# Review of Current and Future Personnel Capability Requirements of the NZ Geothermal Industry

- Revision 3 – FINAL
- October 2005

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# Executive Summary

The NZ geothermal industry is entering into a large and exciting forward development program over the next decade. This represents the most concerted level of development activity undertaken at any time in NZ and may result in an increase of geothermal generation capacity of 500MWe. This would bring total geothermal generating capacity in NZ to 1000 MWe.

An industry survey conducted as a major part of this study confirms that there are some 350 personnel currently engaged in the NZ geothermal industry as professional engineers, scientists and technically qualified plant operators.

The major part of the engineering and science skills in the NZ geothermal industry resides within the consultant sector which is large and highly developed due to a long association with and dependence on work in the international geothermal market.

The overall capability of geothermal personnel in NZ is adjudged to be more than sufficient to meet the requirements of a 500 MWe geothermal power development program over ten years. However, this would require a high level of availability of the consultant sector which might otherwise be engaged on overseas geothermal work, or conflicted in the domestic market. Historically the 6 large NZ consulting companies, which have some 200 geothermal personnel, have been engaged almost 100% on overseas work. It is likely that this will continue, particularly as there are strong indications that the international geothermal workload in SE Asia is ramping up again as the impact of the Asian financial crisis abates. It is thus likely that this will result in there being insufficient geothermal capability resident in NZ over the next decade to meet in full the requirements of the 500 MWe development program.

The results of the industry survey also indicate a looming problem with geothermal capability in NZ beyond the next decade. This is due to a significant industry ageing issue, compounded by current difficulties in bringing younger staff into the areas of plant operations and the consulting sector.

It is recommended that NZGA focuses on both recruitment and training as two key issues facing the NZ geothermal industry today and provides support and assistance to the industry in overcoming these obstacles.

# 1. Introduction

This report has been prepared by Sinclair Knight Merz (SKM) under contract to the New Zealand Geothermal Association (NZGA), with the financial support of the Energy Efficiency and Conservation Authority.

The objective of the report is to review and assess the following:

- the current personnel capability of the geothermal industry in New Zealand
- expected expansion of geothermal power generation capacity over the next decade
- the personnel capability required to support this expansion
- what actions might need to be taken in the near term to ensure that the geothermal industry is able to source appropriate numbers of personnel with the right skills mix as and when required in the future

# 2. Required Capabilities in Geothermal Development and Operations

## 2.1 The Geothermal Development Process

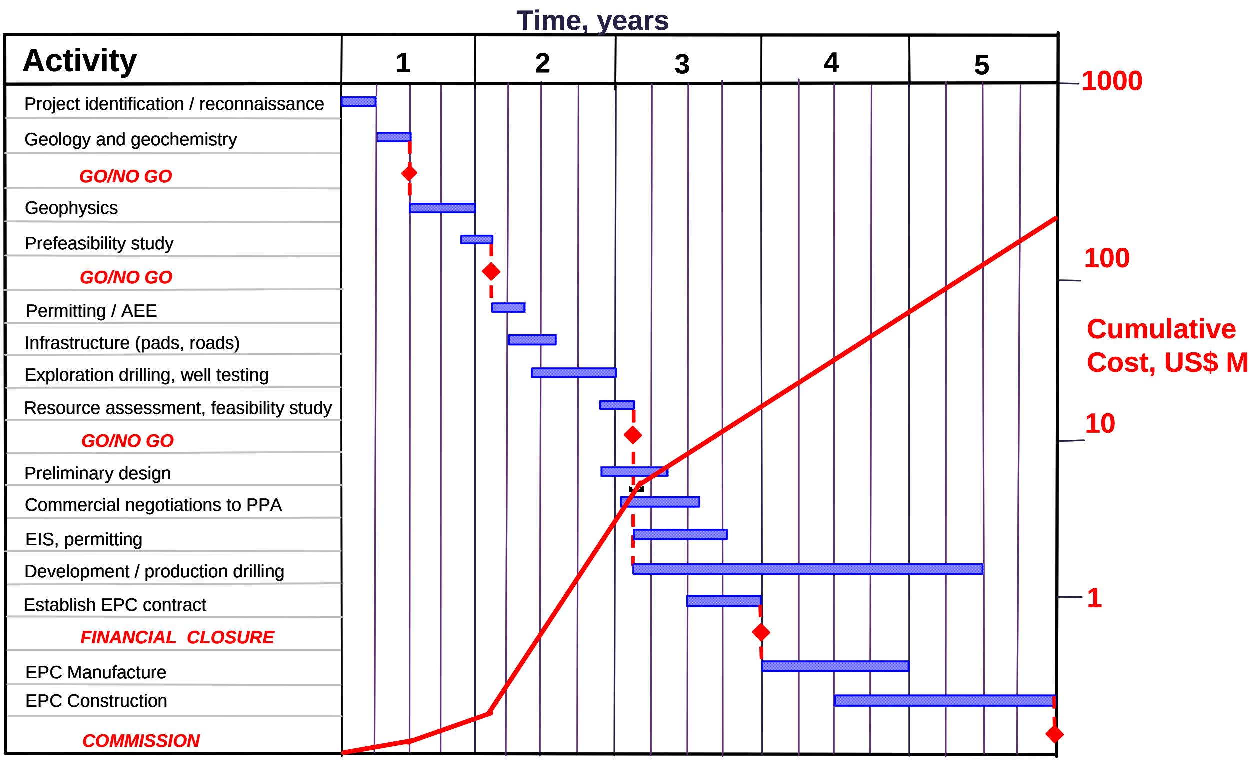
### 2.1.1 Introduction

Geothermal projects in general go through a series of stages with time:

- exploration
- development
- construction
- operation

The separation of the first three stages are marked by major decision points manifested by an increased need for expenditure, but with the successful completion of each stage there is a decreasing amount of risk.

- **Figure 2-1 Typical geothermal development stages, costs and timing (100MWe plant)**



In most countries, the early high risk stage of exploration has been most commonly shouldered by government agencies with projects either being completed by government or turned over to private developers after their viability has been established.

In New Zealand geothermal development procedures have gone through an evolution. Initially all stages of geothermal projects in New Zealand were government-controlled[1], providing a valuable legacy for future developers. Over the past decade, this situation has changed with the private development of projects initially explored by the government and operating geothermal projects sold off to private industry. The point has now been reached where ‘private’ developers[2] are now prepared to undertake their own exploration.

The introduction of the Resource Management Act 1991 devolved environmental management to regional councils and required that adverse environmental effects be avoided, remedied or mitigated. Through regional policy statements and regional plans, Regional Councils designate some geothermal systems for development, some for protection, and others for small uses. They also set the policies and rules concerning development. Developers and other users of geothermal resources need to be involved in the development of these policy documents to ensure their interests are considered and catered for.

While in New Zealand geothermal rights remain vested in Government, the landowner can still exercise *de facto* control over the geothermal resource, by controlling access to it. New Zealand is also unusual in that there is no mechanism for obtaining an exclusive geothermal exploration licence or concession, as there is for minerals or petroleum. Resource development consents are only issued at the development stage, once considerable expenditure may have been undertaken. This means that for a potential developer, landowner agreements become particularly important to ensure exclusivity.

Similarly, local iwi with a kaitiaki role over some surface expressions of geothermal have a measure of control through consultation requirements under the Resource Management Act. Very often iwi and land owner interests meet in the form of Maori Trusts which own substantial areas of land over almost all New Zealand geothermal resources. Any potential developer must obtain

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[1] Licences did allow private sector development of geothermal resources. Thus, the Kawerau geothermal resource was developed by private interests, and commenced operation in 1957, the year before production at Wairakei began.

[2] This report categorises State-Owned Enterprise developers, such as Mighty River Power, as ‘private’ because of their operational characteristics. ‘Private’ also has traditional connotations.

Resource Consents from the relevant regional and district councils to undertake some exploration activities and to develop the resource.

Thus the exploration stage currently prevailing in New Zealand requires not only scientific input, but also requires gaining regulatory approval and that of the landowner, and often support of local Maori interests. This means that the progress of the scientific work may be restricted by these other requirements and takes longer than in some other countries.

The multiplicity of parties involved may lead to a requirement for more scientific input than would be the case in a simpler, centrally-directed regime. The fact that we are operating within an essentially adversarial legal regime only exacerbates the situation. For example, a resource consent application may involve as a minimum the project developer (who may be a JV), a financier (which could be a syndicate), multiple landowners, central, regional and local government, and other potentially affected parties. Each of these parties will have at least some requirement for technical input or evaluation of the project and its potential effects, and to avoid conflicts of interest within the regulatory and legal process, each may require their advisers to be independent. Thus the number of independent agencies with technical capability required could be large.

Another way in which the regulatory regime in New Zealand differs from that in most countries with large scale geothermal development, and which will have an effect on the amount of technical work required and hence manpower, is that in the Waikato Region at least (which includes about 80% of NZ's high temperature geothermal resources), there is a requirement to demonstrate to the satisfaction of the consent authority, the sustainability of a proposed geothermal development to obtain a resource consent (over perhaps 100 years). To do that requires taking a longer-term view (including numerical simulation modelling) than would be required if the only criteria are the physical ability of the resource to support the development, the financial feasibility and physical environmental impacts.

The first step in exploration is to define the area of interest and to review the available literature in a desktop study. Once an area has been defined and necessary regulatory and landowner approval obtained, detailed scientific exploration is undertaken, which can be divided in geological, geochemical and geophysical stages, that depending upon circumstances may be conducted contemporaneously or can be a set of steps in themselves. These culminate in the formation of a hydrogeological model of the system that incorporates all the scientific data. The resource is then assessed using a stored heat calculation. There is a trend to develop numerical reservoir models at a very early stage of resource investigation in order to secure consents.

If the results of the surficial exploration are positive, exploration drilling is undertaken. If the results of the drilling are very encouraging, the project can be fast tracked into production drilling

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and development, but otherwise there would be a phase of delineation drilling, prior to production drilling and some cases significant amounts of production drilling would be undertaken prior to development.

The development stage itself can be broken down into a set of phases. These are planning and permitting, negotiating a power supply contract, obtaining finance, environmental and sociological studies, geotechnical evaluation, design, negotiation and contracting with suppliers, development of infrastructure, building of the steam gathering system and power plant, and construction of electrical transmission lines. These activities overlap and depending upon the timeframe of development may be conducted step by step or as close together in time as the critical path allows. Current practise is to outsource as much of this activity as possible in the form of Engineer Procure Construct (EPC) contracts, and in this review they are generally lumped together as construction.

Once construction has been completed and the power plant commissioned, the field then goes into operation. Operation and maintenance procedures include well measurements and developing a production data base from which a numeric model can be developed.

In practice developments may be staged and station and steamfield may require ongoing development. This is to minimize development risk or follows recognition of a more extensive resource than that on which the first stage funding and consents were based on.

### 2.1.2 Desk Top Study

The desk top study is a literature review that should include a full library search and use of the Internet. The information gathered includes that directly relating to geothermal energy and also involves establishing the regional geology and geophysics, and reviewing other exploration activities that have been undertaken in the area of interest, most particularly mineral and oil exploration, but ground water and geohazard investigations. Even if these do not add to the direct information regarding the presence of geothermal resources they can provide valuable background information for ongoing phases of the exploration and development.

### 2.1.3 Reconnaissance Survey

The reconnaissance study is to physically confirm and document the information from the desk top study. This requires a combination of geology and geochemistry. Since this includes visiting the known thermal features it should also include sampling of the thermal features, associated deposits and hydrothermal alteration for analysis.

### 2.1.4 Detailed Geoscientific Exploration

#### 2.1.4.1 Geological Study

The first step is a geological survey. There are two reasons for this. The first is that the geological survey may locate new or previously unreported thermal features that can be sampled during the geochemical programme. Secondly, there is a need to have geological input to the geophysical survey. This includes establishing the full scope of the area that needs to be included in the geophysical survey and determining the area's structure so that measurement stations for the geophysical surveys can be appropriately located. Much of this information can be gained by remote sensing studies undertaken prior to going into the field. This includes examination of aerial photographs and satellite imagery, which can then checked for ground truth in the field.

#### 2.1.4.2 Geochemical Study

The geochemical study involves sampling and analysing all the thermal features in the prospect area. It is important to do this in one go, so that a set of baseline data is created through which changes to the geothermal system with time can be monitored. The major outcome from the geochemical study is to confirm the information obtained from the reconnaissance study. In particular with regard to possible reservoir temperatures, whether the deep reservoir is vapour or liquid dominated, what its gas content may be, and to exclude the possibility that gases of direct magmatic origin are present. A further major indicator can be established by the distribution of thermal features. The overall area in which they occur can give some indication of the size of the system. The distribution of different springs of different chemistries, particularly with elevation, gives valuable information regarding the systems near surface hydrology and can establish whether there are one or more geothermal systems present.

#### 2.1.4.3 Geophysical Study

A wide range of geophysical techniques have been applied to the exploration for geothermal energy. The techniques which have been the most successful are those that obtain deeply penetrating resistivity measurements that allow a three dimensional resistivity structure of the field to be established within drillable depths. The main technique today for doing this is Magneto-Tellurics (MT), but Transient Electromagnetics (TEM) has been successfully applied. There have also been recent seismic studies (both active and passive) that may be valuable exploration tools, but have not been sufficiently widely used to be cost-effective routine exploration tools.

### 2.1.5 Conceptual Model and Resource Size Estimate

Once the three geoscientific surveys are completed, the information derived from them is combined into a conceptual model of the system. This is presented as a three-dimensional diagram showing the geology, hydrology, estimated temperature contours and the nature of the reservoir fluids. At this stage an assessment of the system's overall capacity can be made, by establishing the potential resource area. For a high enthalpy resource this is the area in which temperatures can be anticipated to be in excess of 200°C at depth. It is then possible to carry out a more detailed stored heat capacity assessment.

If the resource is of sufficient size to meet the needs of the exploration programme and there is evidence for a neutral hot reservoir the decision to begin exploration drilling can be made.

### 2.1.6 Exploration Drilling

Traditionally in most countries this has involved a programme of three deep full-sized wells. The reason that three are needed, apart from the necessity to avoid single site specific problems, is that three wells are the minimum by which any area can be defined. Another approach to exploration drilling, not used to any great extent in NZ, which minimises risk is to initially drill slim holes and then to twin successful holes with a full sized well. In addition to temperature data, slim holes produce very good geological data because they are continuously cored. They can also produce chemical data from the deep reservoir. This approach whilst minimising risk, also adds substantially to early costs of the programme incurring financing charges over a significant period before the project produces income. Particularly since slim holes can not produce income themselves because the outputs of successful slim holes are too low to be worth reticulating them. Where the drilling is high risk, for example if there were good geophysical results, but a dearth of surface features prevented making an assessment of the resource temperature this would be a prudent approach. To do this would require there to be some strong driving factor to actually develop such a system (for example if it was close to a market with high electricity prices).

At the completion of each well a series of injectivity tests and temperature, pressure and spinner[3] runs are made to establish where the well is producing from and the characteristics of that production. The well is left to heat and then discharged to established its overall production characteristics and the chemistry of the produced fluids.

### 2.1.7 Delineation Drilling

The main aim of the delineation drilling is to fully establish the resource area. This would usually be a programme of four full sized wells, but this will vary with the actual size of the resource and as a general rule of thumb there should at the conclusion of the exploration and drilling program be at least one successful well per square kilometre of the resource area that is intended to be developed. There is a trade off in the aims of delineation drilling. The main aim of the delineation drilling is to prove up as large an area as possible, but there is still a need for the wells to be

[3] A ‘spinner’ tool can be used to infer well bore flows.

potentially part of the development and for them to contribute to the available steam at the well head. This area may be more restricted by land ownership, environmental or terrain considerations. In order to maximise the area of the resource some of the wells need to be drilled as close to the interpreted resource boundary as possible. This involves a risk that the wells will not be successful producers or if they are, they may not be able to be connected with the full development (though they may be useful for reinjection). In this case slim holes can be used to establish the resource boundaries with full size wells drilled closer to the centre of the resource to ensure they are productive and connectable.

The wells will then be tested as described above. If possible one of the wells will be discharged and the fluids reinjected under pressure into another permeable well while a micro-earthquake study is undertaken in order to identify potentially permeable structures at depth to provide targeting information for the next round of drilling.

### 2.1.8 Bankable Feasibility Study

The bankable feasibility study reports the results of the foregoing exploration and delineation, primarily to establish the size and nature of the resource. The initial stored heat calculations can be refined to determine the size of the resource by using the temperature distribution at depth determined by the wells as input into a series of stored heat calculations utilising Monte Carlo modelling. At this stage a preliminary numerical simulation model may also be prepared. From the most likely size of the resource the report establishes technically feasible ways of developing the resource and determines their cost. The most economical of the options is then used as input into a financial model. Long-term steam sales or electricity sales contracts should already be established at this stage so the key outcome of the bankable feasibility study is that the financial model is sufficiently robust that the project is economically viable.

### 2.1.9 Initial Production Drilling

The extent of initial production drilling required is that which is necessary to obtain financial closure. For smaller developments this may have been met by the results from the exploration and delineation drilling (including existing wells previously drilled by the Crown as at Ngawha and to a large extent at Mokai and Rotokawa) and no further production drilling will be required. For larger developments requiring more wells, it comes down to what criteria the financing agency require the project to meet. Generally this will be some percentage of the necessary steam at the well head to fully operate the power plant on a sustainable continuous basis. This percentage and definition of how much steam is necessary can vary between financiers.

The wells will be tested and drilling continued until the requirements for financial closure are met. Interference and tracer testing between wells can be undertaken and if necessary further micro-earthquake studies undertaken. Baseline gravity and levelling surveys and other environmental investigations should be undertaken following financial closure.

### 2.1.10 Production Drilling

The final phase of drilling to achieve the targeted steam at the well head will begin after financial closure. The wells will be tested and drilling continued until production targets are met. Interference and tracer testing between wells can be undertaken.

### 2.1.11 Reinjection Drilling

Reinjection drilling is usually left to the last phase of the drilling programme. This is primarily because financial closure is required before reinjection drilling can begin. In some cases reinjection capacity or the reinjection drilling programme can be advanced by using exploration and delineation wells that are not suitable for production as reinjection wells or by identifying favoured areas for reinjection. The reinjection wells will receive completion tests but may not necessarily be discharged. Interference and tracer tests back to production wells can be undertaken and micro-earthquake studies undertaken.

### 2.1.12 Construction

The construction phase begins at financial closure, although preparatory work and planning for construction that involve minimal expenditure should be well advanced at this stage. This phase is no different from any other major civil project, except there may be a smaller range of acceptable contractors with previous experience in the construction of geothermal power or process heat plants and steam field systems than would otherwise be the case. Included in the construction phase is the construction of transmission lines. Generally the construction will be done under an EPC contract or series of contracts.

The power plant is then commissioned and production begins. Operation and management activities include onward going well testing and building up a data base from which the numeric model of the system can be initially calibrated and then updated with time. As the field draws down and/or problems such well scaling and corrosion are encountered it may be necessary to bring a drilling rig in to work over new wells, including drilling new legs or drill entirely new wells. Wells may also be acidised or perforated in order to obtain more production.

## 2.2 Geothermal Operations

Once construction of a geothermal power project has been completed and the steam field and power plant commissioned a long period of operational activities is commenced. These will continue for at least 25 years and more likely for up to 50 years before the plant is decommissioned for generally reasons of obsolescence rather than resource depletion. These long term activities will comprise:

- Steam field and power plant/process heat operational activities in production steam, supplying steam to a facility for use. This will include scientific staff in steam quality testing and managing cooling tower chemistry
- Condition monitoring of all plant and equipment
- Geothermal resource monitoring which includes:
  - downhole surveys, output testing of production wells and capacity testing of injection wells
  - geochemical analysis and interpretation of well brine and steam gases
  - geophysical techniques including repeat micro gravity, and micro seismic surveys
- Geothermal resource management which is based on understanding and reacting to changes in the performance of a geothermal reservoir through assessing and interpreting changes in well behaviour as determined by physical well measurements, well geochemistry and predictive results from numerical reservoir models
- Environmental monitoring which in addition to the above is likely to include:
  - gas emissions and air quality
  - water quality
  - level surveys
  - surveys of thermal activity and ecosystems
- The design and drilling of occasional make up and replacement wells as longer term reservoir pressure drawdown and injection declines will require additional production and injection well capacity
- Occasional well workovers to remedy possible problems with well bore blockages, casing failures, through collapse or corrosion, or to possibly seek additional production with side tracks
- Occasional engineering efficiency studies which may lead to the installation of additional facilities or removal or existing plant. Examples of this might include the removal of high pressure topping plant after some level of reservoir pressure rundown has occurred after project start-up, or the later installation of second stage flash plant or brine binary plant in bottoming mode, or some further use of geothermal heat either upstream or downstream of the power plant.

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## 2.3 Required Personnel Capabilities

The range of personnel capabilities required for undertaking the development and operational activities described above is considerable and involves the disciplines listed in Figure 2.1.

This report is principally concerned with the engineering and science capabilities required for geothermal development and operations. It also takes into account critical peripheral services (e.g. drilling, heavy engineering capability) and comments are made on these.

**Figure 2-2 Disciplines involved in the geothermal industry**

- Scientific
  - geology
  - geophysics
  - geochemistry
- Resource Engineering
  - reservoir
  - well measurements
  - drilling
- Design Engineering
  - mechanical
  - civil
  - structural
  - process
  - civil
- Construction
  - contracting
  - construction
  - safety
  - commissioning and testing
  - project management
- Operations
  - steam field
  - power plant
  - maintenance
- Environmental and regulatory
- General Risk Assessment

The requirement for skilled personnel in the geothermal industry is dependent on the stage of the project. Personnel numbers are highly skewed to a large requirement during the development phase, with far fewer numbers required both prior to that during the preceding exploration phase and even fewer numbers for subsequent long term steam field and power plant/process heat plant operations.

SKM has an extensive store of historical development data from numerous large (100 MWe +) overseas geothermal developments collected over the past 30 years. These all follow a very similar pattern of personnel requirements with time, as summarised in Figure 2.2. Personnel requirements for a 50 MWe project would be similar.

Of note in this figure is that even though the development phase has a high level of focussed engineering input expended over approximately 30 months for production drilling, design, construction and commissioning of steam field and power plant, the total man power requirement

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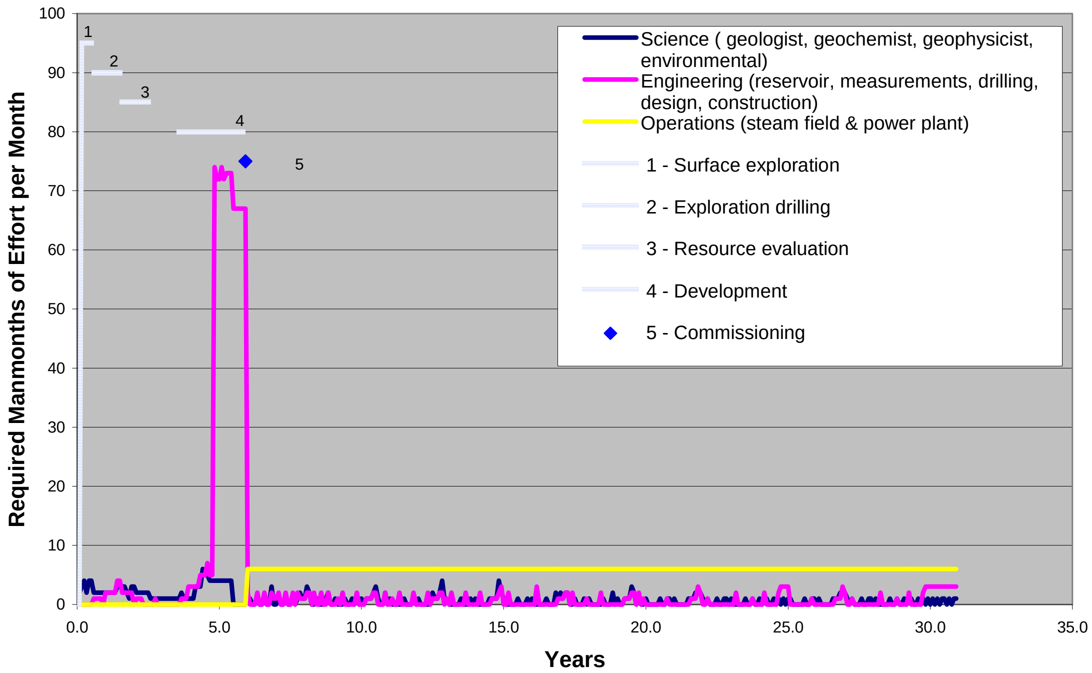
(of about 3000 man months) is about equally split between project start through to commissioning and the subsequent operation of the steam field and power plant for 25 years.

This figure usefully establishes overall personnel and capability requirements for both technical and professional manpower in terms of MWe of installed capacity and this is used in Section 6.3 of this report to estimate future personnel requirements based on expected increases in geothermal generation over the next decade.

- **Figure 2-3 Typical monthly professional and technical manpower requirements during exploration, development and long term operation of a 100MWe geothermal power plant**



# 3. The NZ Geothermal Industry

## 3.1 Historical

Large-scale New Zealand commercial geothermal developments began with Kawerau process heat supply in 1957 then the start up of the Wairakei power plant in 1958. There had been limited power production in 1906 at the Spa Hotel in Taupo. Similarly, there were earlier direct use applications with shallow bores drilled in Hanmer, Tokaanu, near Auckland, Taupo, Rotorua and elsewhere for home, hotel and swimming pool heating and to tap gas for secondary heating and lighting.

The exploration and development of Wairakei were undertaken by government agencies, mainly the Department of Scientific and Industrial Research (DSIR) (and its former incarnations) and the Ministry of Works and Development (MWD) (and its former incarnations), along with engineering input from a UK consulting firm Merz and McLellan (M&M)[4], and the New Zealand Electricity Department (NZED) (and its former incarnations). This required the formation of in-house geothermal drilling capabilities for the MOW, initially based on Mines Department equipment and experience. DSIR, MWD and M&M were involved in the development of separator technology to enable the development of “hot water" geothermal systems. Parallel developments were occurring on the Kawerau field where Bechtel (rather than M&M) were involved with in steamfield and plant design. Consequently the full range of geothermal scientific and engineering skills were built up and many of the fundamental practices that are still in world-wide use were established.

This skill base was maintained by continued exploration drilling at Wairakei and exploration of other geothermal fields in the North Island. The MWD ultimately drilled the Atiamuri, Horohoro, Kawerau, Mangakino, Mokai, Ngatamariki, Ohaaki, Orakeikorako, Reporoa, Rotokawa, Rotorua, Ruahine Springs (Tikitere), Tauhara, Te Kopia and Waiotapu geothermal fields in the Taupo Volcanic Zone (TVZ)[5], and the Ngawha field in Northland. Of these fields only Kawerau was immediately developed, with it supplying both power and process steam to a pulp and paper mill utilising steam equivalent to about 40 MW of electrical generation.

[4] Merz and McLellan recently merged with Parsons Brinkerhoff. The design arm of ECNZ, known as DesignPower had taken over GENZL, which became a division of DesignPower. DesignPower was later bought out by Parsons Brinkerhoff and together trade under the name PB Power. The Australian subsidiary of Merz and McLellan merged with Sinclair Knight to form Sinclair Knight Merz.

[5] A further well drilled at Whakatane did not confirm a geothermal resource.

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The Ohaaki field was drilled out and was ready by the early 1980's for construction of a power plant, but the discovery of and the decision to develop the offshore Maui natural gas field lead to the construction being put on hold. Maui, and various structural changes to Government marked a distinct decline in geothermal exploration and development activities by the government, which to a certain extent was made up for by offshore work.

Outside of New Zealand, starting in 1973 foreign aid programmes for assistance with geothermal development were given to a number of countries, notably Chile, Indonesia and the Philippines. This was initially undertaken by New Zealand government agencies, but then contracted out to private consultancies that worked with government agency overview. GENZL and KRTA were the main consultancies, though later these were joined by DesignPower (the design arm of the Electricity Corporation of New Zealand). Over time with various mergers and buy outs these consultancies have now become PB Power and Sinclair Knight Merz Ltd respectively. These consultancies gained further commercial overseas work in their own right, largely in response to increases in the world oil price. The staff for these consultancies were initially largely sourced from New Zealand Government agencies through secondments, but they steadily built up staff from other sources, as well as continuing to directly employ ex-government staff. With a decrease in worldwide oil prices in the 1990's and the Asian economic crisis this overseas work steadily dried up resulting in a matching decrease in numbers of staff but both companies continue to provide geothermal capability.

As part of the overseas aid programme the Geothermal Institute at Auckland University was formed in 1979. This was mainly aimed at providing post-graduate geothermal education to senior scientists and engineers from developing nations, but a small number of New Zealand students and students from developed countries were also included. Some of the New Zealand students were from government agencies, but others were graduate students and a proportion of these were employed by the consultancies and government agencies; as were some of the overseas students.

From 1984 the government embarked upon a series of free market economic reforms. These included the formation of state owned enterprises from some government departments. The geothermal section of MWD comprising drilling, well measurements and engineering design services was privatised. As Century Resources it is now owned by overseas interests but remain prominent in the New Zealand geothermal scene. However, Century no longer has a monopoly on deep geothermal drilling with at least two other international drilling companies currently providing rigs and a number of other specialist service companies available through the largely Taranaki based petroleum drilling industry.

The NZED initially became a division of the Ministry of Energy, then became the Electricity Corporation of New Zealand (ECNZ). In 1988 as part of the privatisation effort, private

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development of geothermal fields was allowed. In 1989 the Ohaaki power plant was finally commissioned by ECNZ. Wells and information not immediately required by ECNZ at Wairakei or Ohaaki were initially under the management of the Gas and Geothermal Trading Group of the Ministry of Energy, but on abolition of the Ministry (with its associated attrition) the Crown geothermal assets were "temporarily" put under Treasury management (and this continues to the present day)[6]. Throughout this period budget constraints and changes in management style led to an attrition of staff from the government agencies.

Bay of Plenty Electricity installed an Ormat binary plant at Kawerau utilising waste water heat from the Crown-owned steamfield network supplying the pulp and paper plant in 1989.

To this point electricity was distributed locally by Electric Power Boards. In 1990 they began reorganising into a variety of companies with various ownership structures with the passing of the Electric Power Boards Amendment Act.

In 1991 the government split the DSIR into a number of Crown Research Institutes (CRI's) with geothermal capabilities being spread between the Institute of Geological and Nuclear Sciences (GNS) and Industrial Research Limited (IRL). This led to further attrition in staff. A number of those staff and some from the other ex-government organisations successfully established individual or small consultancies that remain active today (see Figure 4.1).

Also in 1991 the Resource Management Act was introduced. This combined the existing plethora of planning and permitting procedures into one process requiring a high standard of environmental protection. This meant that to gain the right to develop a geothermal resource, developers needed to employ scientific staff or consultants to gather the necessary data. Regional government also needed to employ scientific staff to evaluate this data and develop and implement regional plans and policy statements required by the Act. As of today, this planning framework still continues to be developed.

Bay of Plenty Electricity[7] installed a second Ormat binary plant at Kawerau utilising waste water heat from Crown steam supply in 1993.

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[6] A transfer of Kawerau assets was announced as this report was being finalised. The Crown's Kawerau assets, including wells, steamfield equipment and contracts initially passed to Mighty River Power while a back-to-back contract saw the assets transferred from MRP to Ngati Tuwharetoa Geothermal Assets Ltd.

[7] With enforced separation between line businesses and generators under the 1997 Electricity Industry Reform Act, Bay of Plenty Electricity sold their name and generation assets to interests now fully owned by the Todd Group. Distribution assets are held by Horizon Energy.

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Some of the other successor companies to the Electric Power Boards became interested in developing geothermal power and began exploration activities. Of note was the drilling of an exploration well in the previously undrilled field of Rotoma, in 1995, by Power NZ.

The government reforms continued and in 1995 Contact Energy was split off from ECNZ. Part of the national geothermal assets controlled by Contact Energy were Wairakei and Ohaaki. Although much of the necessary scientific and engineering work could be provided by GNS, IRL and Century; Contact also developed in house geothermal capabilities. It built on the skill base initially resident at Wairakei through its former ECNZ staff.

The first modern fully private geothermal power development was commissioned in 1996 at Poihipi Road, a northwestern portion of the Wairakei field. This was undertaken by Mercury-Geotherm, a partnership between the landowner and Mercury Energy, the successor to the Auckland Electric Power Board.

Top Energy, the successor to the Bay of Islands Electric Power Board, developed the Ngawha field in 1998 utilising the existing wells drilled by the government. This marked the first involvement of iwi as part beneficial owners of a power-producing geothermal resource.

The Electricity Industry Reform Act 1998 forced a separationof generation interests above a certain size from line companies. This essentially halted geothermal investment by this sector of the market.

The Rotokawa field was also commissioned in 1997, by TransAlta NZ, with some similarities to the Ngawha development, in that there was iwi involvement, an Ormat power plant (although the Rotokawa plant also included a steam turbine) and existing wells were utilised, although some new production and reinjection wells were required.

After the initial split of Contact from ECNZ, with loss of Wairakei and Ohaaki geothermal power developments, ECNZ proceeded to re-establish a geothermal business. ECNZ continued to cooperate with the Tuaropaki Trust in the development of the Mokai resource. Operation and Maintenance contracts were signed with Mandala Nusantara for the Wayang Windu geothermal project in Indonesia. Other project ideas were followed.

Contact Energy was privatised in 1999 and ECNZ was split into three companies that included Mighty River Power. The Separation of Ownership of Electricity Line and Supply Businesses Act, plus some financial difficulties, led to Mercury Energy selling the Poihipi Rd plant which was eventually bought by Contact Energy in 2000. ECNZ geothermal interests largely passed to Mighty River Power.

Mighty River Power entered the geothermal arena by purchasing TransAlta NZ assets at Rotokawa in 2000. In this year the Mokai power plant was commissioned with iwi taking the lead role in the development through the Tuaropaki Power Company (TPC) but otherwise there are similarities to Rotokawa with utilisation of an Ormat plant and a combination of use of previously drilled wells with new production and reinjection wells. Mighty River Power operated the plant and subsequently has taken a 25% financial interest in TPC. TPC is now involved with the expansion of the Mokai power plant that has just been completed.

The Geothermal Institute despite its success in geothermal education was shut down in 2003 due to a restriction of government funding and the inability of the University of Auckland to make up for the funding shortfall.

During the same year fears of an electricity supply crisis driven by a combination of a dry winter reducing hydro storage and the announcement that the reserve estimates for the Maui field were at the low end of earlier estimates caused a significant increase in power prices. This consequently resulted in an increase in the financial viability of geothermal power projects.

The Crown continued to own exploration wells and information, some of which were made available for the developments previously mentioned. However, a decision was made that Crown assets should be developed and that Mighty River Power, as a state-owned enterprise with an interest in geothermal energy, should be the developer. Negotiations around this and Crown Treaty of Waitangi obligations have continued to the present day.

In 2004 Mighty River Power won a tender by iwi to develop the eastern portion of the Kawerau geothermal field and instituted a drilling programme there.

Since the initial development in 1957, the geothermal facilities at the Tasman Pulp and Paper Plant at Kawerau were maintained and further developed. In 2004, the new owners Norske Skog replaced the 1966 turbo-alternator with a refurbished ex-US Navy 8 MWe turbo-alternator.

Following on from this in 2005 Mighty River Power has made a major public commitment to the development of geothermal energy in New Zealand of which drilling at the Mangakino field has been a public manifestation.

At Wairakei Contact Energy has installed an Ormat plant in 2005 to gain generation from what was wastewater from the Wairakei steamfield.

In July 2005 the Crown took the significant step of transferring the Kawerau geothermal assets to Mighty River Power, with a back-to-back deal in place for transfer of most of these to Ngati Tuwharetoa Geothermal Assets Ltd.

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## 3.2 Current Status of the Industry

Currently Contact Energy continues to operate the Wairakei (including the Poihipi plant) and Ohaaki geothermal fields and is currently engaged in infill drilling. Renewal of resource consents for Wairakei-Poihipi are currently subject to appeal and the impacts of that are uncertain, but no reduction in installed capacity is envisaged. Contact Energy holds resource consents over the Tauhara field and has landholdings and rights over part of the Mokai field. Under the terms of its resource consents for Tauhara, at least limited development will have to occur by the end of 2006 or the consents will lapse. A further development at Mokai will require agreement with the existing operator (TPC), so the timing of that is uncertain.

Mighty River Power continues to operate the Rotokawa development. Tuaropaki Power Company (in which Mighty River has a minority shareholding) has just completed an expansion of Mokai . Mighty River is currently drilling at both Mangakino and Kawerau and is engaged in exploration activities elsewhere in the Taupo Volcanic Zone. A large greenhouse development using geothermal energy has also been installed at Mokai by interests connected to TPC and further expansion of that operation is possible. Top Energy applied for resource consents to expand the Ngawha plant to 25 MW, but this was rejected and it is currently preparing for an appeal.

Norske Skog continues to operate its geothermal process steam and generation facilities at Kawerau. However, future development of generation facilities will now be in the hands of other parties on the field.

Geotherm Group has successfully gained Resource Consent for another geothermal development at Tukairangi Road on the Wairakei field and has purchased a rig to drill there. Consents have been appealed.

The build up of NZ geothermal generation capacity with time is detailed in Table 3.1 and this data is shown plotted in Figure 3.1. Note however that some plants (Ohaaki, Poihipi) can currently not produce at their full rated output.

## 3.3 Expected Future Trends and Developments

### 3.3.1 Technological Trends

There are also some specific technologies that are yet to be widely used, if at all, in New Zealand because the size of the market has not been sufficient to develop or import them, or they have not been considered affordable in the New Zealand context. With increased growth in the industry and rising power prices these perceived impediments may no longer apply. Examples are:

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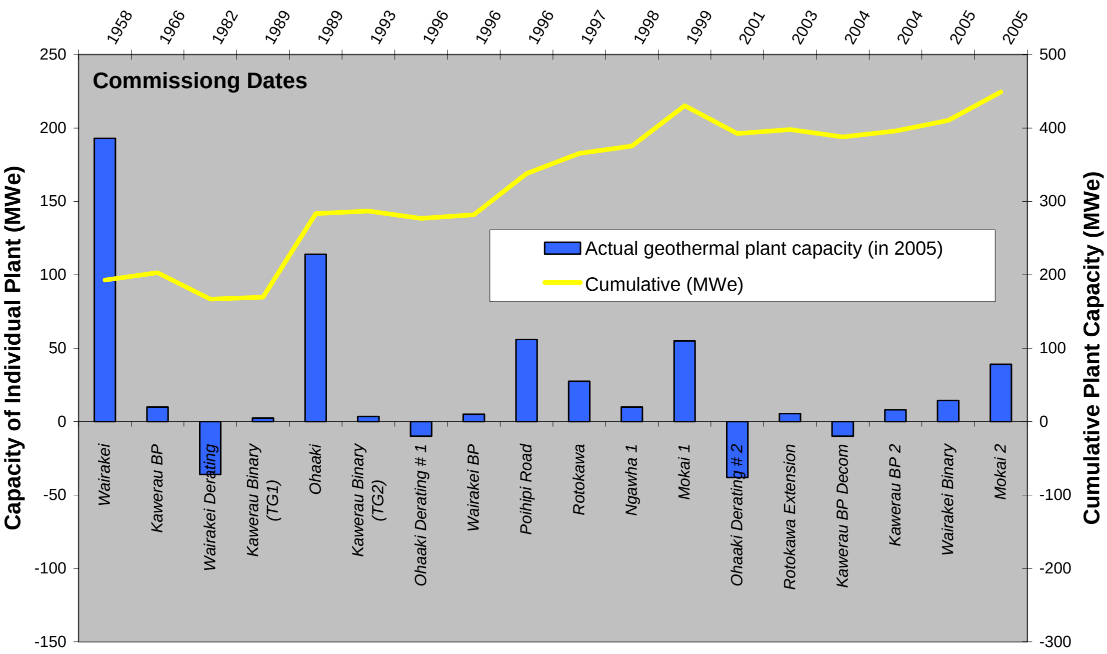
**Table 3-1 Installed NZ geothermal generating capacity**

| Plant Name | Size (MWe) | Commissioning Date | Cumulative Capacity (Mwe) |
|---|---|---|---|
| Wairakei | 193 | 1958 – 1963 | 193 |
| Kawerau BP | 10 | 1966 | 203 |
| Wairakei Derating | -36 | 1982 | 167 |
| Kawerau Binary (TG1) | 2.4 | 1989 | 169 |
| Ohaaki[8] | 114 | 1989 | 283 |
| Kawerau Binary (TG2) | 3.5 | 1993 | 287 |
| Ohaaki Derating # 1 | -10 | 1996 | 277 |
| Wairakei BP | 5 | 1996 | 282 |
| Poihipi Road | 56 | 1996 | 338 |
| Rotokawa | 27.5 | 1997 | 365 |
| Ngawha 1 | 10 | 1998 | 375 |
| Mokai 1 | 55 | 1999 | 430 |
| Ohaaki Derating # 2 | -38 | 2001 | 392 |
| Rotokawa Extension | 5.5 | 2003 | 398 |
| Kawerau BP Decom | -10 | 2004 | 388 |
| Kawerau BP 2 | 8 | 2004 | 397 |
| Wairakei Binary | 14.4 | 2005 | 410 |
| Mokai 2 | 39 | 2005 | 449 |

- Chemical inhibition of silica deposition.
- Logging wells with advanced tools such as FMI to improve geological understanding and improve the success rate of drilling.
- Use of passive microseismic arrays to detect active tensional faults, which represent permeable targets, and once again improve the drilling success rate.
- Use of Kalina-cycle plants now available from various manufacturers, which can operate efficiently on lower-temperature fluid than the plants currently in use, and hence would extend the resource base.

[8] Although Ohaaki still has 114 MWe of plant installed on site, the station generates between 30 and 40 MWe due to field limitations. Some additional Ohaaki drilling has been announced, but the future field output is unlikely to be over 50 MWe in the long term.

**Figure 3-1 Installation with time of NZ geothermal generation capacity**




- High sensitivity airborne infrared, gravity and magnetic surveys to provide targeting information for wells.
- Use of steerable downhole assemblies to reduce drilling times for directional wells.

Application of these technologies has the potential to not only reduce costs, mainly by drilling more successful and hence less wells, but has the potential to increase the production from existing fields and those to be developed in the future. Although these technologies have not so far been applied in New Zealand, some New Zealand companies are familiar with them through their overseas work.

### 3.3.2 Growth Trends

Future growth trends for the geothermal industry in New Zealand depend upon both local and international factors. Locally, a combination of power price trends and the results of government policy implementation are of greatest importance as New Zealand electricity generation is largely derived from indigenous resources. The continued increase in the demand for electricity and current limitations in sources of supply suggest that a general upward trend in power prices would be a reasonable prediction. Fixed price electricity contracts now sit between 7 and 8c/kWh reflecting the current cost of new generation, and set a price that many geothermal developments should be able to compete with.

On the international front, the price of oil is a major factor, as an increase will drive overseas countries to reduce the amount of oil-fired generation by developing geothermal energy (amongst a range of alternatives), in which case there will be a growing market for export of New Zealand geothermal expertise. Currently world oil prices are at post 1970's oil shock highs and there is continued upward price pressure from the economic expansion of China combined with security of supply issues from the Middle East for there to be little expectation of significantly lower prices. The price of internationally traded gas in the form of LNG is directly linked to the price of oil regionally through the Japanese Crude Cocktail formula (a linear relationship). International coal prices are also surging in parallel with oil and gas prices.

It should also be borne in mind that geothermal skills can be redirected into other technologies. The engineering expertise necessary to design or build a geothermal power station could equally be directed towards thermal stations. The scientific expertise could be directed towards minerals exploration or into groundwater research. All of these areas will compete for the same pool of engineers and scientists required for local geothermal development. Thus, growth in these alternative areas will also impact on the availability of a local pool of expertise.

NZ government policy is giving mixed messages on further geothermal development, in part because of conflicting policies between central and regional government. On the one hand geothermal has been classified as renewable and there is a call in the NEECS for 30 PJ of additional renewable generation by 2012. The proposed carbon tax will also be favourable to geothermal relative to other thermal options, even if a tax is applied to geothermal developments also. On the other hand, there is a body of opinion that significant obstacles remain both in the RMA procedures and through the current Waikato Regional Plan and Policy Statement (e.g. Lawless 2005). Recent experience with resource consents for wind and hydro projects as well as geothermal indicate that the 30 PJ target may need to be revised.

Therefore, at least three scenarios have to be considered with all having similar results, but differing in their magnitude. The first scenario is that New Zealand government policy changes will have a negative effect upon internal geothermal development.

The second scenario is that there are no government policy changes with things staying the same, and the third scenario is that government policy changes and the current market will have a positive effect upon the geothermal industry. New Zealand government action is constrained by pressure on power prices and the limited availability of viable alternative generation and will not affect international conditions. Thus, negative government policy outcomes are likely to be sufficiently limited that there will still be growth in the New Zealand geothermal industry even under the first scenario, with successively increased amounts of growth under scenarios two and three. How much this growth will be is ultimately constrained by the amount of undeveloped geothermal resources available.

Given the above scenarios the first and worst case would be if only those projects that have resource consents, but have not yet been developed, were developed, in which case it is estimated that these may yield 80MWe (Lawless, 2002, revised). For the mid-point case of scenario two, all the resources which current regulations allow would be developed. This would give 422 MWe of generation (Lawless, 2002). For the third and best case if the Proposed Waikato Regional Plan reverted to the 1997 draft version 869 MWe (Lawless, 2002) would be available for development. That does not represent by any means total development of the high temperature geothermal resource, but it does include all that is considered currently achievable without undue environmental impact.

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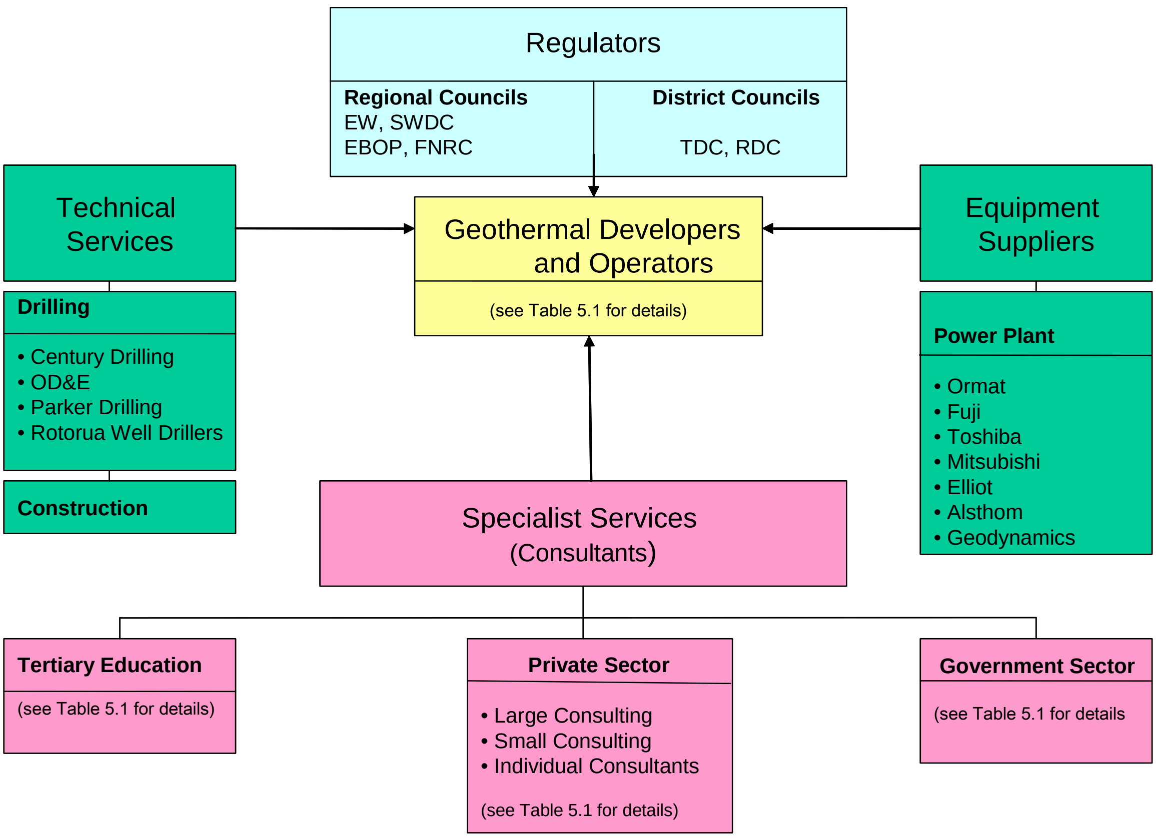
# 4. Key Industry Players

## 4.1 Organization

The New Zealand geothermal industry is organised around a number of project developers and operators as shown in Figure 4.1 and given in more detail in Table 5.1. These entities are the key players. They are controlled by regulations administered by regional and local councils and support a large peripheral industry supplying:

- Equipment ranging from power plant from overseas manufacturers to small locally manufactured items
- drilling and construction services
- specialised engineering, scientific, environmental, economic and legal services provided through a variety of consultant companies from the private sector, tertiary education institutions and government owned entities

- **Figure 4-1 Relationships between key players in the NZ Geothermal Industry**



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The level of activity in the geothermal industry is set by the development and operating companies. During any development phase the entire geothermal industry as depicted in Figure 4-1 is highly engaged, particularly large equipment suppliers and providers of technical services such as drilling and construction companies. Figure 2.3 shows clearly the level of activity that occurs during development.

After the development phase, the level of work for plant suppliers and construction companies is minimal. However, there remains a slow but steady requirement for drilling services - for well workovers and for make up and replacement of both production and injection wells.

The industry requirement for specialised technical services provided through consulting companies is also dependant on the level of exploration and development activity but less so than is the case for equipment supply and construction services. This is because the requirement for specialist services such as reservoir management and monitoring and environmental services continues through the entire production life of an operating field.

The level at which external specialist services are utilised by an operating geothermal development is determined by the extent that the operating company chooses to directly recruit the required skills as in-house capability, or to source them externally. This dynamic is closely set by the level of specialisation of the services required. Most operators will develop and retain in-house capability for commonly required specialist services but seek these externally for less commonly required services, as and when required.

Geothermal consultant services from outside New Zealand, such as GeothermEx of the USA have recently been involved in several New Zealand projects. This is generally not so much because they have skills or provide services that cannot be provided within New Zealand, but rather that available New Zealand companies have been "conflicted out" by competing interest in the increasingly contractually complex and litigious environment that prevails.

## 4.2 The Geothermal Developers and Operators

### 4.2.1 Bay of Plenty Electricity (BoPE)

Bay of Plenty Electricity (BoPE) is a wholly owned subsidiary of Todd Energy and is an energy retailer. The company is located in Whakatane and operates a number of local power generation schemes which include hydro-electricity at Aniwhenua, geothermal generation at Kawerau as well as natural gas cogeneration facilities located in Edgecumbe and Kapuni.

The Kawerau Geothermal plant consists of two power plants known as TG1 and TG2. These provide an embedded form of generation within the BoPE network. TG1 was commissioned in

1989 at a cost of $4.3 million and generates 2.56 MWe of electricity. TG2, was commissioned in 1993 at a cost of $5.4 million.

The plant consists of two geothermal turbines driving a single 3.8 MWe generator. Both TG1 and TG2 are Ormat-manufactured binary power plant using waste brine from steam supply to the Norske Skog pulp and paper plant at Kawerau.

### 4.2.2 Contact Energy

Contact Energy is an electricity generator, and electricity and gas retailer with a mix of generation assets that include hydro, gas, cogeneration and geothermal. The majority shareholder in Contact Energy is Origin Energy of Australia, with the rest of the company freely traded on the New Zealand stock market. It operates the Wairakei, Poihipi Rd and Ohaaki geothermal power stations, has resource consents over Tauhara and a landholding at Mokai.

### 4.2.3 Geotherm Group

Geotherm Group Limited is a geothermal energy generation company based in Taupo. Geotherm developed, constructed and commissioned in 1997 the 55 MWe Poihipi Power Station located on the western edge of the Wairakei field in conjunction with Mercury Energy under a joint venture of Mercury Geotherm Limited. This plant was acquired from Mercury Geotherm by Contact Energy Limited in 2000.

The Geotherm Group re-entered the geothermal industry in late 2004 with the successful application for resource consents for establishing a second geothermal power station in Poihipi Road close to the now Contact Energy owned plant. This new plant will have a capacity of 60MWe and is expected to be commissioned in 2008, subject to consent appeals and financing.

As with the Maori Trusts, the strength of the Geotherm Group has rested with the willingness and determination of a land owner to make a geothermal project happen.

### 4.2.4 Mighty River Power (MRP)

Mighty River Power is one of the three state-owned enterprises split off from ECNZ in 1999. ECNZ interests in geothermal developments were largely vested in MRP.

The company has a range of generation assets, of which the principle assets are the string of hydro stations on the Waikato River. However, it is the only SOE to have developed its geothermal business case, and to subsequently establish a significant team to progress these projects.

MRP has a 25% interest in the Tuaropaki Power Company, and Operation and Maintenance contract for the Mokai development. MRP also owns the Rotokawa geothermal power station, having purchased it from TransAlta in 2000, obtaining steam from the Rotokawa Joint Venture (a 50:50 joint venture between MRP and Tauhara North No 2 Trust), and has an Operation and Maintenance contract for that facility.

The company won a bid with Putauaki Trust at Kawerau east of the mill, and is undertaking exploration drilling under Trust land with a view to staged 50 MWe developments. MRP has also undertaken exploration drilling at Mangakino and is undertaking other geoscientific exploration elsewhere.

As an SOE with geothermal interests, Treasury has identified MRP as the developer of the Crown geothermal assets (subject to fulfilment of Treaty of Waitangi obligations). The Crown has just involved MRP in a deal involving transfer of all Kawerau assets. MRP made a back-to-back transfer with Ngati Tuwharetoa Geothermal Assets Ltd. Norske Skog Tasman is a third party in the deal. Ultimately, there is an interest in additional geothermal generation from the Kawerau field.

### 4.2.5 Ngati Tuwharetoa Geothermal Assets Ltd

Ngati Tuwharetoa Geothermal Assets Ltd appeared on the New Zealand geothermal scene in July 2005. It is a company set up to hold assets transferred to Tuwharetoa ki Kawerau (TKK). This follows a Waitangi Treaty settlement and commercial negotiations involving the Crown, NST, MRP and TKK

### 4.2.6 Norske Skog Tasman

Norske Skog are the current owners of the Tasman Pulp and Paper (TPP) plant at Kawerau, having acquired the plant from Fletcher interests in 1999. The Tasman plant includes the largest geothermal process heat supply in the world. The geothermal steam also supplied a 10 MWe back pressure turbine-generator commissioned in 1966, effectively the first large scale privately-owned geothermal power station in New Zealand.

Norske Skog decommissioned the 10 MWe generator in 2004, and commissioned a refurbished 8 MWe back pressure set in the same year. They continue to own and operate these geothermal facilities, along with other biomass generation and heat plant. They have indicated that further development of the field for power generation will be undertaken by the other parties on the field rather than themselves.

### 4.2.7 Putauaki Trust

The Putauaki Trust is a Maori Trust with land and resource interest in the south of the Kawerau field. In recognition of the value of the resource beneath their land, they outsourced the development of the resource. MRP won the bid with a proposal for exploration and then possible development in 50 MWe stages. Exploration drilling is in progress.

#### 4.2.8 Tauhara North No 2 Trust

This Maori Trust has interests in a centrally located swathe of land through the Rotokawa geothermal field. Consents for the development at Rotokawa were obtained by the Trust, which also acquired Crown wells, and which continues to own steamfield facilities as a 50% joint venture partner with MRP.

#### 4.2.9 Tikitere Trust

The Tikitere Trust is a Maori Trust with land and tourist interests over the Tikitere geothermal field near Rotorua, including the Hells Gate tourist park. The Trust has proceeded with geoscientific investigations with a view to a limited power generation project, and may be proceeding to resource consents before the end of 2005.

#### 4.2.10 Top Energy

Top Energy Limited is the local electricity network company in the mid and far north of the North Island, supplying 26,000 electricity consumers. Established in 1935, the company is owned by its power consumers. Top Energy's shares are held by the Top Energy Consumer Trust (formerly the Bay of Islands Electric Power Trust) on behalf of electricity consumers in the region.

Top Energy manages assets of over $100 million and employs 120 staff. In the last financial year it achieved an income of $160m derived from its networks business ($100 million), geothermal power generation ($30 million) from its 10 MWe Ngawha power plant and with the balance from lines services contracting.

The geothermal plant uses four of the twenty wells drilled by MWD at Ngawha in the early 1980's from which fluid is supplied to an Ormat binary cycle power plant. This produces approximately 35% of the electricity used by consumers connected to Top Energy's network.

Top Energy recently applied for a resource consent to increase geothermal generation at Ngawha. This was denied and Top Energy has filed an appeal.

#### 4.2.11 TrustPower

TrustPower, a NZSE public listed company, is the fifth largest electricity generator/retailer in New Zealand. The company grew from the Tauranga Electric Power Board after deregulation of the electricity supply industry in 1994. TrustPower's current generation portfolio comprises 19 hydroelectric power schemes throughout New Zealand and the Tararua Wind Farm.

TrustPower's interest in geothermal power development goes back more than 10 years. The company's long-term strategy for balancing its hydro and wind power based generation portfolio with thermal generation is the key driver behind this interest. Geothermal is TrustPower's preferred choice because of the nature of the resource and the location of the development opportunities. TrustPower is committed to renewable energy and the prospective geothermal fields are mainly in a supply constraint region.

TrustPower explored a number of opportunities in the Bay of Plenty – Taupo region, amongst them the Kawerau-Putauaki Trust, Te Kopia, Tauhara and the Taheke-Ruahine-Kuhara fields. To date, none of these opportunities have progressed into the exploration and generation development phase. TrustPower lost some of the opportunities to competitors; while other opportunities, such as Te Kopia, became protected resources under the Waikato Regional Plan.

TrustPower is currently pursuing the development of the Taheke geothermal resource jointly with the Ruahine-Kuhara Inc, whom with the company has a long term exploration license agreement.

#### 4.2.12 Tuaropaki Trust and Tuaropaki Power Company (TPC)

The Tuaropaki Trust is a Maori Trust set up to administer land and resources in the Mokai area. The Trust has successful farming and forestry operations and established the Tuaropaki Power Company as the investment vehicle for the development of the geothermal station and steamfield at Mokai.

In 2003 Tuaropaki Trust sold a 25% shareholding in TPC to Mighty River Power, who also hold a contract for the operation and maintenance of the geothermal facilities. Tuaropaki Trust continue to hold a 75% shareholding in TPC.

TPC is the owner of the existing Mokai I station and steamfield (56 MWe), and of the recently commissioned Mokai II development (39 MWe). A major geothermally heated glass house is also located on the geothermal resource.

Plans for further development are unknown, but may include a number of additional direct use applications.

# 5. Industry Survey of Personnel Capability

## 5.1 Survey Methodology

During the course of this study, SKM conducted telephone interviews with senior personnel from companies working in the following areas of the geothermal industry:

- Operators and developers
- Consulting companies and prominent individual consultants
- Regional Councils

In each interview, SKM obtained the following information:

- the company's current staff levels, capabilities, age distribution, current training requirements and how provided
- the company's future expected geothermal program i.e. whether a continuation of the present level of operation or the further development of additional geothermal power generation
- the company's expected future staff levels, training requirements and where to be sourced from
- the company's current use of and views on obtaining geothermal skills through external consulting sources

The results of these interviews are presented in Table 5.1 and discussed in Section 6 in terms of assessed current and future personnel requirements of the New Zealand geothermal industry.

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## ▪ Table 5-1 NZ geothermal industry survey metrics

| Industry Category | Sub Category | Company | Staff | | Scientists | | | | | | | Engineers | | | | | | | | | Operators | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total Staff | Geothermal Total | Geoscientists Total | Geologists | Geophysicist | Geochemist | Chemist | Environment | Regulatory | Engineers Total | Drilling | Reservoir | Measurements | Mechanical | Civil | Chemical / Process | Electrical | Structural | Operators Total | Steam Field | Power Plant | Maintenance |
| Developers and Operator | Operators | Contact Energy | 700 | 46 | 1 | | | | 1 | | | 5 | | 2 | 2 | 1 | | | | | 40 | 8 | 9 | 23 |
| | | Tuaropaki Power Company (TPC) | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | 0 | | | |
| | | Mighty River Power | | 33 | 6 | 3 | | 1 | | 1 | 1 | 9 | 3 | 1 | 1 | 4 | | | | | 18 | 4 | 14 | |
| | | BOP Electricity | 50 | 3 | 0 | | | | | | | 0 | | | | | | | | | 3 | | | 3 |
| | | Top Energy | 120 | 3 | 0 | | | | | | | 0 | | | | | | | | | 3 | 1 | 2 | |
| | | Norske Skog Tasman | | 2 | 0 | | | | | | | 0 | | | | | | | | | 2 | | 1 | 1 |
| | Developers | Geotherm | 3 | 0 | 0 | | | | | | | 0 | | | | | | | | | 0 | | | |
| | | Ngati Tuwharetoa Geothermal Assets | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | 0 | | | |
| | | Putauaki Trust | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | 0 | | | |
| | | Tauhara North No. 2 Trust | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | 0 | | | |
| | | Tikiteri Trust | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | 0 | | | |
| Consultants | Private Sector - Large | Sinclair Knight Merz | 5000 | 64 | 16 | 4 | 3 | 2 | 1 | 3 | 3 | 48 | 2 | 1 | 1 | 18 | 10 | 6 | 6 | 4 | 0 | | | |
| | | Maunsell Limited | 300 | 53 | 10 | 2 | | | | 4 | 4 | 43 | | | | 12 | 9 | 1 | 13 | 8 | 0 | | | |
| | | PB Power | 600 | 32 | 2 | 1 | 1 | | | | | 30 | | 1 | | 15 | 5 | 1 | 5 | 3 | 0 | | | |
| | | Century Resources | 120 | 14 | 0 | | | | | | | 14 | 1 | 2 | 4 | 7 | | | | | 0 | | | |
| | | Dobbie Engineers | 20 | 14 | 0 | | | | | | | 14 | | | | 14 | | | | | 0 | | | |
| | Private Sector - Small | East Harbour Management Services | 10 | 7 | 0 | | | | | | | 7 | | | | 1 | 2 | 2 | 2 | | 0 | | | |
| | | Glucina & Associates | 5 | 2 | 0 | | | | | | | 2 | | | | 2 | | | | | 0 | | | |
| | | Environmental Management Services | 3 | 3 | 3 | | | | | 2 | 1 | 0 | | | | | | | | | 0 | | | |
| | | GeoKem | 2 | 2 | 2 | | | 1 | 0.5 | 0.5 | | 0 | | | | | | | | | 0 | | | |
| | | Geothermal Consultants NZ | 2 | 2 | 0 | | | | | | | 2 | 2 | | | | | | | | 0 | | | |
| | Private Sector - Individuals | Lew Bacon | 1 | 1 | 1 | | | | 1 | | | 0 | | | | | | | | | 0 | | | |
| | | Paul Bixley | 1 | 1 | 0 | | | | | | | 1 | | | 1 | | | | | | 0 | | | |
| | | Andy Bloomer | 1 | 1 | 0 | | | | | | | 1 | | | | | 1 | | | | 0 | | | |
| | | Ashley Cody | 1 | 1 | 1 | 0.5 | | | | 0.5 | | 0 | | | | | | | | | 0 | | | |
| | | KC Foong | 1 | 1 | 0 | | | | | | | 1 | | | | 1 | | | | | 0 | | | |
| | | Dick Glover | 1 | 1 | 1 | | | 1 | | | | 0 | | | | | | | | | 0 | | | |
| | | Malcolm Grant | 1 | 1 | 0 | | | | | | | 1 | | 1 | | | | | | | 0 | | | |
| | | John Hulston | 1 | 1 | 1 | | | 1 | | | | 0 | | | | | | | | | 0 | | | |
| | | Russel James | 1 | 1 | 0 | | | | | | | 1 | | | | | | 1 | | | 0 | | | |
| | | Roy Johnstone | 1 | 1 | 1 | 1 | | | | | | 0 | | | | | | | | | 0 | | | |
| | | Alex McNabb | 1 | 1 | 0 | | | | | | | 1 | | 1 | | | | | | | 0 | | | |
| | | Markos Melaku | 1 | 1 | 0 | | | | | | | 1 | | | 1 | | | | | | 0 | | | |
| | | Mike Mongillo | 1 | 1 | 1 | | 1 | | | | | 0 | | | | | | | | | 0 | | | |
| | | Tricia Scott | 1 | 1 | 1 | | | | | 1 | | 0 | | | | | | | | | 0 | | | |
| | | Doug Sheppard | 1 | 1 | 1 | | | 1 | | | | 0 | | | | | | | | | 0 | | | |
| | | Ian Thain | 1 | 1 | 0 | | | | | | | 1 | | | | 1 | | | | | 0 | | | |
| | | Bill Woods | 1 | 1 | 0 | | | | | | | 1 | | | | | | | 1 | | 0 | | | |
| | Government Sector | Geological Nuclear Sciences | | 26 | 26 | 7 | 11 | 4 | 4 | | | 0 | | | | | | | | | 0 | | | |
| | | Industrial Research | | 3 | 0 | | | | | | | 3 | | 3 | | | | | | | 0 | | | |
| | | Materials Performance Technologies | | 1 | 0 | | | | | | | 1 | | | | | | 1 | | | 0 | | | |
| | | NIWA | | 1 | 1 | 1 | | | | | | 0 | | | | | | | | | 0 | | | |
| **Consultants Totals** | | | | 241 | 68 | 16.5 | 16 | 10 | 6.5 | 11 | 8 | 173 | 5 | 9 | 7 | 71 | 27 | 12 | 27 | 15 | 0 | 0 | 0 | 0 |
| Regulatory | | Environment Bay of Plenty | | 2 | 2 | | | | | 1 | 1 | 0 | | | | | | | | | 0 | | | |
| | | Environment Waikato | | 2 | 2 | | | | | 1 | 1 | 0 | | | | | | | | | 0 | | | |
| | | South Waikato District Council | | 1 | 1 | | | | | 1 | | 0 | | | | | | | | | 0 | | | |
| | | Far North Regional Council | | 1 | 1 | | | | | 1 | | 0 | | | | | | | | | 0 | | | |
| Tertiary Institutions | | Auckland - AUGI | | 3 | 3 | 1 | 1 | 1 | | | | 0 | | | | | | | | | 0 | | | |
| | | Auckland - Eng Faculty | | 3 | 0 | | | | | | | 3 | | 3 | | | | | | | 0 | | | |
| | | UNITEC | | 2 | 0 | | | | | | | 2 | | 1 | | 1 | | | | | 0 | | | |
| | | Massey University | | 2 | 2 | | | | | 2 | | 0 | | | | | | | | | 0 | | | |
| | | Otago University | | 2 | 2 | 2 | | | | | | 0 | | | | | | | | | 0 | | | |
| | | Victoria University | | 1 | 1 | | 1 | | | | | 0 | | | | | | | | | 0 | | | |
| **NZ Industry Totals** | | | | 347 | 89 | 22.5 | 18 | 12 | 7.5 | 18 | 11 | 192 | 8 | 16 | 10 | 77 | 27 | 12 | 27 | 15 | 66 | 13 | 26 | 27 |

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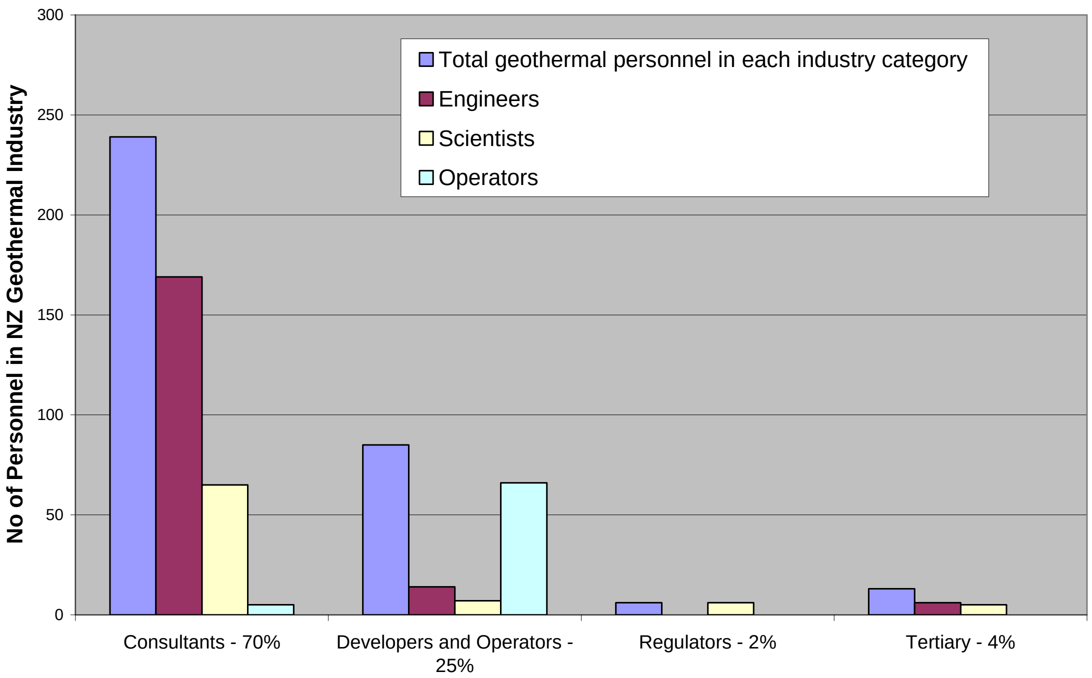
# 6. Results of Survey

## 6.1 Current Personnel Capability

The survey results show some 350 personnel actively engaged in the NZ geothermal industry in the areas of geothermal development and geothermal operations. This number includes professional scientists, engineers and steam field and power plant operators. It includes drilling engineers but excludes drilling rig personnel. Personnel involved with construction and equipment / plant supply, who are part of larger, non-specialised pool that will only be intermittently engaged on geothermal projects, are also excluded.

The distribution of these personnel in terms of professional discipline and industry category are shown in Figure 6.1.

- **Figure 6-1 Breakdown of 344 personnel involved in NZ geothermal industry**



This figure shows that the distribution of geothermal personnel is dominated by the consultant sector having 70% of the industry's professional capability, with the developer and operator sector having 25%, the regulatory sector 2% and the New Zealand tertiary institutions 4%.

The developer and operator sector is, as would be expected, dominated by operators. The sector has relatively few engineers and scientists whose work is principally on steam field and power plant engineering, reservoir monitoring and management and environmental services.

The survey showed the consultant sector to have some 173 ngineers and 68 geothermal scientists. The largest resources of consultant personnel capability are IGNS (26 geoscientists), PB Power (2 geoscientists and 30 engineers), Maunsells (2 science, 8 environmental and regulatory personnel and 43 engineers), and Sinclair Knight Merz (16 geoscientists and 48 geothermal engineers) as detailed in Table 5.1.

While all of the geothermal skills capability of the operator and developer sector is committed to the NZ geothermal industry, much of the consultant sector capability is committed to overseas work. This is particularly the case for the large private sector (PB Power, Maunsells and Sinclair Knight Merz) and government consultant capabilities (IGNS, IRL and MPT).

All of these companies have full current work books, but workloads a year or more out are always uncertain.

## 6.2 Future Likely Generation Levels

The future required capability of the NZ geothermal industry is dependant on the extent that the current level of geothermal power generation as shown in Figure 3.1 is maintained and more importantly to the extent that additional generation might be installed over the next decade. A key question put to each of the developers in the industry survey was what plans they have for future generation expansion. Their responses to this are summarised in Table 6.1.

These figures are impressive with respect to the following:

- The indications are that the installed NZ generation capacity will increase by a further 505 MWe over the next decade. This represents a +104% increase over the current capacity of 488 MWe installed over the past 47 years (see Table 3.1 and Figure 3.1).

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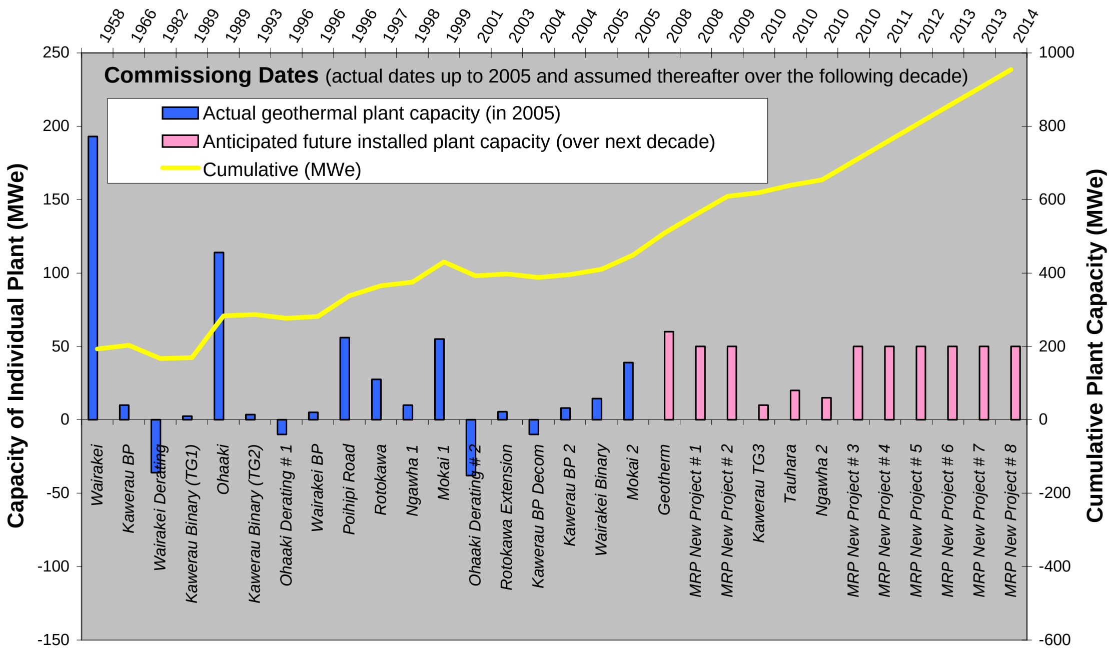
- **Table 6-1 Planned installations of new geothermal generating capacity, 2006 to 2015**

| Plant Name | Likely Size (MWe) | Assumed Commissioning Dates (see text) | Cumulative Increased Capacity (MWe) |
|---|---|---|---|
| Geotherm | 60 | 2008 | 60 |
| MRP New Project # 1 | 50 | 2008 | 110 |
| MRP New Project # 2 | 50 | 2009 | 160 |
| BOPE Kawerau TG3 | 10 | 2010 | 170 |
| Contact Tauhara | 20 | 2010 | 190 |
| Top Energy Ngawha 2 | 15 | 2010 | 205 |
| MRP New Project # 3 | 50 | 2010 | 255 |
| MRP New Project # 4 | 50 | 2011 | 305 |
| MRP New Project # 5 | 50 | 2012 | 355 |
| MRP New Project # 6 | 50 | 2013 | 405 |
| MRP New Project # 7 | 50 | 2014 | 455 |
| MRP New Project # 8 | 50 | 2015 | 505 |

- By far the largest part of the proposed future geothermal generation is to be undertaken by Mighty River Power with an aggressive development program which has been publicly stated at 400 MWe of new development over the next 10 years, at an estimated cost of approximately 1 billion NZ dollars. For the purpose of this report, SKM has arbitrarily assumed that MRP will construct and commission a 50MWe block of new geothermal power at yearly intervals over 8 years between 2008 and 2015.
- By comparison with the MRP program, the proposed generation expansion plans of the other NZ geothermal developers are relatively modest, totalling 105 MWe. The largest individual plant in this other new capacity is a 60 MWe development proposed by Geotherm at Tukairangi Road on the western edge of the Wairakei field. This project is now at an advanced planning / early implementation stage, though is still waiting on resource consent appeals and final funding. Smaller developments are proposed by Contact Energy at Tauhara, Bay of Plenty Electricity at Kawerau and Top Energy plan an expansion of the Ngawha plant. Again, for the purpose of this study, nominal commissioning dates have been assumed for these new plant as a means for examining the likely build up of generation capacity with time so as to assess the impact that this might have on requirements for personnel and skills in the NZ geothermal industry over the next decade.

The overall picture that has emerged from the industry survey is that NZ geothermal is moving into a large and exciting forward development program over the next decade. If this is followed through to fruition, it represents the most concerted level of geothermal development activity undertaken at any time in NZ and will result in New Zealand having an aggregate geothermal generating capacity of around 993 MWe as shown in Figure 6.2.

- **Figure 6-2 Assessed NZ geothermal generation capacity by 2015**




## 6.3 Capability of the NZ Geothermal industry to Meet Future Personnel Requirements

The actual requirements of the NZ consultant sector will depend to a large extent on the types of contracts that are developed between developers and power plant supply and construction companies.

### 6.3.1 Contract Types

Project delivery systems used for the completion of power projects have developed over the past decade due to changes in the market and the greater level of participation of independent power producers.

Power projects undertaken by public utilities have traditionally involved a design and project management engineering company, engaged by the utility, to prepare detailed specifications for the main plant items and to also complete the detailed design for the balance of the plant, the buildings and other project items. This involved the setting up, awarding and administration of multiple contracts. While this approach ensured that each of the main items of equipment was procured at the best price, directly from the manufacturer without any margins applied by a main contractor, it also placed a substantially greater burden of inter-contract management and of the risk of delayed completion of the facility.

The opening up of the power industry to private participants, with differing shareholder expectations of project financial returns and differing appetites for risk, has led to a greater range of project delivery systems. These systems are all focused on management of risk, as well as a reduction in overall capital cost and time for completion of the project. The main project delivery systems in the context of NZ geothermal power industry developments over the next decade will be either EPCM or EPC contracts and will probably be more oriented to the latter which from the perspective of the developer carry less risk and less direct involvement.

#### 6.3.1.1 Engineer, Procure and Construction Management (EPCM)

This is a contracting philosophy where the Owner engages an engineering company that takes responsibility for the completion, either by itself or under sub-contract of the engineering components (substantial parts of the engineering will be undertaken by the main equipment vendor), the procurement of the plant and the construction management. Depending upon the contractual arrangements between the Owner and the Engineer, the Engineer may also take completion risk (the contract may include liquidated damages for late completion), financial risk (the contract may include a ‘construction price not to exceed clause’ above which the Engineer participates in the losses) or performance warranties in which the Engineer participates in the warranty provisions of the plant. Under this scenario, the main equipment supply contracts are generally between the plant manufacturers and the Owner, with the role of the Engineer being to manage and oversee the contracts on behalf of the Owner.

#### 6.3.1.2 Engineer, Procure and Construct (EPC)

This is a contracting philosophy where the contractor assumes total responsibility for the design, procurement, construction and commissioning of the power plant. The contract conditions will normally be based on a fixed contract sum and will specify a time for completion to which the contractor commits and beyond which liquidated damages may be claimed, reflecting the value of the loss that the owner faces due to the late completion. These damages may include items such as the cost of financing, penalty costs the owner may be charged for performance shortfall under its power sales agreement, additional charges for engineering supervision and the like.

Unlike a traditional utility or EPCM project, an EPC contract document should be structured to provide the contractor with a greater flexibility in the selection of plant and equipment. The focus is on the performance of the equipment before handing over to the owner, rather than the detailed specification of equipment. This enables the contractor to optimise the plant for the application and

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gives him the greatest opportunity to reduce the project capital cost. Key features of the plant will be specified in detail only where necessary to ensure that the specific requirements of the owner are met. These may include material specifications that the owner requires due to the particular application, a particular preference for equipment configuration or requirements for installed spare capacity. Without the need for open competitive tendering that is necessary in utility contracts, the private developer is able to even specify the manufacturer and model of specific equipment if that is his requirement. The degree to which this is done needs to be carefully controlled to ensure that the EPC contractor is able to competitively select the equipment that best meets the performance and cost requirements of the project.

### 6.3.2 Estimates of Future Personnel Requirements

Table 6.3 provides an estimate of future personnel requirements from the NZ geothermal industry in meeting a 50MWe geothermal plant. The assumptions underlying these data include:

- The current personnel capability of the NZ geothermal industry is as given in Table 5.1
- The forward development program will be as given in Figure 6.1 and Table 6.1
- Future developments will proceed in blocks of about 50MWe in size and at a rate of 1 x 50MWe development per year
- The forward geothermal development programs will be based on EPC contracts in which:
  - the developer will be responsible for all permitting and consenting, surface exploration, drilling, resource assessment, feasibility studies, preliminary design, preparation of EPC bid documents, EPC bid tender evaluation and award, steam field design, monitoring of EPC construction, commissioning and performance testing
  - The EPC contractor will be responsible for the detailed design of the power plant and procurement and the erection of the steam field and power plant equipment
  - The New Zealand consultant industry will provide technical assistance and support to both the developer and to the EPC contractor. Consultant work for the EPC contractor would be limited to site works, structural design, and some involvement in balance of plant engineering. The main items of engineering equipment, the steam turbine generator and associated components such as condenser and cooling towers would be designed and supplied by overseas companies

From the data in Table 6.3 it can be seen that the capability of the NZ geothermal industry is such that 50MWe development could be undertaken each year with an excess availability of about 350% for geoscientific personnel and some 300% for engineering personnel. The only area where capability is close to the requirements of an annual 50Me development program is in drilling engineering.

In assessing the capability of the NZ geothermal industry it is important to recognize that:

- the bulk of the power project development capability resides within the NZ consultant sector
- the level of availability of the NZ consultant sector for engagement in the future NZ development program is a key issue
- there will be a significant requirement for additional steam field and power plant operators once new plant have been built and commissioned

### 6.4 Availability of the Consultant Sector

There are several important provisions that need to be made with regard to the availability of the NZ consultant sector for supporting the future NZ geothermal expansion program.

- Much of the NZ geothermal consultant capability is frequently committed to overseas geothermal work. The fact that the NZ private consultant industry has survived over the past 3 decades, for most of which time there has been few if any work opportunities in NZ for non governmental geothermal service providers, is strong evidence of the level to which NZ private sector consultants are committed to and depend on the international geothermal market. This is particularly so for the big private sector consulting engineering companies PB Power, Maunsells and SKM.
- The likelihood of strong competition from overseas geothermal projects for NZ geothermal consultant skills over the next decade is real. New Zealand consultants have made strong inroads into the Asian markets, where geothermal developments over the same timeframe to 2015 could be an order of magnitude greater than in New Zealand. Geothermal consultants will continue to pursue these large and premium projects. The key overseas geothermal market for NZ companies is Indonesia which has a firmly committed objective of commissioning a further 2000 MWe of geothermal power over the next decade.
- Further thermal power station development is expected in NZ, with Genesis's e3p gas-fired combined cycle under construction and Contact Energy talking of a further combined cycle plant. These projects could divert engineers with geothermal experience into other areas.
- Some companies may find themselves conflicted out of working for a client because they are actively working for a direct competitor on a field. This may be the case for consultants working respectively for Geotherm and Contact on the Wairakei field. Such conflicts of interest will prevent the matching of availability and requirements, especially since the projected growth is so dominated by a single developer, Mighty River Power.

■ **Table 6-2 Estimated personnel requirements for a 50MWe development on an EPC basis**

| | Professional Geothermal Capabilty Avail in NZ | Professional Geothermal Capabilty Avail in NZ | Estimated Developers personnel requirement for 50MWe development | Estimated EPC Contractors personnel requirement for 50MWe development | Excess NZ personnel availabilty for Developer | Excess NZ personnel availabilty for EPC Contractor | Excess NZ personnel availabilty overall |
|---|---|---|---|---|---|---|---|
| | (Numbers of) | (man months / year) | (man month) | (man month) | % | % | % |
| **Geothermal Total** | **301** | **3612** | **737** | **270** | **490%** | **1338%** | **359%** |
| **Geoscientists Total** | **89** | **1068** | **283** | **0** | **377%** | | **377%** |
| Geologists | 22.5 | 270 | 79 | 0 | 342% | | 342% |
| Geophysicist | 18 | 216 | 48 | 0 | 450% | | 450% |
| Geochemist | 12 | 144 | 42 | 0 | 343% | | 343% |
| Chemist | 7.5 | 90 | 18 | 0 | 500% | | 500% |
| Environment | 18 | 216 | 72 | 0 | 300% | | 300% |
| Regulatory | 11 | 132 | 24 | 0 | 550% | | 550% |
| **Engineers Total** | **192** | 2304 | **348.6** | **168** | 661% | 1371% | 446% |
| Drilling | 8 | 96 | 72 | 0 | 133% | | 133% |
| Reservoir | 16 | 192 | 57.8 | 0 | 332% | | 332% |
| Measurements | 10 | 120 | 48 | 0 | 250% | | 250% |
| Mechanical | 77 | 924 | 49.2 | 36 | 1878% | 2567% | 1085% |
| Civil | 27 | 324 | 36 | 48 | 900% | 675% | 386% |
| Chemical / Process | 12 | 144 | 25.2 | 12 | 571% | 1200% | 387% |
| Electrical | 27 | 324 | 33.2 | 48 | 976% | 675% | 399% |
| Structural | 15 | 180 | 27.2 | 24 | 662% | 750% | 352% |
| **Management** | **20** | | **105.4** | **102** | | | |
| | 1 | | | | | **Max** | 1085% |
| | | | | | | **Min** | 133% |
| | | | | | | **Avge** | 411% |

The potential impact on the likely NZ geothermal development program over the next ten years caused by less than 100% availability is such that if 70% or more of the NZ consultant sector was not available to the NZ development sector there would then be insufficient professional resources to meet the expected future NZ development program of an additional capacity of 50MWe per year on average.

## 6.5 Other Issues Emerging from Survey

### 6.5.1 Industry Ageing Issues

There was a consistent theme from the organisations surveyed for there being a significant demographic issue in the NZ geothermal industry. This amounts to a dominance of people in the upper range of mid career (35 to 50 years of age) through to late career (50 to 65 years of age). From the responses obtained it is expected that some 50% or more of the currently active geothermal professional community will retire in the next 10 to 15 years. Of concern is the strong indication that there is a lack of younger people joining the industry to replace those who will retire in this time frame, with the potential loss not only of capability but also of institutional knowledge.

The reasons for the ageing trend tends to be specific to the industry groups as follows.

#### Operators

- With the age of retirement now abolished in NZ and superannuation payments not commencing until 65 years of age there is a strong incentive for operators to continue working longer before giving way to younger staff
- Plant owners value and attempt to retain experienced staff to maximise utilisation of their plant
- A marked reduction has occurred over recent years in training programs for new operators - again due to cost considerations - thus requiring older operators to continue working
- Difficulties in sourcing trained operators which is also keeping older operators in the work force

#### Consultants

The origins of the NZ geothermal consultant industry are intimately linked to the several large NZ Government aid programs carried out in the nineteen seventies (as described in Section 3.1) in which NZ geothermal technology was consciously exported as a high value international service. These were buoyant days for the consultant sector which attracted quite a number of young professionals into the industry. The work was, and remains intellectually stimulating. Most of these personnel undertook extended site work on overseas projects, developing strong multi discipline geothermal skills and this has kept them firmly involved in the geothermal industry ever since. The NZ consultant sector is still dominated by people of this vintage but most will retire over the next 10 years.

The only group in the NZ geothermal industry that doesn't appear to face a significant ageing issue is the Mighty River Power development team. With the anticipated size of their exploration and development program over the next decade they have chosen to develop a significant in-house geothermal technology capability based on a small, experienced, mid-career management team to which a range of younger, new recruits report.

### 6.5.2 Personnel Replacement Issues

Closely related to industry ageing issue, is the strong indication that personnel replacement in the industry is not proceeding at a pace which will lead to a healthy build up of geothermal capability in younger staff. Reasons for this again tends to be specific to each industry group as follows.

**Operators**

- Most of the NZ operating companies are having difficulties in sourcing trained plant operators and as mentioned they have very limited training funds with which to train new staff. Increasingly, NZ generators are looking overseas to meet their personnel replacement requirements, though there are significant costs in doing this.
- With the industry looking to develop a further 500 MWe of generation over the next 10 years, there will be a requirement to hire some 40 to 50 new plant operators. Given the present tight supply of trained operators, it is unlikely this many experienced operators can be sourced. This indicates that training programs will be needed for raw recruits.

#### Consultants

The NZ consulting community works with international clients who typically now have between 20 and 30 years of experience in operating geothermal reservoirs, steam field and power plants. These clients are therefore competent and knowledgeable. If they have a need for consultant input it is for specialised advice. In this environment it is hard to get younger professionals accepted as providers of technical solutions to clients with many more years in the industry. It is therefore becoming increasingly more difficult for consultants to get younger NZ staff engaged in the geothermal industry.

An opportunity may lie with mentoring programs, where projects have a nominated experienced mentor in specific disciplines to ensure optimal development. Much of the local consultancy work could then be done by a new intake of engineers and scientists. The acceptability of this suggestion needs to be tested.

### 6.5.3 Training Issues

#### 6.5.3.1 Approach of the NZ Geothermal Industry to Training

All of the operating companies interviewed commented on their training programs being less than they felt desirable to maintain a satisfactory inflow of younger staff or for further developing experienced staff.

A particularly clear view on current difficulties with industry training came from one of the major geothermal operators. This was as follows:

- Most major power companies in NZ companies have done little training over the past decade as a cost saving measure
- It is now hard to resurrect formal in-house training programmes because the organisational overhead for running them has been lost
- Training as an investment has too long a time horizon and there are no guarantees that a company's investment in staff training won't go to the opposition or to a consultancy
- The industry is running on the legacy of the excellent training provided a generation ago by NZED / ECNZ. When the personnel in which this experience is held retire then the full impact of the reduced training over recent years will be felt.

It was evident over the range of interviews that there is considerable similarity in approach to the training that is still being undertaken in the industry. These similar approaches to training include the following:

- Using internal training resources where possible / available / relevant
- Using external training resources, usually an appropriate specialist from the consultant sector
- Making observation visits to other companies' geothermal facilities, both in NZ and overseas
- Attending technical conferences both in NZ and overseas with special emphasis on attending conference related workshops and technical networking

#### 6.5.3.2 The Auckland University Geothermal Institute (AUGI)

As mentioned in Section 3.1, prior to its demise in 2002, the AUGI geothermal technology training course provided a good level of training to one or two NZ geothermal scientists and /or engineers each year, although the primary objective was training overseas geothermalists.

This training was of real benefit to both NZ geothermal operating companies and consulting companies in providing their personnel with a post graduate diploma in geothermal technology which readily set the recipient on a career path as a geothermal specialist. It also played a major role in establishing the international reputation of the New Zealand geothermal industry, and contacts with the rest of the world, which assisted the New Zealand companies to maintain their level of expertise through overseas work when there was a down turn in the domestic industry.

In the industry surveys undertaken for this work there was widespread regret that the AUGI course has ceased. One of the operating companies interviewed has made a very positive demonstration of their high regard for the AUGI program by recently contracting staff members of AUGI to provide internal training for their personnel.

Given the concern indicated above for the ongoing training needs in the New Zealand geothermal industry, it seems that there may well be a business case for AUGI to tailor training programs to the NZ geothermal operator sector. This would, however, require some refocusing of AUGI's capabilities into resource monitoring and management, steam field and power plant operational issues.

### 6.5.4 Future Source of Personnel for the NZ Geothermal Industry

It will be difficult through organic growth alone to meet the needs of the NZ geothermal industry for future development and operations personnel and to provide for succession with younger personnel. This raises the question as to where else the NZ geothermal community could source experienced personnel.

#### USA Geothermal Industry

With less geothermal development being undertaken in the US than was the case in the nineteen eighties and nineties, there is a considerable resource of geothermal capability available in the US. In the US, the same thermal fuel price drivers as in New Zealand are now leading to an increase in the demand for geothermal power. Over the past few years there has been an increasing involvement of consultants and personnel from the US in the NZ geothermal industry. This has been particularly evident in:

- the MRP program where the requirement to develop a skilled in-house geothermal technology team exceeded the availability of supply outside of the NZ consulting companies
- consenting issues where much of the NZ geothermal community has conflicts of interest

#### SE Asia

There is a very large geothermal power industry in SE Asia with some 40% of the worlds installed geothermal power plant capacity contained within the Philippines and Indonesia where a number of individual geothermal developers / operators have personnel capabilities well in excess of the 350 person capability of the NZ geothermal industry.

The geothermal industry in SE Asia is now quite mature with 25 years experience in geothermal power plant and steam field operations and there is considerable rationalisation currently in progress within both the private sector and government agencies. This includes:

- Unocal has just been bought out by Chevron Texaco and there is process of consolidation underway for the combined assets and personnel resources of both groups in the Philippines and Indonesia. These amount to some 1400We of plant and 700 personnel respectively
- The National Power Corporation of the Philippines is in the process of selling to the private sector 8000 MWe of generation capacity
- The Philippine National Oil Company (PNOC-EDC) is in the process of privatising with total assets of 1200 MWe of steam field and 800 MWe of power plant being sold to the private sector

The SE Asia geothermal industry is thus in the throes of considerable restructuring with active downsizing, right sizing, early retirement programs in progress. This is leading to a high availability of skilled and experienced geothermal personnel in all disciplines coming into the international market place. These personnel represent a valuable source of capability for augmenting both the short and long term requirements of the NZ geothermal industry.

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# 7. Summary and Conclusions

The following conclusions drawn from this study:

- The NZ geothermal industry is poised to develop up to a further 500 + MWe over the next decade, provided that government policy is supportive. This would bring installed geothermal capacity in NZ to 1000 MWe, elevating NZ from 7th to the 4th largest user of geothermal power in the world (based on present data for world wide installed geothermal capacity, but obviously this capacity will also increase in that time frame). For planning purposes it can be assumed that this additional geothermal generating capacity will be installed in individual blocks of 50 MWe between 2008 and 2015.
- Personnel currently involved in the NZ geothermal industry number around 350. This provides sufficient capability to undertake the development of 50 MWe per year with an average excess personnel capability of some 300%. Nonetheless, this capability is highly dependent on the availability of the NZ consulting sector being available for work in NZ. If less than 30% of the NZ consulting capability was available then there would be insufficient capability in New Zealand to undertake 50 MWe of development on an annual and continuing basis. Historically the large NZ consulting companies with some 200 personnel have been engaged almost 100% on overseas work. This is likely to continue, particularly given that there are strong indications that the international geothermal workload will increase significantly over the next decade. It can then be expected that NZ geothermal developments will have to compete with international projects for personnel (and other) resources.
- The geothermal industry in NZ is now quite mature with almost 50 years operation since Wairakei was commissioned. Similarly, the personnel involved in the industry are ageing and it is expected that the current personnel availability will decline sharply over the next decade. This will be particularly acute in the plant operations and consultant sectors. The issue is compounded by difficulties in providing opportunities for bringing younger staff into the industry. In the area of plant operations, impediments to engaging new staff include difficulties in sourcing new staff with experience and the reduced availability of funds for training new staff. For the consultant sector the prime difficulty is the maturity of the international geothermal industry which increasingly requires 15 to 20 years experience as the minimum qualification levels for international geothermal consultants, and strong competition from local consultancies based on senior level technocrats retiring from the large government owned geothermal companies such as PNOC and the National Power Corporation in the Philippines, and Pertamina and PLN in Indonesia.
- To some extent the difficulties that all sectors are having with sourcing and engaging younger staff reflects the fact that the AUGI post graduate diploma course in geothermal technology

has closed. This provided a small but steady stream of well qualified professional geothermalists back into the NZ geothermal industry. It is encouraging that some segments of the NZ geothermal industry continue to use the technology training capabilities of the AUGI and it is likely that AUGI could / should extend its reach into the NZ industry, targeting the gaps in training that are clearly developing.

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# 8. Recommendations

It is recommended that NZGA pursue a number of outcomes from this study:

- take up the key issues of recruitment and training for the NZ geothermal industry. This should be focused on:
  - increasing the numbers of personnel working in the geothermal industry in NZ to reflect the significant increase in development activity over the next decade, as it is unlikely that the consultant sector will be fully available to contribute to these requirements
  - a substantial need for steam field and power plant operators over the next decade. Initial training will primarily be undertaken through technical institutions.
- consider revitalising the Auckland University Geothermal Institute in some capacity, probably through shorter courses helping new entrants into the geothermal area understand its peculiarities and cross-linkages, and potentially targeting a number of different levels in its programs
- provide links between NZ geothermal power plant operators and additional sources of skilled power operations personnel, particularly from SE Asia, possibly through the proposed Regional Branch of the International Geothermal Association
- undertake a similar review of capability requirements in NZ for low temperature and other process heat applications

# 9. Acknowledgements

The contribution of all the geothermal industry groups who willingly supplied the information used in Table 5.1 was essential to this study and is gratefully acknowledged.

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