New Zealand
Geothermal Association (Inc.)

SKILLS ISSUES IN THE GEOTHERMAL INDUSTRY

- 30 June 2009

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Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
1	12.06.09	BW/JN	BW	15.06.09	
2	15.06.09	BW/JN			DRAFT
3	16.06.09	NZGA Board/EECA	JN	30.6.09	FINAL

Distribution of copies

Revision	Copy no	Quantity	Issued to
3		1	NZGA, EECA

Printed:	10 August 2009
Last saved:	10 August 2009 08:47 PM
File name:	J:\NZGA\Skills issues in the Geothermal Industry_2009_FINAL.docx
Author:	Jane Brotheridge
Project manager:	Juliet Newson
Name of organisation:	NZGA
Name of project:	
Name of document:	Skills issues in the geothermal industry
Document version:	1
Project number:	

Executive Summary

The New Zealand Geothermal Industry is experiencing a period of growth which is expected to continue for the coming 10 years. A number of developers have built up critical levels of skill and confidence to be able to make geothermal investments as part of a broad portfolio of energy projects. Additionally, the geothermal industry in Australia is very buoyant with capital raising, surface exploration, exploration drilling and power development planning actively undertaken by a number of commercial entities.

The objective of the report is to prepare a skills action plan and recommend possible implementation of the plan for providing the projected level of technical and scientific skills required in the wider New Zealand geothermal industry, and developing the required level of understanding of geothermal systems and geothermal energy development for both professional and technical groups.

The report provides background information on the current and future growth of the New Zealand, Australian and World geothermal industry along with a survey of current and future projected staffing levels in the geothermal industry. The heavy involvement by New Zealand consultants in geothermal developments throughout the World is an important feature of the strengths and international reputations of New Zealand's geothermal consultants. These are niche-market skills that deserve to be both maintained and expanded. The forecast rapid growth of geothermal development both within New Zealand and internationally will provide excellent work opportunities for New Zealanders if we embark on the appropriate training strategy.

Training requirements within New Zealand are reviewed from an historical perspective with discussions of current and future requirements for training at both the professional, operational and trade levels. There is a definite bimodal age distribution within the present New Zealand Industry with a significant number of very senior staff (< 20 years experience) and a growing number of very young, recently qualified staff. The shortage of mid-career scientists and engineers is of serious concern and this is prevalent throughout the energy sector worldwide.

The current initiatives developed by the Oil and Gas industry within New Zealand and overseas may prove to be a useful template on which to base New Zealand's geothermal training for both engineering and geoscientific services.

The final solution to New Zealand skills requirements will be through a combination of "make", "fix" and "buy" strategies where:

- Make = growing professional and trade/technical skills for new entrants to the industry,
- Fix = On-the-job up-skilling for those already in the industry, and
- Buy = Immigration - sourcing skilled labour on the world market.

1. Introduction

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

The objective of the report is to prepare a skills action plan and recommend possible implementation of the plan for:

- Providing the projected level of technical and scientific skills required in the wider New Zealand geothermal industry, and
- Providing for the required level of understanding of geothermal systems and geothermal energy development among interested members of the community and other professional and technical groups.

The report was triggered by ongoing discussions within the New Zealand Geothermal Association Board, and assisted by the development of a Skills Action Plan by the New Zealand oil and gas industry. The contract called for:

- A review the skills survey, skills action plan and implementation plan completed for the Oil and Gas Industry and determination of whether the information applies directly to the Geothermal Industry recognising the differences between geothermal and oil & gas resources which may require adjustment in approach: geothermal encompasses a range of uses from power generation to direct use of heat; there are different environmental issues associated with geothermal; ownership of the resource and consenting issues is unlike the oil & gas industry; and New Zealand has a world-leading reputation in terms of consultancy and tertiary training in geothermal.
- A review of the 2005 report 'Review of current and future personnel capability requirements of the New Zealand Geothermal Industry'. Consider how the industry has evolved since 2005 and how this affects the conclusions of the report.
- The review will encompass skill sets associated with low to high temperature geothermal resources, specifically including drilling and heat pumps.
- Consideration of current research being undertaken on 1) Māori capacity in the energy industry, and 2) pathways for energy development projects for resource owners.
- A review of training that is being offered in Australia.
- Consideration of community and professional understanding of the regulatory aspects of geothermal development.
- Production of prioritised recommendations for future training requirements.
- Undertaking consultation with the Industry on the draft findings of the review.

This report was prepared using information available in the public domain and in-house knowledge; it does not use any material supplied under confidentiality. All information presented is subject to uncertainty and will change as more data comes to light.

The report comprises nine sections:

- Section 2 presents a review of previous work;
- Section 3 presents an overview of the present status of the New Zealand geothermal industry and growth projections;
- Section 4 presents an overview of the burgeoning Australia geothermal industry and training options with a brief summary;
- Section 5 presents a short overview of global geothermal growth;
- Section 6 presents the methodology and results of the 2009 survey of geothermal industry personnel with a projection of future requirements;
- Section 7 outlines what geothermal training is currently available within NZ, followed by a brief summary
- Section 8 reviews how the Oil and Gas Industry in NZ has tackled similar problems with skills shortages and training, and how some of these strategies and actions can be adopted by the geothermal industry in order to address the ongoing issues of skills development and recruitment;
- Section 9 presents the Geothermal Skills Action Plan with the 'MAKE, FIX, BUY' model used to address skills shortages including which industry/governmental/education organisations could action the strategies and the intended outputs.

2. Previous work

In 2005, a review of the current and future personnel capability requirements of the NZ geothermal industry was carried out by SKM[1] on behalf of the NZGA. This report was based on an industry survey and projections of the expected increase in geothermal capacity at the time. There were approximately 350 personnel engaged in the NZ geothermal industry as professional engineers, scientists and technically qualified plant operators. At that time generation capacity was expected to grow by 500 MWe over a 10 year period.

It was concluded that many of the NZ geothermal personnel worked as consultants with much of the workload overseas where other countries were also experiencing a growth in geothermal development, and as a consequence a shortage of trained personnel. The overall capability of geothermal personnel in NZ was judged to be more than sufficient to meet the requirements of a 500 MWe geothermal power development program over ten years. However, that 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.

The results of that survey also showed a significant industry ageing issue, compounded by difficulties in bringing or attracting younger staff into the areas of plant operation and the consulting sector. This is not an industry specific issue, but rather a general change to the dynamic of science and engineering skills emerging from developed countries.

Since that report, industry sources have provided some updates on current staffing and training/staffing issues which have been partially addressed or highlighted in a New Zealand Geothermal Association seminar in 2008.

The current report will consider how the industry has evolved since 2005 and whether recommendations have been implemented and the degree of success. Additionally, energy sector reports such as those compiled for the Oil and Gas industry[2] which have some parallels to the geothermal industry have been reviewed.

The National Energy Research Institute (NERI)[3] has undertaken a number of studies regarding capability growth in the NZ energy sector. They have conducted surveys with all tertiary institutions to establish what energy courses are available, including those covering geothermal. They are currently completing study for MoRST on 'World class geothermal capability in New Zealand'[4]. This should be available in July 2009.

[1] SKM. Review of current and future personnel capability requirements of the NZ geothermal industry (2005)
[2] PEPANZ(Dec 2007, Jul 2008, 2009)
[3] NERI Review of Energy Courses in NZ Universities 2007
[4] NERI. Dr Pip Lynch. Pers comm.. June2009

Internationally, several papers document the history of geothermal training until now[5]. By 2003 a course provided by Iceland was the only remaining graduate level geothermal course, with the International Summer School on the Direct Application of Geothermal Energy still running short courses. This situation has been rectified recently by new courses offered at the University of Auckland, which will be discussed later.

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[5] Dickson, M. H. and Fanelli, M., 1995. Geothermal Training at the International Institute for Geothermal Research in Pisa: Twenty-five years of activity, Proceedings, World Geothermal Congress 1995, Italy, vol 4, 2935-2937.; Geothermal Training Centres in the World. GHC Bulletin, December 1998.;
Hochstein, M. P., 2005. 25 years Geothermal Institute, Proceedings, World Geothermal Congress 2005, Antalya, Turkey.;
Fridleifsson, I. B., 2005. Twenty-five years of geothermal training in Iceland, Proceedings, World Geothermal Congress 2005, Antalya, Turkey.
Newson J., 2008. The New Zealand experience in geothermal education. Geothermal Energy Development Framework and Technology Roadmap Workshop. No. 2.1 Dept of Industry, Tourism and Resources Australia

3. The NZ Geothermal Industry

Since the compilation of the 2005 skills update report, much has happened nationally and internationally. Currently, the installed capacity in New Zealand is 585 MWe, an increase of 135 MWe (about 30%) since 2005. There is another 155 MWe under construction, with a further 120 MWe[6] at the resource consent stage. An additional 500 MWe is planned and under review. See Table 1.[7]

Table 1: Installed and planned geothermal generating capacity

Commissioning Dates	Plant	Current Owner	Current MWe	Planned MWe	Cumulative MWe
1958	Wairakei	Contact Energy	193		193
1966	Kawerau BP	Norske Skog Tasman	10		203
1982	Wairakei Derating	Contact Energy	*-36*		167
1989	Kawerau Binary (TG1)	Bay of Plenty Electricity	2.4		169
1989	Ohaaki	Contact Energy	114		283
1993	Kawerau Binary (TG2)	Bay of Plenty Electricity	3.5		287
1996	Ohaaki Derating # 1	Contact Energy	*-10*		277
1996	Wairakei BP	Contact Energy	5		282
1996	Poihipi Road	Contact Energy	55		337
1997	Rotokawa	Mighty River Power	29		366
1998	Ngawha 1	Top Energy	10		376
1999	Mokai 1	Tuaropaki Power Company	55		431
2001	Ohaaki Derating # 2	Contact Energy	*-38*		393
2003	Rotokawa Extension	Mighty River Power	6		399
2004	Kawerau BP Decom	Norske Skog Tasman	*-10*		389
2004	Kawerau BP 2	Norske Skog Tasman	8		397
2005	Wairakei Binary	Contact Energy	14.4		411
2005	Mokai 2	Tuaropaki Power Company	39		450
2005	Ohaaki Derating #3	Contact Energy	*-16*		434
2007	Mokai 3	Contact Energy	17		451
2007	Ohaaki Rerating #1	Contact Energy	10		461
2008	Kawerau	Mighty River Power & partners	100		561
2008	KA24	Independent	8.3		570
2008	Ngawha 2	Top Energy	15		585
2010	Nga Awa Purua, Rotokawa	Mighty River Power & Tauhara Nth No. 2 Trust		132	
2010	Centennial Drive, Tauhara	Contact Energy		23	
2012	**Te Mihi, Wairakei*	*Contact Energy*		*220*	
2012	*Tauhara*	*Contact Energy*		*220*	
2012	*Ngatamariki*	*Mighty River Power & partners*		*80*	
2015	*Rotoma*	*Rotoma No. 1 Inc*		*35*	
2012	*near Poihipi Rd*	*??*		*55*	
??	*Tokaanu*	*??*		*50*	
??	*low-temp*	*??*		*50*	
by 2025	*misc*			*400*	
Actual geothermal plant capacity (in 2009)			**585**		
Anticipated future installed plant capacity (over next decade)				***1110***	
*replaces Wairakei with net gain of 65MW					

Domestic investment is being driven largely by rising electricity demand, with demand increasing by about 660 GWh/year. In terms of this expansion, geothermal development has been a favoured option among the various generation sources because of competitive prices, reliability of generation and location relatively near the major load centre of Auckland. Now that some of our stations are

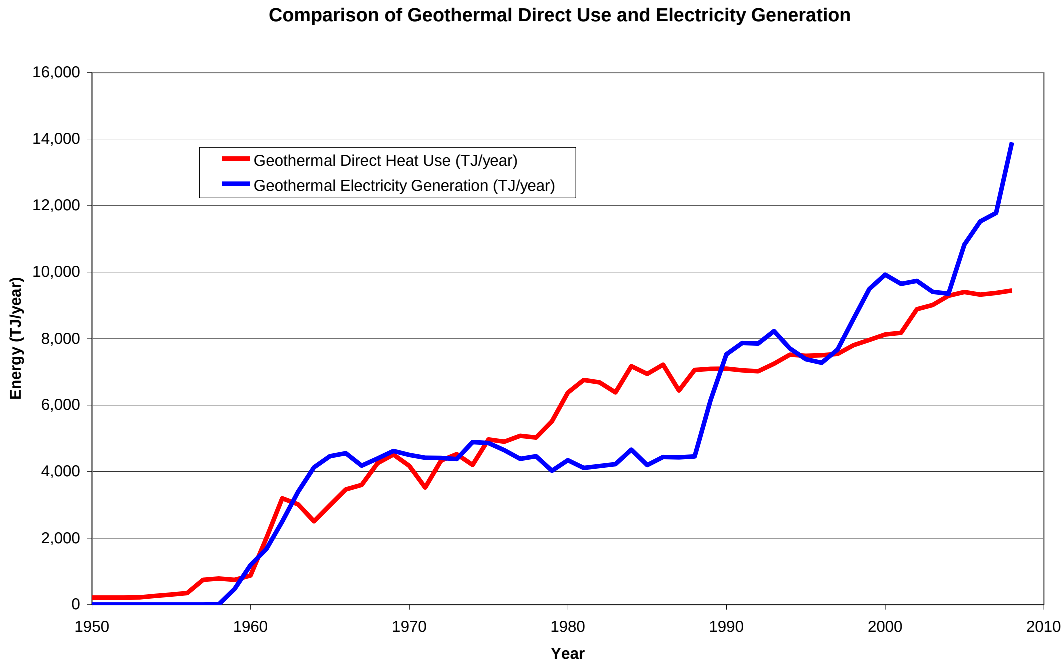
6 65 MWe net gain from Te Mihi replacing Wairakei and 55 MWe Geotherm, near Pohipi Rd

7 Table adapted from table NZGA, www.nzgeothermal.org.nz

aging, replacement is also becoming an issue – a back pressure unit at Kawerau has already been replaced and one of the largest planned investments in the near term is for the Te Mihi development that helps with the retirement of the original Wairakei station. Some units, such as the Ngawha stations have a strategic advantage in meeting generation requirements at the end of a long transmission string beyond the high demand of Auckland, and so help to control local electricity prices.

In addition to electricity generation, geothermal energy makes a significant contribution to direct use requirements. A separate report[8] on national direct heat use is being published in parallel with this report. The following Figure 1 from that report shows that geothermal direct use has also made a significant contribution to New Zealand's energy needs in the past, and there is an expectation of further growth.

- **Figure 1: Comparison of geothermal direct use and electricity generation in terms of consumer energy.**



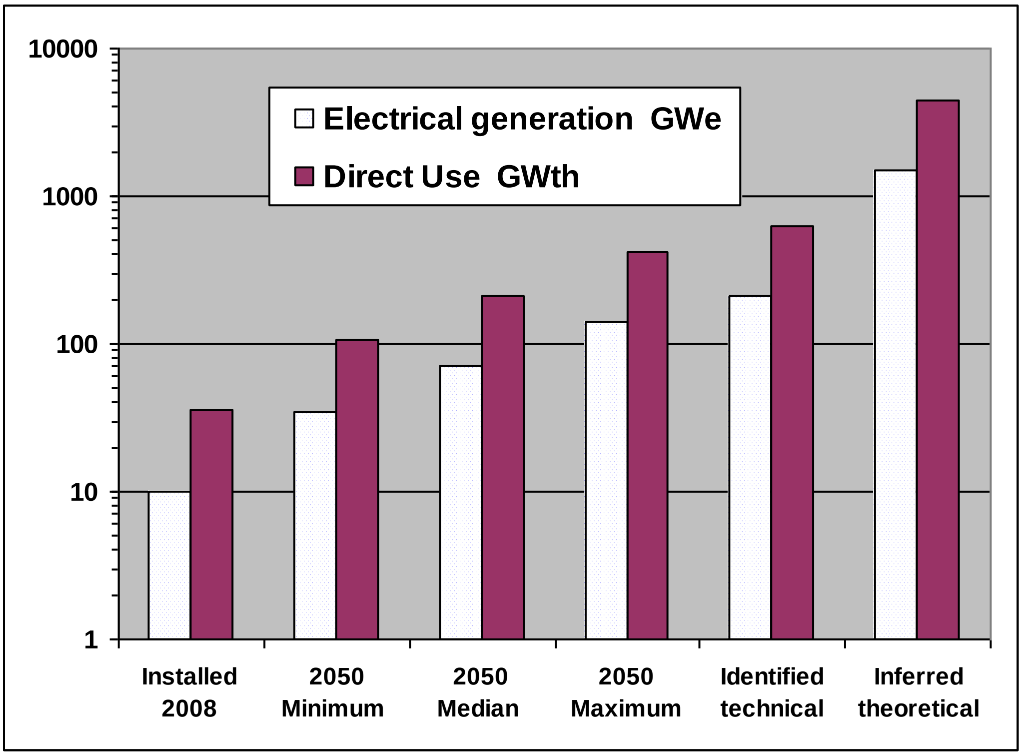
Over half of the direct use growth is associated with the Kawerau supply to the Norske Skog Tasman mill and further expansion of supplies to adjacent mills has now been announced. The majority of developments are low technology developments for pools or home heating requiring differing levels of skills.

Internationally, geothermal electricity generation is expanding. According to the International Geothermal Association (IGA) in IGA News 72 (April–June 2008), total global geothermal capacity is expected to rise to 11 GW by 2010 (currently approximately 10 GW). In the longer term, optimistic projections of generation are shown in Figure 2 which is part of the IPCC documentation which is currently in preparation for the Geothermal Annex of the International Energy Agency (IEA). Note that the vertical scale is a log scale. In addition, many more countries are investing in research and development of Enhanced Geothermal Systems (EGS) and low temperature resources. New Zealand

[8] Brian White, June 2009. An Updated Assessment of Geothermal Direct Heat Use in New Zealand

consultants have not only supported the New Zealand growth, but have also frequently supplied services to the exploration and development of these global developments. This international growth will be discussed in following chapters.

- **Figure 2: Estimated global conventional geothermal electricity and direct use potentials to 2050 and beyond[9]**



[9] Based on projections by the IEA Geothermal Annex June 2009. Assumptions of status-quo growth rates (minimum), present technology (median) and technology improvement (maximum). Identified technically-feasible and theoretical resource potentials (including inferred but unidentified resources) are also shown

3.1. Impact of the current global financial crisis

The current global financial crisis may impact the growth projections in both New Zealand and internationally. In New Zealand, this crisis struck in late 2007 and the New Zealand economy has been in recession since the beginning of 2008. Unemployment rates in NZ are up with the latest figure of 4.5% for the first quarter to March 2009 from 3.7% from the March quarter of 2008. It is expected to rise to nearly 7% in March 2010. This crisis will impact new projects both within New Zealand and internationally, which will thus impact the labour market. Demand for electricity may be reduced and the larger industrial users may be forced to cut back on electricity consumption.

There are, however, a significant number of global economies pushing ahead with ambitious and in many cases legally binding renewable energy targets, creating a platform for a global expansion of renewable energy technology, including geothermal.

3.2. Current Status of the NZ Industry

There are currently seven operating power stations in New Zealand at Wairakei, Poihipi, Ohaaki, Rotokawa, Kawerau, Mokai and Ngawha. The Wairakei power station is now 50 years old. In 2007 a 16 MWe Binary plant was added to the Wairakei plant. A replacement plant has recently been proposed in the Te Mihi area, closer to the centre of production. Consents have been obtained through a call-in process and Board of Inquiry. The new plant will be of modern design and will reduce some of the impacts on the Waikato River while generating an additional 65 MWe for the same quantity of fluid. Commissioning was scheduled for 2011 but it has been delayed. There are several direct use applications linked to the power station development including a brine supply to a tourist facility and brine to a prawn farm venture, now an established part of the Wairakei tourist scene. Pipes to these facilities require process engineering input.

Alastair McLachlan was a separate developer on the Wairakei field initially for his orchid houses (steam is still supplied to these by Contact), but then for a 55 MWe power station on Poihipi Road, subsequently acquired by Contact. The original developer of the Poihipi Road station, Geotherm, has subsequently tried to develop a further 55 MWe station in the vicinity. This second station has been successfully consented, but has been stalled around funding issues. Geotherm is now in receivership with assets being sold off including the planned 55 MWe development.

At Tauhara, the shallow steam-heated aquifer that underlies part of Taupo township and land further to the east and north has been extensively exploited, with over 400 shallow wells extracting heat or steam or water for domestic, commercial and other uses. Contact Energy taps deeper fluid and commissioned a new 20 MWth process heat supply to Tenon for kiln drying in 2006 using the deeper, high temperature resource. More recently Contact has started the construction of their 23 MWe Centennial Drive binary cycle station. This station is due for commissioning in 2010. Four new deep wells drilled at Tauhara have found higher temperatures than Wairakei, adding to the evidence for multiple upflows. Contact Energy is now considering development of a new 220 MWe station at Tauhara. Development will have to take into account potential adverse environmental effects on the surrounding Taupo urban area.

At Ohaaki output declined to about 25 MWe in 2006 but an investment programme including several new wells has restored and maintained production at the 60 MWe level from the end of 2007. Brine is still used for kiln drying facilities, while other direct use applications have ceased operation.

Further development of the Rotokawa field is underway, also based on a Mighty River Power/ Tauhara North No 2 partnership. The 132 MWe Nga Awa Purua powerstation will be the largest development in New Zealand after the initial development at Wairakei. Consents have been obtained through normal processes and construction is underway. The plant is due to be commissioned in May 2010.

At Mokai, a 39 MWe expansion of similar design to the existing plant was commissioned in 2005, and a large geothermally heated greenhouse complex has been developed nearby, recently expanded to 11.2 ha. A further 17 MWe binary plant extension was installed at the station in 2007 to take account of the changing steam/water ratios due to the effects of exploitation. In 2008 Contact Energy sold interests in resources under the Pukemoremore area of the resource to Tuaropaki Power, and active drilling has followed with a view to possible further development.

At Kawerau, Mighty River Power began an exploration programme in a new area of the Kawerau field in 2004, on land associated with the Putauaki Trust. In 2005, a consent application was lodged by Mighty River Power for the development of a 70-80MWe power station. Consents were granted and the 100 MWe Kawerau station was subsequently commissioned in August 2008, in partnership with Putauaki Trust and with the co-operation of other local interests. This is the largest single condensing geothermal turbine in New Zealand's history.

In July 2005, the Crown transferred wells, steamfield equipment and contracts to Mighty River Power, who had a back-to-back transfer arrangement with Ngati Tuwharetoa Geothermal Assets (NTGA). The negotiations involved a balancing of government commitments, Treaty obligations and commercial interests. The transfer marks a change from what has been a caretaking role to a development focus. In May 2009 an announcement was made in which NTGA entered an agreement about the supply of steam to the Svenska Cellulosa Aktiebolaget (SCA) tissue mill which is located beside the Norske Skog Tasman plant, for which the geothermal steam supply will commence in 2010 and will require active engineering. In September 2008 another Māori Trust (formerly known as the Savage Trust) commissioned an 8.3 MWe binary cycle plant based on the production from well KA24. This well had been kept separate from the initial transfer from the Crown to NTGA.

At Ngatamariki, Mighty River Power have obtained exploration drilling consents and have started testing of the old Crown wells, currently drilling their third well with a view to an 80 MWe development possibly by 2012.

The Mangakino geothermal field has been recently investigated by Mighty River Power. While details are confidential, it is known that temperatures of 250°C were encountered but formations were relatively impermeable. A fresh assessment of potential is needed.

The Tikitere geothermal field is located about 18 km northeast of Rotorua City on the southeast shore of Lake Rotoiti and comprises the Hell's Gate geothermal area and the Ruahine Springs several kilometres to the northeast. Energy potential of the field has been estimated at greater than 160 MWe, but significant production could affect the natural features of the field. The Tikitere Trust, through which the Hell's Gate facility is operated, is investigating a limited development for electricity generation.

The Rotorua geothermal field underlies much of Rotorua City and the southern margin of Lake Rotorua. The natural features associated with the field, particularly the geysers and hot springs of Whakarewarewa, are one of New Zealand's foremost tourist attractions. Whakarewarewa has the largest remaining concentration of geysers in New Zealand. As of 1 July 2009, the Central North

Island Iwi Collective will be returned assets, namely forests, but will also include some benefits associated with geothermal resources. The forests here include Whakarewarewa, Highlands, Waimangu, Whaka and Tokorangi. The CNI Collective are looking into the potential of these resources within their forest settlement blocks. Ultimately it may be possible for some alternative use of geothermal energy at Rotorua such as the use of downhole heat exchangers and district heating schemes. The potentially large resource is unlikely to be used for large scale electricity generation because of the effect this would have on the Whakarewarewa geyser field.

The Horohoro geothermal field is located about 15 km southwest of Rotorua City. Horohoro Forest is also included in the settlement to CNI Collective on 1 July 2009. The thermal waters of the surface features are very dilute, and geothermometry suggests temperatures of 150 to 160°C in the aquifer. A very large low resistivity anomaly identified to the west of the Horohoro rhyolite dome and extending beneath the Mamaku Plateau is believed to be the result of hydrothermal alteration or to be a conductive ignimbrite. Several shallow wells drilled just south of the Horohoro dome recorded a temperature gradient much lower than that measured in the 600 m deep well in the Matahana Basin.

Rotoma No. 1 Inc has applied for consent for 35 MWe for the Rotoma geothermal resource. However, there are some rival interests over the resource and appeals have been lodged.

Genesis Energy is investigating possible development of the Tokaanu field and has been in ongoing discussion with Ngati Tuwharetoa representatives. The energy potential of the field is estimated at greater than 150 MWe, but development potential remains uncertain. The Hipaua thermal area located above Waihi village is susceptible to landslides. Any development requires the location of deeper hot water sources. The field is classified as open to limited development by Environment Waikato subject to the resource consent process.

And finally in Northland, further expansion of the Ngawha project was completed in October 2008 with Top Energy bringing the project up to a total of 25 MWe.

In addition to high temperature resources, there is an increasing interest in low temperature resources, including abandoned oil and gas wells.

The developments associated with these various resources have required a wide range of skills related to the following activities:

- In-house scientific and engineering skills for the major developers
- Possibly separate owner’s engineer role for smaller developers (station or direct use)
- General science support (for exploration and operation)
- Drilling support (engineering and science) during drilling for exploration or operational drilling
- Project management support
- Environmental support for field consent application work
- Reservoir engineering support for development or operational fields
- In-house expertise for the councils making decisions on projects

- Technical support at consent hearings for the developer, for the councils, possibly for Government (that normally make submissions in support of projects), and for the various appellants
- Possibly senior people to sit on the consent hearings panel or to sit on subsequent consent review panels
- Parties to undertake feasibility studies
- Parties to undertake due diligence for projects up for sale, or to set up documentation ready for due diligence
- Detailed engineering and science roles in support of the contractor
- Construction skills
- Operations and maintenance skills, and
- The wide range of support skills and expertise necessary for the successful operation of any organisation.

Very often there are multiple parties working for or against a project for various companies or councils such that it can be difficult to find people without conflicts of interest. While there are skills of sufficient depth present in all required areas within New Zealand, conflict of interest has occasionally necessitated the use of foreign companies, particularly at consent hearings.

3.3. Expected future trends and developments

3.3.1. Low temperature geothermal resources

Exploration and development of the vast low temperature geothermal potential of NZ has been marginal compared to other countries partly because of the abundance of high temperature geothermal resources, but also due to reduced flexibility of use, and cost issues relative to competing fuels. However, with developments in Enhanced Geothermal System (EGS) technology, previously uneconomical geothermal sources may now be exploited (MIT, 2006)[10], and many countries are actively pursuing these resources.

There are conventional low temperature resources for which development includes adaption of springs or shallow resources through drilling for bathing or heating. There are also non-conventional sources of geothermal energy that include peripheries of high-enthalpy geothermal systems in the TVZ, 2500 m depth in high-heat flow sedimentary basins and rapidly rising regions of the country such as the Raukumara Peninsula and the Southern Alps, >3500m depth outside high heat flow regions using hot dry rock (HDR) technology and natural conductive heat flow where constant heat at 1.5m and deeper can be extracted by ground source heat pumps (discussed later).

[10]Massachusetts Institute of Technology, 2006. The Future of Geothermal Energy. Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century. An assessment by an MIT-led interdisciplinary panel, prepared under Idaho National Laboratory Subcontract No 63 00019 for the US Department of Energy.
www.renewableenergyfocus.com/view/2005/president-obama-us467m-for-geothermal-and-solar-energy
www.renewableenergyfocus.com/view/2101/doe-us50m-for-geothermal-heat-pumps

For some of the unconventional sources of geothermal energy, such as heat from sedimentary basins and hot dry rock (HDR), permeability and the volume of circulating fluids may be low but could be overcome by using EGS/HDR technology. Assessments of possible energy from this source dwarf any possible use, but economics must be further reviewed before resources can be properly assessed

Recently investigation into the use of low temperatures resources[11], such as abandoned oil and gas wells has gained some interest. New Zealand has 18 hydrocarbon basins within its 4 million sq km Exclusive Economic Zone (EEZ). Of these only the Taranaki basin produces gas and oil from offshore and onshore wells. There are nearly 100 abandoned onshore hydrocarbon wells in Taranaki and 6 other sedimentary basins that can potentially provide low-enthalpy heat estimated to be at least 0.12 PJ (assuming 100 wells at a temperature of 120°C and a capacity factor of 0.15)[12 13].

These wells are deep, some up to 5 km and the heat flow is generally conductive, however temperatures at the bottom of the well are usually in the range from 100 - 160°C. These low temperature resources or prospects are technically suitable for electricity generation but may not be economical at the present time.

Currently only one abandoned hydrocarbon well, located in the Taranaki basin, is being used for its low-enthalpy heat. Warm bicarbonate water (29°C) from the 910 m deep Bonithon- 1 is heated up to 33-38°C by gas and fed into the therapy and private pools of a commercial spa enterprise. The bore water is also bottled and sold as therapeutic mineral water.

There is of course, vast potential for direct use of geothermal resources. This is of particular interest to forestry owners where the geothermal resource can be utilised for timber drying. The use of geothermal steam as a heat source for the kilns, in the TVZ, to dry lumber adds value to these resources.

The skills required to develop conventional low temperature resources for bathing or heating include basic drilling experience, but beyond that are largely applications of plumbing and building services experience.

Developments envisaged using non-conventional resources may be of a similar nature to conventional resource development, but eventually will be of a nature and scale that will draw on the same experience as high temperature resources. In addition, additional skills associated with hydrofracing and design of targeted production zones will be required. New Zealand is already in a greater state of readiness for EGS developments that Australian counterparts. This is discussed further in the following chapter. However it is possible that Australian experience developed with exploration and initial trials of their EGS reservoirs can be matched to New Zealand above ground experience.

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[11] Reyes, A.G. and Jongens, R. (2005) Tectonic settings of low enthalpy geothermal systems in New Zealand: an overview. In: Proceedings World Geothermal Congress 2005; GNS Science Report 2006: A practical guide to exploiting low temperature resources

[12] Reyes, A.G. Harnessing low-enthalpy heat in New Zealand. GNS. 2006

[13] The most appropriate capacity factor will be determined by the application. These factors are likely to be much lower than many conventional applications because of the need for pumping and the desire to maximise the life of the resource

3.3.2. Geothermal Heat Pumps

Geothermal heat pumps (GHPs), although not a new technology, remain a small but growing player in the commercial, residential and retail heating/cooling sector. Although higher in capital cost than air source heat pumps or other heating and cooling options, this technology can, in the right application, repay this cost premium through savings in energy costs. Terms such as geothermal heat pump (GHP), Geoexchange (GX) and ground-source heat pump (GSHP) are used to refer to the industry in general.

GHPs can be used anywhere in NZ for space heating and/or cooling and have been used internationally since the 1940's. This system takes advantage of the fact that the ground below a depth of several metres (approx. 1.5 m), and natural water sources, remain at a near constant temperature; so in mid-winter are warmer than the air, and in mid-summer are cooler. They have the advantage of lower annual operating costs than conventional electrical heating but have a much higher initial capital cost because extensive civil works are required (although these can be combined with earthworks for the house itself).

Dunedin International Airport space heating/cooling system is a recent example of a geothermal heat pump application, for which heat exchange is with groundwater. However, for widespread domestic use of GSHP, the initial capital cost would have to be significantly lower for public uptake (approximately NZ$6000-$7500 capital cost for a 6 kW unit). Uptake is happening in niches at the high end of the housing market.

As far as improving on the existing GHP technology, most of the substantial efficiency gains in heat pump units have been made over the past 15 years. Remaining improvements will likely be small in comparison to what has been achieved[14].

The performance of a ground-coupled heat pump system is partly determined by the quality of the installation. Assuring that proper backfilling is done around the pipe, fusing of the polyethylene piping, flushing the system and purging air from it, all require skills, tools and equipment only available to properly trained contractors. Ground loops are not DIY projects. Selection of a contractor for a geothermal heat pump system is very important, particularly for ground-coupled systems.

As the industry grows in New Zealand, specialised installation contractors fear that inexperienced ones could damage the reputation of GHP just as consumers become aware of their energy-efficiency potential. There are training courses available for heat pump installers and designers, one was held recently (June 2009) in Rotorua by GeoExchange[15] and is also offered through the OIT Geo-Heat Centre. Development involves the meshing of skills in building services, plumbing and drain-laying, and can involve experience with ground water drilling.

3.3.3. Māori involvement with geothermal resources

Many of NZ's geothermal resources lie under land owned by Māori. For Māori, every geothermal area with surface activity has traditional cultural and historic significance. They see themselves as kaitiaki (guardians) of the geothermal resource, ensuring their use for future generations as well as themselves. An outcome of recent Treaty of Waitangi tribunal and other court rulings will result in the

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[14] Kevin Rafferty, P.E. March 2008. Heatspring Learning Institute. An information survival kit for the prospective geothermal heat pump owner.
[15] www.geoexchange.com.au

emergence of Māori as major players in the geothermal energy arena. They have chosen a variety of project ownership models for engagement in projects on their resources that range from receipt of royalties for hosting a power developer to almost full Māori project development and ownership.

Tuaropaki Trust has been very successful in developing their resource at Mokai. Total capacity of the Mokai power station is 110 MWe and now a quarter share of the Tuaropaki Power Company is owned by MRP. Additionally the Trust owns 25% in the Gourmet Mokai joint venture, established on Tuaropaki land which uses geothermal heat for the greenhouses.

Tauhara North No. 2 Trust is also successfully developing their resource at Rotokawa. They have a joint venture arrangement with MRP for Nga Awa Purua 132 MWe project due for completion next year. With their first joint venture with MRP for Rotokawa A (32 MWe) the Trust opted not to take shares in the power station but instead only a 50% stake in the steamfield along with a monthly royalty payment.[16].

Ngati Tuwharetoa Geothermal Assets (NGTA) are a fully owned subsidiary of the Ngati Tuwharetoa (Bay of Plenty) Settlement Trust. As mentioned in section 3.2, they own the assets at the Kawerau geothermal field and this is a revenue stream for the Trust.

The Putauaki Trust and a number of other Māori Trusts are also landowners at Kawerau and have vested interest in current and future development here.

The Central North Island Iwi Collective[17] is a group of eight iwi from the central North Island region. It was formed in July 2007 and agreed to a proposal to advance Treaty of Waitangi negotiation discussions relating to central North Island forest lands. The Collective signed an agreement with the New Zealand Government in June 2008 and is the largest settlement to date in New Zealand history. On July 1 2009 the settlement assets will be transferred to the iwi in the Collective. Nine forests in the central North Island were included in the CNI Collective Settlement. The vast majority of the land in the settlement is part of Kaingaroa forest. Geothermal assets which lie within these forests are included in the settlement and much of this resource can only be developed if iwi owners permit land access.

The CNI Collective has formed a 'Geothermal Energy Strategy' which has the potential to transform the Collective into a supplier of 10-20% of New Zealand's electricity within a 5-10 year time horizon. Their strategy is to:

- create a single geothermal energy company to minimise costs and maximise the use of scarce industry expertise
- develop the known and currently undeveloped 0.5 GW of capacity within 5-6 years
- in the longer term, use new technologies to identify whether further resources lie under Kaingaroa, and aim to develop the 1.0 GW of capacity which has been identified but which is currently unavailable for development; and
- develop direct heat applications (such as timber drying) wherever possible for use in Forestry and other operations.

Paramount to all these geothermal developments and initiatives is the need for strong and robust relationships with joint venture partners. External developers at least take a consultative approach to

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[16] Kevin McLoughlin. Tauhara North No. 2 Trust. Pers comm. 2009.
[17] www.cnidiscovery.co.nz

resource development. In some cases these developers are building up models of operation based on co-operative development. This is a major plank of Mighty River Power's geothermal business case, where they offer themselves in a range of rolls from experienced field operator to full joint venture partner, particularly with Māori land interests over a resource.

For the various Trusts and Māori business units, investment in larger scale geothermal development may be a new thing. Commonly, the background of these businesses is in farming or property development. The Trustees, board members and managers need to have a familiarity with the geothermal concepts and with the participants in the industry so they can make the necessary decisions to step through a potential project.

3.4. Legislative Environment

In 1991 the Resource Management Act was introduced. Its prime purpose is to promote the sustainable management of natural and physical resources. It is hierarchical in operation and ties together the activities of Central government, Regional, City and District Councils. It is concerned with the management of air, water, soil, land, geothermal, some minerals and coastal resources out to the 12 nautical mile limit of the territorial sea.

To gain the right to develop a geothermal resource, developers needed to employ scientific staff or consultants to gather necessary data. This means data-gatherers have to have knowledge of geothermal systems, heat and mass transfer and of course a detailed understanding of resource issues. One of the requirements of the RMA[18] is for the management of natural and physical resources to recognise and provide for the reasonably foreseeable needs of future generations. This translates into the objective of managing the take, use and discharge of geothermal energy and fluid in a way that enables current energy needs, and the reasonably foreseeable energy needs of future generations, to be met. Individual geothermal systems are managed for particular uses depending on characteristics of each system. It has allowed the consideration and incorporation of matters of:

- The national interest;
- The concerns of indigenous people;
- The local effects of large scale extractive use of energy and fluid in an urban environment;
- The maintenance of the extent and variety of significant surface features; and
- The needs to ensure choices are preserved for future generations of New Zealanders.

Because of the very complex nature of geothermal systems, and the various issues which need to be addressed before consents for development are granted, in some cases the geothermal industry has experienced huge costs and delays. Reconsenting of the existing Wairakei power station, for example, took more than 6 years and cost more than $10 million[19]. If consenting delays affect new geothermal developments then it may mean new coal or gas plants will be needed to ensure security of supply. The Resource Management (Simplifying and Streamlining) Amendment Bill 2009[20] is expected to improve environmental, social and economic outcomes by reducing delays, costs and uncertainty associated with RMA 1991 processes.

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[18] Dickie B and Luketina K., 2005. Sustainable Management of Geothermal Resources in the Waikato Region, New Zealand. Proc. WGC 2005
Waikato regional Policy Statement. Dec 2007. www.ew.govt.nz
[19] Balwin D. 2006. New Zealand's Geothermal Renaissance. Proc. NZ Geothermal Workshop 2006.
[20] Resource Management (Simplifying and Streamlining) Amendment Bill. Government Bill. Feb 2009.

The RMA process is a personnel-intensive process, with some of the skills already listed in section 3.1. Major developers have found the need to employ consent specialists to manage the process and the various consultant inputs that feed into the Assessment of Environmental Effects and into the hearing process. As such, the developers compete with the regional and local councils for the same pool of consent specialists.

A factor that was acknowledged in the 2005 study was that despite its objectives of consensual decision making, the RMA is nevertheless operating in an adversarial legal framework. Thus many parties may be involved in geothermal resource consent hearings, all with their own interests and all requiring independent technical advice. This can have a significant impact on the availability of human technical resources. It is not a simple as estimating the total project requirements multiplied by the number of projects, and comparing that number to the total human resources in the country. Conflicts of interest through the adversarial consent process may prevent many of the theoretically available personnel from working on any particular project. This situation can only be expected to get worse if new investors enter the industry.

4. The Australian geothermal industry

Australian companies, researchers and government agencies with an interest in the development of Australia's geothermal resources formed the Australian Geothermal Energy Group (AGEG) in early 2006. The AGEG's purpose is to foster the commercialisation of Australia's geothermal resources at minimum cost and maximum pace. As Australia's geothermal sector-wide alliance, AGEG benefits from, and provides intellectual input into the International Energy Agency's geothermal research cluster, under the Geothermal Implementing Agreement (GIA).

The Australian Geothermal Energy Association (AGEA) is Australia's national industry body representing the Geothermal Energy sector. AGEA works with all Australian Governments, the academic community, relevant scientific organisations and the media to promote information about the progress of the industry and its capabilities. AGEA seeks to assist government develop prudent policy mechanisms to enable all forms of emissions-free energy to increasingly penetrate the national energy market in line with climate change and energy security policy goals.

Although Australia lacks New Zealands' high quality/low cost to develop geothermal resources, this is more than compensated for by the high level of government support to the emerging industry both through direct investment (e.g, in funding geoscientific data acquisiton and research) , direct and indirect subsidies.

The Australian geothermal energy industry is currently undertaking an extensive work program across three areas of research and development activity through to project deployment. The industry is predominantly focussed on producing electricity from Enhanced Geothermal Systems (EGS) or Hot Fractured Rocks (HFR) technology where the underground reservoir or heat exchanger is artificially created or enhanced by fracture stimulation techniques. The industry is also undertaking exploration and project development activity in more traditional geothermal or hydrothermal projects where hot underground reservoirs are utilised as heat exchangers for electricity production. A number of companies and research projects are also focussing on the development of systems that exploit the direct heat use for energy efficiency applications.

The emerging Australian geothermal energy industry expects to provide between 1000 to 2200 MWe of baseload electricity by 2020[21]

There are currently over thirty Australian geothermal energy companies actively involved in various stages of the development of the technology. Even the most advanced company has only recently conducted closed loop circulation tests to reach the proof of concept stage. This required the successful completion of (at least) two wells. A few other companies are expected to commence deep drilling programs within the next twelve months, while most of the other companies are progressing through more preliminary stages of project development.

The Rudd Government was elected in 2007 with a policy platform that included a commitment to a National Emissions Trading Scheme (ETS), a 20% Renewable Energy Target Scheme by 2020 (RET) and a $500m Renewable Energy Fund (REF). The REF included a dedicated allocation of $50m to a Geothermal Energy Drilling Fund (GEDF). The two successful companies who qualified for GEDF were MNGI Pty Ltd and Panax Geothermal Limited.

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[21] McLennan Magasanik Associates Pty Ltd. Installed capacity and generation from geothermal sources by 2020. August 2008

In April 2007 the Council of Australian Governments (COAG) requested the development of a technology roadmap for geothermal energy. The Australian Geothermal Industry Technology Roadmap[22]. is a companion document to the Geothermal Industry Development Framework[23] The Roadmap examines in detail the research and development needs of the geothermal industry in Australia. The Framework examines a broader range of challenges to the commercialisation of geothermal energy in Australia: attracting investment; geoscience; industry networks; international linkages and partnerships; research and development; human capital; community engagement; engagement with energy policy processes; and legislation and regulation. SKM was commissioned to produce this roadmap and thus the form of government support to the developing Australian geothermal industry has had a large input from NZ geothermal experts.

4.1. Skills capability and training

MMA 2008 reported that most of the personnel involved in the emerging Australian geothermal industry have a strong background in minerals exploration and development, but they have less experience in generating and selling electricity, with only a few having geothermal development experience. The study went on to highlight what many in the industry saw as gaps in their knowledge and experience, namely: reservoir engineering and fracture stimulation, electricity generator construction and operation, scaling and corrosion, and down-hole pumps.

For this new industry, in order to reduce costs in the exploration stages, the report felt the following had the potential to impact on this important initial phase:

- a better knowledge of resources across Australia from work by Geoscience Australia, state geoscience organisations and proponents
- improved data collection and dissemination by some state geoscience agencies
- university courses which focus on geothermal
- improved modelling of heat reservoirs
- refinements in measuring down hole temperatures and heat flows
- slimline drilling of shallow exploration holes.

4.1.1. Geoscience Australia

Geoscience Australia is a prescribed agency within the Resources, Energy and Tourism portfolio. Of relevance to geothermal exploration, Geoscience Australia provides geological mapping and interpretations; geophysical surveys including seismic reflection survey and magneto-telluric, gravity, magnetic, airborne electromagnetics, radiometric, thermal conductivity and thermal gradient; drilling data; geochemistry and geochronology; groundwater studies; basin architecture and porosity and permeability; seismic monitoring, stress mapping and hazards assessment. In addition, Geoscience Australia provides satellite data including ALOS, MODIS, RADARSAT, NOAA and Landsat and digital elevation models; bathymetry; and national topological and cadastral mapping.

Each state and territory provides similar geoscience data to that mentioned above. In addition to their own work programs, the state and territory surveys collaborate with universities, the CSIRO and Geoscience Australia. Geoscience Australia works in conjunction with each state and territory via the

[22] Australian Government (RET). Australian Geothermal Industry Technology Roadmap.2008
[23] Geothermal Industry Development Framework (GIDF). Dec 2008.

umbrella of the National Geoscience Accord. This ensures work programs are complementary and avoid duplication.

A major difference from New Zealand is that all of the data is usually publicly available essentially free of charge, as per a minerals regime.

4.1.2. Queensland Geothermal Energy Centre of Excellence

In September 2007 the Government of Queensland committed A$15 million to the Queensland Geothermal Energy Centre of Excellence at University of Queensland, Brisbane, which will have a research and development focus on energy derived from subterranean “hot rocks”. The $15 million is being met by a $3.3 million contribution of expertise and other resources from UQ, making this the largest investment in geothermal energy research in Australia. They currently have four research programs and 11 researchers/staff:

- Power conversion: cycle design and optimisation, key enabling technologies
- Heat removal: heat exchanger design/optimisation, key enabling technologies
- Long distance electricity transmission: grid stability, HVAC versus HVDC
- Reservoir management: monitoring the reservoir performance, optimum extraction and expansion schedules

4.1.3. Western Australian Geothermal Centre of Excellence

On the 29th of February 2008, the Western Australian State Government announced a new $2.3 million WA Geothermal Centre of Excellence. The Centre comprises three participants: CSIRO, the University of Western Australia, and Curtin University of Technology. Because of Perth’s geological setting, the Centre focuses on direct heat use technologies (for example geothermally powered air conditioning and desalination) for use in population centres where there is shallow groundwater of moderate temperature. Geothermal groundwater convection in settings such as the Perth basin provides a natural underground heat exchanger. Owing to the high natural permeability there is no need for artificial hydraulic fracturing. For 3D modelling of these geothermal systems the Centre will harness the supercomputers now being set up in Perth, and will make it possible to drive geothermal research into computationally intensive directions that had previously been out of reach in Australia.

Under the direction of Professor Klaus Regenauer-Lieb (ex Auckland Geothermal Institute, Doctoral studies 1992), the centre will consolidate and extend the multi-scale heat transfer modelling of geothermal aquifers. The Centre will also offer geothermal training to students and industry. The research is organised in three interlinked Programs:

- assessment of Perth Basin geothermal opportunities using presently available data;
- optimal use of geothermal resources; and
- identification of future potential by going deeper.

The Centre is collaborating with the University of Auckland’s Geothermal Program.

4.1.4. CSIRO

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science agency .The Energy Transformed Flagship of the CSIRO will invest $3.47 million into the Western Australian Geothermal Centre of Excellence over its lifetime. This initiative is initially incorporated into the Flagship's Low Emission Distributed Energy Theme. This is a first step in consolidating a number of CSIRO capabilities in the geothermal arena. These areas of expertise include: geomechanics, subsurface heat exchange, surface heat exchangers/multi-phase fluid flow, permeability enhancement by hydraulic fracturing, geochemical thermal history analysis, optimal design of renewable systems, fluid-rock interaction analysis, novel low/medium geothermal uses, remote sensing, exploration geophysics, and integration of geothermal technology with public perception and awareness. In addition to the investments into the WA Geothermal Centre of Excellence, CSIRO plans to respond to and develop geothermal industry relationships and to co-fund research projects. In the longer term CSIRO plans to assist the geothermal sector by expanding its geothermal initiatives into the Low Emission Electricity renewable energy stream of the Energy Transformed Flagship[24].

4.2. Summary

Because Australia relies on its mineral wealth, the Australian capability in geoscience is highly regarded, and the Geoscience Australia and WA Geothermal Centre of Excellence are building on local knowledge and expertise for their geothermal research. Whether this will provide an adequate number of trained geothermalists for the Australian industry is unknown.

With respect to numerical reservoir simulation specifically, at present there are not many institutions within Australia offering geothermal numerical reservoir simulation, with the exception of the CSIRO and SKM. However, as the technology is readily commercially available overseas that is not seen as a major constraint that needs to be addressed. The number of institutions capable of performing research to address the complexity of geothermal reservoir simulation described is even smaller. CSIRO has some established reservoir simulator development capability, particularly in the coupled flow and geomechanical area, which could address some of the issues identified.

The necessity for professionals who understand the reservoir transients induced by well testing and production has not been addressed in Australia. This does not only include reservoir engineers, but production geochemists, environmental scientists, geophysicists, and technicians. Once the Australian industry has progressed into plant development phase, professionals with experience in power plant design, construction, operations (steamfield and power plant) etc will be in high demand. One conclusion is that this situation will increase the demand for trained personnel, resulting in a likely situation of New Zealand supplying either the training, or the personnel, or a combination of both. Given that professional salaries are typically significantly higher in Australia than NZ this could place strain on the NZ human resources.

[24] http://www.csiro.au/news/newsletters/Energy/0812_energy/htm/story01.htm

5. World-wide geothermal growth

It is not in the brief of this report to summarise worldwide geothermal development, but it has to be acknowledged that the large investment in geothermal is likely to impact on the availability of New Zealand geothermalists. For instance, Indonesia has an ambitious development program which is limited by the local personnel capacity. Recent World Bank funding for Indonesian projects has already drawn bids from several New Zealand consultancies. Recent increased investment in geothermal development by the US government may further drain New Zealand resources.

A review of the activities of the larger New Zealand consultancies (PB Power and Sinclair Knight Merz) shows that much of their work load is sourced offshore. Possibly only 10% of the revenue of these companies comes from national activities. Other companies are progressively taking advantage of their growing national experience to market themselves internationally, though are more likely to have 10-15% of their work based internationally.

Traditional international markets include the Philippines and Indonesia. There was strong involvement in the development of some of the Philippines geothermal fields in times predating these surveys, but recently there has been a restructuring of the national electricity supply networks and of associated state-owned enterprises coupled with privatisation and asset sales. This has drawn in New Zealand consultants (and potential investors) into due diligence studies on behalf of multiple investors, and subsequent feasibility studies. Consultants have also provided advice on maintenance regimes for existing facilities. Major projects may follow.

New Zealand companies were also associated with the development of several Indonesian projects, and Indonesia remains a country with the potential to have the greatest installed geothermal capacity in the world, with potential additional capacity from some attractive fields exceeding 10,000MWe. There are still many diesel generators nationally and there is now a programme for fuel substitution driven by high oil prices and Indonesia becoming a net importer of petroleum. Companies have recently been involved in owners engineer roles for several power stations, including detailed steamfield design. Preparations are now underway for feasibility studies for 3 sites that may lead to detailed owners engineer roles at a later stage.

Other developments that have required and will require New Zealand personnel include the Lihir project in Papua New Guinea, the San Jacinto project in Nicaragua, and Olkaria in Kenya. There are frequent calls on geothermal experience for due diligence and feasibility studies through parts of South East Asia and in Europe, and more recently through the Caribbean. Djibouti is one of the latest places for prefeasibility studies. There is growing interest in Central and South American development, including a recent strong drive by the Chilean government to encourage development in Chile.

The neighbouring market in Australia (see the previous chapter) is drawing on more support from New Zealand, though is often counted as a domestic market extension. Consultants are providing advice on drilling, science aspects and surface equipment, coupled with the overall programming of activities.

Until now there have been almost no inroads into the US market (despite PB Power as an example being headquartered in the US) but that could be about to change. The WGC 2005 country update for the USA showed there were approximately 725 professional personnel involved with geothermal activities in the US in 2004 compared with 440 similarly qualified geothermal professionals in New Zealand currently. These professionals were spread across the following projects at various stages[25].

- **Table 2: Geothermal development stages in the USA**

Phase	Not Confirmed	Phase 1 (identifying site, secured rights to resource, initial exploration drilling)	Phase 2 (Exploratory drilling and confirmation)	Phase 3 (Securing PPA and final permits)	Phase 4 (Production and drilling and under construction)
Number of Projects	5	21	19	17	12
Total Capacity	350 MW	648-760MW	578-711MW	585-725MW	333-371MW

Clearly, US personnel resources would have been severely stretched, even before the recent stimulation package.

There was increasing interest in engineered geothermal systems in the United States (MIT, 2006)[26], and the interest in the potential of geothermal energy on every continent has continued despite the 2008 world financial problems. The US DOE has recently announced a massive US$350 million investment targeted at EGS plus an additional US$50 for geothermal heat pumps. The expected program outcomes include demonstrating the ability to create an EGS reservoir capable of producing 5 MWe by 2015. This system demonstration should foster rapid growth in the use of geothermal energy in future years with EGS a major source of baseload electricity in many areas of the US. Also included in the DOE budget is funding for complementary activities such as a web-based, public geothermal database for resource, power plant, and institutional data; international collaborative activities; investigation of low temperature geothermal opportunities; and support for geothermal workforce development to meet the needs of a rapidly growing energy sector.

The US Association of Energy Engineers predicts that with this stimulus package expected to create more than 100,000 green jobs, finding staff with the right skills will be tougher. The AEE, which says its member work in the energy efficiency or renewable energy sector, predicts one in four of its members will retire over the next 10 years.

Close to US$155 billion was invested in 2008 in renewable energy companies and projects worldwide, not including large hydro. Of this, $13.5 billion of new private investment went into companies developing or scaling-up new technologies alongside $117 billion of investment in renewable energy projects from geothermal and wind to solar and biofuels.[27]. The 2008 investment is more than a four-fold increase since 2004 according to *Global Trends in Sustainable Energy Investment 2009*, prepared for the UNEP Sustainable Energy Finance Initiative. Of the $155 billion, $105 billion was spent directly developing 40 GW of power generating capacity from geothermal, wind, solar, small-hydro and biomass sources. It means that renewables currently account for the majority of investment and over 40% of actual power generation capacity additions last year.

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[25] Karl Gawell and Griffin Greenberg, 2007. 2007 Interim Report Update on World Geothermal Development

[26] Massachusetts Institute of Technology, 2006. The Future of Geothermal Energy. Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century. An assessment by an MIT-led interdisciplinary panel, prepared under Idaho National Laboratory Subcontract No 63 00019 for the US Department of Energy.
www.renewableenergyfocus.com/view/2005/president-obama-us467m-for-geothermal-and-solar-energy
www.renewableenergyfocus.com/view/2101/doe-us50m-for-geothermal-heat-pumps

[27] www.renewableenergyworld.com

6. Industry Survey of Personnel Capability

6.1. Methodology

The 2005 skills survey was used as a baseline for the present study. Most companies listed in the previous survey were re-interviewed. Attendee lists of the most recent NZ Geothermal Workshop in November 2008 were also referenced. In addition, contact was made with a number of new 'players' who have entered the industry since 2005. Within many of the companies listed in the 2005 survey, personnel numbers had grown significantly.

During the course of this study, telephone interviews were conducted and site visits were made 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
- Māori Trusts
- Universities, CRIs

For the larger companies, in some instances exact figures were difficult to obtain (e.g. Tertiary qualified, trade qualified, years of experience etc.) so the original table has been expanded to include various diverse roles. Because some staff work in both geothermal and other industry sectors, some difficulty was experienced is knowing who to include. Many consulting organisations cover broader interests and skills other than just geothermal, and there was some difficulty in obtaining consistency between the surveys. There also are a number of new developers, or potential developers who are building up their geothermal expertise and who have the potential to be major players in the industry in the next few years.

There are a number of Māori Trusts involved in geothermal, for which the Table 4 list is partial and will have to be expanded as more details become known. It is a very dynamic period of development and attempts were made to contact as many as was possible within the timeframe.

In each interview, the following information was obtained:

- the company's current staff levels, capabilities, current training requirements and how this was 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 (some of this information was not freely available due to confidentiality).

The results of these interviews are presented in the table below and discussed in Section 5.2 in terms of assessed current and future personnel requirements of the New Zealand geothermal industry.

6.2. Current Personnel Capability

The survey of 2005 show some 350 personnel actively engaged in the NZ geothermal industry in the areas of geothermal development and geothermal operations. That number included professional scientists, engineers and steam field and power plant operators only. However, the current survey expanded on that table and added technicians, steamfield and construction personnel, business development etc who although may not have tertiary qualifications are actively involved in the industry – not just intermittently. The total number is over 650 personnel. See Table 4.

The number of personnel in the industry has therefore grown substantially in the last 4 years, with some developers now employing their own in-house technical team rather than relying on consultants. Despite the current recession, these numbers are expected to grow within the energy industry collectively (and not just in NZ) requiring skilled people in all aspects of the industry. The issue is a long-term one for which rectification involves a combination of training of new entrants, job-skilling of those in the industry and sourcing labour on the world-wide market (these aspects will be discussed later in terms of "make", "fix" and "buy" terminology used in the Oil and Gas Skills Action Plan). The wage gap does not always make NZ an attractive option for scientists and engineers from Western countries but they may be attractive for S.E. Asian geothermal professionals. Potential competition from the oil and gas sector is another issue. This is particularly pronounced in the drilling sector where experience personnel can earn significantly larger salaries in the oil and gas industry abroad.

Home-grown expertise is an obvious solution, and it was unfortunate that the Geothermal Institute was closed for several years. Although some courses have been re-established, those intervening years of closure and lack of international exposure have been detrimental to the geothermal industry here. There is now a clear division in the industry with a large group of highly experienced professionals whose involvement in geothermal spans 20+ yrs, but with much fewer people in the moderately experienced and younger group who are able to replace older professionals as they retire.

Recruitment offshore remains a solution. New Zealand offers an attractive lifestyle to many international professionals that outweighs the salary level disadvantages. We have drawn in people from the Philippines and Indonesia (where NZ offers salary advantages) and South Africa (in recent years) along with other nationalities. In the more distant past there was a significant influx of British professionals and trades personnel. A review of NZGA membership indicates that approximately 1/3rd of the "New Zealand" expertise is held by expatriates, and in some companies the representation is higher.

6.3. Future Personnel Requirements

In the 2005 Skills Survey, an estimate was made on future personnel requirements from the NZ geothermal industry in meeting a 50 MWe geothermal plant. It assumed the current personnel capability and forward planned development was accurate when surveyed at the time. It also assumed that future developments will proceed in blocks of about 50 MWe in size and at a rate of 1 x 50 MWe per year. The estimate also assumed forward geothermal development programs will be based on EPC contract in which the developer had responsibilities for a number of requirements.

The result of these calculations showed there would be an excess of availability of about 350% geoscientific personnel, and approximately 300% excess availability of engineering personnel – based on a 50 MWe development per year. Since 2005 there has been an additional 135 MWe geothermal added to the grid, somewhat less than the 200 MWe assumed. Yet, personnel numbers have grown, new developers and consultants have arrived into the industry and from interviews with various companies, work-load has been extremely high with companies still seeking qualified and experienced people.

Obviously the work consultants carry out (this includes large and small companies, individuals, CRIs and universities) have a significant proportion of it offshore. The NZ based work does not sustain them, and never has done. The 2009 survey results, using the same formula for future personnel requirements as in the 2005 report shows an excess availability of both geoscientists and engineers of over 400%, who are still heavily committed to current workloads. Clearly the formula does not adequately capture the offshore work and conflicts of interest.

Alternative “black box” projections or personnel requirements can be made by comparing personnel bases with past investment and with numbers of projects that have been implemented.

Country updates prepared for the World Geothermal Congress (WGC) record total professional man-years of personnel over a five year period and the equivalent total investments (in US$). The New Zealand data is tabulated below (Table 3) and is shown in the following graph (Figure 3). This table includes data used in the current draft New Zealand update for WGC 2010. The professional personnel numbers are taken from the scientists and engineers identified in the 2005 survey and this current personnel survey. For past numbers to be turned into a projection forward an assumption must be made that the ratio of foreign to national work will remain similar to previous ratios.

- **Table 3: Past and future professional personnel requirements**

Period	Person-years of Professional Personnel	Total Investment as at end of the Period (US$M)	Total Investment (2009 US$M)
1995-1999	475	154	188
2000-2004	325	133	147
2005-2009	1525	1025	1025
2010-2015	*1980 (est)*	*1369* (est)*	*1369 (est)*

*The estimate of expenditure is based on the following crude assumptions: R&D=NZ$3M/year, station costs at NZ$4M/MW with the following stations: balance of costs for 130MW Nga Awa Purua and 23MW Centennial Drive, 220MW Te Mihi (but 2/3rds of normal cost as wells are already present), 220MW Tauhara, 80MW Ngatamariki, 35 MW Rotoma, about 25MW of unspecified MRP projects to bring up installed generation across a program to 400MW.

What is not obvious through comparison of the 2005 survey with the 2009 survey is the huge growth in personnel numbers that happened in the year or so prior to this. This massive growth is clearly seen in the table above. Clearly many people were being diverted into non-geothermal areas prior to this. Some scientists would have been moved into mineral exploration, while engineers could readily divert skills into other generation forms. Further flexibility may still exist to take up future swings.

- **Figure 3: Projected investment vs. number of person-years of professional personnel required**

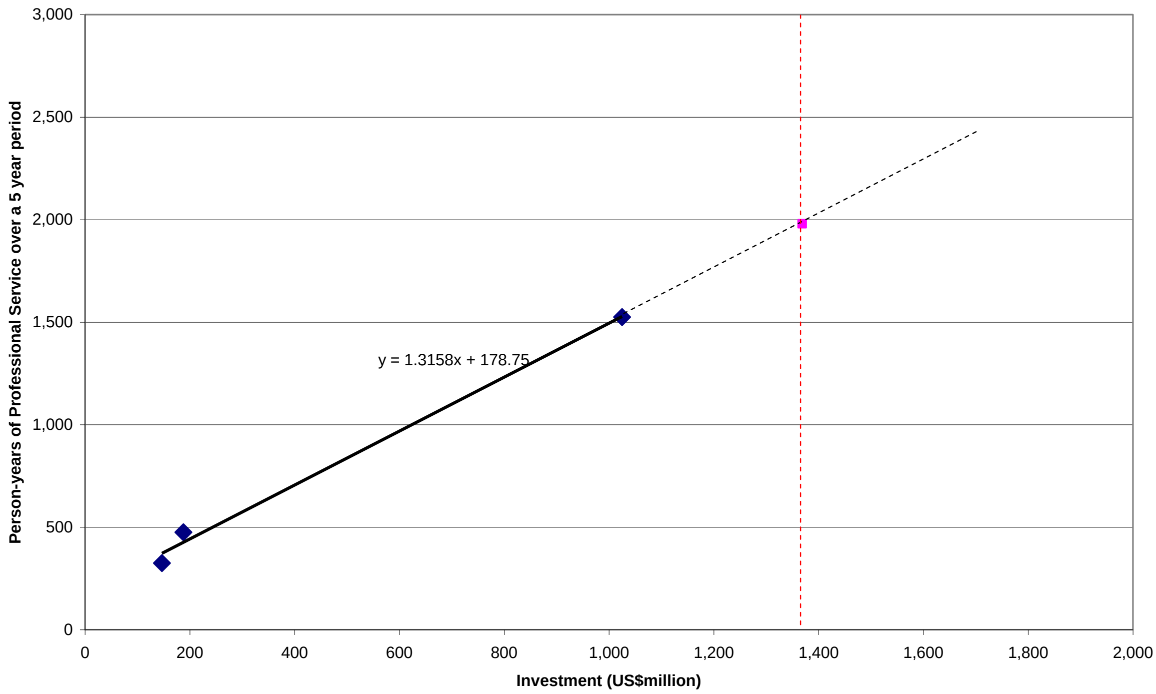

Table 3 and Figure 3 show that, with the forecast expenditure a person-effort of about 2,000 person-years over 5 years is needed i.e. a personnel base of about 400 people compared with the current base of professional-only staff of 320.

An alternative approach could be to look at the number of upcoming projects versus recently implemented projects, recognising that the scientific and engineering inputs for a 25 MWe project can be similar to that of a 100 MWe project. From Table 1, 6 generation projects have been completed and 2 more are well-advanced, while several geothermal direct heat projects have been implemented or modified. The coming period will see the two generation projects under construction finished, and another 5 or 6 projects implemented (though on a larger scale), along with the implementation of at least one major direct heat project. The implication of this being that future workload might be similar to current workloads.

The estimates are crude, but overall suggest that the industry professional personnel base may be at or approaching a sustainable level for the developments currently envisaged. If this is correct then acquisition of new staff for growth could soon become less of an issue, with the new focus being on succession planning.

Another consideration is operations and maintenance staff. Obviously numbers must increase as the number of plants increase. The scale of the construction projects will necessitate greater construction workforces. Some of the welding skills required may mean that geothermal construction requirements are in direct competition with oil and gas industry requirements.

The work consultants carry out (this includes large and small companies, some individuals, CRIs and to a lesser extent universities) has a significant proportion of it offshore. In discussions with industry representatives it appears that the major consultancies of SKM and PB Power have around 90% of their work based offshore, while other consultancies (including CRIs) have closer to 10% of their work offshore. The NZ based work has not sustained the major consultancies.

Determining future personnel requirements is not straightforward and many issues come into play e.g. recent financial crisis, pace of geothermal development in Australia, consenting delays. But all indications of the long-term development of geothermal both nationally and internationally appears to be very encouraging.[28]

[28] Sam Newell, Feb 2009. www.renewablenergyjobs.com; Prof. Peter Crossley, Director Joule Centre, March 2009. Skills Shortage for UK renewables industry revealed.

Table 4: Personnel levels in the geothermal industry in NZ

Industry Category	Sub Category	Company	Staff		Scientists							Engineers									Operators				Technical Staff								Advisory,Strategic,BD, other
			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	Technical Total	Logging	Drilling	Steamfield	Engineering	Maintenance	HSE & Risk	Construction	
Developers and Operator	Operators	BOP Energy	50	3	0							0									3			3	0								0
		Contact Energy	1000	108	2	1			1			29	4	6	3	10		1	5		34	5	22	7	31				5	19	7		12
		Mighty River Power*	752	80	15							15									25				20								5
		Norske Skog Tasman	430	2	0							0									2		1	1	0								0
		Tuaropaki Power Company (TPC)		3	0							0									0				0								3
		Top Energy	120	3	0							0									3	1	2		0								0
	Developers	Kiwi Petroleum/Ormat		7	0							4									2				0								1
		Ngati Tuwharetoa Geo. Ltd (NTGA)		2	0							0									0				0								2
		Putauaki Trust		2	0							0									0				0								2
		Tauhara North No. 2 Trust		3	0							0									0				0								3
	Potential developers and resource owners	Tikitere Trust		2	0							0									0				0								2
		Genesis		3	0							0									0				0								3
		Rotoma No.1 Inc		1	0							0									0				0								1
		Macpower		1	0							0									0				0								1
		Tauhara North No. 3 Trust		1	0							0									0				0								1
		8A Kawerau		1	0							0									0				0								1
		Ruahine-Kuhara Inc. Taheke		1	0							0									0				0								1
		TrustPower		1	0							0									0				0								1
		Meridian Energy		1	0							0									0				0								1
Consultants	Private Sector - Large	AECOM	3700	67	11	5				4	2	56				18	12	5	13	8	0				0								0
		Dobbie Engineers	20	5	0							5				5					0				0								0
		MBCentury	4500	147	0							14	1	2	4	7					0				130	15	60	30		5		20	3
		PB Power	2250	28	0							28				12	4	1	11		0				0								0
		Sinclair Knight Merz	5000	76	18	7	2	2	1	4	2	56	3	1	0	14	10	10	14	4	0				0								2
	Private Sector - Small	Allied Industrial Engineering Ltd	60	5	0							5									0				0								0
		Cheal Consultants	8	8	0							8									0				0								0
		East Harbour Management Services	10	1.5	0							1.5				1			0.5		0				0								0
		Environmental Management Services	3	3	3					2	1	0									0				0								0
		Glucina & Associates	5	2	0							2				2					0				0								0
		GeoKem	2	2	2			1	0.5	0.5		0									0				0								0
		Glassearth		2	2		2					0									0				0								0
		Geothermal Consultants NZ	2	2	0							2	2								0				0								0
		Golder Associates		1	1					1		0									0				0								0
		Halliburton		1	0							0									0				0								1
		PMP Services	6	4	0							4									0				0								0
		Strettons	20	1	0							0									0				0								1
	Private Sector - Individuals	Errol Anderson	1	1	1		1					0									0				0								0
		Lew Bacon	1	1	1				1			0									0				0								0
		Andy Bloomer Geothermal Eng. Ltd	1	1	0							1					1				0				0								0
		KC Foong	1	1	0							1				1					0				0								0
		Dick Glover	1	1	1			1				0									0				0								0
		Malcolm Grant MAGAK	1	1	0							1		1							0				0								0
		John Hulston	1	1	1			1				0									0				0								0
		Russel James	1	1	0							1						1			0				0								0
		Mike Mongillo	1	1	1		1					0									0				0								0
		Hari Pratomo	1	1	0							1									0				0								0
		Tricia Scott	1	1	1					1		0									0				0								0
		Doug Sheppard	1	1	1			1				0									0				0								0
		Ian Thain	1	1	0							1				1					0				0								0
		Bill Woods	1	1	0							1							1		0				0								0
	Govern-ment Sector	DOC		1	1							0									0				0								0
		EECA		0.5	0							0									0				0								0.5
		GNS Wairakei	90	30	26	7	11	4	4			0									0				2								2
		IRL		4	0							4		4							0				0								0
		MfE		0.5	0							0									0				0								0.5
		MED		0.5	0							0									0				0								0.5
		NERI		0.5	0							0									0				0								0.5
		NIWA		1	1	1						0									0				0								0
		Quest Reliability		1	0							1						1			0				0								0
Consultants Totals				409	72	15	17	10	6.5	8.5	3	194	6	8	4	43	15	13	26.5	4	0	0	0	0	132								11
Regul-atory		Environment Bay of Plenty		2	2					1	1	0									0				0								0
		Environment Waikato		2	2					1	1	0									0				0								0
		South Waikato District Council		1	1					1		0									0				0								0
		Far North Regional Council		1	1					1		0									0				0								0
Tertiary Institutions		Auckland University - IESE	24	16	16	6	8	1		1		0									0				0								0
		Auckland University - Eng & Science Faculty		8	3	2	1					5		5							0				0								0
		UNITEC		2	0							2		1		1					0				0								0
		Massey University		2	2					2		0									0				0								0
		Canterbury University		3	0							3									0				0								0
		Otago University		2	2	2						0									0				0								0
		Victoria University		2	1		1					1									0				0								0
NZ Industry Totals				675	119	31	27	11	7.5	19.5	7	253	10	20	7	72	27	19	44.5	12	69	6	25	11	183	15	60	30	5	24	7	20	51
2005 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									

*exact numbers not supplied

7. Current status of geothermal training in NZ

In the 2005 report on skills capability in the geothermal industry, the most common complaint from industry was the lack of training programs available to maintain a satisfactory inflow of younger staff or for further developing experienced staff. It was recommended that the former Geothermal Institute within the University of Auckland (UoA) be re-established but with tailored training programs to the NZ geothermal operator sector. In particular, focus on resource monitoring and management, steam field and power plant operational issues was sought.

7.1. University Training and Research

7.1.1. University of Auckland

In 2006 Professor Mike O'Sullivan, leader of the Geothermal Reservoir Modelling Group in the Department of Engineering Science and Associate Professor Stuart Simmons, Director of the Geothermal Institute assembled a group of geothermalists to activate the one-semester Post Graduate Certificate in Geothermal Energy Technology (PGCert). The philosophy was to provide through the PGCert the backbone for a comprehensive geothermal training program involving university level papers, short lecture courses for professionals, graduate research degree courses and academic research programs.

At the time when the decision to run the course was made the University was in the process of developing a cross-faculty research group called the Institute of Earth Sciences and Engineering (IESE). Geothermal energy was considered to be an important part of the research portfolio for the new Institute and therefore the old Geothermal Institute was taken over by IESE. However because of its research-only status within the University of Auckland IESE cannot host University degree programmes and hence the PGCert course is hosted by the Department of Engineering Science in the Faculty of Engineering. Despite this, the IESE can and does run non-degree 'professional' short course training.

The first new geothermal course was run in 2007. It was a shortened version (one semester) of the original full year course and over 20 applications were received. Several scholarships were offered which were funded by contributions from industry and the IESE. In addition, lecture support came from several specialists and consultancies in the industry. Short courses have also being offered, some tailor-made to meet the needs of different companies wanting to have employee training.

In the first two years of the PGCert course 16 students attended the full course, from Indonesia, Iran, New Zealand, Papua New Guinea, Philippines, Slovenia, and the USA. Students from France, Germany, Iceland, Indonesia, Kenya, Mexico, and New Zealand either credited one or more of the Geothermal lecture courses to another qualification, or attended the short courses. See Table 5.

2009 is the first year where no scholarships have been offered however this had no effect on the number of applicants. The increase in student numbers is probably due to a number of factors, including the low NZ dollar, the time taken for news of the New Zealand geothermal course to spread, and people furthering their training as the recession impacts on employment opportunities.

Table 5: Geothermal training numbers and courses run by UoA

Year	PG Cert Geothermal Energy (one semester)	Short courses in NZ	Short courses outside NZ
2007	8 students 5 scholarships	None offered	
2008	8 students 5 scholarships	3 students	Geoth Sci/Geoth Eng. – KenGen GeothSci – Chevron Geoth Eng - Chevron
2009	25+ students* No scholarships	Still enrolling	Still enrolling / planning

*1 June 2009, 45 applications received. Close off is 4 July.

7.1.2. Canterbury University

In addition to standard courses in mechanical engineering there is a capstone course of Energy Systems Engineering which covers equally demand and supply including system dynamics (e.g. peak power demand, spinning reserve, load duration curve.etc)[29]. This year they have the first 'final year team project' on geothermal sponsored by industry - all feasible low-temperature thermodynamic cycles and possible conversion efficiencies, with subsequent technology review of possible equipment. There are also several post-graduate students working on geothermal research projects. Much of the effort in obtaining these research projects from the geothermal industry is from determination of academic staff in the department. The current projects are:

- Modelling of existing plants for dynamic operation optimisation and adaptive design modification.
- Condition monitoring of the brine components for real-time evaluation of scaling issues and economic analysis for optimal maintenance scheduling.
- Adaptive design options for resource enthalpy increase.
- Flow and chemistry analysis of scaling in vaporizers.

Mechanical Engineering at Canterbury graduates 109-120 students per year, and the past enrolment in the Energy Systems Engineering course has run around 80 students. They have had to turn away students for the past 5 years as more students wish to enrol than they have places for.

7.1.3. Massey University

The Centre for Energy Research was established at Massey University, Palmerston North in 1997 following over 25 years of teaching and research work undertaken in the areas of Renewable Energy, Energy Efficiency and Energy Management. A number of papers are offered relating to sustainable energy, energy efficiency, renewable energy and greenhouse gas emission reductions, although geothermal energy is not one of the core subjects (cores subjects being wind, bioenergy, solar, ocean

[29] Dr Susan Krumdieck. Assoc-Prof. Dept. Of Mech. Eng. Canterbury University. Pers. Comm. 2009.

energy, small hydro, distributed energy). However, there is research work in mathematical modelling and reservoir engineering in geothermal systems.

7.1.4. Professional Development courses

University level and technical short courses for professional development are supported by the geothermal industry. Examples of recent courses are:

- NZGA and Western Pacific Regional Branch of the IGA joint seminar on reservoir management by Cedric Malate from the Philippines. This seminar was well attended, and considered by companies to be part of their professional development program.
- One week and four week short courses organised by the Institute for Earth Science and Engineering have had enrolments from six industry supported students.

Attendance at conferences is also a method of keeping staff up to date with new developments. Local annual conferences such as the New Zealand Geothermal Workshop and NZGA Seminars receive strong support from the industry, and New Zealand is often well represented at international conferences such as the Geothermal Resources Council meeting in the USA, the Australian Geothermal Energy Conference and World Geothermal Congress.

7.2. NERI's Review of Energy Courses in NZ Universities 2007[30]

The NERI survey of stakeholder needs and analysis of course provision revealed gaps in current energy teaching in New Zealand universities. The points raised below suggest action by industry, educational bodies, or, in some cases, suggest a more widespread, general problem relating to the supply of science and engineering students.

I. To meet current energy industry demand, an increase is needed in the number of university graduates from engineering, commerce, science and geography entering employment in the energy sector.

II. There appears to be a shortfall in numbers of graduates in geothermal specialisms, planning, policy analysis, mining specialisms, corrosion sciences, surveying, physics, geology, ICT, human resources, law, resource management and project management needed to meet energy industry demand.

III. University graduates' capabilities in functional skills do not appear to meet energy industry demand for functional skills. The functional skills in most demand are communication, business, and interpersonal skills.

IV. University graduates' relevant work experience does not appear to be sufficient to meet the work experience demanded by employers in the energy industry.

V. There appears to be a need for cross-disciplinary university education relating to energy.

Related to this gap analysis are:

- A desire by energy stakeholders to have more contact with universities

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[30] Report funded by TEC 2007

- A need for better understanding of how to recruit and retain students in/to energy-related courses and/or programmes
- A need for better understanding of university-based vocational education for the energy industry
- A need for better understanding of the stimuli external to universities that influence students' selection of courses, degree programmes and employment options
- A need to ensure that energy education in tertiary institutions includes sufficient focus on issue of strategic national importance
- A need for understanding of iwi perspectives on tertiary level energy education.

7.3. Trade Qualifications and Certification

Trade/Technical skills are catered for in broad disciplines applicable to the energy industry e.g. electricians, fitters etc, but not specific to geothermal. However, the numbers of young people choosing to enter the trades is less than desirable. There is also some confusion about the equivalence of apprenticeships with the newer industry traineeships and this needs explaining, through marketing activities to school students and their parents. In the past, NZ Qualifications Authority (NZQA) has administered many trade and advanced trade certificate qualifications. These are being progressively phased out and replaced by National Certificates and Diplomas registered on the National Qualifications Framework. Assessment is no longer available for most of the trade and advanced trade certificate qualifications. These qualifications are 'Industry training' and thus work-based training.

Industry Training Organisations (ITOs) have the mandate of the industry that they represent to develop training standards for their industry and to register these on the National Qualifications Framework. ITOs are funded by the Tertiary Education Commission to offer training subsidies for their industry. While not directly able to engage in training the ITOs determine which providers will be accredited to award qualifications for the industry and who will be recognised as an accredited assessor. Those ITOs offering qualifications with some relevance to the geothermal industry are the Extractives ITO (EXITO), the Engineering ITO (COMPETENZ), the Electrical Supply ITO (ESITO) and the Electrotechnology ITO (ETITO).

There is one qualification and unit standard available which can be applied to the geothermal drilling industry:

- Drilling – non-hydrocarbon National Certificate in Drilling, National Diploma in Drilling (Driller's asst, Driller, Senior Driller and Driller Supervisor levels).

If necessary ITOs, will respond accordingly if the geothermal industry identifies other needs or will adapt qualifications to meet any specific requirements. MB Century Drilling has been in talks with EXITO to enable their in-house training to be accredited by NZQA. This new certificate will take about 6 months for a trainee to pass through the various steps in order to obtain the required credits.

7.4. Māori and energy research

There are several research projects underway, which although do not deal solely with geothermal energy are more broadly studying the needs of Māori in energy development.

NIWA are presently undertaking an 'Energy for Māori' research project. This project assists Māori authorities in developing their energy resource potential, for the benefit of Māori and New Zealand. In particular, the project is researching how Māori can evaluate resources and apply best practice social and corporate governance[31]. Māori Trusts and Incorporations account for approximately 6% of New Zealand's land area, which covers significant hydro, wind, geothermal, biomass, and coal resources. Consequently, the two primary barriers to development of these resources are considered to be: lack of understanding of resource value and limited / poor governance practice. NIWA and the University of Auckland are undertaking collaborative action research to assist three Māori authorities to review the value of resources that they are interested in developing, and identifying best practice governance principles that are common to successful Māori authorities. Given that Māori Trusts are (and will be) investors in geothermal resources, then these governance skills development and basic training around resource knowledge are relevant to the New Zealand geothermal skills assessment.

Waikato University, Department of Economics also has a research project of this nature - Māori Sustainable Development. This research programme involves collaboration with staff in the School of Māori and Pacific Development and the School of Education at Waikato University and Landcare CRI. It also involves significant collaboration with Ngati Raukawa, Tauranga Māori Trust Board, Te Arawa Māori Trust Board and Runanga of Ngati Porou. The objective is to develop operational models for participatory development planning by Māori organisations/communities. The research will develop an operational development planning and "investment decision" model for Māori organisations /communities, and assist Māori iwi/hapu, corporations and organisations explore culturally relevant training and decision models for positioning Māori development to engage in new economic areas of knowledge services, new technology and value-added production as well as in existing economic opportunities[32].

7.5. Summary

Replacing an ageing workforce with adequately trained new personnel is a problem faced by many engineering based industries around the world. A decline in student interest in science and engineering careers is evident throughout the western world, hence some of the solutions offered in this report are relevant to a much wider section of society and industry than geothermal alone. Nonetheless, if the New Zealand geothermal industry is to benefit from increased numbers of science and technology graduates, then it must participate in and contribute to programs encouraging these career choices, and encouraging public interest in scientific endeavour.

For tertiary students there are a number of Universities which allow some coverage of geothermal or energy engineering topics in their graduate course structure – Canterbury, Massey, and Auckland. It is understood that Victoria University has also been planning geothermal courses but no details are available. Professional short courses are available at the IESE (University of Auckland) which companies can and do use for staff professional development. The University of Auckland is the only institution to host a postgraduate Certificate one semester course specifically in geothermal. This course has close links with the industry and course organisers are aware of the need to keep training relevant to industry needs.

[31] http://www.niwa.co.nz/our-science/energy/research-projects/all/energy-for-Māori

[32] http://wms-soros.mngt.waikato.ac.nz/Departments/Economics/Research/Māori+Research.htm

Generators in New Zealand have a range of practices for trade training, from leaving training to other organisations, to running apprenticeship schemes, and working with the relevant Industry Training Organisation to accredit in-house training to an NZQA recognised qualification.

Given the fact Māori are stakeholders in many geothermal resources, and with recent CNI settlements, there is likely to be increased interest from Māori in participation in energy development and in training programs.

The Australian geothermal industry is likely to use New Zealand professionals as part of the workforce, or to train Australians. Given the lack of skills in geothermal production technology in Australia, this is an area where there will possibly be the most active recruitment from New Zealand.

8. Oil and Gas Industry Skills Action Plan

One of the prompts for this study was the production of an Oil and Gas Industry Skills Action Plan, which was seen as a good basis for a geothermal skills action plan.

The NZ Oil and Gas Industry continue to experience significant investment in the development of existing discoveries (PEPANZ 2009)[33]. The ban on new thermal power stations was repealed late 2008 by the newly elected National Government – PEPANZ think this should do something to restore New Zealand's image as an investment destination. Furthermore, the current tax exemption on the profits of non-resident operators of offshore rigs and seismic vessels was due to expire in December 2009. However, the Budget 2009 will make provision for a five year continuation of this tax exemption. Additionally, there has been $20-million injected into government-funded seismic data acquisition.

However, NZ's oil and gas sector is feeling the effects of the sharp decline in oil prices and on the availability of capital. The rapid increase and then collapse of oil prices during 2008 started to show direct effects on exploration expenditure during the year. Going forward, the industry is likely to see curtailment of new investment and probably quite a few planned exploration projects either deferred or cancelled in the short-term.

In mid 2008 PEPANZ published an action plan to implement work started in 2006 examining skills retention and recruitment issues in the sector. Since December 2008 a detailed project plan has been developed and a separate committee established to oversee implementation of the project made up of representatives funding the project. The project is quite varied: involving work in attraction of skilled migrants; working on developing tools for labour market analysis; developing a package for the school science curriculum and investigating the establishment of a training facility for process operators. Members of the New Zealand Geothermal Association have seen copies of an Oil and Gas Skills Action Plan and see this as a good basis for a geothermal skills action plan.

The Skills Action Plan builds on the research and subsequent report "Exploring the Challenge – New Zealand Oil and Gas Survey 2007' which confirmed that there are skill shortages in the industry both in NZ and globally, caused by an aging workforce and a reduction in graduates in relevant disciplines.

Three priorities provide the framework and context for the Oil and Gas Industry Skills Action Plan[34] including:

- make (growing professional and trade/technical skills for new entrants to the industry);
- fix (on the job-skilling for those already in the industry)
- buy (immigration, source labour on the world market)

Additionally, it was clear a marketing campaign is necessary to widely promote careers in the industry.

The Skills Programme Governance Committee (Gcom) is made up of approximately 7 industry participants, each must contribute NZ$25,000 (or professional time of that value) to fund the programme.

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[33] Annual report of the Petroleum Exploration and Production Association of New Zealand, 2 April 2009

[34] New Zealand Oil and Gas industry skills development. Phase III: Implementation of industry skills action plan. Project Plan 2009. PEPANZ.

9. Geothermal Industry Skills Action Plan

To address current and ongoing skill shortages a skills action plan is proposed. The Plan was developed by the NZGA on behalf of the Geothermal Industry in NZ and was adapted from a similar action planned developed by the Oil and Gas Industry of New Zealand.

It is based on the 'Make, Fix, Buy' model developed by the Department of Labour and aligns with the New Zealand Skills Strategy.

■ MAKE Grow professional and trade/technical skills for new entrants to the industry

■ FIX On-the-job up-skilling for those already in the industry.

■ BUY Immigration – source skilled labour on the world market

These actions are discussed in detail below. The aim of this plan is to present a way forward in increasing the level of participation of skilled personnel in the industry. It also has the aim in raising the profile of this energy resource which often gets ignored in the bigger discussion on renewable energy in New Zealand. The actions and who will implement them are summarised in Table 6.

It should be noted, however, that a key issue raised in the Oil and Gas Industry Action Plan was funding. Without adequate funding or resource the project will not succeed. The advantage the Oil and Gas Industry has over the Geothermal Industry is capital, and contributions made in the past have not been particularly generous. Implementation of the Geothermal Skills Action Plan may, therefore, be hampered by a lack of significant funding and resource.

9.1. 'MAKE'

Education is central to the 'MAKE' section of the action plan. This involves raising awareness of geothermal energy at a community level, school programs in scientific and cultural aspects of geothermal energy use, promotion of renewable energy studies at University, and as a desirable career path.

Development of a package for use in the school science curriculum is recommended for schools. Environmental awareness and sustainable development is now part of the school curriculum, and direct use of geothermal energy would fit well into this particularly at primary school level. It is a straight forward concept to explain and illustrated with a multitude of uses. In addition, the geothermal industry needs a presence at community events raising awareness, and a package for static displays suitable, for instance, for libraries and foyers of community buildings.

The geothermal industry needs to work with the Industry Training Organisations (ITOs) to develop trade and technical courses and qualifications to suit industry requirements. This may involve many interested parties, from Technical Institutes and even Universities for higher level technical skills, to in-house training for school leavers directly entering the workforce.

High level jobs involving tertiary education such as engineers and geoscientists are critical to current and future geothermal exploration and development. In the 2005 report on skills capability in the geothermal industry, the most common complaint from industry was the lack of training programs available to maintain a satisfactory inflow of younger staff or for further developing experienced staff. It was recommend that the former Geothermal Institute within the University of Auckland (UoA) be re-established but with tailored training programs to the NZ geothermal operator sector. In particular, focus on resource monitoring and management, steam field and power plant operational issues was sought.

Collaboration is suggested to capture fourth year and graduate students with project and thesis topics. Industry can provide relevant topics, and logistic and financial support for useful projects.

For the long term it is suggested companies must consider actively recruiting graduates and mentoring/training them over a 2-4 year period to build up necessary experience. The most immediate action required is company participation in careers evenings at Universities and other training institutions. However, in the long term this is also dependent on an increase in school leavers entering the requisites disciplines at university. Programs promoting renewable energy and the green economy as viable career paths need to be targeted at senior school leavers.

9.2. 'FIX'

9.2.1. On-the job up-skilling

On-the-job up-skilling is also vital. The benefits of on-the-job training include higher standards of safety, higher productivity, less down time, and employees feeling valued. Technological advancements require on-going training as well as the need to extend /expand the knowledge of workers moving to new areas of operation and up skilling those moving to supervisory or management roles. Employees report that they value training as long as it is delivered by someone experienced and knowledgeable who can transfer that knowledge in a way that learners can relate to, is timely and that they have the opportunity to learn in group situations. In order for these programs to be successful, workers must have a specified number of paid training hours, and training programs must be available.

9.2.2. Knowledge capture and succession

The dilemma of the aging workforce in the energy sector, as in many other industry sectors, is how to retain all that accumulated knowledge, also known as 'corporate memory'. So in fact, as well as a shortage of people to do the work, a second problem that the industry faces is a knowledge crisis—a transformation in how knowledge is valued, leveraged, and distributed in the marketplace. Knowledge management has traditionally been considered an IT function, a way to archive competencies that can be plugged into the larger structure.

Organisations talk about people being assets, but the real asset is the knowledge that people apply. To develop and retain this knowledge, it must be woven into the institutional fabric of the organisation. This can only be done if an organization provides to its business units a suite of practices that capture and develop the strengths of individuals. These practices, whether craft-based apprenticeships or formal mentorships for managers, must be flexible enough to serve the needs of individual units yet consistent enough to support the organization's culture. For that to be the case, knowledge management must be jointly owned by Human Resources and the business units.

9.3. 'BUY'

The energy industry as a whole needs to address the remuneration issue urgently and consider moves towards pay parity especially with Australia which is New Zealand's major competitor for skilled resources.

As a proportion of overall demand for skilled employees, the numbers are smaller and in the short term can be recruited in the global market. Companies will however have to prepare for a longer lead-in time to source experienced personnel because of the scarcity worldwide or to seek recruits from both traditional and non-traditional sources.

A major consideration for recruiting people from overseas is remuneration. Skills scarcity coupled with escalating demand has had the effect of adding premiums to wages and salaries for those employed within the sector. The general wage pressure is however wider than the NZ market, evidenced as a continued creep towards Australian rates of pay for some skills and in limited circumstances, global pay rates for workers prepared to work in the more lucrative international day-worker market.

Immigration, or the recruitment and retention of skilled migrants, has become an important lever right across the New Zealand labour market, and has been a key contributor to the current geothermal workforce. As examples, many of the senior geothermal positions in MRP have been filled by overseas recruitment, while SKM and PB Power have brought in a number of people in recent years. It is however only one part of the solution to the ongoing needs of industry and in the geothermal industry it is not one of the priorities companies have focussed on. There undoubtedly is recruitment overseas, but internationally the geothermal market appears to be quite stretched.

The Oil and Gas industry hold ‘immigrant workshops’, but this is probably unrealistic for the NZ Geothermal industry and would require a reasonable level of funding and commitment from the major players. Such action is better left to individual employers. However, it may be possible for the NZGA to broadly promote geothermal energy in NZ particularly through Ministerial Trade tours.

Immigration New Zealand has a team of Relationship Managers who work with industry to support the recruitment and retention of skilled migrants. This team can support industry to plan and carry out strategies that ensure migrant recruitment work is well targeted – attracting people with the skills needed by employers, who will be able to migrate and who are likely to settle successfully in New Zealand, whether short term or long term.

However, Immigration NZ reports that while salary level is a strong factor in decision making for some segments of the talent pool, some employers do find it possible to attract skilled migrants to NZ by emphasising the positive attributes that NZ has to offer candidates and their families. Whilst salary levels can be a significant influence, targeting the segment or segments of the talent pool for whom living in NZ itself is an attraction, will yield results.

Table 6: Geothermal Industry Skills Action Plan

MAKE

General community education and primary to secondary educational level *(NERI findings in italics)*	Who	Output **(note – underlined is output already known to occur or planned for near future)**
There appears to be a shortfall in numbers of graduates in geothermal specializations, planning, policy analysis, mining specializations, corrosion sciences, surveying, physics, geology, ICT, human resources, law, resource management and project management needed to meet energy industry demand (NERI). *A need to ensure that energy education in tertiary institutions includes sufficient focus on issue of strategic national importance (NERI).* *A need for better understanding of the stimuli external to universities that influence students' selection of courses, degree programmes and employment options (NERI).*	This appears to be part of a larger problem that extends over many engineering and science based industries. This requires long-term action from a range of educational and government organisations. The Geothermal industry should remain alert to the chance for input into relevant decisions.	Maintain a network of interested people who are in contact with regards this type of promotion – ie PR people in companies plus interested people at research and teaching organisations plus government departments/agencies.
Market to school and tertiary sectors to promote employment opportunities in the sector	Currently GNS Wairakei and Kaikohe School. Industry	Assess and collate all existing marketing material Work alongside other stakeholders to develop relevant material. <u>Some development underway with GNS Wairakei & Kaikohe school.</u>
Development of a package for use in school science curriculum - approach schools to assess interest. Funding needs to sought.	University or research company/government department/agency.	Package developed.
Target one school then extend to three schools in 2 years time	As above.	Identify a pilot school for package. Roll to more schools in future

Tertiary education (*NERI findings in italics*)	**Who**	**Output (note – underlined is output already known to occur or planned for near future)**
Increase numbers participating in university programmes relevant to the sector (note that specialisation would occur in 3rd or 4th year of Bachelor Degree). Recruit graduates for the geothermal industry. *To meet current energy industry demand, an increase is needed in the number of university graduates from engineering, commerce, science and geography entering employment in the energy sector (NERI).*	Industry/NZGA/Universities	List of contact people from each University/faculty, who organise careers presentations. Company participation in career/recruitment days. Career evening presentations hosting the Geothermal Industry as a whole. <u>Geothermal research promoted for Postgraduate topics.</u>
Development of specific qualifications, specialist papers and projects	Universities/Industry/NZGA	<u>Courses at the University of Auckland since 2007</u>
Build internal expertise by collaborating/developing relationships eg. universities and utilities/developers. *A desire by energy stakeholders to have more contact with universities (NERI)*	Industry/Universities/NZGA	Develop a relationship that involves: • <u>training using real-world scenarios</u> • <u>encouraging students to engage with the industry</u> • <u>Student projects</u> • <u>Course support</u> • <u>Fund research</u>
Support increased numbers of MSc and PhD projects	Industry/Universities	<u>Currently Masters and PhD research in geothermal topics at several institutions. Industry is already supportive,</u> can always provide more research topics and funding for projects. ‘Real world’ topics can justify paying a student to research them.

Provide work experience/mentor graduates to build industry experience. *University graduates' relevant work experience does not appear to be sufficient to meet the work experience demanded by employers in the energy industry (NERI)*	Industry	Internship programs. Already some in the industry do this, needs more coordination with students and industry
A need for understanding of iwi perspectives on tertiary level energy education (NERI).	TPK/Universities	Input to Māori Geothermal Seminars, liaise with Māori groups on Campus, for instance UoA SPIES (South Pacific Island Engineering Students), liaise with other University groups researching wider Māori Energy Development.
There appears to be a need for cross-disciplinary university education relating to energy	Universities	Currently development of a Masters in Energy course at the University of Auckland starting 2010. Organised in the Faculty of Engineering but will have the potential for cross-disciplinary study.

Trade/Technical Qualifications (NERI findings in italics)	**Who**	**Output** **(note – underlined is output already known to occur or planned for near future)**
Trade level roles: Disseminate information to contractors and the community including iwi, to improve understanding of the current industry training system and how it compares with the former apprenticeship system. *A need for better information about the supply of non-university graduates for employment in such roles as field technicians and maintenance engineers in the energy industry (NERI)*.	ITO's/NZGA	Liaise with the engineering and electrical sectors for joint marketing of the industry as a career option Develop a communication strategy
Develop introductory pre-qualification packages for use in secondary schools.	ITO's/NZGA	Liaise with school careers advisors, ESITO etc. Establish relationship between these groups and industry to see what the needs are, and where the gaps are
Manage the relationships between schools and industry for work experience through the Gateway programme	Industry	Assess what marketing/promotional work needs to be conducted to increase industry participation in gateway. Work alongside schools to identify potential students.
Increase the number of apprentices/industry trainees	Industry	Liaise with industry to encourage the uptake of more trainees

FIX

General culture of ongoing education	Who	Output **(note – underlined is output already occurring)**
Employers in the industry need to ensure ongoing training	This is an ongoing obligation for all employers and for the self-employed	Regular widespread attendance at seminars and workshops Employees should be continuously adding to their skill base
Provision of suitable courses and topical seminars	NZGA, universities, technical institutes	Regular targeted seminars and workshops e.g. one day overview seminars useful for managers and non-technical people
Assist IESE in developing a business plan for their courses as the basis for a New Zealand/regional geothermal training facility	Industry, NZGA with some Government funding	Active and expanding training programme including input from experienced industry professionals
Ensure employees have a minimum of paid hours of training per year	Industry	Delivery of training

BUY

Preparedness for Expatriate Workers	Who	Output **(note – underlined is output already occurring)**
Individual employers should recruit internationally	Industry	<u>Industry members are currently recruiting internationally</u>
Where skill shortages are identified by employers, make submissions on behalf of industry to Immigration NZ's biannual shortage lists	NZGA, Industry	Shortage lists will address broad gaps, especially in trades
Utilising an independent remuneration consultant, promote a collaborative approach to benchmarking of NZ salaries. Include an assessment of the extent to which NZ geothermal compensation and benefits are aligned internally and regionally, and with the O & G sector, which are all competitors for skilled NZ geothermal workers	Industry and Government funding of an independent consultant managed by NZGA	Report on bench marked salaries, with repeat reports showing a move toward competitive values
Use Ministerial trade shows and trade fairs and international conferences to publicise the opportunities in the NZ geothermal industry	Industry/NZGA working with Government	NZ presence at wide range of events with booths highlighting opportunities