# IS Kawerau – Kawerau Geothermal Field Background Study

## 1. Background

The Kawerau geothermal field is located directly to the east of Kawerau and covers an area of approximately 35 km² [1]. The original development of the field was undertaken to supply steam to the Tasman Pulp and Paper mill built by the New Zealand Government and Fletcher Trust and Investment Limited in the early 1950s. Drilling began at the end of 1952, with production from the field commencing in 1957 [1].

Since initial production the field has gone through a range of drilling programmes to both deepen existing wells and develop new wells, in order to negate field decline and maintain steam supply. From the mid 1970s through to mid 1980s the New Zealand Government had an active program focused on maintaining supply to the mill and investigating a major expansion for power generation and the supply of further steam for direct use.

Up until 2005 the geothermal resource at Kawerau was owned by the New Zealand Government (the Crown), which by law owned all geothermal resources. In July 2005 the Crown negotiated a Treaty of Waitangi settlement with Ngati Tuwharetoa Ki Kawerau, a prominent local Maori tribe. This settlement resulted in a contemporaneous transaction taking place between the Crown, Mighty River Power (MRP - a state owned energy company) and Ngati Tuwharetoa (BOP) Settlement Trust (NTST), whereby the Crown transferred its Kawerau geothermal assets to MRP (at market value) in order for MRP to develop the field. The sale covered physical assets (47 wells), commercial contracts, applicable land, resource consents, intellectual property related to the field, and all associated liabilities and obligations [2]. MRP then on-sold the majority of the geothermal assets, including the Crown's direct heat business and steam supply agreements to NTST. The assets are managed by Ngati Tuwharetoa Geothermal Assets Limited (NTGA), a wholly owned commercial entity of NTST [3].

## 2. Geothermal wells

The field's productive assets currently consist of 12 production wells and 9 injection wells. Three companies currently tap the field for its geothermal resource, represented as follows:

1. Mighty River Power (Kawerau Geothermal Ltd) – 6 production and 5 injection wells [3].
2. Ngati Tuwharetoa Geothermal Assets Ltd – 5 production and 3 injection wells [4].
3. Eastland Group (Geothermal Developments Ltd) – 1 production and 1 injection well [4].

Depth of production wells typically range between 950m and 2,100m, while wells for the reinjection of geothermal brine range from between 300m and 3,000m. Injection wells offer a method for disposing of spent brine while also providing pressure support to help maintain the integrity of the field.

Reinjection is a move away from the previously accepted disposal method where waste water was discharged through a cooling channel into the nearby Tarawera River. This practise was more common when extraction volumes were much lower than today, however some waste water is still discharged in this manner. Current resource consents pertaining to the extraction and disposal of geothermal water require ongoing efforts to reduce discharge into the river.

Reinjection takes place through a mix of shallow infield wells and deep peripheral field wells to the north. The typical reinjection temperature, although variable, is around 120℃ and wells are developed in a manner that ensures they don't negatively affect the temperature of production wells or contaminate groundwater aquifers. In addition to the production and injection wells the

field contains a range of unused, offline and abandoned wells, and a further 24 wells for monitoring purposes.

As is common in the majority of geothermal fields, the deposition of minerals (such as silica) in geothermal wells can lead to declining production through restricting the flow of geothermal brine. At Kawerau various measures are taken to maintain extraction and reinjection volumes, including the de-scaling of wells through drilling and the use of chemical additives to create anti-scalant systems that remove and negate mineral build up [1]. The mining of minerals from geothermal brine has also received international attention as a potential method to negate mineral build up and assist with brine flow.

Down-hole temperatures at the deeper extraction points within the field range between 250°C and 310°C [5], making it the northernmost high temperature (up to 300℃) field in the Taupo Volcanic Zone. This is depicted in Figure 1 below. Estimates place the total available resource of the Kawerau field between 350 and 570 MW electrical (MWe) [5].

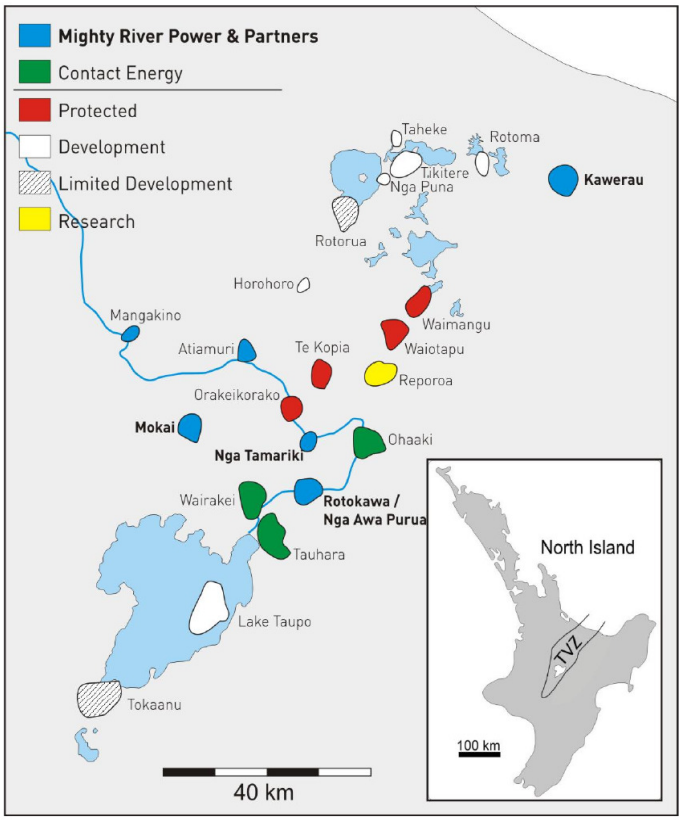


***Figure 1: The Taupo Volcanic Zone [3]***

## 3. Development of the Kawerau field

Since 1957 direct heat use has expanded to cater to growing demand for process heat from the industrial site. In 1966 a 10MW embedded geothermal generator was installed on the mill site to supply electricity to the mill. In 2004, Norske Skog Tasman (NST) upgraded this plant, replacing the turbine and refurbishing the generator. The embedded generator connects to the local lines network, with output consumed locally – by NST in this case.

In 1989 a partially embedded 2.4 MW Ormat binary turbine (first in NZ) was installed utilising lower grade separated brine from the industrial supply. A 3.5 MW Ormat binary turbine followed in 1993 [6]. Owned and operated by Bay of Plenty Energy (BOPE) they continue to be supplied with brine by NTGA. Most output is consumed locally.

In 2003, having concluded an agreement with Putauaki Trust (a land owning entity related to the prominent Ngati Awa tribe) MRP began to explore the eastern part of the field for electricity development [3]. Exploratory drilling began in early 2004 and MRP filed for resource consent in August 2005. In September 2006, following further negotiations with Putauaki Trust, NST, Government and NTGA, MRP were granted consent for the development of a 90 - 100 MW double flash geothermal power station on the NST mill property. Construction began in January 2007 with final commission of the plant in August 2008. The project was completed over a month ahead of schedule, under budget and able to generate 10% more energy than initially specified [3].

At about the same time as MRP was investigating geothermal development options, the land owners of well 'KA24' were granted resource consent to extract 5,500 tonnes of brine per day through Onepu Geothermal Energy Limited [7]. 'KA24' was one of three wells not subject to the Crown, MRP and NTGA settlement [3]. A related company and ultimate project developer, Geothermal Developments Limited (GDL), secured benefits under the 'Projects to Reduce Emissions' scheme (no longer operational) and penned a contract with Ormat to deliver an 8.3 MW embedded power station from what was an otherwise unused well [8]. This plant was commissioned in September 2008 and supplies electricity directly to the NST mill. Eastland Generation Limited, a subsidiary of Eastland Group, purchased the plant in January 2010. Operation and maintenance is contracted to MRP.

Beyond the provision of steam to existing customers, in May 2009 NTGA agreed to supply the SCA Hygiene Australasia (SCA HA) tissue mill with steam for direct heat use. The plant features two 16 MW, 55 tonne steam generating heat exchangers [9] delivering up to 26 tonnes of clean steam per hour [10]. Commissioned in September 2010, the new plant replaced SCA HA's two natural gas boilers [9]. SCA HA research shows this is the world's first tissue manufacturing plant to use geothermal energy for production and it is estimated the adoption of geothermal steam will reduce $CO_2$ emissions from SCA HA's Kawerau plant by up to 39% [11].

## 4. Current utilisation of the geothermal resource

Of the 12 production wells, seven are used for electricity generation (6 by MRP and 1 GDL), four to supply direct heat to industrial users (NTGA), while one well (KA47) supplies both MRP for electricity production and the industrial site for direct heat. Figure 2 below demonstrates the flow of geothermal brine and steam from production to electricity generation and industrial use, through to brine disposal. It does not display the internal use within the industrial site.

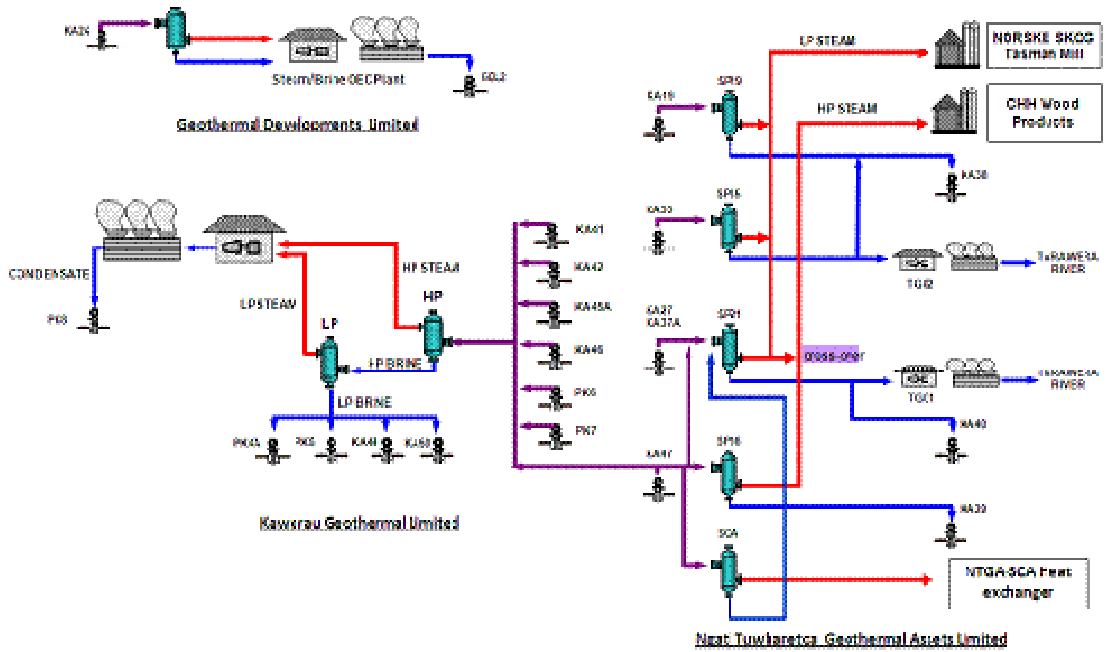


*Figure 2: Schematic of the Kawerau geothermal field [4]*

**Ngati Tuwharetoa Geothermal Assets Limited -** Controls the field's longest established assets and supplies about 305 tonnes of raw geothermal steam to the industrial site per hour for process heat and power generation [12]. NST contracts for the majority of the overall supply and further

distributes a portion to CHH Woodproducts for timber drying. This plant accounts for over half of New Zealand's geothermal direct heat use and is understood to be the world's largest application of geothermal energy for direct industrial use.

SCA HA's supply is distributed as clean steam, with typical quantities in the order of 18 tonnes per hour [10]. This is separate to the NST supply & equates to approximately 23 tonnes of raw steam per hour. Peak steam demand from all NTGA customers is estimated at 369 tonnes per hour, with typical demand of around 328 tonnes [10]. As stated previously, BOPE's two binary units totalling 5.9 MW use separated brine from the industrial supply and generate about 34 GWh of electricity annually [5]. All steam provided by NTGA is done so from its current resource consent for the extraction of up to 44,600 tonnes of brine per day [8]. MRP operates and maintains the assets for NTGA.

**Geothermal Developments Limited –** The original Onepu Geothermal Energy consent to extract 5,500 tonnes of brine per day is separate from that of NTGA. Ownership of this consent now sits with Eastland Group as the asset owner.

**Mighty River Power -** Currently taps six wells and is consented to extract 45,000 tonnes of brine per day. It also calls upon top up supply from NTGA as needed, helping lift generation to a maximum capacity of 106 MW [3]. Through initial negotiations between MRP and NST, the two parties entered into a power purchase agreement whereby NST contracted to take a majority of MRP's generation. Due to the fact that MRP's plant is grid tied, this is effectively a financial agreement offering NST price certainty and MRP a customer contracted to take the majority of supply.

Current power stations tapping the Kawerau field are represented in the following table.

| Plant name | Commissioned | No. of units | Installed Capacity (MWe) | Energy produced (GWh/yr) |
|---|---|---|---|---|
| TG1 | 1989 | 2 | 2.4 | 8 |
| TG2 | 1993 | 1 | 3.5 | 26 |
| NST | 2004 | 1 | 10 | 43 |
| KA24 | 2008 | 1 | 8.3 | 65 |
| Kawerau | 2008 | 1 | 106 | 877 |
| Total capacity and generation | | | 130.2 MW | 1,019 GWh/yr |

As indicated above, NTGA typically supplies 328 tonnes of steam per hour to the Kawerau industrial site. Recipients of the steam and quantities are broken down as follows:

- Norske Skog Tasman – Gross delivery of 285 tonnes per hour. Net use of 259 tonnes after on-selling 26 tonnes to Carter Holt Harvey Woodproducts [12]. Approximately half of this is used to power NST's 10MW turbine, with the other 130 tonnes used in NST's industrial processes [13].
- Carter Holt Harvey Woodproducts – Direct delivery from NTGA of 20 tonnes per hour plus the 26 tonnes purchased from NST for a total of 46 tonnes per hour [12].
- SCA Hygiene Australasia – Direct delivery from NTGA of 23 tonnes per hour [12].

From the above details we can estimate the total current exploitation of the Kawerau geothermal field at 130MWe plus approximately 200 tonnes of steam per hour for industrial use. With an available resource estimated between 350 MWe and 570 MWe, we can assume there is considerable capacity available for further development.

## 5. Future development of the field

With further regional demand for process heat and electricity generation, developers continue to assess expansion options at the Kawerau field. There hasn't been any power plant development

since 2008, due in part to a lack of transmission capacity from the Kawerau 110 kV network. During periods of low load and/or high generation, the electricity generated can be constrained from being dispatched on the national grid. Transpower New Zealand (the owner of New Zealand's national electrical grid) has investigated options to increase the transmission capacity of the Kawerau network [14] so that current and future generation can be connected to the grid without the existing constraint.

Regarding immediate development of the field, three entities are moving forward with the following plans:

**NTGA –** Is seeking permission to extract an additional 45,000 tonnes of brine per day, having lodged resource consent with the Bay of Plenty Regional Council (BOPRC). This application has been supported by KDC and other entities, and will provide NTGA with the capacity to expand supply to both current and new customers. The increased steam supply will most likely require upgrades and modifications to existing infrastructure, which as a result would be made more cost and environmentally efficient. Additional supply could be used for electricity generation and/or direct heat use.

**NST –** Is developing a 25 MW Ormat binary plant on its industrial site. This will provide electricity directly to the NST mill which is connected to the electrical grid, allowing for expansion of activities, greater energy self sufficiency (when including other supply contracts) and/or operation as an electricity provider to the national grid. NTGA will supply NST with geothermal brine out of its current consent, re-routing spent brine from other activities to the NST plant. This agreement benefits both NST and NTGA, in that NST gets the resource it requires while NTGA receives an additional use for its brine.

**Eastland Group –** Is seeking to acquire further steam from NTGA to maximise productivity from its 'KA24' station. This includes the option to drill a new well for connection to the plant. In addition, Eastland is seeking to develop a 12 – 15 MW binary power plant at well 'KA22' in partnership with the A8D Ahuwhenua Trust and Hawaiian owned Innovations Development Group (IDG). Further investigation has shown significant additional resource underneath the 174 hectare A8D block.

## 6. Process for accessing the geothermal resource

It is possible for any person or entity to seek to utilise the geothermal resource for industrial use or electricity generation. This may be achieved in one of two ways:

1. Negotiate with a geothermal consent holder to secure supply under a commercial arrangement, in much the same way as achieved between NTGA and SCA HA in 2009.
2. File for a separate consent to extract brine from the geothermal field.

Under the second method the party would become the holder of the consent for the quantity sought. However, there is a process that must be followed. If the party seeking consent is not the landowner of the property from which they wish to secure the geothermal brine, they must conclude an access / lease agreement with the land owner.

With land access secured, the party can apply to the BOPRC for consent to extract the brine. BOPRC will deal with a range of stakeholders and effected parties, including NTGA, NST and MRP (as parties to the Kawerau geothermal steam field management agreement), in order to progress the consent. Consent from consulted parties cannot be unreasonably withheld, but the longevity and productivity of the field as a whole should be the main concern when judging the affect of additional consents on stakeholders and the field itself.

Beyond access to the resource, parties need to deal with either Whakatane or Kawerau District Council (depending on the location of the land) for the consent of any above ground structures and the supply of services to the site if they don't currently exist.

## 7. Geothermal and carbon emissions

Placing value on carbon emissions acts as an incentive to adopt low emissions technologies such as geothermal. Although low emission, geothermal is not emission free as it releases small elements of gas when discharged. This gas is mostly $CO_2$ but includes small amounts of hydrogen sulphide and methane. It is discharged naturally through the surface of the field but can also be carried in the brine extracted by commercial operations [5].

The emissions profile of geothermal alters when used in different circumstances. $CO_2$ emissions from electricity generation vary from plant to plant depending on the characteristics of the geothermal field and the type of power generation plant. Binary plants produce very small levels of $CO_2$ emissions, while dry steam and flash steam plants produce emissions between 10 to 400 grams per kWh. This compares to 900-1000 grams per kWh for oil or coal-fired plants and 400 grams per kWh for gas-fired combined cycle plants [5]. Atmospheric emissions from geothermal power plants typically average about 10% of those from equivalent sized fossil fuel plants [5].

The Kawerau field produces approximately 59,000 tonnes of $CO_2$ per year, emitted at a rate of about 226 grams per kWh [5]. This is higher than the average 100 grams per kWh for geothermal plants across New Zealand, but is approximately ¼ of the emissions from oil or coal fired plants, and a little more than ½ the emissions from gas-fired combined cycle plants [5].

Most modern geothermal plants re-inject all separated brine and condensate, thus have zero liquid emissions. Currently a little over 700 tonnes of separated brine is discharged into the Tarawera River per hour [12]. A condition related to NTGA's consent requires that all separated brine from the industrial part of the Kawerau operation is to be re-injected prior to the expiry of the consent in December 2012 [15]. A new consent will need to be negotiated to supersede the expiring consent.

## 8. Geothermal and the New Zealand Emissions Trading Scheme

The New Zealand Emissions Trading Scheme (ETS) applies to geothermal brine used for generating electricity or industrial heat, where the emissions of $CO_2$-equivalent ($CO_2$-e) exceed 4,000 tonnes per year from a single installation [5].

All facilities have a prescribed emissions factor which when multiplied by the annual fluid production calculates reportable annual emissions [5]. It is possible for individual producers to gauge their production process and apply for a unique emissions factor specific to their facility.

The ETS effectively taxes industries for their carbon emissions. This assists facilities that adopt low emissions technologies and sources, such as geothermal, as it increases their economic performance when compared to higher emitting fuels used for process heat or electricity generation - such as coal, oil or gas [5].

## References

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[4] New Zealand Geothermal Association – www.nzgeothermal.org.nz/nz_geo_fields.html#Kawerau – depicted in schematic illustrating geothermal activities at the field

[5] New Zealand Geothermal Association website. See www.nzgeothermal.org.nz

[6] Bay of Plenty Energy website. See www.bope.co.nz/generation/kawerau

[7] Young and White, July 2005. Consent Scenarios for the Kawerau Geothermal Field. Industrial Research Limited, Lower Hutt, New Zealand.

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