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2000-2005 New Zealand Country Update

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ABSTRACT

This paper reports on a period of consolidation in the NZ electricity industry as it matures from what was a government monopoly to a privatised competitive commercial business. Tightening gas supplies have refocused attention on renewable energy resources and several dry autumns have highlighted the risk of dependence on limited hydro storage. Details of new geothermal power developments and expansion projects undertaken over the period 2000 to 2004 are provided along with an update of existing operations.

1. INTRODUCTION

Most of the historical development of the New Zealand electricity industry has occurred under direct control of the central government. However, over the past decade or so successive New Zealand governments have placed almost all aspects of the electricity business onto a commercial footing and privatized large sections of the industry. The most aggressive changes were made in the mid and late nineties when the generation and retailing of electricity was transformed under Electricity Industry Reform Act 1998.

1.1 Competition

The objective of electricity market reform was to reduce the dominant position of ECNZ and provide competition in the supply of electricity.

The Electricity Corporation of New Zealand (ECNZ), which was responsible for 95% of the generation, was split into four entities. Initially, Contact Energy was formed, inheriting around 30% of ECNZ's generating assets including the Wairakei and Ohaaki geothermal power stations. Contact Energy was privatised in April 1999, with Edison Mission Energy Group from the USA as a cornerstone investor. Edison Mission gained a controlling interest in the company and in 2004 sold this interest to Origin, an Australian utilities company with oil and gas exploration interests. Contact is the largest of three privately owned electricity generation and retailing companies in New Zealand.

The remaining ECNZ assets of were divided among three state owned generation companies in April 1999. These generation companies are Genesis Energy (North Island hydro and the 1000MW Huntly conventional thermal power station), Meridian Energy (around 2340MW of South Island hydro power) and Mighty River Power Company, with 1095MW of hydro power stations located on the Waikato River and geothermal plants in the North Island.

At the same time as the three state owned generation companies were formed local power supply and distribution companies were forced to split electricity retailing businesses from the local distribution businesses. The lines companies were thus forced to sell off generation assets, a number of which were acquired by TrustPower, the second largest of the privately owned generation and retail operations.

Separation of the lines business from generation and retailing was intended to increase competition, remove cross subsidization and promote economic efficiency.

Since the break up of ECNZ and the separation of lines and retail operations there has been a period of considerable rationalization within the industry, with the state owned generation companies acquiring retail customers to balance their generation portfolio and the merging of numerous local distribution companies mainly into two much larger companies.

The extent to which the original aims have been achieved has been endlessly debated although there is no doubt that many avenues for cross subsidization have been removed.

The last round of major reforms occurred in mid 1999 before a change of government. Since that time New Zealand has been led by two centre left Labour led governments. Further privatization of generation is against the policy of the present government, which has shown an increasing willingness to become involved in electricity market issues.

1.2 Market behavior and governance

The performance of the new electricity market was severely tested during 2001 when an extended period of dry weather resulted in very low hydro lake levels. Many companies received an unwelcome introduction to the need to manage electricity market risk through the use of financial contracts. Prices on the spot market soared and several participants in the new market found themselves exposed to prices never anticipated. Two electricity companies made very large losses, with one forced to quit retail operations. Some commercial and industrial users chose to curtail production to reduce exposure to the spot market. The ensuing political fallout was severe with claims of market manipulation and calls for voluntary savings from the residential sector, which received little if any financial gain for the sacrifices made.

Further disturbances in the market occurred in 2003, when a dry autumn combined with uncertainty over thermal fuel supplies again led to a period of sustained high prices. With fresh memories the 2001 dry winter the 2003 event triggered nervous reactions within the market (and the government), long before lake levels became critical.

Part of the response was the introduction of a government funded “reserve generation” scheme in 2004 which represented the first intervention in the market since the 1999 reforms. Since then the government has also moved to underwrite a new gas combined cycle plant being constructed by Genesis (government owned), sharing commercial risks arising from uncertainty in gas supplies.

An important industry structural change, also in 2004, is the establishment of an Electricity Commission, charged with ensuring that the principal objective of the Electricity Act 1992, *"To ensure that electricity is generated, conveyed, and supplied to all classes of consumers in an efficient, fair, reliable, and environmentally sustainable manner"*, is achieved. Between 1999 and 2004 the industry had been essentially self regulating, but the mix of private and state owned companies responsible for generation transmission and retailing was unable to agree on a set of rules for future self governance. As a consequence the market became regulated by the new Electricity Commission. Although the new regime has only been in place a short time most of the industry functions as it did under self governance.

2 CURRENT AND FUTURE POWER DEVELOPMENTS

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

Official statistics (Ministry of Economic Development, 2004) show that during the past five years there has been a net loss in system generating capacity of about 330 MW. Around 500MW less gas fired generation is recorded in the latest figures, compared to 2000, although part of the reduction in gas fired generation is attributable to increased use of coal in the dual fuel Huntly plant. Most of the decommissioned plant was older gas fired peaking plant, some of which has since been replaced as part of the Government's reserve generation initiative.

There have been modest additions to hydro (140 MW) and geothermal (6 MW) and, very recently, a large increase in wind generation (120 MW). An additional 236 MW of capacity is recorded for coal plant (mostly attributable to altered fuelling at Huntly). Biogas is essentially unchanged, while wood and waste heat cogeneration is down by 70 MW.

Geothermal currently represents 5.5% of the installed generating capacity and provides around 7.1% of the total electricity needs of the country.

2.1 Salient generation statistics for 2004

Peak power generation occurred in mid-August 2004 when system demand reached 6,513 MW, which is equivalent to 76% of the total installed generating capacity.

The average annual wholesale spot price of electricity in 2003 was 8.29 cents/kWh (5.22 US cents/kWh), whilst the twelve months to October 2004 averaged 3.84 cents/kWh (2.42 US cents/kWh). The high year on year price volatility in New Zealand is due to the predominance of hydro generation and the relatively short term storage available, which leaves the market susceptible to extended periods of high price during dry spells.

The large range in annual price movement underscores the need to manage electricity market price risk through the use of financial contracts, although a number of participants have found the contracts market is relatively illiquid.

2.2 Geothermal development

Compared to the period of rapid deregulation between 1995 and 2000, the recent rate of geothermal development has been slow, with only 6 MW of new electrical generation recently added as part of energy efficiency improvements at Rotokawa. However, the immediate outlook is more promising with construction of the phase two expansion at Mokai and drilling for new generation facilities in the Putuaki sector at Kawerau and construction underway on a binary plant at Wairakei.

All of the developments under construction or on the immediate horizon are on fields that are already used for power generation, which helps to keep installation costs down. Expanding an existing scheme also has the benefits of reducing resource development risk and an easier pathway through the regulatory processes. No completely new developments have been progressed past the pre-feasibility stage, although interest has been expressed in the Ngatamariki and Te Kopia fields at the resource planning level and some scientific work has been done on the Atiamuri, Horohoro and Tikitere fields..

Geothermal power plant in current operation and developments planned to come into service before 2010, are detailed in Table 2.

2.3 New focus on renewable energy

Over the past decade the low cost and plentiful supply of natural gas appeared to provide the most obvious path forward for new electricity generation in New Zealand. Three new combined cycle gas turbine (CCGT) plants and a large scale South Island hydro project called Project Aqua were expected to underpin the base load needs for some years to come.

However, the Maui gas field, which has been the mainstay of gas supply in New Zealand, is reaching the end of its economic life slightly sooner than expected and replacement fields have proven to be both smaller and more expensive to develop than anticipated. Only one of the three proposed CCGT plants is now likely to be built in the next five years and even then only after a Government risk sharing arrangement to cover the gas supply risk.

Project Aqua, touted as the last low cost large scale hydro opportunity in the country, has also foundered, being shelved in 2004 due to uncertainties around access to the water and community concern about land use.

The outlook for future energy supplies has therefore moved quite quickly away from gas and large hydro over the past two years. Much of the current debate now revolves around the acceptability of coal versus alternatives such as wind, small scale local hydro and geothermal, and the effect implementation of the Kyoto Protocol may have.

In 2003 The New Zealand Ministry for Economic Development published a New Zealand Energy Outlook to 2025, in which geothermal is expected to make a substantial contribution to New Zealand's future energy needs. The outlook projects a total contribution of 3325MW of new electricity generation by 2025, with 630MW coming from geothermal, increasing the share from about 7% currently to around 15% (MED, 2003).

The overall framework for Renewable Energy in New Zealand is the National Energy Efficiency and Conservation Strategy (NEECS) which was released in September 2001. NEECS contains a target for an additional

30PJ per annum of consumer energy (over 2000 levels) from renewable sources by 2012. To date about 6.5PJ has been achieved, with a further 5.3PJ committed (East Harbour, 2003). Another 10PJ is under investigation, but the 30PJ target now appears very ambitious following the demise of Project Aqua, which alone would have provided approximately 11PJ.

If the 30PJ renewables target is retained, the demise of Project Aqua may shift the focus toward geothermal resources. It is difficult to see how this target can be met without a major contribution from geothermal, as, compared to other renewables, geothermal has the best potential for development on the scale required.

One new mechanism being used to promote the development of renewable energy is to offer tradable carbon credits to projects that will reduce carbon emissions over the first Kyoto commitment period. Eligible projects must demonstrate that the additional value of the carbon credits will make an otherwise uneconomic project attractive. Several power generation projects including wind, hydro and geothermal have secured credits under the scheme.

The accelerated development of geothermal resources forecast in central government plans is, however, difficult to reconcile with recent regional government plans, where most of the technically feasible resources are either controlled by existing operators or protected from development. The issue of local government control over geothermal resources versus the national interest in energy supply has been debated at some length. Good progress is being made although there are many significant issues to be resolved and widely disparate views on appropriate use of natural resources. Recently the central government has shown a greater willingness to become involved in these issues.

2.4 Renewable energy supply

Official figures for total renewable energy use in New Zealand are skewed somewhat by the distinction (or lack thereof) between the provision of heat and electricity. The useable form of geothermal energy is considered to be heat provided at the wellhead, despite the fact that almost all the geothermal heat produced in New Zealand is converted into electricity. This system of accounting, where it is essentially primary energy that is measured, inflates the relative importance of geothermal in the renewable energy totals.

Geothermal heat at the wellhead is considered to provide about 40% of New Zealand's renewable energy supply (7% of the electricity), while hydro (which produces 63% of the electricity) contributes 42% of the renewable energy. The use of woody biomass in the forestry industry makes up most of the rest, with a contribution from cogeneration in other process industries. Wind generation currently provides less than 0.5% of the total renewable energy, although the rate of growth is presently high.

3. DIRECT USE UPDATE

Thain and Dunstall (2000) provided a direct use update to the 2000 WGC meeting, where they reported that little had changed on the direct use scene since 1995. This report confirms that for almost a decade the direct use scene in New Zealand has been quite stagnant. System capacities are shown in Table 3 and a summary is provided in Table 5.

Absolute consumption figures remain quite high, as they continue to be dominated by industrial use at the Pulp and Paper Mill operation at Kawerau (now owned by Norske Skog and Carter Holt Harvey, previously Fletcher Tasman) but new uses of geothermal heat are small and dispersed and probably only partly offset those that have been discontinued through natural attrition.

The Kawerau operation continues as a very successful use of geothermal energy on an industrial scale, with geothermal fluids being 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 is also collected and treated for reuse as a source of feed water in power and liquor recovery boilers. A small greenhouse at the same site, which ran as a separate operation, previously made use of steam from the Kawerau field but this operation (greenhouse area of 5250m^2) has been closed to make way for a log yard.

A new greenhouse operation, on a much larger scale, is currently under consideration by the same operators. The project is at a formative stage but the plans are very ambitious. The project proponents consider the Kawerau geothermal resource, with its large area of flat free draining land, good labour pool and industrial support infrastructure, has the potential for a major greenhouse area (200-500+ha) that could essentially replace the existing bulk of the present NZ industry. The potential for carbon taxes on fossil fuels to impact on present greenhouse operations and the possibility of using CO_2 from geothermal sources for plant growth stimulation are key factors in this scenario which, if it is developed, could become a complex of international significance with a key marketing advantage of being an off-season producer to the large northern hemisphere markets.

Other uses in New Zealand are very minor in comparison to direct use at Kawerau, although there have been some encouraging developments at Mokai, where the most notable new development in the agricultural use of geothermal energy for some time is the establishment of a 5ha greenhouse operation. This operation uses fluid from the same supply that feeds the Mokai geothermal power station and is another initiative of the Tuaropaki Trust, who own the power plant. The main crops are tomatoes and capsicum (green peppers) and the operation is a significant provider of work for the local community. Expansion of the Mokai greenhouse area is planned up to 20ha.

Other small-scale operations are scattered about the central North Island, but industrial use of geothermal heat is not extensive. Recent data indicates that there has been little expansion of industrial energy use of geothermal in New Zealand and that the relative cost compared to other energy sources is the most significant barrier to greater uptake (East Harbour, 2003). The economic benefits of using geothermal energy are only realized when the scale and intensity of heat use is high, as it is in Kawerau. For many other individual operators the energy intensity of their operations is too low to make geothermal a viable alternative.

The largest concentration of small direct use applications remains in the city of Rotorua, where use has been quite static for the past decade or so. There is a long history of geothermal use in Rotorua that was linked to a decline in the natural features at the Whakarewarewa reserve, resulting in major restrictions on use during the 1980s to prevent further decline of these features. A period of regulatory uncertainty followed, which stifled development, before better management systems were put in place. The field recovery has been quite good with many old springs resuming surface flows, sometimes with problematic consequences. Most of the heating systems that survived through the period of regulatory uncertainty remain in use, but there has been relatively little new development.

3.1 Heat Pumps

Geothermal heat pumps have made little impression on the energy market in New Zealand, particularly when compared to their rapid uptake in Europe and the United States. Despite a number of energy cost increases over the past decade the cost of electricity and gas remain low on a world scale. A 2004 electricity cost comparison shows that New Zealand is cheaper than at least 15 European countries, the USA and Japan, and has only slipped ahead of France and Canada in the most recent survey (MED, 2004).

Even more importantly the relative cost of natural gas and LPG compared to electricity has remained low, so the incentive to switch to more efficient electric powered systems has not existed to any great degree. This is less so for the South Island than the North, where average temperatures are lower, the climate has more annual variation and natural gas is not reticulated.

Most of the few known examples of ground source heat pumps have been in the central South Island although the uptake is small and consists of isolated examples rather than an emerging trend. The uptake of air source heat pumps has been more noticeable in the domestic market and this may spearhead the penetration of more sophisticated equipment into this market in the future.

4. NEW ZEALAND GEOTHERMAL RESOURCES

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

Wairakei power station is now just a few years away from 50 years of operation and 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 older parts of the field has continued to decline, but the rate of decline at Wairakei is now much slower than experienced early on. Periodic drilling of make up wells allows steam production to be maintained.

The most significant recent event at Wairakei has been the application for new consents to operate the plant, which have been in preparation for several years. A large number of consents are required, covering all aspects of operation from well drilling and fluid gathering through the process to air, surface water and ground water discharges. The mitigation or avoidance of adverse effects is a key consideration in the granting of consents and the application and hearing process is the first time the environmental effects of the Wairakei operation have been under public scrutiny since the plant began production in 1958.

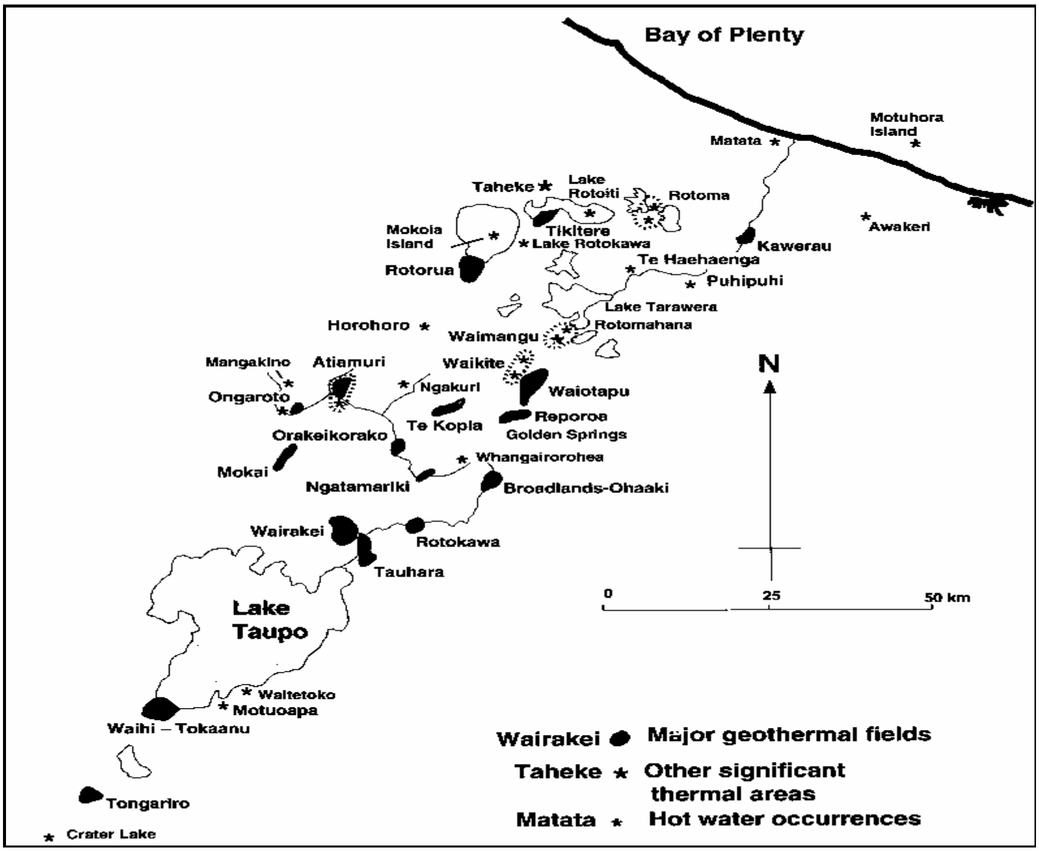

Figure 1: Geothermal Fields in the Taupo Volcanic Zone

As at 13 October 2004 all the consents required for the continued operation of Wairakei have been granted albeit with a large number of conditions which will change the way operations are conducted, particularly with regard to the disposal of waste fluids and management of the effects of subsidence.

It is almost certain that some of these consents or their conditions will be appealed either by Contact Energy or by groups concerned about aspects of the Wairakei operation. The final outcomes will, therefore, not be known for some time. However, whatever the outcomes, they will represent a very significant milestone for geothermal development in New Zealand.

4.2 Efficiency improvements at Wairakei

Resource consents have been held by Contact Energy for some time for the installation of a 15 MW binary power plant at Wairakei. This plant is now under construction and is expected to come on line mid-2005. Two air cooled ORMAT units will use approximately 2,800 ton per hour of brine at 127°C sourced from the current steam field operations. Output of approximately 120 GWh per year is expected without any additional wells.

The 55 MW Poihipi Station, located on the south-western side of the Wairakei field, was the first privately owned geothermal power station to be built in New Zealand. The plant was built as a joint venture between the land owner and an Auckland based lines company but law changes in 1999 prevented continued ownership by a lines company and the plant was sold to Contact Energy.

The steam supply for the Poihipi plant is currently provided from four shallow wells into a shallow steam cap which formed as a result of liquid drawdown during operation of the original Wairakei plant. Although the plant has a 55MW turbine generator unit installed it cannot generate at this output due to a restriction on the available steam. The resource consents held for the plant only allow it to operate at an output of about 30MW for two thirds of the day, so it is operated as a two shift peaking station to maximize revenue.

It is technically feasible to provide steam from the main Wairakei steam field to the Poihipi plant to obtain better utilization of the turbine. However, some changes to the resource consent conditions for Wairakei and Poihipi are required to implement this. These changes are being managed as part of the Wairakei consent renewal process.

4.3 Ohaaki

Steam production from the Ohaaki field has continued to decline due to cool water from the field margins encroaching on production wells. Over the last five years net output has reduced from 50 to around 30 MW (Thain and Dunstall, 2000).

Some new wells have been drilled to maintain production at current levels and a more intensive drilling program could probably boost steam supply. However, there do not appear to be any firm plans to drill further wells at this time.

4.4 Kawerau

The Kawerau field has produced steam for direct use at the Kawerau Pulp and Paper mill since the early 1950's. Two phase fluid is produced and until relatively recently much of the separated water was directly disposed of in the Tarawera River. Since the early nineties some of this separated water has been used in ORMAT binary plants, increasing the utilization efficiency of the resource and reducing the heat load on the river.

Current resource consents to discharge separated water into the river require that ongoing efforts be made to further reduce the brine discharge.

Starting in 2004, Mighty River Power has begun a drilling program to prove up a new area of the Kawerau resource. The Putauaki sector lies to the east of the previously utilised area and within the same resistivity boundary. Three wells have been drilled thus far although the results have not been reported. Ultimately, it is expected that up to 100 MW of electricity may be produced from wells in this sector.

4.5 Ngawha

Operations at Ngawha have continued essentially unchanged from those reported by Thain and Dunstall (2000). The Ngawha development utilizes fluids with low temperature (220 to 230°C) and enthalpy (975 kJ/kg) compared to the high enthalpy fields of the TVZ. The fluid has high levels of dissolved minerals such as boron and mercury.

The low enthalpy and presence of toxic pollutants in the fluid necessitated a closed cycle system so a 10 MW binary plant was selected as the first stage of a 25 MW development. Two 4.5 MW Ormat units are used.

The resource consents granted in 1996 were obtained for only 12 years and an application to renew these consents and to extend the plant capacity by 15MW was made this year. A renewal was granted for the existing operation to continue for another 15 years, rather than the 35 years requested, and the application to expand the operation was declined due to concern over the potential effects on surface features including springs used for bathing. These decisions are to be appealed by the field operator.

4.6 Mokai

The Mokai geothermal field, located 20 km north-west of Taupo, has been in production since 2000, providing high enthalpy fluids for a 55 MW ORMAT Combined Cycle power plant. The plant consists of a 30 MW back pressure turbine with an inlet 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 fluids are reinjected.

The Mokai field is notable for the high output of its production wells, which have some of the highest downhole temperatures recorded in New Zealand (>320°C). The capacity of the field has been estimated at greater than 180MW and a 39MW expansion of the Mokai plant is currently under construction at a cost of NZ$70M (US$44M). The expansion will add a 34MW steam turbine and an 8MW ORMAT unit operating on brine. Commissioning is expected mid-2005.

The Mokai plant is the first geothermal development in New Zealand to be fully owned by a Maori Trust, and is operated for the Trust by Mighty River Power.

The Tuaropaki Trust, who own the station, have also developed geothermal greenhouses using the same resource.

4.7 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 was undertaken in the 1960`s and early 1980`s, when 8 wells were drilled by the government. Good production was encountered 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.

Problems with external casing corrosion resulted in four of the investigation wells being cemented up and abandoned in 1993/4. Two of the remaining wells (RK5, RK1) were used to build a 24MW power station, along with a new production well RK9 and two new reinjection wells RK11 and RK12.

Rotokawa power station uses high pressure two phase fluid piped to a separator at the station. Steam at a pressure of 23.5 bar abs. is fed to a 14 MWe back pressure steam turbine 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 original plant, which was commissioned in December 1997, has an installed capacity of 29 MWe and gives a net output of 25 MWe. An additional 6MW brine unit was added in 2002 increasing the total output to31 MW.

A continuation of the well casing failures experienced in the exploration wells was experienced with the loss of well RK9 in 2003. This well was replaced by a new well (RK13) which was part of a three hole make up program drilled at the same time as the new wells needed for the Mokai expansion.

Rotokawa is owned and operated by Mighty River Power.

4.8 Tauhara

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

Contact Energy, who operate the neighboring Wairakei field, applied for a resource consent for a development of up to 60 MW capacity. This was declined, but they were successful with a revised application for consents to build a 15 MW geothermal power plant on the field.

These resource consents will expire in 2006 in they are not exercised.

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.

The number of personnel employed directly by government in geothermal activities has continued to decline. Almost all activity over the last five years has come from private industry, or from government owned enterprises run along business lines. In particular, over the past two years, Mighty River Power has been adding geothermal expertise in anticipation of future needs as they enter a growth phase. Mighty River Power is involved in the current expansion of the Mokai facility, operates the Rotokawa field and is undertaking exploration drilling in the Putuaki sector of the Kawerau geothermal field.

The closure of the Geothermal Diploma Course, previously offered by the Geothermal Institute at The University of Auckland has been a major change for the New Zealand industry. The Institute had, through the Diploma Course and the associated annual Geothermal Workshop, provided a focal point for the industry. The Workshop continues, but without the presence of the students. The Geothermal Institute itself is now fully absorbed within the course structure of the Science faculty, rather than providing its own specialised courses.

6. INVESTMENT

The total capital investment in new geothermal generation plant over the last five years is estimated to be of the order of NZ$10-12 million (US$6.5-7.5 million) not including wells needed to maintain existing operations.

Current spending is however at a much higher rate with the construction of the Wairakei binary plant and the Mokai expansion underway. Active exploration of the Putauaki sector of the Kawerau resources is also being undertaken.

It is estimated that the completion of the expansion projects will result in at least NZ$120M (US$76M) having been invested over the 2004-2005 period, for a total capacity increase of 54MWe.

7. CONCLUSIONS

There has been relatively little completed development in NZ over the last 5 years. However, several significant projects are currently under construction. Recent developments in the gas sector and the demise of a large scale hydro project may see some refocused attention being given to geothermal energy.

Geothermal energy has some significant barriers to overcome in terms of public perception about the environmental effects and faces competition from wind and coal.

The period of rapid development of private generation just prior to 2000 created significant over capacity that suppressed development for a time. This period is over and the timing of the latest expansion projects reflects this. However, the construction of a 385MW combined cycle gas turbine scheduled to come on line in 2006 is expected to suppress further geothermal development other than that discussed until about 2008. The next phase of development is likely to include expansion at Rotokawa and Kawerau.

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr
In operation in January 2004	435	2745	71 2567	534 cogen 11587 coal/gas	5524	24560	0	0	36 64 27	107 wind 402 wood 93 biogas	8720	40028
Under construction in January 2004	39 15	320 120							36+90	375 wind		
Funds committed, but not yet u construction in January 2004	15											
Total projected use by 2010	570											

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2004

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash; 2F = Double Flash; 3F = Triple Flash; D = Dry Steam; B = Binary (Rankine Cycle); H = Hybrid (please specify); O = Other (please specify)

3) Data for 2004

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Unit Rating MWe	Total Installed Capacity MWe	Annual Energy Produced 2004[3)] GWh/yr	Total under Constr. or Planned MWe
Wairakei	Wairakei	1958-63	10 3	OP Const.	2 IP - BP 1 LP - BP 4 LP - C 3 IP - C Binary	2 x 11.2 1 x 5 4 x 11.2 3 x 30 3 x 5	165	1290	15
Wairakei	Poihipi	1996	1	OP	1 x D	1 x 55	55	215	
Wairakei	Tauhara								15
Reporoa	Ohaaki	1989	4	OP	2 x 2F 2 x 2F	2 x 11.2 2 x 46	104	300	
Kawerau	Tasman P&P Co	1966	1	OP	1 x 1F	1 x 10	8	80	
Kawerau	Kawerau Binary	1990	3	OP	Binary	2 x 1.3 1 x 3.9	6.5	50	
Rotokawa	Rotokawa	1997 1997 2003	4 1	OP OP	Combined Cycle Hybrid	1 x 14 3 x 4.5 1 x 4.5	31	290	
Northland	Ngawha	1998	2	OP	Binary	2 x 4.5	11	79	
Mokai	Mokai	1999	7	OP	Combined Cycle Hybrid	1 x 25 6 x 5	55	470	39
Total			36				435	2774	69

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT (excluding heat pumps) AS OF 31 DECEMBER 2004

[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

[3] Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

[4] Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

[5] Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate (kg/s)	Temperature (°C) Inlet	Temperature (°C) Outlet	Enthalpy[2] (kJ/kg) Inlet	Enthalpy[2] (kJ/kg) Outlet	(MWt)	Ave. Flow (kg/s)	Energy[4] (TJ/yr)	Capacity Factor[5]
Kawerau	I	89			2780	420	210	74	5500	0.83
Kawerau	A	6.8			2780	420	16	3.4	253	0.5
Reporoa	A	25	142	90			5.43			<0.5
Wairakei	F	244	125	75			51	146	963	0.6
Rotorua	H	110			600	400	>22		694	
Mokai	G				2795	420	>0.08	0.034	2.5	
Taupo	G				2760	420	0.055			
Taupo	H, B	180	73							
Waiotapu	H, B, I	2	130							
Waikite	B	35								
Horohoro	G	1.5								
Te Aroha	B	0.868	85							
Miranda	B	13.5	64							
Waingaro	B	10	54							
Hot Water Beach	H, B	0.833	63							
Okoroire	B		43							
Okauia	B	24.5	47							
Okauia	O	15	47							
TOTAL		758					300	223	7413	

Note: Okauia - irrigation of crops for frost-protection

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2004

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC). (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% capacity all year

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Space Heating[4]	>22	>700	
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish and Animal Farming	18.6	363	0.62
Agricultural Drying[5]	29.3	>253	
Industrial Process Heat[6]	210	5500	0.83
Agricultural drying and dehydration			
Snow Melting			
Bathing and Swimming[6]	28	265	0.3 (est)
Other Uses (specify)			
Subtotal	310	7081	
Geothermal Heat Pumps (heating mode only)			
TOTAL	310	7081	

4) Includes district heating (if individual space heating is significant, please report separately)
5) Includes drying or dehydration of grains, fruits and vegetables
6) Includes balneology

Note: please report all numbers to three significant figures.

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2000 TO DECEMBER 31, 2004

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				6
Production	>150^o C	9				18
	150-100^o C		20?			4
	<100^o C					
Injection	(all)		1			0.15
Total						

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)
2000	15	5	7	nil	nil	50
2001	12	5	7	nil	nil	40
2002	10	5	5	nil	nil	35
2003	8	5	2	nil	nil	40
2004	7	5	2	nil	nil	60
Total	52	25	23	nil	nil	225

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1990-1994	5	16		nil	5	95
1995-1999	4	30		120	70	30
2000-2004	13	40		80	20	80