Geothermal Week 2024

Background

BusinessNZ Energy Council were pleased to partner with the New Zealand Geothermal Association and Amplify NZ to have our Policy Advisor attend Geothermal Week in Taupo from 2 to 5 July 2024. This report details what was discussed during the Week's sessions, workshops and other events.

Day 2

Tuesday 2 July

Industry Leaders Breakfast

We started day two of Geothermal Week in Taupo, co-hosted by NZGA and Amplify, with an Industry Leaders breakfast generously sponsored by Cheal. Cheal has a long history in Taupo, dating back to the 1940s. As a company specialising in planning, surveying, and engineering, they have made significant contributions towards the development of geothermal heat in the region.

Accompanying our breakfast of distinguished leaders across the geothermal sector, we had the great pleasure to host the Mayor, Council members of the Taupo District Council and Dr Marcos Pelenur. Marcos delved into his interesting and extensive career journey, starting as an engineer tasked with substation maintenance out to his current role as CEO of EECA.

He discussed EECA's role over the last years. It previously had its one strong northern start of decarbonisation, said Marcos. With the change of Government, he reinforced that the direction of travel is still clear, and its ambition has not reduced, but the 'how' has changed and including the role of Government in decarbonisation. The northern star has expanded into also security of supply and affordability, not just decarbonisation.

Marcos wants EECA to be in the consumer corner, encompassing residential, commercial and industry sectors. EECA reported on the potential and clear benefits of electrification in the residential sector. It's clearly beneficial for households, he mentioned. He believes the consumer has not had a strong voice. He wants EECA to empower users for flexibility and demand management. Accelerating renewables is not just about supply for EECA, it's about downstream demand side response.

He mentioned EECA's clear remit: an information and engagement lever, an investment lever, and an accelerate renewables lever. EECA will work with the Government to pull those levers where appropriate. He emphasised the power of timely updates to standards that can ensure New Zealand has the latest technologies, improving connectivity and optimise network operation, reducing costs across the system. He reiterated the barrier of slow-moving changes to regulation in New Zealand. EECA has to put out an Order of Council to change regulation. It takes four years after a Cabinet decision before the particular change in standard occurs. He mentioned that this is unacceptable.

"We are being lapped by Australia, where standards are updated instantly once the Minister approves the update."

When it comes to the right standards and technology, EECA works with the Electricity Authority and Commerce Commission to ensure ESBs send the right signals. He mentioned Orion which has demonstrated a 25% reduction in demand through ripple control. Managed and optimised electrification is important as we don't want to overbuild for the sake of it, said Marcos.

He mentioned wider changes at EECA over the past year, mentioning that GIDI is no longer available, but the low emission transport fund, including funding for heavy transport remains. EECA is thinking about them more holistically. EECA is still supporting new processes at the commercial end, and work closely with Are Arke, who are doing great work to bring in innovators, while taking the good ones and demonstrating them up to scale. He mentioned that the Warmer Kiwi Homes Program will continue but has become more targeted. The Government does not want to provide grants but instead initiate private investment. ECCA said there are opportunities to partner with banks to provide offers and mechanisms to the market that are not grants but instead reduce uncertainty.

EECA has restructured, reducing its workforce by about 25%. He believes it is a calculated and sensible risk. He mentioned that it was not fair for staff members who did not have certainty and clarity. It was disappointing to see them go, he said, but it has left EECA in a strong fitting and sets EECA up for a clear run. The restricting process is now finished and EECA can focus on action over the next year.

First workshop of Day 2 : *What is our geothermal potential*?

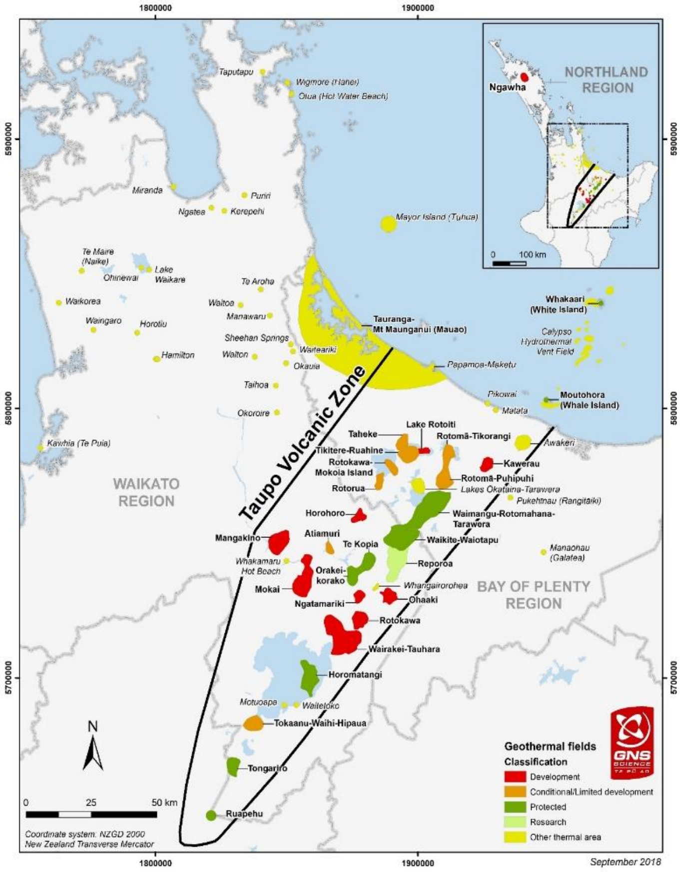
Yale Carden from GeoExchange Australia kicked off with an insightful discussion on the power of geoheat. He mentioned that when geoheat is discussed, it is important it is broadened as much as possible, it includes for example, a project one of GeoExchange's students is looking at on how to optimize heat reinjection from data centers into district heating systems in Norway. There's plenty of areas where heat can be used. The future is about where it is and how can we utilise it as much as possible said Yale.

Low temperature geothermal is often anything above 30 degrees. The deeper wells are drilled, the temperatures available start to rise. There's no perfect boundary on the spectrum. Typically, low temperature heat is below 130 degrees. But for geoheat it comes down to its application, balancing temperature in the ground and what you need on the surface. It is often discussed as being used either directly or indirectly. New Zealand uses it directly for industrial processes with heat exchange for example. As soon as the temperature is not high enough, it is indirectly used with applied heat pumps. For most building applications, it is about 30 degrees, but this varies.

With heat pumps, the temperature of the steam can increase to about 120-130 degrees. This technology is available and progressing rapidly. When people often think about geothermal, they think about where geoheat resource is available. With an indirect approach, this can occur mostly anywhere. All that is required is a stable temperature and geology which can be accessed. There are many ways to do this, such as drilling holes on a closed loop system, using energy piles, waster bodies and open systems using ground water directly through a heat exchanger through a heat pump and back under the ground.

Why geoheat? says Yale. There are many applications, including the removal of gas and coal boilers to reduce emissions. Geoheat is abundant, accessible, and affordable. Yale says that there is no more efficient way to heat than heat. The demand for heat is significant and geoheat can play a significant role, regardless of if there is geothermal resource at the location or not. You just need a heat pump says Yale. Instead of the air it uses water. This provides a solution to reducing the demand on the grid from more electrification. In some cases, projects that install ground source heat, rather than air source, avoid the need for grid upgrades and project cost, while minimising energy costs from electricity, gas, or coal for example.

Katie McLean, President of the NZGA, gave a comprehensive overview of the crucial role conventional geothermal power plays in our electricity system since the 1950s. Most of New Zealand's potential surrounding geothermal has been its conventional use for power generation rather than the untapped potential for direct and indirect use.



Map showing geothermal fields and thermal areas classified by the RMA

The coloured shades are outlines where geothermal systems are located, while being colour coded by the regional council's classification. The green shades are protected because the surface features are significant and vulnerable. The light green shade areas are research fields, where GNS does not know too much about its characteristics. The orange shades are classified as conditional and limited development fields, with limited use and minimal impact on surface features. The development fields are the red areas where the power stations are currently located. This is where large scale energy use is allowed in an environmentally sustainable way.

The potential for more geothermal generation is shown in both brown and green fields. Potential brown fields which include already consented, planned or underway projects, are shown, with some at Tauhara and Ngawha for example. These are not insignificant expansion potentials but show the promise of more conventional geothermal generation. The numbers become more uncertain as we discuss exploration due to data availability.

Green fields are even more uncertain, as these fields have not yet been developed. There is a lot of potential, especially in the Bay of Plenty. In summary, Katie showed us we currently have 1,200MW of geothermal electricity capacity, with expansions underway of 169MW, potential future expansions of 225MW and exploration potential is 440MW. However, with the latter, there is uncertainty surrounding land ownership and land size. On the other hand, it could be used for direct heat. All up, it could be 2,000MW in New Zealand for conventional generation.

Chris Bromley, from GNS Science, took us on a journey into the realm of superhot (supercritical) geothermal resource of above 375 degrees inventory in New Zealand. Superhot resource would provide low cost, super reliable and abundant renewable energy. The Taupo Volcanic Zone has the best geological conditions on the planet to access these resources, and technical and scientific experience to advance superhot resource.

GNS collected information over the last five years that shows resistivity from a model of data that has been collected across the TVZ. The red areas are low resistivity anomalies (Apologies that the image is not provided). The red outlines are the geothermal resource boundaries defined by the regional plans based on early resistivity data from the 1960s.

There's an obvious difference between the red blobs of 5km of depth and the regional boundaries says Chris. Chirs mentioned that this means, when we think about geothermal resource we must think in three dimensions, including resource boundaries for the regulatory environment as well. The regulatory environment needs to be flexible because the boundaries might need to change with access to new information. We might find these resources are in more locations. We currently do not know the extent of the resource says Chris.

Looking at the data, GNS, with the help of Castalia, assessed the potential from a 3.5 to 6km depth. GNS calculated a result of 4.6GW worth of electricity potential or 38TWh each year. Of which, 3.5GW is within unprotected systems. Out of this, 1.4 – 2.1 GW would be economic to build between 2037 to 2050. Chris showed that this could mean New Zealand might not need to rely on a large increase in wind and solar build out in the future. Generation which could have consequences on amenity values, social buy-in and grid infrastructure. Transpower is expecting, in its modelling work, a growth in wind generation from 7.4% of supply to 28%. Chris mentioned whether four times as many wind turbines in New Zealand would be doable and desirable, noting the potential geothermal could play to minimise build.

Superheat could also mean New Zealand could be an attractive location for new energy intensive industries. One such use could be from datacentres which require large amounts of power for cooling. Out of the many actions that need to take places is to develop modelling capability to improve confidence in projections into superhot behaviour – will they influence the amount of energy we receive from conventional generation, or will there be a smaller net-surface effect the deeper we go? Says Chris.

If geothermal developers can improve their modelling, this would mean a less precautionary approach to developing future green fields, because if we can go deeper with less impact on the surface than New Zealand does need to be concerned about the adverse effects experienced in the 1950s and 1960s. Regulatory planning and regulatory planning is also important, including investment challenges. We need to think about the timely development of studies that can solve some of these technical challenges that we are aware of in drilling, managing wells, scale formation, corrosion, and stress issues, and invest in solving these problems says Chris.

New Zealand has demonstrated that we can solve large engineering challenges in the past. We were pioneers in solving technical challenges in geothermal. The Government commenced exploratory drilling in the 1940s. By 1958, the Wairakei Power Station became the world's second geothermal power station and the first to use flash stem.

Andreas Heuser, from Castalia, worked on assessing the economic value of superhot resource in New Zealand. It could provide up to 30,000 GWh energy per year from non-protected sites. It represents about 70% of New Zealand's current electricity consumption. Andreas work estimated it could be available by 2037 if the necessary investment occurs and the regulatory environment aligns. Their modelling showed that 2,000 MW would be economic to build by 2050, which would complement wind and solar which will also be developed.

There is significant opportunity for direct and indirect use for industry, especially in the dairy and wood processing sectors. In many respects, the modelling probably underestimates the amount of built supercritical because we used Transpower's demand forecast which doesn't consider demand from AI datacentres or more wide land transport electrification. Castalia's assessment showed that even if the cost of supercritical is much higher than initially expected, it would still be economic to build the same amount of generation capacity, even at double the cost of conventional geothermal.

How can we realise its economic potential says Andreas:

- We will not get there without investment and buy in from policymakers.
- We can play a similar role to the 1950s and communicate the findings of the report to the Government.
- Investment in pilot wells should be prioritised and partnerships with investors explored. There are a range of investors willing to take risk on drilling projects and partnership with landowners and mana whenua already exist and should be pursed further.
- Technical partnerships with overseas researchers

Lauren Boyd, from the US Department of Energy, shared her insights from the United States and Enhanced Geothermal Systems (EGS). EGS is a human made version of a naturally occurring geothermal reservoir. These are created by fluids that are injected into the subsurface with the aim to increase the size of the fluid pathways that bring heat to the surface.

The Department of Energy (DOE) is currently undertaking this work on the margin of existing fields or completely unexplored regions in the United States. EGS enables the use of heat in the subsurface to develop firm and baseload power generation. The U.S Government considers it vital to develop more EGS and has put in place robust plans and public funds into developing the technology further. The programmes established by the DOE in late 2022, aims to reduce the cost of EGS by 90% to $45MWh.

Traditionally, resources have been in the Western regions of the U.S, with technology improvements in EGS, geothermal resource can be unlocked across the country to West Virginia, Pennsylvania, and other areas on the Eastern seaboard. They expect it to occur by as early as 2035. Their modelling shows that we can get to about 90GW worth of deployment. If other renewables face challenges with deployment, geothermal could provide about 130GW of electricity capacity. However, state, and local incentives vary state by state in many cases. This will impact deployment. We have seen improvements in drilling wells, less maintenance pressures, improvements in equipment quality and the time it takes to drill. Boyd believed there is plenty of promise in EGS currently and there are many ways New Zealand the U.S could collaborate and share on common challenges.

Samantha Alcaraz, from GNS Science, concluded the workshop with a discussion on the role of underground thermal energy storage. To meet net-zero, we need to decarbonise the heating and cooling sector globally. This includes New Zealand. It represents 50% of demand in Europe. The continent's grid is struggling and will not be able to cope with projected increases in demand. Like everywhere, supply needs to adapt to seasonal influences. European countries are active in developing underground thermal energy storage solutions. Heat has a key role, not just electricity says Samantha. There is various technology depending on need.

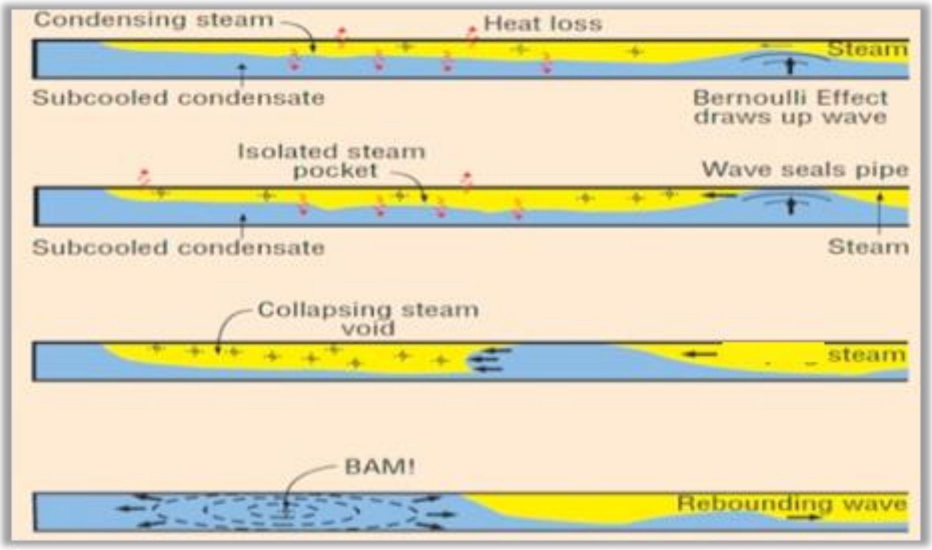
What is the concept of thermal energy storage? Baseload geothermal energy demand is higher over winter than baseload geothermal energy might be. In summer, you have more energy than you need for heating and cooling needs. The idea is to use the excess energy in summer to store it to be used later in winter. There are different types of technology for underground thermal energy storage.

The most common is Aquifer Energy Storage, which is an open system (AES). The choice of technology depends on the local conditions and needs are. Overall, it is a proven technology with millions invested in research and development in Europe and the United States. The Netherlands currently has over 3,000 systems operating, most are developed in shallow ground, but they are developing deeper systems to access higher temperature. For underground systems to work, demand needs to be adequate, available access heat that can be produced cheaply, underground conditions must be suitable, and temperatures must be useable to make economic sense. For AES systems, aquifers must also be suitable. Risks include ground water contamination and surface effects, which must be accounted for and managed.

Second workshop of Day 2

Ivo Lemmens, from Mercury, presented during our workshop on the main lessons learned from the Rotokawa Steam Hammer Incident in 2021. Before Ivo dived into explaining the details behind a Steam Hammer event and the one which occurred in 2021, he started with an icebreaker, testing the knowledge of the audience and providing a flavor of fun and competition.

A steam hammer event happens when a pocket of saturated steam collapses due to steam condensing as it meets sub-cooled liquid, generating an overpressure shock wave that travels the length of the liquid-filled portion of the line. Overpressure may be sufficient to rupture pipe elements or dislodge pipe from its support. In other words, causing a 'hammer effect.'



Overall, we learnt that condensation induced water hammer (CIWH) can generate severe overpressures and can cause catastrophic failure of equipment and piping. It can result in the uncontrolled release of hazardous energy – in the form of hot water and steam – which can potentially cause serious injury or death. Steam Hammer events can be prevented with proper job planning, adequate procedures, correctly designed and maintained equipment, and a sound understanding of steam and water conditions.

He explained to us the real-life scenario which occurred in 2021 and how condensation induced water hammer events can be avoided. In his scenario he showed that an operational issue in valves 1 and 2, downstream of two units, lead to an outage of the downstream units to inspect the piping. For this to happen, the steam trap had to be isolated, stopping the release of hot condensate and flash steam to keep inspectors safe. The pipes were closed and cooled down while eventually being filled with subcooled condensate. With the pipe full of subcooled condensate, the system is primed for a condensation-induced water hammer incident.

All that was required was a triggering event. As condensate was drained, the level of condensate would drop until steam was able to re-enter causing a condensation induced water hammer. The pressure was estimated to exceed 100 bar. In 2000, at a plant in Scotland, a steam pipe fractured, opening a hole which spewed out steam 35 meters across a road. Thankfully not hurting anyone. To avoid an accident, the steam upstream needs to be isolated, and the system needs to be depressurised, then the condensate can be drained.

Fortunately, in the case of Mercury's steam hammer event, no one was injuried. However, it could have caused serious harm if workers were in the area at the time. Since then, Mercury has invested and worked hard to improve safety at its Rotokawa station and its other geothermal power stations, implementing more safeguards to protect against Steam Hammer, limiting hot brine bypass control value capacity, introducing comprehensive training relating to Steam Hammer and utilise robust isolation methods. The main lessons learned also extend to the importance of not downplaying the risk of steam hammer. Mercury is committed to sharing its learnings with the entire industry, ensuring the event is not repeated. Upholding the robustness of geothermal plant and the safety of people.

DAY 3

Wednesday 3 July

Presentation by Nikkiso-Egesim

The NZGA Winter Seminar started with a presentation from **Reza Agahi,** from Nikkiso Clean Energy & Industrial Gases Group. His presentation detailed the advantages of radical inflow turbines in Organic Rankine Cycle (OCR) geothermal plants. The Company provides this solution in partnership with Egeism Group. Drawing on their collective experience, both companies offer technologies and expertise integral to ORC plant development, including plants used to produce green hydrogen.

The combined entity can provide end-to-end turnkey solutions or support ORC projects as part of a broader development team, depending on the preference of an end user. To date Egesim has supported more than 60 geothermal power plant projects and supplied ORC plants generating a combined total of more than 350 MW of power.

Radial inflow turbines are a key differentiator of Nikkiso-Egesim's ORC plants, as presented in detail at the morning seminar. Their main function is to convert thermal energy from the working fluid into mechanical energy, which in turn generates electricity. Ideally suited for ORC plants, they enhance the efficiency of the conversion process relative to alternatives, such as axial turbines.

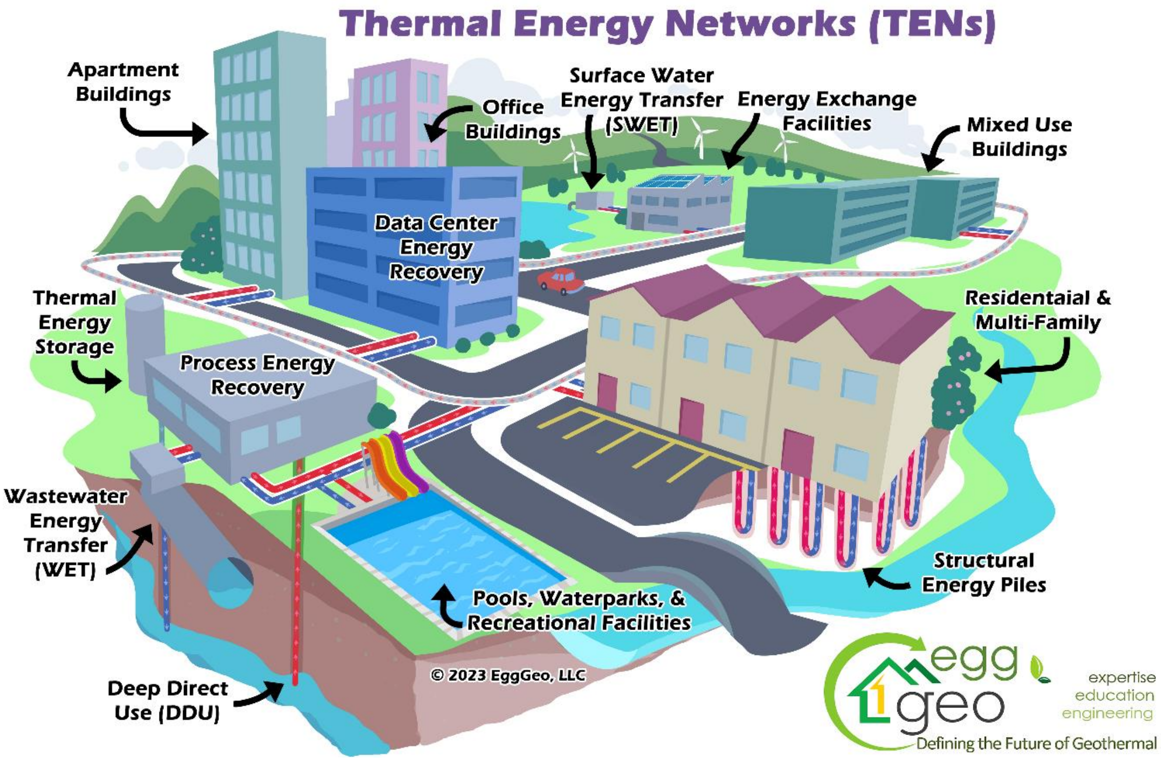
The process starts with **e**nergy conversion, where Geothermal heat vaporizes the working fluid; the high-pressure vapor is directed into the radial flow turbine. Radial inflow turbines accommodate variable inlet guide vanes, which convert a portion of the static head into kinetic energy channeled at an optimal direction into the turbo expander wheel; specifically, the working fluid enters the turbine at the outer edge and flows inward toward the center, different from the flow pattern of axial turbines (parallel to the axis of rotation).

As the working fluid flows inward through the turbine blades, it expands and loses pressure. The expander wheel extracts energy from the working fluid to produce mechanical energy that drives an electric generator coupled with a rotor, causing the turbine to spin. The radial-inflow-turbine-enabled process detailed above offers advantages over axial turbines in geothermal energy recovery plants, including enhanced efficiency.

Specifically, the variable guide vanes (bullet 1), which lend their name to *variable geometry turbines*, are designed to adapt to changing operating conditions; accordingly, they maintain efficiency and power despite variable ambient conditions and or changes in the geothermal resource. Studies have demonstrated that the cumulative power production of an ORC plant with radial inflow turbine could be anywhere from 5 to 7% more than a plant equipped with alternative turbine technologies.

Keynote speech by Jay Egg from Egg Geo

We were fortunate to host **Jay Egg**, the keynote speaker for the Winter Seminar 2024, from Egg Geo. Jay discussed Cascaded Geothermal Systems for the heating and cooling of homes and commercial properties. Cascaded systems could aid the production of hydrogen. Producing green hydrogen is an energy intensive process. Using a hot geothermal resource, as waste-energy, we could produce green hydrogen says Jay. Nikkiso is working closely on this potential.



Jay pointed to the grey pipeline in this picture above, wrapped around this animated city center. This is a pipeline full of water which moves energy from one building and process to another. We have an opportunity for cooling dominant buildings, like data centers or office buildings, to move heat energy out to heat and cool other buildings across a thermal energy network. In a cascaded system, there are several levels. Typically, there are many geothermal electricity generation facilities, they could be deep direct use system, or could be enhanced geothermal systems. Either way, you have hot resources to create electricity. After this, you have waste steam that could go to the next level, for chilling operations for example. The next level could be heating for buildings or domestic hot water. Then the water could be returned underground.

In the United States, and around the world, natural gas has been considered a clean bridge fuel says Jay. In the 1950s and 1960s, the U.S experienced a large buildup of natural gas pipelines. In total, there were close to 2.5 million miles (about 4,023,360 km) of pipelines installed in the US to 65 million buildings. In the geothermal industry, Egg Geo have been complementing natural gas pipelines with additional pipelines. With geothermal pipelines, you get cooling and heating, compared to natural gas with only heating. In the US, and in New York, they are removing old residential natural gas pipelines, one street at time, and supplementing them with geothermal pipelines.

State Government's subsidise this replacement because of its efficiency, especially compared to air source heat pumps. In New York City, Egg Geo was commissioned with the task of solving how to take fifteen separate twenty-storey buildings which are homes to 2,500 families off natural gas using a cascading system. Next to the housing area is a Postal Service serving center which rejects heat from their operations of 8MW. Egg Geo proposed to divert the rejected heat to a heat pump to heat the homes, displacing natural gas combustion. The project has grown. Now Egg Geo is working on doing the same for a neighboring university campus and several other buildings. Jay demonstrated other current uses of Thermal Energy Networks. He explained the network of 42-inch lines under the Hudson River that use geothermal power for the One World Trade Center in New York.

Speech by Chelydra Percy, CEO of GNS Science.

Following a quick morning tea break, we heard from **Chelydra Percy**, CEO of GNS Science. Chelydra started by noting that discussions about heat and its true cost and availability in New Zealand seem to be missing. "And for most New Zealanders, it's easy to forget that heat is energy**.** And what most New Zealanders don't know is they are paying for a wasteful and inefficient energy conversion for the heat they need."

"The great news for this room today is the science is demonstrating that geothermal heat, or "Geoheat", can be a significant part of New Zealand's answer for heat energy."

One key statistic Chelydra mentioned was key is the **c**onversion of heat energy to electricity is only about 10-15% efficient. Which means there is no more efficient way to heat rather than with heat.

She mentioned that geoheat opportunities are not isolated to the Taupō region. The development of ground source heat pump technology and heat exchangers has enabled the cooler resources to produce both heat and cool at useful temperatures. Counties without volcanic zones are leading the way, like the Netherlands for example. We can be confident in saying that Geoheat can be accessed virtually "everywhere" across NZ.

She mentioned that GNS researchers found that with the range of technologies available today including ground source heat pumps and heat exchangers, businesses can harness heat for process requirements at a range of temperatures up to 150C.

They also found that those requiring higher temperatures of up to 220C are restricted to locations in proximity to the high temperature geothermal systems in the North Island.

Chelydra highlighted that geothermal is not just a matter of environmental sense but also economic sense. Cost is relatively low. With the commercially available tech now, the heat energy supply from established geothermal sources hovers around at ~$10.25 per gigajoule. This cost includes the average cost of carbon at about $70 per tonne of emissions and accounts for conversion and emissions factors rather than just baseline fuel costs. With today's technology and factoring in cost-savings and carbon reductions, most mid to large-scale users can achieve a less than a seven-year payback period for the cost of Geoheat installation. Some in fact have pay backs in months.

More needs to happen in NZ, despite the great use cases currently being applied says Chelydra. Just looking at the geothermal heat area, there are only about 130 known geothermal heatpump installations in NZ. More than 70 of these are in Canterbury compared to 6.5 million geothermal pump installations across the globe.

Chelydra discussed NZGA's "Geoheat Strategy for Aotearoa New Zealand 2017-2030." The strategy's vision is for New Zealand to significantly grow its geoheat use by 2030. To make the strategy a reality, goals were focused into 2-year action plans. The most recent of these was released in May this year. By 2025, the strategy wants to see at least seven new geoheat ventures or projects either announced or completed. By 2030, the industry wants to see the use of geoheat increase in New Zealand by an additional 7.5 petajoules from the benchmark set in 2017, and an additional 500 new jobs created, associated with geoheat projects.

Chelydra finished her speech by emphasizing that she believes that there's a need for change in emphasis. She thinks the answer is for the geothermal industry, regional developers and governance to take over the lead from the science at GNS and secure geoheat as a critical part of New Zealand's sustainable energy future.

Speech by Indonesian Secretary General at the Ministry of Energy & Mineral Resource

We had the privilege to host **Dadan Kusdiana**, the Secretary General at the Ministry of Energy & Mineral Resource in Indonesia. He discussed the huge potential of geoheat in Indonesia and the work underway by the Indonesian Government to harness the resource under their feet. Like New Zealand, Indonesia is located on the ring of fire. They have the world's largest geothermal potential of about 29GW worth of resource. It accounts for 40% of the world's geothermal resources. Yet development has proceeded slowly in terms of the national target and is facing difficult challenges. Today, geothermal is about 5% of total power generation.

Fossil fuels still account for around 80% of the country's electricity generation, with coal holding a 61.55% share. It also has the largest fleet of coal-fired power plants in Southeast Asia. However, the larger problem is that Indonesia's coal-fired plants are relatively new. Their average age is less than 15 years compared to the 40-year typical lifespan of a coal power plant.

However, the country has set goals to harness this energy as part of its net-zero strategy. The country has a 7.2GW and 9.3GW goal by 2025 and 2030 respectively. The challenges Indonesia face include slowing development include high upfront exploration costs, technological barriers and environmental concerns associated with geothermal drilling. Faced with those challenges, the Indonesian Government is streamlining regulatory processes and reducing unworkable regulations, while also partnering with the World Bank to reduce exploration risks and accelerate geothermal development. The $20 Billion Just Energy Transition Partnership, announced in November 2022, is also promising, providing a financing mechanism of both public and private capital to come together and support the transition away from fossil fuels.

Mr Kusdiana reinforced the valuable science developments in Aotearoa New Zealand and the important relationship between our two countries in collaboration and coordination in geothermal by unlocking investment and realising collective opportunities. The connection between Indonesia and New Zealand in geothermal is strong and has been well established for decades.

In the past, the two countries have signed agreements for specialised geothermal training, geothermal drilling, project development, scholarships for Indonesian students, and other bilaterial agreements. Mr Kusdiana issued a call to our industry to attend the upcoming 10th Indonesia International Geothermal Convention in September this year, all in the purpose of accelerating global innovation and stakeholder collaboration.

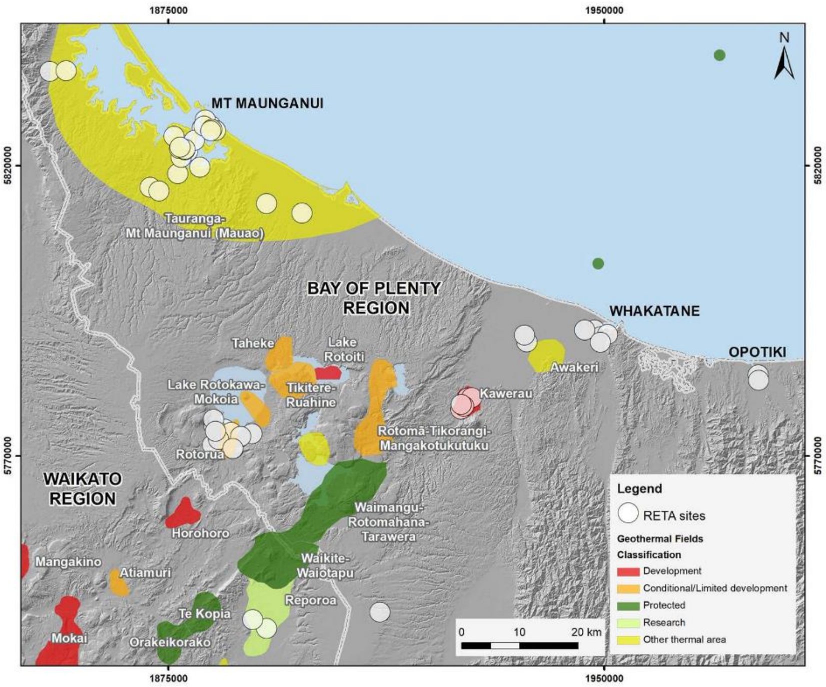
Presentation on BOP RETA

We heard from **EECA** about its report on the Regional Energy Transition Accelerator (RETA) for the Bay of Plenty and the geothermal assessment that accompanies the report. He first reminded us about RETA and the scope of its work. RETA assesses each region in New Zealand and its significant process heat sites, assessing what fuel and timing is needed for their transition. It looks at alternative fuels and whether it is achievable and affordable to switch by investigating electricity infrastructure availability, costs and timing, as well as biomass availability and cost.

They investigate the potential for bioenergy availability while accounting for known demands for resources and un-utilised Bioenergy and costs. EECA then models different decarbonisation scenarios, while providing recommendations on the actions that are needed. Stakeholder engagement and workshops are complemented. Overall, in simpler terms, the main objective of RETA is to eliminate as much process heat emissions as possible from demand reduction, thermal efficiency and switching away from fossil-based fuels to a low emissions source such as biomass or electricity.

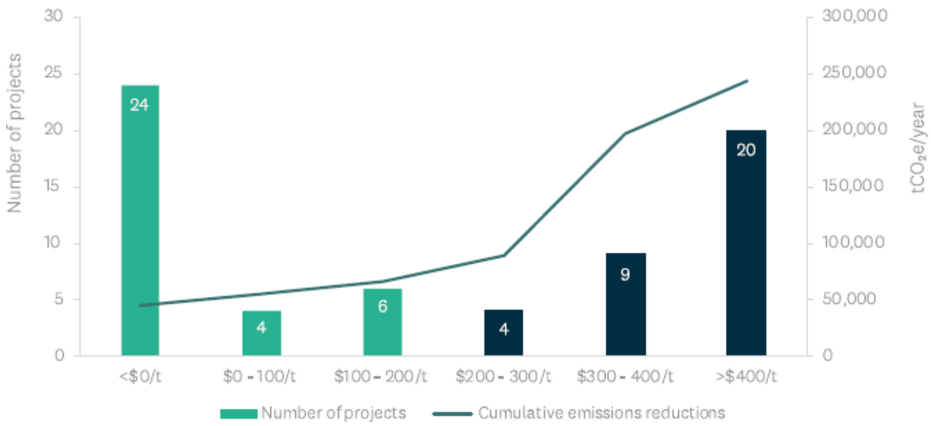
They have recently completed a RETA report for the Bay of Plenty (BOP) in May. They will continue throughout the country until they finish with Wellington in early 2025. He discussed the findings of the BOP report.

52% of BOP emissions are attributable to energy, with about 22% attributable to process heat. This is about 281kt CO2e from RETA sites in the region each year. The 28 sites cover the dairy, industrial and commercial sectors. Collectively, they consume about 14,700 TJ of processed heat energy, mostly from piped fossil gas, other by-products, and geothermal. Only about 4,700TJ of the demand relates to the consumption of fossil fuels. Most of the demand is met from by-products (8,000TJ), with another 1,980TJ coming from geothermal.



Map showing RETA sites and geothermal resources in the BOP

We heard that from expected carbon prices, 24% of emission reductions from RETA projects will be economic by 2028 and abatement costs below than $200/tCO2e. The MAC Optimal pathway sees fuel decisions that result in 6% of the energy needs in 2050 supplied by electricity, 13% by geothermal and 81% supplied by biomass. They tested a range of sensitivities on their modelling, which included a higher and lower electricity price, different decision-making metrics, and higher network upgrade costs for electrication options for example.



This chart summarises the resulting MACs in the BOP associated with each decision, and the emissions reduced by these projects.

While the pathway of emissions reduction was relatively unaffected, the 'low' electricity cost scenario changed the fuel choice for one process heat user, from biomass to electricity. The large dominance of biomass reflected the lower cost compared to electrification as a fuel for large industrial and dairy projects which require high temperature boilers for their process heat. It also remained cheaper due to more biomass availability in the area.

In their work, they tested the potential for geothermal. Four case study sites were analysed by GNS Science for their geothermal potential and included in the economic analysis of fuel switching conducted in the BOP RETA report. The case study sites which were included were Whakatane Growers and Whakatane Hospital using low temperature groundwater, Dominion Salt in Mount Maunganui using the Waiteariki Ignimbrite Aquifer and Fonterra using the Reporoa Geothermal System.

The report did not have a Geothermal Centric pathway but it did calculate MAC values for the five unconfirmed geothermal projects that were included in the pathways. This meant that geothermal was considered alongside electricity and biomass as fuel switching options. In the MAC Optimal pathway, geothermal was the optimal fuel for all unconfirmed fuel switching decisions in these instances, delivering about 490TJ of energy to these process heat users.

RETA's analysis highlighted a range of opportunities in geothermal in the BOP for reducing emissions associated with process heat and recommendations which included:

- **More case studies** should be conducted and evaluated to highlight opportunities for low temperature geothermal around the country.
- Pairing **ground-source heat pumps** (GSHP) and high temperature GSHP with low temperature resource should be included in regional economic strategies.
- Funding should be pursued for the exploratory activity necessary to **enable the Reporoa Geothermal Field** to be further investigated as an energy source for industrial use.
- **National guidance on consenting process and subsurface management** for GSHP low temperature geothermal technologies should be commissioned.
- **More economic analysis** should be undertaken on the opportunities for co-location or shared investment of geothermal deep wells, heat transportation over extended distances, and GSHP district infrastructure in New Zealand.
- **A drilling insurance scheme**, similar to the French model, should be investigated for New Zealand to de-risk geothermal applications and accelerate decarbonisation targets.

Interview with Contact CEO Mike Fuge

Following the update from EECA on RETA, Kennie Tsui interviewed **Mike Fuge** with a flare of intriguing questions. Mike discussed his career journey and interests throughout the years leading up to his current role as CEO of Contact. He illustrated his keen interest in geothermal, calling it the 'unsung hero' of New Zealand's energy mix, providing a clean and stable source of energy. He said geothermal energy is effectively our nuclear power, without the side-effects of nuclear power. With Contact acting as an influential participant in the geothermal industry, Mike has championed the untapped potential for using more geoheat.

Geothermal plays a large role in Contact's generation portfolio and its decarbonisation strategy. The company has commissioned Tauhara geothermal plant outside of Taupō (which we visited on Day 3 of Geothermal Week). It is currently also building a new geothermal station unit, Te Huka 3. The expected new capacity is an additional 51MW with a date of completion in late 2024.

Carbon emissions will be reinjected into the reservoir in the future. The company will also update its ageing Wairakei plant. An update on Wairakei's extension will be provided at Contact's FY24 results in August. To finish, Mike emphasized that the energy transition is a once in a lifetime opportunity, and he advises future leaders to participate in this once in a lifetime moment. He also emphasised the importance of making prompt decisions, getting things done, accepting risk and taking a chance on innovation. He highlighted that New Zealand's history demonstrates the importance of not being too risk averse. Risk is the prerequisite to innovation and progress.

Presentation by Andy Blair, Director of Business and Innovation at Upflow; Energy Engineer Ellergy Peters from Vegetables NZ;

We also heard from **Andy Blair,** Director of Business and Innovation at Upflow. Andy discussed Upflow's work on extremophiles. Research has shown that bacteria and algae consume industrial waste gases to make a protein-rich biomass. This could be used as animal feed and nutritional supplements. Their incredible work is the first in the world to couple the production of a biofeedstock with geothermal waste gases and geothermal-sourced microorganisms.

Nature's Flame Operations Manager **John Goodwin** discussed the efficiency gains from using geoheat to dry wood fibre at his company's pellet factory outside Taupo. In 2019, Nature's Flame, replaced their aging biomass boiler used for drying wood fibre. They decided to use geoheat supplied by Contact Energy instead. The extracted heat is reduced through three heat exchanging loops (two heat exchangers) to supply 125 degrees of clean hot water to the drier with 22MW of thermal energy available. This decision reduced their carbon emissions by around 90,000 tonnes a year.

The decision was not only environmentally advantageous, but it was also beneficial for their bottom-line. They were able to double their manufacturing capacity and now receive up to 20MW of renewable geothermal heat continuously. The company currently produces close to 150,000 million tonnes of wood pellets which are distributed across New Zealand and the global. The switch also had a flow-on effect for their users. The pellets they supplied to the Te Awamutu Dairy factory allowed Fonterra to phase out a 43 MW coal-fired boiler.

Vegetables NZ energy engineer **Ellery Peters** discussed the opportunity of geoheat in the horticultural sector. Growers face high energy costs, eating away half of their costs in many incidences, especially as gas and coal has become more expensive. Growers are now struggling to lock in gas contracts. Ellery mentioned this should concern policymakers. He reiterated that many of these businesses would have no other option but to close if they cannot source an alternative fuel to gas. Switching is expensive and receiving finance to fund a new boiler is a big risk for growers with limited and sometimes uncertain cashflow. Ellery mentioned that the closure of many growers would be a threat to food security in New Zealand. The industry also faces challenges with changing regulations and consenting issues, fluctuating energy prices and an aging workforce.

The industry is evolving said Ellery. It's either they become more energy efficient or in many instances relocate to the source of available heat. When new greenhouses are being built the first question is where the energy is coming from and where are they getting our CO_2. In the future, more greenhouses will relocate to areas with low-cost energy options. In many examples, geoheat shows the way. Internationally, the horticulture sector is adopting more geoheat.

In the Netherlands over 40% of their greenhouses are expected to convert from natural gas to low temperature geothermal by 2030. The country wants 65% of its glass greenhouses using geothermal heat by 2050. This is some 30 petajoules of geothermal heat energy per year. Domestically, geoheat provides many opportunities for providing an affordable and reliable source of energy. An example is NZ Gourmet Mokai with its 12HA of tomato, capsicum and cucumber glasshouses.

It uses direct use geothermal steam from the Mokai Geothermal site, obtaining cheap electricity from a nearby geothermal plant. Compared to natural gas, the main disadvantage is a lack of CO2 from geothermal. However, switching cost and moving locations provide challenges for many small and medium sized growers. Moving would be disruptive and be consequential for locally employed people and their families. It is also a complex and costly exercise with plenty of risk, especially as they continue to run their daily business with all its responsibilities.

The potential for indirect geothermal use in New Zealand is significant. GNS Science's conducted work on aquifer modelling around Pukekohe shows its potential. Harnessing ground temperatures at around 20C used in ground source heat pumps is beneficial as it provides consistent performance for growers due to the consistent ground temperature. Pukekohe has significantly low temperature underneath Pukekohe, which has the most horticulture activity.

DAY 4

Thursday 4 July

He Ahi Clean Energy Industrial Park

On Thursday, we visited the He Ahi Clean Energy Industrial Park, purchased by Te Pae o Waimihia, a trust representing six local hapū. 44 hectares have been divided into sections for industrial and commercial premises. The trust has partnered with Contact to utilize existing geoheat capacity and infrastructure to supply the sections with clean, renewable, and affordable energy.

Joining us on the day, we had the enormous privilege of showcasing the Hon Minister Simon Watts around the Energy Industrial Park. We were also joined by Hon Tim Grosser, who also has a keen and deep interest in geothermal. On site, we visited Tnue, a business presiding in the Energy Park that manufactures Control Release Membrane (CRM) technology which is applied to fertilizer to improve nutrient use efficiency, while also reducing emissions and nitrate leaching. Tnue's facility, opened in February, uses the geoheat at temperatures around 130 degrees Celsius for its manufacturing process.

Afterwards, we visited CaSil Technologies, who also reside at the park. The team at CaSil have developed technology that captures problematic silica before silica scaling can occur. This means low temperatures for brine can be achieved without scaling, while reducing maintenance and plant downtime, including maximising direct heat.

CO2 Industry Panel discussion

We later heard CO2 Industry Panel discussion facilitated by Eastland Generation CEO Alice Pettigrew with discussions from Chris Abbott, Steward Hamilton and Faben Hanik**.** Several highlights stood out.

Chris Abott explained the work undertaken by Contact to reduce the carbon footprint of its geothermal portfolio, explaining its interests and RFP for taking naturally occurring carbon released during geothermal power generation and converting it into food grade quality. He discussed the importance of getting regulatory settings right, including the importance of the ETS in sending the right signals. He was disappointed by constant interferences with the Emissions Trading Scheme's settings which weakened the signal sent by the ETS.

Steward Hamilton discussed among many things, the journey and development of Mercury's key drivers to reduce its geothermal emissions, as well as the importance of striking the right balance between R&D in the 'unknowns' and investing in the 'known' technologies. Steward is enthusiastic about geothermal potential, and the progress made to reduce its emissions in such a short time. We also heard from the work of Fabian Hanik and his team at Ngawha Generation on its achievement to reduce 128,000 tonnes of emissions at its plant every year, making it carbon neutral. Fabian reiterated that the decision to inject carbon dioxide was largely due to a high and rising carbon price.

The decision was driven in part by their expectation of prices hitting close to $85-90 in early 2021. This did not eventuate. If price expectations were not that high at the time we would not have moved so fast, said Fabian. Fabian discussed the benefits and advantages of innovation in small organisations, the power of the ETS to accelerate action, the importance of political will and the key ingredients of getting things done.

Visit to Tenon and Taurhara

To finish off the day, we headed off for a tour around Tenon Clearwood's facility. Since 2007, Tenon has been using geothermal energy for kiln-drying and heating for its manufacturing operations. They use geothermal fluid supplied at about 195 degrees to provide heat at 180 degrees and 150 degrees through pressurised secondary water systems to the nine kilns drying sawn timber. In a two-phase supply, the geothermal fluid is supplied to the process as a mixture. The geothermal mixture releases heat through heat exchange to a secondary loop that delivers energy to the facility. After the heat is used in heat exchangers, the fluid is reinjected back underground. For Tenon, using geoheat is a matter of environmental and economic sense. Before 2007, running its nine chambers that dried the timber cost of using gas was over $380,000 a month. After adopting geoheat, Tenon was able to reduce the cost of running its kilns by 30%.

Our last visit of the day was to Contact's new Tauhara power station. It is one of the largest single-shaft geothermal turbines in the world, generating a sizeable amount of electricity, enough to power 200,000 homes, or 3.5% of total supply. Contact expects the fully commissioned power station to run at about 150MW until further modifications are scheduled to occur in October 2025, with the outlook to secure about 170 MW of generation long term. Tauhara is expected to displace just over 500,000 tons per year of carbon emissions as fossil fuel generation is shut down. This is equivalent to removing over 220,000 petrol cars from the New Zealand roads. Contact's Te Huka 3 power station remains on schedule to start generating another 50 MW of geothermal capacity before the end of the year.