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1995-2000 UPDATE REPORT ON THE EXISTING AND PLANNED USE OF GEOTHERMAL ENERGY FOR ELECTRICITY GENERATION AND DIRECT USE IN NEW ZEALAND

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ABSTRACT

This paper traces the restructuring of the NZ electricity industry from government monopoly to becoming a privatised competitive commercial business. Details of new geothermal power developments undertaken over the period 1995 to 1999 are provided along with a performance update of existing operational fields at Wairakei, Ohaaki and Kawerau.

1. THE NZ ELECTRICITY INDUSTRY: TRANSFORMATION FROM MONOPOLISTIC TO COMPETITIVE MARKET

Up until the late 1980's central government, in New Zealand, played a direct and active role in the bulk electricity supply business. The electricity industry thus evolved under political rather than commercial influence, resulting in a monopolistic electricity supply industry directed more at providing a social service than a commercial operation.

In 1986 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. The new enterprise, called the Electricity Corporation of New Zealand (ECNZ), was structured as a commercial undertaking with private sector management brought in to drive the business. Management were charged by the government to make a commercial return on shareholders assets equivalent to best private sector businesses. On establishment, ECNZ was responsible for the generation of 95% of the countries electricity needs.

The commercial measures undertaken by ECNZ management were successful and from 1990 to 1995 the company was consistently providing its government shareholders with a 10 to 13 % return on assets; in dollar terms this equated to around NZ$500 million annually. At the same time it achieved a significant reduction in the wholesale price of electricity. Compared with the price in 1987, the 1995 price had fallen by 21% after allowing for inflation.

Complaints to government, by local electricity distribution and retail companies, about the dominant position of ECNZ in the wholesale electricity supply business, led in 1996 to ECNZ being split into two competing generating companies. The new company, called Contact Energy, inherited around 30% of ECNZ's generating assets including the Wairakei and Ohaaki geothermal power stations. This move signalled the government's strong commitment to establish a competitive wholesale electricity energy market in the country.

The next sector of the electricity industry to feel the effects of government electricity sector reform were the 38 local power supply and distribution companies. These private and local authority owned companies in effect enjoyed a monopoly position of power supply to their customers through their ownership of the local distribution systems. While wholesale electricity supply prices had fallen significantly as a result of the commercialisation of ECNZ these energy price saving were not being passed onto the end use customer by the local supply companies.

To address this situation the government passed new legislation - the **Electricity Industry Reform Act 1998**. This legislation had the following aims:

- Bring about ownership separation within power supply companies of their energy trading and energy transmission businesses.
- Elimination of electricity price cross-subsidisation of the riskier energy trading by the monopoly lines transmission business.
- Split the still dominant state owned generator ECNZ into three separate competing companies.
- Allow generator companies to retail electricity.

The electricity industry was given until May 1999 to comply with the new legislation. In April 1999 three new state owned generation companies, formed out of the ECNZ assets, came into being. The new generation companies are:

- Genesis Power, with 1708MW of generation capacity including the 1000MW Huntly conventional thermal power station.
- Meridian Energy, with around 2340MW of South Island hydro power stations.
- Mighty River Power Company, with 1095MW of hydro power stations located on the Waikato River in the North Island.

Most of the local power supply companies have chosen to offload their electricity retailing businesses and to retain their much less riskier lines business, becoming in effect operators of electricity networks.

Out of the mad scramble to sell off electricity retail businesses, seven companies have emerged as the main generation and retail players. These key players include the three new state owned generating companies formed out of ECNZ, Contact Energy; two local supply companies (who decided to remain in the electricity generation and retail supply business after selling off their distribution assets) and one new small private generator. Analysts see room for only three or four energy generation players in the small NZ market thus further mergers and consolidation is predicted in the future.

As a result of this industry restructuring customers are now able to shop around to obtain competitive energy supply contracts from any of the main generator companies.

Concurrent with the above restructuring the government privatised Contact Energy Ltd. This was implemented in April 1999 when 60% of the shares in the company were sold to New Zealand and overseas investors with the remaining 40%

being bought by Edison Mission Energy Group from the USA. As a result of this action all of New Zealand's geothermal power plants are now in private ownership.

Further privatisation of the New Zealand electricity generation industry has now been effectively deferred indefinitely as a result of the November 1999 general election which returned a centre left government coalition of Labour and Alliance parties. It is the stated policy of the new government that it will not sell the three state owned generation companies and it has also indicated it will consider putting them back into one organisation.

2 CURRENT AND FUTURE GEOTHERMAL POWER DEVELOPMENTS

The present and planned electricity generating capacity and energy requirements of New Zealand are summarised in Table 1.

During the past five years 1147 MW of new generating plant has been added to the New Zealand electricity supply system and 314 MW of conventional thermal plant decommissioned, giving a net gain in system generating capacity of 833 MW over that in operation in January 1995.

The additional installed generation capacity consists of 172 MW of co-generation plant, 774 MW of natural gas fired combined cycle plant, 154 MW of geothermal, and 47 MW of renewable energy (39 wind and 8 landfill biogas)

Geothermal represents 5% of the installed generating capacity and provides around 6.5% to the total energy needs of the country.

The total capital investment in new geothermal generation plant over the last five is estimated to be of the order of NZ$285 million (US$150 million) giving an average installation cost of around NZ$1.85 million /MW (US$1.0 million/MW). This low installation cost is partly due to the new developments obtaining existing government owned investigation well assets at below replacement value, minimal resource investigations to carry out, pre owned land and in one case the purchase of second hand unused geothermal turbine generator plant from the USA at a very good price.

Geothermal power plant in current operation and developments planned to come into service before 2005, are detailed in Table 2.

The low cost of natural gas and a desire to make more efficient use of this resource by utilising it in high thermal efficiency combined cycle power plants are the main reasons for the large increase in thermal generation over the last five years.

Salient generation statistics for 1999

Peak power generation occurred on the 2 August 99 when system demand reached 5,923 MW, which is equivalent to 69% of the total installed generating capacity. Most of the surplus generating capacity consists of inefficient conventional thermal plant.

The average annual wholesale price of electricity was 3.48 cents/kWh (1.82 US cents/kWh). This represents a 38% reduction over the 1994 average wholesale price and clear evidence of the effect of competition in the New Zealand electricity market.

3. DIRECT USE UPDATE

Thain and Freeston (1995) provided an update on low temperature and direct use to the 1995 WGC meeting. Since that time there have been only minor changes in the New Zealand direct use scene. System capacities are shown in Table 3 and a summary is provided in Table 5.

The major direct user continues to be the Tasman Pulp and Paper Mill operation at Kawerau where geothermal fluids are used to generate clean process steam for paper drying, as a source of heat in evaporators, for timber drying, as well as for electricity production. Geothermal condensate, which was previously disposed of in the Tarawera river, is now collected and treated before reuse as a source of feed water in power and liquor recovery boilers. At the adjacent Tasman Lumber sawmill a number of timber drying kilns currently using clean steam are planned for conversion to geothermal steam in the short term. A small greenhouse, which runs as a separate operation, also makes use of steam at Kawerau. The total greenhouse area is 5250m^2 and the main crop is capsicum (green peppers) (Dunstall and Foster, 1998).

The conversion of the Taupo Lucerne Ltd drying plant from using steam from the Ohaaki field to using hot water from the reinjection system is now complete. The plant uses up to 150 tonne/hour of hot water in the main drying facility to produce "De-Hi"; dry lucerne fibre (alfalfa) pellets, and "Lucerne Protein Concentrate"; a high protein product made from the plant juice. Up to 70 tonne/hr of additional hot water is used in a fence post drying facility. Water is received at 142°C and rejected at 90°C.

In 1995 the Wairakei Prawn Park was reported as using hot water from the Wairakei stream at about 60°C to provide heat to raise Malaysian river prawns in outdoor growing ponds. The hot water in the stream originated from the Wairakei geothermal field. Now, the Prawn Farm heats its 5.8 hectares of growing ponds with hot water taken directly from the Wairakei reinjection system at about 130°C. The water is rejected at about 80°C and up to 320 tonne/hr is used during cold periods. The average flow is about 200 tonne/hr.

Other small-scale operations are scattered about the central North Island, but industrial use of geothermal heat is not extensive. Recent data published by EECA (Energy Efficiency and Conservation Authority) indicates that 39% of all industrial energy use in New Zealand is for process heat under 300°C, illustrating the large potential for substitution with geothermal where the demand is in suitable locations.

The largest concentration of small direct use applications is in the city of Rotorua, where there is a long history of geothermal use. Increasing use of the Rotorua resource was linked to a decline in the natural features at the Whakarewarewa reserve and during the 1980s restrictions were imposed to prevent further decline of these features. Thereafter, about a decade of regulatory uncertainty existed, and relatively little investment in geothermal systems occurred. The management systems put in place to protect the field appear to have been successful and in July 1999 the regulatory situation stabilised with the implementation of the Rotorua Geothermal Regional Plan. Rotorua geothermal users are once again able to take a long-term view and the outlook for geothermal users has improved. The total number of wells in operation has remained steady at about 150 during the past decade although there has been a trend for exploitation to move toward the downtown business area, away from the Whakarewarewa area. Many of the older systems remain in place, with more efficient controls and heat exchangers. The current field withdrawal rate is estimated at some 9500 tonnes/day.

4. NEW ZEALAND GEOTHERMAL FIELD UPDATE

The location of the main high temperature geothermal fields in New Zealand are shown in Figure 1 and Table 6 provides details of the numbers of wells drilled for exploration, production and injection use on these fields over the last 5 years.

4.1 Wairakei Field

McLachlan Power Station.

The 55 MW McLachlan Geothermal Power Station was the first privately owned geothermal power station to be built in New Zealand. The plant is located on the south-western side of the Wairakei field. The plant was commissioned in December 1996 and is a joint venture between the McLachlan family, who own the land on which the plant is built, and Mercury Energy, an Auckland based power supply company.

Steam for the plant is provided from four wells which tap a shallow steam cap which developed above the south-western side of the Wairakei field as a result of the drawdown of the liquid resource during the many years of operation by the original Wairakei plant.

The 55MW Fuji Electric turbine generator unit installed at the McLachlan plant has strong links with the Geysers, having been originally procured by the California Department of Water Resources for its planned South Geysers development, which was never completed due to declining steam production on that field. The unit underwent modification by Fuji Electric to enable it to operate at 50 cycles and 3,000 RPM instead of its design parameters of 60 cycles and 3,600 RPM.

The station output is resource consent restricted to 17 hours generation at 40 MW and 7 hours overnight generation at 2 MW. This “two shifting” mode of operation has caused no operational problems and the plant has been a reliable and consistent producer since commissioning.

Recent legislation requiring power supply companies to separate their power generation/ retail business from their transmission business, has resulted in the McLachlan Power Station being put up for sale by the principal joint venture partner, Mercury Energy Ltd. On the 31 December 1999 it was announced that the plant had been purchased by Contact Energy Ltd for NZ$50.5 million.

Wairakei

Wairakei, now in its 42nd year of operation, continues to be a consistent and reliable producer of electrical power. Annual generation over the last 10 years has averaged around 1250 GWh/ annum which equates to an average annual load factor of 93%.

Steam production from the field has continued to decline at the previously reported rate of around 4% per year. (Thain and Freeston, 1995). To make up this annual decline five new production wells have been drilled and connected into the steam supply system over the last five years. Four of the new wells tap the Te Mihi steam cap at a depth of around 450m and the fifth well was drilled to tap the deeper liquid resource.

Steam utilisation efficiency at the plant was improved in 1996, when two pressure reducing valves which reduced around 200 tonnes per hour of secondary flash steam from 1.3 bar g. to atmospheric pressure were replaced by a back pressure steam turbine. This resulted in a net gain in station output of around 4 MW.

In 1996 five deviated injection wells were drilled as part of the reinjection project approved in 1992, to inject up to 2,500 tonnes per hour of separated geothermal water. This system was put into service in late 1997 and is currently injecting around 2000 tonnes per hour. To date no adverse effects on field production have been observed.

Resource consents were sought and obtained by Contact Energy for the installation of a 15 MW binary power plant at Wairakei. This plant would have extracted additional energy from the separated water prior to its injection. However, due to the low cost of electricity in New Zealand this project has not yet been implemented.

4.2 Ohaaki

Steam production from the Ohaaki field has continued to decline due to cooler sub-surface peripheral water invading the West bank production field. Over the last five years net output has reduced from 80 to around 50 MW (Thain and Freeston, 1995).

To curtail this rundown, three new deviated wells were drilled in 1995 with the aim of encountering hot fluid moving upward through buried faults in the basement greywacke at 2,500m depth. Permeable conditions in the target geological formation were not encountered, however, two of the wells BR48 and BR49 did encounter hot production about 100m above the basement greywacke. Two existing production wells, BR15 and BR42, were deepened during the 1995 drilling programme, using deviated drilling to try and encounter this deep permeable layer. Only BR15 was successful. The additional steam obtained from this drilling programme had a combined output of around 15 MWe.

The Wairakei and Ohaaki drilling program of 1995, which was completed within 10 months using a single top drive drilling rig, consisted of 8 new wells and extension of 2 existing production wells having a total overall drilled length of 22,000m.

4.3 Kawerau

This field produces mainly direct use steam for the Tasman Pulp and Paper Company’s Kawerau mill. Steam production is affected by calcite scaling blocking some of the main production wells. This problem is managed by an effective on line chemical injection inhibition system and a program of regular well clean outs. Over the last five years no new production wells have been connected to the steam supply system.

One new injection well, KA39 was drilled in 1998 and injection of the separated geothermal brine was increased to around 30%. Resource consents permitting the continued discharge of the remaining separated water to a natural waterway were renewed in 1998 for another 14 years. This new resource consent requires, however, that ongoing efforts be made to further reduce the brine discharge to the Tarawera River.

4.4 Ngawha

Ngawha geothermal field is located about 245 km north of Auckland and is the only high temperature geothermal field outside the Taupo Volcanic Zone (TVZ). Extensive geothermal drilling investigations were undertaken by the government in

the late 1970`s when 15 wells were drilled. Of these, 6 were good producers having a mean fluid enthalpy of around 975 kJ/kg at a temperature of 220 to 230°C. The resource has an estimated potential of about 100MW. The fluid, however, contains high levels of dissolved minerals such as boron and mercury. As the high enthalpy fields of the TVZ were seen to be more economically viable than Ngawha no development eventuated as a result of these investigations.

In 1995 studies were undertaken by the local power supply company (Top Energy Limited) to utilise some of the investigation wells for a small geothermal power development. The presence of the toxic pollutants in the fluid necessitated a development design that would eliminate the risk of airborne or ground water pollution and for this reason a 9 MW binary plant was selected as the first stage of a 24 MW development. In 1996 resource consents were obtained, however, these were granted for a 12 year period only and this caused some difficulties in securing financial backing for the project.

Construction of the Ngawha power plant, comprising two 4.5 MW Ormat Energy Converter units, commenced in late 1997 and the plant was commissioned in July 1998.

Under the new electricity industry legislation power companies are required to separate their power generation/retail business from their distribution business. Top Energy Ltd. sought a dispensation from the Ministry of Commerce to retain ownership of the Ngawha power plant and this has been refused. However, Top Energy has applied for a judicial review and this is likely to take place early in 2000. If this fails Top Energy plans to transfer the plant ownership to a separate Trust.

4.5 Mokai

The Mokai geothermal field is located 20 km north-west of Taupo. Between 1981 and 1983 the government drilled six exploration wells on the field. Three of the wells demonstrated excellent production potential with downhole temperatures of 326°C recorded and one well, MK5, tested capable of generating 25MWe. The other two wells, situated on the periphery of the field margins, are useful for reinjection purposes. The resource has an estimated potential of at least 180 MWe.

The investigation wells at Mokai were drilled on Maori land belonging to the Tuaropaki Trust. With the New Zealand electricity market open to private generators the Trust established the Tuaropaki Power Company (TPC) in 1994 and charged it to investigate and if financially viable build a geothermal power station that would utilise the Mokai geothermal resource. After long and protracted negotiations TPC acquired the Mokai investigation wells from the government. Resource consents for the construction of a 57 MW power plant were obtained in 1997 and in the same year a bankable power sales agreement was negotiated with the Electricity Corporation of New Zealand, who were also contracted by TPC to undertake the operation and maintenance of the plant.

In January 1998 an Engineer Procure and Construct contract was awarded to Ormat Pacific Limited for the provision of a 57 MW Ormat Combined Cycle power plant and the construction of a 20km transmission line to link the Mokai plant to the national grid. Construction of the plant commenced in late 1998 and consists of a 30 MW back pressure turbine generator having an inlet steam pressure of 17 bar abs. and an exit steam pressure of 1.3 bar abs. The LP steam passes to four 4.5 MW Ormat Energy Converter units and the hot separated geothermal water is used to power a further two 4.5 MW Ormat OEC units. All condensate and cooled geothermal brine is reinjected. In addition to the 6 investigation wells the project required one additional production well and one reinjection well to be drilled.

The Mokai plant is programmed to commission in December 1999 and is the first geothermal development in NZ to be fully owned by a Maori trust.

4.6 Rotokawa

The Rotokawa geothermal resource is a deep high temperature field covering about 25sq km and located adjacent to the Waikato River approximately 8 km north of Wairakei.

Investigation drilling of the field was undertaken in the 1960`s and early 1980`s, when 8 wells were drilled by the government. Good production levels were found at around 2000 to 2500m depth where the wells intersect high temperature flows along faults. Reservoir temperatures of up to 330°C have been measured at depth, and shut in well pressures are around 80 bar abs. The resource has an estimated potential of at least 200 MWe.

Casing corrosion resulted in four of the investigation wells being cemented up and abandoned in 1993/4. Two of the remaining four investigation wells RK1 and RK5 are located on Maori land, belonging to the Tauhara North Tribal Trust, who purchased these wells from the government. With the New Zealand electricity market open to private generators the Trust entered into a joint venture partnership in 1995 with Power New Zealand Limited, to build a power station having a net output of 24 MWe to serve the growing township of Taupo.

The JV project used RK5 as a production well and RK1 as a reinjection well and drilled one additional production well RK9 and two more reinjection wells RK11 and RK12 to provide the necessary production and reinjection requirements for the plant. The Rotokawa power station is configured as a geothermal combined cycle plant and was procured and engineered by Ormat Pacific Limited. High pressure two phase fluid is piped to a separator located within the station compound. Separated steam at a pressure of 23.5 bar abs. is fed to a 14 MWe back pressure steam turbine generator which exhausts at a pressure of 1.5 bar abs. into two 5 MWe binary units. Hot brine from the separator is fed to a third binary unit having an output of 5MWe. The plant, which was commissioned in December 1997, has an installed capacity of 29 MWe and gives a net output of 24 MWe at ambient climatic conditions. The annual generation is around 190 GWh.

Under the new electricity industry legislation requiring power companies to separate their power generation/retail business from their distribution business, Power New Zealand Limited choose to remain a “lines company” and sold its interest in the Rotokawa joint venture to Transalta (NZ) Limited. In December 1999 Transalta sold their interest in the project to Mighty River Power Company.

4.7 Tauhara

The Tauhara geothermal field is situated to the north-east of Taupo township and is connected at depth with the nearby Wairakei field.

In 1998/99 a Waikato Regional Council Planning Tribunal heard resource consent applications from four private developers, including Contact Energy, for geothermal

developments of up to 60 MW capacity. The Planning Tribunal turned down all the applications mainly on the grounds of the closeness of the respective developments to the Taupo township. Contact Energy have appealed this decision and submitted a revised application for consents to build a 15 MW geothermal power plant on the field. A decision on this application is currently awaited.

5. GEOTHERMAL PROFESSIONAL MANPOWER ALLOCATION

Professional manpower allocation to geothermal activities within New Zealand and overseas during the past five years are shown in Table 7.

Personnel employed by government in geothermal activities over the last five years has reduced significantly due to government selling its geothermal business units to private industry. This movement is reflected in the increase in personnel employed by private sector. Also reflected in the private sector numbers is the increase in geothermal development in South East Asia during the years 1995 to 1998 and then the slump in this development brought on by the economic crisis to hit the area in late 1998.

6 INVESTMENT IN GEOTHERMAL DEVELOPMENTS

Table 8 outlines the general order of investment made in geothermal investigations and developments in New Zealand from 1985 to 1999.

Of note during the last five years is the big change from public to private funding which is a direct reflection of the governments privatisation policy towards the electricity generation industry.

7 CONCLUSIONS

NZ geothermal developments under taken over the last 5 years have an average installation cost of around NZ$2 million/MW (US$1.1 million/MW) which is significantly lower than similar developments elsewhere in the world. This low cost is partly as a result of the projects being able to use investigation wells previously drilled by the government and with one project the windfall purchase of unused power plant.

Restructuring carried out over the last 12 years has seen the NZ electricity industry change from being an inefficient government dominated monopoly business to one which is truly competitive and providing customers with one of the lowest electricity prices in the developed world.

The rapid development of private generation over the last 5 years has resulted in a significant over capacity in the electric power generation needs of the country. This factor and the low price of natural gas will inhibit further geothermal power development for the foreseeable future.

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICTY

	Geothermal		Fossil Fuels		Hydro		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
Operational in January 2000	441	2,335	2,901	11,215	5,100	23,245	39 (wind) 8 (biogas) 40 (wood)	148 57 275	8529	37,275
Under Construction in January 2000	nil	nil	nil		120	520	nil	nil	nil	nil
Funds committed, but not yet under construction in January 2000	15	125	nil		nil		10 (wind)	40	145	685
Total projected use by 2005	456	2,460	2,901	11,215	5,220	23,765	97	520	8,674	37,960

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 1999

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status	Type of Unit	Unit Rating MWe	Total Installed Capacity MWe	Annual Energy Produced 1999 GWh/yr	Total Under Construction Or Planned MWe
Taupo	Wairakei	1958-63	10	OP	2 IP - BP 1 LP - BP 4 LP - C 3 IP - C	2 x 11.2 1 x 5 4 x 11.2 3 x 30	162	1290	
			3	Planned	Binary	3 x 5			15
Taupo	McLachlan	1996	1	OP	1 IP -C	1 x 55	55	225	
Reporoa	Ohaaki	1989	4	OP	2 HP BP 2 IP C	2 x 11.2 2 x 46	114	350	
Kawerau	Tasman P&P Co	1966	1	OP	1 BP	1 x 10	10	60	
Kawerau	Kawerau Binary	1990	3	OP	Binary	2 x 1.2 1 x 3.5	6	40	
Taupo	Rotokawa	1997	4	OP	Combined Cycle	1 x 12 3 x 4.5	25	200	
Northland	Ngawha	1998	2	OP	Binary	2 x 4.5	9	73	
Taupo	Mokai	1999	7	OP	Combined Cycle	1 x 25 6 x 5	55	30	
Total			35				436	2268	15

BP = Back Pressure C = Condensing OP = Operational

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 1999

[1] I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish and animal farming
S = Snow melting
H = Space heating & district heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

[2] Enthalpy information is given only if there is steam or two-phase flow

Locality	Type[1]	Maximum Utilization					Capacity	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Avg. Flow	Energy	Capacity Factor
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	
Kawerau	I	89			2780	420	210	74	5500	0.83
Kawerau	A	6.8			2780	420	16	3.4	253	0.5
Kawerau	G	-			2780	420	>0.08	0.034	2.52	-
Reporoa	A	42	142	90			9.14			<0.5
Reporoa	A	19	142	90			4.14			<0.5
Wairakei	F	89	130	80			18.6	55	363	0.62
Taupo	G				2760	420	0.055			
Rotorua	H	110			600	400	>22		694	
TOTAL		335.8					280	132	6813	

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 1999

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Space Heating[1]	>22	>700	-
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish and Animal Farming	18.6	363	0.62
Agricultural Drying[2]	29.3	>253	
Industrial Process Heat[3]	210	5500	0.83
Snow Melting	-	-	-
Bathing and Swimming[4]	28	265	0.3 (est)
Other Uses (specify)	-	-	-
Subtotal	307.9	7081	-
Geothermal Heat Pumps	-	-	-
TOTAL	307.9	7081	-

[1] Includes district heating (if individual space heating is significant, please report separately)

[2] Includes drying or dehydration of grains, fruits and vegetables

[3] Excludes agricultural drying and dehydration

[4] Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JAN, 1995 to Dec 1999

[1] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	(all)	3				4.5
Production	>150° C	15				22
	150-100° C					
	<100° C					
Injection	(all)	9	1			17.5
Total		27	1			44

TABLE 7. Allocation of Professional Personnel to Geothermal Activities
(Restricted to personnel with a University degrees)

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
1995	40	2	7	nil	nil	36
1996	25	2	8	nil	nil	55
1997	25	2	8	nil	nil	68
1998	14	2	7	nil	nil	102
1999	8	9	7	nil	nil	48
Total	112	17	37	nil	nil	309

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (1999) US$

Period	Research & Dev`nt Incl. Surface & Drilling Exploration	Field Development Incl. Production Drilling & Surface Equipment	Utilization		Funding Type	
	Million US$	Million US$	Direct Million US$	Electrical Million US$	Private %	Public %
1985-1989	15	85		90	5	95
1990-1994	5	16		nil	5	95
1995-1999	4	30		120	98	2

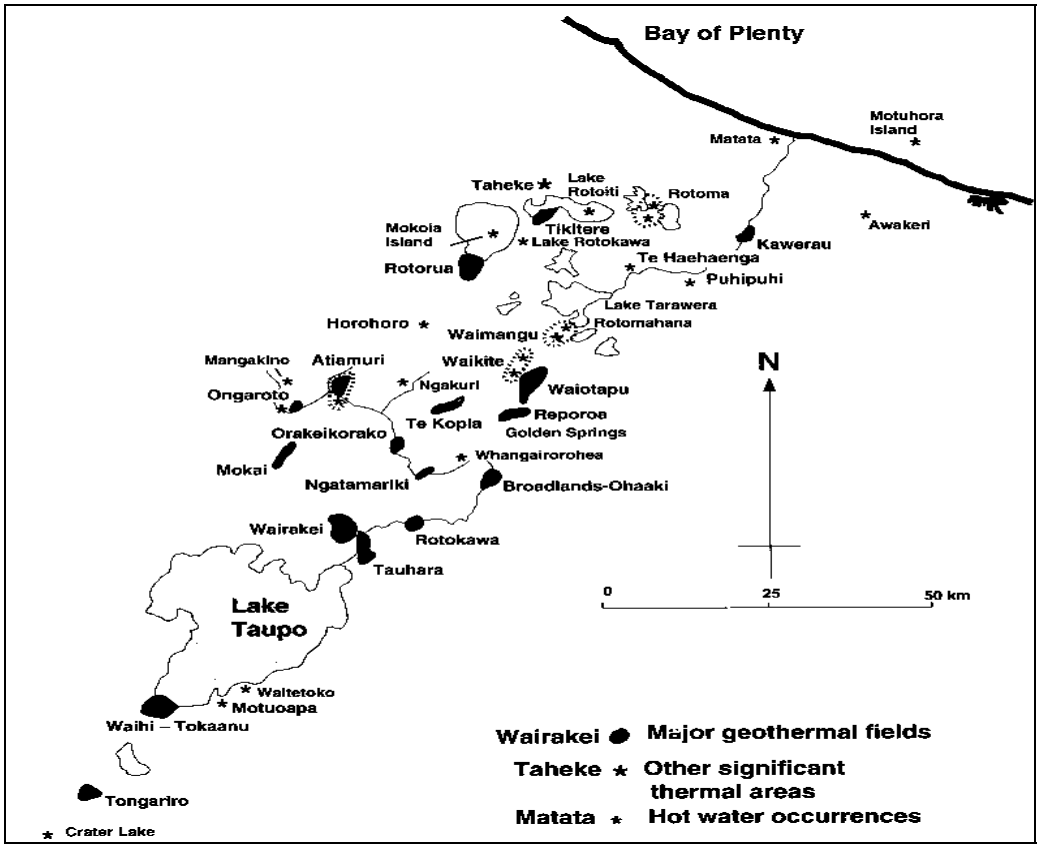

Figure 1: Geothermal Fields in the Taupo Volcanic Zone