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Direct Use: Opportunities and Development Initiatives in New Zealand

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ABSTRACT

The technological, economic and environmental benefits of direct geothermal use are well demonstrated internationally. In New Zealand, direct geothermal use includes applications in industrial timber and food processing, agriculture, aquaculture, geothermal (ground-source) heat pumps, tourism, balneology, and commercial and domestic heating. There is growing interest from the geothermal industry, economic development agencies, the New Zealand government and others to promote and further develop direct geothermal heat use.

This paper presents an update on the direct use opportunities in New Zealand, and the initiatives that are underway to promote growth and increased uptake. Opportunities for new increased direct-use development include: supplying new businesses with geothermal heat; substituting for fossil fuel based energy; developing industrial / commercial geothermal heat parks; and attracting industries to take advantage of New Zealand's geothermal assets. Initiatives include the following: consultation with architects, engineers and energy managers to understand their energy perceptions and decision-making practices; development of promotional and educational materials; improvement of the regulatory regime; economic modelling; development of an online interactive geothermal use database and web map; and improvement of the communication among industry, government and research sectors.

These initiatives are assisting in meeting New Zealand's energy needs; contributing to economic and social development, strategic energy targets, and further promotion of New Zealand's commitment to efficient and clean energy use.

1. INTRODUCTION

New Zealand has abundant geothermal resources. The benefits of geothermal energy use include:

- Energy supply security
- Sustainable, renewable energy use
- Reduced carbon-intensive energy use
- Regional development- new business opportunities and economic growth
- Energy efficient heating/cooling
- Healthier living and working environments
- Positive brand recognition and marketing opportunities for use of renewable technologies

Figure 1 (left) shows the areas best suited to geothermal direct use in New Zealand, where localised zones of high surface heat flow occur with high volcanic and tectonic activity (Reyes, et al., 2010; White, 2009). There are many thermal springs in both the North and South Islands (Reyes, 2007; Reyes et al., 2010). Areas such as Rotorua, Kawerau, Taupo and Ngawha, associated with high temperature geothermal systems, are recognised for their geothermal resources. Unsurprisingly, the majority of the existing direct use operations are located in these areas (Figure 1, right). The dominant areas are the North Island's Bay of Plenty Region, which include the Districts of Rotorua, Kawerau and Tauranga, and the Waikato Region, which includes the Taupo District.

2. EXISTING USES

There are over 200 examples of commercial uses of geothermal energy in New Zealand, as well as numerous (100+) free bathing hot springs. Bathing and swimming is New Zealand's largest geothermal direct use by total number of operations (Figure 2A) with a rich heritage of balneology throughout New Zealand's history. Māori who settled around active geothermal areas traditionally used geothermal hot springs for bathing and cooking and early tourists came for the health benefits of geothermal waters and iconic sights such as the Pink and White Terraces (which were destroyed by a volcanic eruption in 1886).

Today, the industrial sector is the largest direct heat use consumer of New Zealand's geothermal energy (Figure 2B). The Norske Skog Tasman paper and pulp facility in Kawerau, established in the early 1950s (Bloomer, 2011), is the primary consumer of direct use geothermal energy in New Zealand. Other uses of direct geothermal include timber drying, space heating and cooling, food processing, milk drying, greenhouse heating, aquaculture and bathing.

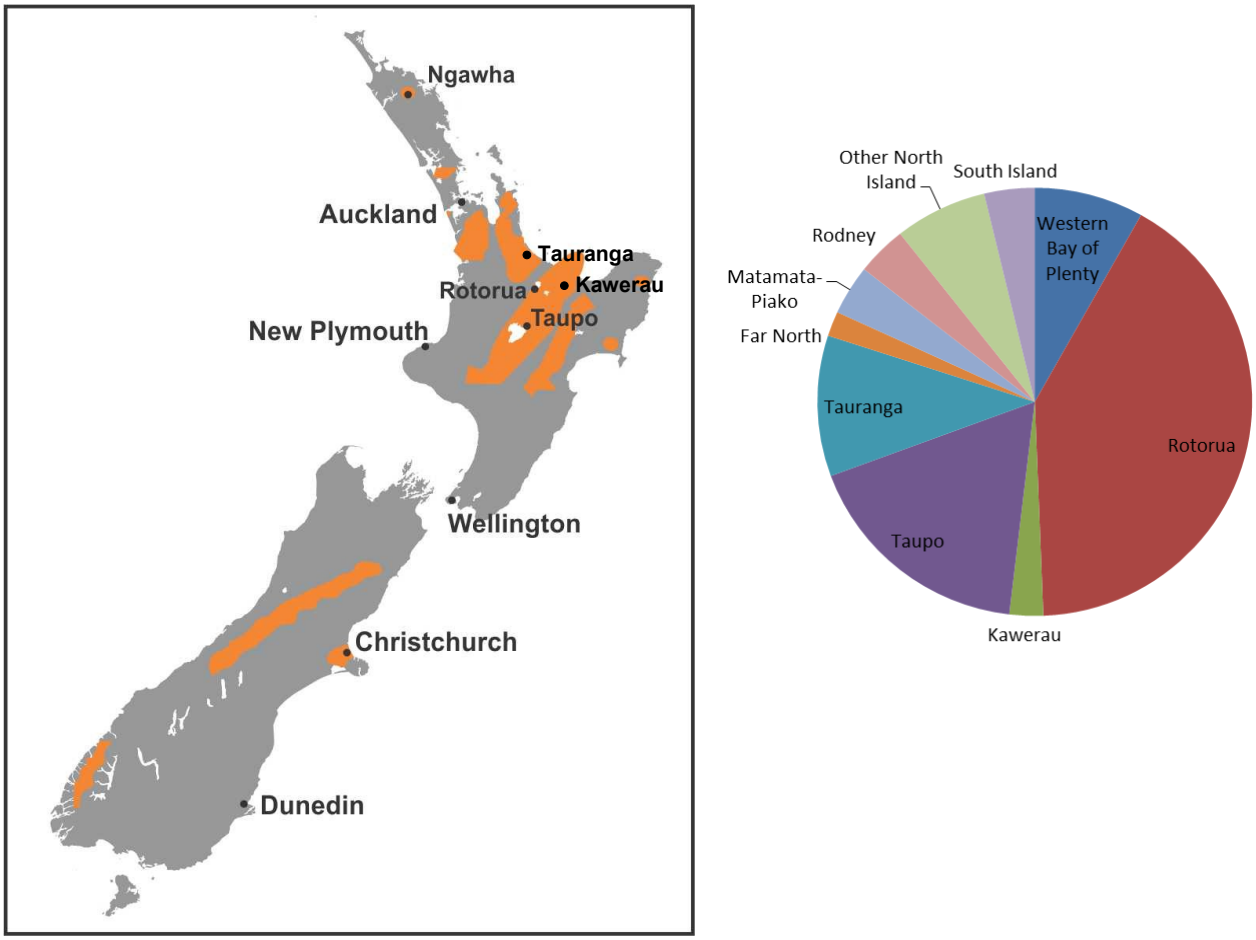


Figure 1: (LEFT) Areas of high heat flow (orange areas) associated with tectonic, volcanic and geothermal activity in New Zealand (revised from White, 2009). (RIGHT) Relative number of geothermal direct heat use operations in New Zealand (2012) by district. Figure excludes domestic use, geothermal heat pumps and non-commercial bathing.

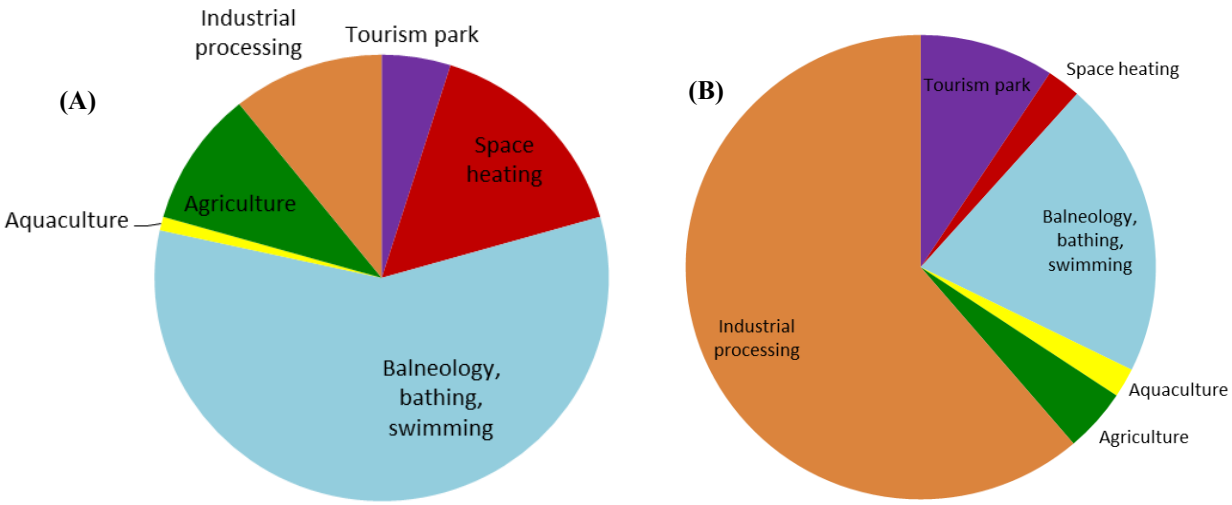


Figure 2: Geothermal direct use in New Zealand (2012) by category, presented by (A) relative number of installed operations; (B) by relative energy use. Figures exclude domestic use, geothermal heat pumps and non-commercial bathing.

3. OPPORTUNITIES FOR GEOTHERMAL DIRECT USE

Most processes that require heat input can use geothermal energy directly, instead of supplementing electricity and/or fossil fuels. Direct use viability depends on the temperature of the geothermal fluid available (Figure 3). The resource must also be able to sustain the extraction of heat and/or fluid proposed. Installations can be stand-alone (i.e. one heat source, one use) or clustered (i.e. shared heat source). Cascading direct usage after a high temperature use is often possible. However, it may be problematic because the cooling of high temperature geothermal fluids can precipitate silica, which presents a silica management issue. Parallel supply for direct use and generation offers an alternative for commercial use of these energy resources, and some developments have cascaded power generation off the direct use.

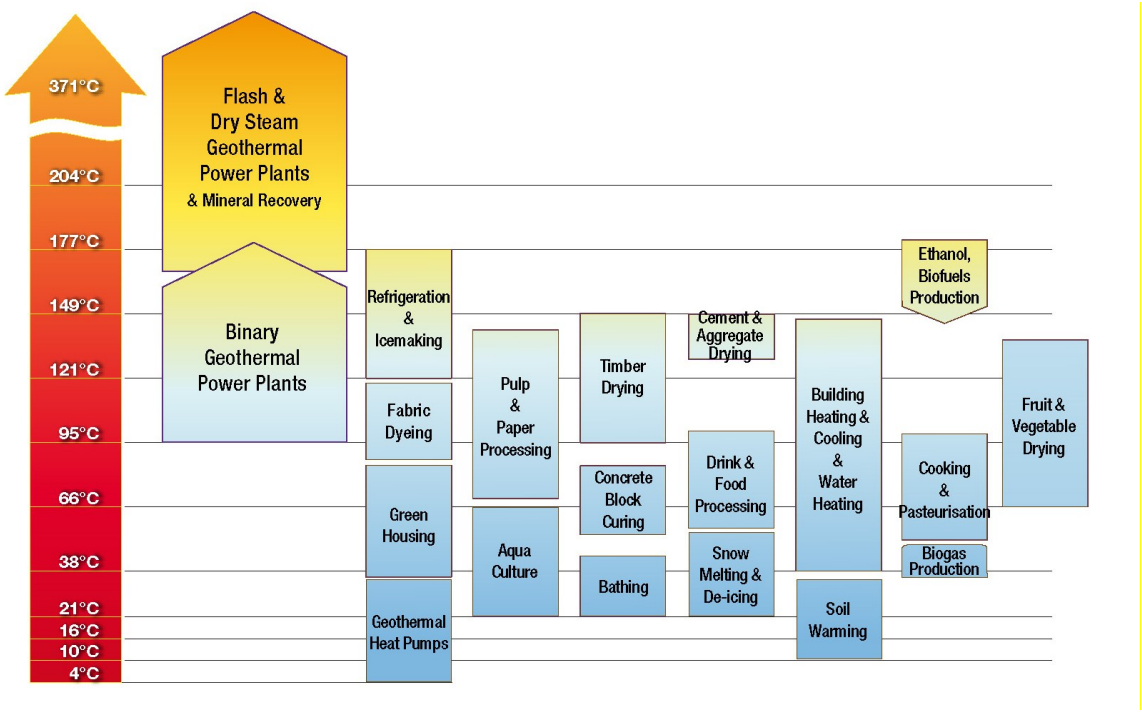


Figure 3: Lindal diagram showing examples of potential uses for geothermal resources, as a function of the temperature required for the process.

Geothermal resources are a key component of New Zealand's energy scene, providing around 14% of the nation's electricity supply by 2012 (MBIE, 2013), and approaching 18% in 2014. Renewable electricty generation currently accounts for around 75% of New Zealand's supply, with the balance produced from coal and gas. Geothermal energy is likely to make a large contribution towards achieving New Zealand's 90% renewable electricity target by 2025, as the only renewable, base-load generation option. The government has also called on geothermal energy to make a contribution to a direct use target of an additional 9.5PJ/year from biomass and direct use geothermal energy above 2005 levels by 2020 (EECA, 2011).

Going forward, geothermal has the capability to provide a sustainable heat source for the industrial, commercial and residential sectors. There is an opportunity for industries using coal, oil, or natural gas to replace or supplement their current systems with geothermal heat. Long term benefits can be realised as growing demand for energy is paired with reducing the availability of fossil fuels at an increased price. Examples of industries that can take advantage of geothermal heat are listed in Table 1 under "Process Energy". Commercial use opportunities are in space conditioning and water heating, such as hospitals, rest homes and educational institutions. Geothermal energy cannot be directly used for transportation, but it could play a role in domestic biofuel production. An energy contribution could also be made in the agricultural and residential sectors.

In considering these opportunities, colocation of multiple users should be explored to share upfront capital costs, infrastructure and ongoing maintenance. New Zealand has few examples of geothermally supplied industrial heat parks or district heating schemes, which are present in other countries with geothermal resources (e.g. USA and Iceland), where a thermal distribution infrastructure is established to service multiple users. A New Zealand example is at Kawerau, where several wells supply a number of processes in parallel, including electricity generation, timber drying and paper production. The Tuaropaki Trust's operations at Mokai are a second New Zealand example, where a geothermal power station shares wells with greenhouses and a milk drying facility. Note that the Mokai development is not an example of a cascaded use off power generation, but rather, a parallel use for the glasshouse and an upstream use for the milk drying plant. There is potential to develop more of these geothermal hubs.

There are opportunities to create new businesses and to relocate existing businesses from other regions to geothermally-rich districts to benefit from renewable heat energy supply. There is also the potential to convert industries already in these areas from fossil fuel-based energy supply to geothermal. Wood processing, and paper and paper products make up the largest demand for thermal energy in districts in close proximity to high temperature geothermal resources (EECA, 2007). Energy is also required for space conditioning (heating/cooling) and/or water heating. The majority of the thermal heating demand is in the intermediate range (100°C - 300°C) with smaller amounts in the lower temperature range (<100°C).

Table 1: Industries with commercial and industrial energy demand.

Process Energy	Space Conditioning and Water Heating
Basic Metals Industries	Basic Metal Industries
Chemicals, Related Products and Plastics	Central Government Administration
Concrete, Clay, Glass and Related Minerals Manufacture	Central Government Defence Services
Dairy Agriculture	Communication
Dairy Products	Construction
Fabricated Metal Products, Machinery and Equipment	Education Services: Pre-School, Primary and Secondary
Fishing and Hunting	Education Services: Tertiary Education
Health and Welfare Services	Dairy Agriculture
Mining and Quarrying	Dairy Products
Motels Hotels and Guest Houses	Financing, Insurance, Real Estate and Business Services
Non-Dairy Agriculture	Fishing and Hunting
Other Food Processing Sectors	Health and Welfare Services
Other Manufacturing Industries	Local Government Administration
Retail Trade – Food	Motels, Hotels and Guest Houses
Slaughtering and Meat Processing	Other Food Processing Sectors
Textile, Apparel and Leather Goods	Other Social and Community Related Services
Wholesale Trade – Food	Paper and Paper Products, Printing and Publishing
Wood Processing and Wood Products	Retail Trade – Food
Paper and Paper Products, Printing and Publishing	Slaughtering and Meat Processing
	Wholesale and Retail Trade – Non Food
	Wholesale Trade – Food

Well drilling is a significant capital cost in establishing a geothermal development and, given these costs, there is a minimum energy demand required for a new, standalone geothermal projects to be financially viable. However, direct use applications may not necessarily require drilling to a deep (>1 km) geothermal reservoir. As the depth to the geothermal resource decreases, the capital costs for extraction also decreases and the demand threshold becomes lower. A recent report by East Harbour Energy (2013) investigated the relative costs of process heat supply from geothermal energy (drilled to four different depths) versus coal, wood and gas energy supplies. This study showed that, at any particular depth, there is a demand threshold above which geothermal is competitive against other fuel options (Figure 4). For example, the demand threshold of a geothermal resource versus coal is about 45 MWth for a 2,000 m well but less than 5 MWth for a 250 m well. The capital payback, the annual heat requirement, and the fuel cost all drive actual heat cost.

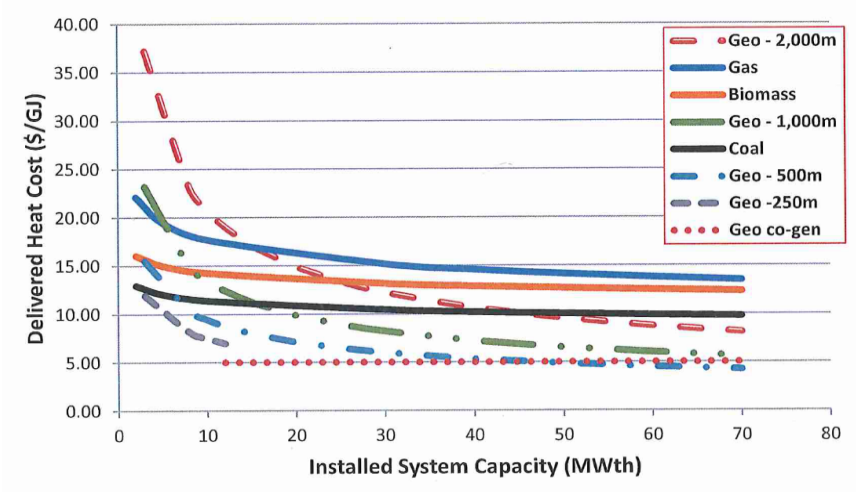
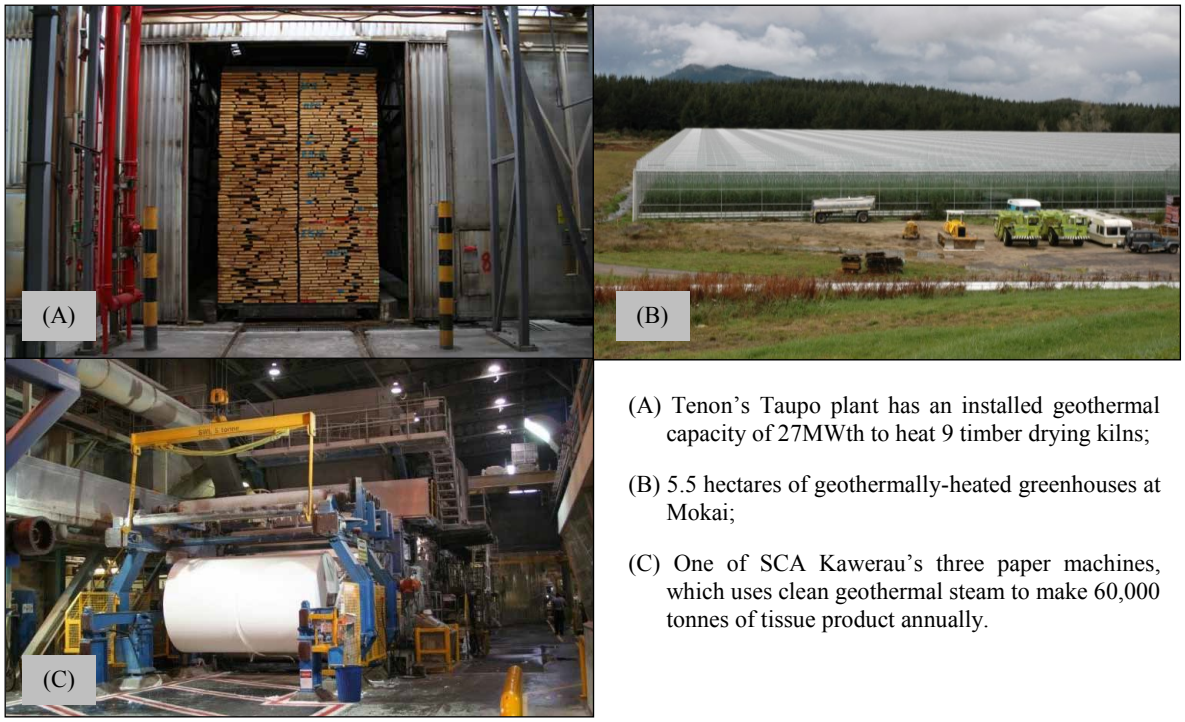


Figure 4: Delivered cost of heat for large industrial heat applications for geothermal, coal, wood and gas energy sources.

Note the size of developments being considered in Figure 4, with some of these being in the 10s of megawatts in capacity. Studies have identified that large-scale commercial and industrial projects can be very attractive and can readily compete with fossil fuels. Opportunities at this scale are limited, but in New Zealand have included applications related to wood processing and dairy processing, as well as large scale glasshouses (Figure 5).



(A) Tenon's Taupo plant has an installed geothermal capacity of 27MWth to heat 9 timber drying kilns;

(B) 5.5 hectares of geothermally-heated greenhouses at Mokai;

(C) One of SCA Kawerau's three paper machines, which uses clean geothermal steam to make 60,000 tonnes of tissue product annually.

Figure 5: Examples of large-scale commercial and industrial operations utilizing geothermal heat in New Zealand.

There is a growing interest from the geothermal industry, economic development agencies, regulatory authorities and others to develop new direct use projects in New Zealand. There are a range of factors driving this change. The lack of electricity demand is driving geothermal electricity generators to consider diversification into other opportunities (White, 2013). Māori are major stakeholders and contributors to economic growth in the regions, and the Māori economy potential is significant with interests in many geothermal resources (TPK, 2012). Government targets pursue increased use of renewables and direct use of geothermal energy (EECA, 2011; MED, 2011), as do local and regional economic development agencies. New Zealand is well-placed to fulfill some of these aspirations. The success of geothermal direct use is well demonstrated both domestically and internationally.

4. BARRIERS

Geothermal energy is a competitive advantage for New Zealand, it is embedded in energy targets and goals for economic growth. Yet, the potential is still to be realised. The recurring themes for barriers to the increased use of geothermal resources are: limited understanding of the resource, lack of information about opportunities, complex processes, and an absence of leadership.

The scale and breadth of the geothermal direct use opportunity remains unclear. There is a considerable need for access to robust information on existing direct use operations, available resources and their characteristics, and certainty and clarity in regulatory processes. Additionally, direct use developments require financial data on economic viability and market drivers.

Domestically, New Zealand has a (mostly) temperate climate and a "cold-house" culture (Coyle, 2014). New Zealanders generally have lower expectations of indoor comfort levels in winter compared with a number of other countries. Attitudes are moving towards considering central heating/air conditioning, double glazing and good insulation as basic necessities, with warm homes increasingly being seen as important for good health. Also, New Zealanders typically move houses every five to seven years, so little investment is typically made in the infrastructure (such as efficient central heating systems) that might provide long-term costs savings but have higher upfront costs. Thus, while the benefits of green energy, such as geothermal, are well recognised, there are cultural and environmental barriers to overcome, particularly in the residential sector.

At commercial and industrial scales, the barriers are more complex. Internationally recognised barriers to renewable energy technologies apply to geothermal energy, and include legal, economic, market, social, institutional, technological and legislative impediments. A recent study by Coyle (2014) sought to define these barriers in a national context, through an investigation of architects, engineers and energy managers' perceptions of geothermal energy, their decision making processes, barriers to uptake and suggested solutions. Barriers to geothermal use were also discussed by over 100 participants at a 2014 geothermal direct use workshop (Grow Rotorua, 2014). These forums both found mixed levels of awareness of the opportunities for geothermal energy. This was mirrored in an earlier study of the New Zealand public's perceptions of geothermal energy (Doody and Becker, 2011), which showed that generating power was the most commonly understood use of geothermal resources along with bathing, but less was known about the commercial and industrial direct heat use opportunities.

A related, recurring theme in the Coyle (2014) study was the emphasis on proving that these technologies are viable in the New Zealand context. There was a focus on needing successful demonstrations in the local climate, culture, geography and economy. There are already world-class examples of very successful geothermal direct use applications (e.g. pulp and paper processing in Kawerau, glasshouses and milk processing at Mokai). However, there is little technical information publically available (e.g. design, economics) to guide other industries who might wish to follow their lead. There is a need for case studies that include economic analyses to be made available. These should cover a range of scales (e.g. domestic to industrial), sectors (e.g. agriculture to industrial processing), and also include retrofits, where conversion has been made in an existing business to a geothermal energy supply.

The published literature does include a number of introductory reports (e.g. Reyes, 2007) and "how-to" guides (e.g. Lund et al., 1998; Thain et al., 2006) for developing direct use applications. Country reporting has identified past trends in direct use development and identified areas of change (e.g. White, 2009; Harvey and White, 2012). Economic development strategies identify geothermal energy as a key asset (e.g. TPK, 2012; BOPRC, 2011). However, there is a need for greater coordination and leadership from the individuals and organisations driving, and/or are interested in seeing an increase in geothermal resource use. There are roles for central and regional governments, economic development agencies, research organisations and associations, Māori, private industry and others. Role clarity is also needed.

5. INITIATIVES

Climo and Carey (2011) identified a suite of critical steps to increase the geothermal energy use, which are summarised here:

- Set up working groups comprised of relevant and enthusiastic agencies and organisations to take ownership of the initiatives.
- Develop and disseminate educational, marketing and technical collateral to raise awareness and to support informed decision making.
- Incentivise and showcase early adoption of geothermal applications and technologies.
- Develop a coordinated approach to entering new market segments (new uses), converting nonusers to users, and increasing annual usage.
- Harmonise the planning regime across New Zealand, with a focus on reducing regulatory barriers.
- Focus the resource characterisation studies and demonstration sites in high demand areas and/or those with geothermal resources.

A range of initiatives (underway or proposed) during the past five years, relevant to commercial and industrial direct use applications are summarised below.

5.1 Understanding & Information

Various studies (e.g. Doody and Becker, 2011; EMS, 2011; Coyle, 2014) and workshops (e.g. Grow Rotorua, 2014) have highlighted the need for greater education, marketing and information dissemination to improve investor awareness and consumer confidence.

GNS Science has produced a series of fact sheets, case studies and posters on its "Earth Energy" webpages (www.gns.cri.nz/earthenergy). A national geothermal use database and webmap (http://data.gns.cri.nz/geothermal) includes existing direct use applications, as well as power generation and geothermal heat pump installations. This inventory aims to support a number of goals, including: more robust estimation of New Zealand's geothermal use for national and international reporting; and increasing the awareness of the opportunities for geothermal resource use (Climo and Hall, 2013).

A range of information is also available online in the form of reports, including

- introductory reports to geothermal direct resources and use (e.g. Reyes, 2007; White, 2009)
- demand analysis (e.g. Rossouw and Lind, 2010; Lind, 2012),
- technologies (e.g. Gazo and Lind, 2010)
- economics (e.g. Gazo et al, 2011; East Harbour Energy, 2013)
- societal perceptions (e.g. Doody and Becker, 2011; Coyle, 2014; EMS, 2011)
- guides for developing direct use applications (e.g. Lund et al., 1998; Thain et al., 2006)

Conference papers are available through the International Geothermal Association conference paper database, and the New Zealand Geothermal Association has a range of workshop papers online (www.nzgeothermal.org.nz), including presentations from a direct use seminar held in October 2011. Presentations from a 2014 direct use workshop are also available online (www.bayofconnections.com/geothermal). Efforts continue to be made to increase the information available, including plans to develop more in depth case studies and "how-to" guideline documents (Grow Rotorua, 2014).

5.2 Processes

Every geothermal project is unique, determined by its local geological, regulatory and market conditions; no two geothermal projects will follow exactly the same development path. However, there is a need to build on previous work and develop a New Zealand "how-to" guide that covers the *process* for developing an understanding of the presence or otherwise of commercially developable geothermal heat in a specific land area. The target audience for this guide are potential project developers, such as landowners, existing business owners and potential business owners. It will also be relevant to inform and educate planners, architects, engineers and government agencies. Based on a stepwise process with a series of go or no go decision points (Figure 6),

the process will allow the potential users to progressively increase their understanding of the resource and the technical and commercial viability of the proposed development, while reducing risk.

New Zealand's regulatory environment needs to be understood as part of any planning in the development of geothermal resources (EMS, 2011). The consenting requirements can be considerable and complex, as applicants are required to identify and assess the effects of their proposed resource utilisation, and methods to avoid, remedy or mitigate those effects. This is an area in which specialists and economic development agencies can assist potential investors to understand and successfully navigate through the sometimes complex processes.

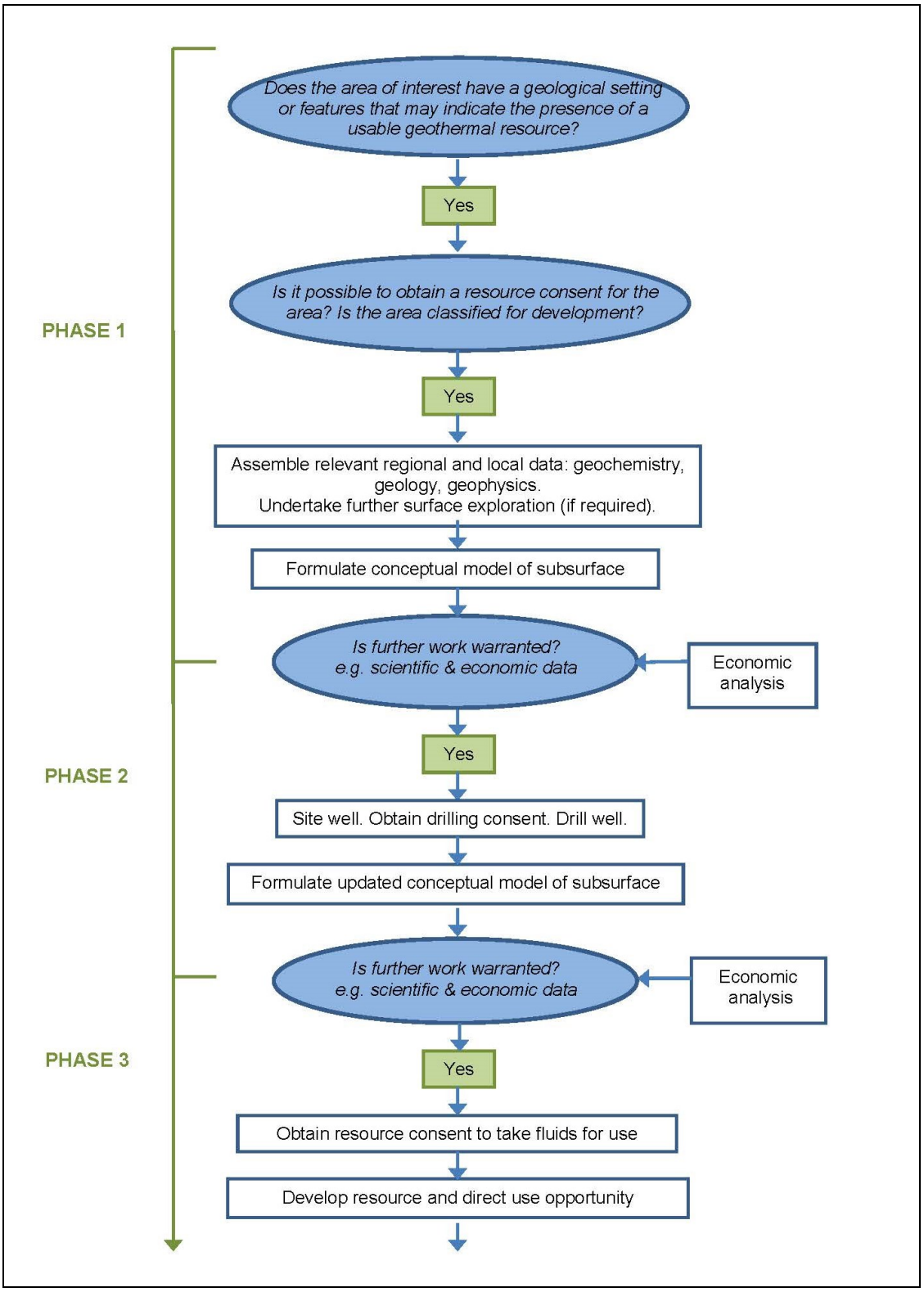


Figure 6: Generic strategy/process for developing a geothermal resource for direct use (revised from Lund et al., 1998).

5.3 Leadership & Collaboration

A range of stakeholders have an interest in New Zealand's geothermal energy use, including the following:

- New Zealand Geothermal Association (NZGA)
- Geothermal generators / power companies
- Central government departments and agencies
- Geothermal New Zealand Inc.
- Regional and city/district councils
- Regional development agencies
- Researchers
- Māori / Iwi groups
- Large scale industrial heat users
- Geothermal tourism operators
- Geothermal Heat-pump Association of New Zealand (GHANZ)
- Associated industry bodies (e.g. New Zealand Drillers Federation, Institution of Professional Engineers New Zealand (IPENZ))

While there are numerous inter-agency collaborations underway, to date there is no clear leadership structure, nor clarity of roles for advancing geothermal use as either a whole, or for some of its individual parts (Figure 7). The NZGA has a number of special interest groups who are taking a lead in developing a forward path for their particular area. Geothermal heat pumps, geothermal tourism, and generation are advancing. A more active direct use working group could provide useful leadership.

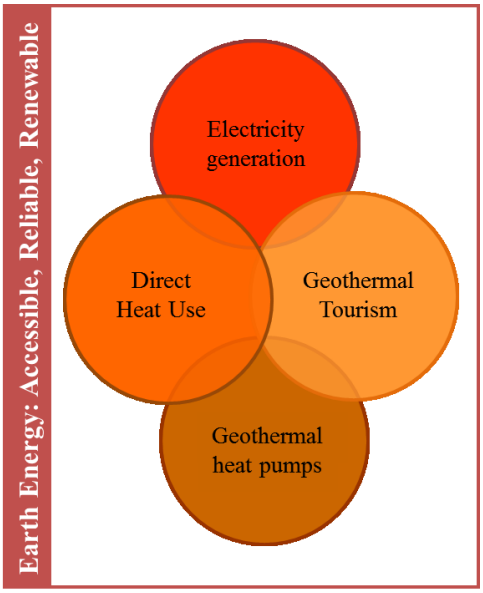


Figure 7: Key areas of "Earth Energy" use in New Zealand.

For a coordinated, high-level approach, a national geoheat strategy could assist in driving the uptake of geothermal energy use in New Zealand (Carey and Climo, 2012). To deliver economic, social and environmental benefits from geothermal energy use, this strategy will require a common vision, collaboration and strong leadership. This strategy would provide a mechanism for a coordinated approach and embody the principles, shared visions and goals of a range of stakeholders. A geoheat strategy could influence government policies at the national, regional and local levels. It would assist in the implementation of energy strategies, as well as planning and decision making.

6. CONCLUSION

In summary, New Zealand is a country well-endowed with indigenous geothermal resources. Increased use of geothermal energy is relevant in the current context of long term increasing energy costs, changing social views towards energy use, renewable energy substitution opportunities, future growth in energy demand and government strategies promoting increased renewable energy usage.

In New Zealand, there are a range of examples of direct use applications for geothermal heat, including timber drying, pulp and paper processing, space heating and cooling, food processing, milk drying, greenhouse heating, aquaculture and bathing. There is an opportunity to grow this sector, to create new businesses and to relocate existing businesses into geothermally-rich districts to benefit from this renewable heat energy supply. There is also the potential to convert industries from fossil fuels to geothermal energy.

Identified barriers to increased geothermal direct use can be simplified into four recurring themes: understanding, information, processes and leadership. A range of initiatives are underway to overcome these impediments and to catalyse positive change. Activities include socialisation; consultation; development of promotional and educational materials; investigation of regulatory regimes and economics; compilation of data on existing uses; and improvement of interagency collaboration. The concept of a geoheat strategy for New Zealand is being developed as a key tool in furthering the use of geothermal energy. The key question is this: who will lead the next phase of geothermal energy growth in New Zealand?

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