Development of a web-based tool to identify geoheat opportunities for covered crops

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ABSTRACT

77% of New Zealand's covered crop growing operations are currently reliant on fossil fuels (62% natural gas; 15% coal) for space conditioning of greenhouses. The recent rise in the cost and decline in availability of natural gas, along with the global transition to renewable and environmentally friendly energy, has sparked the interest of local growers to the opportunity of geoheat. The transition from natural gas to geothermal heating observed in several European countries has inspired interest in achieving a similar transformation within New Zealand.

Most greenhouses in New Zealand currently rely on piped hot water heating systems designed to operate at temperatures of between 60 and 80°C, to maintain adequate growing temperatures and manage greenhouse humidity. These water temperatures are commonly found at depths of 2-3 km in non-geothermally active areas, however, they can often be found at shallower depths in locations around New Zealand. Information regarding where these shallow resources are located and how the subsurface heat can be utilised is hard to find, resulting in missed opportunities for low temperature heat users.

This project focusses on developing an online prototype tool which will provide relevant and easy to understand information regarding the potential of geothermal heat in the greater Auckland, Bay of Plenty and upper Waikato regions of the North Island. The project collates subsurface information, case-studies, and technological and financial feasibility estimates, in a publicly available web-based tool. It is being developed through close collaboration between earth-scientists, engineers and growers, ensuring that the tool is accurate, informative and useable.

1. BACKGROUND

Covered crop operations are an integral part of New Zealand's food system, enabling New Zealanders to access freshly grown vegetables from a local supplier throughout the year. Growing crops indoors have several benefits, with the controlled environment allowing better pest control, water usage, and nutrients, providing resilience within the domestic food system.

There are currently approximately 256 hectares of covered crops in New Zealand (Seward et al., 2023). The majority are located in the Auckland, Waikato and Bay of Plenty regions, with some located on the South Island (Tasman, Marlborough and Canterbury). Many of the North Island greenhouses are using natural gas to provide heating and dehumidifying for the crops. With increased costs of natural gas and the reduced national supply, growers have been looking at alternative energy and decarbonization options for their operations. Energy costs currently account for 30-40% of growers' costs.

Internationally, tapping into subsurface geothermal resources have been proven to provide large benefits for covered crop growers (Ngirubiu, 2023). The uptake of geothermal direct heat use in New Zealand could be very beneficial to the industry, however currently information about the resource, technology and costs are very hard to find. This project aims to combine data, information and economics together to provide growers with a tool to make a initial assessment as to the potential of converting to geothermal heat at their current site or a new site.

This paper describes the process of the tool development and collaboration.

1.1 Project Objectives

The project aims to support the covered crop industry in New Zealand to decarbonize their energy operations through investigating the opportunities of using naturally occurring heat stored in the ground. The project includes an assessment of publicly available subsurface data and an estimate of energy and costs of converting typical New Zealand greenhouse operations to geothermal heating in differing climate and geological locations. It will include both opportunities for direct heat use and indirect heating, i.e., with ground source heat pump technology. The tool will provide a key input for assessing low-temperature geothermal options for an individual grower's energy decarbonization plans and help to de-risk the geothermal option.

1.2 Project design

The program is co-designed with Vegetables NZ and Tomatoes NZ (both national organisations representing vegetable growers), and GNS Science and GeoExchange NZ. This team consists of scientists, engineers, social scientists, growers, website developers, and communication specialists to ensure the outcome is useful, useable and used.

While the current demand for the tool is coming directly from covered cropping, there are wider applications for other small to medium users of heat. We anticipate that by

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generating awareness of the opportunities with this sector that it could

Figure 1: Global examples of greenhouses using geoheat in their operations

expand into other sectors. It was therefore decided that GNS Science will develop and maintain the web-based tool, allowing for the potential further development to support other industries.

Our multi-disciplinary and multi-agency team plans to facilitate engagement with industry representatives to ensure that the project meets the needs of industry.

1.3 Project Approach

The project aims to develop a web-based tool which will provide a key means for assessing low temperature geothermal as an option for an individual grower's energy decarbonization plans and help to de-risk the geothermal option. Our planned approach for this is as follows:

1. Identify suitable range of **subsurface characteristics** for heating a greenhouse, based on international examples.

2. **Compile and characterise geothermal** resources using relevant and available datasets.

3. **Develop a map-based tool** to identify areas of suitable thermal conditions for supporting greenhouse heating demand in South Auckland, Waikato, Hauraki and Bay of Plenty.

4. **Estimate financial feasibility** using case studies of representative NZ greenhouse thermal demand and "rule of thumb" energy and financial calculations based on available subsurface conditions.

5. **Develop a website** to host a map-based database and feasibility case-studies

6. Deliver a **stakeholder** report on development and use of the tool, and recommendations for future mechanism for supporting transitions.

2. PROJECT PROGRESS

2.1 Subsurface characteristics – international examples

The purpose of this milestone is to investigate global use of subsurface heat for greenhouse applications. This investigation highlights the range of temperatures and technologies used in a variety of locations for a variety of crops around the world (Figure 1).

Initial research has identified at least 30 greenhouses that use subsurface heat in their operations. The applications range from projects using deep (>3000m) bores accessing 80-100°C to shallower systems tapping into warm (30-40°C) aquifers at 1000-1500m depth. The size of greenhouses ranged from 3 to 500 ha with energy demands between 2000kW to 50MW.

It was interesting to note that during this exercise information was difficult to find. There was generally no central government database that keep track of geothermal use, and that information had to be obtained through growers websites, technology supplier websites, geothermal newsletters, newspaper articles, and word of mouth. It was even more difficult to find details on geothermal greenhouses that utilized the ambient groundwater temperatures for greenhouse operations, although one has been included in the selected case studies (Figure 2). We believe that the lack of information around the use of ambient groundwater is not that they do not exist, but rather because it is not considered noteworthy.

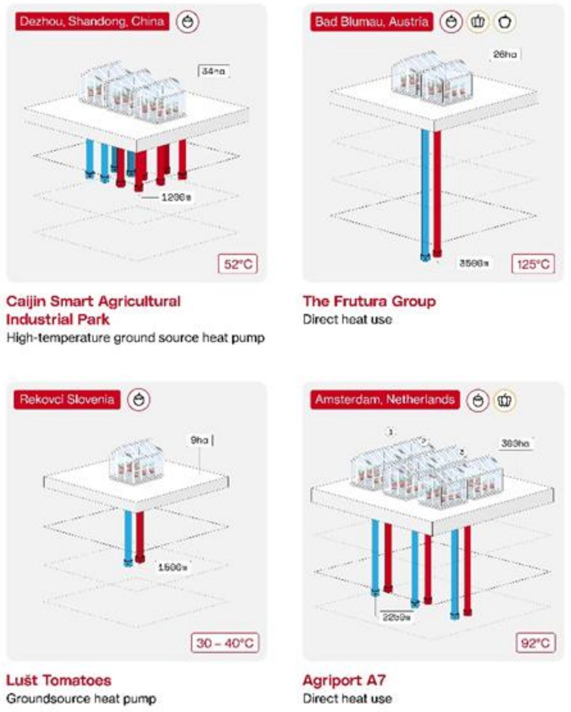

Figure 2: Schematics of examples of geoheat setup for different greenhouses

2.2 Geothermal data collation

The objective of this workstream is to compile useful public datasets, including regional geology, subsurface temperatures, depth to temperature, aquifer catchment zones, surface feature locations (e.g., springs), depth to aquifer, and groundwater flow, to help characterise the geothermal resource in the Auckland, Waikato and Bay of Plenty regions. This information will then be compiled into the web-based tool that functions as a first-pass decision making tool to inform growers of the potential to convert to geothermal heating, either through direct or indirect (GSHP) technologies.

Bore databases from Regional Councils were used to find bores containing temperatures and flow rates (WRC, 2025; BOPRC, 2025; ARC, 2025). Water temperatures (Figure 3) and flow rates (Figure 4) are not routinely measured under many consent conditions, and so restricted the amount of useable data. Useful borehole data for this application would include annual water temperatures, flow rates, water level, and occasional water chemistry. These data would provide information of subsurface aquifer depths, temperatures, groundwater flow and water quality.

Springs data have also been compiled from the Geothermal and Groundwater database (GGW, 2025) with a focus on surface flow rates and temperatures (included in Figure 3(a)). This dataset mainly provides insight into locations of shallow groundwater and geothermal fluids, indicating potential resource close or near the surface, providing more economical access to the resource

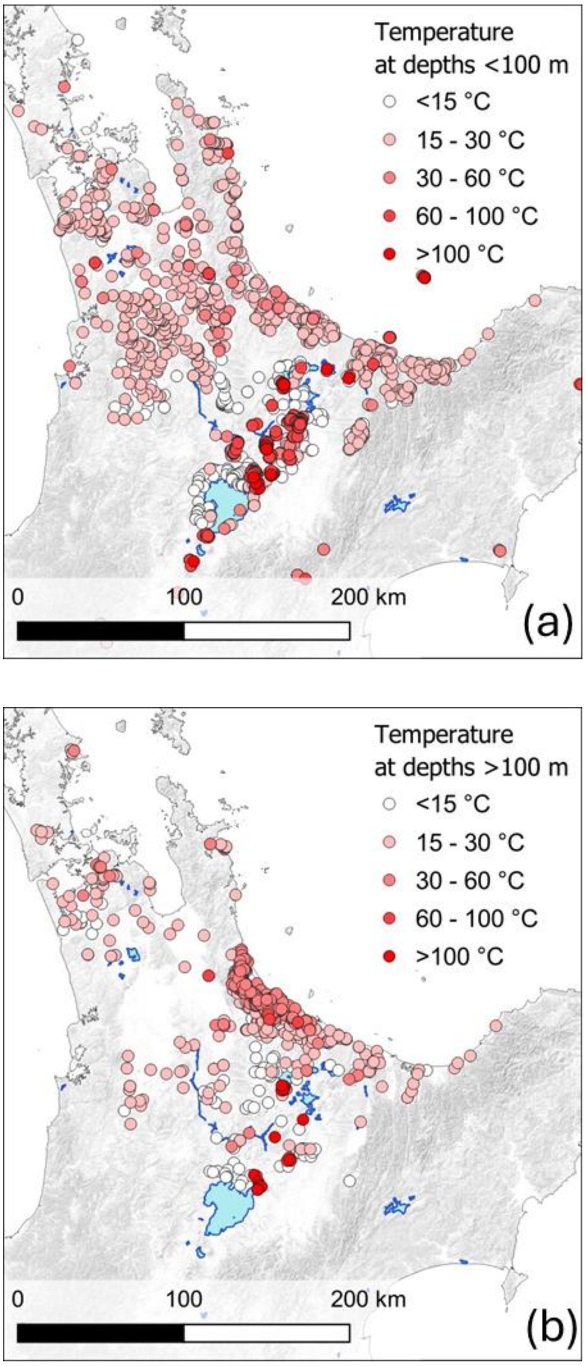

Figure 3: Measured water temperatures in (a) wells of depths < 100m and surface springs, and (b) wells of depths > 100m.

Available flow rates recorded in groundwater bores are shown in Figure 4, along with modelled near surface aquifers. These datasets provide an indication of where flowing groundwater is likely to be found at shallow depths. These aquifer boundaries (yellow) are determined from regional geology and correlated with known permeable sands and sediments. Areas outside of these yellow zones may also have smaller subsurface aquifers or aquifers at greater depths than those classified by the "shallow" depth criteria. The presence of bores with measured flowrates outside of these yellow areas also confirm that not all flowing aquifers are detected in the model.

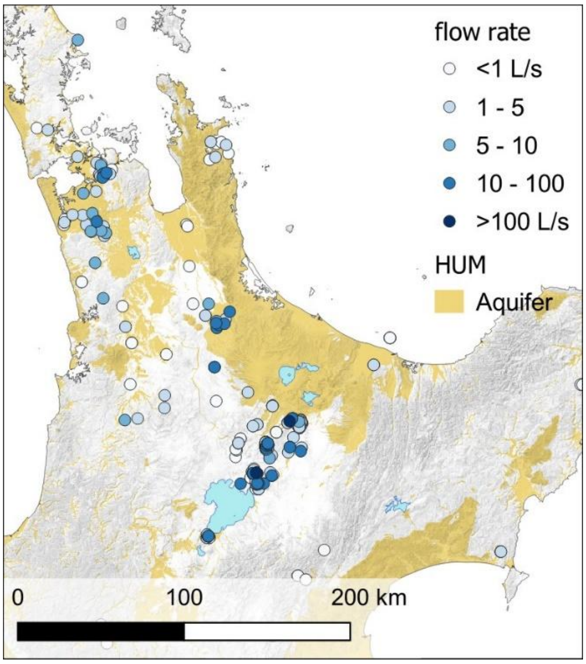

Figure 4: Map showing the locations of wells with measured water flow rates, overlain the HUM model of shallow/surface aquifers (Tschritter et al, 2017)

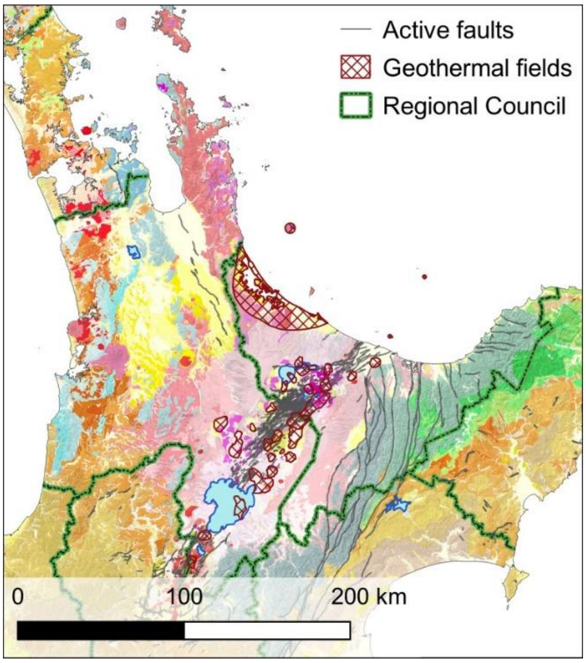

Figure 5: Geological map showing the different geological units in different colours (Qmap 1:250,000), with outlines of known geothermal reservoirs shown in maroon hatch, active faults (grey lines; NZAFD) and the regional boundaries shown in green.

Regional geology and faulting can also help classify subsurface heat potential. Faults often indicate pathways for meteoric water to be transported into subsurface aquifer systems and also provide pathways for heated waters to rise to the surface, often resulting in warm thermal springs.

Other useful data and models include the recently published heat flow model (Kirkby et al., 2025), thermal properties of New Zealand rocks (e.g. Gouwland et al, 2025; Wright et al, 2025; Kirkby et al., 2024; Sagar et al, 2022; Sanders et al, 2024), and water chemistry of springs (Reyes, 2015 and references therein). These datasets will be combined into an accessible tool which will provide geological and hydrological information to help assess geothermal opportunity at the chosen site.

2.3 Web-based tool development

The objective of this task is to develop an online tool which presents the data described in Section 2.2, to identify areas of suitable thermal conditions for supporting greenhouse heating demand. A key objective of this tool is not only to present the geological data but also to provide an input for a financial feasibility estimation calculator (Section 2.4).

Our goal is to co-design this with end users to ensure that data and information is easy to understand and useful.

2.4 Financial feasibility estimate

This objective will connect geological and climate conditions with typical thermal demands of different sized representative New Zealand greenhouses, to provide an estimate of potential operational energy saving.

An assessment will be made with site specific input from the web-based tool. The user will enter critical information into the calculator, this includes greenhouse size, thermal fabric (predetermined settings of 'poor', 'average', 'above average'), indoor set temperature, whether humidity control is present or not, and energy costs. The calculator will combine these inputs with the geological location set and will present geothermal options at site and required technology for heating needs. The tool will also provide a comparison of operating cost of different geothermal options compared to alternative energy sources, and an estimated "rule of thumb" assessment of capital costs to convert to geoheat options.

2.5 Website development

The dissemination of information is key to this project and the uptake of geothermal heat use. The development and ownership of the website was discussed at length at the start of the project, with the decision landing that GNS Science will develop, house and maintain the website. Primarily as this is proposed to be a prototype project with aims to develop the tool further for other regions of New Zealand and potentially to evolve to cater for other heat users as well.

A website was set up within the GNS Science web-domain, currently providing background to the project, motivation, links to useful information, press releases and other material of potential interest to users.

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As progress is made on the milestones, this website will also contain the tools discussed in the previous sections.

2.6 Stakeholder engagement and feedback

A comprehensive engagement plan was developed in conjunction with the funding applications at the start of this project. The aim is to get the growers/horticulture industry to consider geoheat as a viable option for investment in decarbonization pathways. But also for landowners/ mana whenua and regional authorities to realise the potential for applications using geoheat resources on their land and in their jurisdiction. There are three main aims for this engagement:

1. Give growers tools, resources and support to build business cases for geoheat investment

2. Engage in a wider community and national stakeholder group to enable favourable regulatory pathways

3. Engage with Iwi and Manawhenua on long term benefits of geoheat for business and community opportunities.

The key drivers for engagement are to ensure that end users have a tool that is useful, useable and used. It is key that they trust the tool and information and have access to up-to-date and relevant information for better decision making. Additionally, policy makers need to support the potential of geoheat energy for sustainable communities, so that landowners and iwi groups can unlock an economic energy source for their community.

As part of regular stakeholder engagement the project team, with representatives from GNS Science, GeoExchange NZ, Vegetables NZ and TomatoesNZ, meets monthly with each other and a small advisory panel of growers. The organization also use their stakeholder networks to also provide input into the project.

A series of in-person stakeholder events have been held to help build support and raise awareness of the geoheat opportunity for greenhouses. The first "launch" was held as part of the Horticulture Industry Forum in Wellington, December 2024. A project overview was given to horticulture industry association chairs and chief executives. This was followed by a media release issued in January 2025 (GNS 2025). Two regional stakeholder meetings were held in Tauranga and Auckland with 12-20 attendees, with presentations from Vegetables NZ, GNS Science and GeoExchange NZ.

Feedback from these stakeholder meetings is included in project development, including development of case studies and collateral material to take home for spin-off discussions with neighbours and communities.

3. CONCLUSIONS

This project aims to create a prototype for an online mapping and information tool that draws together existing data and knowledge about low temperature geothermal resource availability in the greater Auckland, Northern Waikato, and Bay of Plenty regions, and how to use it for temperature control of covered crop operations. This will provide growers with accessible and understandable information on geothermal potential when considering heat energy decarbonisation options for their operations. It aims to support business case development for energy conversion to support operational cost and carbon savings.

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REFERENCES

ARC, 2024, *pers comms*, Maria Gin, Corporate Records Administrator, Auckland Council, Works Division Water Laboratory files. September, 2024

BOPRC, 2024, Bay of Plenty Maps, Well/Bore Locations in the Bay of Plenty, https://maps.boprc.govt.nz/datasets/BOPRC::well-bore-locations-in-the-bay-of-plenty/about

GGW, 2025, GNS Geothermal and Groundwater database, https://www.gns.cri.nz/data-and-resources/gns-geothermal-and-groundwater-ggw-database/

GNS 2025 https://www.gns.cri.nz/news/geothermal-grown-greens-projectnews/

Gouwland, A.; Sutherland, R.; Seward, A.M. 2025 Thermal properties of orogenic flysch and schist, Rakaia Terrane, Torlesse Composite Terrane, New Zealand. New Zealand Journal of Geology and Geophysics, Online: doi: 10.1080/00288306.2025.2489174

Kirkby, A.L, Funnell, R.H., Scadden, P.G., Seward, A.M., Tschritter, C., Jones, K.E., 2025, Heat Flow in an active plate margin: New Zealand's crustal thermal regime from borehole temperatures and numerical modelling. *Tectonophysics,* 899

Kirkby, A.L.; Mortimer, N.; Funnell, R.H.; Sagar, M.W.; Seward, A.M.; Faure, K.; Sanders, F. 2024 Composition-based estimates of the thermal properties of New Zealand basement rocks. New Zealand Journal of Geology and Geophysics, Online: doi: 10.1080/00288306.2024.2362769

Ngiruliu I, 2023, Circular Economy and its Governance in Dutch Agri-food Greenhouse Horticulture : Overcoming the barriers to implementation, MSc Environmental and Energy Management, University of Twente.

NZAFD, New Zealand Active Fault database, GNS Science. https://www.gns.cri.nz/data-and-resources/new-zealand-active-faults-database/

Qmap 1:250,000 series, GNS Science. https://www.gns.cri.nz/data-and-resources/digital-qmap-geological-maps-at-1250000/

Reyes, A.G., 2015. Low-temperature geothermal reserves in New Zealand. *Geothermics*, *56*, pp.138-161.

Sagar, M.W.; Funnell, R.H.; Randell, K.; Faure, K.; Seward, A.M.; Sanders, F.; Stratford, W.R. 2022 Physical properties of Te Riu-a-Maui / Zealandia crustal rocks: Reconnaissance study and future research. GNS Science internal report 2022/05. 34 p.

Sanders, F.; Seward, A.M.; Sagar, M.W.; Faure, K. 2024 Thermal properties of Zealandia basement rocks: results of Thermal Conductivity Scanner measurements, 2023. Lower Hutt, N.Z.: GNS Science. GNS Science report 2024/08. 127 p.;

Seward, AM., Wells, C., Peters, E., 2023. Low-temperatuare geothermal : a decarbonising solution for covered crop growers in New Zealand. *In proceedings 45th New Zealand Geothermal workshop, 15-17 November 2023, Auckland*

Tschritter, C.; Westerhoff, R.S.; Rawlinson, Z.J.; White, P.A. 2017 Aquifer classification and mapping at the national scale

- phase 1 : identification of hydrogeological units. Lower Hutt, N.Z.: GNS Science. GNS Science report 2016/51. 52 p.; doi: 10.21420/G2101S

WRC, 2024; Waikato Data Portal | Waikato Regional Council

Wright, S.; Sutherland, R.; Boulton, C.; Seward, A.M. 2025 Thermal properties influence earthquake slip on the Alpine Fault, New Zealand. Geophysical Research Letters, 52(11): article e2024GL113830; doi: 10.1029/2024GL113830