1990-1995 UPDATE REPORT ON THE EXISTING AND PLANNED UTILISATION OF GEOTHERMAL ENERGY FOR ELECTRICITY GENERATION AND DIRECT HEAT USE IN NEW ZEALAND

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ABSTRACT

This paper reviews the progress being made to restructure and introduce private power generation in the New Zealand electricity supply industry. It also examines the inhibiting effect the current low price of electricity is having on new power developments in the country, and what measures are being adopted to meet future energy needs in the face of an economy growing at between 3 to 5% per annum.

1. RESTRUCTURING OF THE NEW ZEALAND ELECTRICITY INDUSTRY

For the past decade, major restructuring of the New Zealand's electrical power generation and distribution system has been taking place 'The update report briefly reviews the key changes which have taken place since the last repon

The 1984 labour Government began considenng reforms in ihe energy sector In 1987 the Electricity Corporation of New Zealand (ECNZ), was established as a state owned enterprise, with commercial objectives and acquired the assets of the Ministry of Energy's Electricity Division

A review of the entire electricity industry was subsequently undertaken in 1988 by a government established Electricity Task Force Objectives identified by the Task Force were

- promotion of competition in generation;
- development of a wholesale electricity market;
- separation of the National grid system operation from ECNZ; and
- commercialisation of the electricity supply authorities (ESAs) ie local Electric Power Boards and Municipal Electricity Departments.

Resulting from this Review, the Energy Sector Reform Bill enabled the legislative framework for corporatisation of the ESAs and governance of the future operation of the electricity industry

The legislation, from 1 April 1993, removed exclusive franchises enabling any power company to sell power to any consumer anywhere in New Zealand.

A draft disclosure regime requiring power companies to disclose financial statements, performance measures, and line charges has recently been circulated for comment.

Currently ECNZ possesses a dominant market position in electricity generation, generating approximately 95% of the country's electricity.

Monopolistic rights to future generation opportunities have been rescinded by the new legislation enabling any person or company to enter the power generation business. New Zealand energy policy is in effect now one of - "let market forces prevail." This policy is reliant on the principles of competition and the discipline of markets to replace a past centrally directed, monopolistic industry.

Reform of the electricity sector over the past 5 years has largely involved the distribution side of the industry. While break up and privatization of ECNZ has not been signalled by the government, it is possible that this may occur in the long term.

The Electricity Review Task Force recommended the separation of the national grid operator Trans Power from ECNZ and placing ownership of this natural monopoly in a structure involving a mix of industry participants. Failure of the electricity industry to agree upon an acceptable ownership structure has resulted in the government making Trans Power, as from 1 July 1994 a separate crown owned company.

To drive the formation of a Wholesale Electricity Market a Development Group was established in August 1993. This Group, comprising a wide range of interested parties, was charged by the Government with developing and agreeing on:

- the component pans of the market.
- their function and overall relationship with each other,
- the cost benefit and viability, and
- the implementation scheme

The Group released draft proposals in April 1994 consisting of six key recommendations. These recommendations are:

- Main power needs to be traded through long term contracts between suppliers and wholesale buyers.
- Establishment of a "spot market" which will give energy suppliers and traders access to back up or additional supplies, and trade in long term contracted power at the spot price.
- Market to be operated by a neutral pool company which would be owned by market participants.

- Incentives to be offered through the market to promote, facilitate and reward energy efficiency and conservation

- The National Grid company (Trans Power) to be responsible for the physical security of the system through the dispatching of stations and the arranging of back up supplies

- The market dominance of ECNZ in generation to be addressed and provision made to encourage the development of competition.

It should be noted that these proposals are a first cut of the shape and form of the new market and significant work remains to be done to establish if the proposals are economically viable.

The above outline brings up to date the status of the restructuring of the New Zealand electricity industry The process of reform and consultation has been comprehensive. lengthy and is continuing.

Table 1. Present and Planned Production of Electricity

	Geothermal		Fossil Fuels		Hydro		Nuclear		Total	
	Capa-city MW	Gross Prod GWh/yr	Capa-city MW	Gross Prod GWh/yr	Capa city MW	Gross Prod GWh/yr	Capa-city MW	Gross Prod GWh/yr	Capa-city MW	Gross Prod GWN yr
In operation in January 1995	286	2353	2309	7278	5100	22842	Nil	-	7635	32471
Under construction in January 1995	Nil	-	Nil	-	Nil	-	Nil	-	Nil	-
Funds committed but not vet under construction in January 1995	154	1210	430	2070	300	1300	Nil	-	884	4580
Total projected use by 2000	440	3563	2739	9348	5400	24142	Nil	-	8397	37051

2. ELECTRIC POWER DEVELOPMENT STRATEGY

Promotion of private generation in new power projects is strongly supported by the Government and this has resulted in a multitude of small scale development proposals involving local electricity supply authorities and private companies.

However none of these proposed developments have staned. The principal reason being the low cost of electric power in New Zealand (average 1994 wholesale price 5.67 cents NZ/kWhr) which makes it uneconomic for otherg, at present, to build new generating plant to compete against the dominant supplier (ECNZ).

The 1990 update repon (Thain 1990) indicated the development strategy to be adopted by ECNZ in the shon to medium term (5-15 years) would be to improve the overall efficiency of its existing system rather than to construct new power stations.

In pursuing this strategy over the past seven years, ECNZ has gained almost the equivalent of a new 1000 MW power station. The assessed capability of the ECNZ generating system has risen from 32,000 GWh/yr to around 36,000 GWh/yr. Costs have also been contained and employee performance improved from 5 56 GWhrs/employee in 1988 to 10.96 GWhrs/employee in 1994.

With these improvements largely accomplished future expansion will require to be met by new generation. The 1990 update repon indicated no major power plant construction would be required until around 2000 This is no longer the case, as New Zealand's market driven economy is now growing at an annual rate of between 3 to 5%. To sustain this growth new major generation will be required before the turn of the century

The present and planned electricity generating capacity and energy requirements of New Zealand are summarised in Table 1. During the past 5 years two major power developments have come on stream One was the commissioning of a new inter-island DC transmission cable which increased the carrying capacity of this power link from 600 MW to 1200 MW, thus enabling a greater flow of South Island hydro power to the main power demand centres in the Nonh Island. The second development was the commissioning in 1993 of the 432 MW Clyde Hydro Power Station in the South Island.

To meet future electricity demand approximately 900 MW of new generating capacity is planned to be added to the New Zealand power system before 2000. Geothermal power developments are expected to make up 17% of this new capacity.

However, as mentioned, the low price of electricity is inhibiting the entry of new private generators into the market. Realising that power shortages in the next 5 years could cause and seriously impact

on New Zealand's economic recovery, has prompted ECNZ to commence planning for the construction of a new 350 MW gas fired combined cycle plant which would come on stream in 1997/98.

3. CURRENT AND FUTURE GEOTHERMAL POWER DEVELOPMENTS

Geothermal power plants in current operation and developments planned to come into service before 2000, are detailed in Table 2.

Key events which have had greatest impact on the progress of geothermal developments over the past five years has been the dis-establishment of the government's Gas and Geothermal Trading Group, (G&GTG), and the passing of the 1991 Resource Management Act (RM Act). The dis-establishment of the G&GTG resulted in their planned developments at Rotokawa and Tauhara not proceeding.

The greatest long term impact on geothermal development in New Zealand is likely to be brought about by the passing of the 1991 Resource Management Act. The stated purpose of this legislation is to promote the sustainable management of New Zealand's natural and physical resources. (Thain, 1992). The cornerstone of the act is the principles of sustainable, efficient, and environmentally acceptable management of resources.

In this context the Regional Council responsible for administering the RM Act with respect to approximately 80% of the country's high temperature geothermal resources, has proposed that these resources be sustainably managed from a Macro perspective rather than

attempt to sustainably manage individual geothermal systems. This entails identifying geothermal systems which can be developed and used, and others which will be protected Also recommended. and generally supported by the New Zealand geothermal community. is the proposal that development fields would be under the control of a single Steamfield Management Organisation (SMO) which would be responsible for ensuring the resource is managed efficiently and equitably The SMO would be required to prepare a management pian for the resource and have this vetted and reviewed at regular intervals by the controlling regional authority to ensure ongoing compliance with RM Act requirements.

To date, July 1994, only one such development is progressing along these lines This is on the Rotokawa field, near Taupo, where a SMO consisting of landowners and those with access rights to the resource has been formed

Agreement has also been reached on a resource allocation to a Joint Venture organisation to construct and operate a 18 MW power development on the Rotokawa field.

Table 2. Utilisation of Geothermal Energy for Electrical Generation in December 1994

Locality	Power Plant Name	Year Commissioned	No. of Units	Status	Type of Unit	Unit Rating MW	Total Install-ed Cap. MW	Annual Energy Prod. GWh/yr	Total Under Constr. or Planned MW
Taupo	Wairakei	1958-1963	9	Operational	2 IP BP 4 LP C 3 IP C	6x11.2 3x30	157	1334	24
Reporoa	Ohaaki	1989	4	Operational	2 HP BP 2 IP C	2x11.2 2x46	114	919	-
Kawerau	Tasman P&P Co.	1966	1	Operational	1 IP BP	1x10	10	60	-
Kawerau	Tarawera	1990	3	Operational	Binary	2x1.2 1x3.5	6	40	3.5
Taupo	Rotokawa			Planned	C	1x18	-	-	18
Northland	Ngawha			Planned	Binary	-	-	-	8
Rotorua	Lake Rotoma			Planned	C	-	-	-	55
Taupo	Wairakei (Geotherm)			Planned	C	-	-	-	15
Taupo	Mokai			Planned	C & B	-	-	-	30
TOTAL							286	2353	154

BP =Back Pressure C =Condensing B = Binary

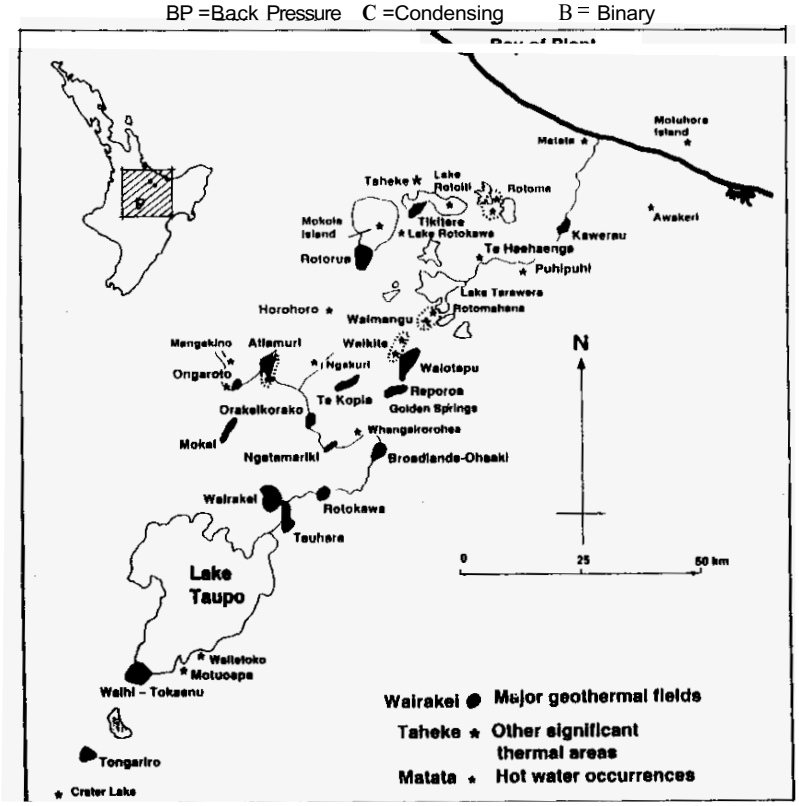

Figure 1 : Geothermal Fields in the Taupo Volcanic Zone

Table 3. Wells Drilled for Electrical and Combined Use of Geothermal Resources

From January 1, 1990 to December 31, 1994.

(1) Type or purpose of well:

I = Injection P = Production C =Combined Electrical and Direct use

(2) Total flow rate at given wellhead pressure (WHP)

Locality	Year Drilled	Well Number	Type of Well(1)	Total Depth m	Max Temp °C	Fluid Enthalpy kJ/kg	Well Output(2)	
							Flow Rate kg/s	WHP bar
Wairakei	1990	WK304	I	1467	)			
Kawerau	1990	KA36	C	1328	)			
	1993	KA37	C	1518	)Confidential	Commercial	Data	
	1993	KA38	I	380	)			
Tauhara	1992	TH5	P	496	)			
Ohaaki	1993	BR41	I	428	)			
TOTAL								

4. NEW ZEALAND GEOTHERMAL FIELD UPDATE

The location of the main high temperature geothermal fields in New Zealand are shown in Figure 1. Since 1990 there have been 6 wells drilled on these fields for electrical and combined use of geothermal resources. The wells drilled are detailed in Table 3

4.1 Wairakei

Power production from Wairakei has been maintained at around the 150 MW net level over the past 5 years, with an average annual energy output of approximately 1180 GWhrs. In 1993/94 a highest ever generation of 1297 GWhrs was achieved.

The field "at depth" pressure still remains reasonably constant, however steam production continues to decline at approximately 4% per year, due mainly to a declining fluid temperature.

In 1992/93 a new one metre diameter main steam transmission line was constructed with the prime aim of reducing the steam pressure drop between the steamfield and the power station. This enabled all production wells to operate at a reduced wellhead pressure, thus marginally increasing the fluid and flashed steam output from all production wells.

One new production well was connected into the steam supply system in 1994 This well had been previously drilled as an exploratory well to find the extent of the dry steam cap which has evolved over the Te Mihi sector of the field.

A reinjection project was approved in 1992 which entailed the construction of a separated water gathering system and the drilling of sufficient reinjection wells to enable up to 2500 tonnes/hr of fluid to be reinjected. Whilst the fluid gathering system has been completed, together with some reinjection wells, the drilling of the remaining 4 reinjection wells has been delayed pending the granting of the necessary reinjection resource consents.

The private power development on the Wairakei field, by Geotherm Energy Ltd of Taupo, is still awaiting to proceed. After lengthy appeal hearings all necessary resource consents for a 15 to 20 MW development have now been received and construction is reported to be imminent.

ECNZ are to proceed with a 20 MW binary plant, which has been made economical by the reinjection system gathering and delivering the separated geothermal water to a convenient location close to the existing Wairakei Power Station (Harper. Thain 1995). Resource consents for this plant are in the process of being obtained and construction is planned to commence in 1995

4.2 Broadlands (Ohaaki)

During the last 5 years the High Pressure (HP) steam production from the Ohaaki field has declined at a much more rapid rate than initially predicted. The consequences of the decline is that the predicted life of the HP (2 x 11 MW) steam turbines is now only 7 years and these machines are likely to be decommissioned in 1996 compared to the original prediction of 1999 or beyond

Production well temperatures are decreasing at about 5°C per year. The temperature change is largely due to the invasion of cool peripheral water probably with a temperature significantly less than 200°C. The greatest rate of decline is occurring in the shallowest feed zones which are at about 500 metres in depth. Reservoir assessments Suggest that the bulk of the stored heat in the reservoir exist at below 2500 m depth where fluid temperatures of 270 to 310°C exist. Exploratory drilling to tap this deep resource is to be carried out in 1994/95.

4.3 Ngawha

The relatively low heat content (960 to 980 J/g) and high levels of dissolved minerals in the fluids produced from the wells are the main drawbacks to using the Ngawha resource for electricity generation. Systems which use the total flow of wells through heat exchangers offer the best prospect of utilising this resource.

The feasibility study for a 9 MW binary plant reponed in 1990 is being followed up by a joint venture group consisting of the local electricity supply company Top Power Ltd and the Tai Tokerau Trust representing the Maori owners of the land on which the Ngawha field is located A two stage project, the first stage of 8 MW is planned for completion in 1997/98. The second stage would take the development up to 24 MW.

Table 4. Allocation of Professional Personnel to Geothermal Activities
(Restricted to personnel with a University degree)

Year		Professional Man Years of Effort				
	(1)	(2)	(3)	(4)	(5)	(6)
1990	42	Nil	7	Information	Information	20
1991	41	1	7	not	not	19
1992	43	2	7	available	available	29
1993	44	2	7			34
1994	46	2	7			30

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

4.4 Mokai

The Mokai geothermal field is located 20 km nvrth west of Taupo Between 1981 and 1983 six exploration wells were drilled The drilling indicated that the Mokai field was a very promising energy source with an available heat supply of around 3200 PJ. The Mokai wells are some of the hottest geothermal wells in New Zealand with down hole temperatures of up to 326°C recorded.

The chemistry of the fluids is very similar to Wairakei, but with higher gas, chloride and silica content, as a result of hiyher reservoir temperature.

Current development proposals are for an initial 50 MW project consisting of two 25 MW integrated HP steam turbine and binary power plant modules. Resource ownership issues are the main cause of delays to this development. and the need to form an acceptable Steamfield Management Organisation (SMO).

4.5 Rotokawa

The Rotokawa field is located approximately 13 km north east of Taupo and 9 km east of Wairakei. Eight investigation wells have been drilled in the field, with the last four wells being drilled in 1984/85. The recently drilled wells have high production zone temperatures, up to 320°C, so the wells have a high flashed steam content.

As indicated in section 3 a Steamfield Management Organisation has been formed to manage this development resource. An initial 18 MW power development joint venture consisting of Taupo Electricity Ltd, Works Geothermal Ltd. and the Maori Trust land owners is in the process of being implemented. The steam turbine contract for the power plant has been conditionally awarded to Ansaldo of Italy.

4.6 Tauhara

This field is situated to the north east of Taupo township and is connected at depth with the nearby Wairakei field.

An exploratory shallow well was drilled in December 1991 lo try and locate the dry steam cap which has formed over part of this field The well failed to find permeable conditions at its target depth.

Resource consents have been lodged for a 10 MW power development together with a 20 t/hr direct heat steam supply to serve a nearby timber drying operation. However resource management issues relating to the connectivity of the Tauhara and Wairakei resources have delayed progress on this development

4.7 Lake Rotoma

The Rotoma geothermal system is located about 26 km north east of Rotorua city

Integrated resistivity, gravity, and magnetic surveys were conducted in 1987 Based on these and other limited studies to date, the inferred available heat is reported to be sufficient to sustain between 50 and 150 MW ofgeothermal development

Resource consents were lodged by Waitemata Electricity Ltd for a 55 MW development, however, only consents for exploration drilling have been granted. There is a high degree of confidence that this drilling will proceed.

5. DIRECT HEAT AND LOW TEMPERATURE UTILISATION

At the 1990 International Symposium on Geothermal Energy, Lumb and Clelland (1990) described the status of the Direct Use and Lower Temperature Utilisation of Geothermal resources in New Zealand in great detail. Since that report no major developments have taken place although a number of modifications to existing plant has resulted in improved overall efficiency in the utilisation of the resources. As mentioned earlier in this report. the passing of the resource Management Act into Law in 1991 has provided the incentive for initiating these modifications

A number of companies are endeavouring to utilise their waste waters to provide electrical energy with Einary plant. At Kawerau 3 units of 2 x 1 2 and 1 x 3 5 MW Ormat plant are using separated water at 170 deg. C. The major use of the Kawerau geothermal fluid is in the Tasman Pulp and Paper Plant, Lumb and Clelland (1990). Hotson (1995), but by discharging the separated water through the Binary plant rather than directly into the Tarawera River overall efficiency of use of the resource is improved. In addition Tasman is planning to extract Silica from the bore water and a horticulture project and hot pools are operated by other parties, Hotson (1995). Also at Kawerau the Tasman Lumber Co. have installed a timber drying facility which is utilised 24 hrs/day, 340 days per year using on average 16 t/h of 9 barg steam in two high temperature kilns to dry 100,000 cum/yr of timber in a batch process. Taupo Lucerne Limited is located on the Ohaaki Power Station steam Geld and uses geothermal steam and hot water as the heat source for the drying of lucerne (alfalfa) into "De-Hi" produced from the fibrous part of the plant and lucerne protein concentrate (LPC), a high protein product, from the extracted juice (Pirret and Dunstall, 1995). Approximately 100 tonnes per hour of separated hot water from the Ohaaki reinjection system and 4 tonnes per hour of steam from on site rcparators are used in the process air heaters. High enthalpy steam generated from the 13 bar two phase fluid supply is also used for drying round woods (pinus radiata) in a batch type direct steam drying process.

At the Wairakei Power Station, the separated waste water is currently discharged from the stem field through concrete channels into the Wairakei stream and finally into the Waikato River The Wairakei Prawn Farm pumps hot geothermal fluid at approximately 60 deg. C from the stream through plate heat exchangers to heat river water. This is then fed to two and a half hectares of prawn breeding ponds to keep the temperature around 28 deg. C which produces **20** t/y of prawns. A smaller heat exchanger using the Same stream fluid provides heat for the nursery ponds

The development of the power station reinjection systcm with the proposed binary plant, mentioned above, will provide approximately **4000 t/hr** of separated water which will allow a planned expansion of the Prawn Farm to over 30 hectares.

6. 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**

Impacting on the professional manpower allocation over the past five years has been the government's drive to restructure the economy and the disbanding of the Department of Scientific and Industrial Research (DSIR), in June 1992. The DSIR is now replaced by Crown Research Institutes, two of which do geothermal research funded by money disbursed through the Foundation for Research, Science and Technology by way of competitive bidding.

7. CONCLUSIONS

The low wholesale price of electricity has been a key factor in inhibiting the entry of private power generators in the New Zealand electricity supply industry.

With electricity growth predicted at 3 to 5% per year, major new power generation will be required before 2000. Small private geothermal power developments are expected to play a key role meeting this increasing generation need.

The concept of a single steamfield management organisation assuming responsibility for the whole **resource** is recognised as the best way of ensuring the country's geothermal resources are utilised in the most efficient and effective manner.

The use of separated waste water downstream of power generation or high temperature plant is demonstrated to improve the overall efficiency of that plant and includes in New Zealand. Binary plant, timber and lucerne drying and aquaculture.

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