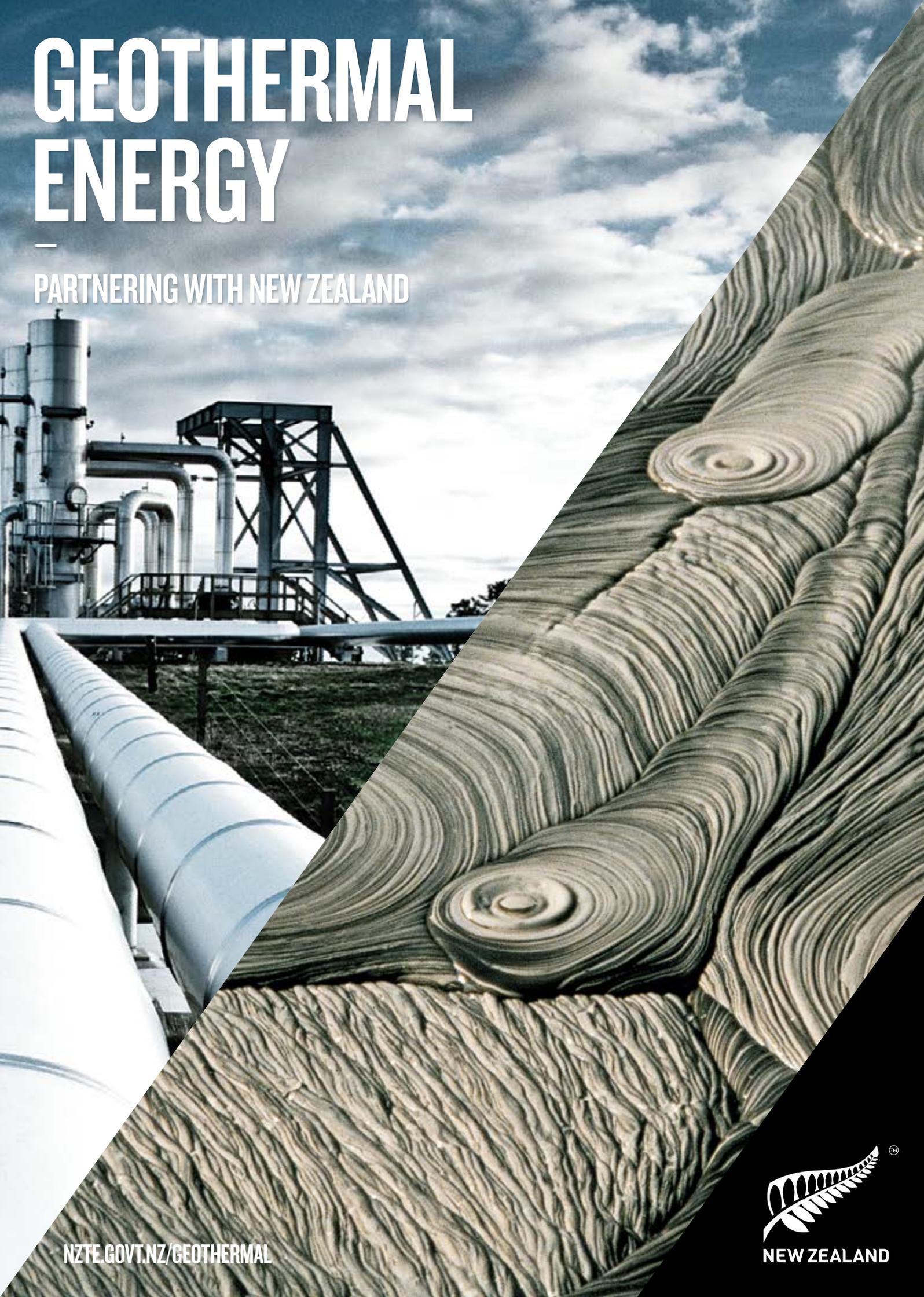


GEOHERMAL ENERGY

PARTNERING WITH NEW ZEALAND



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GEOHERMAL ENERGY

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MINISTER'S FOREWORD



Clean, cost-effective and reliable, geothermal energy is increasingly becoming a significant energy source around the world. Drawing on heat from within the earth, it provides a consistent flow of energy day and night, in any climate, and in any weather.

Now our second most important electricity fuel source behind hydro, New Zealand has a long and successful history in the development of geothermal resources, and we have the experience and expertise to play a leading role in this growing international industry.

Geothermal energy has historical significance for Māori, who lead many developments and exercise Kaitiakitanga over our natural resources.

The term Kaitiakitanga means guardianship, protection and preservation.

Kaitiakitanga is integral to New Zealand's pioneering approach to the successful, sustainable and respectful management of geothermal resources both at home and with partners around the world.

In the 1950s the Wairakei geothermal power plant in the North Island was the first in the world to generate electricity using a liquid-dominated geothermal resource. Since then, it has provided the country's most reliable source of electricity.

The Kawerau geothermal field has been the site of the largest industrial use of geothermal energy in the world for over 50 years, and continues to expand. The world's single largest geothermal turbine can be found at the Ngā Awa Pūrua geothermal power station, and the largest binary plant in the world is at Ngātamariki.

Māori-owned and managed dairy business, Miraka, is the first company in the world to use renewable electricity and steam to run milk powder processing operations.

Scientific and engineering skills from New Zealand have contributed to a wide range of geothermal power developments internationally, and to the identification of potential resources in geographies far from our own including in Africa, Asia and South America. Added to this, many of today's leading geothermal engineers and scientists were trained in New Zealand at the University of Auckland's world-leading Geothermal Institute.

New Zealand's world-class expertise in renewable energy makes us a natural partner for countries looking for innovative assistance and advanced technology to harness and realise their own renewable energy opportunities.

Whether it is expertise in research and development, project management, exploration and design, operations and project management, maintenance or monitoring, New Zealand's expertise and experience covers the full spectrum of the industry. You can read more about our companies and expertise in the following pages.

A handwritten signature in black ink, appearing to read 'S Bridges'.

Simon Bridges

Minister of Energy and Resources

INDUSTRY FOREWORD

The New Zealand geothermal community has always played an important role in building the geothermal industry worldwide. Many in our community have spent time working internationally, often based for extended periods within project teams or in advisory roles to governments or international agencies.

These engagements are mutually beneficial; we have been able to build experience across all types of resources in a range of countries, sharing our knowledge with those with whom we work; learning through this process and, together with our international colleagues, applying fresh skills and innovation to a growing number of new developments.

An essential element of our New Zealand approach is to share information and experiences. We are proud to have built an alumni network of colleagues through our international collaborations, project experience and the post graduate programmes at the Geothermal Institute in Auckland.

The New Zealand Geothermal Association (NZGA) was formed in 1990 and is central to the interests of the New Zealand geothermal community. With a scientific and educational focus, the NZGA promotes coordination and collaboration with activities related to New Zealand and worldwide geothermal research, development and the application of geothermal resources.

The more recently formed Geothermal New Zealand Inc. (GEONZ) is an industry association that has an export focus promoting and marketing New Zealand companies with particular geothermal capabilities and interests in international markets. Drawing from this wide industry base, GEONZ has helped build teams that are now partnering with international contractors to bring a number of major projects on line.

These two organisations represent the aspirations and capabilities of the New Zealand geothermal community; we look forward to even stronger partnerships so together we can grow the international geothermal industry to the point where the significant value of this unique resource has the global recognition that it deserves.

The pages that follow cover the cultural and commercial significance of New Zealand's geothermal resources, with over 60 years of research, development and operations and the recent investments in new power plants that have geothermal electricity generation providing some 16.2 percent* of our annual demand.



A handwritten signature in black ink that reads "B S Carey".

Brian Carey

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geothermal@gns.cri.nz



A handwritten signature in black ink that reads "Bernard Hill".

Bernard Hill

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**Source: Ministry of Business, Innovation and Employment, 2014*

INTRODUCTION

PARTNERING WITH NEW ZEALAND

He aha te kai ō te rangatira? He Kōrero, he kōrero, he kōrero. What is the food of the leader? It is knowledge. It is communication.

New Zealand's Wairakei geothermal power plant was the first dedicated station in the world to generate electricity using a liquid-dominated geothermal resource. In more than a half-century since commission, Wairakei has continued to provide New Zealand's most reliable source of electricity. A new plant at Wairakei and several other fields will ensure this geothermal benefit continues for many years to come.

As early adopters, New Zealanders have had decades of experience harnessing geothermal energy, both for electricity generation and direct use. Today some 16.2 percent* of annual national electricity generation is from these resources. This has led to an innovative and world-leading workforce, boasting expertise in geothermal science, engineering and construction.

Today, as demand for renewable energy surges amidst concerns over energy security, geothermal energy is receiving growing international attention.

An increasing number of countries are actively investigating geothermal as a reliable, cleaner alternative to the diminishing reserves of carbon-based fossil fuels, providing secure base-load generation within their expanding electricity markets. Where there are premium geothermal resources, as in New Zealand, geothermal can be one of the most attractive commercial energy options.

Public and private utilities, corporations, and financial institutions increasingly see geothermal energy developments as viable commercial opportunities. Many of these investors have significant power generation portfolios, but often little or no geothermal experience.

New Zealand is perfectly positioned to play a leading role in this flourishing international industry. New Zealand has recently commissioned a number of innovative geothermal power plants: Kawerau, Ngā Whā, Ngā Awa Pūrua, Te Huka, Ngātamariki and Te Mihi. These new plants have helped make New Zealand the fourth largest geothermal producer in the world. As well as this, a number of industrial-scale, direct-use projects have been developed as more companies recognise the value of the heat available.

For New Zealand, securing significant generation from geothermal is a key element of the Government's stated plan to achieve 90 percent renewable electricity by 2025.

Current global geothermal generation is around 12,600 MW. Estimates suggest this will more than double in the next 10 years – an investment of some US\$50 billion.

Why geothermal? Clean, renewable and reliable

In addition to being clean and cost-effective, geothermal energy offers large capacity plants with reliability unmatched by other renewable energy resources.

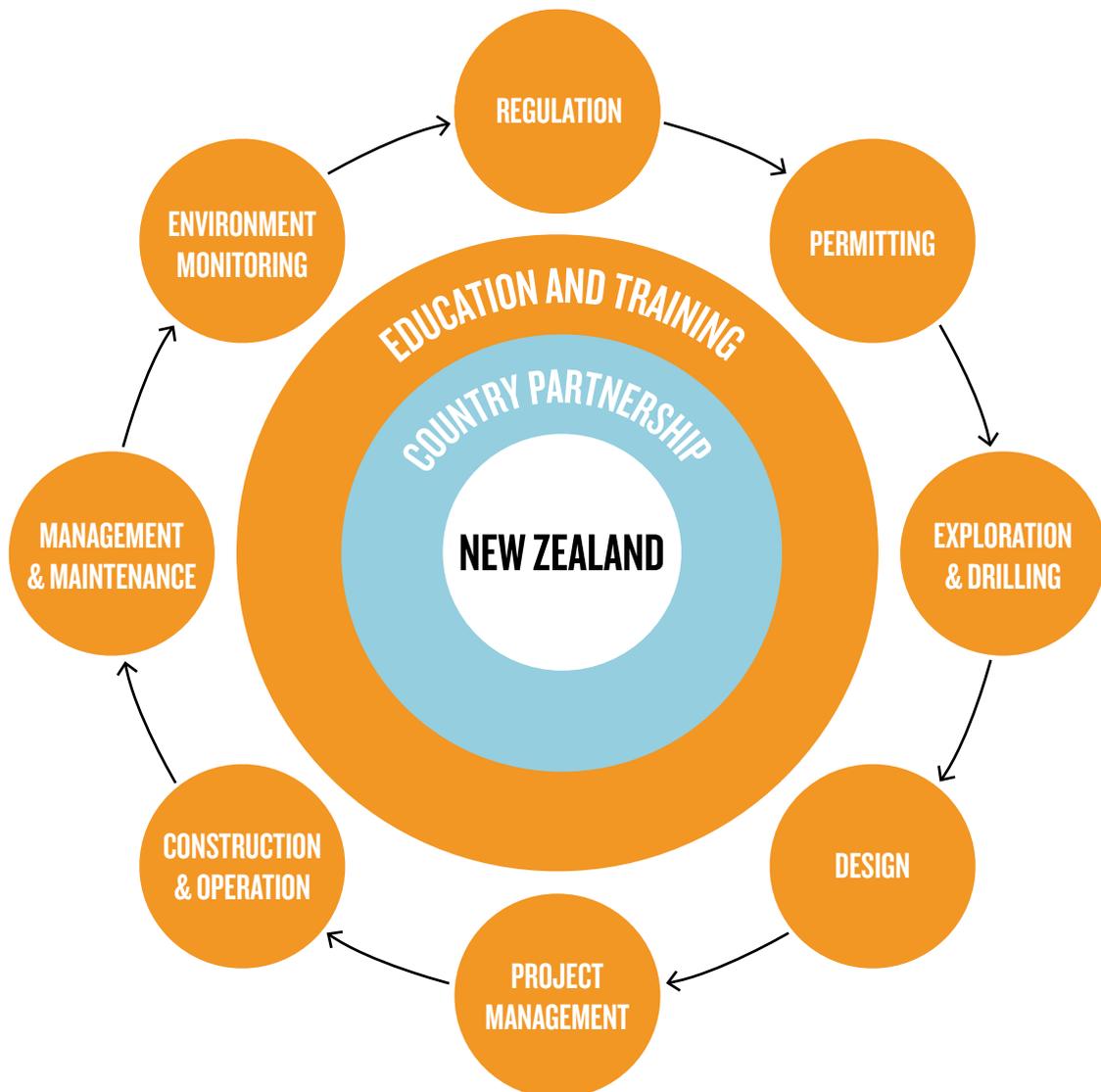
Drawing on heat from within the earth, it provides a consistent source of energy day and night, in any climate, and in any weather. In a world of unstable energy prices, geothermal energy offers an untapped form of energy with a price largely fixed at the time of project commitment.

Geothermal power stations have a capacity factor of over 90 percent, producing around three times the energy of a wind farm of equal size (capacity). Geothermal provides an invaluable base to complement a wider portfolio of renewables such as hydro, wind and solar.

**Source: Ministry of Business, Innovation and Employment, 2014*

CAPABILITY

While 30 leading companies are profiled in this book, there are over 70 New Zealand companies with geothermal expertise across the value chain; from regulation, permitting, exploration and drilling through to design, project management, construction and operation, management and maintenance and environment monitoring. There are few geothermal developments in the world where this expertise has not played some part, either through the provision of these services, or through education and training of country partners.



NURTURING VALUED CULTURAL TRADITIONS

New Zealanders are world leaders in indigenous geothermal development.

Early Māori harnessed geothermal power for everything from cooking to warming rudimentary shelters, and today New Zealand continues to respectfully utilise the country's natural resources. The Māori term Kaitiakitanga means guardianship, protection and preservation, and that's how New Zealand approaches its role in successfully, sustainably and respectfully managing geothermal resources. Geothermal resources play a leading role in the empowerment of Māori communities. Landowners' holdings are strengthened through economic development of geothermal resources.

Harnessing the earth's raw power

Geothermal energy is considered a taonga (treasure) with intrinsic value in the traditional Māori world and the contemporary world view. Through many centuries, stories and histories have been handed down orally from one generation to the next, explaining the value of geothermal in the traditional oral histories and its place in early Māori economics.

The origins of geothermal activity

The origin of geothermal activity in the volcanic plateau is from Ngātoroirangi - a great navigator and priest of the Arawa canoe - his sisters, Kuiwai and Haungaroa, and the two deity spirits Te Pupu and Te Hoata.

When Ngātoroirangi arrived in New Zealand after leaving Hawaiki, he climbed the mountain Tongariro to view the extent of this new country he had arrived in. As he neared the top he was affected by the intense cold which was so severe he feared he would die. In desperation he prayed to his sisters to help him and they sent Te Pupu and Te Hoata, the subterranean spirits of fire to help him.

Te Pupu and Te Hoata, knowing that time was of the essence, plunged into the waters beneath the crust of the seabed, heating the ocean floor.

Sensing their destination was near, they surfaced and finally emerged through the peak of (Mt) Tongariro, beneath 'his' feet, saving the life of Ngātoroirangi - giving warmth to his frozen body, warming his blood and restoring him back to health.

Geothermal features were left wherever Te Pupu and Te Hoata emerged. Geysers and many hot pools were created and today it's still possible for people to visit and take in the wonderful geothermal landscape - a gift (taonga) from Ngātoroirangi.

To this day, Māori have retained many of the customs, beliefs and practices of their ancestors, including a belief in the intrinsic value of the geothermal taonga.*

Traditional use

Recorded evidence from Māori and Europeans, in the form of photographs and written documentation, shows how Māori lived and used geothermal energy in everyday life.

Geothermal areas have historically been used by Māori for their curative properties, especially for skin disease and rheumatism. Since firewood was not easily found in the central volcanic region, hot springs were also essential for cooking. Indeed, from time immemorial Māori have used thermal springs as a natural kitchen, whilst housing around the volcanic regions was deliberately built over hot springs as a form of natural central heating.

Settlement patterns were determined by access to surface geothermal activity because it was essential for daily activities, such as cooking, bathing and curing ailments, in a region that was otherwise agriculturally deficient. It is unsurprising that Māori developed a strong spiritual and cultural connection with the geothermal areas.

**Source: GNS Sciences (abridged)*

Modern development

Today, Māori landowners are utilising their geothermal resources, in partnerships with domestic and international developers, to increase opportunities for their communities.

Māori who partner or lead many developments, exercise guardianship (kaitiakitanga) over resources. Some of these initiatives with a strong Māori focus include:

- **Miraka** - the Māori-owned and managed dairy business uses renewable electricity and steam to run its processing operations, a world first for the whole milk powder processing industry
- **Ngā Awa Pūrua** - the world's single largest geothermal turbine
- **Ngātamariki** - the largest pure binary plant in the world.



Photo: Ross Setford. The Māori carved figure Ngatoroirangi standing sentry at the entrance to Wairakei Terraces, Taupo

DEDICATED, RESPECTFUL GUARDIANSHIP OF RESOURCES

New Zealanders are world leaders in geothermal resource management and regulation.

New Zealand boasts a wealth of natural and rare geothermal settings – geysers, mud pools, boiling lakes, rare flora and fauna. They are a vital element of the nation’s character and how it is seen by those who visit.

The ability to develop geothermal resources within New Zealand’s natural landscape and pure environment, by engaging in true partnerships with those for whom these resources are of critical cultural and commercial significance, is a vital plank of the country’s offering to the international geothermal industry.

New Zealanders have learnt much along the way about effective and equitable resource management; developments that respect the interests of all stakeholders while advancing regional and national interests to utilise clean, secure, natural energy sources. These lessons and successes are of key interest and importance to those approaching similar undertakings, wherever these may be.

Examples of New Zealand’s approach and successes include:

- A national geothermal classification system. This ensures respect for the diversity of use and value that geothermal sources have for the whole community. It is accepted that some of these must be given a high degree of protection in a planning environment which balances development interests with protection issues.
- Development of almost 1,005 MW of geothermal generation facilities. Within the constraints of New Zealand’s national resource management and regulatory controls, the geothermal industry has grown to supply around 20 percent of domestic annual electricity production.

- The largest industrial direct use of geothermal energy in the world for over 50 years is the Kawerau geothermal field, in the North Island of New Zealand. Kawerau's diversity continues to expand, alongside newer power facilities, on a resource that is recognised for its harmonised utilisation by a number of independent parties. Established processes for resource allocation, monitoring and rational regulation allow this to be accomplished in everyone's best interests.



EXPERT AND PARTNER

New Zealanders work to the highest standards of integrity, honesty and reliability.

New Zealand's greatest assets are New Zealanders themselves. The country boasts a workforce which marries exceptional talent and intellect with integrity, honesty and world-renowned reliability. With a long history in geothermal power, New Zealanders have developed the expertise and experience to ensure world-best execution of any geothermal project. These global leaders attract the most challenging roles on offer in geothermal development; opportunities which ensure they maintain the most up-to-date skillsets available.

Partnership

Geothermal plants recently commissioned in New Zealand reflect global best practice and over sixty years' experience in the industry. New Zealand engineering and construction experts worked with international equipment suppliers to deliver projects under budget, ahead of schedule and with performance exceeding design.

New Zealand scientists and engineers have been key contributors to many of the world's geothermal developments. Their expertise ranges from exploration, development and sustainable management to design, construction, operation and maintenance of plants.

As part of every international assignment, sharing knowledge and experience is central in New Zealand's contribution to building self-sufficiency in emerging geothermal markets.

Technical expertise

New domestic plants represent global best practice from the application of exploration sciences, through feasibility, design, construction and operation.

The heavy engineering sector is undertaking a number of equipment and process developments targeted at the more efficient utilisation of geothermal resources. There is a particular focus on binary cycle units as demand increases in smaller scale and lower temperature resource developments.

Research and Development (R&D)

Geothermal research and development in New Zealand is intensifying to ensure the next generation of geothermal technology is aligned with the sector's needs.

Programmes are currently underway with universities, Crown Research Institutes and a number of independent service providers. These programmes provide high quality technical expertise for the sector's continuing growth.

Support from major geothermal developers in New Zealand anchors these programmes to the current and expected needs of "real-world" developers. Through the Auckland-based Geothermal Institute alone, New Zealand has trained more than 1500 geothermal professionals.

The Institute is a widely acknowledged global centre for postgraduate studies in geothermal earth sciences and engineering.

Innovation in action

The New Zealand geothermal industry has always sought new and improved methods of locating, developing and managing geothermal energy.

Recent innovations include:

- Joint Geophysical Imaging (JGI): Technology that combines data from seismographs and other geophysical instruments. This information is analysed to locate optimum-drilling targets, which significantly lessen development risks and therefore costs.
- Hydrothermal Geochemistry: Specialist equipment is now available to perform fluid rock interaction experiments at temperatures up to 400 degrees Celsius and 500 bar pressures. This equipment enables permeability, scale formation and fluid-rock interaction simulation experiments.
- Deep Borehole Observatories: A cable-less, down-hole seismometer and data acquisition array is available to help develop and manage a geothermal field. This new tool is capable of recording the faintest of seismic signals, perhaps the smallest ever detected in deep boreholes. In more standard applications, micro earthquake monitoring networks track seismic locations related to fluid production and injection.

- 300 Degree Celsius Well Bore Formation Imaging: High temperature acoustic borehole imaging has been opened up to the New Zealand geothermal industry in the last two years. Interpretation specialists assess the captured data including image quality, structural orientation, density and aperture, structural dip and in-situ stress orientations, and perform correlation with cut core, gamma logs and other available downhole data.
- 3D Geological and Geothermal Modelling: sophisticated software and tools have been developed and adopted internationally, for geothermal well-bore simulation, automated well test analysis, tracking geothermal tracers and visualisation of geology, structure and other resource data.



INDUSTRY ASSOCIATIONS
REPRESENTING THE ASPIRATIONS AND
CAPABILITIES OF NEW ZEALAND



NEW ZEALAND GEOTHERMAL ASSOCIATION



The New Zealand Geothermal Association (NZGA) is a scientific, technical, educational and cultural organisation working for its members. A non-political, non-governmental, non-profit organisation, it is an affiliated member of the International Geothermal Association (IGA) and of the Royal Society of New Zealand (RSNZ). It has 340 members.

Its objective is to encourage, facilitate and, when appropriate, promote coordination of activities related to New Zealand and worldwide research, development and application of geothermal resources.

It aims to

- Encourage the research, development and use of geothermal energy in New Zealand in a manner compatible with the natural environment
- Develop appropriate geothermal resources and provide information on these resources and associated industry
- Support appropriate legislation, rules and regulations for developing and using geothermal energy resources
- Serve as a public forum to provide objective and unbiased information on the nature of geothermal energy and its development
- Cooperate and communicate with national and international governmental, institutional and private agencies in matters relating to developing and using geothermal
- Make public submissions on government initiatives such as the Health and Safety Regulations.

Join us; we have individual, corporate and institutional memberships.

Go to www.nzgeothermal.org.nz for details.

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NEW ZEALAND
GEOTHERMAL
ASSOCIATION



GEOHERMAL NEW ZEALAND INC.

Geothermal New Zealand Inc. (GEONZ) provides access to the diverse skills of New Zealand's geothermal expertise for countries exploring their geothermal potential. Supported initially by New Zealand Trade and Enterprise (NZTE), GEONZ is now an independently registered industry association representing its members' interests in the international market.

A collaborative approach

GEONZ can introduce clients to experts at every stage of a geothermal development, applying international best practices in exploration, resource confirmation, feasibility, design, procurement, construction, commissioning and operations. The GEONZ initiative provides a comprehensive and respected level of support to the international geothermal market. The track record for New Zealand expertise is recognised globally and the quality and success of recently commissioned plants in New Zealand have set new standards. The rapidly maturing global geothermal market, and the entry of a range of new players into this market, demands these standards be replicated wherever possible. Building on this recent domestic success New Zealand-led teams are now embedded within major Engineering, Procurement and Construction (EPC) contracts underway internationally; the GEONZ model's success is being demonstrated.

New solutions for a new era:

GEONZ looks forward to continuing to provide innovative solutions in this new era of geothermal development which will require the highest standards of environmental protection, health and safety, engineering design and construction.

Key to success in this evolving market are issues that include:

- finding the most cost effective solution to quick resource confirmation while minimising risk but accelerating the development schedule
- handling centralised projects of increasing size and investment, often in remote areas with challenges in establishing access and supporting infrastructure
- developing effective models for the opportunities within small island nations where geothermal offers a cost effective alternative to diesel generation
- meeting investor's needs for bankable feasibility studies and cost effective front-end engineering
- growing involvement of private sector finance in geothermal projects



- the need for returns on geothermal investment which match those available through other energy sources
- a fluctuating demand for scientific, engineering and construction skills in a resurgent but often unpredictable market
- matching resources; scientific, engineering, manufacturing, construction, operations and maintenance, to drive the market ahead using world best practices and ensuring successful outcomes for all developments.

Meeting these challenges requires a combination of resources and a mix of national, foreign and multinational company contributions; an approach that ensured the success of recent New Zealand projects. The aim of the Geothermal New Zealand initiative is, through appropriate partnerships, to continue to replicate this success internationally.

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NEW ZEALAND'S UNIQUE CODE OF PRACTICE FOR DEEP GEOTHERMAL WELLS NZS 2403

The New Zealand standard on well drilling that has been adopted by the geothermal energy industry and regulators worldwide has been revised and updated.

NZS 2403:2015 Code of practice for deep geothermal wells promotes best practice in the management of deep geothermal wells throughout their lifetime.

The New Zealand geothermal industry contributed to updating the code to ensure the safe drilling and operation of wells that penetrate hot subsurface conditions, particularly in volcanic regions.

The code reflects design and work practices that have been proven in the geothermal industry since the 1950s. While largely based on the standards, equipment, and practices of the onshore petroleum drilling industry, it reflects the material difference of below-ground conditions encountered in geothermal systems.

As well as embodying a design process for geothermal wells, the code provides guidance on the drilling work and subsequent well operations up to the time the well is cemented up at the end of its life.

It includes preparing and managing the well site, drilling equipment, tools and materials, drilling techniques, and managing well integrity.

The code also applies to continuous wireline coring, coiled tubing operations, and some non-typical methods for constructing and maintaining deep geothermal wells.

Adhering to the code's best practice guidance will support both safety and sound environmental stewardship.

The code of practice can be purchased from Standards New Zealand at <http://shop.standards.co.nz/catalog/ics/> and entering in the search line NZS 2403:2015.

COMPANY PROFILES

PARTNERING WITH NEW ZEALAND



Geothermal developments have unique technical requirements that influence plant efficiency and reliability. AECOM has significant depth of experience in the geothermal industry, having worked on over 50 geothermal developments worldwide, with a combined output of over 2500MW over the last 30 years.

To service the growing geothermal market, AECOM has developed a dedicated, highly qualified and experienced team, led by engineers who have designed and built numerous successful geothermal projects worldwide. Their team's talent is recognised and respected internationally and in 2014, ENR ranked AECOM #1 in its Top 500 Design Firms Survey for the fourth consecutive year. This global experience ensures designs are benchmarked against international best practice and opportunities for value engineering are never overlooked.

Products and services

AECOM's experience includes:

- Complete project multidiscipline delivery from concept to operation
- Capacity building and training
- Site layouts and preliminary plant layouts
- Environmental Impact Assessments
- Licensing permitting
- Owners/Lenders Engineers
- Feasibility studies
- Front End Engineering Designs
- Detailed Design (Steamfield and Power Plant)
- Transaction and Technical Advisors

- Planning and scheduling
- Procurement
- Cost estimating
- Tender evaluations
- Inspection and expediting
- Construction management and site supervision
- Start-up, testing and commissioning.

AECOM's specialist geothermal services include:

- Strategic (optimisation of resources, steam field and power station to provide maximum returns)
- Technology selection (power plant type and location, separator locations, steam quality advice, non-condensable gas handling and disposal, silica and calcite management, reinjection philosophy)
- Process engineering (in-house tools include heat and mass balance modelling, gas extraction system, separator, scrubber, flash tank designs, 2 phase flow modelling)
- Infrastructure development (seismicity, geotechnical, wellpad design, access roading, drainage, stabilisation, water reticulation and storage, layout and design)



- Steamfield piping (layout and integration of separators, brine management, vents, drains, pressure segregation, ponds, drilling access, pumping and safety systems)
- Underground services (planning, layout and coordination)
- Power plant (civil, structural and architectural design including carnage)
- Cooling system (design and optimisation, wet bulb, cooling tower, pumping sizes and rates)
- Electrical (Switchyard, HV, MV and LV, design and integration)
- Control systems and SCADA
- Transmission and protection systems.

Key projects

- 330MW Sarulla, Indonesia
- 140 MW Olkaria VI, Kenya
- 220 MW Rantau Dedap, Indonesia
- 30 MW Bacman III, Philippines
- 3x30 MW Wairakei, NZ
- 4x70 MW Olkaria I (additional unit) & Olkaria IV, Kenya
- Geothermal Power Plants Refurbishment Program, Philippines
- 200–300 MW Sorik Marapi, Indonesia
- 250 MW Muara Laboh, Indonesia
- 100 MW Bacman I, Philippines
- 50MW Lihir Geothermal, PNG
- 30 MW Karaha, Indonesia
- 2x55 MW Sungai Penuh, Indonesia
- 2x2.5 MW Mataloko, Indonesia
- 25 MW Te Huka Steamfield, New Zealand
- 50 MW Jailolo, Indonesia
- 4x55 MW Lumut Balai, Indonesia
- 2x55 MW Ulubelu 3 & 4, Indonesia
- 3x20 MW Lahendong 1 to 6, Indonesia
- 127 MW Wayang Windu III, Indonesia
- 20 MW Lihir Geothermal Steamfield, PNG
- 120 MW Wayang Windu II, Indonesia
- 130 MW Ngā Awa Pūrua, New Zealand
- 225 MW Te Mihi, New Zealand
- 20 MW Nasulo, Philippines
- 100 MW Kawerau, New Zealand
- 50 MW Mutnovsky, astern Russia
- 55 MW Gunung Salak, Indonesia
- 6.2 MW Aluto Langano, Ethiopia
- 110 MW Ohaaki, New Zealand
- 18 MW Rotokawa, New Zealand
- 2x55 MW Darajat, Indonesia
- 1x30 MW / 2x55 MW / 1x50MW Kamojang Stages 1 to 4, Indonesia.

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ALLIED INDUSTRIAL ENGINEERING

Allied Industrial Engineering (AIE) delivers a range of superior solutions to the geothermal, thermal and hydro power generation industry through its purpose-equipped workshops and experienced, skilled people.

Located in the heartland of the New Zealand geothermal region, AIE is also close to the Port of Tauranga for efficient and safe transport from other countries.

AIE's large CNC machine tools and open workshop space enables it to efficiently handle, manufacture or refurbish large components of geothermal machinery with speed and accuracy to exacting standards. AIE places a high emphasis on documented systems and procedures, and is able to guarantee high quality products and services at all times. Its customised planning systems, project management skills and dedicated staff enable AIE to deliver tight lead times for critical projects.

Recently AIE extended its offering to the turbine refurbishment market by employing two very experienced steam/gas turbine engineers.

With the employment of these personnel, AIE can offer well-trained Senior Turbine Engineers both with more than 30 years' experience working on turbines for large OEMs. These personnel are available to work with the owner's staff or AIE staff, to undertake work on-site or in the workshop.

AIE was last year awarded the manufacture of a complete replacement turbine rotor for a 10 MW geothermal turbine with updated material specifications for geothermal steam use. AIE's price was approximately 50% cheaper than the OEM.

AIE is now available to provide replacement rotors and diaphragms for turbines up to and beyond 30 MW's.



Products and services

AIE's services include, but are not limited to:

- Turbine and generator rotor specialist welding
- Shaft diameter weld repairs, including journals and packing areas (interstage glands)
- Diaphragm repairs, weld overlay and re-machining and manufacture of replacement diaphragms and nozzles
- Journal refinishing
- Rebabbitting of journal and thrust bearings
- Rotor un-stack and re-stack
- Coupling repair, modification and replacement manufacture
- Buckets and covers re-blading
- Turbine case repairs and full machining
- Valve restoration, seats, spindles, discs and casings
- Strainer manufacture
- Heat exchangers/condensers refurbishment and manufacture
- Generator rotor retaining rings (end bells) manufacture and fitting
- Electrical rotative equipment machining, rewinding, re-wedging, insulation and all aspects of electrical repair

- Computerised dynamic balancing, with two machines at 32T and ISO 1940 G1 or better
- Power house site overhaul services
- Manufacture of replacement turbine rotors and diaphragms

Key projects

- 100 MW MRP Kawerau turbine, run and shut maintenance contract
- 140 MW MRP Ngā Awa Pūrua, shut maintenance
- 30 MW MRP Mitsubishi turbine full recondition inclusive of complete re-machining case upper and lower, weld-inserts, and machining of diaphragms, reinstate interstage glands on rotor by welding and machining
- Reverse engineer and manufacture CL 55 turbine complete nozzle assembly Newcrest mining
- GE ST-10 upper and lower case re-machine, and rotor interstage glands reconstruct
- Ka24 Ormat overhaul and machining renewal
- Manufacture Generator rotor retaining rings (end bells) Otahuhu and Norske Skog turbines
- Carter Holt Harvey turbines refurbishment including reblading

- 10 MW dresser turbine rotor repairs
- G55 rotor repairs
- Overhaul and manufacture valve and control components Fonterra and Balance
- Overhaul turbines 2 MW to 6 MW sugar mills and PNG mines

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WEB aie.co.nz



ANZ Bank New Zealand is the largest financial services group in New Zealand and counts among the very few banks with geothermal power project financing expertise; with over 15 years of experience on both a project finance and corporate basis.

The wider ANZ Group (Australia and New Zealand Banking Group) has the largest Asian and Pacific footprint of any of the trans-Tasman banks. ANZ has had a presence in the Pacific since 1988, and today has over 2,300 staff across 12 countries. ANZ has been in Asia for over 45 years and today has a presence in 15 countries and is ranked as one of the top four corporate banks in Asia.*It also has a presence in Europe and America. This extensive network gives clients access to those markets, whether to grow trade flows or source alternate pools of capital to fund domestic growth.

ANZ overlays the understanding of its clients' businesses with in-depth knowledge of industry and wider market experience, to structure innovative funding solutions for customers.

Many geothermal transactions are funded using project finance, export credit finance funding solutions or hybrid project finance / corporate finance structures.

ANZ has a structuring team based in New Zealand, specialising in project finance, including PPPs and export credit finance as well as trade, asset finance, acquisition finance, syndications and securitisation.

*Greenwich Associates 2014 Asian Corporate Banking Index



Key Projects

In conjunction with the Export Credit Agency of Japan, ANZ funded Contact Energy's Te Mihi Project in Taupo. This commenced operations in 2014.

In 2011, ANZ financed the development of the Mokai Geothermal Clean Steam Power Plant for Tuaropaki Trust.

In 2012, ANZ funded the increase of Tauhara North No.2 Trust's shareholding in its geothermal joint venture Ngā Awa Pūrua Geothermal Power Station.

ANZ also funds Ngati Tuwharetoa Geothermal Assets which owns and operates the Kawerau Geothermal Field providing industrial steam for electricity generation and industrial use.

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Callaghan Innovation is a New Zealand government agency tasked with helping businesses get their ideas to market faster. Callaghan Innovation works closely with the industrial sector to provide research and technical services relevant to industry needs.

The Callaghan Innovation Advanced Materials Group has extensive experience in developing materials for extreme environments. The cements team has been working in the field of geothermal well cementing for over 20 years and has comprehensive laboratory facilities to characterise materials, assess cement properties and test the performance of cements, as well as other materials, in simulated geothermal environments.

In the last six years, the team has developed purpose-built facilities to simulate the high temperatures and corrosive conditions that geothermal cements must endure. This capability has been essential to understand the durability of conventional geothermal cement systems, particularly in CO₂ rich environments.

Understanding the reactions that occur when the well cement is exposed to geothermal fluids at temperature has led to the development of new cementing blends with improved durability and longer lifetimes for wells.

In addition to these facilities, the Callaghan Innovation cements team has a full complement of well-cement testing equipment to assess slurry formulations, providing an independent testing service. This capability is used to evaluate the nature and amount of admixture(s) added to the cement to ensure it can be 'placed' and cured in high temperature well systems to protect the casing and deliver durability.



Technical Services

Cement slurry properties

- High-pressure high-temperature consistometer to determine thickening time
- Heated viscometer to determine rheology
- Pressurised fluid loss equipment to measure slurry stability.

Hardened cement properties

- Specialised autoclave facilities that operate to 300°C and 100 bar to simulate the geothermal environment (pictured above) with automated water and gas flow to cure samples
- High-temperature calorimeter to follow cement hydration at elevated temperatures.

Analytical tools to assess cement reactions

- Thermal analysis and x-ray diffraction to characterise the cement phases formed
- Electron and optical microscopy of polished sections to allow changes in chemistry of the phases to be followed.

Projects

The team has undertaken a range of projects, which include:

- Forensic examination of recovered well cements and samples where flash setting has occurred
- Investigations into the effect of CO₂ on well cements, to evaluate effects during curing and on subsequent durability
- Examination of cement/rock interactions up to 300°C
- Development of carbonation resistant calcium silicate well cements
- Development of alternative cementing systems.

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Cheal provides expertise across the disciplines of engineering, surveying, planning, and health and safety for the geothermal industry. Located in the heart of New Zealand's Central North Island geothermal zone, Cheal has extensive experience and refined processes covering the following aspects of the geothermal energy industry:

- Geothermal drilling
- Powerstation survey setout and control
- Health and safety management and auditing
- Structural engineering
- Geotechnical engineering
- Civil engineering
- Legal surveys
- Resource management advice
- Project Management

**Geothermal drilling:
Well pad design and
construction management**

Cheal has led the design and construction management of an extensive drilling programme across New Zealand's Taupo and Eastern Bay of Plenty volcanic zone for many years.

The team of engineers, surveyors and CAD experts implement proven processes and procedures, which create cost effective and efficient delivery of well pad requirements including:

- Ground assessment and survey for a site plan
- Geotechnical drilling and interpretation of results
- Site management and engineered design of the drilling platforms
- The design and installation of precollar and cellar construction
- Reservoir design and construction
- Pumping solutions
- Temperature monitoring wells
- Soakage testing and design of cooling channels
- A flocculation process to purify geothermal fluids for reuse in the drilling process.



Civil Engineering

Cheal has a well-formulated process for design of well pads and construction management including geotechnical investigations to ensure these sites are designed, constructed and certified on time and within budget. This ensures timely programming to get drilling rigs on site and operating.

Powerstation survey setout

Cheal controls every aspect of the civil build of geothermal powerstations from a survey setout perspective. A combination of expertise in construction setout, innovation and the latest in survey equipment and technology ensures work is carried out efficiently and meets the high precision and schedule requirements of the project.

Cheal's Quality Management System (ISO9001:2008 certified) verifies construction data and resolves any conflicts prior to set out and construction.

Cheal works closely with operations teams following construction to implement and undertake deformation monitoring, development of earthquake monitoring and recovery plans, cadastral surveys defining operation boundaries and easements and as-built surveys for GIS purposes.

Health and safety management

Cheal is committed to achieving a safe working environment and works with organisations to provide leadership and develop effective relationships in health and safety for the geothermal industry. Taking into account the specific needs of clients and the environment in which they work, Cheal develops safety management plans, process improvement advice, setting and tracking of Key Performance Indicators, hazard management, audit/inspection and contractor management.

Key Projects

Mighty River Power:

Geothermal drill prospecting in Rotokawa, Mokai, Kawerau, Mangakino, Atiamuri

Mighty River Power:

Ngā Awa Pūrua Powerstation

Mighty River Power:

Rotokawa I Powerstation

Mighty River Power:

Mokai Powerstation

Mighty River Power:

Kawerau Powerstation

Geothermal Development Ltd:

Drill prospecting in Kawerau

Contact Energy:

Poihipi Powerstation surveys for GIS purposes.

New Zealand Institute of Surveyors: Gold Award of Excellence for Construction Survey and Setout: Ngā Awa Pūrua powerstation

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Contact is one of New Zealand's largest electricity generators and retailers. It owns and operates five geothermal power stations across the Taupō region, which have a gross installed capacity of 431 megawatts.

Contact has been harnessing the geothermal power of the Wairākei steamfield for the last 56 years and has one of the most experienced geothermal workforces in the world. The pioneering Wairākei power station, commissioned in 1958, was the second geothermal power station to be built, and the first to utilise wells that produce a mixture of steam and water. Contact's newest power station, Te Mihi, was commissioned in May 2014. Over that time, the company has grown its skill and expertise in operating and maintaining geothermal power plants, and exploring and managing geothermal resources.

Recently Contact has developed further expertise in progressing new developments, as demonstrated through the commissioning of the Te Mihi and Te Huka power stations, significant investment programmes to upgrade its existing assets, and a greenfields appraisal of the Taheke field. That experience means Contact can integrate across operations, exploration, assessment, consenting and financing of projects.

Complementing electricity generation, Contact also provides geothermal energy to the Tenon wood processing plant near Taupo, the Huka Prawn Farm, Ohaaki Thermal Kilns and the Wairakei Terraces bathing complex. Contact continues to investigate opportunities to make further direct and cascade use of geothermal energy.

In December 2010, Contact obtained resource consents to develop a 250 MW geothermal power station on the Tauhara geothermal field, north east of Taupo. It considers Tauhara New Zealand's most attractive new generation option, however the project is currently awaiting demand growth in the New Zealand market.

Contact has developed strong partnerships that have supported both current operations and new developments. Examples can be seen in relationships with indigenous tribal groups Ngāti Tahu at Ohaaki, Ngāti Tūwharetoa at Wairākei - Tauhara, and Ngāti Pūkiao to the north of Rotorua. Contact is proud of those relationships, and maintaining them remains a key focus.



Company Highlights

Contact is one of New Zealand's largest electricity generators and retailers. Its electricity generation business is focused on meeting New Zealand's energy needs in a safe, reliable and efficient manner.

- 12 Power Stations across New Zealand
- 5 Geothermal Power Stations in the Taupo region
- NZD\$3.6 billion in net assets
- 567,500 customers supplied with electricity, natural gas or LPG
- 22% share of the retail electricity market in New Zealand
- NZD\$2.45 billion of annual revenue
- 1066 Employees.

**Energy Project of the Year (Wairakei Bioreactor), 2013
Deloitte Energy Excellence Awards**

Excellence in Health and Safety, 2013 Deloitte Energy Excellence Awards.

Key Projects

Wairakei Investment Programme

In 2014, Contact celebrated the completion of its Wairakei Investment Programme. This significant investment in geothermal resource included building the \$623 million Te Mihi power station and steamfield connections as well as developing the Wairakei Bioreactor, drilling a number of new wells and expanding the Wairakei steamfield.

This investment programme has dramatically grown the breadth of expertise within Contact. Te Mihi has proven Contact's ability to develop and operate large, world-class geothermal power stations. Its combined gross geothermal generation output is now 431 megawatts (MW) which is globally significant in geothermal terms.

Through the Wairakei Investment Programme, Contact has further increased the flexibility of its generation portfolio and lowered its overall fuel costs for generation. Contact has improved the resilience of its business, and secured investors a strong, sustainable financial future.

Contact

Dennis Barnes

Chief Executive Officer

James Kilty

Chief Generation and Development Officer

Mike Dunstall

General Manager Geothermal Resources and Development

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EASTLAND GENERATION

Eastland Generation is an owner, operator and developer of small to medium scale geothermal projects in New Zealand, as part of a small generation portfolio including hydro and diesel generation.

Eastland Generation works closely and collaboratively with landowners to help them invest in the power of their land, developing projects which deliver real value to all partners. It approaches projects with small teams of the right people to ensure projects are commercially, environmentally and culturally successful.

Eastland Generation is part of the Eastland Group, a community-owned company based in Gisborne, New Zealand, which has a strategic focus on the energy and logistics sectors. With total assets of \$365.5m, Eastland Group has the capacity to pursue new power generation projects and leverage off both internal and external expertise to deliver world class projects in partnership with landowners and key stakeholders.

Products and Services

Eastland Generation's focus is on sub 50 MW electricity generation project and creating genuine partnerships with landowners and stakeholders.

Its product is that of a developer, investor and active owner and operator of small to medium sized geothermal power station schemes. The end result is one that is sustainable, commercial and environmentally and culturally appropriate.

Eastland Generation works with landowners to develop geothermal projects that fit with their needs and allow them to receive real value - 'value' as they define it, with a say in governance and equity in the schemes if they desire it. Eastland Generation actively engages with partners to determine their requirements and objectives for each project.

Following commissioning, Eastland Generation can then operate and maintain the plant and equipment in line with industry best practice, incorporating asset management plans and adaptive management of geothermal resources.



Key Projects

- Geothermal Developments Ltd - acquired in 2010, the Geothermal Developments plant is a 9 MW Ormat plant operating on the Kawerau geothermal field. The plant was fully reconseented for a further 35 years of operation in 2014. Investment in the plant since acquisition has improved plant availability to 97% in the 2014 calendar year.
- Te Ahi O Maui Geothermal Project - Eastland Generation is the funding and technical partner in this project, together with the land owners Kawerau A8D Ahu Whenua Trust. In July 2014, the project secured full resource consents for the construction and operation of an 18-20 MW geothermal power plant.

Further planning and analysis is now underway for the tendering and construction of this project.

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ENVIRONMENTAL MANAGEMENT SERVICES (EMS)



Environmental Management Services Limited (EMS) was established in 1994 and operates from offices in Auckland, Hamilton, Taupo, Napier and Wellington, New Zealand. The company is owned and operated by six working directors supported by a complement of 10 professional staff.

EMS specialises in environmental consenting and analysis with experience and expertise in policy development and consenting / permitting of geothermal projects in New Zealand, the Pacific Islands and Asia. Its experience includes greenfield and brownfield geothermal developments as well as consent renewals for existing geothermal power stations and associated steamfields.

Services include project management and planning, environmental and social impact assessment (ESIA), community consultation, environmental auditing and the development of regulatory policies and plans.

New Zealand Geothermal Projects

Tauhara II Geothermal Development Project Consenting

This project involved consenting New Zealand's largest geothermal energy project, 250 MW, on the door-step of Taupo township. A wide range of Māori landowning and hapu interests in the project area required careful consideration.

Tauhara II received the Resource Management Law Association 2011 award for Advancement of Best Practice.

Ohaaki Power Station Consent Renewals Project

EMS was appointed Project Manager to renew resource consents for the 105 MW Ohaaki Geothermal power station. Consents were successfully granted in October 2013 for a 35 year term. The station is located approximately 26 km north-east of Taupo township.

Low Temperature Geothermal Energy Programme

EMS has provided ongoing assistance with the GNS Science-led programme seeking to maximise the use of New Zealand's low temperature geothermal energy resources.



Pacific Region Geothermal Projects

Savo Island Geothermal Proposal, Solomon Islands

EMS provided an independent review of the ESIA that had been prepared for a proposed 20 – 30 MW geothermal development on Savo Island in the Solomon Islands.

Papua New Guinea - Geothermal Resource Policy

During 2013 and 2014, EMS was engaged by MFAT, as part of the New Zealand Aid Programme, to prepare a Geothermal Resource Policy for Papua New Guinea. Preparation of the Policy has been completed and is now to be implemented.

Takara Geothermal Project, Vanuatu

During 2014, EMS was engaged by MFAT to assist the Vanuatu Ministry of Climate Change in the preparation of a Terms of Reference for an ESIA for the Takara Geothermal project on Efate Island.

A permit for the exploration phase of the Takara Geothermal project was granted on 30 January 2015.

Asia Region Geothermal Projects

Wayang Windu Geothermal Project, West Java, Indonesia

EMS was engaged as Lead Environmental Advisor to oversee environmental impact assessments and securing environmental (AMDAL) approvals for the exploration and production phases for Wayang Windu in the late 1990s.

Kamojang Geothermal Expansion Project, West Java, Indonesia

For the 60 MW Kamojang Geothermal Expansion project (1996 – 97) EMS was engaged to oversee the preparation of environmental impact assessments required under Indonesian law and also needed for the benefit of project investors.

Consent was granted for the project in 1997.

Sibayak Environmental Appraisal, North Sumatra, Indonesia

This project entailed preparation of an Environmental Appraisal Report of a 50 MW geothermal project at Sibayak in North Sumatra, Indonesia.

EMS was engaged as Environmental Advisor for the USA based company, Ensearch. The project area is located in a National Park area.

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Environmental Management Services
Environmental Planners and Project Managers

FITZROY ENGINEERING

Fitzroy Engineering is New Zealand's largest and most accomplished heavy fabrication and multi-disciplined engineering company. It has a reputation for successfully delivering complex engineering scopes.

Operating for over 60 years, Fitzroy Engineering has substantial experience and expertise in all aspects of heavy engineering and offers complete full life cycle engineering capability. Its quality, cost competitiveness and ability to deliver on-time have helped Fitzroy Engineering secure substantial agreements in a number of geothermal developments.

Products and Services

- EPC contracting
- Project management
- Heavy fabrication
- S&T heat exchangers
- Pressure vessels
- Coded piping
- PWHT
- Plate rolling
- Site installations
- Shutdowns
- Planned maintenance
- Commissioning
- De-commissioning
- Blast and paint
- Scaffolding and rigging
- Precision machining
- Catalyst handling
- Bolt torquing, tensioning
- API licensed well servicing
- Downhole tool rental



Key Projects

Wairakei Geothermal Power Station, Taupo, New Zealand

Design, fabrication and delivery of two carbon steel hp steam separators weighing 75 tonnes, 3.7m diameter x 16m tall to PD5500.

Gourmet Mokai Ltd, Taupo, New Zealand

Design, fabricate, obtain statutory approvals, deliver and install new heat exchanger. Remove existing heat exchanger for re-tube and re-install. To ASME VIII, Div1 and TEMA R.

Ngati Tuwharetoa Geothermal Assets Steam Field Site, Kawerau, New Zealand

Provide mechanical design and validation, prepare detailed workshop drawings, procure materials, workshop fabricate, inspect, test, obtain statutory approvals, surface treat, provide documentation and deliver (x2) Steam Generator Heat Exchangers at 45t each and (x2) Feedwater Preheaters at 3.5t each. To ASME VIII, Div1 and TEMA R.

Wairakei Geothermal Power Station, Taupo, New Zealand

Mechanical installation and fabrication of mechanical equipment and piping for 14 MW greenfields binary plant project.

Mokai Geothermal Power Station, Taupo, New Zealand

Mechanical installation of machinery, equipment and piping for Stage 2 expansion of the 60 MW Mokai Geothermal power station.

Mokai Geothermal Power Station, Taupo, New Zealand

Mechanical installation of machinery, equipment and piping at the new 54 MW geothermal power station

Wairakei Geothermal Power Station, Taupo, New Zealand

Supply, install and commission 4 MW turbine generator with joint venture partners.

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GEOTHERMAL INSTITUTE, THE UNIVERSITY OF AUCKLAND

The Geothermal Institute is hosted in the Faculty of Engineering at the University of Auckland. It is the portal for engaging with the University on all matters related to geothermal energy.

Scientists spread across several Faculties, Institutes and Research Centres at the university carry out the geothermal-related research, education, consulting and training programmes while the Geothermal Institute coordinates the expertise.

The Geothermal Institute is one of the premier geothermal training centres in the world. Since 1978, more than 1500 students from over 50 countries have graduated from the Geothermal Institute with a world-recognised qualification in geothermal energy; today, many of those graduates hold senior positions in the geothermal industry. The Geothermal Institute provides tailored, bespoke training programmes for the geothermal industry, as well as coordinates the postgraduate geothermal programmes for the University of Auckland.

The Geothermal Institute provides research and development, testing and laboratory services, commercial and consultancy services, as well as education and training for the New Zealand and international geothermal industries. The Geothermal Institute also convenes the annual New Zealand Geothermal Workshop, New Zealand's longest running energy conference.



How the Geothermal Institute can work with you

The Geothermal Institute is internationally renowned for its research and training activities. It is also proactively seeking opportunities to work alongside government, energy companies, commercial consultancies and other universities and research organisations in New Zealand and globally, by providing geothermal research and development expertise, training and capacity building. The Geothermal Institute believes these relationships are very important for the future of geothermal technology development, geothermal exploration and development, and for geothermal capacity building.

The Geothermal Institute includes at least 35 researchers, graduate students and support staff across the Science, Engineering and Business faculties.

Education

- Post Graduate Certificate in Geothermal Energy Technology
- Masters of Energy Geothermal related Masters and PhD's in Science, Engineering and Business
- Short courses, workshops and training in a range of countries and regions including New Zealand, Australia, Indonesia, Chile, the Caribbean and Kenya.

Development & projects

- Development of next generation integrated geothermal modelling tools capable of building models of multiple geothermal systems
- Reservoir modelling studies including Wairakei-Tauhara, Ohaaki, Rotorua, Mokai, Ngawha, Wayang Windu, Dieng, Darajat, Silangkitang, Namora, Leyte, Northern Negros, Bacman, Olkaria, East Mesa, Fushime, Kakkonda and Los Humeros
- Rock typing for reservoir modelling
- Application of TOUGH2 to the simulation of supercritical conditions in geothermal systems
- Automated calibration of computer models of geothermal fields using inverse modelling software (iTough2 and PEST)
- Economic modelling and regulation
- Geochemical studies of sinter deposits
- Moisture removal system design
- Geothermal steam water separators research and development
- Advances in geothermal well test analysis
- Pressure drop in large diameter geothermal two phase pipelines.

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GEOTHERMAL
INSTITUTE



Geoscientific expertise to support your geothermal project.

The GNS Science geothermal team is internationally recognised for innovative, robust geoscientific research, specialist expertise and consultancy advice.

As the leader of New Zealand's geothermal research programmes, GNS Science applies cutting edge science to developing industry best practice methods, techniques and tools.

It applies geoscientific and modelling skills to exploration, drilling advice, environmental sustainability, field development, optimal production and ongoing resource management.

GNS Science specialises in the design and execution of exploration programmes, which includes detailed geologic, petrologic and geochemical surveys as well as a selection of geophysical methods.

It has supported the global geothermal community for more than 50 years, with experience in over 35 countries and regions. Country experience includes New Zealand, Pacific Islands, Indonesia, Philippines, Iran, Ethiopia, Madagascar, El Salvador, Nicaragua, Turkey, Japan, Papua New Guinea, the Caribbean and Chile.

Its New Zealand Geothermal Analytical Laboratory (NZGAL) analyses water and gas samples from around the globe with accuracy, precision and fast delivery of results.

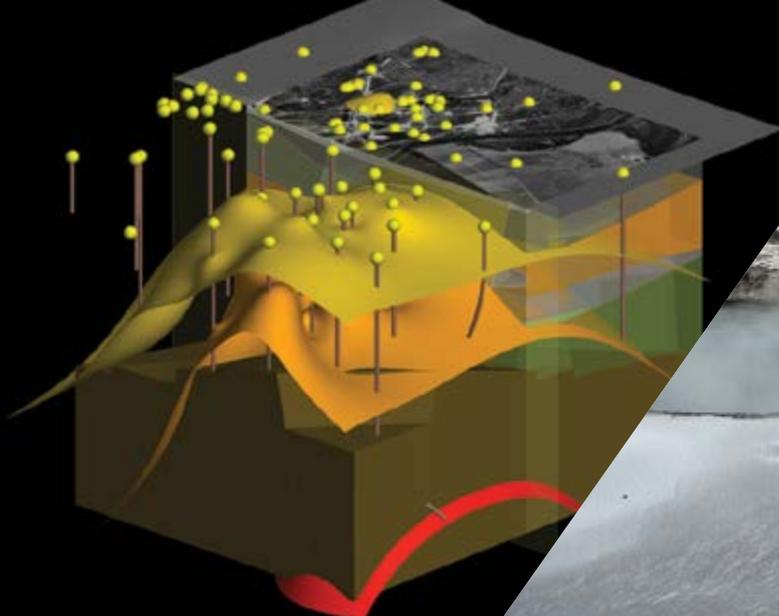
GNS Science provides practical training for the geothermal industry, from introductory to specialist level, to build capability and transfer knowledge. Individual or small group training is delivered in New Zealand and internationally, tailored to client requirements.

As specialists in the subsurface, GNS Science partners with others to build whole development teams.

Capabilities

GNS Science has the capability to undertake;

- Country and regional geothermal potential assessments
- Due diligence projects
- Development of reconnaissance and exploration strategies
- 3D geological and reservoir modelling
- Electrical surveys to delineate geothermal resources (Resistivity, MT, TDEM)
- Gravity and microgravity surveys
- Thermal infra red surveys
- Baseline heat flow assessment for environmental impact
- Seismic investigation for structural interpretation
- Microseismicity assessment and monitoring
- Environmental impact assessment and monitoring



- Well targeting and geological advisory services associated with drilling programmes
- Preparation of resource assessment documents
- Training in geothermal technologies
- Field sampling
- Water and gas analysis
- Reservoir and production geochemistry
- Radioactive and chemical tracer studies
- Resource management advice
- Peer review services
- Geothermal microbiology studies
- Direct use resource assessments.

Key Projects

New Zealand

GNS Science’s consultancy work in New Zealand has included exploration and consenting activities at Wairakei-Tauhara, Kawerau, Ngatamariki, Rotokawa, Ohaaki and Mokai, and exploration at other undeveloped geothermal fields.

GNS Science’s geothermal services have included (but were not limited to) production and reservoir chemistry, geological well site services, geophysical and surface feature monitoring, groundwater monitoring, geophysical surveys (magnetotelluric, aeromagnetic, resistivity, microgravity, thermal infrared), geothermal gas analyses, reservoir and field modelling, resource evaluation, and resource consenting.

International

GNS Science’s geothermal staff have played major roles in the exploration of geothermal fields in Indonesia, and addressed development and/or field utilisation issues in the Philippines, Iran, Ethiopia, Madagascar, El Salvador, Nicaragua, Turkey, Japan, Papua New Guinea, Pacific Island Nations, the Caribbean and Chile.

Through research programmes and targeted consultancy work, GNS Science has developed a range of exploration and measurement techniques, which have been applied world-wide.

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HAWKINS INFRASTRUCTURE

Hawkins is a high performing organisation, in step with a rapidly changing world, that excels in planning, managing and delivering complex projects across multiple disciplines.

Greater accuracy, buildability, transparency, quality and shorter timeframes are all part of Hawkins' approach.

A delivery-driven business

Big enough to tackle anything, yet small enough to be agile, Hawkins are a market leader in delivering innovative responses to technically demanding geothermal projects in New Zealand and international markets.

Hawkins has built a depth of knowledge and experience in delivering cost-effective solutions to complex challenges, offering a multidisciplinary approach to turnkey project delivery.

A culture is established on each project where all stakeholders are focused on early completion of a quality project in a safe manner, building a hard-working, dedicated team with the skills to respond to engineering challenges quickly and efficiently.

Hawkins relish the opportunity to work collaboratively with clients, communities and stakeholders to achieve common goals.

Ahead together

Hawkins approaches every project as a unique partnership opportunity. Based on trust, integrity and transparency, Hawkins forms integrated teams and utilises extensive relationships with international partners to provide a better overall implementation offer.

Significant relationships include:

- EPC contractors – Sumitomo and Marubeni in New Zealand, Indonesia and opportunities in Africa
- Fuji - the delivery of Kawerau and Ngā Awa Pūrua geothermal stations in New Zealand and we are actively looking for opportunities in Africa together
- Toshiba - delivering the 55 MW Lumut Balai Project in Indonesia
- Alstom - undertaking the 35 MW Karaha Project in Indonesia
- Ormat - the delivery of a number of binary projects in New Zealand
- Exergy - actively pursuing binary work together in South East Asia.



Integrated project delivery is the key

Hawkins work alongside technology partners to direct all phases of the project including planning, design, delivery and operation, ensuring risk mitigation with the highest quality, safety and environmental standards.

Key projects:

- Kawerau Power Station 100 MW Double Flash
- Ngā Awa Pūrua (NAP) Power Station 140 MW Triple Flash
- Te Mihi (BAU) Steamfield
- Ngatamariki Binary civil works
- Lumut Balai 55 MW Flash (currently underway)
- Karaha 35 MW Flash (currently underway).

Key capabilities:

- Site investigation
- Design
- Planning
- Consenting
- Procurement
- Logistics
- Construction
- Installation
- Commissioning.

Delivering better outcomes, value and communities

- Best-for-project outcomes, better buildability, accuracy, transparency, quality and timeframes
- The optimum balance of specification, output spec, savings, innovation, and future benchmarks for design
- A transparent relationship with the client's contractor
- Better productivity and efficiency, minimising risk and disruption
- Hawkins' proven track record in constructability ensures no rework, provides cast-iron delivery assurance and saves everyone time and money
- Maximum whole-of-life value through lower total cost of ownership
- Communities are better-served, more sustainably.

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International Earth Sciences (IESE Ltd) is a scientific engineering services and manufacturing company specialising in seismology, geophysics and earth sciences.

Premier commercial provider of:

Seismic instrumentation and monitoring services, including:

- Borehole seismometer manufacture
- Seismometer installations, shallow and deep borehole deployments
- Real-time communication (telemetry) system installations.

Seismic processing and analysis services, including:

- Standard seismic processing - event detection, location and magnitude determination
- Advanced seismic processing - shear wave splitting analysis for fracture interpretation
- Analysis for seismic source characterisation, relative event location for active seismic structure delineation, 3D velocity tomography, and stress field inversion from focal mechanisms

- Real-time seismic monitoring - state of health system alerts and semi-automated processing and reporting
- QC data processing
- Joint interpretation of seismic with other geophysical data.

Training services, including:

- Training in seismometer installation and network operation
- Workshops on micro seismic theory and application to geothermal monitoring
- Workshops on processing methods including practical application.



Geotechnical instrumentation and monitoring services and software, including:

- System design and procurement services
- Installation and commissioning of in-ground and above-ground systems
- Telemetry and data management, including hosting on ring-fenced cloud servers.

Sales:

- IESE Borehole Seismometers
- RefTek seismic dataloggers
- Sisgeo geotechnical instrumentation, including piezometers, inclinometer casing, and dataloggers.

Geophysics:

- Magnetotellurics for geothermal exploration
- Engineering geophysics, including MASW, seismic refraction, cross-hole seismics, seismic tomography, resistivity imaging, microgravity, EM and magnetometry.

Software:

- In-house Ambient Software allows the client to visualise up to 500 time series on one screen, with drill-down to individual georeferenced data sets
- A range of in-house and proprietary software packages for processing, analysing, interpreting and visualising seismic, geotechnical and geophysical data.

IESE is owned by seasoned entrepreneurs and its staff, and has offices in New Zealand and the United States. Its people include senior international experts in geology, seismology, physics, instrumentation and data analysis technologies.

Current customers include private and public sector organisations in Germany, the United States, New Zealand, Australia, Indonesia, India, Mexico, Japan and various African countries. IESE operates in a variety of sectors, including geothermal, mining, oil and gas, civil and environmental.

IESE is proud of its ability to deliver services and products worldwide at a competitive cost with exceptional support and service.

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JACOBS (formerly Sinclair Knight Merz – SKM) provides a fully integrated consultancy and engineering service across almost all aspects of geothermal development, from exploration to power plant development and long-term resource management.

From early beginnings nearly 40 years ago in New Zealand, the geothermal group has developed expertise and capability to deliver globally through JACOBS' presence worldwide.

JACOBS has been involved in developing over 2,500 MW of geothermal power production - almost a quarter of the world's installed geothermal capacity. It has more than 70 staff engaged on geothermal projects and can provide home office and field staff for all stages of exploration, development, construction and commissioning. It also supports projects through environmental, planning, civil works, transmission and carbon financing studies.

With experience and knowledge of high and low temperature resources in a wide variety of settings, JACOBS brings a whole-of-life systematic approach to geothermal development at all scales.

Services include:

- Project concept and development plans
- Reconnaissance, project identification and selection
- Exploration survey management and interpretation
- Resource concepts and energy assessment
- Reservoir modelling
- Drilling strategies, program design, well design
- Drilling rig, services and materials procurement management

- Drilling program management and supervision
- Steamfield concept and process design
- Steamfield, separation and injection systems detailed design
- Power plant and steamfield concepts, FEED and specifications
- Owner's engineers services for procurement and construction supervision
- Transmission interconnection studies
- Technology transfer
- Technical due diligence
- Bankable feasibility studies
- Environmental, permitting and consenting.

Key projects:

Olkaria I (additional units) and Olkaria IV, Kenya

KenGen:

Owner's engineer managing the procurement, design review and construction supervision of 3 major contracts for power plant, steamfield and transmission system for this 2 x 140 MW power plant project. The steamfield component included Jacobs delivering issue for construction detailed designs to the contractor. All units commissioned in 2014.



Sorik Marapi surface exploration, Indonesia

Origin Tata Power:

Assistance with bidding for the concession, then planning and delivering a full surface exploration programme including geology, geochemistry, geophysics and LiDAR interpretation. Resource assessment and proposed drilling strategy delivered and then workshopped with client.

Salak Steam Gathering and Injection Projects, Indonesia

Chevron Indonesia:

Master plan for long term development of the steam gathering system, including well pad 2-phase piping, steam-brine separation, steam lines, brine lines and pumps. Option studies, detailed design and technical support during construction and commissioning for multiple projects.

Ngā Awa Pūrua (Rotokawa), New Zealand

1x140 MWe triple flash condensing. Detailed design of triple flash separation steamfield and scrubbing system for EPC contractor.

Kawerau Geothermal, New Zealand

Mighty River Power:

1 x 105 MW dual flash condensing. Exploration surveys, resource assessment, drilling management,

geological logging, subsidence assessment for owner. Detailed design of dual flash separation steamfield and scrubbing system for EPC contractor.

San Jacinto/Tizate, Nicaragua

Polaris Geothermal (now Ram Power):

2 x 36 MW single flash, condensing. Whole of life services from exploration, resource assessment, drilling and related sciences, early engineering designs, and feasibility studies. Preliminary design included power plant and steamfield.

Darajat III, Java, Indonesia

Chevron Geothermal Indonesia (previously Amoseas Indonesia, Inc.):

1 x 110 MWe condensing power plant and steamfield. Development study for Darajat including power plant options, geotechnical investigations, project scheduling, capital cost estimation and financial modelling. Detailed design of steamfield, technical specifications for power plant, bid evaluation, design review for power plant.

Olkaria II Unit 3, Kenya

KenGen:

1 x 35 MWe Unit 3 single flash condensing. Front-end engineering including concept design for steamfield, bid documents for power plant and steamfield, owner's engineer for construction phase.

Olkaria II Project/Olkaria, Kenya

KenGen:

2 x 35 MWe condensing cycle. Project management, steamfield and civil/structural design. Power plant bid document and tender evaluation. Plant and steamfield construction supervision.

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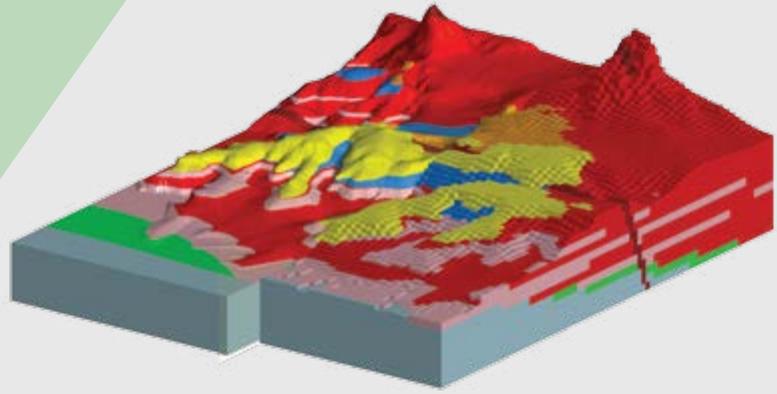
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JACOBS

LEAPFROG GEOTHERMAL



Leapfrog Geothermal is 3D geological modelling software designed specifically for the geothermal industry. International industry participants that use the software appreciate the ease of model construction and the compelling visualisation of the geology.

It helps users to manage geological risk associated with geothermal projects. Leapfrog Geothermal uses an implicit modelling approach to construct geological models and visualisations directly from the data without the need to wireframe. The straightforward interface allows geologists to focus on understanding the geology, geophysics and reservoir models at hand rather than the operation of software tools.

Leapfrog Geothermal has features and workflows that support the modelling of hydrothermal alternation, temperature, pressures and feed zones in a geothermal environment. Dynamic updating of the models enables the user to compare multiple hypotheses built with the latest data at hand.

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MIGHTY RIVER POWER



Mighty River Power is one of New Zealand's largest electricity companies - generating 15 to 17% of the country's electricity. Mighty River Power's core business is focused on harnessing natural resources to produce electricity, and every year the Company's power stations generate enough electricity for about one million homes.

The Company is more than 90% renewable and one of the world's largest geothermal power station owners, investing more than \$1.5 billion in geothermal development since FY2006 and successfully completing three geothermal power plants domestically since 2008.

Mighty River Power supplies electricity to about one in five homes and businesses across New Zealand, through its flagship brand Mercury Energy and other specialty brands. The Company's metering business, Metrix, the second largest meter provider in New Zealand, is building an important strategic platform with a growing network of 'smart' meters and services to electricity retailers and their customers.

A key foundation of Mighty River Power's successful track record of geothermal development has been the long-term partnerships with Māori Trust land owners, and the establishment of business models that enable their equity involvement and ensure direct and aligned economic participation.

This allows the Company's partners to generate long-term value related to their land and its resources - and to invest the returns for the benefit and well-being of their people.

Key Projects

- 82 MW Ngatamariki Power Station (completed 2013)
- 138 MW Ngā Awa Pūrua Power Station (completed 2010)
- 100 MW Kawerau Power Station (completed 2008)

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MB CENTURY

MB Century is New Zealand's only world-class, one-stop-shop geothermal and energy solutions provider. The company offers a full range of geothermal services including drilling, reservoir data logging, environment monitoring, steamfield design & construction, mechanical & power station maintenance and health & safety support & training.

It owns and operates one of the most comprehensive and modern fleets of drilling rigs in the Asia Pacific region.

With over 60 years of geothermal experience - and having completed projects in New Zealand, Australia, Papua New Guinea, Indonesia, Philippines and Malaysia - MB Century offers hard-won know-how and expertise across the full spectrum of geothermal development.

MB Century offers the following services:

- Geothermal drilling and Oil/Gas drilling
- Reservoir Data Logging
- Pipeline/Steamfield Design & Construction
- Geothermal & Hydro Power Station Maintenance
- Geothermal & Water Sampling Analysis
- Environmental Monitoring
- Health and Safety Support and Training

- Process Engineering
- Hydro Engineering/Consultancy
- Heavy Fabrication and Plant Assembly
- Precision Machining
- Industrial Coatings.

Onshore drilling rigs are at the heart of MB Century's core markets. It is one of the most experienced service providers in the Asia Pacific region, having drilled in excess of 2,500 wells since the first wells were drilled in 1949.



MB Century offers one of New Zealand's leading steamfield design and engineering teams and provides a total design and/or construction service for steamfield development. Its expertise has been gained through continued involvement in the development of New Zealand's Kawerau, Wairakei, Rotokawa, Mokai, Ohaaki and Ngawha geothermal fields. It has also been involved in the development of geothermal fields in the Philippines, Indonesia, Papua New Guinea and the emerging market of Chile.

MB Century's services include hydro and geothermal generation plant maintenance. Its highly experienced and dedicated professionals provide hydro engineering consultancy, inspection and overhaul services, modifications and commissioning services.

Energy is a challenging industry, where high-stake projects and very real safety issues are part of everyday operations. Because the experts at MB Century play such a critical role in their clients' operations, they understand what is most important to the client. What sets MB Century apart is a company-wide commitment to:

- Being responsive and flexible
- Skilled and internationally recognised resources
- Sector leading research & development
- Delivering projects on time, and on budget, safely.

Recent Key Projects

Kawerau TOPP1 Steamfield

- Steamfield process civil, piping and electrical design
- Steamfield build.

Piping Design Rotokawa and Ngatamariki (2013 & 2014)

- Steamfield piping design.

Mokai MK22 Fluid Supply (2013)

- Steamfield build.

Wairakei Te Mihi Station (2011)

- Steamfield process, civil, piping & electrical design.

Ngā Awa Pūrua Geothermal Power Project, New Zealand

- Steamfield design & build for 140MW geothermal power station.

Miraka (Mokai) Clean Steam Supply (2011)

- Power plant specification
- Steamfield design & build.

Mechanical Maintenance for the Mokai, Rotokawa & Ngā Awa Pūrua Power Stations

- Mechanical maintenance
- Annual maintenance outages
- Wellhead inspections & maintenance.

Company Highlights

- Excellence in Health & Safety Award - Deloitte Energy Excellence Awards
- EnviroMark - Diamond Certification
- AS/NZS ISO9001 and API Q1 Certification.

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Geothermal Steamfield and Power Plant Designers. Specialist design company MTL is an innovative engineering business with a team that offers extensive experience in geothermal steamfield and power plant design.

The company provides a complete service from project inception and feasibility studies through to installation supervision and commissioning. Able to see the big picture, MTL also has the capability to concentrate on the complex design details of steamfields and power stations, which ultimately make a geothermal design project successful.

Project management skills are a key part of the MTL package. Longstanding partnerships with specialists in related areas allow the company to bring together a comprehensive array of skills. This partnership approach ensures MTL provides expertise to the highest international standards, with minimal complication and maximum cost-effectiveness.

MTL has completed geothermal projects in New Zealand, Australia, Nicaragua, Papua New Guinea and Indonesia.

Key projects

Steamfield Projects:

Karaha Steamfield Design

- Process and detailed design of the 30 MW Karaha Geothermal Power Plant Steamfield, located in Central Java, Indonesia.

Lumat Balai Steamfield Design

- Process and detailed design of the Steamfield for Stage I of the 55 MW Lumat Balai project, located in South Sumatra, Indonesia.

Ngatamariki Steamfield Detailed Design

- Detailed design of the steamfield for a new 82 MW binary power plant in New Zealand. MTL has been responsible for the detailed piping design for the two-phase fluid to the station, and the reinjection system. Included in the design has been a cold injection system to reinject fluid drained on start-up and shut down.



Te Mihi Steamfield

- Process design of steamfield for new 170 MW geothermal power plant, including integration into existing steamfield for Wairakei and Poihipi Power Stations.

Wairakei S — Main Process Design

- Development of station steam model to integrate new steam main into operating steam plant. Consideration of steam distribution and NCG capability of multi unit station with new steam supply.

Wayang Windu II

- Design lead for 117 MW geothermal steamfield detailed design.

Power Plant Projects:

- Poihipi Geothermal Power Plant — 55 MW
Detailed mechanical design, construction supervision and commissioning.
- Lihir 30 MW and 20 MW Geothermal Power Plants
Mechanical design of balance of plant for this Papua New Guinea power plant. MTL's role included extensive construction supervision and commissioning on site.
- Ngawha Geothermal Power Project — 19 MW
Mechanical balance of plant designer for this 19 MW binary plant.
- Te Huka Power Station — 23 MW
Development of contract documents, and site layout for this 23 MW binary plant power project.
- Tauhara 2 Concept Design — 240 MW
Steamfield and station concept design for this 240 MW proposed power plant.

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NGATI TUWHARETOA GEOTHERMAL ASSETS

Ngati Tuwharetoa Geothermal Assets Limited is a subsidiary company of Ngati Tuwharetoa Bay of Plenty (BoP) Settlement Trust (NTST).

NTST traces its connection to the Kawerau geothermal field from the arrival of its great ancestor, Ngatoroirangi in 1300s. In this way, there is a connection between the people of Ngati Tuwharetoa (BoP) and the natural resources of the Kawerau geothermal field.

The energy and water located in the Kawerau geothermal field is a taonga to Ngati Tuwharetoa.

Use of the geothermal resource has enabled people to live and thrive in the region since early times when geothermal was used holistically, as a place of healing and recuperation and for the early cultivation of plants, especially kumara. The steam was used for cooking (similar to a hangi) and for its warmth, a breeding ground for eels and morihanga (fresh water fish / carp). The sulphur was used for medicine and the hot water from thermal lakes, springs and seepages was used for bathing. In as late as the 1950s prior to the industrial development in Kawerau, Ngati Tuwharetoa people were still extensively using the geothermal resource for their daily living.

The 1953 Geothermal Energy Act was introduced at the time of negotiations to construct the Tasman Pulp and Paper Mill in Kawerau, and development of the Kawerau geothermal field began. The Kawerau Township and mill site were located above the geothermal field to enable the Crown to have a cost effective supply of geothermal energy to the mills, for the processing of logs from the surrounding forests. The development was undertaken without the consent of, or consultation with, Ngati Tuwharetoa (BOP).

The mill complex was established on local tangata whenua lands and Kawerau township was established partly on land the Crown had confiscated. These lands were acquired by the Crown under threat of acquisition under the Public Works Act and resulted in alienation of lands.

In 1988 Ngati Tuwharetoa (BoP) lodged a Treaty of Waitangi Claim relating to breaches by the Crown through the Raupatu (confiscation). In 2003, Ngati Tuwharetoa (BoP) signed a Deed of Settlement with the Crown, settling historic grievances. As part of the settlement, the historical connection with the Kawerau geothermal field was recognised by way of Statutory Acknowledgements.

NTST was established to give effect to the Treaty Settlement. NTST established Ngati Tuwharetoa Geothermal Assets Ltd (NTGA), who purchased the Crown's interests and assets in the Kawerau steamfield in 2005.



The purchase facilitated reconnection to the geothermal taonga and enabled opportunity for social and economic growth within the rohe (tribal territory or boundary).

NTGAs activity is that of a wholesaler of geothermal energy to industries for process heat, electricity generation and downstream cascade developments. The company works with customers to develop infra-structure and systems (wells, separation plants and pipelines) to suit their unique industry requirements for the delivery of geothermal energy (steam and brine), it also manages its supply network infra-structure to ensure secure ongoing supply.

The residual fluid is returned to NTGA for discharge. NTGAs innovative approach is enabling design solutions which provide developers with opportunity to adapt typically oil or gas supply operations, to that of geothermal. The projects are researched and conceptualised, examined to ensure project viability before design build contracts are let.

The business model of NTGA as a wholesaler of geothermal energy is unique in NZ. Typically, the NZ geothermal industry is dominated by the electricity generation business. NTGA manages what is reputed to be among the world's largest direct heat energy supplies for industrial purposes.

NTGA undertakes its activities in accordance with its geothermal take and discharge resource consents. The company has recently been granted a new take consent and now holds the largest consented take on the field. This provides opportunity for potential high energy customers and enables geothermal supply without having to go through a new consenting process.

Kawerau is attractive for future industrial development. Factors include:

- New Zealand's log harvest industry, which is set to increase by over 50% in the next decade
- Kawerau's close proximity to neighbouring forests, established rail and road links to the Tauranga port
- The New Zealand Energy Strategy, which has set a target of 90% electricity to be generated from renewable sources by 2025.

NTGA is assisting to promote processing raw log to a processed product and creating additional downstream jobs. Expanded industry in Kawerau has greater potential for flow on social and economic benefits in terms of increased employment, than electricity generation does.

With the reconnection and sustainable management of the geothermal field, the people of Ngati Tuwharetoa (BOP) are able to give effect to a long expressed desire to promote and facilitate economic development by and amongst its people.

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PAGE MACRAE ENGINEERING



Page Macrae Engineering offers a diverse range of engineering solutions complemented by a highly skilled and experienced team with up-to-date facilities. The company's ability to solve problems through innovation and thinking outside the square has gained it a reputation across the Australia-Pacific region as one of New Zealand's premier engineering companies.

Page Macrae Engineering has had major involvement with the construction of all recent New Zealand geothermal power stations. These projects include Mighty River Power's Kawerau 95 MW Geothermal Power Station, Ngā Awa Pūrua 135 MW Geothermal Power Station, Ngatamariki 88 MW Geothermal Power Station and Contact Energy's Te Mihi 170 MW Geothermal Power Station.

Project management and high quality standards were seen as the key to the successful early completion of these projects. Page Macrae's undertaking was vast and included mechanical installation of plant, turbines and generators, fabrication and installation of pressure piping and pressure vessels.

Products and services

With a company history stretching over 60 years, Page Macrae Engineering has an enviable reputation for delivering large engineering projects on time and within budget. It has forged lasting partnerships with several significant Australasian companies and built a solid reputation for reliable after-sales support.

The Page Macrae team includes more than 160 skilled engineers and tradespeople who unflinchingly focus on quality results. The company's facilities include more than 8,500m² of covered workshop on a four-hectare site, located just three kilometres from New Zealand's leading port. This proximity to shipping allows Page Macrae to competitively export large, heavy items.

Services offered are:

- Pressure piping (all codes and materials)
- Pressure vessels to ASME XIII
- Manufacture of bulk storage tanks (to API 650)
- Heavy fabrication
- Stainless steel fabrication
- Site construction
- Project management
- ISO9001 certified
- 3D modelling and design.



Key projects

Page Macrae has delivered high-quality and highly complex projects for major companies across Australia, New Zealand and the Pacific.

Power generation companies: Mighty River Power, Contact Energy, Genesis

- Turbine generator installation
- Pressure piping
- Pressure vessels
- Mechanical installation
- Project management.

Major oil companies: BP, Shell, Chevron, Mobil, Terminals NZ

- Tank builds to API650
- Product piping to ASME
- Fire systems
- Vapour recovery plant.

Petrochemical companies: Downers, Fulton Hogan, Orica

- Tank builds to API650
- Reactors
- Shell and tube heat exchangers
- Distillation columns
- Pressure vessels
- Pressure piping.

Material handling companies: QUBE, Nyrstar, NSS, Bulk Cargo Services, Koniambo, Patricks Stevedoring

- Design and build material handling solutions
- Bulk grabs - mechanical and diesel hydraulic
- Dust-controlled discharge hoppers
- Log handling equipment
- Specialised spreaders.

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PLANT & PLATFORM CONSULTANTS

Plant & Platform was formed in 1986 and has since continued to provide premium engineering services to the oil and gas industry in New Zealand, Australia and other countries. Two of the cornerstone strengths of the company are its extensive track record of delivering solutions fit-for-purpose, coupled with a willingness to engage collaboratively with clients.

Innovation and industry best-practice skills underpin the company philosophy of meeting or exceeding client expectations. The company has professional engineering personnel with many years' experience across a number of disciplines.

Products and services

- Process engineering
- Mechanical and pipeline engineering
- Instrumentation and electrical engineering
- Civil and structural engineering
- API653 and HSNO inspection and certification
- Project and construction management
- Risk and safety engineering, including "Bowtie" risk analysis
- Procurement
- Document management
- Specialist cathodic protection engineering.

The company also has professional engineering experience in:

- Petroleum refining
- Mining and natural resource extraction, handling and transportation
- Public utilities infrastructure
- Transportation fuel supplies.

Key projects

Swift Energy (NZ) Ltd, Rimu Production Station development

This NZ\$50 million project included conceptual design, FEED, detailed engineering design, procurement, construction management and supervision, commissioning, start-up and hand-over. The project commenced in December 1999 and was commissioned in February 2002.

The project consisted of:

- Wellsite development
- 10km pipelines
- Wellstream fluids separation
- Crude stabilisation and storage, capacity 3500 BPD
- Gas processing and export, capacity 10MMscfd
- LPG processing and storage, capacity 40 TPD.



Todd Energy New Zealand, Mangahewa 'C' wellsite development

This NZ\$19 million project spanned 10 months in 2012, and included conceptual design, FEED, detailed engineering design, procurement, construction and commissioning assistance.

The project consisted of:

- Wellsite re-development, including adding a third well to an existing two well site
- Conversion from a single-train to a manifold system.

Todd Energy New Zealand Mangahewa 'D' pipeline project

This NZ\$14 million project included conceptual design, FEED, detailed engineering design, procurement, construction and commissioning assistance. The project spanned eight months during 2011/2012.

The project consisted of:

- 6km of high pressure underground carbon steel pipelines
- Hook-up of existing wells to a manifold system
- Shale and sand handling capability
- Incorporation of High Integrity Pressure Protection System (HIPPS).

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PROGEN



ProGen Ltd is a leading specialist provider of expert technical supervision and project management services for a wide variety of plant overhaul and construction projects. Its team has extensive and in-depth experience in the electricity generating industry, and offers these skills in the thermal, geothermal and gas turbine power generation, mining, dairy and pulp and paper industries.

Over recent years ProGen has completed major engineering projects for key New Zealand clients such as Genesis Energy, Contact Energy, Mighty River Power and Fonterra, and internationally, Newcrest Mining in PNG, Star Energy in Indonesia and Energy Development Corporation in the Philippines.

ProGen recognises that owners and operators of large, high-value equipment need expert advice, guidance and management of the construction and on-going maintenance of this equipment.

The risks associated with construction and maintenance can be enormous; for example, the loss of a generator to a power company, even for a short period, can seriously jeopardise the company's ability to maintain continuity of supply. Loss of this equipment could result in the short term loss of supply-generated income and it could also result in the loss of customers in the long term, as a result of perceived unreliability of supply provision.

The loss of vital equipment caused by project over-runs can be crippling. That is why ProGen offers the reassurance that all its projects will be managed and overseen by its own specialists.

The company's highly skilled professionals make certain every aspect of a project is noted, assessed and managed to ensure any risks are recognised, mitigated and avoided. The Project Managers within the ProGen team also ensure that milestones are identified and agreed with clients, and regularly update client management of progress or changes to the project plan.

Products and services

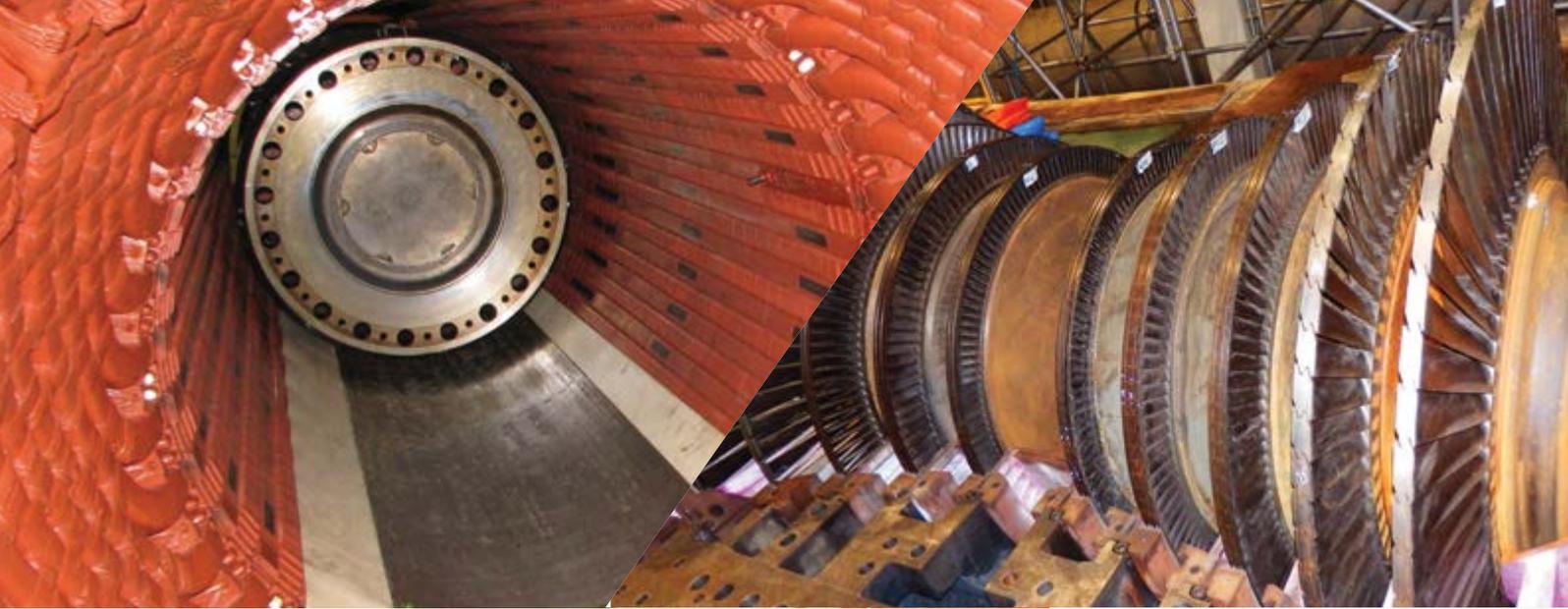
ProGen's key areas of expertise include:

Project Management Services

- Project management
- Project controls and management systems
- Project planning
- Tender development and appraisal
- Quality systems development and documentation
- Project auditor.

Project Development

- Pre-feasibility and feasibility studies
- Cost benefit analysis.



Project economics

- Risk appraisal.

Maintenance Management Services

- Development of maintenance strategies
- Maintenance system analysis
- Maintenance control and documentation
- Maintenance work planning
- Contracting of maintenance services
- Implementation of major maintenance projects
- Risk management of maintenance projects.

Asset Valuation and Acquisition Services

- Due diligence of asset sales
- Valuation of generating plant assets
- Valuation of specific plant items.

Supervision Services

- Turbines
- Generators
- Gearboxes
- Auxiliary plant
- Control valves and servo's.

Key projects

Genesis Power, Huntly Power Station, New Zealand

- Turbine overhauls of units 1, 2, 3, 4 and 5
- Work package leader
- Supervision and technical support
- CPM network project planning.

Northern Power Station, South Australia

- Surveys, upgrades and major works on turbine, generator and excitor
- Supervision and technical support.

EDC, Malitbog Power Station, Philippines

- Geothermal turbine overhauls
- Supervision and technical support.

EDC, Mahanadong A & B Power Stations, Philippines

- Geothermal turbine overhauls
- Supervision and technical support.

Newcrest Mining, Papua New Guinea

- Geothermal turbine overhaul
- Supervision and technical support.

Contact Energy, Wairakei Geothermal Power Station, New Zealand

- Supervision of turbine overhauls
- Project planning.

Contact Energy, Te Rapa/Otahuhu/Whirinaki/Ohaaki Power Stations, New Zealand

- Project planning.

Mighty River Power, Southdown Gas/Kawerau and Rotokawa Geothermal Power Stations, New Zealand

- Project planning.

A detailed list of completed projects is available on the ProGen website www.progen.co.nz

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ReEx Capital Asia (ReEx Capital) is a business advisory boutique specialising in the Asia Pacific Clean Energy sector. From its headquarters in Singapore and office in New Zealand, it offers consulting and investment banking type services.

Since 2006, ReEx has been offering technical/commercial/financial consulting services in the clean energy space. The team has been advising policy-makers, financiers, start-ups, project developers and companies including Medco Oil & Gas, GDF Suez, BNP Paribas Clean Energy Fund, E.ON, ADB, UNEP, UNDP, IFC, Australian Clean Energy Council, REEEP, Singapore National Environment Agency and others.

With DNVGL's Clean Technology Centre in Singapore, ReEx is running the first-of-its-kind technology exchange that was launched by the ADB on the sidelines of the COP20 in Lima.

The pilot service will initially focus on clean energy and energy efficiency technologies with the average transaction size expected to be \$2 million-\$5 million. IPEX Cleantech Asia, will broker technology transfers from developed countries to developing Asia and between developing Asian nations, as well as provide a platform for knowledge sharing.

Through the experience of Dr Mike Allen, one of the Principals, ReEx Capital can provide input to the assessment of geothermal investment opportunities based on over 40 years extensive international activity in this field.

ReEx Capital's consulting services focus exclusively on the Green, Environmental, Renewable Energy and Energy Efficiency sectors including:

- Market analysis and feasibility study
- Corporate/business development strategy, expansion via M&A and joint-ventures
- Due diligence support and investment strategy
- Financial advisory, business plan, financial models
- Valuation, project structuring, risk mitigation
- Policy and regulation.

In addition, ReEx Capital Asia offers capital-raising services: originating investment opportunities, structuring deals and raising funds (debt/equity) for renewable energy infrastructure, biofuel production facilities, energy efficiency projects, clean-tech start-ups and green products/services companies.

The team has many years of cumulative experience providing independent strategic advice, structuring investment opportunities, developing business plans and financial models, assessing technical, environmental, commercial and financial viability to inform feasibility studies and due diligence.

Key Projects

Energy Efficiency Fund (Singapore)

In collaboration with the Ministry of Finance, National Environment Agency & EDB, ReEx designed a \$100m fund to provide financing for equipment retrofits in commercial buildings and industry SMEs in order to reduce utility bills.

Asia Biogas Divestment (Thailand, Indonesia, Vietnam, Philippines)

Engaged by AIM-listed fund to divest its majority stake in SE Asia's largest biogas power plant operator, Asia Biogas. Advised on corporate restructuring, prepared IM & financial models, conducted valuation exercise (based on FCF and comparable analysis),



arranged roadshow and supported client in price negotiation.

Investment Strategy & Transaction Execution (South East Asia)

ReEx advised the USD 600M Indian Family Office of N.S. Raghavan (co-founder of Infosys Technologies in India) regarding investment strategy in the "Green" sector in Asian Emerging Countries (Energy, Water & Waste). The ReEx mandate extended to deal origination and transaction execution.

M&A, JV and Partnerships for ESCO business (Philippines)

ReEx provided advisory services to support the corporate development of US\$7B energy services subsidiary: strategy consulting, identification, screening and transaction support for acquisition of projects and operational plants, acquisition of local energy services company and JV with local partners.

Strategy & structuring (Indonesia)

ReEx formulated a strategy for business structuring and capital raising and developed a Business Plan to finance the company's portfolio of Energy Efficiency Projects with clients such as PT AngkasaPura and PT Indosat.

Climate Finance Innovation Facility (Indonesia, Mongolia, Philippines, Nepal, Pakistan, China, India)

Advised UNEP's Climate Finance Innovation Facility (CFIF) which

helps mobilise and scale up financial flows into climate change solutions by supporting finance-industry engagement in the sectors of renewable energy (RE) and energy efficiency (EE) in Asian developing countries.

Renewable Energy Fund at NDP of Palau (Palau)

ReEx established a multi-million Renewable Energy Finance Window at the National Development Bank of Palau in order to provide affordable capital and financing costs for acquiring Renewable Energy Technologies through innovative financing mechanisms.

Indonesia Debt Vehicle for small hydro power projects (Indonesia)

Provided support to the Indonesia Investment Agency to carve out a hydro power project finance facility. Prepared detailed due diligence guidelines, advised on the internal organisational structure and roles best suited to review and approve applications from potential borrowers and defined underwriting standards and procedures.

Energy Efficiency Regional Analysis (Thailand, Malaysia, Vietnam, Philippines)

Evaluated the EE market in SE Asia (economics, market size, Energy Services Company (ESCO) maturity, regulatory & legal frameworks) in order to (i) analyse the barriers to the widespread uptake of efficiency

solutions and (ii) design appropriate approaches to address these.

BNP Paribas' Asia Renewable Energy Fund (Indonesia, Philippines, Thailand)

Advised BNP Paribas for the establishment of a new clean energy infrastructure fund including financial instruments and fund positioning. Completed a market analysis / due diligence study of the Asian Renewable Energy markets in order to build the PPM.

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SWITCHFLOAT



Switchfloat provides an improved float valve system for geothermal air drilling operations. Switchfloat string float valves are able to be actuated down a hole allowing tools to be safely conveyed through the valves to the bottom hole assembly (BHA).

This system provides significant rig time savings by allowing well intervention activities without the need to trip pipe.

Rig time associated with directional surveys on wireline is greatly reduced. Reduced costs associated with directional surveys enable more frequent surveys and improved well accuracy.

Reliable wireline access to the BHA in stuck pipe scenarios results in optimal and efficient drill string recovery.

Application

To reduce bleed off time when breaking connections during underbalanced drilling, it is necessary to install string floats close to the surface in the drill string. In stuck pipe scenarios, conventional string float valves are a barrier to wireline operations necessary for optimal pipe recovery. To undertake directional surveys on wireline, conventional string float valves must be removed from the drill string. Additional tripping of pipe to achieve this adds significant rig time to directional surveys on wireline.

Switchfloat valves are used in place of conventional string float valves. In stuck pipe and directional survey operations, Switchfloat valves are opened with a pump down or slickline tool to allow wireline access through the valves. All Switchfloat valves are able to be opened by pumping a single actuation tool or alternatively with one slickline run in hole.

Benefits of Switchfloat

- Immediate wireline access to BHA in stuck pipe scenarios.
- Allows surveys in drill pipe without the removal of drill string float valves

- Reduced tripping saves rig time and wear and tear
- Reduced make and break cycles on drill string threaded connections
- Safety benefits associated with reduced drill string movements.

Key projects

Utilised in the drilling of geothermal wells in the following fields:

Ohaaki – Contact Energy

Wairakei – Contact Energy

Mokai – Tuaropaki Power Company.

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TAUHARA NORTH NO. 2 TRUST



Tauhara North No. 2 Trust (TN2T) is a Māori Lands Trust affiliated to the Ngati Tahu-Ngati Whaoa Iwi. Its primary function is to administer the lands that it owns (land at Rotokawa, Taupo, depicted above) on behalf of its more than 5900 beneficial owners.

As part of that role it has developed a series of benefits and targeted programmes for its people, designed to improve health and wellbeing.

TN2T owns an equity interest in the 147Mw Ngā Awa Pūrua Geothermal Power Station on its land as well as financial interests in the Rotokawa and Ngatamariki Power Stations. It also owns four dairy farm operations and its own land at Rotokawa which is a dairy support operation.

Its future commercial investment aspirations will be based around five distinct pillars:

- Energy
- Direct Use Steam
- Farming
- Medical
- Property.

It has a strong commitment to maximise its economic potential so as to allow it to support an ever increasing base of owners and their needs.

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The University of Canterbury partners with New Zealand's geothermal energy providers and Crown Research Institutes to produce world-class research on the identification and development of geothermal resources - from the heat source to the surface.

The University is renowned worldwide for education in Geological Sciences, delivering geothermal field and laboratory training at undergraduate and postgraduate levels. Each year industry, university and government-sponsored postgraduate students are led by eight accomplished scientists on a range of geothermal topics. These scientists produce highly skilled graduates who make a significant contribution to New Zealand and international scientific knowledge in the geothermal industry.

Key Research Areas

Exploration:

Locating and/or assessing the deep heat source, blind geothermal resources and high upflow zones using integrated geologic, geochemical and geophysical techniques.

Geomechanics and Permeability:

Field and experimental studies focussed on drilling, well-targeting, subsidence and stimulation in geothermal systems.

Fluids and Numerical Modelling:

Field, experimental and numerical studies in fluid-rock interaction, resource conceptual models, production sustainability and efficiency.

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WESTERN ENERGY SERVICES



Providers of well services to the geothermal industry.

Western Energy Services is a Taupo-based, New Zealand-owned and operated well services provider, specialising in advanced solutions to the international geothermal industry.

Western Energy has comprehensive, audited health and safety systems ensuring professional and safe procedures.

Western Energy Services employs a comprehensive staff of full-time engineers and technicians; all of them contributing their (international) experience and specialised training to the company and its clients.

This is reflected in its innovative thinking and ability to find practical solutions to an array of complex problems.

The company is specialised in service provision to the geothermal sector, providing a broad range of Well Services including:

- Wireline
- Coil Tubing and Pumping
- Capillary Tube
- Well Testing and Sampling
- Consulting.

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WINTEREC, WAIKATO INSTITUTE OF TECHNOLOGY



Wintec works in collaboration with the University of Auckland's Geothermal Institute to provide Geothermal education for both national and international needs.

Energy sector training and study programmes, as well as operator competency assessment, have been developed with leading New Zealand geothermal energy generators (such as Mighty River Power and Contact Energy) and major international operators.

Wintec is a leading training provider for energy centre operations in New Zealand and around the world.

Located in the city of Hamilton, on the doorstep of New Zealand's geothermal region, Wintec is one of the country's leading institutes of technology. It has a reputation around the world for providing quality technical education. With a history spanning more than 90 years, six campuses, 20,000 students, 700 staff and close connections to employers and community, Wintec is a vibrant and innovative organisation.

It has more than 150 educational programmes from entry-level qualifications through to degrees, post-graduate diplomas and masters-level qualifications.

Wintec's approach to learning is hands-on and relevant. It incorporates practical sessions along with involvement and input from leading industry personnel. This is an approach that has earned Wintec an international reputation as a provider of skilled work-ready graduates.

Key expertise

Wintec offers Energy Sector Operator and Maintenance Training in:

- Thermal operations
- Boiler operations
- Process operations
- Mechanical engineering
- Bachelor of Engineering Technology.

It can also train and mentor your trainers to develop your own in-house competency for Energy Operator and Maintenance skills training.

Wintec can also assist with competency definition and assessment, training needs analysis, and design and operation of Learning Management Systems for plant operations and maintenance engineering functions.

Training tailored specifically for you

Wintec's training programmes are tailored, in terms of content and delivery, to meet both industry specifications and individual client needs. It takes a collaborative approach with clients to develop programmes that deliver workforce objectives.

Contact

Discuss your energy sector operator training needs with Wintec.

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WSP | PARSONS BRINCKERHOFF / THORNDON COOK



WSP | Parsons Brinckerhoff is one of the world's leading engineering professional services consulting firms. The company brings together 31,500 staff, based in more than 500 offices across 39 countries, to provide engineering and multidisciplinary services in a vast array of industry sectors. The focus is technical excellence and client service.

Within WSP | Parsons Brinckerhoff, the geothermal group based in New Zealand has become one of the leading teams of geothermal power experts in the world. The New Zealand-based geothermal team comprises a wealth of engineering knowledge and experience, which enables highly effective services to be delivered at all stages of project development. In January 2015, the Geothermal Centre of Excellence in New Zealand formed a new independent company, Thorndon Cook Power, www.thorndoncook.com

Parsons Brinckerhoff engineered the original Wairakei geothermal power station in New Zealand and managed the construction of the first geothermal plants to be built in Indonesia, Kenya and Ethiopia.

Projects are conceptualised, examined for viability, prepared for financing, contracted and managed by staff who understand the factors that drive geothermal power projects. As every geothermal system is different, the team's practical approach to design and solving technical issues, helps identify cost-effective solutions during all stages of the project.

This team is a trusted advisor to private and public organisations of all sizes, often over many years. Most work comes from repeat contracts with clients consistently rating the expertise on offer 'best practice' for technical delivery and client service.



Key Projects

N2N Geothermal Power Plant Relocation, Philippines Energy Development Corporation

The 49 MW Northern Negros Geothermal Plant was unable to operate at full load due to steam supply limitations. The team worked closely with the owner and contractor to establish the techniques and approach used to relocate the plant and achieve rated output.

Te Mihi Geothermal EPC, New Zealand Contact Energy

PB formed a fully integrated joint venture with McConnell Dowell and SNC-Lavalin for the delivery of the EPC contract and the team led the engineering design for the new 2 x 83.5 MW power plant.

BacMan 1 and 2 Power Stations Rehabilitation, Philippines Energy Development Corporation

The team provided engineering and project management of the rehabilitation of the 150 MW geothermal plant. This included major overhaul and repair of 55 MW units and the dismantling, relocation and refurbishment of a 20 MW unit to a more suitable site.

Darajat III Owner's Engineer Indonesia Chevron

The team acted as owner's engineer for the construction of a 100 MW geothermal power plant in West Java. The role included the review of the EPC contractor detailed design and supervision of the construction and commissioning phases.

Innamincka Hot Dry Rock Power Plant, Australia Geodynamics

The team undertook the front end engineering design for a 50MW power plant.

PNOC-EDC Due Diligence, Philippines First Gen Corporation

The team undertook technical due diligence of the Bacman 155 MW, Tongonan 700 MW, Palinpinon 192 MW, Northern Negros and Mindanao 100 MW steam fields; and Malitbog 235 MW, Mahanagdong 180 MW, Upper Mahaio 125 MW, Optimisation 50 MW and Northern Negros 50 MW power plants.

Dieng Geothermal Power Plant Recommissioning, Indonesia BDPD

The team provided technical assistance and direction for rehabilitation and recommissioning of the 60 MW condensing geothermal power station and steamfield.

Wayang Windu Owner's Engineer, Indonesia Magma Nusantara

Wayang Windu is a 2 x 110 MW geothermal power plant using the largest single geothermal steam turbine to date (110 MW). The team undertook conceptual design, specification and contract preparation, design review, construction and commissioning monitoring and performance testing.

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ABOUT NEW ZEALAND TRADE AND ENTERPRISE

New Zealand Trade and Enterprise (NZTE) is New Zealand's international business development agency. Our role is to help New Zealand businesses to build strategic alliances and develop commercial relationships internationally. Through our global network of people in 50 locations, we connect New Zealand businesses with the world, sharing opportunities, knowledge, experience and networks.

New Zealand creates world leading innovations and solutions for key markets, backed by science and technology, which NZTE works to promote around the world.

We help investors identify New Zealand-based opportunities and gain access to government and private sector contacts. We connect international buyers and investors to industries in which New Zealand has a long-term sustainable advantage and to businesses with high-growth potential, in particular value-added food and beverages and knowledge-intensive manufacturing and services such as marine, aviation, health, IT; and to businesses with high-growth potential.

NZTE focuses on international opportunities that match New Zealand's business capability and provide significant, sustained economic benefit to New Zealand.

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NEW ZEALAND

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