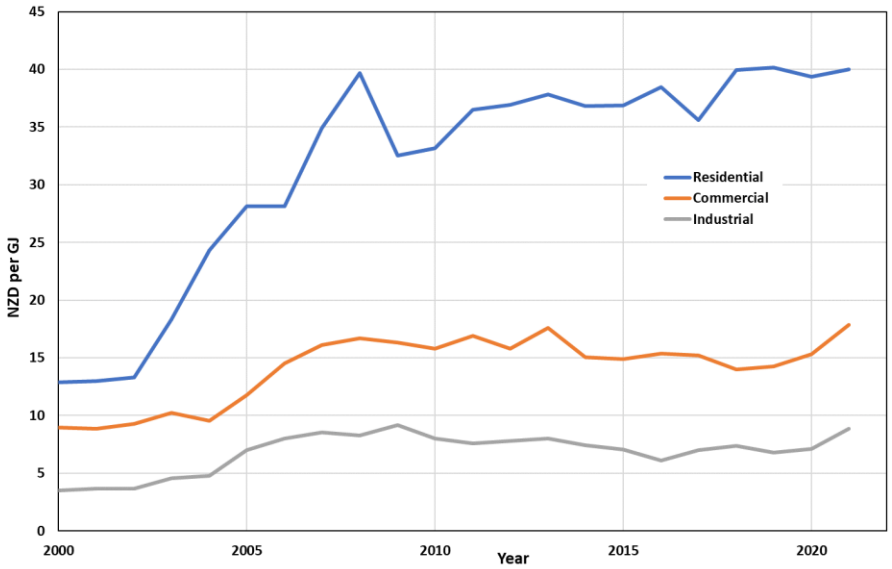

Figure 3: Natural Gas - NZD per Giga-Joule data 2000 to 2021.

Shown are residential (blue), commercial (orange) and industrial (grey) rates. The industrial rates are relevant to the discussion in this paper and in 2021 for which data is available this is taken as $9 / GJ.

2.3. Coal

Coal is widely used in New Zealand in the process industry. The New Zealand government introduced a ban on the installation of new coal fired boilers supplying low (<100 °C) and medium (<300 °C) temperature heat energy effective from the end of December 2021. With increasing unit carbon prices, the carbon emission charges are heavily weighted against coal-fired heat production.

The New Zealand government is currently considering the shut-down of any coal fired boilers that are still running, in 2037.

2.4. Biomass Energy

In New Zealand, there is currently no biomass crop production focused solely on energy production. Biomass energy production is based on scavenging waste residues from timber processing operations.

Biofuel pellet production in New Zealand is a by-product from wood processing operations, turning wood waste residues into pellets. Two of the producers are Azwood (Nelson) and Nature's Flame (Taupō) producing the white pellet fuel which is being, or proposed to be used, widely across New Zealand. There is some consideration for importing more processed pellet fuel for a trial in the Huntly Power station, seeking to extend the life of this coal fired plant out beyond 2040.

It is worth noting that Nature's Flame is co-located with developed geothermal industry in the Taupō District and they converted their heat processes from using waste biomass to Geoheat in 2020. This highlights the potential for Geoheat to not only supply heat energy to co-located processing and production industries, but to also be used to produce other renewable energy sources that can be exported.

3. NEW ZEALAND UNIT CARBON PRICING

Figure 4 plots the carbon unit pricing in New Zealand over the last 12 years. The unit price in 2013 was at a low of ~$3 / tonne. Unit pricing has increased rapidly over the period 2020 to 2022, rising from $25 / tonne to about $85 per tonne.

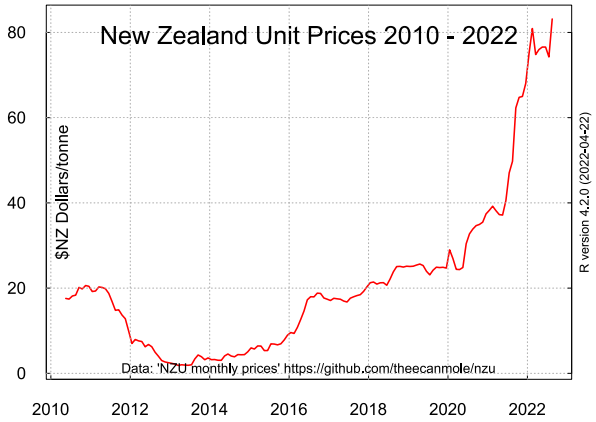

Figure 4: Carbon market unit pricing 2010 to 2022.

The cost of carbon in the delivered fuel costs comparative analysis in Section 4 has been taken at $85 per tonne.

4. DELIVERED FUEL COST COMPARATIVE TABLE

Delivered energy costs for different fuel types have been assessed, and the data is tabulated in Table 1. The calculations are based on heat energy production for process use, not for the conversion of energy in the fuel to electricity.

The base fuel price is in column 2, column 3 is the Carbon factor from the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009. The carbon cost is calculated in column 4 at a unit price of $85 per tonne. The conversion efficiency of the base fuel into delivered heat energy is identified in column 5. For the conversion of electricity to heat there are three rows in the table, two of these use heat pump technology with different performance coefficients (2.5 and 3.5) to produce heat energy at temperatures up to about 100 ºC and the third is for resistance heating for which temperatures over 1500 ºC can be attained.

The delivered energy cost is tabulated in column 6. For electricity, carbon costs have been calculated but are not additive in the delivered energy cost, because they are already included in the base cost of the electricity.

The data has been sorted on least to greatest delivered energy cost (column 6). Geoheat - the direct use geothermal energy - is the lowest cost of any fuel type in delivering energy to an industrial process in New Zealand.

Fuel Type	$/GJ	Carbon Factor tCO2e/GJ	Carbon costs[1]	Conversion Factor[9]	Total Cost $ / GJ Delivered
Geothermal - Direct	8	0.0070[2]	$0.60	0.83[3]	$10.36
Biomass	8	0	$0.00	0.64	$12.50
Electricity - Heat Pump	45	0.0265[4]	$2.25[5]	3.5	$12.86
Gas	9	0.054[7]	$4.59	0.85	$15.99
Wood Pellets	14	0	$0.00	0.81[8]	$17.28
Coal	6	0.0944[6]	$8.02	0.81	$17.31
Electricity - Heat Pump	45	0.0265[4]	$2.25[5]	2.5	$18.00
Electricity - Resistance	45	0.0265[4]	$2.25[5]	1	$45.00

1 Carbon units at $85/tonne – Jarden Securities limited - https://www.commtrade.co.nz/ Downloaded 5 September 2022.
2 Kawerau Industrial emissions factor (steam) from Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 Geothermal p74 Table 6 Part A - 0.0194 times 1000/2780 to convert to t/GJ
3 Using Geothermal steam - computed from geothermal steam (2780j/g) condensed to 100 C liquid (461j/g)
4 MBIE data for 2019 – 157.75 PJ of electrical energy and 4,181.26 kt CO2 equivalent emitted– Carbon factor is 0.0265 tCO2e/GJ
5 Carbon cost associated with electricity is included in the purchase price for electricity. User does not pay this as an additional charge under the Emissions Trading Scheme.
6 Emissions factor for lignite from the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 (SR 2009/285) p73 Table 2
7 Emissions factor for natural gas from the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 (SR 2009/285) p75 Table 10
8 Wood pellet conversion efficiency set to be the same as coal
9 Factor applicable for delivery of heat energy and not for conversion to electricity

The basic data for the table was assembled in late 2021 with an update in electricity, natural gas and the unit carbon price as of September 2022. Base fuel pricing is currently quite dynamic as different fuels experience different demand and supply pressure. For instance, base biomass price is expected to be above $8/GJ as more pressure to use this fuel in substitution for coal increases as the government policy on phasing out coal fired heat production is implemented.

5. GEOHEAT STRATEGY - NEW ZEALAND GEOTHERMAL ASSOCIATION

The NZGA is working to foster the uptake of Geoheat through the Geoheat Strategy for Aotearoa NZ (Climo et al 2017) and the associated Action Plans (Climo et al 2018, Climo et al 2020, Climo et al 2022).

Facilitating innovation, enabling businesses to grow and economies to prosper, jobs to be created, and regions to see the benefits of geothermal first-hand is all part of the Association's vision of "Creating a sustainable future for Aotearoa New Zealand through geothermal".

The increased use of sustainable geothermal resources in Aotearoa New Zealand, including increased uptake of Geoheat, is a key outcome for the NZGA. Members of the association, individuals, and organisations active in the Action Group (Figure 5), are working collaboratively to foster the uptake of Geoheat in ways that also align with their business or organisational priorities.

Figure 5: Organisations involved in the Action Group.

The 2022-2023 Action Plan (Climo et al, 2022) provides a roadmap for the approach through these two years to further progress the uptake of Geoheat in industrial and large commercial applications. An enhanced focus on collective activity underpins the 2022 – 2023 Action Plan, with six aspects in focus:

- Communicate
- Showcase
- Partner
- Represent
- Advocate
- Advance

The collective activity of active participants during 2022-2023 builds on the more separate and individual effort approach that prevailed through the 2018 to 2021 period.

The Strategy and associated Action Plans are designed to be directive, yet flexible, incrementally evolving as efforts reveal the next best steps in the rapidly changing business and energy sectors in New Zealand. Geoheat can deliver temperatures from chilled (4 ˚C) to around 220 ˚C and is on point with particularly relevant characteristics for energy requirements in today's energy sector environment, being:

- Renewable
- Low carbon
- Cost effective
- Available
- Proven at scale
- Low risk

Fostering Geoheat uptake is primarily associated with geothermal operations in the Taupō Volcanic Zone in the Kawerau, Taupō and Rotorua Districts, where there are existing developed geothermal reservoirs. A diverse range of operations in these districts already use Geoheat, including timber processing, pulp & paper products, dairy product manufacturing, large-scale hothouses and aquaculture. The EDAs in the districts and the Bay of Connections are actively involved. Section 6 has material on the Bay of Connections, the economic development arm of the Bay of Plenty Regional Council and Section 7 has material on Amplify, the EDA for the Taupō District.

6. BAY OF CONNECTIONS

The Bay of Connections (BoC) is a regional EDA supporting sustainable economic development in the wider Bay of Plenty area, that includes the Taupō District. Its purpose is to help the region's economy make a positive move into a net-zero carbon economy, creating jobs and fostering higher standards of living for its residents.

BoC has a goal of promoting and sharing knowledge and expertise that is needed to transform the region's economy to take on the challenges that it faces. BoC leads projects where a regional approach is appropriate and works alongside organisations in the development of initiatives focused on advancing sustainable economic development in the wider Bay of Plenty.

There is significant potential for more Geoheat use in businesses, whether existing or new, specifically in the Kawerau, Rotorua and Taupō Districts. BoC have recognised this and have been involved with the Geoheat Strategy since it was launched in 2017 and helped to fund (along with other organisations), a Geothermal Business Development Lead from December 2017 to June 2020, that was focused on fostering the uptake of Geoheat. On the conclusion of that funding, BoC have continued to be an active participant in the Geoheat Action Group.

BoC hosted a Decarbonising Industry workshop on the 26th July 2022 to bring together operators and industry experts to showcase Geoheat solutions, with a focus on the availability and benefits of Geoheat as an option for industrial processes and production systems requiring heat up to 200 °C. The role of Geoheat in the production of other renewable and exportable energy sources (biofuel pellets) for industrial processes was also highlighted.

Kawerau-based tissue manufacturer, Essity, was among those that spoke about the benefits of transitioning parts of their operation to Geoheat. As part of an ongoing commitment to reduce its carbon emissions, Essity has been using Geoheat since 2010 and is now converting the entire heat source used to dry tissue paper on one of its two paper machines to Geoheat, supported with NZ$1.65 million of co-investment from the GIDI fund (discussed in Section 1).

Another presenter, Tnue Ltd, has raised capital from existing and new shareholders, including New Zealand Green Investment Finance (NZGIF), to develop a Geoheat powered manufacturing facility at He Ahi (see Section 8.2). Tnue's SmartFert product offers a significantly reduced environmental footprint compared with standard nitrogen-based fertilisers, including reduced nitrogen leaching and lower CO_2 emissions. Construction is scheduled to start later in 2022, with fertiliser production underway from mid-2023.

7. AMPLIFY

Amplify is the EDA for the Taupō District, with a mandate to grow the local economy, leveraging Taupō's natural advantages while working with business and stakeholders to champion sustainable growth throughout the district. Amplify reworked its strategic approach in 2021, focusing on six strategic areas:

- Home of competitive, innovative and sustainable business
- Smart, nimble and connected
- A place where talent thrives
- Great ideas grow from shed to stock exchange
- Leverage our natural advantage
- Investment ready environment to accelerate growth

Recognising the geothermal features and related industry in the district as a key natural advantage for the Taupō District, Amplify has been active in working to attract new investment and companies into geothermal, while continuing to support the sustainable growth of existing geothermal companies and development of shared infrastructure and collaborations that will underpin these. A broad definition is applied to "geothermal industry", encompassing not only electricity generation, but also Geoheat for processing and production, sustainable mineral recovery, and supporting service and consulting firms.

Geothermal is also recognised as a long-held taonga (treasure) and enabler of economic prosperity for local Māori , the indigenous people of Aotearoa New Zealand. Māori trusts and incorporations are active owners, investors and employers in the industry, including Geoheat-powered dairy factories, hothouses and eco-industrial parks. The kaitiakitanga (guardianship) principles and quadruple-bottom line investment philosophy upheld by Māori – People, Purpose, Planet and Profitability – is consistent with Amplify's vision for sustainable growth of the Taupō district economy.

Recognising geothermal as an opportunity for sustainable economic growth in the Taupō district, Amplify has invested in a part-time Geothermal Cluster Lead since early 2021. This role supports in-bound geothermal opportunities and initiatives for pre-competitive industry collaboration and shared infrastructure, as well as promotion of the Taupō district's geothermal offering. Promotion efforts include launching NZ Geothermal Week in 2021, an annual event showcasing the New Zealand geothermal industry to a wide range of industry, government, education and community stakeholders. The Geoheat opportunity has been raised at several events in the 2021 and 2022 NZ Geothermal Week programs, including highlighting the newly-established He Ahi eco-industrial park, discussed further in Section 8.2.

8. CONCLUDING COMMENTARY

8.1. Industrial and Large scale commercial Geoheat utilisation

Industrial-scale Geoheat supplies can be readily accessed at Tauhara, (Northeast of Taupō) and at Kawerau, and will also be made available on land adjacent to Contact Energy's 170MW Tauhara power station currently under construction (completion date late 2023). Currently about 1 PJ per annum of Geoheat is supplied to the Tauhara industries and about 4 PJ per annum to the Kawerau industries. Industrial-zoned land is available at both locations, and sound transport links exist through either off-road highway roading networks and / or railheads to the Port of Tauranga. The energy suppliers are Contact Energy Limited (Tauhara) and Ngati Tuwharetoa Geothermal Assets (Kawerau).

8.2. Small and Medium Scale Enterprises – He Ahi

Historically, it has been difficult for small and medium enterprises (SMEs) to connect up with Geoheat, due to the large upfront capital investment presenting a significant barrier to entry. Recently at Tauhara, on the outskirts of Taupō on the western side of Rakaunui Road (Figure 6), the Te Pae o Waimihia trust and Contact Energy Limited have partnered to develop an eco-industrial park. This development of over 45 hectares will encompass up to 40 lots ranging from 0.5 hectare to 1.0 hectare in size, with Te Pae o Waimihia offering tenants custom builds for lease and access to Geoheat from Contact Energy wells on the site. With up to a few megawatts available to each of the lots, He Ahi will enable SMEs to establish Geoheat-powered industrial facilities at much lower initial capital costs than previously possible, and this is expected to open up new opportunities and benefits for this size of enterprise.

Figure 6: Land Area identified for He Ahi eco industrial park.

8.3. NZGA, Bay of Connections and Amplify

NZGA continues to take a leading role in the Geoheat Strategy for Aotearoa NZ 2017-2030 which reflects the four key pillars of the Association's vision "Creating a sustainable future for Aotearoa New Zealand through geothermal" through connection, innovation, advocacy, and education. Through the Strategy and the Action Plans, the Association is working to increase the uptake of Geoheat, a genuinely cost-effective and sustainable opportunity for New Zealand industry, that has been firmly embraced as an enabler by the economic development agencies in the Bay of Plenty Region (Bay of Connections) and the Taupō District (Amplify).

8.4. Summary of Geoheat and potential

Geoheat is a sustainable and readily available energy source when utilised alongside developed geothermal industries. We have illustrated why the use of Geoheat is not only economically viable, but also an environmentally sustainable approach to fueling industrial needs in Aotearoa New Zealand. The journey towards decarbonisation requires that all energy sources be scrutinised for their benefit, and that those at our fingertips be used to their fullest potential. Continued uptake of Geoheat will require the support of regional and central governments, as well as focused efforts by operators who can provide Geoheat to end-users.

Geoheat is available now at several locations in Aotearoa New Zealand, and is cost-effective for industrial applications ranging from small (few megawatt) to large (100 megawatt) scale, and should be considered as a viable alternative to traditional fuel sources whether for new ventures or decarbonising established operations. There are many success stories of Geoheat use in Aotearoa New Zealand and, by increasing uptake, we envisage that Aotearoa New Zealand can continue to be a market-leader in geothermal innovation and sustainable utilisation of this native energy resource.

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