An Assessment of Geothermal Direct Heat Use in New Zealand

B.R. WHITE[1]
Executive Officer, New Zealand Geothermal Association, Wellington, NZ

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Full addresses/phone/fax

[1]New Zealand Geothermal Association, C/- East Harbour Management Services Limited, PO Box 11-595, Wellington, N.Z.
Ph. (0274) 771-009 Fax (04) 473-9930

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B.R. WHITE[1]

[1]New Zealand Geothermal Association, Wellington, New Zealand

The New Zealand Geothermal Association has completed an assessment of geothermal direct heat use in New Zealand, with the assistance of EECA funding. The study started from a list of known thermal areas and springs and then attempted to quantify any known use of these resources. Assessments have been made of both primary energy supply and consumer energy use. Total direct heat use was found to be about 9,700TJ/year (a figure currently equal to that of recorded geothermal electricity generation in New Zealand), coming from a supply of over 20,000TJ/year.

1. BACKGROUND

The New Zealand Geothermal Association has developed an Action Plan (White, 2006a), which amongst other goals, aims to develop more accurate and useful information on New Zealand geothermal resources and their development. One of the action items under the Action Plan was the reporting on geothermal direct use in a more comprehensive manner. In July 2006 the Association published “An Assessment of Geothermal Direct Heat Use in New Zealand” on its website (White, 2006b). The project was directly sponsored by the Energy Efficiency and Conservation Authority.

In preparing this report it was recognised that even rudimentary attempts to itemise current usage would have the effect of putting NZGA in touch with current users, and give greater understanding of usage.

2. OTHER STUDIES

There have been other reports on geothermal direct heat use in New Zealand in the past. The most obvious from the perspective of the geothermal community are those published as part of country updates within the Proceedings of World Geothermal Congresses (e.g. Dunstall, 2005). In these reports, the tables on direct heat use have been a portion of much wider reporting on geothermal development and operating environment, and there has been no claim that the direct heat use tables have been comprehensive. This drew on information provided by Environment Waikato backed up by direct enquiries of some known major users. The latest report gave a minimum estimate of direct heat use of around 7,000TJ/year.

Statistics New Zealand (SNZ) also publishes quarterly information on direct heat use. In turn, SNZ data is picked up by the Ministry of Economic Development and published in their Energy Data File (MED, 2006). This has preferentially drawn on information provided by Environment Bay of Plenty, backed up by approaches to some known major users. In the process of researching the NZGA direct heat use study, it was discovered that there was an error in the data provided to SNZ that may have seen double counting of mass flows associated with direct heat use from the Kawerau and Rotorua fields. This indicated total direct heat use of around 14,000TJ/year.

While researching the NZGA study, it was discovered that the Ministry for the Environment was undertaking an updated report on water takes around New Zealand. A previous report (Lincoln Environmental, 2000) had a focus on irrigation. It is understood that the current reporting on takes will only feature geothermal direct heat use incidentally.

While the NZGA direct heat use study was being undertaken, GNS Science published a complementary report, entitled “Practical Guide to Exploiting Low Temperature Geothermal Resources” (Thain et al, 2006). This report included practical costed descriptions of direct heat applications and updated information on known thermal areas and their use.

3. METHODOLOGY

In an effort to ensure a comprehensive approach, the first step in the assessment was to review all known thermal areas and springs and any reported use of these (Figure 1). The starting point for this assessment was the “Concise Listing of Information on the Thermal Areas and Thermal Springs of New Zealand” (Mongillo and Clelland, 1984). Information from this report (now over 20 years old) was cross-checked with Agnes Reyes of GNS Science, who is currently researching low temperature New Zealand geothermal resources.

All thermal areas are grouped by both regional council jurisdiction and by the geothermal regions to which they belonged.

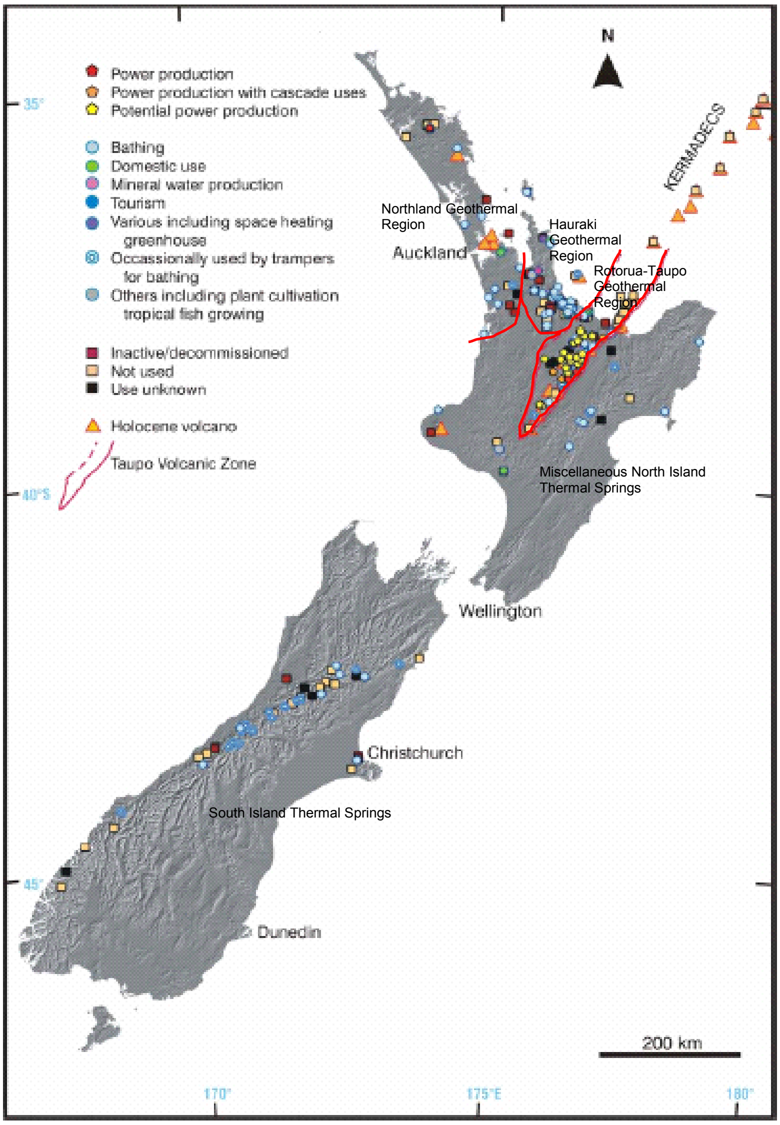

Figure 1: Map showing the main uses of geothermal fluids in New Zealand, and showing the five geothermal regions (based on Thain et al, 2006)

Regional Councils (or users themselves) were approached for information on water takes in their area.

A questionnaire was developed with a view to the eventual development of a comprehensive database on direct heat users. The questionnaire parallels a similar questionnaire that has been developed for boilers, again under EECA funding.

A limited budget meant that some short cuts had to be taken. Most notably, assessments for any particular field were often based on aggregate numbers. As an example, for the Rotorua field, broad information on takes and discharges had been included in a reservoir model. This information was used rather than an assessment of individual use. Similarly for the Auckland fields of Waiwera and Parakai, the Auckland Regional Council had information on actual takes, and rough assessments of field supply and rejection temperatures, which were then used to assess heat supply and use.

Great care was taken over the assessment of the use at Kawerau. This is a complex arrangement now involving several parties. It is one of the worlds largest geothermal direct heat applications and by itself accounts for more than half of New Zealand's geothermal direct heat use. Some of the use is associated with electricity generation, so care was taken to extract this component from the direct use.

Several interviews indicated that many users only had limited knowledge of their own use. Hence direct enquiries of smaller users do not necessarily add to the accuracy of assessments, though future surveys should seek this information, along with more details of arrangements and nature of use.

Calculations looked at all heat supplied relative to a base of 0^oC. This allows comparisons with primary energy supply for other fuels on the same basis (as no adjustment is made for ambient conditions for other fuels such as gas or coal). Heat use was assumed to be the difference between heat supplied and heat rejected. (This assumption may not always be correct. In some cases, geothermal fluids may be extracted at relatively high temperatures and efforts may be required to reject heat to the point that it becomes comfortable for bathing or other uses.)

To be counted as direct use for assessment purposes, criteria were developed that fluids had to be accessed by drilling, or flow from springs had to be significantly diverted for use. This latter criterion was applied to avoid unrealistic high estimates associated with the many springs occasionally visited by trampers or other casual users. However, this criterion does mean that high usage resources such as those at Hot Water Beach or Ngawha have not been included in the assessment.

Further criteria for assessment included consideration only of direct use of thermal properties of geothermally-sourced heat. Thus provision of tourist visitor centres (as at Whakarewarewa) or chemical and biota applications were not considered.

Eventually, all uses were allocated to one of the categories normally identified in World Geothermal Congress surveys.

4. ASSESSMENT OF DIRECT HEAT USE

Table 1 summarises the primary energy supply while table 2 summarises the consumer energy (actual heat use) associated with geothermal direct heat applications.

Note that although space heating is indicated as zero for the Northern Geothermal Region (Waikato) and South Island Geothermal Region (Marlborough), these represent the first specifically identified recent installations of geothermal heat pumps (space heating load is probably close to 0.007TJ/year each). These are domestic applications located in Hamilton and Blenheim. While other geothermal heat pumps have been reported, including another now-decommissioned system in Hamilton, no specific information on these other heat pump systems is known.

The small Taranaki use is associated with an old oil and gas well in an otherwise non-geothermal area. This takes advantage of the natural thermal gradient present everywhere to deliver water at elevated temperature to a swimming pool and water bottling facility.

Currently no use is indicated for agricultural drying. The lucerne-drying facility at Ohaaki has been decommissioned. There are several major timber drying operations, including those in Taupo and Kawerau which have been categorised as industrial process heat uses for this report. This treatment appears different to the previous New Zealand assessments undertaken for the World Geothermal Congress country updates.

Table 1: Assessed Primary Energy Supply for Geothermal Direct Heat Use (TJ/year)

Geothermal and Council Regions	**Space Heating**	**Space Cooling**	**Water Heating**	**Greenhouse Heating**	**Fish and Animal**	**Agricultural Drying**	**Industrial Process heat**	**Bathing and Swimming**	**Other Uses**	**Total**
Northern										
Northland								71		**71**
Auckland								144		**144**
Waikato	0							165		**165**
Hauraki										
Waikato								94	2	**95**
Bay of Plenty					6			1,253		**1,259**
Rotorua-Taupo										
Waikato	26		5	319	1,502		993	1,919	1,284	**6,048**
Bay of Plenty	38						10,585	2,171		**12,794**
Misc. North Island										
Gisborne								0.4		**0**
Hawkes Bay								16		**16**
Taranaki								0.2		**0**
South Island										

Marlborough	0									**0**
Canterbury								56		**56**
West Coast								36		**36**
Total	**64**	**0**	**5**	**319**	**1,508**	**0**	**11,578**	**5,925**	**1,286**	**20,684**

Table 2: Assessed Geothermal Direct Heat Use (TJ/year)

Geothermal and Council Regions	**Space Heating**	**Space Cooling**	**Water Heating**	**Greenhouse Heating**	**Fish and Animal**	**Agricultural Drying**	**Industrial Process heat**	**Bathing and Swimming**	**Other Uses**	**Total**
Northern										
Northland								6		**6**
Auckland								65		**65**
Waikato	0							63		**63**
Hauraki										
Waikato								20	2	**22**
Bay of Plenty					2			412		**414**
Rotorua-Taupo										
Waikato	13		3	167	271		398	1,238	844	**2,935**
Bay of Plenty	19						5,315	786		**6,120**
Misc. North Island										
Gisborne								0.1		**0**
Hawkes Bay								3		**3**
Taranaki								0.2		**0**
South Island										
Marlborough	0									**0**
Canterbury								30		**30**
West Coast								14		**14**
Total	**32**	**0**	**3**	**167**	**273**	**0**	**5,713**	**2,638**	**846**	**9,672**

Total energy for space heating is shown as a relatively low value and will be uprated slightly as more surveys are undertaken of actual users. However, the final value is likely to remain fairly low. The total number of homes with geothermal heating is probably of the order of 1000. Other studies indicate that average homes consume about 8,000kWh/year of electricity of which about 30% is used for space heating (BRANZ, 2004). If that need for space heating was fully met for the 1000 homes then direct heat use would be 8TJ/year. There will be similar quantities for hotel/motel heating, and possibly similar quantities again for Rotorua hospital. An assessment in the WGC country update that direct heat use for space heating in New Zealand might exceed 700TJ/year appears excessive.

Direct use at Kawerau for industrial process heat has been assessed as 5,315TJ/year. This is very similar to the assessment in the WGC country update, though based on different heat rejection assumptions.

When comparing primary energy with consumer energy it can be seen that there is roughly a 50% conversion factor on average. This conversion factor is consistent with International Energy Agency data and their own default assumptions about geothermal energy conversion for direct heat use applications (IEA, 2005).

For comparison purposes, MED’s Energy Data File records that total New Zealand electricity generation from geothermal energy for the year ended September 2005 equated to 9,520TJ/year (MED, 2006). Hence, it appears that geothermal energy makes equal contributions to electricity generation and direct heat use after conversion efficiencies are taken account of.

5. SOME OTHER OBSERVATIONS

Given that there is significant direct use of geothermal energy in New Zealand, then it is important to ensure some balance between direct use applications and electricity generation applications in all of the New Zealand Geothermal Association planning and activities.

Survey results are currently incomplete, but did show a variety of arrangements for developing resources. Typically water is either collected from wells or from springs, and disposed of either to shallow reinjection wells or to surface waterways.

Surprisingly, there are some geothermal developments at protected fields such as Orakei

Korako. In the case of Orakei Korako, a heat exchanger was submerged in a nearby spring so there was no diversion of fluid.

A number of larger bathing and spa developments reported recent investment, both in terms of general upgrade and in terms of improved control and monitoring.

Several people with existing developments were interested in doing more with geothermal heating. This included those with swimming/bathing complexes and horticultural developments. There would be value in facilitating networking, though some parties would end up in competition with each other. There is demand for consulting services in this area. This market can only expand as people become more aware of the potential of the resource beneath their properties.

In some cases far more could be done with resources already developed. One example is a small hot pool complex in the Rotorua-Taupo geothermal region, whose energy take is three times the combined energy take of all facilities at Parakai and Waiwera. In this case, much of their energy "use" is involved in dissipating heat to reduce the temperature to an acceptable level.

An impression from the survey is that there has been little net change in total direct use in recent years.

A review of all thermal areas and their associated use shows that there are many areas where significantly greater development should be possible. There have been some areas used in the past which are no longer used but could be. One example is the Kerepehi Hot Springs near Coromandel. In the past, wells drilled into this thermal area were part of the largest geothermal direct use application in New Zealand (for flax washing). In recent years the resource has not been used at all despite temperatures similar to those found at Waiwera, Hanmer or Maruia.

As a rough rule, it seems that where temperatures in a resource exceed 50^{o}C there is opportunity for spa and hot pool development. On this basis, areas (in addition to those normally considered for electricity applications) that could be readily developed include Parakai, Waiwera, East Tamaki-Whitford-Clevedon, Great Barrier, Kawhia, Lake Waikare, Miranda, Naike, Waikorea, Waingaro, Hot Water Beach, Kerepehi, Manawaru, Te Aroha, Waitoa, Oropi, Tauranga, Whangairorohea, Awakeri, Lake Rotokawa (Rotorua), Te Puia, Mangatainoka, Morere, Puketitiri all in the North Island, and Cow Stream, Hanmer, Hope River and Maruia in the South Island. There are several other South Island resources of sufficient temperature but that are remote from roads.

While there may be many resources that could be developed further, there are still significant gaps in terms of knowledge of the "size" of most of these low temperature resources. Of 145 listed thermal areas, the obvious fields for which potential development size has been defined include Parakai, Waiwera and Rotorua, along with the potential electricity generation fields, but few if any others. Current work being undertaken by GNS Science aims to define some of the characteristics of low temperature systems, but does not go as far as fully defining parameters that will allow assessment of ultimate potential.

Much can be learnt from current investment in low temperature field assessment and development in Asia. In China, aquifers only marginally warmer than would be expected from the geothermal gradient found anywhere in New Zealand are being exploited for district heating schemes. Clearly the economics of this is helped by the high density of load, and there are environmental drivers in terms of the need to improve air quality. However, the Chinese geothermal community are strongly aware of the parameters that define a resource's potential and programs to assess and develop these.

6. FUTURE DIRECTIONS

Low temperature geothermal resource capacities need to be defined but this is beyond the ability of the New Zealand Geothermal Association, and beyond the interest of the current major geothermal developers with their focus on electricity generation.

Case studies could be assembled from the initial survey of direct heat users, to encourage efficient commercial development.

Repeat surveys could be undertaken when additional funding becomes available, both to fill in gaps in information and as part of long term monitoring of trends.

Ultimately a full database of direct heat users could be developed with a view to assisting further development through networking.

Geothermal heat pumps are a market area with considerable potential. A short costed study has already been included as an action item in the NZGA Action Plan.

7. ACKNOWLEDGEMENTS

Funding of this project by the Energy Efficiency and Conservation Authority is acknowledged.

Advice has been received from many direct heat users around the country, for many of whom the New Zealand Geothermal Association was a stranger at the time of the initial approach.

Both Mike Dunstall and John Lund have provided guidance in the research and assessments within the report. Various regional council officers provided assistance.

Sponsorship by the organisers of the 7th Asian Geothermal Symposium to attend the symposium in Qingdao, China is also acknowledged along with the valuable learning opportunity and contacts formed by this experience with its lower temperature focus.

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Figure 2: Geothermally heated 5 ha glasshouse at Mokai, Waikato region (Mokai power station in the background)