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Electricity Market Measures submissions
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Submission on the Measures for Transition to an Expanded and highly Renewable Electricity System

The New Zealand Geothermal Association (NZGA) would like to thank the MBIE for the opportunity to comment on the Draft report on *Measures for Transition to an Expanded and highly Renewable Electricity System*.

Geothermal[1] is an Aotearoa New Zealand icon and has been part of Māori culture for generations. Geothermal is an iconic kiwi symbol. Geothermal stories and geothermal energy have been part of Māori culture for generations, and geothermal is entrenched in our modern history. Over the past 70 years, geothermal has been a vibrant, proven, indigenous renewable resource, which enables other industries to thrive and our regions to grow. Through this period the significance of the kaitiaki role of Māori of this taonga has been progressively recognised.

New Zealand Geothermal Association (NZGA)

1. The NZGA, incorporated in 1992, is a non-political, non-governmental and not-for-profit organisation, with a focus on fostering a sustainable future for Aotearoa New Zealand through the use, development or protection of geothermal resources. The NZGA connects with global geothermal communities and is well positioned to positively influence geothermal initiatives on the international stage.

2. NZGA membership comprises ca. 480 individuals, as well as 31 corporate members, representing, research organisations, Māori trusts, geothermal electricity generators, engineering consultants, technology companies and planning consultants. This diverse and skilled network of people work and live with Aotearoa's geothermal resources.

[1] The reference to 'Geothermal' throughout this submission is a term that is used to describe both low enthalpy resources (potentially down to ambient conditions for geothermal heat pumps), and high enthalpy conventional geothermal resources (<3.5 km deep with reservoir temperatures <350°C).

Our recommendations:

Recommendation 1. Support the development of a co-create Geothermal Roadmap between MBIE and the geothermal community.

Recommendation 2. Support the development of a high quality Geoheat Database to enable vast deployment of low carbon, renewable, cost-competitive heating solutions.

Recommendation 3. Increase Geoheat funding to accelerate its deployment. Identify, nurture and support business to explore and commit to new geoheat projects.

Recommendation 4. Use the new Natural and Built Environment Act and the Spatial Planning Act to accelerate supply of new geothermal baseload generation – the Game Changer.

Recommendation 5. Geothermal storage: The New Zealand Battery Project flexible geothermal base case

3. We strongly recommend that the Ministry of Business, Innovation and Employment (MBIE), a proven leader in energy policy, prioritise our critical recommendations. By doing so, MBIE can take the lead in expediting the transition to a highly renewable electricity market, which is essential for ensuring an equitable and sustainable renewable electricity future.

4. It is important that MBIE consider our proposals in conjunction with market measures and industry projects. This collaborative approach will help create a highly renewable electricity market that effectively fosters the decarbonisation of our energy sector, ultimately contributing to a cleaner and greener future.

This submission

This submission is divided into five sections, namely:

Section 1: Building cohesion and clarifying strategic direction.
Section 2: Enabling vast deployment Geoheat solutions for the decarbonisation of process heat
Section 3: Accelerating new geothermal generation for reliable, renewable baseload.
Section 4: Employing flexible geothermal generation for hydro dry-year supply security.
Section 5: Unlocking Emerging Industries with Geothermal Resources
Appendix 1: Geothermal resources explained.

Section 1: Building cohesion and clarifying strategic direction.

5. In the consultation paper, the approach to renewable electricity market policy has been characterised by a number of different interventions, but with less emphasis on how they work collectively. Many existing interventions seek to support specific renewable types (e.g., wind and solar), but the cohesiveness and overall strategic direction is less clear. There is limited confidence (among Ministers, officials, and the private sector) that all renewable types are working consistently together and pushing in the same direction.

Recommendation 1. A co-create Geothermal Roadmap between MBIE and the geothermal community

Why?

6. In order to build that cohesion and confidence, NZGA propose that both MBIE/NZGA co-create an explicit **Geothermal Roadmap** and improve the acceleration of geothermal resources in support of the renewable electricity uptake by:

   - Taking a public/industry partnership-led approach, developing solutions with stakeholders, including Iwi/Māori.
   - Building and using a strong evidence base to guide MBIE and industry focus and interventions, including robust evaluation and on-going monitoring.
   - Using sector specific knowledge/strategies and bringing into Mātauranga Māori.
   - Providing clear and consistent signals from the Government on a proposed course of action to realise economic and sustainable growth, while improving wellbeing for New Zealanders.

What?

7. A **Geothermal Roadmap** (akin to the recent hydrogen roadmap or previous bioenergy roadmaps) which will:
   - Detail how geothermal could contribute to New Zealand's core objectives of reducing carbon emissions, supporting economic development, and ensuring energy system security and resilience.
   - Detail the role of geothermal in New Zealand's energy transition and its strategic role in New Zealand's energy system for baseload generation; flexible, dispatchable generation; and geoheat for direct use.
   - Assess geothermal future scenarios in line with New Zealand's objectives and detail a geothermal pathway to 2050.

Section 2: Enabling vast deployment Geoheat solutions for the decarbonisation of process heat

8. Geoheat is available now at many locations in Aotearoa New Zealand, and is a low carbon, renewable, cost-effective solution for industrial process heat applications and thereby should be considered as a viable alternative to fossil fuels. Moreover, Geoheat reduces demand on the national electricity grid, as it provides a heating option not dependent on electricity (otherwise a prime alternative to fossil-fuelled heating).

Recommendation 2. Support the development of a high quality Geoheat Database to enable vast deployment.

Why?

9. Improved data quality and better captured geothermal direct use data is necessary to increase awareness to open up new ideas and opportunities for further uptake of geothermal direct use. Moreover, it would allow for analyses of key criteria for estimating future trends, such as heat energy used, economics, number of existing installations and planned developments[2].

10. There can be real advantage in bringing expertise resident in the NZGA together with the requisitioning authority of MBIE officials and data held by regional councils and by GNS Science to develop a comprehensive but still confidential database on use. Collective data could be disclosed while keeping individual user data confidential. This work needs investment which MBIE is capable of, and arguably has a responsibility to do, given its role in monitoring energy and plotting our progress to a lower carbon future.

11. In 2022, the Government completed a Regional Heat Demand Database, an “interactive data visualisation tool that allows users to view fuel demand for process heat by region, site count, heat demand and energy demand”[3]. A geoheat database could be viewed together with Regional Heat Demand Database to determine locations where geoheat availability matches with heat demand and can therefore be considered an option for fuel switching, and prioritised as part of the regional energy transition plans which are used by the GIDI fund to inform investment and optimise fuel switching at a regional level.

What?

12. A centralised **Geoheat Database** will be a comprehensive and user-friendly digital platform, consisting of the following key components (but not limited to):
    - Resource Maps: detailing geothermal resources, including heat gradients, hot springs and potential geothermal reservoirs.

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[2] M. Climo, S.D. Milicich, P. Doorman, S.A. Alcaraz, A. Seward and B. Carey, 2021 New Zealand Direct Geothermal Use Inventory Update â€“ Data, Visualisation and Information (geothermal-energy.org)
[3] IEA (2023) *New Zealand 2023 Energy Policy Review (windows.net)

- Demand/customer information: temperature profiles at different depths and regions, enabling precise heat resource characterisation.
- Case studies: Examples of successful geothermal projects, including information on geothermal energy policies, permits, regulations and technologies.

Recommendation (3). Increase Geoheat funding to accelerate deployment. Identify, nurture and support business to explore and commit to new geoheat projects.

Why?

13. The use of geothermal direct heat use for many low-medium temperatures applications, such as wood processing and horticulture are well-established practice in New Zealand and offers material competitive advantages by providing low cost, reliable, sustainable and how-carbon energy.

    Figure 1 below shows a schematic diagram of different applications from direct heat use.

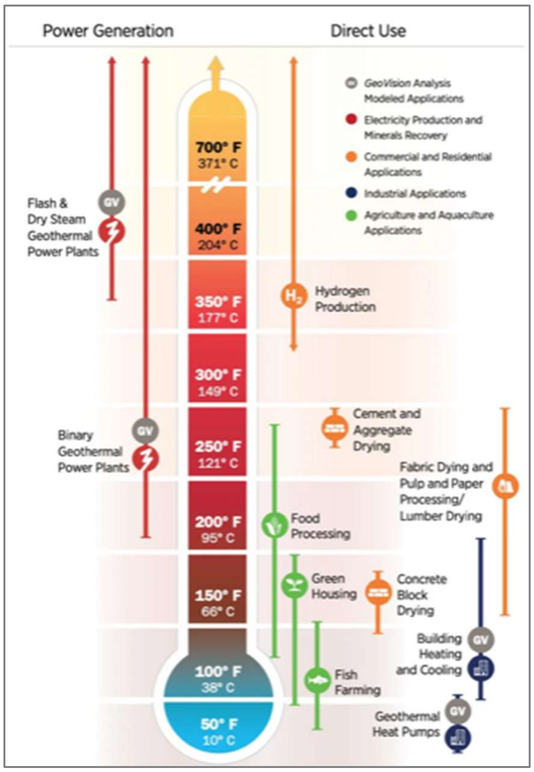

Figure 1: A schematic diagram of different applications from direct heat use.[4]

14. Geoheat reduces demand on the national electricity grid, as it provides a heating option not dependent on electricity (otherwise a prime alternative to fossil-fuelled heating); thereby also avoiding the need for additional investment in generation, transmission and distribution infrastructure that may be required for electrification.

15. To date, the Government Investment in Decarbonisation of Industry (GIDI) fund, which co-invests with industry in major decarbonisation projects, has supported only one geoheat project.

[4] https://causewaygt.com/

16. Other government funds also relevant to geoheat development are the Māori and Public Housing Renewable Energy Fund, which could benefit local geothermal heating schemes in the future; and the Carbon Neutral Government Programme (CNGP) which aims to transition the public sector to carbon neutrality by 2025.

17. Geothermal developments have also benefitted from other central government incentives not specifically targeted to carbon reduction, including 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 also 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. Table 1 presents the cost of fuel types to industrial process in New Zealand.

Table 1 Cost of fuel types 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.

What?

18. NZGA would like to see MORE government investment in Research, Science and Technology into both value-add and wider (greenfield) geotheat potential, such as MBIE/Callaghan/MPI Sustainable Food and Fibre Future/EECA, to share geoheat infrastructure and reducing barriers for SMEs, attracting investment into the regions and promotion of geoheat as a readily available energy option.

More information about geoheat direct heat use is detailed in Appendix 1.

Section 3: Accelerating new geothermal generation for reliable, renewable baseload

19. Geothermal energy generates over 18% of New Zealand's electricity in 2022CY[5] and has been the single biggest contributor to the decarbonising the New Zealand electricity sector for over sixty years.

20. Geothermal energy offers a reliable, renewable baseload electricity supply, operating at close to 90% capacity and regardless of weather or climatic conditions. This manner of operation should be accelerated and act as the **primary renewable electricity baseload option**, replacing gas/coal, and thus (unlike other renewables) does not require an overbuild of infrastructure or massive storage assets to ensure reliability.

Recommendation 4. Use the new Natural and Built Environment Act and the Spatial Planning Act to accelerate supply of new geothermal baseload generation – the Game Changer.

21. The geothermal community seeks to ensure that the new Natural and Built Environment Act (NBA) and the National Planning framework, not only allows, but *enables* further geothermal development while ensuring protection for significant geothermal features.

22. To enable future exploration, testing, understanding and sustainable utilisation of geothermal resources, the NBA needs to directly provide for a consideration of the local, regional, national and climate change benefits of renewable energy use, alongside a consideration of the actual and potential environmental effects of geothermal energy projects.

23. Our current approach to geothermal resource use and development under the RMA is world recognised! The uncertainty associated with geothermal resource use and development requires that the NBA provide flexibility to facilitate exploration to increase knowledge and understanding of geothermal resources, and to support an appropriate regulatory regime for geothermal development projects.

24. The Spatial Planning Act needs to be cognisant of the practical reality that Regional Councils are heavily reliant on external expertise in regulatory processes due to the specialist nature of the field. A cross-regional spatial strategy is an opportunity to optimise the expertise available, by providing a consistent and comprehensive approach to the management and use of geothermal resources at a scale relevant to the resources themselves, while avoiding existing cross-boundary issues at a regulatory level that add

[5] Contact Energy (2021)
Contact and Genesis announce long-term renewable electricity agreement

unnecessary complexity, uncertainty, and duplication. This approach has been taken up by the Bay of Plenty and Waikato Regional Councils in their respective planning documents.

Section 4: Employing flexible geothermal generation for hydro dry-year supply security

Recommendation 5. Geothermal storage: The New Zealand Battery Project flexible geothermal base case

25. The New Zealand Battery Project has conducted options analysis and feasibility assessment identifying a base case for new geothermal generation to run at part load and ramp up to meet supply shortfall during dry years. However, the renewable technology portfolio assessed under the New Zealand Battery Project including flexible geothermal, was only briefly mentioned in this draft report, despite being a critical component of the issue paper topic.

26. The proposed base case for flexible geothermal under the New Zealand Battery Project is to build 400 MW of new geothermal generation (ahead of planned market supply) at several (currently undeveloped) sites, distributed across New Zealand's known geothermal regions (primarily the Taupō Volcanic Zone). Each plant would typically be built in modules, which could then be brought on, as required, for dry years in controlled increments, depending on the extent of the energy gap.

27. As acknowledged by the New Zealand Battery Project, flexible geothermal offers the future optionality to switch back to providing conventional baseload and therefore presents a relatively safe, "no regrets" solution for New Zealand.

28. The critical factor to the success of operating geothermal power plants as providers of flexibility will be whether the operators can capture the value of the flexibility they provide to the grid and be assured compensation for lost revenue due to their running at part load.

29. In the current European market system, some studies estimate the value of behaving as a flexible provider for gas power plant to be around 7-15 EUR/MWh on the long term (14-30% of the average electricity wholesale price prior to the current crisis). Studies also highlight the high value put by the market on the capacity of operators to react to volatility of electricity supply (i.e., linked to higher penetration of variable renewables like wind and photovoltaic): when volatility increases by 100%, the value of solving this need increases by up to 5 times. Other estimates put the value of flexibility by other providers such as demand response at between 15-31 USD/MWh[6]

Section 5. Unlocking Emerging Industries with Geothermal Resources

30. If green hydrogen is to become a significant player in the energy of the future for Aotearoa New Zealand, it must be produced using renewable energy sources. Hydrogen provides the connecting point between

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[6] EGEC (2021) Energy Prices - the geothermal answer (egec.org)

renewable electricity production and transportation, storage and portable energy needs. Geothermal energy provides an affordable, clean method of generating electricity and providing thermal energy. In this regard, there is potential **to overbuild geothermal in a load-following manner and using excess resources for green hydrogen production and liquefaction** can be proven to be effective option in the future hydrogen structure.

31. In December 2021, the Tūaropaki / Obayashi joint venture (Halcyon Power) started hydrogen production at its 1.5MW geothermally powered (green) hydrogen pilot plant. The Halcyon plant (supplied by Hydrogenics Ltd.) is New Zealand's first green hydrogen plant with a design capacity of up to 250Nm3 per hour of hydrogen; the first-year production target is 180 tonnes per year.

Conclusion

Recognising and harnessing the vast potential of Aotearoa New Zealand's geothermal resources is critical to addressing the key challenges outlined in the consultation document, meeting the New Zealand Government's energy targets and objectives, and to ensuring an equitable, sustainable, renewable electricity future.

Geothermal resources can replace fossil fuels with low carbon, renewable, reliable baseload generation; ensure system resilience and stability; provide supply security in dry years; decarbonise industrial process heat and reduce demand for electrification; tap into innovative industries like green hydrogen that will shape the energy landscape of the future; and offer new avenues for economic growth and sustainability.

We would be happy to answer any further queries.
Nāku noa, nā,

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Appendix 1.1 Geothermal baseload electricity generation for over sixty years.

Reliable, renewable, low carbon baseload generation

32. Geothermal has been decarbonising the New Zealand electricity sector for over sixty years, operating at close to 90% capacity factor. It therefore provides reliable, renewable, low carbon baseload generation, producing power at a constant rate regardless of weather or climatic conditions.

33. Over the decade from 2006-2016, the overall greenhouse gas emissions intensity of New Zealand's electricity sector approximately halved, due to displacement of fossil-fuel based generation, primarily by geothermal. [7]

34. To enable further decarbonisation of the electricity grid, with geothermal energy acting as the potential primary renewable electricity baseload option, replacing gas/coal, and thus (unlike other renewables) does not require an overbuild of infrastructure or massive storage assets to ensure reliability.

Significant Geothermal generation potential

35. In addition to the existing baseload geothermal generation of 8,060 GWh/annum, the following tables are a summary of anticipated additional geothermal generation (plant capacity in brackets):

[7] McLean and Richardson, 2019: GREENHOUSE GAS EMISSIONS FROM NEW ZEALAND GEOTHERMAL POWER GENERATION IN CONTEXT, NZGW conference paper

Table 2: Projects Under Construction

Field / Project	Capacity (MWe)	OEM	Forecast COD	Developer	Comments
Tauhara	184 CST-TF	Fuji Electric	Q1 2024	Contact Energy	Commissioning began in Q3 2023
Tauhara Te Huka U3	50 ORC	Ormat	2024	Contact Energy	Civil works and design underway

Table 3: Projects Under Development

Field / Project	Capacity (MWe)	Forecast COD	Developer	Comments
Nga Tāmariki OEC5	50 ORC	2026	Mercury (NZ) Ltd	Financial Investment Decision achieved in Oct 2023
Ngāwhā OEC5	32 ORC	2028	Ngāwhā Generation Ltd	FEED ongoing
Wairakei repower	45 ?	2026	Contact Energy Ltd	WRK A & B to retire, new plant at Te Mihi, FEED ongoing
TOPP2 25	25 ORC	2025	Eastland Generation Ltd & Ngāti Tūwharetoa Geothermal Assets	FEED ongoing

Table 4: Potential Greenfield Projects

Field/Project	Capacity (MWe)	Forecast COD	Developer	Comments
Taheke A	30	2027	Eastland Generation Ltd. & Taheke 8C Inc.	Concept design & permitting
Tikitere A	45	2028	Ormat & Tikitere Power Company	Awaiting litigation
Rotoma A	15	2029	Tuara Matata collective	Recon exploration

Key to Abbreviations

CST–TF = condensing steam turbine – triple flash

COD = commercial operations date

ORC = Organic Rankine Cycle (binary)

FEED = front end engineering design

Appendix 1.2. Reducing Geothermal lifecycle emissions by capturing CO_2 and reinjection towards zero emissions geothermal power plant

36. The MWe-weighted average operational emissions intensity of the 14 geothermal power stations in the below Table 5 is **63 gCO2-e/kWh(net) for CY2022**.

37. The full lifecycle CO_2-e emissions from New Zealand geothermal power stations for CY2022 are also estimated in Table 5. The full lifecycle emissions for geothermal can be estimated by adding 10 gCO2e/kWh(net) to account for emissions associated with materials and construction, maintenance, and decommissioning[8].

38. The overall MWe-weighted average lifecycle emissions intensity is 73 gCO_2-e/kWh(net). Other sources of energy are compared on the basis of median lifecycle emissions intensity, which is 64 gCO2-e/kWh(net) for NZ geothermal in 2022 (Table 5). This compares to lifecycle emissions from other renewables of 44 for solar photovoltaics, 19 for hydro and 11 for wind (median lifecycle emissions intensity). Fossil fuels have median lifecycle emissions intensities an order of magnitude higher, of 450 gCO2e/kWh(net) for gas combined cycle plants and 980 for coal (McLean and Richardson, 2021). Figure 2 compares the lifecycle emissions intensity of all fuels in Aotearoa New Zealand (2022 calendar year).

[8] Fridriksson, T., Merino, A.M., Orucu, A.Y. and Audinet, P. (2017): Greenhouse Gas Emissions from Geothermal Power Production. Proceedings 42nd Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, February 13-15, 2017.

Table 5 Full lifecycle CO2-e emissions from NZ geothermal power stations for CY2022

Year - 2022	DATA INPUT							
Station	Total Steam, t	UEF t CO2e/t stm	Net Generation GWh	Average MW for CY2021	Total Em. t CO2e/an	Emissions rate t CO2e/day	Operational emissions intensity gCO2e/kWh(net)	Estimated lifecycle emissions intensity (operational E.I. +10) gCO2e/kWh(net)
Wairakei A&B and binary	8,575,775	0.0022	1013.1	116	18,867	52	19	29
Te Mihi	11,502,092	0.0044	1384.1	158	50,609	139	37	47
Poihipi	2,487,258	0.0049	317.1	36	12,188	33	38	48
Ohaaki	2,686,088	0.0333	317.2	36	89,447	245	282	292
Te Huka	1,331,899	0.0073	199.4	23	9,723	27	49	59
Rotokawa	1,161,833	0.0119	244	28	13,826	38	57	67
Nga Awa Purua	7,121,629	0.00871	1114	127	62,029	170	56	66
Mokai	4,716,085	0.00418	778	89	19,713	54	25	35
Ngatamariki	4,071,925	0.00728	735	84	29,644	81	40	50
Kawerau	6,679,817	0.0169	896	102	112,889	309	126	136
TOPP1	912,708	0.0102	126	14	9,310	25	74	84
TAOM	1,088,322	0.0106	194	22	11,536	32	60	70
GDL	304,734	0.0119	68	8	3,626	10	53	63
Ngawha (OEC1-3)	697,890	0.0442	191	22	30,847	84	162	172
						MEDIAN	54	64
						25th PERCENTILE	39	49
						75th PERCENTILE	70	80
						MW WEIGHTED AV	**63**	**73**

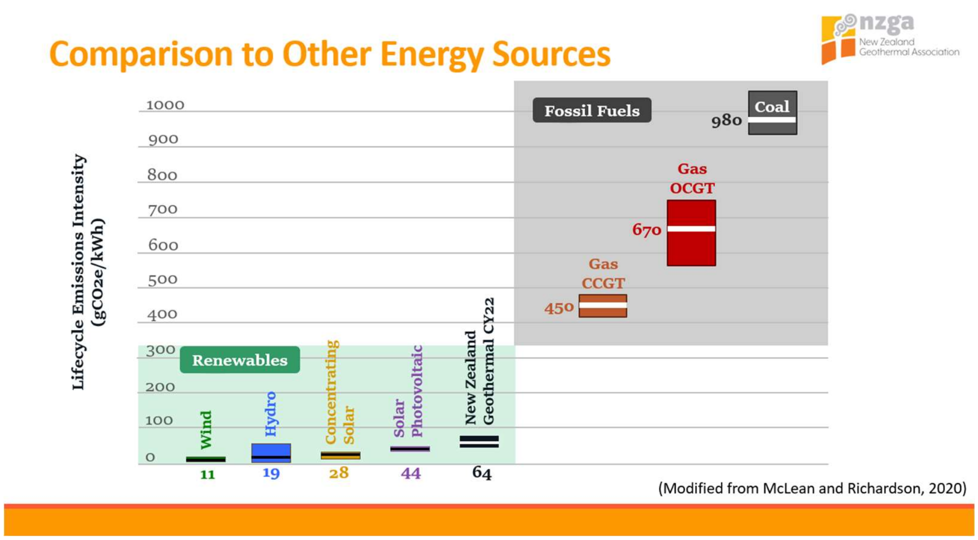

Figure 2: Lifecycle emissions intensity of all fuel types in Aotearoa New Zealand (CY2022)[9]

39. Geothermal emissions intensity in New Zealand has an ongoing declining trend. The 8-year trend of data from 2015 through to 2022 shows a decline rate of **6% per year** in the overall emissions intensity of the industry (Figure 3).

[9] https://www.nzgeothermal.org.nz/downloads/CO2-Emissions-Reduction-project.pdf

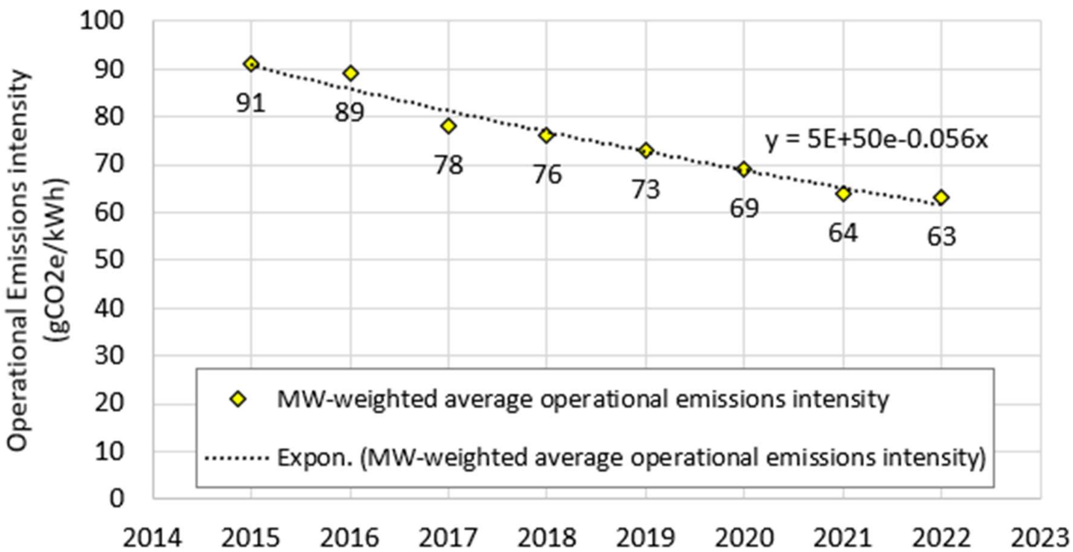

Figure 3 Steady decline of MWe-weighted average emissions intensity for seven years from 2015 to 2022

40. Also there will be step changes downwards, as geothermal operators have embarked upon projects/programmes to return the gases back underground to where they came from, dissolved in the reinjected geothermal water.

41. The CO_2 reinjection technology diverts the CO_2 gas stream (along with CH_4 and H_2S) from venting to the atmosphere and instead dissolves the gases in water (separated geothermal water and/or condensate) where is carried back underground to where it came from, via the usual reinjection system.

42. All the major geothermal companies in New Zealand have active trials, or plans for, CO_2 reinjection since 2021. This includes Mercury Energy, Contact Energy, Ngāwhā Generation and Eastland Generation, which together represent 96% of New Zealand's geothermal electricity generation. These trials have been successful to date and are anticipated to continue into the future, where they will come to be reflected in the emissions intensity values for those power stations.

43. Plans are underway for similar projects in more geothermal power stations.
    - Contact Energy's trial of CO_2 reinjection at the Te Huka power station became fully operational in November 2022. The plant is currently reinjecting 100% of emissions with no detrimental effect on the plant or reservoir. When CO_2 reinjection is not being utilised the emissions from Te Huka are around 8,000 tonnes of CO2-e annually.
    - Ngāwha Generation has 100% CO_2 reinjection at Stations 1 and 2 (OEC1-3), which came into operation from May 2022 to January 2023. The new Station 3 (OEC4) has been at 70% reinjection since April 2023 and will transition to 100%.

- Eastland Generation plans to transition to CO_2 reinjection at its Te Ahi O Maui power station and TOPP1 by 2025.
- Mercury Energy Ltd commenced a trial of CO_2 reinjection at Ngā Tamariki Power Station near Taupō in October 2021, the first trial in NZ. This involved full injection of gas emissions from one of the four OEC units (therefore a ¼ reduction in emissions), added into the brine-condensate reinjection fluid, and reinjected. One quarter of the emissions from Ngā Tamariki represents around 9,000 tonnes of CO_2e annually. This trial proved successful, with the ongoing carbon reinjection process showing no disruption to power generation or detrimental effect on the underground reservoir environment and geothermal well performance[10]. Mercury is now evaluating whether a similar technology can be extended to more units at Ngā Tāmariki and to Mercury's other geothermal power stations.

44. Another opportunity exists to utilise CO_2 from geothermal power plants to enhance growing conditions in greenhouses. For example, during 2022 the Rohe Hothouse scheme successfully won consent for 18Ha of glass-house capacity at Ohaaki geothermal field. This greenhouse will use heat and CO_2 from the Ohaaki Power Plant to enhance growing conditions.

45. NZGA Industry Emissions Working Group was established in 2021. This provides a framework for members to discuss, share and collaborate on issues associated with emissions from the use of geothermal energy, including: Knowledge/Mātauranga Māori, Risk and Engineering Solutions, Reinjections and Reservoir Management, Other Uses, Regulatory Matters, and Education. As of end of 2023, it involves all of the owners/operators of geothermal power stations in NZ.

Appendix 1.3 Geoheat: direct heat use and industrial process heat: always-on, off-grid, co-location, complementarity

Geo-heat Strategy and Action Plan objectives

47. In 2017, the NZGA published the Geo-heat Strategy[11] which is the primary geothermal programme in Aotearoa New Zealand focussed on increasing the use of direct geothermal energy through industrial and commercial scale applications (e.g., glasshouses, timber processing, dairy processing).

48. About 60% of process heat demand in Aotearoa New Zealand is supplied from fossil fuels, mainly coal or natural gas (MBIE 2019). Therefore, in order to meet the 50% economy-wide target for renewables by 2035, considerably more progress is needed in the industry sector. The importance of this Strategy therefore, is that it provides guidance and drive towards increasing uptake of geothermal direct use which can in turn displace heat sources that rely on fossil fuels and produce carbon emissions.

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[10] Ghafar, S.A., Allan, G., Ferguson, A., Siega, F., Rivera, M. and Murphy, B. (2022): Non Condensable Gas Reinjection Trial at Ngatamariki Geothermal Power Plant. Proceedings 44th New Zealand Geothermal Workshop, 23-25 November 2022, Auckland, New Zealand.

[11] https://nzgeothermal.org.nz/app/uploads/2017/06/Geoheat_Strategy_2017-2030__Web_Res_.pdf

49. In 2018, The Interim Climate Change Committee was established to consider how New Zealand could transition to 100% renewable electricity and a low-emissions energy future. It concluded that achieving the goal of 100% renewable electricity, especially the last few per cent, could be costly.

50. It recommended that New Zealand should instead pursue an electricity system 90-95% based on renewables and prioritise decarbonisation of industrial process heat and transport. The modelling behind the report included scenarios with ambitious levels of electrification of process heat to 2035.

51. The Strategy's primary focus is to develop such resources in Northland, Waikato and Bay of Plenty regions with the goal of additional 7.5 PJ of geothermal utilisation. The secondary focus is to further push development of direct use of geothermal resources for residential scale use as well as the industrial use in other regions. It should be noted here that the **South Island**, although lesser known for geothermal resources, **does in fact have geoheat resources** and several geothermal direct use applications including Christchurch Airport geothermal heating and cooling, pools and spas for bathing. For example, Maruia Hot Springs on the West Coast, and Hanmer Springs Canterbury.

52. Every two years, we publish the bi-annual Action Plan where we celebrate our achievements and report on progress and details for the next two years. We have published the 2022-2023 Action Plan in early 2022[12]. 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.

53. 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.

Diverse range of applications

54. 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, always available, proven at scale and low risk.

55. 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.

56. Geoheat examples such as Nature's Flame demonstrates complementarity with other renewables. Nature's Flame produces biofuel pellets from wood waste residue. it is co-located with developed

[12] https://www.nzgeothermal.org.nz/downloads/2022-23-GEOHEAT_ACTION_PLAN-Spread-with-Bookmarks-1.pdf

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.

57. Even more widespread use could be made of geothermal heat pumps as highly efficient heat providers almost anywhere in New Zealand. These systems are effective in supplying greater than 3 units of heat (or cool) for one unit of electricity, they are being adopted extensively in Europe as part of the energy transition being pursued by the European Commission. In some circumstances and for larger facilities they can provide some support for grid stability and line capacity management through central control of some of the operations.

Figure 4 below shows a schematic diagram of different applications from direct heat use.

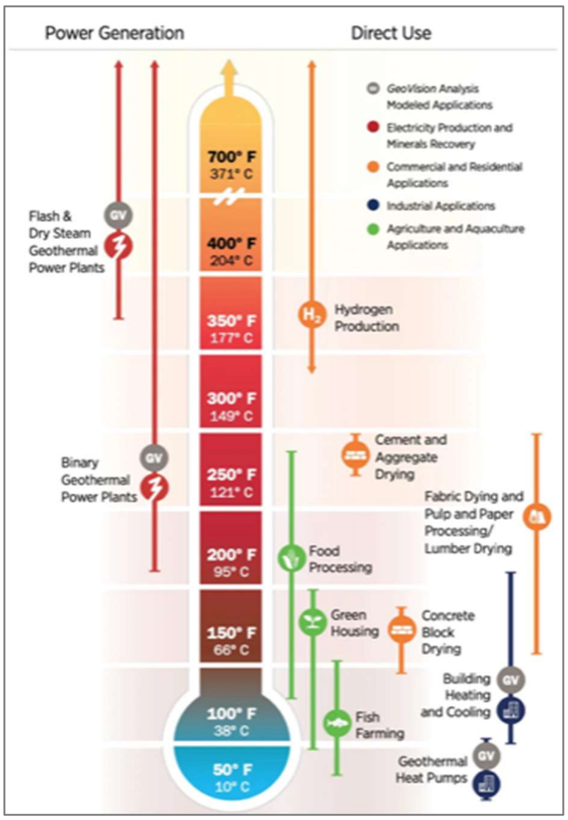

Figure 4: A schematic diagram of different applications from direct heat use.[13]

Cost-effective, sustainable solution

58. Geoheat is available now at many locations in Aotearoa New Zealand, and is a cost-effective, sustainable solution 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

[13] https://causewaygt.com/

new ventures or decarbonising established operations. The Geoheat Strategy 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) which are actively involved, as are a range of Māori-owned entities, consultants, commercial businesses, research organisations and government agencies.

59. The food and beverage industry is New Zealand's largest export sector. Provision of geoheat to the agri-food sector in New Zealand prevents the agri-food businesses being subjected to high energy prices if the heat was otherwise run on fossil gas or electrified. Geoheat - the direct use geothermal energy - is the lowest cost of any fuel type in delivering energy to an industrial process in New Zealand, as highlighted in the table below.

Table 6 Cost of fuel types 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.

Co-location

60. A new industrial estate is being developed in Taupō, called He Ahi, the Tauhara Clean Energy Park. Users will have the opportunity to tap into geothermal energy to power their activities. The 45-hectare site is located in the existing industrial area on the northern edge of Taupō town. The land is co-owned by several local iwi groups and is subdivided into numerous sections. Each site will be specifically designed and built to meet the requirements of the tenant. Contact Energy Ltd. will supply geothermal energy to the tenants from the existing infrastructure associated with the nearby Te Huka geothermal power station.

Reliable data

61. Low awareness is a substantial barrier to increasing the diversification of geothermal resource use in New Zealand[14]. Showcasing existing applications is one way to raise awareness, promoting potential business uses and opportunities. Successful implementation of direct use development also requires financial data on economic viability, market drivers and sound business cases to be developed by the potential user. Moreover, reliable data is necessary on both energy use and employment for projects established to track progress of the geoheat strategy. More detail on the Geoheat Strategy and the implementation approach can be found in Climo et al., (2020)[15].

62. Furthermore, the quantification of geothermal resources economic value[16] provides policy makers with a framework for considering the impact of resource management decisions and assists economic development agencies and investors to better understand the opportunities. Direct use data can be used to support economic studies, as well as the creation of multipliers for industries where quantitative information is less readily available, for example, horticulture, fish farming and honey processing.

63. Historically, geothermal research and data collection in New Zealand has focused on high temperature resources and electricity generation, while direct use and lower temperature geothermal research has been more ad-hoc[17].

64. A fundamental limitation to reporting, past reviews and geothermal energy use assessments in New Zealand, has been that the direct use data sets are incomplete, much is estimated, and the data is of variable quality. The most accurate data is associated with the larger use industrial installations, where flow (and energy) metering are often linked to industrial/commercial supply contracts and/or resource consent monitoring. Commercial, domestic, and small mineral bathing uses are the least well defined, less monitored, with estimates often based on consented take, coupled with known resource and use characteristics. Smaller users are often unaware of the thermal capacity or the daily to annual energy delivery from their heat producing facilities. Also, for 'Permitted' uses (or any other uses that are unconsented), there is usually no requirement to submit monitoring data[21].

65. Geothermal resource consent applications require the developer to pay the costs of exploration to acquire data required for the resource consent application. A thorough investigation must be undertaken but with no right of priority or access. Since geothermal exploration carries no rights of priority, there is a strong incentive for the data collected to remain confidential. In these cases, data is commercially sensitive and

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[14] Carey, B., Climo, M., Watt? A Geoheat Strategy For New Zealand. Proceedings of the NZ Geothermal 34th Workshop, 19-21 November 2012, Auckland (2012)
[15] Climo, M., Blair, A., Carey, B., Bendall, S. Daysh, S. Driving the Uptake of Geothermal Direct Use in New Zealand: Successful Strategies, Empowered Champions, and Lessons Learnt Along the Way. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26 – May 2, 2020. (2020)
[16] Barns and Luketina, 2011; Conroy and Donald, 2013; Luketina et al., 2016
[17]M. Climo, S.D. Milicich, P. Doorman, S.A. Alcaraz, A. Seward and B. Carey, 2021 [*New Zealand Direct Geothermal Use Inventory Update â€“ Data, Visualisation and Information (geothermal-energy.org)]

can be treated as such under New Zealand law, and therefore will not be readily available. However, if consent data could be integrated directly with the database, it would provide the most accurate and timely measure of direct use nationally. This would require agreed protocols with regional councils around data reporting and aggregation, and subsequent processes put in place to feed data into a centralised database.