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Low Enthalpy Geothermal Research – New Zealand

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ABSTRACT

New Zealand is endowed with significant geothermal resources which are being further developed under a New Zealand Energy Strategy to 2050 seeking to increase the nations use of renewable energy. As part of the strategy there is potential to increase the use of lower temperature, low enthalpy geothermal resources. Data and information on lower temperature resources is distributed and the nations potential is currently not documented adequately. A three year low enthalpy geothermal research programme has been funded by the Foundation for Research Science and Technology which seeks to better characterise New Zealand's low enthalpy resources. It is the start of a stock take of these resources seeking to increase the quality of information available and ultimately to encourage an increase in use of these energy resources.

The programme covers aspects of technologies, technology development, economics, social understanding and the national and regional policy framework. Some work is focused on geophysical techniques for locating low temperature systems and on rock thermal property characterisation.

The programme will identify and report specific actions that will promote the increased use of this energy source. These are broader than technology and resource issues and include social understanding and policy interventions that might assist in increasing the use of these energy sources with time. The paper discusses details of the programme and progress to date.

1 CONTEXT

Direct energy use of ground source energy has been a part of New Zealand's energy use since early human occupation of the country (Figure 1).



Figure 1 – Photograph of bath houses at the Otumuheke Stream Taupo 1885 (Rockel 1986 p 93).

The use of Geothermal Energy occurred in places where this energy was freely expressed at the ground surface. It was used for bathing, cooking, building heating and more laterly for industrial heat supplies.

The area where use is more prevalent is within the Taupo Volcanic Zone (TVZ). Some uses occur at Ngawha and other warm spring areas (Figure 2).

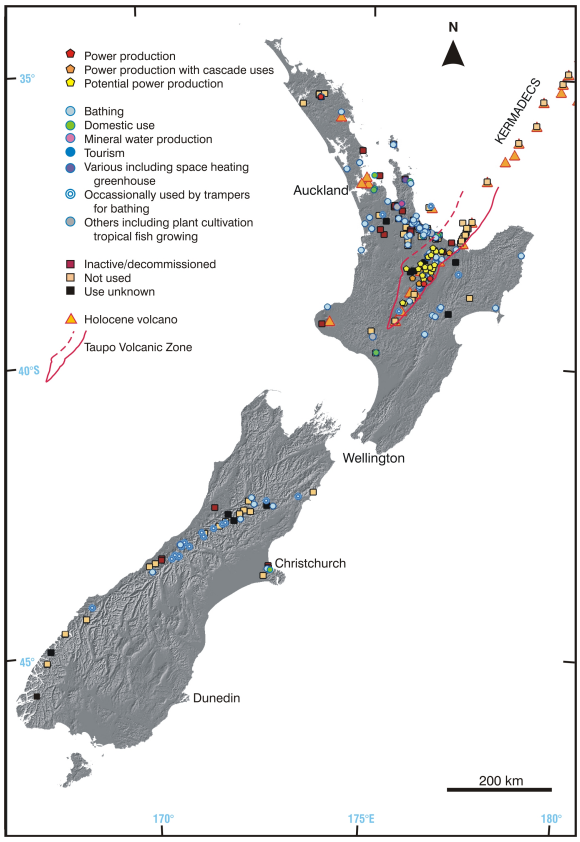


Figure 2 – Sites where thermal energy naturally expressed (Reyes 2007).

In the 1950's the Kawerau Geothermal Field was developed to supply energy for the Tasman Pulp and Paper Mill at Kawerau. This development became and is today the largest direct heat user of geothermal energy at any site in the world. Currently the Kawerau facility uses some 8 PJ per annum.

Direct heat use in New Zealand as a whole was estimated in 2005 to be 10 PJ per annum. The New Zealand Energy Efficiency and Conservation Strategy is seeking to increase direct use of geothermal energy by at least 20% (to over 12 PJ) by 2025 (EECA 2007 p 38). It is recognised that low enthalpy geothermal is a green house friendly energy source, overall the resource potential is considered large but quantification of the useable resources are relatively poor constrained. The low enthalpy research programme will

seek to provide a sound platform from which the increase in direct heat utilization can be built off.

Questions posed concerning New Zealand's low enthalpy geothermal resources are:

- what is the extent of the resources ?
- what is their sustainable capacity ?
- what are the available technologies for energy extraction, are they appropriate ?
- Where are the demands for energy and heat that might be able to be supplied from these resources ?
- what technology needs to be developed ?
- What are the impediments, such as socio-economic, policy, or Maori-specific barriers, that currently limit use of low enthalpy sources, and how might these barriers be removed ?

Part of the answer to these questions will come from geoscientific, engineering, social, economic and policy studies funded as part of the 3 year Foundation for Research Science and Technology (FRST) research programme running from 2008 to 2011.

The one intermediate outcome programme has been structured with four objectives:

- National Review
- Resource Characterisation
- Technology & Tool Development
- Integrated Assessment

Several key outcomes will result from this study:

- A quantitative review and assessment of low enthalpy resources and technologies identifying research gaps.
- Improved tools and methods for resource assessment.
- Identification of knowledge gaps, including, resource information and exploration techniques.
- Recommended actions for increasing utilisation of low enthalpy resources,
- The development of web based access to data, maps, research reports and models.

2 BACKGROUND RESEARCH

Low enthalpy research had previously been undertaken as part of the FRST contracted Enhanced Geothermal Energy for the New Millennium C05X0201 research programme undertaken from 2002 to 2007.

Various research had been completed as part of that programme. Papers had been prepared by White, Thain and Reyes. Those readily accessible have been assembled in the reference list at the end of the paper.

Low enthalpy research was not funding under the FRST contracted Geothermal New Zealand's Energy Solution C05X0704 research programme for the period 2007 to 2013 instead a focused 3 year low enthalpy programme C05X0710 was contracted to GNS Science in 2008.

3 NATIONAL STOCK TAKE

A stock take of the available resource information, technologies, demand, economics, social understanding and policy framework for the use of low enthalpy resources in New Zealand will be undertaken seeking to identify specific knowledge gaps which will then be used to assist in focusing future work.

Published science and industry-sourced data, policy and planning documents will be reviewed. Preliminary field visits, surveys and hui to gather new information will be undertaken.

A technology review will examine technologies that are appropriate for use of low enthalpy sources, determine their status as; ready for use, research, or under development and determine technology applicability with source and use temperature ranges.

Demand characterisation will better identify the specific areas that low enthalpy energy solutions might best contribute.

Barriers to uptake will be identified through a review of current policies and economics, as well as elucidating the current public understanding of technologies and available resources. Statistically robust state of knowledge surveys of private and commercial entities in selected areas are proposed.

Māori traditional knowledge pertaining to low temperature geothermal resources will be researched.

Review and assessment activities will consider international trends with a particular focus on nations where low enthalpy resource uptake has been accelerating in recent years, for example the US, Hungary, Iceland and Germany. This will provide an understanding of the social and policy environment within which this acceleration occurred and its possible relevance to the New Zealand context.

The stock take will focus on existing knowledge seeking to identify gaps. An information prioritisation process based on likely use (and demand) will be developed to inform selection of areas for further study.

The outputs will be reviewed by a technical panel, comprising members from crown research institutes, government agencies and industry collaborators.

4 RESOURCE CHARACTERISATION

Better understanding requires improved delineation and assessment of resource quality and quantity.

This work will identify the low enthalpy energy resources associated with some of New Zealand's thermal waters; including springs and borehole fluid discharges, energy available in shallow groundwater aquifers, warm waters associated with abandoned oil and gas wells, and flooded underground coal and mineral mines.

Assessment will be undertaken:

- at 4 sites on the margins of high temperature geothermal systems including Tauhara, Mokai, Rotorua and Ngawha;
- at 12 thermal water discharge sites outside of the Taupo Volcanic Zone and Ngawha;
- selected onshore abandoned hydrocarbon wells;
- at selected underground mines;
- at selected industrial sites assessing low enthalpy exhaust sources.

Data from shallow and deep wells, and heat flow studies will be used to assist in developing an improved surface conductive heat flow map of NZ. Temperatures at shallow depths will be estimated and correlated to regional and local geological and hydrogeological conditions.

Two low temperature mathematical modelling case studies of Tauranga and Whitford at Auckland will be prepared seeking to identify the longer term sustainable energy yield from these low enthalpy resources.

5 METHODOLOGIES FOR IDENTIFICATION

5.1 Tool Development

The focus of this is to refine techniques and tools which might assist in accelerating identification of low enthalpy resources there by assisting increased uptake of low enthalpy resources use in New Zealand.

Various geophysical methods and combinations of methods, including resistivity, electromagnetic and siesmoelectric, will be trialed and assessed for their effectiveness in locating structure and faults that might preferentially channel warm water to the surface. These methods will be used to map shape, size, and depth of geological structures seeking to identify the presence of low-enthalpy resources at up to three sites in different settings across New Zealand.

Field and laboratory measurements of thermal rock properties will be undertaken. Temperatures at shallower depths will be evaluated and correlated with the regional and local geological and hydrogeological conditions. Four standard temperature calibration holes will be set up in selected parts of New Zealand looking to characterise seasonal phase lag in ground temperatures with depth down to about 10m. Rock property characterisation will seek to provide increased use of ground heat sources by improving available heat transfer data for ground source heat pump technology. Laboratory and field testing will be conducted to better characterise a selected range of near surface soil and rock formations determining their heat transfer characteristics, thermal conductivity and specific heat capacity. Measurements will also be undertaken to enable rock heat transfer characteristics to be established for ground source heat pump loop sizing for New Zealand conditions. This will be focused on anticipated locations where the installation of ground sourced heat pumps might occur.

5.2 Technologies

Identifying of technologies that are appropriate for use with low enthalpy sources will identify their status as;

- ready for use,
- under commercial development, or
- further research required,

Ground Source Heat Pump case studies will be developed from Swedish and Germany experience providing insight into the embracing of this technology in those nations.

Other case studies will include a hydrocarbon well conversion study, a small scale binary cycle geothermal electricity generation plant study and a direct heat use study using heat discharged from an industrial process.

Recommendations will be made as to the areas of technology that hold the most promise and a strategy will be developed for emerging technologies.

6 INTEGRATED ASSESSMENT

Information and data collected as part of the programme will be summarized into an integrated assessment and review that will be prepared in the final few months of the programme. The review will summarise findings from the work including:

- low enthalpy resource information collected as part of the work
- low enthalpy demand characterisation
- Discussion on the appropriate technologies and the technology strategy
- Simple economic models (costs and benefits) for various types of resources and technologies
- Identification of areas where further study would be beneficial

The data will be worked into a ranking hierarchy to assist in prioritisation to achieve the most beneficial outcomes from low enthalpy resource utilization. Policy enhancements that might further encourage use of low enthalpy energy sources in New Zealand, and increase social acceptance, including addressing Māori specific needs will be identified. Recommendations on steps to be taken to further enhance the uptake of low enthalpy energy use will be identified.

7 INFORMATION

Resource assessment data is being assembled in a GIS referenced database which will enable easy addition of future data as it is collected.

Reports and other data collected will be disseminated and a low enthalpy web site has been set up for that purpose. This will become the focus of information dissemination and possibly a forum for discussion on low enthalpy technology and issues.

To visit the web site use this URL http://www.gns.cri.nz/research/geothermal/lowtemperature/

If you would like to contribute ideas or have material that you consider might be useful to the low enthalpy programme then please email your views to geothermal@gns.cri.nz .

8 PROGRAMME MANAGEMENT

The research programme is led by Brian Carey Geothermal Section Manager at GNS Science. A multidisciplinary team of GNS scientists are involved in the programme. Cito Gazo an energy research engineer from Coal Research Ltd is involved in technology aspects of the programme and Mike O'Sullivan University of Auckland is supervising students performing resource modeling case studies.

9 PROGRESS TO DATE

The work programme is in the early phases of data gathering which will intensify over the coming year. The outputs from some of the data gathering along with early interpretation and opinions will be presented at WGC 2010.

10 OUTCOMES

The programme seeks to support further utilisation of low enthalpy geothermal resources in New Zealand. Targeting a 20% increase on the 2005 direct heat utilisation level of 10 PJ / year increasing that to 12 PJ / year by 2025. It is considered that societal expectation and policy will have as much to contribute to realising this target as will appropriate economic technologies.

11 ACKNOWLEDGEMENT

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