NOTICE CONCERNING COPYRIGHT RESTRICTIONS

Geothermal Resources Council TRANSACTIONS, Vol. 14, Part I, August 1990

1985-1990 Update Report on the Existing and Planned Utilisation of Geothermal Energy for Electricity Generation in New Zealand

I.A. Thain

NEW ZEALAND BOARD MEMBER IGA

ABSTRACT

No account of the current or future use of geothermal energy within New Zealand would be complete without an overview of the far reaching political and organisational changes which have taken place over the past three years within the electricity supply industry.

This paper briefly reviews these changes and outlines their possible impact on the future utilisation of geothermal energy in the country.

Deregulation of the New Zealand Electricity Supply Industry

In New Zealand central government has played a direct and active role in the electricity business from its early origins. Private sector involvement in the generation of electricity has been minimal. By Act of Parliament in 1896 the government prevented local authorities from granting concessions to private companies without government consent, while with the Water Power Act 1903 central government vested in the Crown the rights to use New Zealand lakes and rivers for hydro-electric power generation. The Geothermal Energy Act 1953 gave the government very similar powers over the use of the country's geothermal resources.

The electricity industry has therefore evolved under political rather than commercial influence which gave direction to electricity supply being a social service rather than a commercial operation. It was the government who invested to ensure there was adequate production of electricity and that government rather than the price mechanism attempted in a centralised manner coordinated current and projected supply and demand.

Characteristically, the resulting emphasis throughout the industry was on ensuring that physical shortages of capacity did not occur, with a lesser importance on price and efficient production.

In August 1985, the Labour Government of the day decided to place its electricity business on a more commercial footing by turning it into a limited liability company. On 1 April 1987, the New Zealand Electricity Corporation was formed as a state owned enterprise with its own Board of Directors. Central government politicians are no longer involved in the day to day running or price regulation of the business.

At the same time the government has lifted the statutory barriers to entry into the electricity generation side of the business by competing firms. Previously anyone wishing to set up an electricity generating station had to seek and obtain specific approval from government to do so.

The new Electricity Corporation has restructured itself into four separate business divisions :

- ***Production*** — responsible for the operation of the system power stations;
- ***Marketing*** — responsible for the bulk sale of electricity to major industrial users and to the local area supply authorities;
- ***Transpower*** — a more remote separate company which manages the national high voltage (220 kV) transmission system; and
- ***Design Power Build*** — Group which provides a design and build service on a contractual commercial basis to the Electricity Corporation and the industry world wide in general.

Since its creation in 1987 the Electricity Corporation has made significant strides in improving its productivity, reducing staff numbers by 19 percent (from 5080 in March 1987 to 4100 in March 1989) at the same time as electricity sales increased by 5 percent.

When the Electricity Corporation was created the assets employed were valued at $6.3 billion, which puts the size of its 1989 after tax profit of $332 million in perspective. It is a very large business and the government's largest single asset.

In 1987 New Zealand had 96 power generating station. , 38 of these stations are owned and operated by the Electricity Corporation and they generated 95 percent of the electricity produced in New Zealand. The 58 generating stations in private or local electricity supply authority control were capable of producing only around 300 MW.

Privatisation and Monopoly Power

It is the stated policy of the current government to review the ownership of its business activities. A major objective of this policy is to maximise national income by encouraging greater efficiency in resource use. This objective is being pursued through a much greater reliance on market incentives and a re-defining of the role of government to that of establishing a legal framework within which commercial decision making can take place.

However, the government gave notice that prior to deciding whether or not to sell a business the competitiveness of the market place in which it operates would be examined. The government committed itself to making any legislative or institutional changes necessary for the establishment of competitive markets before selling any business.

It is against this background that in February 1988 the government set up a Task Force to review the structure and regulatory environment of the bulk electricity supply industry of New Zealand.

The Electricity Corporation is the largest business enterprise that the government owns and as such is a possible candidate for sale. However it dominates the New Zealand electricity market and at present faces very little direct competition. It has a total natural monopoly of the high voltage national grid distribution system and a 95 percent share of the electricity generation market.

The Task Force reported publicly on its findings and recommendations in September 1989. These are still being considered by the government but the following section of this report outlines the most likely future shape of the New Zealand electricity supply industry.

Future Shape of the New Zealand Electricity Supply Industry

Features of the industry would include:

There would probably be a number of privately owned generating and distribution companies, including one or two operating former Electricity Corporation plants, with the largest company being a privatised Electricity Corporation. Many of the companies would have shares traded on the Stock Exchange.

New entrants wishing to establish generating plants will be free to compete in the industry.

The generation and distribution companies would together own and control the transmission company, Transpower, on a club basis, with the government retaining a "golden" share.

The dispatch and loading of generators would be carried out by the transmission club company (Transpower) according to strict rules with the most efficient plants being used first.

Generating companies would be compensated for keeping plants in reserve to meet the fluctuating demands of consumers.

There would be a wholesale market in electricity with prices varying according to demand so that off peak electricity would be cheaper.

A gradual rebalancing of commercial and domestic tariffs with domestic consumers paying relatively more, reflecting the true cost of supply and ending cross-subsidisation.

Remote rural communities would also pay more to meet the high distribution costs of serving them.

The bills sent to consumers would separately identify the fixed costs of providing transmission and distribution lines from the variable costs of the amount of electricity used.

The natural monopoly parts of the industry (HV Transmission) would be "ring fenced," have to be open about their accounts ("transparency") and would be closely monitored to see whether they are operating and pricing in an efficient manner. They would have the threat of regulation under the Commerce Act hanging over them.

Electric Power Development Strategy

The Electricity Corporation's development strategy in the short to medium term (5 to 15 years) will be to improve the overall efficiency of its electricity system rather than to construct new power stations. It considers that its present generating capacity of 6837MW plus 432 MW of hydro under construction will be sufficient to meet market demand until the turn of the century. The present and planned electricity generating capacity and energy requirements of New Zealand are summarised in Table 1. One major new power development project currently in hand, is the expansion of the inter-island DC transmission link. This project will increase the capacity of that link from 600 MW to 1200MW thus allowing a greater flow of South Island hydro power to the main power demand centres in the North Island.

In the first decade after the year 2000 there is likely to be an increased level of construction of new power stations.

The reasons for this are:

- To meet load growth
- Make up for reduced future availability of natural gas
- To replace older thermal power stations in the North Island
- And to replace any generation lost from reductions in existing water rights.

Table 1 Present and Planned Production of Electricity

STATUS	Geothermal		Fossil Fuel		Hydro		Nuclear	
	Capacity MWe	Utilisation GWhr/yr	Capacity MWe	Utilisation GWhr/yr	Capacity MWe	Utilisation GWhr/yr	Capacity MWe	Utilisation GWhr/yr
In Operation January '90	293 (1)	2000	2267	5050 (2)	4287	21900 (2)	NONE	
Under Construction January '90	2	15	NONE		432	1900	NONE	
Funds Committed But Not Yet Under Construction January '90	47	300	NONE		NONE		NONE	
Total Projected Use by '95	342	2315	2267	5000 to 9000 (3)	4719	24000 to 20000 (3)	NONE	

Notes:
(1) Includes 20Me installed at Tasman Pulp & Paper Co at Kawerau.
(2) Utilisation data for year ending 31 March 1989.
(3) Indicates expected utilisation for normal and dry year hydro generation.

However, decisions on the timing and type of these new stations will be affected by electricity demand, competition, fuel prices, fuel availability, and the actual loss of water rights for existing generation plants.

Since the sixties there has been in New Zealand a very strong lobby opposing the damming of rivers for hydro electricity generation. To many people damming of a river into a lake is seen as more environmentally damaging than the use of fossil fuels for power generation.

The lobbying against the use of water for electricity generation is likely to continue as the Electricity Corporation forego their perpetual water rights and seek renewal of these rights for ones of a finite time (30 years). If the efforts of this lobbying are severe then this may necessitate the increased use of coal and geothermal for future electricity generation.

Geothermal Resource Administration

(a) ***Technical and Safety Standards***

Energy allocation and health and safety aspects of geothermal resources in New Zealand are currently being administered by central government through the Geothermal Energy Act 1953 and the Geothermal Energy Regulations 1961 by the Geothermal Inspectorate of the Energy and Resources Division of the Ministry of Commerce. (Administrative functions of the Ministry of Energy were absorbed into the Ministry of Commerce on 1 January 1990).

The prime function of the Geothermal Inspectorate is to ensure all geothermal facilities are designed, operated, and maintained to good industry accepted standards. This calls for the annual inspection of all geothermal wells, and pre-notification and approval, by the Inspectorate, of all planned modifications and major maintenance activities on each well.

To fund this function a geothermal levy is imposed on all users of geothermal energy. The levy is calculated on a per well basis, irrespective of whether the well is in productive use or not, in accordance with the following formulae but only up to a maximum of $900 per well.

$$\text{Annual Levy (\$) per well} = \frac{TM \times MCD}{50}$$

where : MCD = Maximum clear depth of the well in metres measured from the casing wellhead flange.

TM = Maximum well temperature in degrees celsius in a fully heated condition.

(b) ***Resource Royalties***

In New Zealand all resources (minerals, geothermal energy, etc.) beneath the land, irrespective of whether the land is in private or government ownership, are owned by the Crown (central government). As resource owner central government is responsible for allocation and pricing of minerals and energy resources. When a resource is exploited economically for commercial gain the owner is entitled to a share of the economic benefit arising from the development by way of rent or royalty.

Within the Geothermal Energy Act there is provision for the collection of such a rent. However, this rental is not currently collected from the Electricity Corporation, as it is wholly a government owned business, and the rent is assumed collected by the profit the company earns. With the pending privatisation of the electricity industry such rentals or royalty payments are to be put on an equitable basis for all users of geothermal energy.

The proposed method of geothermal royalty calculation in New Zealand is known as the Tauhara formulae. It requires a forecast of future costs to allow a unit or life cycle cost to be calculated which is then subtracted from the prices achieved in any year to arrive at the base for royalty.

The payment per kW hour is given by the expression **r x (p-b)**, where

"r" is the proportion due to the resource owner

"p" is the wholesale price of a kW hour of electricity, and

"b" is the unit cost, below which no payment is due.

If "b" is set at the unit cost of production including a return on capital used, a royalty will be paid only when economic rent is being generated. If "b" has been set at too low a value this method will have the same drawbacks as an ad valoreum royalty, payment method although to a lesser extent; if "b" is too high, insufficient revenue will be collected.

Current and Future Geothermal Power Development in New Zealand

Geothermal power developments in current operation or under construction/planned in New Zealand are identified in Table 2.

The main change from that reported in 1985 has been the commissioning and commencement of commercial operation of the Ohaaki Geothermal Power Station in October 1989.

The change in government policy in 1987 which opened the door to private power generation in New Zealand has brought about two private geothermal power development proposals. These are :

(a) On the Wairakei field Geothermal Energy Ltd. of Taupo, has obtained water rights and Ministry of Energy geothermal licenses to sustain a 15 MW power development. Because of the possible detrimental effects on the existing Wairakei Power Station operation the statutory licenses have only been granted for a period of 15 years instead of the normal 30 year period.

(b) A small binary plant using Ormat units is also under construction for the Bay of Plenty Electric Power Board on the Kawerau geothermal field.

Geothermal power will be a main contender in any future New Zealand power development programme, irrespective of whether that development is for the Electricity Corporation or a private power company.

The main factors which favour geothermal over other power generation options being:

- Availability of modular power units of up to 50 MW having very reduced construction times and therefore gain a faster return on capital expenditure. Proven geothermal fields all located in the centre of the North Island and hence much closer to the main load centres.

- The small incremental size of the modular geothermal unit is a better match for the expected load growth.
- Staged field development, facilitated by the modular unit, enables the true power potential of a field to be proven thus the developer would not have to spend as much money up front investigating the size of the field, or waste a large amount of steam proving the field.

New Zealand Geothermal Field Update

Figure 1 shows the location of the geothermal fields within the Taupo Volanic Zone.

Wairakei

As already mentioned statutory approval has been granted for the private development of a 15MW power plant on the Wairakei steamfield. The planned development is located on private land adjacent to the southwestern boundary of the field.

As yet no test drilling has been undertaken by the private developer (Geothermal Energy Ltd. of Taupo) to prove the viability of the project.

On the main Wairakei field power production has been maintained at around the 150MW level over the past 5 years, with an average annual energy output of approximately 1190 GW hours.

The field "at depth" pressure has remained reasonably constant over the past 5 years, however steam production has declined at approximately 4 percent per year, due in the main to declining fluid temperature.

Sustained field output has been maintained by the drilling of five new production wells. Three of these new wells were drilled to intercept the dry steam cap which has formed over the Te Mihi area of the Wairakei field. Two of the replacement wells, although

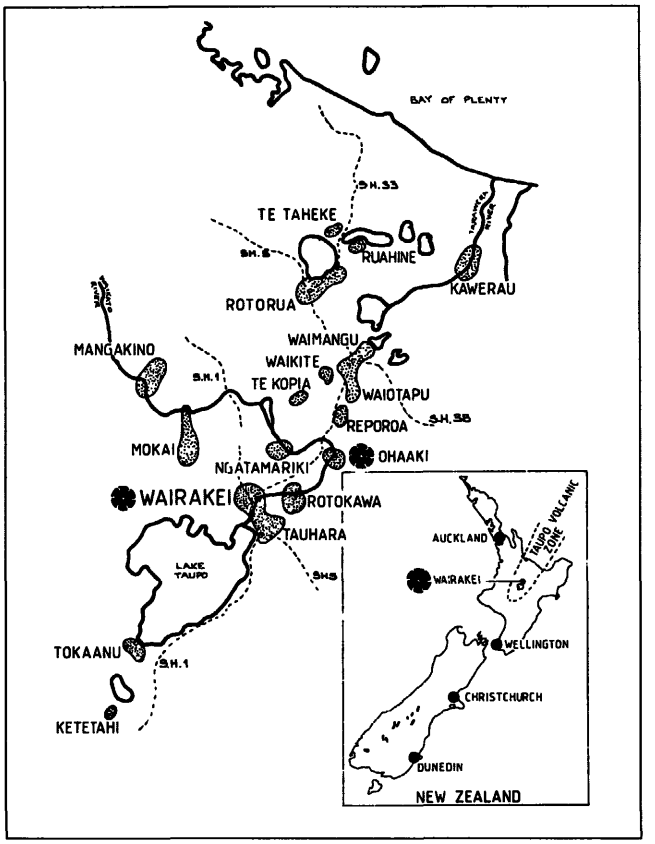

Figure 1. Location of Geothermal Systems in the Taupo Volcanic Zone, New Zealand.

Table 2. Utilisation of Geothermal Energy for Electricity Generation in January 1990

LOCALITY	POWER PLANT NAME AND/OR OPERATOR	YEAR COMMISSIONED	No of UNITS	STATUS	TYPE of UNIT	UNIT RATING MWe	TOTAL INSTALLED CAPACITY JAN '90	TOTAL UNDER CONSTRUCTION OR PLANNED
Wairakei	Wairakei A&B Electricity Corporation of NZ	1958-63	9	Operational	2IP Back Pressure 4LP condensing 3IP condensing	6x11.2MW 3x30MW	157MWe	
Wairakei	Geotherm Energy of Taupo Ltd (1)	-	Not known as yet	Planned	Binary or Steam Cycle	Not known as yet		15 MWe
Broadlands	Ohaaki Electricity Corporation of NZ	1989	4	Operational	2HP Back Pressure 2IP condensing	2x11.2MW 2x47MW	116MW	
Kawerau	Tasman Pulp & Paper Co	1964	1	Operational	1IP Back Pressure	1x20MW	20MW	
Kawerau	Bay of Plenty Elec Power Board	1990	2	Operational	Binary	2x1MW		2 MW
Rotokawa	Gas & Geothermal Trading Ministry of Energy (1)	-	1	Planned	IP Back Pressure	1x61/2MW		61/2MW
Tauhara	Gas & Geothermal Trading Ministry of Energy (1)	-	1	Planned	IP Condensing	1x25MW		25MW
					Total		293MWe	49MW

(1) Planned and for which production water Rights held.

initially targeted for the same steam zone, failed to encounter permeable conditions and were drilled on until good permeability was found, at over 1000 m depth, within the liquid reservoir. Brief details of these replacement wells are given in Table 3.

Details of wells drilled at the other geothermal fields over the past 5 years are also included in this table.

It is with regret that the salient production data from these wells cannot be reported, due to the commercial nature of the data. It would seem that New Zealand is now heading down a path trodden by many of the US geothermal field developers of the 1970s and 80s.

During 1988/89, a trial injection of 600 tonnes per hour of separated fluid was reinjected into the eastern Wairakei borefield through the now unused production well Wk 62. This injection was carried out under the gravity head of the separated water. The trial lasted 12 months, during which time minimal interference was experienced within the main production area. Whilst this is very encouraging for the long term viability of any Wairakei reinjection system, it was disappointing to note that no measurable pressure recovery of the field was experienced.

As a result of the success of this trial two new reinjection wells were drilled in late 1989 in the River Flats area, adjacent to the Wairakei power plant. Initial testing carried out on both wells indicate reasonable injectivity under gravity feed will be obtained.

Broadlands (Ohaaki)

During the commissioning and early period of commercial operation of this field significant production difficulties have been experienced due to 30 percent of the production wells becoming blocked with calcite. Various measures, such as acid cleaning, chemical inhibition, high pressure waterblasting and well workovers are being used to restore the affected wells to production.

The only new well (BR 46) to be drilled on this field over the past 5 years has been a condensate reinjection well.

Ngawha

The Ngawha field is situated 6 km east of Kaihoke, North Auckland. Geothermal investigations began in the 1960s with the most intense period of drilling during the years 1981-83. Planning for a 100 MW power station proceeded as far as the preparation of a draft Environmental Impact Report but was abandoned when the proposal for a large industrial electricity user in the South Island floundered.

Power production from this field is expensive due to the low enthalpy content of the geothermal fluid, high gas content, considerable distances between the wells and the requirement to reinject over a long distance.

The Gas and Geothermal Trading Division of the Ministry of Energy (GGT) completed a pre-feasibility study in early 1989 for a 9MW binary phase modular plant utilising both steam and separated hot water. The economics of this project are enhanced by the use of three wells in close proximity. Further incremental development is possible but requires strategic placement of the plants and steamfield to minimise the expense of long pipelines.

Mokai

Investigations on the Mokai field have progressed since 1985 with the publication in mid 1987 of a draft EIR for the installation of a 50 MW plant. Studies have shown that electricity can be generated at a very competitive price. Of the six wells drilled to

Table 3 - Wells Drilled for Electrical Utilisation of Geothermal Resources
From January 1985 to January 1990 at all New Zealand Geothermal Fields

* Type of Well T = Thermal Gradient P = Production E = Exploration I = Injection

Locality	Year Drilled	Well Number	Type of Well *	Total Depth Metres	Maximum Temperature C	Flowing Enthalpy kJ/kg	Flow Rate kg/s
Wairakei	1986	Wk228	P	400	DATA NOT AVAILABLE FOR GENERAL RELEASE		
	1986	Wk229	P	1120			
	1987	Wk230	E	600			
	1987	Wk231	E	600			
	1988	Wk232	E	600			
	1988	Wk233	P	400			
	1988	Wk234	P	400			
	1989	Wk235	P	1000			
	1989	Wk302	I	900			
	1989	Wk303	I	650			
Broadlands (Ohaaki)	1989	Br46	I				
Kawerau	1985	KA35	P	1094			
Rotokawa	1985	Rk6	E	2438			
	1986	Rk8	E	2720			
Ngatamariki	1985	NM1	E	1302			
	1985	NM2	E	2403			
	1985	NM3	E	2193			
Mangakino	1986	MA1	E	606			
Horohoro	1986	HH1	E	593			

date, three have proven to be excellent producers of a high enthalpy fluid. The proven resource of 50 MW has been further shown to be capable of a 100 MW development at an 80 to 90 percent confidence level.

The considered proposal for development is for installation of a 25 MW station for short term reservoir monitoring with a staged incremental 25 MW modular development.

Rotokawa

The Rotokawa field is located approximately 10 km northeast of Taupo township and 9 km east of Wairakei. Eight investigation wells have been drilled in the field with depths ranging from 308 m to 2783 m.

Three wells are capable of producing very high outputs at very high temperatures. An early conclusion drawn from preliminary reservoir modelling is that energy available from the field is equivalent to 355 MWe over a 30 year generation period.

Present project work by GGT is based around the installation of a small backpressure turboalternator for the purpose of resource testing and also generation. Water rights were granted in 1988 for production and reinjection purposes.

Tauhara

Assets managed on the field by GGT consist of four deep wells and five shallow monitor wells and development water rights for a 25 MW project. The field is situated to the northeast of Taupo township and is connected at depth with the Wairakei field.

A 25 MW power station has been the focus of developmental work at Tauhara since late 1985. Parties involved in joint venture contract negotiations are GGT, Fletcher Challenge Limited and Taupo Electricity Limited (the local supply authority).

In November 1987, advice was received from the Justice Department that a land and geothermal resource claim had been received, and lodged before the Waitangi Tribunal covering the Tauhara field, from a local Maori tribe, the Ngati Tahu.

This claim, in conjunction with legislation passed in 1987 concerning the transfer of Crown land to state owned enterprises, has imposed a level of risk currently unacceptable to financiers. This situation is resolvable and there is hope for a Tauhara project to proceed, though in a different form, in the near future.

Ngatamariki

The Ngatamariki field lies some 19 km northeast of Taupo and is one of the more recently defined geothermal resources in the Taupo Volcanic Zone. Four deep wells were drilled in 1985 by the Ministry of Energy and are now held by GGT.

Testing of the field in 1986 gave a probable 49 MW and possible 100 MW total field capacity at a 90 percent confidence level. Only one of the four existing wells has no value to further development.

There is no present proposal for the development of Ngatamariki.

Mangakino

The Mangakino geothermal field lies predominantly between the townships of Mangakino and Tokoroa. Recent geophysical surveys indicate that the field also extends to the southwest beyond Mangakino.

One well was drilled in 1986 to a depth of 606 m. Testing of this well confirmed earlier scientific investigations that a potential high grade geothermal resource exists. GGT has investigated the local market for development ventures but further extensive scientific and drilling work is needed to prove the resource to the point where power generation could be substantiated.

Horohoro and Whakatane

These two wells were drilled as shallow investigation wells in the mid 1980s to explore local resistivity anomalies. No conclusive evidence was detected of a geothermal resource in either locales.

Geothermal Professional Manpower Allocation

Professional manpower allocation to geothermal activities both within New Zealand and overseas, over the past 5 years are shown in Table 4.

Table 4 - Allocation of Professional Personnel to Geothermal Activities

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programmes
(6) Private Industry

YEAR	Professional Man Years of Effort					
	1	2	3	4	5	6
1985	76	Nil	5	INFORMATION		43
1986	71	Nil	5	NOT		44
1987	68	Nil	6	AVAILABLE		33
1988	62	Nil	6			26
1989	56	Nil	6			24

Conclusions

The deregulation of the electricity supply industry will have a significant impact on future geothermal developments in the country. The government's stated aim of seeing greater competition within the industry will open the way for private generating companies to exploit many of the already proven geothermal fields in the country.

Key to these developments will be the price charged by the present predominant electricity supplier in the country, the Electricity Corporation of New Zealand. Currently its price exceeds the "Long Run Marginal Cost" (LRMC) of providing electricity by a small margin. One implication of pricing above the LRMC is that superficially it will encourage other potential generators to enter the market.

Acknowledgement

The author acknowledges the assistance given by the Gas and Geothermal Trading Division of the Ministry of Energy and the Electricity Corporation of New Zealand in preparation of this paper.