nzga
New Zealand Geothermal Association

ACTION PLAN 2024-2025

Geoheat Strategy for Aotearoa NZ

FOREWORD

It is a pleasure to introduce you to the 2024 – 2025 Geoheat Action Plan. The New Zealand Geothermal Association (NZGA) is proud to continue in its role supporting the delivery of Geoheat outcomes, driving the implementation of fuel-switching along with the establishment of new ventures that utilise geothermal heat in Aotearoa New Zealand.

This Action Plan has been developed to assist in furthering the uptake of Geoheat for industrial, commercial and grower process heat applications, enabling businesses to grow and regional economies to prosper. Work is continuing as decarbonisation activities ramp up in the regions. This includes programmes such as the Regional Energy Transition Accelerators, ventures such as He Ahi, Taupō, where it is exciting to see the opening up of opportunities for small and medium sized enterprises (SMEs) to access geothermal heat, and interest from the covered crop sector in low temperature geothermal as it navigates away from fossil heat.

I wish to thank Amplify for funding a Geothermal Cluster Lead through the 2022 – 2023 period. Business development roles continue to be instrumental in raising the visibility of Geoheat use with dedicated roles vital for connecting businesses with opportunities.

Working with our partners, NZGA will continue to champion the Strategy, the Action Plans and the associated activities. Please join us, share the vision, and dedicate time and resources to actively grow geothermal process heat use for the benefit of Aotearoa New Zealand.

Dr. Katie McLean
President - New Zealand Geothermal Association

GEOHEAT TOMORROW'S ENERGY AVAILABLE TODAY

Ngati Tuwharetoa Geothermal Assets Kawerau geothermal / process steam generation plant

EXECUTIVE SUMMARY

Geoheat is a future energy solution available today, with well-established technologies able to support New Zealand's transition to low carbon energy by 2050. The drivers for the energy transition are changing, with pull now coming from businesses, communities and consumers, as well as push from government commitments, policy, programmes and regulatory change.

Geoheat is the use of geothermal heat energy beyond electricity generation. It is a proven, sustainable, cost-effective source of low / no carbon heat, delivering temperatures from chilled (4°C) to around 220°C. Geoheat can be utilised in a diverse range of industries and production systems that require process heat or controlled temperature environments. Applications in New Zealand and globally include wood processing, food processing, industrial manufacturing, aquaculture, horticulture and biotechnology. It is a local off-grid energy source, not beholden to spot prices and market fluctuations, and reduces demand on electrical infrastructure.

The New Zealand geothermal community has long been aware of the benefits of Geoheat, with it being used by New Zealand industries since the late 1950s. In an effort to proactively increase uptake, in 2017 the New Zealand Geothermal Association (NZGA) commissioned a Geoheat Strategy 2017-2030. This strategy outlined a vision for the future of Geoheat in New Zealand, and aimed to double Geoheat use by 2030, an increase of 7.5 PJ, with an associated 500-plus new jobs created. Subsequent two-yearly Action Plans developed by the Geoheat Action Group have identified interim goals and specific activities intended to adapt to the changing energy and carbon landscape in New Zealand to continue to give life to the vision.

This, the 2024-25 Geoheat Action Plan is increasing the focus on low and ambient temperature geothermal opportunities. This broadens the geographic scope to encompass most of New Zealand, substantially increasing the potential uptake and positive contribution of Geoheat.

2024-2025 Ambitious Goals

- The announcement and / or completion of at least 7 new ventures or projects, comprised of a mix of large, and small and medium (SME) enterprises using high temperature Geoheat and new or fuel-switching users to low temperature Geoheat.
- A collective emissions reduction relative to natural gas and coal of between 25,000 and 40,000 tonnes of carbon (CO_{2e}) pa.
- Over $80 million in new investment, including $5-10 million of central government funding for energy transition, industry transformation and economic development.

2022-2023 Achievements

- He Ahi eco-industrial park is being developed in Taupō by Te Pae o Waimihia, and was officially opened in 2022. Its shared infrastructure tenancy model creating an economically-attractive option for SMEs to access high temperature Geoheat.
- He Ahi's first tenant, Tnue, completed construction of the fertiliser encapsulation plant in 2023. Commercial production commenced in March 2024.
- Nature's Flame in Taupō increased production capacity to manufacture wood pellets using Geoheat from 85,000 to 150,000 tonnes pa.
- Full conversion of Essity's paper machine (KPM3) to Geoheat is underway in Kawerau.
- Wai Ariki Hot Springs & Spa in Rotorua, opened in June 2023, uses Geoheat for space heating as well as offering spa experiences directly utilising geothermal waters.

All of these projects and ventures have received some support from government funds intended to support New Zealand's energy transition and grow local economies, including the Regional Strategic Partnership Fund, Government Investment in Decarbonising Industry (GIDI) fund or the New Zealand Green Investment Fund (NZGIF).

The Geoheat Action Group has also gained traction raising awareness and support for Geoheat in New Zealand's energy transition during the 2022-23 period.

2022-2023 Highlights

- GNS Science, with GeoExchange and Dobbie Engineers delivering four Geoheat case studies as part of the Energy Efficiency and Conservation Authority (EECA) Regional Energy Transition Accelerator (RETA) for the Bay of Plenty (BOP) region. This is the first RETA to incorporate a geothermal workstream.
- Geoheat was acknowledged as part of the solution to realise the Forestry and Wood Processing Industry Transformation Plan (ITP), released by MPI in November 2022.
- Increasing international requests for New Zealand advisory services on Geoheat development and technologies. A newly-formed NZGA International Subcommittee can assist the Geoheat Action Group facilitate connections in the international space.
- Partnering with Ministry for Primary Industries (MPI) and covered crop industry bodies to support those sectors to explore options as they transition away from fossil fuels, including a workshop with over 100 attendees delivered during Geothermal Week 2023.

Reassessment of energy costs for process heat undertaken in late 2023 continues to show that geothermal is the lowest cost fuel per GJ, including the cost of carbon at $70 per tonne, for industrial supply at sites such as Kawerau and Tauhara. Geothermal is well positioned to further improve this leading cost-effectiveness, as carbon charges under the Emissions Trading Scheme (ETS) increase in the future. Unabated geothermal process heat technologies have the potential to achieve emissions reductions of between 80% to 100% relative to fossil fuels. This comparison can be made where a geothermal solution can meet the required temperature duty of the application.

In the coming 2024-25 period, the Geoheat Action Group has set out an Action Plan to **POSITION** Geoheat as a viable option for New Zealand operators, **ENABLE** uptake through relevant and timely information and support, and **DEMONSTRATE** the technology to build operator and investor confidence, ultimately leading to more **NEW PROJECTS**.

This will be achieved through targeted **COMMUNICATION**, **PARTNERING** with potential end-users, stakeholder groups and other organisations that support or influence uptake, and **SHOWCASING** Geoheat ventures and success stories. Funding will be sought to secure business development resource to **REPRESENT** the Geoheat community in these activities. Alongside the NZGA, the Action Group will continue to **ADVOCATE** for government policy and investment to enable and support Geoheat use. The group will also **SUPPORT** businesses exploring new Geoheat projects and ventures.

Realising Geoheat's enormous potential requires us all to work together.

We invite you to join us on this mission to realise Geoheat's potential to support New Zealand industries transition to a net carbon zero future and look forward to supporting you on yours.

Truss of Campari Tomatoes.
Photo courtesy Gourmet Mokai.

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Bibliographic Reference

Carey, B., Miller, F., Howie, D., Wells, C., Carden, Y., Tsui, K., Seward, A., Allen, M., 2024. Action Plan 2024 – 2025: Geoheat Strategy for Aotearoa NZ., New Zealand Geothermal Association.

Authors organisational affiliations are documented on page 30.

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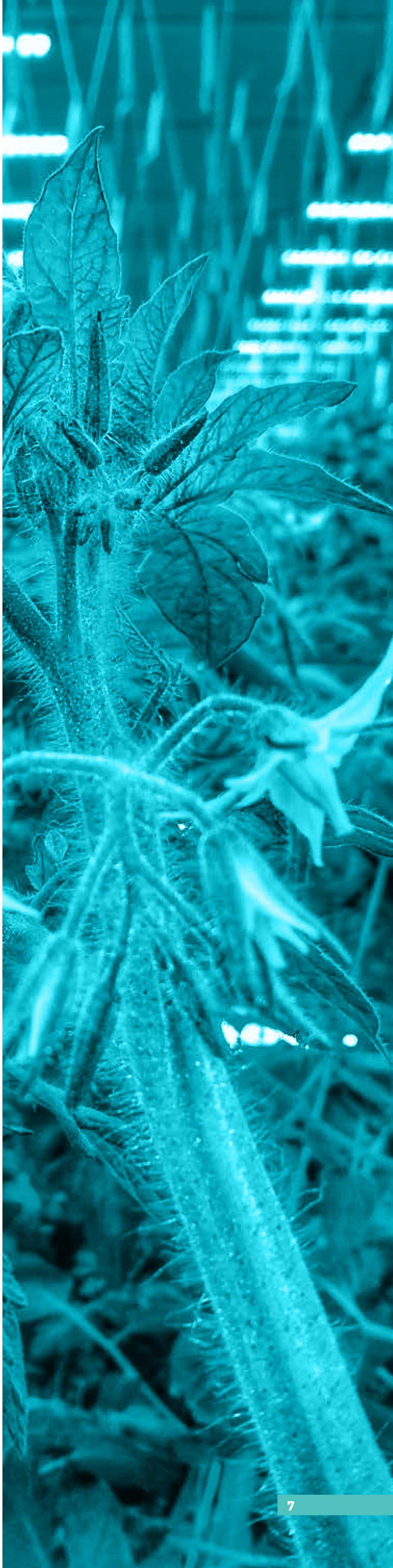
Brief Description

This is the fourth Geoheat Action Plan in the NZGA series fostering the uptake of direct geothermal heat use in industrial and commercial businesses. The 2024 – 2025 Action Plan has an increased focus on low temperature geothermal energy with heat pump augmentation. This has potential for broader application across New Zealand, in sectors such as covered crops, space heating and low temperature processes such as drying produce that are looking for low carbon heat solutions as an alternative to coal and gas.

The Geoheat Action Group that drives this Geoheat Action Plan meets every two months. If you would like to be involved with the group, please email committee@nzgeothermal.org.nz



THE CHANGING ENERGY, CARBON AND GEOTHERMAL LANDSCAPE

There has never been more impetus on businesses to adopt low / no carbon process heat energy.

The drivers for the energy transition are rapidly changing, driven both through governments employing levers to effect change, as well as companies, consumers and communities calling for change.

At the global level, governmental Conference of Parties (COP) commitments will continue to underpin member nation transitions, along with the established national targets and reporting of initiated changes. The COP 28 agreement executed on 13 December 2023 heralds

"the 'beginning of the end' of the fossil fuel era by laying the ground for a swift, just and equitable transition, underpinned by deep emissions cuts and scaled-up finance".

At individual country level, there is continued growth in interest and adoption of Geoheat. Its potential to support new industries and enable sustainable economic development is being explored and implemented across several continents, including Africa, Europe, Asia and Central America. This includes development of large-scale high temperature Geoheat industrial parks, such as the Geothermal Development Company project at Menengai, Kenya.

There is also extensive development of Geoheat solutions, notably in the European Union (EU), to transition existing industry away from fossil-fuels. For example, the Netherlands has developed strategy and implemented related policies and tools to support geothermal uptake to transition from fossil fuels. Covered crops were specifically highlighted in the strategy as having good potential for conversion, and by 2030 ~40% of this sizeable industry is targeted for conversion to Geoheat, producing ~2 million tonnes pa of produce. The transition to 2030 is targeting 30 PJ pa of Geoheat which will reduce emissions by ~1.6 million tonnes pa.

Closer to home, the New Zealand Government support for its COP commitments to date has come through instruments such as the EECA GIDI scheme, the EECA RETA workstreams, the NZGIF, and policy and regulatory change.

In 2023 the Ministry for the Environment (MfE), under the Resource Management Act (RMA 1991), released a National Policy Statement (NPS) for Greenhouse Gas (GHG) Emissions from Industrial Process Heat and a National Environmental Standard (NES) for GHG Emissions from Industrial Process Heat. Consequently, coal-fired heat can only be used for industrial processes that require temperatures above 300°C, with the NES prohibiting discharges of GHGs to the atmosphere from new low to medium temperature coal boilers from July 2023, and from existing coal boilers after 2037. The regulations also prescribe requirements for non-coal fossil fuel discharges, including maximum consent terms of 20 years. The NPS and NES significantly influence heat use at temperatures below 300°C. This will require responses from several sectors including those with controlled production systems, such as covered crops in the horticultural sector, bioreactor applications, food and other primary processors, and other manufacturers using process heat.

In recent years, intent to lower carbon emissions has also developed amongst organisations, communities and companies striving to meet their customer and constituent demands. Green investment is now more mainstream than niche, with a range of financial institutions targeting and funding green solutions. Many councils, non-profit organisations and business are incorporating and reporting on low carbon solutions in their activities and portfolios.

New Zealand's primary sectors and related processors and manufacturers are also needing to respond to product specifications of their international business to business (B2B) and business to consumer (B2C) customers. This drive for transition to low carbon production is reaching back up the supply chain to source and is occurring at a pace that outstrips any government directed emissions targets and budgets. Over $56 billion of New Zealand's $90 billion export earnings come from the primary sectors; international customer carbon mandates will have a profound effect on New Zealand's export-focussed primary industries.

For example, in 2020 Nestle outlined their Net Zero Roadmap to reach net zero emissions by 2050, with interim targets of 20% by 2025 and 50% by 2030. As a major supplier to Nestle, Fonterra announced its own plans in 2023 to reduce its Scope 3 emissions by 30% by 2030. Fonterra is New Zealand's largest dairy company, processing around 80% of total New Zealand milk production, with the entire dairy industry comprising about 28% of New Zealand's export revenue (2023). Multi-faceted approaches along the supply chain will be required to achieve emission reduction targets.

However, energy transition in New Zealand is not straightforward.

While the majority of New Zealand's electricity generation capacity is renewable (87% in 2022), additional electrification requires significant increases in generation capacity and grid upgrades, along with increasing capacity at user's facilities, all with associated investment to meet the increased electrical loads.

Biomass has significant implementation challenges, including supply chain issues such as availability and cost. For instance, increasing use of biomass for energy in Southland moving from 1 to 3 GJ of delivered energy sees the cost of biomass increase three-fold (Figure 18 EECA 2022). In the Central North Island, home of New Zealand's largest plantation forests, forestry experts, Indufor, noted at the EECA RETA BOP November 2023 workshop that only ~12% of total biomass that is not utilised could be diverted for heat energy use, i.e. harvested and not currently utilised.

Geothermal has much to contribute to support New Zealand's transition. Geoheat can provide temperatures from chilled (4°C) to 220°C, able to support a wide range of industries and production systems. Interestingly, many of these relate to primary industry production and processing where Geoheat has potential to not only support New Zealand's energy transition goals, but also enable our primary sectors to develop sustainable processing solutions and capture additional value from produce before export.

As well as being renewable and having low / no carbon emissions, Geoheat has the advantage of being off-grid, cost-effective and cost-stable, not subject to spot prices and market fluctuations. It is not impacted by weather being available 24/7, and collectively, various Geoheat options (high, low and ambient temperature) provide coverage widely across New Zealand. Being a "local" heat resource reduces the need for upgraded grid infrastructure or other transportation capacity increases associated with other energy sources being used for decarbonisation.

Additional geothermal electricity generation capacity is being constructed, with more planned (Montague et al, 2023), and there is significant potential to be explored

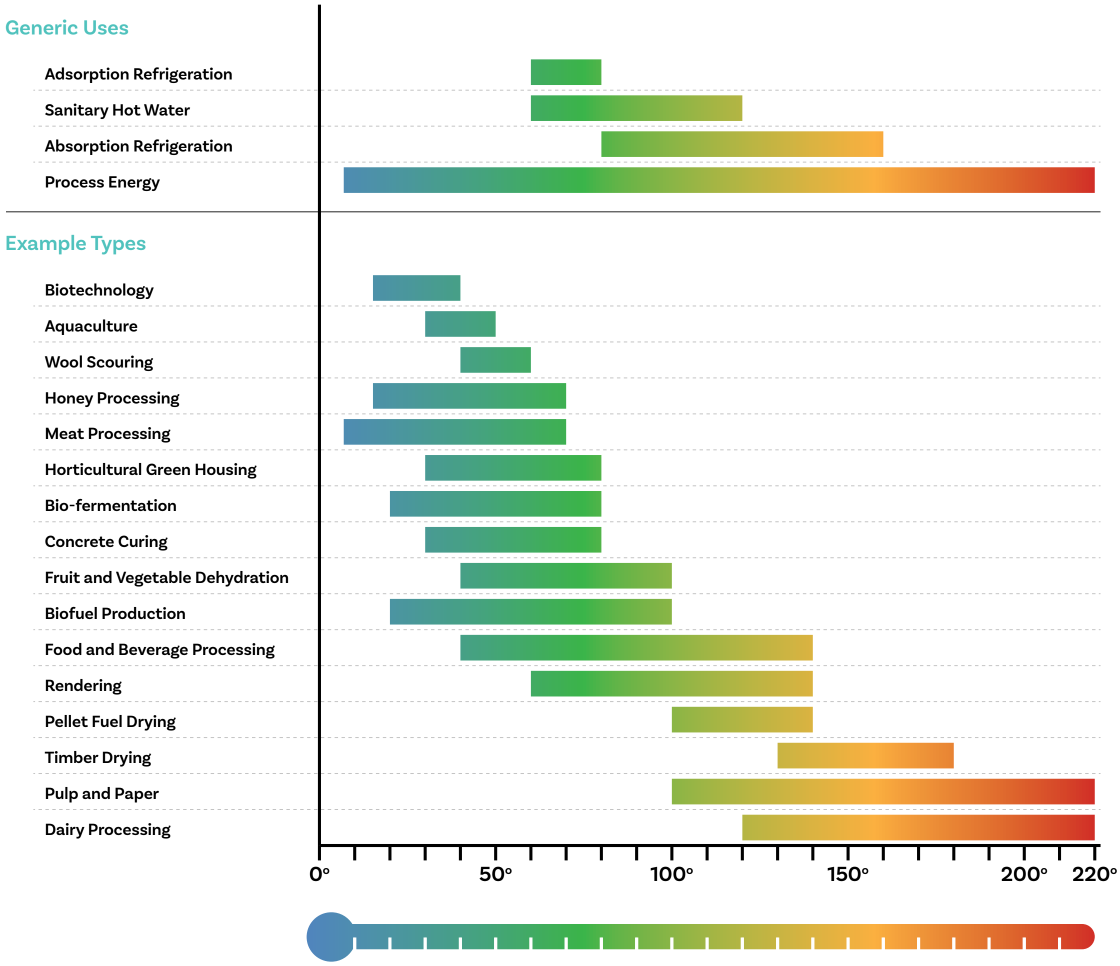


Figure 1 Geoheat Uses

and released from the deeper hotter geothermal resources in the 3km to 6km range (Castalia, 2023). High temperature Geoheat applications are and can further be developed alongside energy generation infrastructure, such as at the Contact Energy Ltd Tauhara site and the He Ahi eco-industrial heat park, Taupō. Low temperature geothermal and ambient geothermal with heat pump augmentation further broadens potential Geoheat applications to essentially encompass most of New Zealand. Kirkby et al (2024) have developed crustal thermal structure, heat flow and temperature models as part of developing a national temperature map. Published work to date includes a heat flow map. The temperature map(s) are expected to be published later in 2024.

In the international arena, since the mid-1950s, New Zealand expertise has supported various government and individual company geothermal development and construction projects, primarily for electricity generation (Bolton 2009). In the last few years there have been increasing international requests for New Zealand advisory services on geothermal process heat energy development and technologies. The NZGA have established an International Subcommittee and the Geoheat Action Group is looking to work collaboratively, supporting their activity in the international arena.

Geoheat is already providing cost-effective low carbon energy solutions for New Zealand industry and processors and has potential to make a far greater contribution to our country's energy transition. Geoheat has been underrated, if not overlooked in agency thinking and government policy, in part because the carbon emissions profile of the sector and its geographic availability has not been well understood, along with perceived risk associated with such investment. By promoting the opportunity, including providing accurate technical information to grow investor confidence, the NZGA Geoheat Action Group is working to ensure potential heat users and those who support and influence energy transition solutions are more aware and better able to realise Geoheat's potential.

If ever there is an opportunity for geothermal process heat it is now.

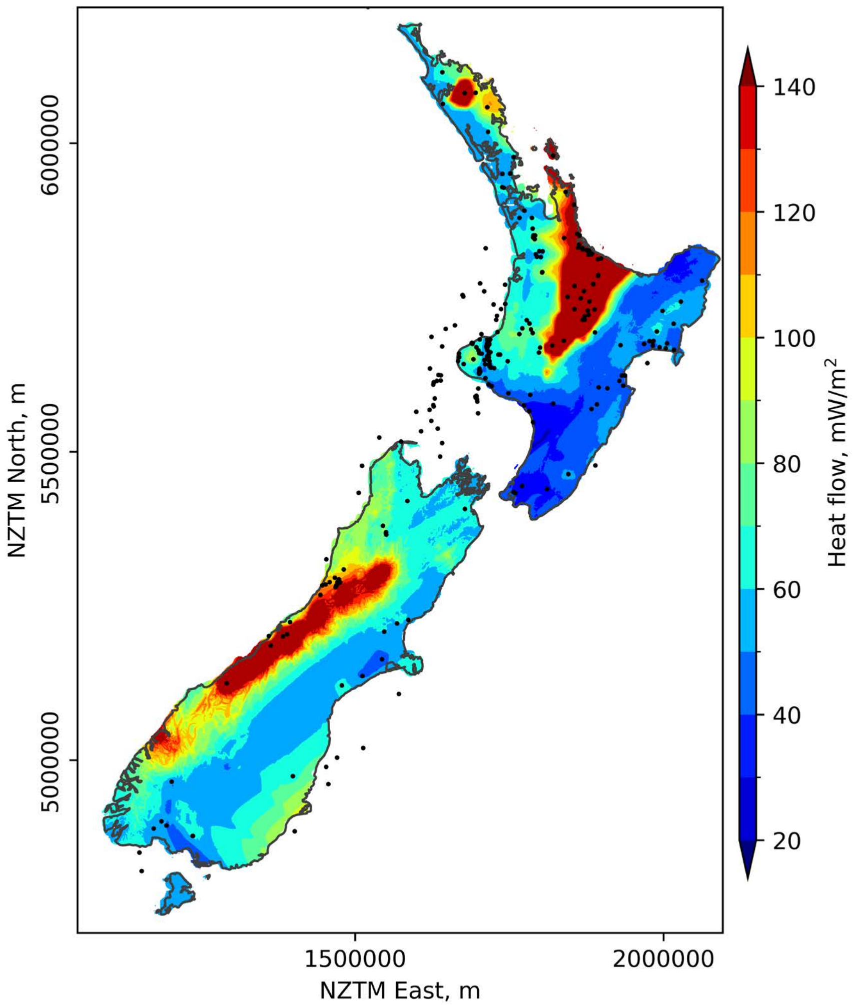


Figure 2 NZ heat flow model map (Kirkby et al 2024).

"In 2011 we had a vision of producing fertiliser products which reduce the environmental footprint of farming, and that vision has now been realised. Geothermal energy plays a big part, though capital intensive, it is light on operational costs with minimal environmental impact... This is a long-term investment not just in business, but in the world we live in."

Bruce Smith
Co-founder and Director, Tnue

"Geothermal is at the very heart of the sustainable energy which underpins our business and role as kaitiaki. It has positioned us as a world leader in the manufacture of low carbon emissions dairy products."

Karl Gradon
CEO, Miraka

"Geothermal heat to our greenhouses is cost effective, flexible and importantly, fully capable of meeting all the heat demanded by our crops. It is great to be using Geoheat with its much lower CO_2 emissions footprint than fossil heat."

Hans van Heen
Tomato Grower, Gourmet Mokai

Geoheat powered timber drying kiln, Tenon, Taupō. Photo courtesy Tenon.

WHY GEOHEAT?

Geoheat is a future energy solution available today, with well-established technologies able to support New Zealand's transition to low carbon energy by 2050. It is renewable, recognised as such in New Zealand law (RMA 1991). Sustainable management of geothermal resources provides an underpinning ethos for industrial and commercial businesses seeking to future-proof process energy supply, with ready availability and sustainability credentials.

Geothermal has low or no atmospheric carbon emissions, making it an ideal future energy source as New Zealand transitions from fossil fuels. Relative to natural gas, unabated geothermal has the potential to reduce emissions by between 81% and 100%, and for coal between 88% and 100%.

Data for unabated geothermal steam, two examples of geothermal two-phase fluid and geothermal water are tabulated. The comparison with fossil heat can be made where a geothermal solution can meet the required duty temperature. Carbon emissions associated with grid electricity required to operate the application are excluded.

Geoheat Low Emissions Profile

Type		tCO_{2e}/t	GJ/t	tCO_{2e}/GJ	Emissions Reduction[5]	
Coal (Sub-bituminous)				0.09043[1]		
Natural Gas (National Average)				0.05573[2]	N Gas	Coal
Unabated Geothermal						
Steam	Geothermal Steam (default)	0.03[3]	2.78	0.01079	81%	88%
	Kawerau - Steam	0.0202[3]	2.78	0.00727	87%	92%
Two Phase	Tauhara - Two Phase	0.0009[4]	1.2	0.00075	99%	99%
	Mokai - Two Phase	0.0009[4]	1.6	0.00056	99%	99%
Water	Geothermal Water	0	0.4	0	100%	100%

1 Emissions factor for sub-bituminous coal from the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 (SR 2009/285) p73 Table 2.
2 Emissions factor for natural gas (national average) from the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 (SR 2009/285) p75 Table 10.
3 Emissions factors from Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 Geothermal p74 Table 6 Part A.
4 Emissions factors from Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 Geothermal p74 Table 6 Part B.
5 Potential operational emissions reductions achievable using geothermal and at lower temperatures, GSHP technologies, when compared with fossil heat, providing the geothermal solution can meet the process temperature requirements.

Geoheat options available to New Zealand include high, low and ambient temperature. Some of the similarities, differences and benefits of these are summarised in the material that follows.

HIGH TEMPERATURE GEOHEAT

High temperature geothermal resources in the Taupō, Rotorua and Kawerau districts deliver Geoheat across a range of scales up to 10's MW_{th} and temperatures up to 220°C, with energy drawn from wells up to 3km deep. Geoheat utilisation at a number of the sites has been developed alongside geothermal electricity generation infrastructure.

Geoheat Benefits

Renewable

Low Carbon

Available

Cost Effective. Commercially available now, with delivered energy supplied at ~$10 / GJ (including the cost of carbon), cheaper than other renewable options and fossil fuels.

Proven at Scale. Geoheat use has been proven at individual supply scales at capacities up to 100 MW_{th}, supplying ~3PJ of energy per annum.

Low-risk. Geoheat technology has been in use in New Zealand since the late 1950s, and is backed by a wealth of established engineering expertise able to support plant design, installation, maintenance and ongoing operations.

Geoheat Delivers Cost-Effective Energy

Fuel Type	$/GJ	Emissions Factor tCO_{2e}/GJ	Carbon costs[1]	Conversion Factor[2]	Total Cost $ / GJ Delivered
Geothermal - Steam	8[3]	0.0073[4]	$0.51	0.83[5]	$10.25
Electricity - Heat Pump COP 3.5	43.34[6]	0.0206[7]	$1.44[8]	3.5[9]	$12.38
Biomass	13[10]	0	$0.00	0.8[9]	$16.25
Gas	11.57[6]	0.0557[11]	$3.90	0.85[9]	$18.20
Coal	9[10]	0.0944[12]	$6.61	0.78[9]	$20.01
Wood Pellets	18[10]	0	$0.00	0.9	$20.00
Electricity - Resistance	43.34[6]	0.0206[7]	$1.44[8]	0.99[9]	$43.78

1 Carbon units generally at ~$70/tonne through the period September to November 2023. https://www.carbonnews.co.nz/story.asp?storyID=29419 Accessed 20 December 2023
2 Factor applicable for delivery of useable heat energy and not for conversion to electricity.
3 Nominal Kawerau geothermal steam price.
4 Kawerau Industrial emissions factor from Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 (SR 2009/285) Version 1 Jan 2023. Geothermal p74 Table 6 Part A - 0.0202 times 1000/2780 to convert to t/GJ.
5 Using Geothermal steam - computed from geothermal steam (2780J/g) condensed to 100 C liquid (461J/g)
6 MBIE data for 2023 for industrial electricity and for 2022 for gas from energy price data from https://www.mbie.govt.nz building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-prices/
7 Data for 2022 – Ministry for the Environment. 2023. Measuring emissions: A guide for organisations: 2023 detailed guide. Wellington: Ministry for the Environment, ISBN: 978-1-991077-52-3 Publication number: ME 1764. Table 9 Sec 5.2.
8 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.
9 Net calorific values to useable heat provided by EECA - December 2023
10 Indicative values provided by EECA - December 2023.
11 Emissions factor for natural gas (National average) from the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 (SR 2009/285) Version 1 Jan 2023. p76 Table 10.
12 Emissions factor for lignite (all other) from the Climate Change (Stationary Energy and Industrial Processes) Regulations 2009 (SR 2009/285) Version 1 Jan 2023. p73 Table 2.

LOW TEMPERATURE GEOHEAT

Low temperature geothermal is well understood and extensively used in many European nations, but poorly understood and underutilised in New Zealand.

It is mature technology and is used in both shared infrastructure and standalone user installations. For example, geothermal is used in more than 240 district heating schemes in Europe, ranging from 0.5 to 50MW$_{th}$ in capacity. Project Aarhus in Denmark, consisting of 17 wells on seven sites, with a 110 MW$_{th}$ capacity is under development targeting provision of 20% of the city's heating for its 336,000 residents by 2030. Over 40% of the greenhouses in the Netherlands are expected to convert from natural gas to low temperature geothermal by 2030. This is some 30 PJ pa of geothermal heat use.

Closer to home, low temperature Geoheat has gained traction through the Christchurch rebuild after the 2010 / 2011 earthquakes (Seward and Carey, 2021). A number of commercial facilities in Christchurch with heat requirements ranging up to ~4 MW now utilise energy from aquifers under the city that are at a temperature of 13°C. In these facilities ambient temperature groundwater is the source and sink of the thermal energy. Heat pump augmentation raises the temperature of the energy, typically to less than 80°C. However, with heat pump innovation and further development being driven internationally at pace, temperatures up to ~150°C are now achievable.

The potential application of low temperature Geoheat in other regions is now starting to be explored. Within the EECA RETA BOP workstream, scenarios have been modelled for a 3.2 ha Whakatane greenhouse using ground source heat pumps. The model assumes a peak requirement of 4.8 MW$_{th}$ with the heat pumps supplying 65°C water into the greenhouse from Matahina formation aquifer water at 15°C.

Even more can be achieved if the temperature of the aquifer water is naturally "elevated". The Whakatane example was modelled with water temperatures up to 30°C, which reflects temperatures found in places such as; some shallow BOP aquifers in the broader Tauranga area, in a number of areas of the Hauraki Plains, and at Parakai near Helensville. A 25°C increase in aquifer water temperature results in both a 40% reduction in capital of the installation and of the annual electricity costs for a 4.8 MW$_{th}$ capacity Geoheat facility supplying heat at 65°C. Ambient and low temperature Geoheat infrastructure is often replicable over broader areas than is the case with high temperature Geoheat. More information on the EECA RETA BOP geothermal workstream can be found in Carey et al (2024).

The wider geographical spread and thus greater accessibility of low temperature Geoheat across New Zealand and potential for in situ switching of heat sources by existing users, including SMEs, suggests that lower temperature Geoheat could have as big or even bigger impact on New Zealand decarbonising efforts than high temperature Geoheat. For example, five covered crop facilities that use 4 MW$_{th}$ each (3.2ha in size) utilising low temperature Geoheat collectively equate to one large high temperature Geoheat user, such as a Tenon or Nature's Flame (20 MW$_{th}$).

Characteristics of Geothermal / Ground Source Heat Pumps

- Mature, established and widely used technology internationally.
- Heat supply temperatures of up to 80°C with rapidly evolving technology, with temperatures of up to ~150°C becoming attainable through high temperature heat pump technology.
- CO_2 emissions reductions are substantial, usually the only operational emissions are associated with the electricity used in running the fluid and heat pumps.
- Wide geographical reach across New Zealand, being particularly relevant where there are accessible groundwater aquifers. The aquifer water use is non-consumptive when used in geothermal heat pump applications.
- Low greenhouse gas emissions technology.
- Geothermal heat pumps (GSHP) are effective and efficient when compared to air source heat pumps (ASHP) which is the main technology alternative for electrification and decarbonisation. Generally, an ASHP system has a lower capital cost, higher annual running costs and greater operational carbon emissions compared to a GSHP system for the equivalent duty. Due to the variety in GSHP applications payback periods range from months to a few years.
- Geothermal heat pump solutions are more able to address decarbonising / and fuel switching for existing business operations because shifting the business to a new location is not required, as might be the case for utilisation of high temperature Geoheat.

ThermBooster high temperature heat pump. Image courtesy of SPH Sustainable Process Heat GmbH.

2024-2025 GEOHEAT ACTION PLAN

Geoheat Action Plan activities are intended to support energy users needing information, advice and connections to explore, design and implement the transition to both high and low temperature Geoheat.

The 2024-2025 Geoheat Action Plan builds on priorities identified in the 2022-23 Geoheat Action Plan (Climo et al 2022), which was the latest in a series of Action Plans intended to progress the Geoheat Strategy for Aotearoa NZ 2017-2030 (Climo et al 2017).

2017-2030 Geoheat Strategy Goals

- Increase the uptake of Geoheat in New Zealand by 7.5 PJ by 2030.
- Create an additional 500 new jobs associated with new Geoheat projects by 2030.

Actions identified in this plan are for the Geoheat Action Group to collectively progress, over and above the efforts of individual companies, in advancing the uptake of Geoheat in New Zealand.

The Geoheat Action Group is comprised of individuals from a range of stakeholder groups.

Figure 3 Geoheat Action Group Stakeholder Groups.

ACTION GROUP GOALS 2024 - 2025

GOAL 1 The ultimate goal of the Geoheat Strategy is the establishment of **NEW PROJECTS** using geothermal energy for process heat. Targets for the 2024-25 period are:

At least seven new Geoheat ventures or projects announced and / or completed. These will ideally be comprised of:

- One new major industrial high temperature venture announced and / or completed.
- 3 new SME high temperature ventures announced and / or completed.
- 3 new or fuel-switching low temperature ventures announced and / or completed.

Collectively, these ventures should equate to emission reductions (relative to fossil fuels) of between 25,000 to 40,000 tonnes carbon pa.

These new ventures and fuel-switching projects should represent over $80 million in new investment. Ideally, several of these will be supported by $5-10 million of central government funding for energy transition, industry transformation and economic development.

The Geoheat Action Group believes the following intermediate goals are key to enabling this level of Geoheat uptake:

GOAL 2 **POSITION** Geoheat so it is widely acknowledged as a viable sustainable process heat option for industrial and commercial operations in New Zealand. Within this, the Geoheat Action Group will support efforts by geothermal process heat and technology solution providers.

GOAL 3 Further **ENABLE** Geoheat by ensuring information and case studies are available to operators and investors, giving them knowledge, networks and confidence to invest in Geoheat.

The Geoheat Action Group will also support and work with organisations who provide funding and solutions for energy and innovative processes requiring research, incubation, solution definition and business case development. These enabling organisations include:

Central government departments and agencies, at both policy and funding mechanism levels:

- Callaghan Innovation
- EECA
- MPI and its Sustainable Food and Fibre Futures (SFFF) fund
- New Zealand Trade and Enterprise (NZTE)
- Regional Economic Development Investment Unit (REDIU / Kanoa) and associated regional development funding instruments.

Regional and district economic development agencies (EDA) that provide location-specific support for establishing and operating a business venture. These typically are in areas where high temperature geothermal operations have already developed:

- Amplify (Taupō district)
- Bay of Plenty Regional Council (BOPRC) Economic Development Group
- Priority One (Western Bay of Plenty)
- Northland Inc (Northland region)
- Toi EDA (Eastern Bay of Plenty)
- Toi Kai Rawa (BOP Maori EDA)
- Te Waka (Waikato region)

Organisations that provide general knowledge and technical support across both high and low temperature opportunities:

- GNS Science
- GeoExchange
- Dobbie Engineers
- MB Century

And high temperature geothermal heat providers:

- Contact Energy Ltd (Taupō)
- Ngati Tuwharetoa Geothermal Assets (Kawerau)

GOAL 4 Provide access to Geoheat facilities that **DEMONSTRATE** the technologies, which operators and investors can visit firsthand. This is to demonstrate Geoheat infrastructure and associated processes in established businesses, providing confidence and peer networks to prospective Geoheat adopters. As part of this, establish a group of "Leading Geoheat Adopters" keen to share their stories and learnings.

These goals form the core of the 2024-25 Action Plan.

Figure 4 2024-2025 Actions and Goals.

ACTIONS FOR 2024 - 2025

To progress the four goals, the Geoheat Action Group will undertake the following integrated, mutually-reinforcing actions over the 2024-25 period.

COMMUNICATE

Raise the profile of geothermal process heat advantages and opportunities. This will be undertaken in coordination with broader geothermal sector communication activity. The Geoheat Action Group may also target specific stakeholder groups and individual stakeholders over and above the audience receiving regular geothermal sector communications.

PARTNER

Partner with stakeholders across industries, sectors, government, regions, Māori entities, investors, the green finance sector, and the regional and local economic development organisations to raise awareness and unlock support for Geoheat solutions.

Related to this, the Geoheat Action Group expects to become more active in the international arena, leveraging strong connections being developed between the Geoheat Action Group and the newly-formed NZGA International Subcommittee. This subcommittee already partners with the Ministry of Foreign Affairs and Trade (MFAT) and New Zealand Trade and Enterprise (NZTE), who provide aid and expertise to international geothermal development projects. With increasing international interest in Geoheat, New Zealand is well placed to support other countries and overseas entities to explore, develop and utilise Geoheat.

REPRESENT

Secure funding for and appoint an experienced business development specialist to represent the Geoheat community, promoting Geoheat opportunities to relevant industries and prospective users.

ADVANCE

Identify, nurture and support businesses to explore and commit to new Geoheat projects, in both high temperature brownfield sites where geothermal resources can be readily accessed, and low temperature groundwater-based resources across New Zealand.

SHOWCASE

Continue to build and make available a repository of information that showcases Geoheat success stories, to increase awareness and assist in building confidence for businesses to invest in Geoheat. This information will continue to be shared through NZGA and GNS Science websites, as well as be presented directly to industry and government audiences and delegations.

ADVOCATE

Engage with think-tanks, in government policy and planning processes, and development of energy transition and sector strategy where geothermal energy for process heat use needs to be championed. Much of this activity will be led by the NZGA, with the Geoheat Action Group providing information and support where relevant.

REALIGNED FOCUS

A key change for the 2024-25 is the increased focus on low temperature geothermal resources. This substantially increases the geographical spread and the potential positive impact of Geoheat in New Zealand industries and businesses. Work in this area has already commenced in the 2022-23 period.

2024-2025 Action Plan Foci

- Increasing the use of Geoheat by industrial or commercial enterprises in central North Island locations, where high temperature geothermal energy is already a well-established low-carbon energy option.
- Promoting the Geoheat opportunity across New Zealand where the use of low temperature and ambient geothermal can assist in sector decarbonisation, such as covered crops.

ACTIVITY

To effect this, the Geoheat Action Group will:

- Partner with other industries to raise the profile and support exploration of Geoheat as a fuel switching opportunity or establishing a new enterprise using Geoheat. Industries identified to align with and support during this period are:
  - Wood processing / products sector. This has a solid industry transformation plan (ITP) and is a well-organised and innovative industry. The co-location synergies of forestry and geothermal are well-established.
  - Continuing work with MPI, EECA and Vegetables NZ on the use of Geoheat for horticulture and covered crops.

- Working with New Zealand Government agencies, in conjunction with NZGA and directly, to garner support for promotion and uptake of Geoheat in New Zealand. In November 2023 NZGA (Tsui, 2023b) proposed the creation of a forward looking, 2050 geothermal roadmap to be developed by MBIE and the Geothermal Sector. Additionally, Tsui calls for investment in a Geoheat database and increased government funding to accelerate Geoheat deployment. Action Group members will also look to ensure Geoheat is considered for future EECA RETA workstreams and workshops.

- Working with relevant and proactive Economic Development Agencies and regional groups, typically those with developed high temperature resources or with significant aquifers offering potential for low temperature and ambient solutions. This will include work associated with EECA's RETA programme and in particular RETA 4.8 and follow up activity in the BOP Region. Similarly, ongoing involvement with New Zealand Geothermal Week, being co-hosted by NZGA and Amplify in Taupō in July 2024, which will include Geoheat specific events.

- Develop and disseminate information to support public and private investment for enabling and installing Geoheat-based ventures. The Action Group will seek to engage with financial institutions in this activity, such as the NZGIF and venture capital firms applying climate change and environmental, social and corporate governance (ESG) lenses to their portfolios.

- Establishing a Leading Geoheat Adopters group to assist with showcasing and demonstrating the Geoheat opportunity.

- Support organisations and companies seeking to adapt, develop technologies and demonstrate technical and commercial proof-of-concept for projects using Geoheat.

- Securing funding for dedicated Business Development resourcing for Geoheat progress and project development. This will include supporting Amplify in its efforts to establish a geothermal cluster in 2024, which proposes to incorporate a workstream with associated resource to advance Geoheat uptake.

- Raising the profile of New Zealand Geoheat expertise and ventures internationally, in coordination with the NZGA International Subcommittee, MFAT and NZTE. This could include supporting in-bound and out-bound linkages with international opportunities (expertise, investment, projects), along with opening up opportunities for New Zealand business working in Geoheat developments offshore and attracting overseas funds into New Zealand Geoheat ventures.

- Communicate the opportunity, by preparing and releasing material for national business and international geothermal media, and presenting at industry, business, investor and public forums.

The Miraka factory at sunrise. Photo courtesy Miraka.

TUAROPAKI GEOTHERMAL - MOKAI

At Mokai, Tuaropaki Trust and associated entities and venture partners, have well established business operations that utilise geothermal energy.

There is an overarching philosophy of integrating business activities and in so doing creating circularity that maximises value whilst minimising impact. The ventures include:

- Tuaropaki Power Company – 115 MWe power plant.
- Halcyon Power – Hydrogen production pilot facility using geothermal electricity to produce green hydrogen.
- Miraka – Dairy Processing
- Gourmet Mokai - Greenhouses
- Ngaire George Sustainability Centre - Worm farm, nursery and seedbank.

Waste from the Miraka dairy processing plant, Gourmet Mokai greenhouses and the dairy farms are processed by worms to produce nutrient rich vermicompost. The Centre is also a native nursery servicing the riparian needs of the Trust's farms, has an established seedbank and has established heritage gardens.

Miraka and Gourmet Mokai use Geoheat and are featured in the material that follows.

MIRAKA

Miraka is New Zealand's first Māori owned milk processing company and the first in the world to use renewable geothermal energy. Miraka was established in 2010 by a small group of Māori trusts and incorporations and founded upon a Te Ao Māori worldview which places kaitiakitanga; the care of the land, people and the environment, at the heart of the business. Today Miraka is one of the world's most sustainable dairy producers, with a low carbon footprint, B Corp certification and a world-class farming excellence programme, Te Ara Miraka.

The Miraka dairy factory uses geothermal energy supplied from the Mokai Geothermal Field to produce process steam. The combination of geothermal steam and electricity from the Mokai power station provides an energy supply which is 93% renewable. The facility has an excellent carbon footprint with 92% less emissions than an equivalent coal-fired plant. Key processes include an 8MT per hour dryer and two high speed UHT manufacturing lines, capable of producing 48,000 UHT units per hour. This enables Miraka to convert 300 million litres of milk per annum into a range of products which are sold under Toitu Carbon Reduce certification to 24 countries around the globe. The geothermal heat plant is designed to deliver up to 30 t/hour of 20 barg process steam. Two 100% redundant trains have assured a reliable supply of process steam since the plant became operational in 2011. The geothermal heat plant was modelled on its Kawerau predecessors, at Norske Skog Tasman and NTGA / Essity, it was designed by MB Century with the details described in Taylor (2011).

"Geothermal is at the very heart of the sustainable energy which underpins our business and role as kaitiaki. It has positioned us as a world leader in the manufacture of low carbon emissions dairy products."

- CEO Karl Gradon

Miraka continues to build on the innovation of its geothermal foundation. 2030 targets include the complete elimination of all fossil fuels from the manufacturing site.

Left The Miraka factory **Right** The geothermal heat plant

GOURMET MOKAI

Gourmet Mokai established a 5.5 hectare greenhouse in 2003 and enlarged the operation to 12 hectares in 2007. The facility employs 100 staff, growing 4,275 tonnes of tomatoes and 900 tonnes of capsicums per annum for export and local consumption using hydroponic techniques.

In 2018 supplemental LED lighting was installed in 2 hectares of the greenhouse enabling Gourmet Mokai to produce the popular Campari truss tomatoes year-round.

The greenhouses are heated with geothermal energy through two shell and tube heat exchangers capable of delivering up to 24MW of heat to the secondary conditioned water loop that circulates heat through the greenhouses. The geothermal two-phase fluid is supplied from well MK 2 at ~220°C to the tube side, with the secondary loop conditioned water on the shell side of the heat exchangers heated to ~95°C.

"Geothermal heat to our greenhouses is cost effective, flexible and importantly, fully capable of meeting all the heat demanded by our crops. It is great to be using Geoheat with its much lower CO_2 emissions footprint than fossil heat."

- Hans van Heen, Tomato grower, responsible for crop production at Gourmet Mokai.

Clockwise from left Hans van Heen. The two shell and tube heat exchangers (12 MW capacity each). The greenhouse LEDs visible at night. Photos courtesy Gourmet Mokai.

TNUE

In 2011 Bruce Smith and business partner Ingar Dolk established Eko360, with the vision of reducing the environmental footprint of fertiliser. They developed Smartfert and distributed this control release low emissions nitrogen fertiliser manufactured offshore. Through research they developed the technology to manufacture control release fertiliser in New Zealand with specifications meeting the wide needs of the New Zealand growing conditions, crops and pasture.

Trials confirmed that the New Zealand control release membrane product greatly increased nutrient use efficiency resulting in plants using more of the applied fertiliser with significantly reduced losses to the environment. This is particularly important with nitrogen fertiliser such as urea, where losses include leaching to waterways and atmospheric greenhouse gas releases.

In 2022, Eko360 founded Total Nutrient Use Efficiency (Tnue) for the purpose of raising the capital required to build and operate a factory producing Smartfert in New Zealand. This successful capital raise resulted in Tnue having three shareholders, Eko360, New Zealand Green Investment Finance (Government owned investment company) and an agritech investment company, WBC Barn.

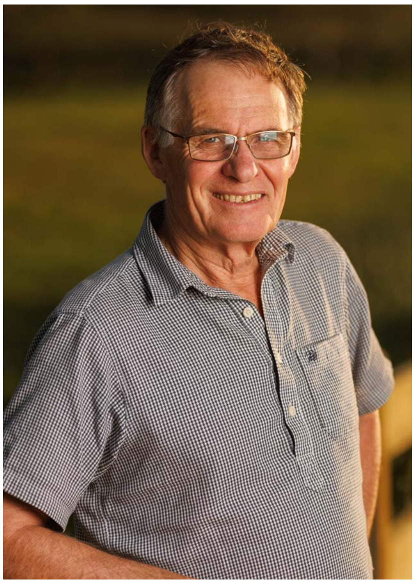
Tnue has established its manufacturing operation as the first tenant in the 45 hectare He Ahi eco-industrial estate, Taupō. He Ahi estate is being developed by Te Pae o Waimihia Trust, with access to cost-effective renewable geothermal heat from Contact Energy Limited. Heat is required to process the control release membrane and Tnue has entered into a long-term supply agreement for geothermal heat.

Tnue's factory has zero carbon emissions in the production process and by using up to 4000 MWh pa of geothermal heat eliminates 800 tonnes CO_{2e} pa of potential emissions compared with the default alternative of natural gas supplied heat. The supporting energy source is electricity, it drives production and handling equipment in the factory and by using electric fork hoists they have removed the need for front-end loaders and other vehicles which would otherwise be diesel-powered. This clean energy strategy strongly aligns with Tnue's brand ethos and product value proposition.

Production commenced in March 2024 and with Tnue's sales and distribution agreement through industry-leader Ballance Agri-Nutrients the product will be available to farmers throughout the country.

"In 2011 we had a vision of producing fertiliser products which reduce the environmental footprint of farming, and that vision has now been realised. Geothermal energy plays a big part, though capital intensive, it is light on operational costs with minimal environmental impact... This is a long-term investment not just in business, but in the world we live in".

- Bruce Smith, Tnue Co-founder and Director



Left Tnue co-founder Bruce Smith.
Bottom Right Aerial of Tnue facility. Photos courtesy Tnue.
Top Right Tnue's 1200 kW geothermal plate heat exchanger (blue) and air blower equipment.

MOUNT MAUNGANUI INDUSTRIAL AREA GEOHEAT SCHEME

Low temperature geothermal is used in the Mount Maunganui area now. An example of this is the Baywave TECT Aquatic and Leisure Centre which is 100% heated by low temperature geothermal. Mount Hot Pools also use geothermal to heat their facilities. These facilities use geothermal water directly for their heating applications.

In the event that temperatures required are greater than directly available from the ~45°C geothermal resource, heat pump technology can be used to augment temperatures. Conventional heat pumps can produce temperatures up to ~80°C or with high temperature heat pumps temperatures up to ~150°C are achievable. In looking to decarbonise higher temperature applications the options available are either water source heat pumps or electric boilers, as current air source heat pumps cannot attain the temperatures required.

Around the Mount Maunganui Industrial Area there are a number of facilities that could benefit from accessing the 45°C geothermal water from the Waiteariki Ignimbrite aquifer from a depth of ~400m. As a case study GeoExchange Australia has developed an application that considers a 1 MW_{th} steam production operation producing steam at 120°C using high temperature ground source heat pumps (HTGSHP) that utilise the underlying 45°C as their source of thermal energy. Currently in the Mount Maunganui area natural gas would be used to generate steam with the low carbon options being electric boilers with a COP of 0.99 or a HTGSHP with a COP of 2.8 when using a 45°C source temperature.

To deliver 1 MW_{th} the natural gas input would be the equivalent of 1.17 MW, or a HTGSHP could be used sourcing energy from the aquifer water beneath the industrial area which would require ~360 kW of electrical input or a 1 MW electric boiler could be considered requiring slightly more than 1MW of electrical input. Annual CO_{2e} emissions for gas generated steam would be ~2000 tonnes. The reduction in energy use (14 and 70%) and the emissions reduction (67 and 88%) for an electric boiler and the HTGSHP option respectively relative to a natural gas fired system are computed and tabulated.

Technology Comparison for a 1MW_{th} 120°C Steam Application

Technology Option	Conversion Factor	Energy Supplied		Emissions[1]	
		TJ / Annum	Reduction	tCO_{2e} / Annum	Reduction
Natural gas boiler	0.85	37.1		1996	
Electric boiler	0.99	31.9	14%	657	67%
HTGSHP	2.8	11.3	70%	232	88%

1 Note the emissions associated with the electrical solutions will decrease as the grid becomes more renewable whereas the emissions associated with natural gas will remain unchanged.

The influence on overall power system investment upgrading from using HTGSHP applications relative to electric boilers is a key aspect that flows back up from the facility, through the local network, through the national grid and then to the amount of electrical energy required to be generated. The capital investment required is reduced in all of these power system components through the use of HTGSHP.

The use of geothermal as part of a demand driven energy transition has not gone unnoticed in the USA where in the recently published *Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States* (Liu et al. 2023) the benefits to the grid are clearly identified.

If the HTGSHP approach is extended to a number of the operations at the Mount Maunganui Industrial Area for decarbonisation by reducing / removing gas from industrial use and moving away from electric boilers, then local network and grid upgrade investment can be expected to be substantially reduced.

A shared industrial park energy scheme that interconnects various energy users, both sharing energy and the energy infrastructure associated with using the low temperature geothermal source is a study that could reap benefits for the Tauranga Port / Mount Maunganui Industrial area.

EFFECTIVENESS REVIEW OF 2022 – 2023 GEOHEAT ACTION PLAN

This section summarises outcomes relative to the two objectives in the 2022-23 Geoheat Action Plan and aligned Geoheat Action Group outputs and activities during this same period.

OBJECTIVE 1: Position Geoheat

That geothermal heat is no longer overlooked or misrepresented in Government and industry strategies, and becomes top-of mind as Aotearoa New Zealand's proven, renewable, cost-effective, low-carbon energy option.

- Geoheat was acknowledged as part of the solution to realise the Forestry and Wood Processing Industry Transformation Plan (ITP), released by MPI in November 2022.
- The Geoheat Action Group partnered with MPI and covered crop industry bodies Vegetables NZ and Tomatoes NZ to support those sectors to explore options as they transition away from fossil fuels. This included a workshop with ~100 attendees delivered during New Zealand Geothermal Week 2023 and a field trip to existing Geoheat sites.
- GNS Science delivering four Geoheat case studies as part of the EECA RETA for the Bay of Plenty region, presenting to a stakeholder workshop in November 2023. This is the first RETA to incorporate a geothermal workstream, and incorporated both standalone and shared infrastructure examples, encompassing high temperature, low temperature and ambient geothermal scenarios.
- The new projects and ventures noted under Objective 2 below have received some support from government funds intended to support New Zealand's energy transition and grow local economies, including the Regional Strategic Partnership Fund, Government Investment in Decarbonising Industry (GIDI) fund or the NZGIF.

OBJECTIVE 2: New Geoheat Projects

At least five new projects (including energy conversions and expansions of existing operations) using Geoheat are committed to and in development, as a key part of their enterprise, by the end of December 2023.

A number of projects are in development or have been completed:

- He Ahi eco-industrial park, officially opened in 2022, is being developed in Taupō by Te Pae o Waimihia in partnership with Contact Energy Ltd. With its shared infrastructure and tenancy-based model, this creates an economically-attractive option for SMEs to access high temperature Geoheat. Up to 20 sites will be available in the 45ha park with geothermal heat supplied by Contact Energy Ltd.
- He Ahi's first tenant Tnue completed constructed of their facility in 2023. Refer to the case study on page 24 for more detail.
- Full conversion of Essity's paper machine to Geoheat is underway in Kawerau. Conversion of the paper drum on Machine 3 (KPM3) will complete a transition from natural gas to Geoheat, with the conversion reducing carbon emissions by 6400 tonnes per annum. The GIDI Fund supported this $15 million project with a grant of $1.65 million. Refer Climo et al (2020) for more information on Essity's decarbonisation journey.
- Nature's Flame in Taupō nearly doubled production capacity manufacturing wood pellets using Geoheat. Talleys Group Limited acquired Nature's Flame for $47.5 million in 2022 to support decarbonisation of their Open Country Dairy processing operations. This investment has supported a 2023 pellet production capability expansion from 85,000 to 150,000 tonnes pa. The Geoheat energy supply to the plant from Contact Energy Ltd is fundamental to the Nature's Flame production operation.
- Wai Ariki Hot Springs & Spa in Rotorua opened in June 2023. This $60 million project, seeded in 2017, is located on a prime lakefront location in Rotorua. The stunning building, which has received numerous design awards, uses Geoheat for space heating, and also offers spa experiences directly utilising geothermal waters.
- Contact Energy Ltd has set aside land for an industrial park off Broadlands Road, Taupō, with land being set aside for large-scale Geoheat use. The site is adjacent to the Tauhara Power Station currently under construction, scheduled to come online in Q3 2024.

ACTIVITY HIGHLIGHTS

Considerable activity during the 2022-23 period has led to increasing traction of Geoheat with both potential end-users and government agencies and other organisations that can support Geoheat uptake through policy, investment, regulation and direct support. Activity highlights over this period include:

2021

In **late 2021** Bay of Connections funded, through the Shine Collective, a Geoheat communications workshop leading to the development of a communications plan in early 2022 with three phases; Establish, Accelerate, and Groundswell.

2022

In **May 2022** GNS Science began engaging with Tomatoes NZ and Vegetables NZ on the use of low temperature geothermal for the supply of heat in the covered crop sector.

The Economic Development Agency, Amplify, have been very active in developing events associated with New Zealand Geothermal Week in 2022 and 2023, including the following with a Geoheat focus in 2022;

- Opening of Geothermal Week, **25th July 2022** at the He Ahi site a 45 hectare eco-industrial park being developed by Te Pae o Waimihia, north east of Taupō,
- Bay of Connections hosted a Decarbonising Industry workshop in Rotorua on the **26th July 2022** bringing together operators and industry experts showcasing solutions, with a focus on the availability and benefits of Geoheat as an option for decarbonising industrial processes and production systems requiring heat up to ~200 °C.
- Presentations at the **28th July** NZGA 2022 winter seminar that included presentations introducing *He Ahi* by Blandina Diamond and the 2022-2023 Geoheat Action Plan and associated activity by Brian Carey.

In **August 2022** GNS Science and Geoexchange AU presented on geothermal use applications to Tomatoes NZ and engaged with MPI on Sustainable Food and Fibre Futures projects using low temperature geothermal heat energy.

A Geoheat presentation was delivered by Brian Carey on **22 September 2022** to the 2022 Resource Management Law Association of New Zealand conference in Rotorua.

In **October 2022** Celia Wells from GNS Science presented to MPI on the geothermal heat opportunities in horticulture along with key messages from a visit to the horticultural sector in the Netherlands which is actively embracing geothermal heat targeting 40 PJ pa by 2050 of all greenhouse heat coming from geothermal.

In the period **November through to December 2022** meetings were held with individual growers, EECA, Tomatoes NZ, Vegetables NZ and MPI. GNS Science continued work with Vegetables NZ and MPI through 2023.

ACTIVITY HIGHLIGHTS

2023

At the end of **May 2023** GNS Science, with consultant support from GeoExchange and Dobbie Engineers, were contracted by EECA to prepare material on geothermal energy for four sites in the broader Bay of Plenty as part of the EECA RETA work. This was the first region that geothermal energy was to be included in a RETA assessment.

A presentation on *Decarbonising Primary Industries with Geothermal: Risk vs Reward* was delivered to the **June 2023** Carbon and Energy Professionals Conference by Celia Wells.

In **June 2023** NZGA submitted (Tsui 2023a) on the Climate Change Commissions Proposed Second Emissions Reduction Plan. The submission included material on Geoheat.

As part of New Zealand Geothermal Week, held in Taupō in **July 2023**, there was again significant profile of Geoheat. This included:

- Targeted engagement with the horticultural sector. A "Geoheat for Horticulture" workshop led by GNS Science and Amplify attended by ~100 participants.
- A field trip that followed the workshop took around 30 participants to Gourmet Mokai's 12ha greenhouse operation, the He Ahi eco-industrial park and the 12ha Huka Prawn Park, an aquaculture venture with development potential.
- A Geothermal Cluster workshop led by Amplify, garnering support for a proposed formal geothermal industry cluster, which includes a workstream focused on promoting and supporting uptake of Geoheat.
- Blandina Diamond from He Ahi, and Jim Johnston and Michael Schweig from Casil Technologies presented at the NZGA Winter Seminar.

An NZGA Geoheat paper (Miller et al 2023) was prepared for the 2023 World Geothermal Congress (WGC). The paper was presented to the congress in Beijing on **16th September 2023** by Jaime Quinao.

On **1st November 2023** NZGA submitted to MBIE (Tsui 2023b) on the Measures for Transition to an Expanded and highly Renewable Electricity System. The submission included material on Geoheat.

On **7th November 2023** the Bay of Plenty RETA feedback workshop was held in Rotorua, with a geothermal presentation to the event, Geothermal Availability and Cost Workstream, delivered by Celia Wells, GNS Science.

GLOSSARY

Ambient temperature Geoheat	Geothermal energy in the ground at a temperature less than 30°C
BOPRC	Bay of Plenty Regional Council
Brownfield (Development)	A proven resource and producing geothermal field with geothermal development infrastructure in place
Carbon	Used generically and interchangeably with CO_{2e} in this document
Direct Use / Direct Geothermal Use	The use of geothermal energy or fluid directly. Essentially, this is any application using geothermal heat for a purpose other than generating electricity.
EECA	Energy Efficiency and Conservation Authority
Geothermal heat / Geoheat	Thermal energy sourced from underground
GIDI	Government Investment in Decarbonising Industry
GJ	Giga Joule, a unit of energy equal to 10^9 Joules.
Greenfield (Development)	A geothermal area with no existing geothermal development infrastructure
GSHP	Geothermal or ground source heat pump
High temperature Geoheat	Geothermal energy in the ground at a temperature above ~150°C
HTGSHP	High temperature ground source heat pump
Low temperature Geoheat	Geothermal energy in the ground at a temperature between 30 to ~150°C
MPI	Ministry for Primary Industries
NTGA	Ngāti Tuwharetoa Geothermal Assets
NZGA	New Zealand Geothermal Association
NZGIF	New Zealand Green Investment Fund
PJ	Peta Joule, a unit of energy equal to 10^{15} Joules.
Primary Geothermal Energy	The total amount of geothermal energy supplied to a process. This will be greater than the amount of energy consumed in the process.
Renewable Energy	Energy produced from solar, wind, hydro, geothermal, biomass, tidal, wave, and ocean current sources. Definition from the Interpretation section of the RMA (1991).
RETA	Regional Energy Transition Accelerator
SFFF	Sustainable Fibre & Farming Futures, an MPI fund.
SME	Small and medium sized enterprise

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Photography: Front Cover Frutura geothermally heated greenhouse, Blumau, Styria, Austria. Photo courtesy Brian Carey.
Rear Cover Steam sampling, Mokai Geothermal Field. Photo courtesy Miraka.

AUTHORS AFFILIATIONS

Carey[1], Miller[2], Howie[3], Wells[4], Carden[5], Tsui[6], Seward[1], Allen[6]

1 GNS Science, 114 Karetoto Road, RD4, Taupō.

2 Consultant Advisor, 6 Botanical Heights Drive, Taupō.

3 BOPRC, PO Box 364, Whakatāne 3158

4 Consultant Advisor, c/- 29 Black Barn Lane, Bethlehem Tauranga

5 GeoExchange Australia Pty Ltd, PO Box 1142, North Sydney, NSW 2060, Australia

6 NZGA

DOCUMENT LINKS

Links to Geoheat Strategy and Action Plan Documents and Associated Materials:

Resource	Hyperlink
Geoheat Action Plan, 2022 - 2023	Click here
Geoheat Action Plan, 2020 - 2021	Click here
Geoheat Action Plan, 2018 - 2019	Click here
Geoheat Strategy for Aotearoa New Zealand, 2017 – 2030	Click here
Geoheat Strategy Launch Video, 2017	Click here

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nzga
New Zealand
Geothermal Association

www.nzgeothermal.org.nz
committee@nzgeothermal.org.nz