27 March 2021

Attn: Submissions Analysis Team
Climate Change Commission
PO Box 24448
Wellington 6142

Submission on He Pou a Rangi Climate Change Commission 2021 Draft Advice for Consultation

This is document is submitted on behalf of the New Zealand Geothermal Association (NZGA) by Dr Paul Siratovich (President, NZGA). This document forms one part of the NZGA submission to this process. The second part of the NZGA submission - the online response to the consultation questions provided by the Climate Change Commission - has been submitted by Dr Katie McLean (Vice President, NZGA).

Key Messages:

- Geothermal is an abundant, low-carbon and cost-effective energy resource that gives Aotearoa New Zealand a competitive advantage in transitioning its energy sector and economy.
- Geothermal energy has been decarbonising New Zealand's electricity and process heat sectors for over sixty years and is capable of innovating to decarbonise further so as to be a key part of Aotearoa's future energy solution.
- Geothermal energy is a critical enabler: of other renewables, of low-emission fuel production (biomass and green hydrogen), of investment in New Zealand's strong and competitive business sectors (food and beverage, horticulture, renewable energy, tech and innovation, tourism, and wood processing), and of regional economic growth and Māori socio-economic development.

Summary & Recommendations

Geothermal is a vibrant, proven, indigenous renewable resource, which enables other industries to thrive and our regions to grow. Aotearoa's legacy of low-carbon geothermal use gives the nation a competitive advantage in transitioning its energy sector and economy. Many of the elements needed for low-carbon geothermal to make a greater contribution to New Zealand's energy scene are established.

Geothermal energy has been decarbonising New Zealand's electricity and process heat sectors for over sixty years, and is capable of innovating to decarbonise further so as to be a key part of Aotearoa's future energy solution. A supportive and enabling policy environment will incentivise greater geothermal investment, technology development and fuel switching. Growth should also be encouraged in non-energy socio-economic streams, such as minerals, industrial tourism, Māori innovation, and training/education.

We recommend that in their 2021 advice to Government, the Climate Change Commission revise the Advice to:

i. Promote *increased* geothermal energy use in Aotearoa New Zealand.
ii. Remove any recommendations suggesting closure of geothermal plant.
iii. Establish a more enabling regime and policy environment at the national level for renewable energy solutions.
iv. Make capital / R&D tax credits available for energy transition and technology deployment for generators and large process heat users to influence energy and efficiency investment decisions.

Supporting details are laid out in the following pages.

1. New Zealand Geothermal Association

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 geothermal.

NZGA membership comprises ca. 400 individuals, as well as corporate members, representing geothermal electricity generators, research organisations, regional councils, engineering consultants, technology companies, planning consultants and Māori trusts. This diverse and skilled network of people work and live with Aotearoa's geothermal resources.

The NZGA is an affiliated member of the International Geothermal Association and the Royal Society of New Zealand. The NZGA connects with global geothermal communities and is well positioned to positively influence geothermal initiatives on the international stage.

2. CCC 2021 Draft Advice for Consultation

The NZGA applauds the Climate Change Commission' Draft Advice, and believes that New Zealand's 2050 carbon zero target is achievable, subject to the introduction of appropriate policies and incentives. There are technically achievable, economically affordable, and socially acceptable pathways to reaching the zero-carbon target.

For the NZGA, the Draft Advice focus areas (where geothermal will play a key role), are in 'heat, industry and power' and 'transport'.

The NZGA sees that timing is critical and starting now is important to keep costs low. Localised transition planning and phasing is a necessary approach for both electricity generation and process heat to ensure replacement of assets and infrastructure while maintaining growth and minimising costs.

The CCC's approach to shift away from a 100% renewable electricity target and instead to set a renewable energy target (60% renewable by 2035, 90% by 2050) is a sound move. This viewpoint and language will ensure New Zealanders are aware the nation's energy supply and consumption is about more than just changing our electricity generation (which represents only 5% of the NZ emissions problem, and is a sector that is already 84% renewable). The messaging needs to be clear that New Zealand still has a long way to go (to replace ca. 70% of New Zealand's consumed fossil fuel-based energy use).

The NZGA agrees electrification will play an important role in decarbonisation, along with increased use of low-emission fuels, such as biofuels and green hydrogen. The geothermal industry stands ready to not only expand geothermal electricity production, but also to provide low-carbon electricity and heat needed to support industry decarbonisation and development of low-emission fuels.

The abundance of geothermal resources in Aotearoa, and our sustainable use and management of these resources, is an enviable asset on the global stage. This gives our country a competitive advantage for the low-carbon transition and offers future-proofed, low-carbon infrastructure projects that should be prioritised. However, we believe that the CCC's 2021 Draft Advice has underestimated the huge potential of geothermal as a keystone in Aotearoa's low-carbon future. The Draft Advice appears to perceive geothermal energy as a net producer of carbon, and thus has disregarded geothermal energy and its significant economic, environmental, and societal benefits.

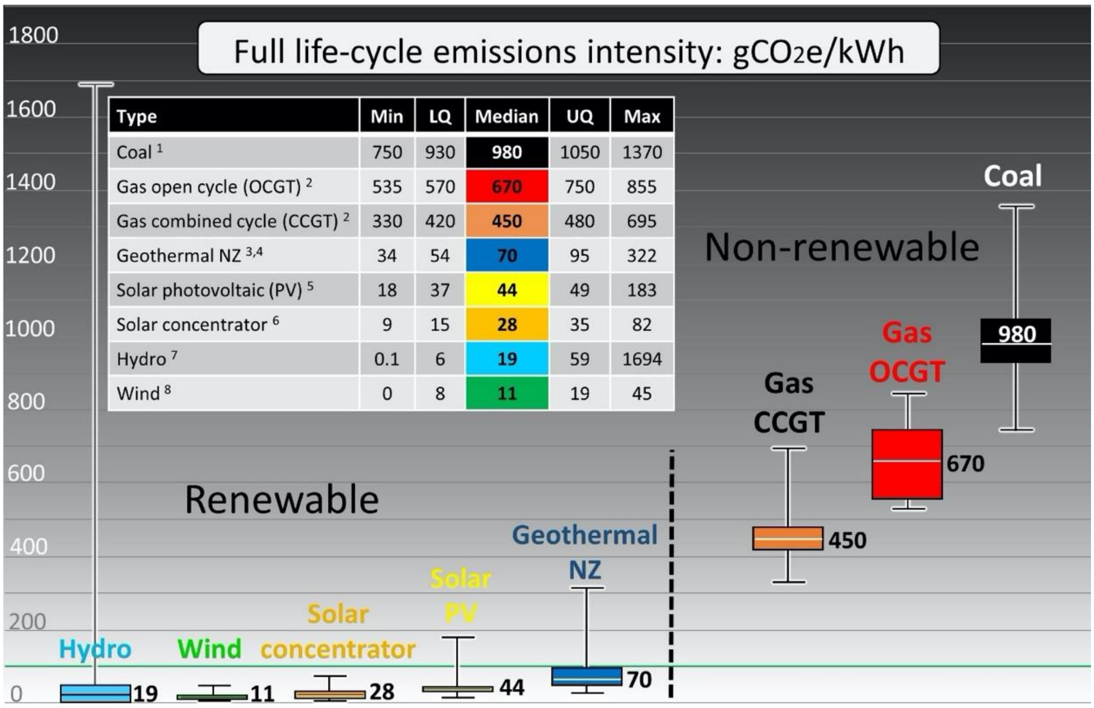
This submission by the NZGA seeks to clarify the environmental performance of geothermal energy and highlight the ability of the geothermal community to innovate so that there is no need to shut down a reliable, renewable, indigenous energy source. Here, we will outline the significant value geothermal offers New Zealand as a proven, indigenous, low-carbon, reliable, accessible baseload energy source.

3. *Geothermal can manage CO2-equivalent emissions to net-zero*

It is true that geothermal electricity production *in the current operating environment* releases dissolved carbon dioxide from geothermal fluids. Unlike solar and wind, which do not produce emissions directly during operation, geothermal power stations do release CO2e during operation. However, operational emissions are only one part of the emissions story, and in reality *there are no zero-emission sources of energy*.

A full life-cycle assessment (LCA) of emissions is necessary, to include all emissions associated with materials and construction, operation, and decommissioning at the end of the project life. For this reason, lifecycle emissions are used by the IPCC when comparing different energy types. All the renewable energy types, including geothermal, have lifecycle emissions at least one order of magnitude less than fossil fuels (see figure below[1]).

In the case of geothermal, the majority of lifecycle emissions come from operational releases. In the case of solar and wind, the majority are related to materials, manufacturing and construction. Hydro can be quite variable, as there can be significant emissions associated with land-use change (i.e. the creation of bodies of freshwater covering land formerly providing a carbon sink).



Type	Min	LQ	Median	UQ	Max
Coal [1]	750	930	980	1050	1370
Gas open cycle (OCGT) [2]	535	570	670	750	855
Gas combined cycle (CCGT) [2]	330	420	450	480	695
Geothermal NZ [3,4]	34	54	70	95	322
Solar photovoltaic (PV) [5]	18	37	44	49	183
Solar concentrator [6]	9	15	28	35	82
Hydro [7]	0.1	6	19	59	1694
Wind [8]	0	8	11	19	45

Geothermal has the advantage over other renewables of having higher availability, as seasonality does not have significant impact on energy generation, and thus does not require an overbuild of infrastructure assets to ensure reliability.

The current level of operational geothermal CO2e emissions in electricity generation (which are steadily declining[2]) is purely an engineering challenge to be overcome. Returning the gases to the reservoir (where they came from) is a feasible solution, which has emerged relatively recently (usually called Non-Condensable Gas (NCG) reinjection) and is in operation at a small number of geothermal power stations around the world. The New Zealand geothermal industry is globally recognised for leading innovation, and, with sufficient support, will be well placed to drive geothermal CO2e emissions towards net-zero. NCG reinjection is already being actively investigated by the two major geothermal power generators – Mercury and Contact Energy. The international

[1] Data sources and references for this figure can be found at the end of this document.

[2] McLean, K., Richardson, I., Quinao, J., Clark, T. and Owens, L. 2020. Greenhouse Gas Emissions From New Zealand Geothermal: Power Generation and Industrial Direct Use. Proceedings 42nd New Zealand Geothermal Workshop, Waitangi, NZ, 24-26 November 2020.

geothermal industry is producing emerging technologies for geothermal NCG reinjection, that could be trialled and adapted for New Zealand conditions.

Whilst the CCC has recognised that there are readily deployable carbon reinjection technologies, it falls short of making recommendations to incentivise trials and deployment in New Zealand geothermal power plants. Rather, the CCC suggests the closure of reliable, renewable, and regionally important geothermal power plants in the Draft Advice; we recommend that the CCC remove any suggestion of geothermal plant closure. Without emissions reduction, the rising price of carbon will make high-emitting geothermal plants uneconomic to run anyway.

Additionally, we recommend the CCC advocate for financial incentives to stimulate technical advances in geothermal emissions reduction (NCG reinjection and other uses). Such incentives might include adjusting the R&D tax credit facility or establishing a capital fund (for example, in the form of grants or low interest loans) to support capital expenditure by geothermal operators investigating and trialling decarbonisation of plant and NCG reinjection in operating geothermal fields.

Geothermal should be encouraged and promoted as having a key role in New Zealand's energy future — because geothermal is already low-carbon and set to get lower.

4. Geothermal resources are a low-carbon electricity solution with significant growth potential

Geothermal energy generates 17% of New Zealand's electricity[3], and supplies 21% of New Zealand's primary energy[4].

Geothermal has been decarbonising the New Zealand energy sector for over sixty years. In the last ten years, the overall GHG emissions intensity of New Zealand's electricity sector approximately halved[5], due to displacement of fossil-fuel based generation, primarily by geothermal.

Geothermal energy offers a reliable, renewable baseload supply (i.e., producing power at a constant rate regardless of weather or climatic conditions). This manner of operation will enable further decarbonisation of the energy grid, with geothermal energy acting as the primary renewable baseload option, replacing gas/coal. In future, there will be an increased demand for renewable baseload power to stabilise the grid, with increasing variable power generation capacity expected (due to reduction in baseload fossil fuel plants and increase in weather- and climate-dependent renewables).

The NZGA would like to challenge those aspects of the draft advice that (i) recommends closure of high-emitting geothermal power stations (Ohaaki and Ngawha), and (ii) has no recommendation for expansion of geothermal generation.

Closing Ohaaki and Ngawha would reduce New Zealand's renewable baseload capacity by 6%, for a minimal emissions reduction (i.e. 25% of geothermal's minor (ca. 2%) contribution to New Zealand's CO2 emissions). Ohaaki and Ngawha would be replaced with an overbuild of weather-dependent renewables, to cover the loss of generation capacity from a reliable and renewable baseload energy resource that could be effectively decarbonised.

Plant closure is not the only way to achieve emissions reduction, as NCG reinjection technologies are set to cut emissions significantly. It may be more effective to set an emissions reduction target to apply to all geothermal power stations (rather than just focussing on two stations), or to simply allow the rising carbon price to achieve emissions reduction. That would incentivise development and implementation of decarbonisation solutions, and drive plant closure for economic reasons, if emissions abatement were not possible. We note the Draft Advice makes no recommendation for

[3] MBIE Electricity Statistics, 2021
[4] MBIE Energy in New Zealand, 2020
[5] McLean, K. and Richardson, I. 2019. Greenhouse Gas Emissions from New Zealand Geothermal Power Generation in Context. Proceedings 41st New Zealand Geothermal Workshop, Auckland, 25-27 November, 2019.

incentivising the deployment of geothermal NCG reinjection technologies that could enable further decarbonisation of geothermal energy use. We recommend such incentives be introduced.

Not expanding geothermal generation leaves a significant gap in supply, at a time when ca. 27 petajoules of electricity generation[6] (17.5% of the current supply, for current demand) would be required if all New Zealand's fossil fuel-based plant is closed. Closure of geothermal plant, and disregarding world-class low-carbon geothermal resources, would disadvantage New Zealand environmentally, economically, and socially. Geothermal plant closures would also send the wrong signal to the world and diminish New Zealand's geothermal energy leadership and advantage. The world energy markets are showing growing interest in geothermal as a sought-after sustainable energy solution; New Zealand companies and experts benefit from increased global geothermal growth).

We believe our challenge as a nation is in ensuring that we maximise all our renewable energy resources during our transition to a low-carbon future, especially baseload renewables. Baseload geothermal energy partners with and enables other renewable energy sources, such as solar, wind, hydrogen, and biomass. Maximising geothermal development (with its high availability of 90%-99%), through a more enabling regime and policy at the national level will reduce the overbuild (and associated life-cycle emissions) likely required for variable and weather-dependent energy sources, while minimising New Zealand's current reliance on fossil-based sources. Increased geothermal generation will ensure that our decarbonised future will remain affordable[7].

5. *Geothermal is a low-carbon industrial process heat solution that enables other industries to thrive*

Geothermal is used for more than electricity generation — the direct use of geothermal heat (8 PJ pa[8]) offers significant opportunities for industrial energy efficiency and decarbonisation. As a clean, reliable energy source, geothermal reduces production costs and improves environmental performance across a range of strong and competitive business sectors, including food and beverage, wood processing, horticulture, and dairy processing.

Since the 1950's, geothermal has offered New Zealand a low-carbon energy option that has been embraced by the timber and pulp/paper processing industries (e.g. Norske Skog Tasman, CHH, Asaleo Care, Oji Fibre Solutions, Sequal Lumber, Tenon). Successful industrial-scale conversions from fossil energy to geothermal sources have included Asaleo Care (tissue production, 2010), Tenon and Sequal (timber drying, 2007 and 2015, respectively), and Oji Fibre Solutions (pulp production, 2019). Geothermal heat is also being used directly for dairy processing (Miraka at Mokai, 2010; Waiū Dairy in Kawerau, 2019), and being used to make biomass (e.g. wood pellets at Nature's Flame) or free up biomass (Oji Fibre Solutions) to decarbonise other processes.

Opportunities exist to further decrease carbon emissions in process industries. For example, the conversion of Tenon to geothermal from natural gas resulted in a CO2e emissions reduction of 93%[9]. The majority of process heat demand is supplied from fossil fuels, mainly coal or natural gas.

Geothermal process heat has scope for growth in co-located industrial processes around existing geothermal power plants, and recent conversions have occurred in Kawerau and Taupō to do just this. Existing or relocating process industries that utilise notable quantities of process heat should be encouraged and incentivised to relocate to a geothermal cluster.

6. *Geothermal enables Māori socio-economic development*

The principles of Te Tiriti o Waitangi, including self-governance, kaitiakitanga and resource ownership, are demonstrated by Māori land-owners, Māori-owned enterprises and other partners

[6] MBIE Electricity Statistics, 2019

[7] Sepulveda, N.A., Jenkins, J.D., de Sisternes, F.J., Lester, R.K. 2018. The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation. Joule. Volume 2, Issue 11, 2403-2420.

[8] MBIE Energy in New Zealand, 2020

[9] McLean, K., Richardson, I., Quinao, J., Clark, T. and Owens, L. 2020. Greenhouse Gas Emissions From New Zealand Geothermal: Power Generation and Industrial Direct Use. Proceedings 42nd New Zealand Geothermal Workshop, Waitangi, NZ, 24-26 November 2020.

in geothermal developments and enterprises. There is scope to enhance this relationship by further embedding tikanga and Mātauranga Māori in geothermal management.

Geothermal is Aotearoa's indigenous renewable energy solution, and it creates genuine, active, and enduring partnerships with iwi/Māori. Māori are driven by principles of investing in projects that provide intergenerational prosperity and sustainability of natural resources. This philosophical view (combining kaitiaki and Māori economic development) aligns with geothermal resource developments, with the long-term project life of geothermal power plants i.e. 30+ years.

Most geothermal fields that have operating power stations, have some form of commercial or other beneficial arrangement i.e. ownership, fluid supply, royalties, land lease etc., with a Māori-owned enterprise. Geothermal energy developments have enabled true partnership and participation for Māori in the energy industry, as owners, developers, or co-owners and co-developers of geothermal fields (e.g. energy ecosystem owned by Tuaropaki Trust at Mokai; Ngāti Tūwharetoa Geothermal Assets at Kawerau; Tauhara North No. 2 Trust at Rotokawa). At Ngawha, a community geothermal energy solution addresses a lack of regional renewable power generation and high energy transmission costs.

Māori groups have led and grown successful businesses by leveraging their geothermal assets, people, and resources in other sectors. Māori innovation is driving new approaches to geothermal developments: collectives such as Waiū Dairy (a group of eleven Māori groups processing dairy products using geothermal heat) and whole ecosystem approaches, like Tuaropaki Trust (building a business cluster that combines electricity, horticulture, green hydrogen, dairy processing, composting and more).

Significant revenues/profits from geothermal enterprises create opportunities for Māori shareholders to further development aspirations, and funds are reinvested in their people through financial, health, wellbeing, educational, cultural, and sporting endowments.

7. High-temperature geothermal energy catalyses regional growth

High-temperature geothermal resources are a competitive regional advantage, catalysing decentralisation of high energy businesses and promoting regional tourism. Without conversion to electricity, geothermal heat energy (direct use) is typically used locally due to the costs of long (in excess of several kilometres) pipeline systems. This necessitates high energy users across a range of sectors (e.g. food and beverage, horticulture, tourism, wood processing) locating their businesses in these regions. Clusters of business parks can be (and are) created around geothermal (e.g. Kawerau and Tauhara).

For the Bay of Plenty, Waikato and Northland, high-temperature geothermal resources are a part of regional identity beyond electricity generation and industrial heat applications, supporting geothermal tourist parks, cultural experiences, and spa and wellness facilities. There is scope to not only grow electricity and industrial and commercial ventures, but also to pair geothermal tourism more closely with outreach, education, and industrial energy use into the future. Sustainable resource management frameworks (e.g. develop/protect classifications for geothermal fields) ensure these different uses for geothermal can be effectively supported.

Geothermal energy benefits regional economies by providing employment and stimulating economic activity (by attracting businesses into geothermal regions), while providing affordable and reliable energy. Geothermal energy developments can improve social outcomes as they are significant employers. For example, recent funding towards geothermal developments in Rotorua support 460 jobs in the new Wai Ariki Hot Springs and Spa, and 190 jobs in the Taheke Geothermal Power Station[10] development.

[10] www.beehive.govt.nz/release/rotorua-benefits-over-62-million-boost

8. Geothermal provides innovative opportunities

The high temperature geothermal industry is keen to advance beyond existing technologies and conventional geothermal resources. Some opportunities on the horizon are:

Hotter, deeper resources (supercritical geothermal) offer an as-yet unknown energy potential (being explored in the New Zealand Government funded *Geothermal: The Next Generation* research programme).

Geothermal energy could form a key component of hybrid energy systems. For example, surplus renewable electricity generation can be used to produce green hydrogen, which is stored and then rapidly converted back to electricity when renewables cannot meet energy demands. Tuaropaki Trust and Obayashi Corporation are exploring this opportunity.

Closed-loop and carbon recycling[11] technologies are being developed overseas, gaining investment from multi-national energy companies and could be deployed in New Zealand.

Additional opportunities, beyond expansion of electricity generation and process heat, include mineral extraction from geothermal fluids (e.g. Geo40, lithium-extraction), strategically aligned with increasing global demand for rare earths for EVs and batteries.

Geothermal energy also offers a sound opportunity for those regions without high-temperature geothermal fields. Low-temperature geothermal energy is everywhere. In all regions, the natural heat flow (increasing about 25-30°C for every kilometre depth) offers a primary energy for low-grade process heat. This geothermal energy can be accessed using existing technologies, in use internationally, and have potential, especially in large residential, large space builds. Ground-source heat pump technologies (for space heating and cooling) and low enthalpy power generation technologies are ready to deploy. While these technologies are in use extensively internationally, the market is immature in New Zealand. Growth in this area, to transition to or create new industries (which displace carbon-based heating) requires policy support and feasibility studies.

9. Policy incentives will accelerate decarbonisation

As a small country, we have the advantage of being able to mobilise efficiently for robust outcomes with the appropriate policies and leadership. Geothermal development in New Zealand was directly enabled by Crown investment in exploration drilling in the 1950s — this investment has underpinned an industry worth over $3 billion[12]. New Crown investment, strong policy signals and suitable incentives will act as a springboard to build on this strong legacy of geothermal resource use.

New Zealand should not walk away from its geothermal global leadership and legacy. The CCC's Draft Advice must be revised to promote *increased* geothermal energy use. New Zealand led the world in harnessing geothermal energy at scale, hosts the world's largest industrial geothermal direct use operation, and recently became the second country in the world to use geothermal for hydrogen production. Geothermal is a key part of our low-carbon energy future and has room to grow.

There was 73% growth in the amount of energy consumed from geothermal sources between 2010-2015[13], with net geothermal electricity generation doubling between 2007 and 2015[14]. Yet, in the past five years, due to flat electricity demand, geothermal development has slowed; generators have gone from exploration and growth to a focus on operation and maintenance.

There exist viable opportunities for the industry to grow once more and reduce emissions and can be deployed in short timeframes. Geothermal operators and industry are keen to develop or deploy

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[11] www.carbonrecycling.is/
[12] business.scoop.co.nz/2017/04/27/wind-and-geothermal-emerge-as-significant-sources-of-energy/
[13] Bertani, R. 2015. Geothermal Power Generation in the World 2010-2014 Update Report, Proceedings, World Geothermal Congress, Melbourne, Australia, 2015
[14] MBIE Electricity Statistics, 2021

lower-carbon tech solutions but will welcome government/policy support to increase uptake and increase the speed of transition. Decarbonisation solutions, new technologies and the shift to lower emissions geothermal should be encouraged through policy incentivising. This could reasonably include mechanisms such as R&D funding, capital funds and tax incentives to accelerate industry investment in low-carbon technologies.

Although there are significant differences in the concept, carbon capture and storage (CCS) policies could potentially be the most relevant to NCG reinjection in New Zealand[15], but these are out of date and not aligned with current government aspirations. New Zealand could usefully develop equivalent enabling policy incentives, equivalent to those in place in Australia[16], the UK[17] and the US[18].

Capital availability for energy transition, fuel switching, and technology deployment is a key aspect that constrains energy and efficiency investment decisions by large process heat users.

The NZGA would also like to point the CCC to a series of recommendations[19] made in a 2020 submission on the MBIE discussion document 'accelerating renewable energy and energy efficiency', and a 2019 submission to EECA and MBIE on the Process Heat in New Zealand document: 'opportunities and barriers to lowering emissions'. Recommendations here included funding and policy support for feasibility studies and industrial-scale pilot trials of promising technologies.

10. Geothermal is a New Zealand icon and legacy, on a global stage

Geothermal is an iconic kiwi symbol. As well as being home to numerous world-class geothermal operations, Aotearoa benefits from the intrinsic value in our geothermal landscapes, biodiversity, and recreational potential. Geothermal stories and geothermal energy have been part of Māori culture for generations, and geothermal is entrenched in our modern history.

Geothermal is one of the ways we introduce New Zealand to the world. New Zealand's investment in geothermal has produced significant intellectual property (IP), and our experts, their knowledge, and technical skills, are sought-after internationally.

New Zealand leverages domestic geothermal skills and IP (consulting, science, engineering and training) to maintain a large international service industry. Entities include Jacobs, MB Century, MTL, Thorndon Cook, Aecom, Beca, Seequent, Upflow, GNS Science, Wintec and University of Auckland, as well as a host of smaller companies and independent consultants, and the work done overseas by New Zealand's geothermal electricity generation companies. Our expertise attracts students and professionals to train in New Zealand institutions and organisations. Our technical support for geothermal developments throughout the globe, (usually in places with high-carbon power generation markets) positively impacts the global carbon balance by displacing fossil-fuel based energy generation and reducing CO_2 emissions outside of New Zealand.

Geothermal is a New Zealand pioneering engineering innovation. We have developed expertise that has revolutionised the global geothermal industry. As early-adopters, New Zealand's geothermal companies have helped to develop international best practice – including exploration, reservoir management, design, engineering, and environmental modelling. Some examples:

1. the Weber-type separator[20], an equipment used to separate geothermal steam from water, was first developed and used at Wairakei in the 1950's and enabled the development of water-dominated geothermal power plant systems for the world;
2. the geothermal clean steam reboiler technology was developed in Kawerau and has enabled the use of geothermal clean steam in the Kawerau Industrial Complex and in Miraka;

[15] www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/low-emissions-economy/carbon-capture-and-storage/
[16] www.business.gov.au/grants-and-programs/carbon-capture-use-and-storage-development-fund
[17] www.gov.uk/environment/low-carbon-technologies#policy_and_engagement
[18] www.energy.gov/fe/science-innovation/office-clean-coal-and-carbon-management/carbon-capture-utilization-and-storage
[19] nzgeothermal.org.nz/app/uploads/2020/04/2020-02-28-NZGA-Submission-to-MBIE-re-REnewable-Energy_with-bookmarks.pdf
[20] www.geothermal-energy.org/pdf/IGAstandard/WGC/2005/1338.pdf

3. the development of geothermal reservoir simulation expertise is sought after, shared between the Geothermal Institute of the University of Auckland, GNS Science, Flow State Solutions, and Seequent.

Our geothermal leadership has enabled New Zealand to expand its sphere of influence in foreign affairs and diplomatic settings. This includes support for NZ-based training of international students, and in New Zealand assistance programmes supporting geothermal development in, the Caribbean, Indonesia, and East Africa, where it is acknowledged that New Zealand geothermal skills have a key role to play in decarbonising the economies of these regions.

11. Conclusion & Recommendations

As stated in the opening paragraphs of this submission, the NZGA concludes with re-statement of the following summary points and recommendations:

Geothermal is a vibrant, proven, indigenous renewable resource, which enables other industries to thrive and regions to grow. Aotearoa's legacy of low-carbon geothermal use gives the nation a competitive advantage in transitioning its energy sector and economy. Many of the elements needed for low-carbon geothermal to make a greater contribution to New Zealand's energy scene are established.

Geothermal energy has been decarbonising New Zealand's electricity and process heat sectors for over sixty years and is capable of innovating to decarbonise further so as to be a key part of Aotearoa's future energy solution. A supportive policy environment will incentivise greater geothermal investment, technology development and fuel switching. Growth should also be encouraged in non-energy socio-economic streams, such as minerals, industrial tourism, Māori innovation, and training/education.

We recommend that in their 2021 advice to Government, the Climate Change Commission revise the Advice to:

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iv. Make capital / R&D tax credits available for energy transition and technology deployment for generators and large process heat users to influence energy and efficiency investment decisions.

I would be pleased to be contacted regarding this submission and can provide additional and supporting information on request.

Sincerely,

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Additional Note: References for Figure

[1] Whitaker, M., Heath, G., O'Donoughue, P. and Vorum, M. (2012): Life Cycle Greenhouse Gas Emissions of Coal-Fired Electricity Generation: Systematic Review and Harmonization. Journal of Industrial Ecology, 16(S1), pp S53-S72.

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[5] NREL Solar Fact Sheet (2012): Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics. National Renewable Energy Laboratory, U.S. Department of Energy <https://www.nrel.gov/docs/fy13osti/56487.pdf>.

[6] NREL Concentrating Solar Fact Sheet (2012): Life Cycle Greenhouse Gas Emissions from Concentrating Solar Power. National Renewable Energy Laboratory, U.S. Department of Energy <https://www.nrel.gov/docs/fy13osti/56416.pdf>.

[7] International Hydropower Association (2018): Hydropower Status Report: Sector Trends and Insights, pp 28-29 <https://www.hydropower.org/publications/2018-hydropower-status-report>.

[8] NREL Wind Fact Sheet (2013): Wind LCA Harmonization. National Renewable Energy Laboratory, U.S. Department of Energy <https://www.nrel.gov/docs/fy13osti/57131.pdf>.