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Low Carbon Emissions Targets – Contributions from Geothermal Energy

Background

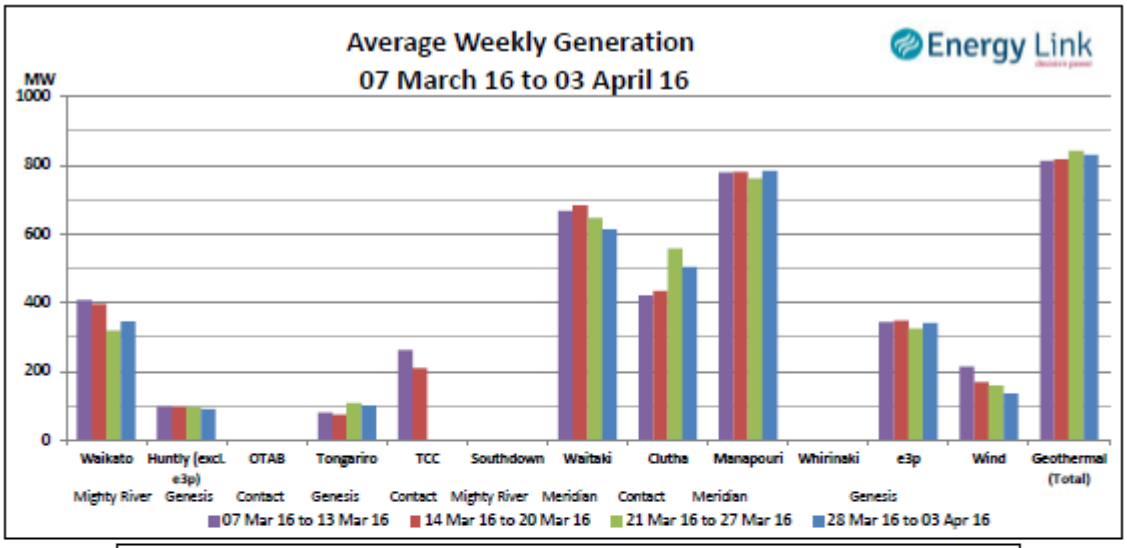
This briefing is prepared as input for discussions and development of a coordinated Action Plan through the ""Yes We Can!" Achieve the Greenhouse Gas Emission Reduction Targets Symposium" to be held in Wellington on 31 May 2016.

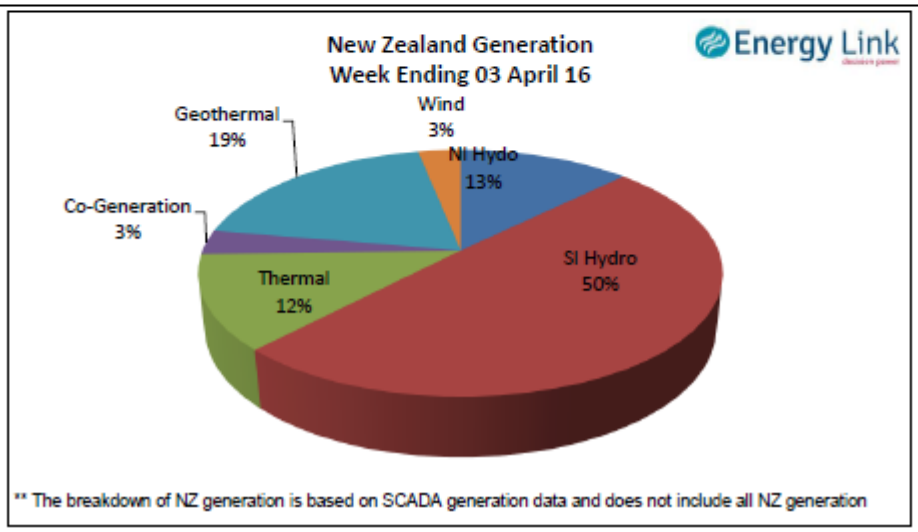
Discussion has been broken into the three pre-agreed work-streams of Electricity, Heat and Transport.

Electricity

There is approximately 1000MW of installed geothermal capacity in the New Zealand electricity market. Typically our stations generate around 840MW on average per week, and supply around 17% of all generation, second only to hydro. Geothermal generation is renewable, baseload, largely independent of weather, with low natural CO_2 emissions. Generation facilities (and future prospects) are focused in the Taupo-Rotorua area with some additional generation in Northland at Ngawha, all relatively close to the major load centre of Auckland.

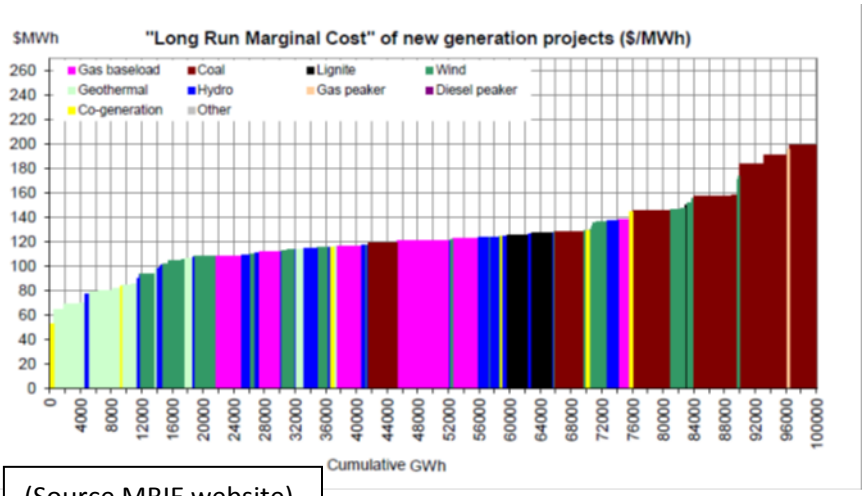
Generation:





(Source: EnergyLink website, weekly report)

In terms of future prospects, geothermal generation could be increased by about 800MW capacity using available geothermal resources not otherwise protected under Regional Council plans. There are some suggestions that this figure should be reduced further to account for the more conservative findings of recent exploration, while there are suggestions that the reserve should be increased as developers drill deeper into the proven reservoirs, so the 800MW future capacity increment has been retained. MBIE cost modelling has shown that much of this geothermal generation has lower unit cost than any other form of generation, although some premium wind sites may compete.



(Source MBIE website)

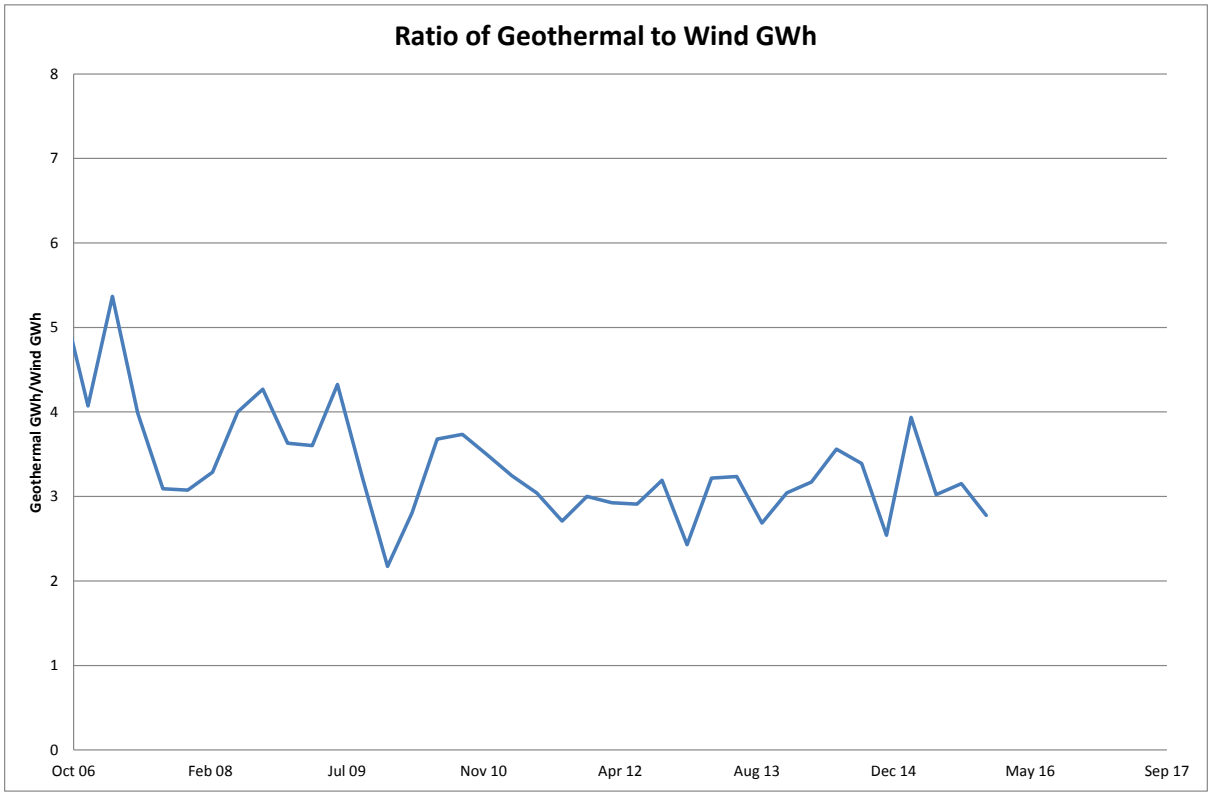
Contact Energy and Mighty River Power have developed staff with wide expertise in geothermal development and maintenance, together with companies such as Top Energy, Eastland, Norske Skog Tasman, Ngati Tuwharetoa Geothermal Assets and Nova Energy (not an exhaustive list). In addition, New Zealand has diverse supporting companies some of whose dominant work load is international geothermal work. New Zealand is recognised as a World Centre of Excellence in geothermal development and expertise, and attracts further high quality international expertise to work in this environment.

Regional Councils have developed plans and policy statements which enable the development of certain resources while protecting others. Consenting paths are available for the 800MW of additional generation mentioned above. Developers normally seek their consents close to development time partly as a strategy to avoid the attraction of competition to the resource, because it is a "use it or lose" process, and they may want to hold off on development.

Geothermal energy is a baseload form of generation, though arguably could do limited load-following. A comparison of baseload (and "must run") capacity with baseload requirement in the New Zealand electricity system will set a soft cap for future geothermal generation. This cap might be exceeded:

- If demand-side management can shift load to fill troughs in demand, or
- If load grows say through proliferation of electric vehicles (including further public transport electrification), or
- If geothermal developers can see advantage in load shedding, or
- If pumped hydro or large scale battery storage (potentially through EVs with night charging) is added to the grid.

Wind and geothermal electricity generation essentially compete to supply growing generation requirements, with differing companies favouring differing technologies and retaining staff to implement these options when ready. Wind interests argue that wind costs are rapidly dropping due to global uptake, but future cost advantages are being balanced by the initial takeup of the best sites. An argument could also be developed for potential radical changes in geothermal costs with drilling to supercritical conditions or towards magma bodies. In the face of respective industry bias, it is recognised that in recent years a steady ratio of geothermal to wind generation has been maintained and is likely to continue in the medium term.

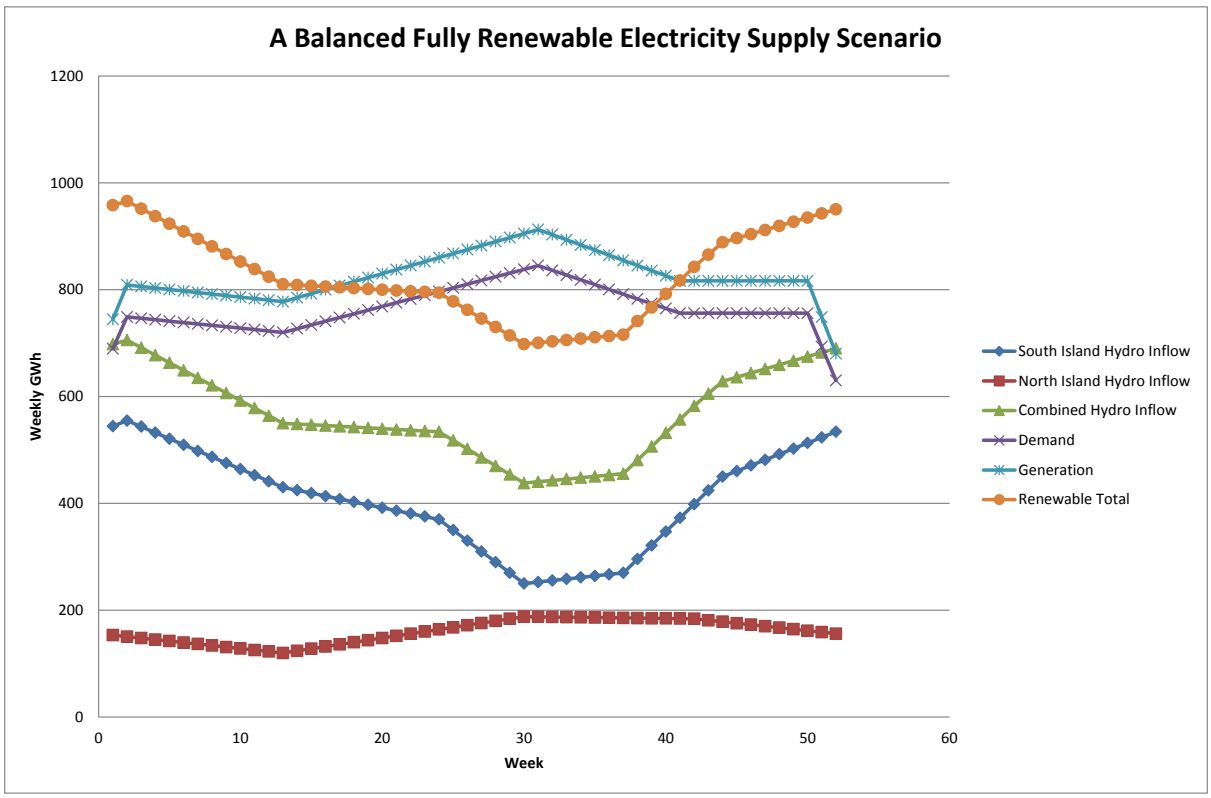


(Source data: MBIE website http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity)

From 2008 the ratio of geothermal to wind generation in terms of GWh/year has been fairly steady at around 3:1. Average geothermal load factor through this period has been a surprisingly low 82% while wind load factor has been 36%. Hence the ratio of geothermal to wind capacity (in MW) is likely to be about 1.35:1.

The Wind Energy Association recently considered whether or not a 100% renewable electricity generation scenario was possible (see http://www.windenergy.org.nz/store/doc/11.15JCarnegieandSteveBatstone2050ScenariosPresentationtoNZWEA.pdf). Modelling was carried out on a scenario with very heavy additions of wind generation creating distortions, as the total geothermal and wind capacity considerably exceeded the minimum daily load implying the need for load shifting, geothermal venting or wind spilling. If a normal geothermal to wind ratio is considered, then combined capacity will still be less than minimum daily demand leaving hydro to take up normal daily swings. The following graph shows a revised fully renewable scenario in which total geothermal capacity has been increased to 1400MW and wind capacity has been increased to 950MW. A review of hydro storage capability in this scenario indicates considerable flexibility, though detailed modelling would be required to see if the HVDC link capacity needed to be increased, or if the flexibility was adequate to handle multiple dry years.

Further new generation may be required if pressure from irrigators leads to a diversion of water from hydro lakes.

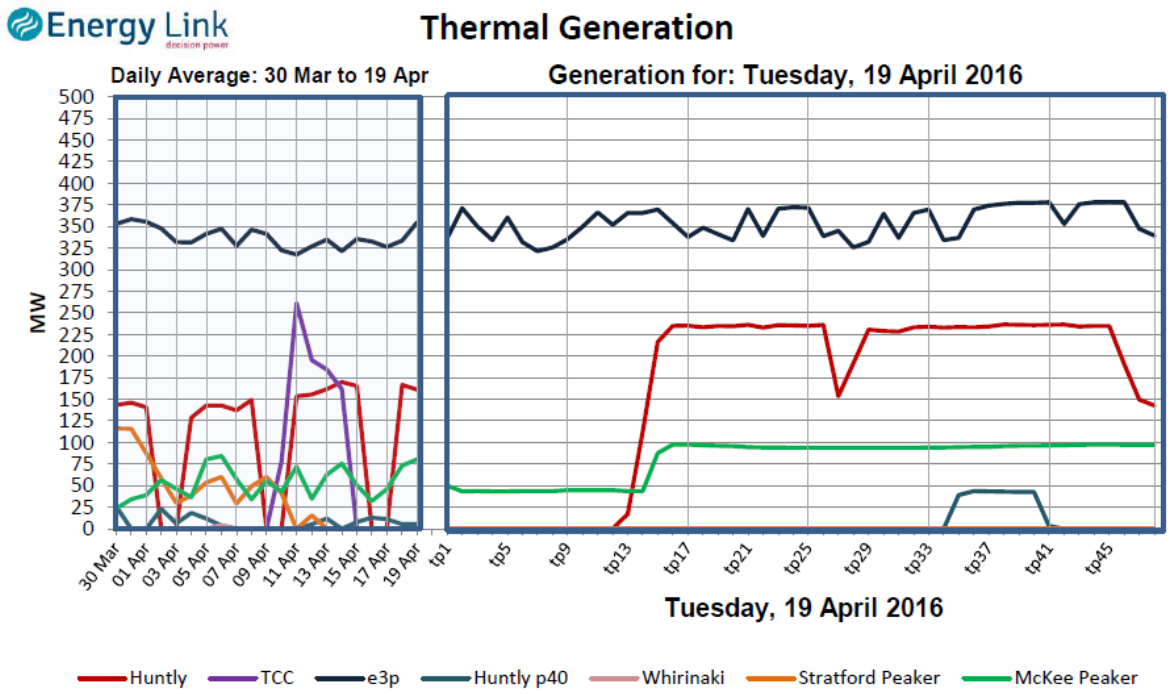


(Various sources, principally Electricity Authority website)

In practice, there is likely to be an ongoing role for thermal stations as a form of dispatchable load to offset the winter periods when much hydro potential is locked up in snow or as an emergency supply in dry years. That thermal generation would be better in the form of simple cycle gas turbines as this technology is much better at handling regular full shuts than the boilers and heat recovery steam generators of other thermal technology. Simply building excess renewable generation with a view to hydro and wind spillage or geothermal steam venting represents inefficient investment.

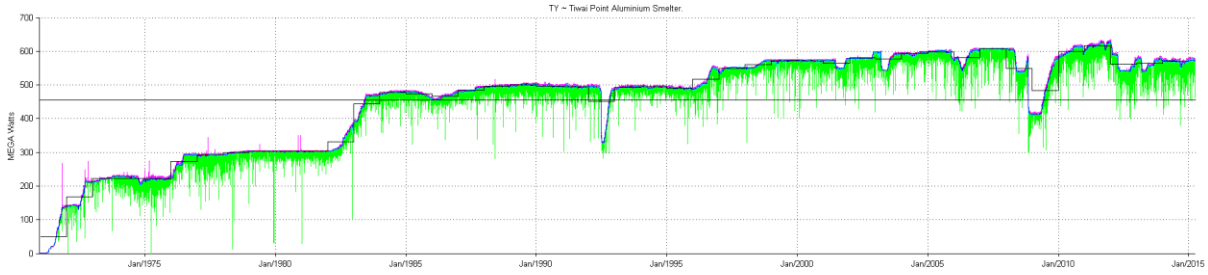
There are immediate plans for new geothermal generation. Eastland Energy is now proceeding with the Te Ahi O Maui 20MW project at Kawerau, initially drilling wells, but shortly to start construction with generation expected by 2018. Top Energy has secured consents for a staged 50MW additional development at Ngawha and now anticipates the first 25MW will be generating by 2020. Contact Energy has secured consents for the 250MW Tauhara II development for which consents need to be exercised by 2020, but may choose to stage its development or initially use consents for a heat project i.e. of the 800MW potential, 320MW is firm.

We can speculate that with the final retirement of Huntly (just reset to 2022) or Taranaki Combined Cycle plant (2 years older than the recently retired Otahuhu B) or Genesis's e3p Combined Cycle plant (7 years younger than Otahuhu B), provided that the Tiwai Point smelter continues to operate, there will be opportunities for geothermal to partially replace these plants. The following graph indicates the off-design operation of many of our thermal plants currently (McKee Peaker base-loaded, Huntly Rankine Cycle units off at weekends and early mornings, Taranaki combined cycle rarely used, Stratford Peaker in frequent use at a time when hydro levels are especially high).



(Source: EnergyLink website, daily report)

While the Tiwai Point smelter sits as a general threat to the whole electricity generation supply business, able to quit the market with one year's notice from 2018, it can also be considered a friend to renewables (at least geothermal and wind). When closure finally happens, this represents a sudden loss of about 570MW of demand. Wind and geothermal energy are bid into the market at zero or close to zero price. Hydro is operated to minimize spill. So adjustment must be made primarily by thermal generation. In practice there is now a close match between the annual generation from the Rankine and gas combined cycle thermal stations and the demand from Tiwai Point. Hence closure of Tiwai Point will be the final death knell for Huntly coal-fired generation and possibly for the combined cycle plants and will force a renegotiation of any existing gas contracts. If the thermals are sustained until Tiwai closure then impact on renewables will be minimised



(Source: Tiwai Point Aluminium Smelter entry in Wikipedia)

Other factors to consider include demand side management and progressive entry of photovoltaics into the New Zealand market. Demand- side management mainly has the effect of shifting load between nearby periods, or possibly reducing load for a limited period. This will have limited effect on total GWhs across a year so will have minimal effect on geothermal and wind, though will affect the daily operation of hydro stations. Photovoltaics will naturally grow from a small base, but may also be assisted by lines companies who will see PV/battery combinations as a means of removing consumers on long remote lines from their system, thus slowly whittling down total demand.

Battery costs are likely to plummet as electric cars proliferate so this has the potential to be highly disruptive in the long term.

Transport

Geothermal generation can take up the growth in electricity demand associated with proliferation of electric vehicles. A recent Royal Society paper suggested that electric vehicle fleets (or hydrogen-fueled fleets) in New Zealand could lead to a 5% increase in electricity demand by 2050. This is equivalent to a 3,000GWh load on the system, but ideally recharging will be focused at night raising baseload demand requirements even more.

Geothermal heat may also contribute to the processing of biofuels as direct additives to the conventional transport fleet.

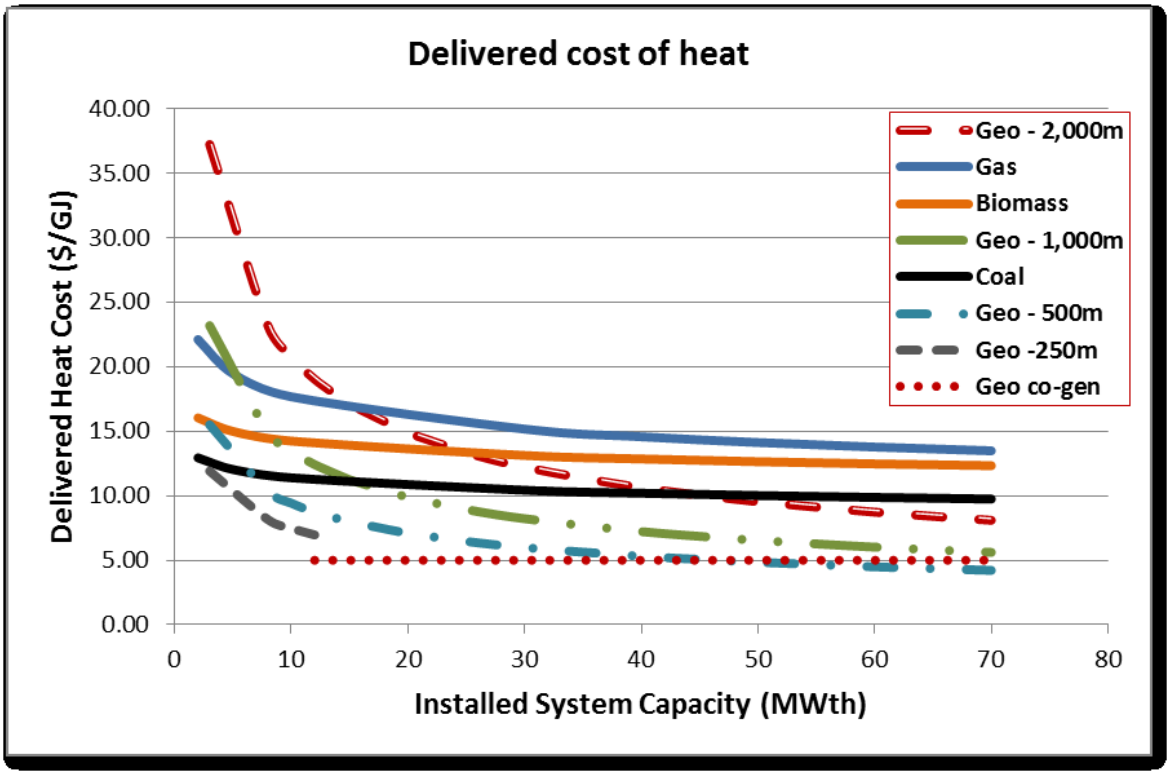
(Source: Tesla promotional material)

Geothermal fluids could help directly with the development of an electric vehicle fleet. Tesla has just set up a "Gigafactory" in Nevada for the manufacture of lithium-ion batteries, partly for the new Model 3 Tesla. Part of the attraction of Nevada was access to lithium (see http://www.thinkgeoenergy.com/tesla-the-electric-car-for-the-masses-fuelled-by-geothermal/?utm_source=ThinkGeoEnergy+List&utm_campaign=b9b96cf5c8-TGE_Newsletter_RSS1_12_2015&utm_medium=email&utm_term=0_657e42f767-b9b96cf5c8-415229249). Our geothermal fluids contain lithium. Economic extraction of lithium on our producing fields as a co-product could stimulate a whole new industry, consistent with the Business Growth Agenda.

Direct Heat

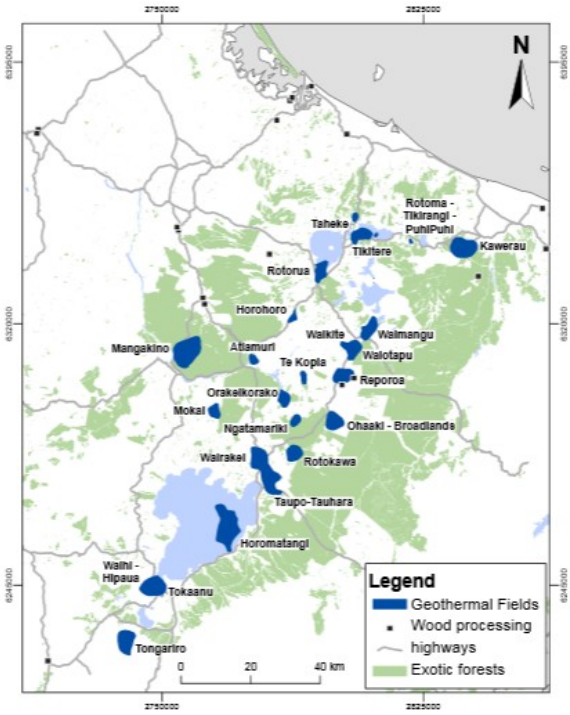
Geothermal energy is an economically attractive form of energy at premium locations. Thus on the relatively rare high temperature fields through the Rotorua-Taupo region and in Northland at Ngawha geothermal energy can be a great source of energy for new energy intensive industries or industries prepared to relocate. Steam diverted from geothermal power stations could potentially

undercut the cost of steam from any other source at any scale. Stand-alone heat plants may otherwise require a scale of the order of 10MWth to enable a competitive geothermal supply.



(Source: 2013 Report for Grow Rotorua by East Harbour Energy)

There is a strong correlation between major plantation forests and geothermal resources around the central North Island. Some of these forest resources are processed at Norske Skog Tasman's Kawerau plant into pulp and paper, this still being the largest geothermal direct use in New Zealand and the largest industrial application of geothermal heating in the world. The Kawerau geothermal steam supply undertaken by Ngati Tuwharetoa Geothermal Assets also supplies power stations at Kawerau, the Asaleo Care (formerly SCA) mill and two timber drying kiln operations. There are other geothermally-heated kiln drying facilities for forest products at Ohaaki and at Tauhara. Lower grade geothermal resources could potentially be used to dry biomass as an alternative fuel for kilns or boilers. Contact Energy has been involved with geothermal steam supplies for various purposes at Ohaaki, Wairakei and Tauhara and is known to be in discussion with other parties to use these resources. The Fenglin forestry group is one party mentioned in media, possibly using Tauhara resource and consents.



(Source: 2016 Geothermics paper by White and Chambefort)

The following table shows a recent breakdown of geothermal direct use applications around New Zealand. Bay of Plenty and Waikato dominate currently, with a significant component associated with industrial process heat supplies at Kawerau.

Assessed Geothermal Direct Heat Use 2013 (TJ/year)

Council Regions	Space Heating	Water Heating	Greenhouse Heating	Fish and Animal Farming	Industrial Process Heat	Bathing and Swimming	Other Uses	Total
Northland						6		6
Auckland	2					56		58
Waikato	28	51	331	196	848	774	812	3,040
Bay of Plenty	290	213	34	2	4,196	521	179	5,435
Gisborne						0		0
Hawkes Bay						3		3
Taranaki						0	0	0
Marlborough	2							2
Canterbury	25					46		71
West Coast						12		12
Otago	8							8
Total	355	264	365	198	5,044	1,418	991	8,635

(Source: unpublished direct heat data for EECA by B White)

In terms of projection forwards, most applications have been increasing linearly by about 125 TJ/year in total. We need to question the ultimate future of newsprint which is the main product of the NST mill. A pessimistic view is that this could cease in 10 years. Overall geothermal energy supply on the Kawerau site will continue to grow with continued focus on wood products, though some of this may be an increased diversion to electricity generation, and there is likely to be a drop in direct use by around 2,000TJ/y from the time of paper machine closure.

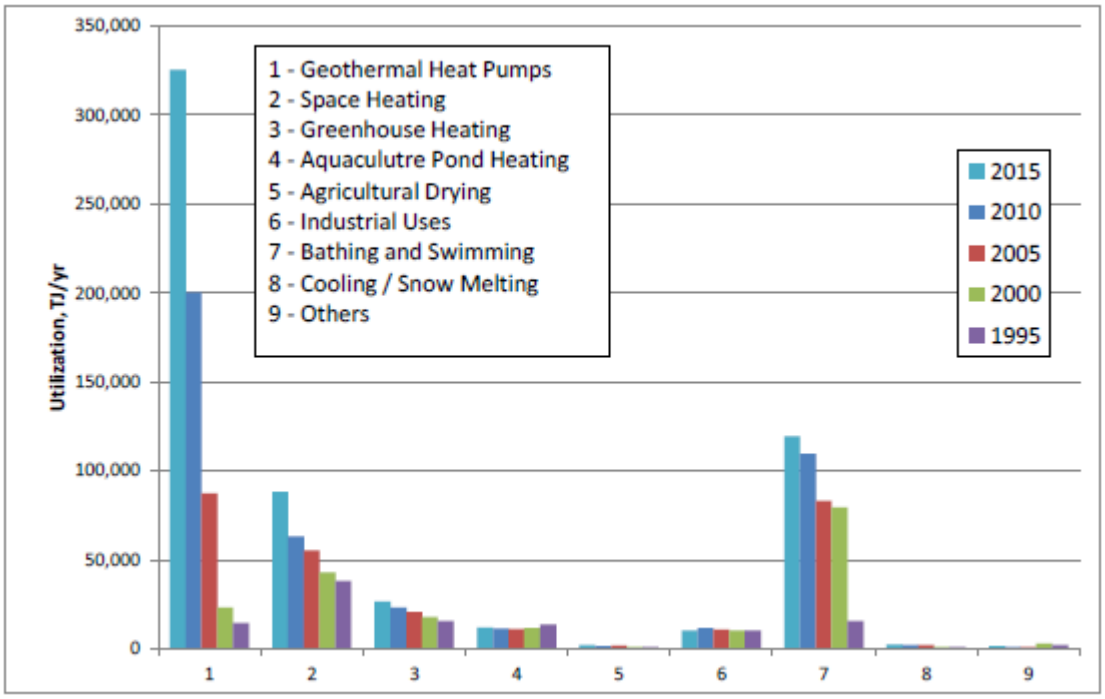
A relatively recent development was that of the Miraka milk drying plant at Mokai. This has subsequently been expanded and represents a global first in terms of geothermal industrial heat application. Other milk processing plants may need to follow suit with geothermal application if clean low carbon products are going to be a selling point.

NZGA has been developing a GeoHeat Strategy targeting the greater uptake of direct use geothermal energy consistent with government direct use targets and with the government's Business Growth Agenda. This sets out a number of actions designed to stimulate growth and measure progress. There is a market failure in that industry is not aware that attractive geothermal options exist for industry. This needs funding to be effective. Once implemented, multipliers on the Business As Usual scenario of 125 TJ/year growth will apply. Growth could be at 2 or 5 times the current rates.

Geothermal heat pumps also come under the geothermal banner. These are like air-source heat pumps but exchange heat with the ground or groundwater. There are a growing number of competent designers and installers. In recent years, in addition to some minor domestic and commercial installations, there have been some major commercial installations including Christchurch and Dunedin airports. The Christchurch rebuild has seen a major uptake in geothermal heat pumps. This has been encouraged by (as advised by Peter van Meer, EECA):

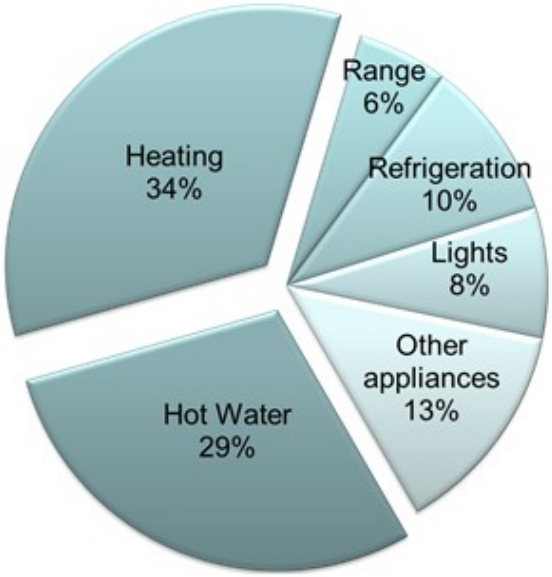
- Growing cluster of supporting consultancies
- Good information about Canterbury aquifers (this risk factor remains for other locations unless they tap into river, lake or sea water)
- Non-notifiable consents that mean these can be quickly approved
- Clean slate (in terms of leveled CBD) to enable possible interlinking with other users
- Slightly higher density people/m^2 in the new buildings (now more like national average)
- EECA feasibility study assistance
- Limited renewables subsidies through Christchurch Agency for Energy (CAfE) and from EECA to demonstrate underutilized technologies
- Payback period of 5 years or less for projects over 6,000m^2.

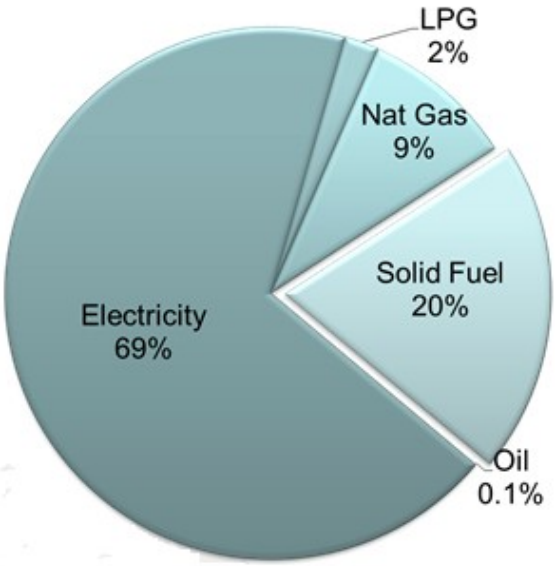
Where geothermal heat pump technology has been employed in other countries, its' growth has been exponential. Globally, geothermal heat pumps are now the largest category of geothermal direct use applications as shown in the following figure.

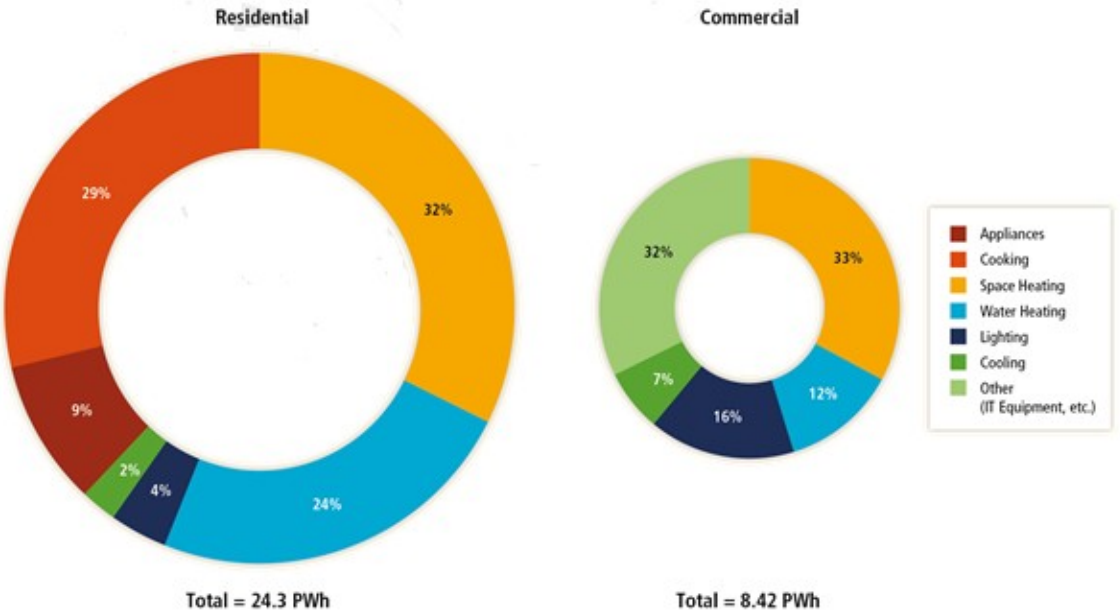


(Source: 2015 World Geothermal Congress paper by Lund and Boyd)

Geothermal heat pumps have been developed for space and water conditioning. The following graph shows that water and space heating are major components of New Zealand domestic and international (no equivalent data for New Zealand) commercial energy requirements.







(Source: Royal Society of New Zealand report on "Transition to a low-carbon economy for New Zealand")

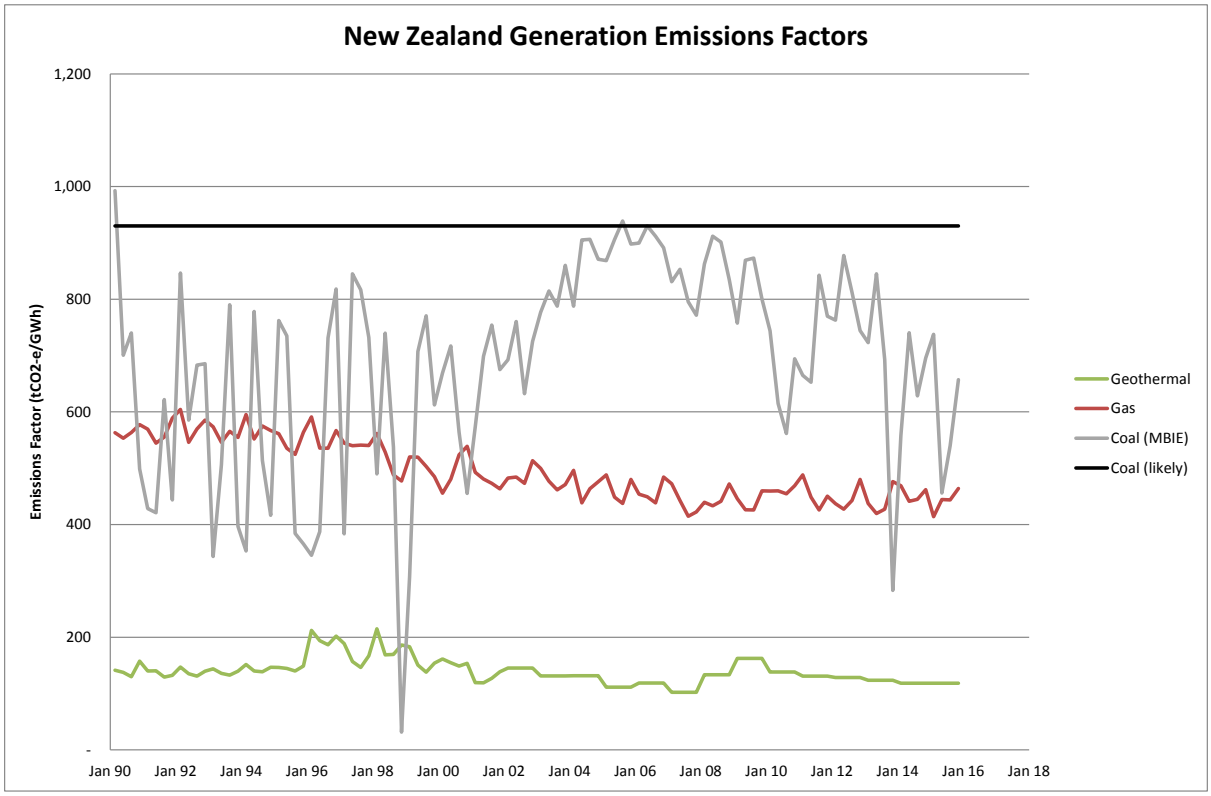
In New Zealand about 2/3rds of domestic needs could be met by geothermal heat pumps either directly substituting for fossil fuels or biomass, or reducing domestic electricity consumption in each house significantly. Based on international commercial property figures, about 50% of energy requirements could be met with heat pumps. Given these can have coefficients of performance (ratio of heat output to electricity input) of around 4, then substitution for simple heating systems of fossil-fueled systems will have major benefits in terms of reduced emissions. In New Zealand domestic electricity demand accounts for 32% of total electricity demand while commercial demand accounts for 24% of total electricity demand.

Interviews with industry practitioners indicates that New Zealand growth in geothermal heat pump usage has followed linear trends. Typically about 20 large houses have heat pumps installed per year.

Commercial building growth is focused on Christchurch with about an additional 20,000m^2 of commercial building space being heated and cooled through geothermal heat pumps each year. For Christchurch, the GHPs mainly displace air-source heat pumps, while nationally they are likely to displace gas.

Emissions Reduction Possibilities from Geothermal Energy

Geothermal energy is a renewable, low carbon energy form. However, it is associated with some CO_2 emissions. If we ignore the life cycle emissions that may be associated with every sort of generation form, and just concentrate on hard emissions, then geothermal emissions for electricity generation are as follows.



(Source data: MBIE website http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity and http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-greenhouse-gas-emissions)

Data is taken from MBIE reporting and there are clearly some spurious coal emission data points. Coal-fired emissions are around 930 t CO_2-e/GWh, gas-fired emissions are around 450 t CO_2-e/GWh while average geothermal emissions are around 120 t CO_2-e/GWh. The geothermal figures show typically declining rates with time because our fields are degassing. This is most noticeable for Ngawha which initially had emission factors between that of gas and coal, but now sits just over 200 t CO_2-e/GWh.

Emissions factors for each field cover a wide spread, so in the absence of specific data it is assumed that the current levels of 120 t CO_2-e/GWh will continue indefinitely for electricity generation.

Initially this will offset emissions from the Huntly coal station, but will later offset emissions from gas-fired plant.

In terms of heat plant, many of the major load growth opportunities will be on the same high temperature fields as the power stations are located on. As such a simple conversion from station emission factors is possible. Typical energy conversion efficiencies for geothermal power stations are in the range 10-12% taking into account thermodynamic limitations due to relatively low temperature and an economic requirement to reinject much of the heat initially extracted. Reinjection is still required for direct use applications so conversion efficiencies of heat provided versus heat extracted of around 50% apply. On this basis typical emissions factors for geothermal direct use will be around 26 t CO_2-e/GWh or 7 t CO_2-e/TJ of heat supplied. Equivalent emissions from a coal-fired heat plant are about 111 t CO_2-e/TJ and from a gas-fired heat plant are about 70 t CO_2-e/TJ (see http://www.eastharbour.co.nz/assets/pdfs/RenewableEnergyandtheEfficientImplementationofNZsCurrentAndPotentialFutureGHGasCommitmentsAugust2002.pdf with adjustments for recent figures). As can be seen, major reductions in emissions can be achieved through use of geothermal heat for industrial processes when compared with fossil-fuelled options.

The other factor that may need to be taken into account in considering emissions reductions, is whether a renewable energy project is substituting for a fossil-fuelled project or represents an additional load due to new business. Many of the projects may be substitutionary e.g. milk treatment plants that follow the Miraka example will not represent an increment in milk production but a substitution for fossil-fuelled treatment plants elsewhere. The argument is not so strong for new timber kilns where there is an effort to have greater onshore added-value rather than exporting timber as logs. In any case, geothermal energy will be substituting for fossil fuels so represents a reduction on the emissions that would otherwise have resulted.

Assessment of emissions reductions for road transport is by a more indirect method. The Royal Society paper on "Transition to a low-carbon economy for New Zealand" outlined Unitec's modelling of a Waka-S scenario in which, "by 2050 New Zealand's GHG emissions from the road transport sector could drop by around 60% from 12.69 Mt CO_2 in 2013".

Based on the information above, the following emissions reduction possibilities have been assessed.

Electricity Generation Possibility

	1990	2000	2010	2020	2030	2040	2050
Geothermal MW	261	365	723	1,140	1,450	1,650	1,800
Geothermal GWh	2,011	2,756	5,546	9,823	12,494	14,218	15,510
Avoided CO_2 emissions kt CO_2-e/year	0	600	2,860	6,330	3,460	4,030	4,455

- Expected geothermal growth to 2025 can be achieved with the staged development of currently consented sites (Tauhara II, Ngawha and Te Ahi O Maui (Kawerau)).
- The apparent reduction in avoided CO_2 emissions after 2025 results from the assumption that coal generation would have ceased so only emissions from gas are being offset.
- The effects of photovoltaics and electric vehicles are still likely to have second order effects on total generation by 2025, and will continue to offset each other beyond that.

- Closure of Tiwai Point will primarily impact thermal plant forcing the closure of Huntly and of gas combined cycle stations (if not already closed), creating a renewables-dominated supply, causing some delays in renewable plant construction, and has been assumed to occur before 2025.
- Beyond 2025 the approaching full usage of available geothermal resources, combined with improving wind costs will drive a slower uptake of geothermal energy than expected based on load growth.

Transport Possibility

Benefits are simply assessed in terms of generation contribution to electric vehicles. Because all significant electricity load growth can be satisfied by renewable energy (dominantly geothermal and wind), geothermal's contribution to transport electricity is assessed based on the relative contribution of geothermal relative to wind, combined with a mid-level scenario for EV uptake.

	2010	**2020**	**2030**	**2040**	**2050**
EV GWh	~0	190	585	1,465	3,000
Geothermal GWh	~0	145	400	960	1,830
Avoided CO_2 emissions kt CO_2-e/year	0	170	470	1,130	2,150

- For this estimate, emissions data for the NZ light vehicle fleet was sourced from MOT data, EV fuel efficiency was sourced from J. Leaver, EV uptake scenario curve was sourced from MBIE.
- Note the very substantial avoided emissions for transport relative to electricity generation despite the small GWh contribution from geothermal. This results from the high emissions of road transport.
- I have not subtracted emissions from geothermal as these have already been accounted for in the electricity generation scenario.

Direct Heat Possibilities

The following table shows growth in various sectors based on an assumption that the GeoHeat Strategy will double business-as-usual uptake, but with these gains starting from 2020 after a suitable campaign.

	1990	2000	2010	2020	2030	2040	2050
Space heating	386	375	358	402	536	669	803
Water heating	287	279	266	299	398	498	597
Greenhouse heating	62	79	391	413	551	688	826
Fish and animal farming	382	382	372	224	299	373	448
Dairy	0	0	0	306	407	509	611
Wood products	4,638	5,391	5,778	5,140	4,185	5,230	6,275
Bathing/ swimming	1,543	1,499	1,431	1,605	2,139	2,674	3,208
Other uses	30	33	554	1,122	1,495	1,868	2,242
Total TJ	7,329	8,039	9,150	9,510	10,010	12,510	15,010
Avoided CO_2 emissions kt CO_2-e/year)	0	45	114	138	169	327	484

- Emissions calculations have been undertaken on the conservative assumption that only gas will be displaced rather than coal.
- Assuming the newsprint production finishes in the 2020's, this will set the industry back, though growth across the decade is still expected.

For heat pumps, advice is that domestic installations are increasing steadily by about 20 large houses per year. As these houses often have swimming pools the total displaced heating per home is about 14,000kWh/year (0.05TJ/year). Outside of Christchurch this mainly displaces gas.

Commercial installations are currently focused in Christchurch, but are likely to progressively disperse to other locations. With a simple space conditioning load of around 100kWh/m^2 and 20,000m^2/year installed, this leads to the following contributions:

	1990	2000	2010	2020	2030	2040	2050
Domestic	0	0	8	18	28	38	48
Commercial	54	54	69	157	229	301	373
Total TJ	54	54	77	175	257	339	421
Avoided CO_2 emissions kt CO_2-e/year)	0	0	1	2	8	13	19

- Note that this estimate is conservative based on modest linear growth, ignoring the normal exponential growth observed elsewhere and ignoring any impact of government or industry stimulation.
- It assumes that half of the first five years the commercial growth displaces air-source heat pumps then displaces gas.

Action Plan

The following Action Plan sets out the draft framework of an overall Action Plan being formalised by the New Zealand Geothermal Association. Some of these are actions that can be taken by Government.

Brand and Structure

NZGA is a highly respected global brand that the New Zealand industry and members stand behind.

1. *Review and implement the most effective organisational structure to deliver the strategic Action Plan and meet members' needs*. To this end, NZGA will seek member feedback on its current value and potential value proposition from its current members. This will drive operational focus, will identify the best way to reach the target markets, and most effective way to communicate.
2. *Build the Brand*. NZGA will continue to build the brand, promote and communicate, improve credibility and continually evolve.
3. *Support the development of a strategic Action Plan*, support its implementation, monitor and report on its progress, and review and revise this plan at regular intervals.
4. *Ensure a strong relationship* between NZGA and:
    a. Its affiliate organisations (including International Geothermal Association and Royal Society of New Zealand),
    b. Its sub-groups (including the Geothermal Heat-pump Association of New Zealand and other interest groups),
    c. Closely linked interests (including Geothermal New Zealand and Women in Geothermal), and
    d. Especially with aligned industries and professions that may contribute to the development and uptake of geothermal technologies and business opportunities (including tourism, Maori Trusts, manufacturers, architects/engineers/scientists, building services industry, property and land developers).
5. *Develop a strong relationship* between Government, NZGA and the New Zealand geothermal industry. This will involve:
    a. Regular meetings between NZGA and ministers and officials with an emphasis on business growth opportunities through the strategic Action Plan.
    b. Active consultation on key policies impacting on geothermal development.
    c. Formal Government-funded partnerships in relation to key aspects of the strategic Action Plan
        i. to assist with the delivery. EECA has a particular role to play,
        ii. to assist with the effective monitoring of progress and understanding the industry. This may involve contracts with MBIE or MfE for data capture and analysis,
        iii. to identify and reduce market barriers.
6. *Establish a Geoheat*[1] *Strategy Steering Group under an appointed coordinator*. This group will identify a host as the centre for geothermal direct use advocacy and activity. A direct use geothermal research and advisory hub for New Zealand would greatly simplify access to

[1] A Geoheat strategy has been highlighted because this is a developing sector of the market place that can lead to significant business growth and emissions reduction. Electricity generators have sufficient expertise to be able to effectively progress opportunities (though this does not take into account some areas of the value chain (e.g. New Zealand manufacturing) that could be further assisted).

expertise, information and advice. The research and advisory hub could also host the Strategy Coordinator role. They would identify and prioritise work plan for implementation of strategic action.

Value to Members

NZGA will deliver value, tangible benefits, and connect an increasing breadth and number of members.

1. *Forms of Communication*. NZGA will review effective communications with members to ensure these are timely, effective and appropriately targeted. This will include newsletters, website and social media.
2. *Member Survey*. Part of this will be a survey of members to find out what is important and relevant to them, what to do to represent them, and what is the best mechanisms to connect. This will identify the value to members and what should be done differently.
3. *Opportunities for Discussion*. These opportunities are expanded on below through the Seminars and Workshop, interest groups, and submissions.
4. *Facilitation*. People will be brought together to connect, discover synergies, inform, educate, help external or internal people make internal contacts, provide lists of available people, provide company and personal capability profiles for external parties, and to participate in two way exchange of information.
5. *Build a Sense of Integrity and Trust*. This can be achieved through developing standards and competencies, codes of practice, protocols, standard answers to frequently asked questions and through sound and thorough public and government briefings.
6. *Write the history.* New Zealand was a world pioneer in geothermal development and is a continuing centre of excellence. The history of this industry can connect members and open eyes to potential.
7. *Annual NZGA Seminar and the New Zealand Geothermal Workshop*. The NZGA Seminar is organized annually to highlight a key theme to members and the public. Sub-groups such as GHANZ hold their own seminars and networking events. The New Zealand Geothermal Workshop is independent of the NZGA but is supported by it and is the premier national industry event for information dissemination and networking. This is part of pro-actively promoting geothermal to potential users and the public, as well as broadening understanding of our members and the international community. There isa need to continue efforts to bridge the gap between technical and non-technical people.Discounts to these events should be available to members.
8. *Support Appropriate Training Opportunities in New Zealand*. NZGA has undertaken preliminary studies on training needs and opportunities. Training and currency of information is critical in an expanding industry with ongoing development. We want to encourage people to consider geothermal careers whether through trades or university studies. In some cases, special training from international groups (e.g. International Ground Source Heap Pump Association/Canadian GeoExchange Coalition) can be facilitated. There may be opportunity to develop toolkits for training engineers, architects, drillers and builders for heat pump applications.

   One specific training course which NZGA wants to seek funding for is a “Well Control” course targeted at “company men” (the lead drillers in a drilling operation). This will outline best geothermal drilling practice, so should avoid costly mistakes and increase the success rates and production from geothermal wells, significantly improving project costs and uptake.

9. *Geothermal Interest Groups*. Geothermal is a broad topic and our members have specific interests within this. Various interests of like minds have been grouped but these groups need to be developed. The intent of these groups is that they enable a large mobilized membership, with interests duly represented and addressed. A more united, connected and cooperative industry can effect a far greater amount of change than an individual approach, particularly in the areas of policy reform, research and funding.
10. *Broadening Geothermal Base to Tourism*. Our members include landowners and varied businesses including tourism. Geothermal tourism is a means of raising the profile of geothermal resource such that it forms part of our national identity and consciousness. While awareness can and has led to protection of some resources (which NZGA supports) it also opens minds to the possibility of use. Tourism operators are often also direct users of heat so have special information needs.
11. *Establish and maintain connections and networks* with potential end users/consumers by targeting sectors with the greatest potential for increased uptake of geothermal technology. Geothermal energy can be used to produce a variety of products, but accessible markets must exist for those products in order for business to be profitable and successful.
12. *Establish relationships across the value chain*, especially where new knowledge may bring about reduced costs e.g. with drillers for geothermal heat pumps.
13. *Develop and maintain a directory* of appropriately experienced/qualified geothermal service providers and publish this on the NZGA website. We note that the "geothermal register" currently published as a document, is the most visited document on the NZGA website.
14. *Energy Dating Service*. Some landowners and potential developers don't have the connections or expertise to realise geothermal aspirations. A service to connect these parties with industry and business interests seeking energy solutions can help to unlock this potential. This is done on an as requested basis currently, but funding would enable a more pro-active and involved approach. The International Geothermal Association has recently launched a similar programme.
15. *Maori Economic Development*. With increasing numbers of Iwi entering the post-settlement era, as well as existing large landholdings and the active pursuit of development opportunities, Maori economic development is expected to play a significant role in the New Zealand geothermal future. Already, Maori-owned trusts and companies are amongst NZGA's major financial supporters. As well as general knowledge sharing, there will be specific areas of help that may benefit these groups.
16. *Matauranga Maori*. Geothermal resources have been used by Maori for hundreds of years, over which time a rich body of knowledge, customs and practices has developed. Recognising that there are differences between Iwi and Hapu, there is significant opportunity and value in the greater integration of this knowledge base, where appropriate, in geothermal enterprise.
17. *Awards and Honours*. A function of NZGA is to recognize significant achievement by members. This can be done through awarding of Life Memberships, or supporting nominations for external awards and honours.

Independent All-of-Industry Perspective

NZGA will be considered the connection point to the New Zealand geothermal body of knowledge and to this global centre of excellence.

1. *Raised Public Awareness*. NZGA will lift communications and education of the public. This will include education material to be developed for schools and universities. NZGA should

develop as a highly trusted sought after organization for the knowledge it represents through its membership. It will be the domestic and increasingly international pathway for enquiries, understanding the industry and the context in which it sits.

2. *Facilitator of leading edge innovation information dissemination for domestic and global geothermal industry*.
3. *Advocate/lobby*. NZGA will promote the importance of appropriate sustainable geothermal energy use, jobs, standards (safety, quality), regulations.
4. *NZGA Website*. The NZGA website (www.nzgeothermal.org.nz) will be maintained and reviewed to include latest studies and information. Some of the tasks below reflect current weaknesses in the website and NZGA's knowledge base. This is one of the principal means by which we educate the public and inform our own members.
5. *Newsletters*. NZGA produces occasional newsletters which are well read by industry and are amongst the most read material by the public on the NZGA website.
6. *Geothermal Short Courses*. Short courses can give a broad overview of geothermal energy for consenting agencies, developers and other interested parties. This assists development directly.
7. *Development Guideline Report*. NZGA would like to implement a report on beginners guide to development, targeting small scale developers and potential direct heat users. At the smaller scale, the complexity of developing geothermal use can be a significant barrier. Plain language advice and information on regulatory requirements, technology and resource information can assist to reduce these barriers.
8. *Showcase and Share Lessons Learned*. Success breeds success. Actively show-casing existing success stories in geothermal energy use increases awareness and stimulates further development. In addition, by sharing lessons learned, future projects have greater chance of success.
9. *Submission on Policy*. NZGA will make relevant submissions in response to government consultation documents taking a selective approach e.g. health and safety regulations. Major areas for review in the near terms are Geothermal Regulations and implementation of Major Hazards Regulations. Almost all geothermal resources are accessed through wells which can be covered by Geothermal Regulations, Codes of Practice and Guidelines, and Rotorua bylaws as examples. NZGA has already been instrumental in revision of the Code of Practice for deep geothermal wells but the guidelines for shallow wells also needs to be revisited. A whole new Health and Safety regulatory regime will be established for which substantial time must be dedicated with limited budget.

   Regulatory barriers, particularly for smaller-scale development, can be reduced through improved Policy Statements, Regional Plans and to some extent District Plans. NZGA is supportive of continuing evolution within the RMA framework, rather than any radical change.

   NZGA will support the development of protocols e.g. surface feature mapping and modelling.

   There is also more potential for enabling non-regulatory documents such as Energy Strategies.

   Regional Plans are a primary source of environmental regulation for geothermal energy development and use. Improved policy alignment across the 3 major geothermal regions (Northland, Waikato and Bay of Plenty) can reduce regulatory barriers.

It is noted that one of the contributing factors to recent uptake of Christchurch heat pumps was enabling plans in which that use became a non-notifiable activity for consent purposes. Similar enabling Plans could facilitate wider uptake, when the net effect is non-extractive.

10. *Direct Use Data*. Geothermal direct use data forms a measure of progress against targets for emissions reduction or under the Energy Strategy. Current MBIE data is incorrect. NZGA has industry knowledge to be able to derive more accurate data and to distinguish between electricity generation and direct use in the complex Kawerau supply situation. Collection of data across all industry is time-consuming so must be externally funded. EECA has funded three such studies in the past, but data collection is the responsibility of MBIE. NZGA is also concerned about the levels of assumption built in to the current estimates and would like assistance to probe into this to better understand usage at the domestic and Small Medium Enterprise level. In turn this would enable a better understanding of growth opportunities.
11. *Specific Studies*. NZGA has coordinated specific studies in the past, with reports on cost of geothermal electricity generation, of current uptake of geothermal direct use and on heat pumps all being well-referenced on the website. One of the most referenced areas of the website is on our geothermal resources. There may be opportunity to expand that to cover lower temperature fields for direct use. Access to data on these low temperature resources will reduce the risk for potential developers (and was one of the contributing factors to heat pump uptake in Christchurch). Further specific studies can be undertaken.
12. *Specific Information on the Economics of Projects*. In this task micro- and macro-economic cost data will be collected to summarise the benefits of adopting new geothermal technologies. This can assist decision making. These calculations can be complex so access to tools and assistance to calculate pay back periods for geothermal energy could encourage uptake.
13. *Advice on Infrastructure*. NZGA has previously given advice on the concentration of geothermal development affecting Transpower's Wairakei Ring. It is recognised that other infrastructure development could be useful to accelerate direct use of geothermal energy. Direct use is not transportable over large distances; strategic transportation connections for products to reach markets for areas rich in geothermal energy opportunities will boost the competitiveness of businesses seeking to utilize this resource. In the case of the Christchurch rebuild, the opportunity for geothermal heat pumps has been kept before developers where there is now a significant uptake.
14. *Best Practice Resource Utilisation*. Accessing and using geothermal resources requires expertise. Ensuring that all users are operating to industry and regulatory standards will protect the resource, the user and the reputation of the sector. A recent survey of a selection of Rotorua bores found almost all had significant problems in terms of well safety, control or maintainability, so best practice guides would be immediately useful and should ensure that future wells and wellhead equipment will be adequate.
15. *Retirement Survey*. A survey of retirement plans across the industry would assist with planning of uptake of new entrants into the industry. At one time the community was heavily weighted to senior levels but now is a more balanced workforce.
16. *Research and Development Direction*. NZGA will shepherd and guide geothermal research through representation on key committees and discussion with officials and internally. Initial focus will be on deep geothermal and scaling issues and de-risking of investments.
17. *Memorabilia and Industry Archive Facilitation*. New Zealand was a world pioneer in geothermal development and is a continuing centre of excellence. Key information and

equipment could be lost if an industry archive is not established. NZGA is now working with industry to collate and preserve this material.

International Connection

NZGA will lead New Zealand geothermal interests increasing its international geothermal presence to benefit NZGA members.

1. *Geothermal New Zealand Initiatives*. There are great opportunities for international growth and NZGA can facilitate some of the efforts by GeoNZ aimed at a more integrated approach and assist with provision of useful information. NZGA and GeoNZ still need to formally agree on their relative split of responsibilities, but work in close cooperation. NZGA will work in conjunction with GeoNZ to build and maintain reputation and engagement in key international markets.
2. *Strong Links with the International Geothermal Community*. Our members need to be linked to international leaders in geothermal thought and their projects. We are affiliated to the International Geothermal Association, and our members have taken Board and leadership positions within that organisation. We were co-hosts of the World Geothermal Congress 2015. NZGA was instrumental in New Zealand joining the International Partnership for Geothermal Technology.
3. *Conference Representation*. NZGA should actively seek conference speaking slots for geothermal representatives so the wider community can know about geothermal energy (forward marketing of our potential services). Currently this activity is constrained by budget, with opportunities passed to GeoNZ or other volunteers.

Funding

NZGA will secure funding sufficient to support its operational activity, domestic developments and strategic international aspirations, or will facilitate the funding of others (e.g. through support of Government-funded R&D or international aid-funded work).

1. *Develop a sustainable financial management model and strategy for NZGA*. This will involve usual individual and corporate membership fees (member numbers could be grown), and profits from organized events (e.g. conferences/workshops/seminars) to support normal functioning. Other options to be explored include online advertising and licensing. However, the major activities now identified and being developed within the strategic Action Plan require a step increase in funding. Very often the activities of the Association are supported by hidden in-kind funding through the availability of staff generally or for specific projects e.g. the recent revisions of NZS2403 Code of Practice for Deep Geothermal Wells. Further significant funding is required if the strategy is to be implemented.
2. *Government taking strategic leadership*. The New Zealand Government can take strategic leadership through the funding of geothermal energy solutions for its own uptake, and consideration of greenhouse gas emissions. In many cases these are sound commercial options and can form case studies for wider industry to follow. If life cycle analysis is undertaken, rather than relying on least cost solutions then geothermal heat pump solutions could be applied in many locations such as in offices close to the sea, lakes or rivers, or to schools where heat pump networks in school grounds form the dual function of sustainable energy source and effective drainage, or in prisons or hospitals where high floor areas and high occupancy rates make these options particularly attractive. Other geothermal heating solutions may be possible for government premises located in the central North Island,

Ngawha or over our low temperature geothermal fields e.g. near Tauranga. As an extension of this, Treasury should be instructed to assess wider and life cycle benefits when weighing proposals from these institutions for approval.

Though less obvious from a geothermal perspective, leadership could also be taken with the purchase of electric vehicles. Replacement of petrol vehicles has a major effect on net emissions. There are renewable energy electricity generation options available to supply the growing fleet.

3. *Loan Schemes*. New Zealanders have short term perspectives when it comes to investment and geothermal solutions tend to be high capital cost/low life cycle cost. Suspensory loans from central government, or restructured rates schemes at city council level could assist uptake of this low emission technology. There may be a role for a Clean Energy Fund to make money available to private sector projects to compliment the Crown loans available through EECA for renewable investment projects (currently rarely applied to geothermal solutions).
4. *Subsidies*. It was previously noted that subsidies from EECA and the Christchurch Agency for Energy were contributing factors to the uptake of geothermal heat pumps in Christchurch. While these have not been substantial sums, small amounts can tip the balance in favour of renewable developments.
5. *Investment in Renewable Energy Projects*. New Zealand is a world centre of excellence in geothermal development. The Government has already given some support through significant funding of aid projects (particularly in Indonesia), the establishment of Geothermal New Zealand for linked-up international marketing of these skills and funding of specific marketing ventures (e.g. attendance at the World Geothermal Congress 2015). A weakness with the GeoNZ grouping is the lack of financial backing. New Zealand companies must compete with, for example, groups from Iceland supported by their own investment banks. Establishment of an investment bank to directly invest in international low emission geothermal projects, using our national expertise, in projects which by themselves should be profitable would also ensure that money was linked to real emissions reductions rather than spurious international emissions credit purchases. Currently our consultants are involved with many projects globally that would go a long way to offsetting our national emissions if benefits could be captured.
6. *Funding of Feasibility Studies*. EECA already has a scheme for funding renewable energy feasibility studies and this scheme should be continued and extended. Feasibility studies may give investors sufficient confidence to invest.
7. *Specific Government-funded contracts*. Some of the tasks outlined above can be framed into specific contracts between government departments and NZGA (or industry), with potential contracting parties including MBIE, CRI's, MFAT, EECA, Regional Councils and MfE.
8. *International funding sources*. Options here include contracts and partnerships with IGA, IRENA, Global Geothermal Alliance, World Bank and United nations.