TE MIHI GEOTHERMAL POWER PROJECT – FROM INCEPTION TO EXECUTION

R. Hudson[1], G. Morris[2], B. Pummer[3] and P. Tearne[4]

[1]Parsons Brinckerhoff, PO Box 3935, Auckland 1140, HudsonR@pbworld.com

[2]Parsons Brinckerhoff, PO Box 668, Wellington 6140, MorrisGr@pbworld.com

[3]Contact Energy, PO Box 10742, Wellington 6143, Bernd.Pummer@contactenergy.co.nz

[4]Parsons Brinckerhoff, PO Box 3935, Auckland 1140, TearneP@pbworld.com

Keywords: *Te Mihi, cooling tower, reinjection, noise level, steam quality, acid dosing, IEC 61850.*

ABSTRACT

The inception of the 166 MW Te Mihi geothermal power project followed the successful re-consenting of the Wairakei power station in 2007. The configuration and construction of the Te Mihi power station in the west of the field optimised the use of the geothermal resource and addressed some of the additional resource consent conditions relating to the continued operation of the Wairakei power station.

Although the existing steamfield and any extension would be able to supply steam for electricity generation for many more years, any additional re-consenting of the Wairakei station in its existing location and current, or even altered, configuration was considered to be difficult beyond its current consent expiry in 2026. The Te Mihi geothermal power station is a staged replacement of the existing Wairakei A and B power station.

The Te Mihi power station is currently one of the single biggest geothermal developments in the world. This paper discusses some of the challenges relating to development, consenting, design and construction of this significant project.

1. INCEPTION, DEVELOPMENT AND CONSENTING

1.1 Background

The Wairakei A and B power stations were constructed in the 1950s with the B station commissioned in 1958. Wairakei was the first geothermal power station in the world to operate on geothermal steam separated from a liquid dominated reservoir. Wairakei power station's current generating capacity is 157 MW and in 2001 a process of renewing its operating consents commenced. This included the consents for the take and discharge of geothermal fluid from the Wairakei part of the Wairakei-Tauhara geothermal system.

After six years, in 2007, consents were granted to Contact Energy that extended the expiry for the core of its resource consents to 2026. These included the take and discharge of geothermal fluid as well as other discharge consents relating specifically to the operation of the Wairakei power station. This suite of consents included a number of new conditions relating to discharges to the Waikato River from the Wairakei power station. The new consent conditions also capped the annual maximum allowable take from the geothermal field, with step increases in 2011 and 2013. Stepped reduction in total geothermal fluid discharges to the Waikato River was also required as well as limits to specific components, such as hydrogen sulphide (H_2S), Arsenic (As), Mercury (Hg) and heat.

The Wairakei power station was initially supplied with steam from the Eastern Borefield, but over time this extended further west into the Western Borefield and, since about 2007, into an area now known as Te Mihi. Scientific studies and an extensive drilling programme confirmed that the Te Mihi area of the field would become the main source of steam for the long-term operation of any power station on the Wairakei geothermal field, whether this be Wairakei or any new power station, such as Te Mihi.

1.2 Inception

The inception of the Te Mihi power station had two principal drivers;
1) new consent conditions that were granted for the operation of the Wairakei power station needed to be addressed, many of which would require significant capital investment and
2) the fluid take quantities granted by the consents and the expected future source of geothermal fluid supply offered an opportunity for optimisation, both, in terms of average energy take (the consents are based on annual mass take, not energy take) and, in terms of pipeline transmission losses.

In 2007 various studies were undertaken that focused on the optimisation of the available resource. Contact conducted an assessment of the ability to consent a new power station at or close to the current location of the Wairakei power station, as well as the investments required to address the new consent conditions in order to be able to keep Wairakei in operation.

The studies also addressed the geothermal reservoir, optimisation of above ground steamfield infrastructure, and environmental effects assessments that would impact on the ability to consent a new power station.

Physical trials were also undertaken on treatment of H_2S in the cooling water discharge from the direct contact condensers (one of the principal discharges of concern from the Wairakei power station), and mitigation of silica scaling with direct reinjection of separated geothermal water.

The outcome from the various studies identified the optimum solution to be a new power station at Te Mihi.

1.3 Consenting

Suitable locations were investigated during the scoping phase that considered the location of the power station in a rural environment, options to connect into the national grid, and locations for future well pads and separation stations. Extensive work was undertaken to develop concepts for the integration into a complex steamfield system that supplies

Wairakei power station, Poihipi Road power station and the new station at Te Mihi whilst achieving operational flexibility for its future operation. Other location specific issues, such as local known and suspected fault lines and localised subsidence were incorporated into the concept design for consenting of the power station.

Although some of the footprint of the selected power station location was zoned ‘industrial environment’ in the Regional Plan, not all of the power station could be fit into this zone and accordingly the Te Mihi power station was consented on the basis of the rural environment. This resulted in the requirement to design the Te Mihi power station for low boundary noise limits.

Most of the consenting work for the Te Mihi power station focused on the possible environmental effects of the construction and operation of the power station, although some additional reinjection consents were also applied for.

Given the rural environment, particular importance was given to noise effects (both during construction and operation), visual effects and traffic management effects during the construction of the power station. Extensive simulations were undertaken and included in the consultation process which resulted in a customised landscape mitigation scheme that included planting, limitation of total building heights, (in particular of the turbine hall) and the selection of an appropriate colour scheme for the buildings and main structures (such as the cooling towers).

Because of the significance of the Te Mihi power station project for the New Zealand economy, and in order to minimise the risk of potential delays relating to the traditional consent application to the district/regional councils, Contact made the decision to apply to the Minister for the Environment for the project to be called in. This meant that the consenting authority would be a Board of Inquiry (BOI), as selected by the Minister for the Environment, instead of district/regional councils. The Minister granted this application. The call-in also posed some risk to Contact as the company would not be able to appeal the decision. A decision by the BOI cannot be appealed (by the applicant or by any other party) other than on a point of law (but not such things as specific conditions of the consents). The Te Mihi power station project was the first project where this avenue under the Resource Management Act was used for the consenting of a significant infrastructure project.

Following an expeditious BOI process, consents for the Te Mihi power station, construction and operation of the switchyard, and transmission line modifications were granted in 2008.

1.4 Development

The development phase of the Te Mihi project went through a number of evolutions. What was initially a seller’s market, where supply of major components relating to the power station were the main constraint, changed towards a buyer’s market prior to and after first bidding of the EPC contract, and accordingly some favourable terms could be negotiated with suppliers and subcontractors.

One of the evolutions was forced by the global financial crisis, which led to the recommendation to defer the project in 2008. During this 12 month hiatus Contact undertook some additional work to further improve the definition of the scope prior to any further competitive bidding.

Finally in 2010 Contact restarted the EPC procurement process and in December 2010 an Early Works Contract was signed with the MSP Joint Venture followed by a fully executed EPC contract on the same day the Christchurch Earthquake struck in February 2011.

2. DESIGN

A number of challenges needed to be overcome with the design for the project in order to meet specific resource consent conditions. Foremost of these was the requirement to design for very low boundary noise limits.

In addition a number of innovations and leading edge technologies were applied for the project, including:

- Researching the best concepts for the separated geothermal water acid dosing system and taking advantage of the latest available technological advances, including use of Ion Field Effect Transistor type pH probes.
- Mixed 1.30 bara and 3.0 bara LP steam turbine operating pressure modes to permit operation at a higher second stage separation pressure to avoid silica scaling when the acid dosing system was not available.
- Continuous steam quality measurement of IP and LP flash steam, with integrated wash water and scrubber operation to deliver consistent steam quality to turbines.
- No leak off valving/pipework for the hotwell pumps.
- Use of multiple condenser CW inlet control valves installed above cooling tower basin water level.
- Site testing of options for controlling the ground friction between the cooling tower basin and ground to fit within a narrow range of coefficient of friction that balanced the ability to post-stress the cooling tower basin slab versus restraining movement of the basin under seismic loading.
- Extensive use was made of network communications technologies to reduce cabling requirements. This included use of an IEC 61850 network for the electrical protection and control of HV and LV switchgear and HV MCCs, and use of a Profibus network for control of the LV MCCs

2.1 Noise Control

The noise limits applicable to the Te Mihi Power Station are based on the predicted noise emissions from the power station at the noise control contour (which is close to the Contact owned land boundaries):

- Leq 37.5 dBA and Leq 52 dBC applicable to 2 turbines and all associated equipment operating.
- Leq 38.5 dBA and Leq 54 dBC applicable to 3 turbines and all associated equipment operating.

The 38.5 dBA level was set to leave a margin below the 40 dBA night time limit for the Rural Area of the Taupo District Plan to cover other noise sources, such as Contact’s steamfield operations.

Noise levels from the power station have been predicted using the software package SoundPLAN version 7.0 with the in-built ISO 9613-2: 1996 prediction method which predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favorable to propagation from sources of known sound emission.

Extensive mitigation measures were required to be able to achieve a compliant design. Noise level limits were specified as part of the procurement of all key equipment and in addition the following specific measures were incorporated in the design:

- Low noise fans were used for the cooling towers, having a sound power level of 103 dBC for each of the 8 fans per Unit cooling tower.

- The total sound power level from each cooling tower was specified to be 113.9 dBZ. Three layers of rubber noise absorption baffles are provided just above basin water level.

- Acoustic pack insulation was applied to steam venturi ejectors and also steam vent valves.

- Location of powerhouse ventilation fans on the East side of the building with acoustic lining on the fan exhaust ducts and downward discharge direction.

- Acoustic louvers used for ventilation intake air to the power house on the western side.

- Turbine hall cladding density selected to provide required level of attenuation for the turbine generator noise, varying from 3 kg/m^2 to 17.7 kg/m^2 depending on location. The additional wall mass is achieved using Fibre Cement Board (FCB) on the walls, and plywood (for support) plus FCB on the roof.

- Limiting wall and roof penetrations and paying attention to fabrication and sealing details for those unavoidable penetrations, including doors.

Steam vent systems are also designed to meet the best practicable option requirement of consent conditions for intermittent steam venting:

- Due to the low pressure for the LP steam (only approximately 3 m of water gauge which is insufficient to produce sonic flow) commercially available cylindrical silencers have been selected for the LP vent silencers.

- Rock mufflers have been selected for silencing the high energy IP vent steam. Noise generation from the vent valves operating under choked sonic flow conditions can be minimised by back-pressuring the valves to the downstream critical pressure for choked flow. The size and number of holes in the rock muffler discharge diffuser sparge pipes have been selected to achieve this back-pressuring criteria at rated discharge flow.
  The rock muffler diffusers are also operating under choked flow conditions and double concentric diffusers have been used to drop the pressure in stages, with each operating at a critical pressure ratio, in order to further minimise the noise generation.

- The IP vent valves also incorporate integral diffuser noise attenuators as part of the valve.

- The vent valves and upstream piping are insulated and clad to minimise break out noise from the valve and piping.

- In addition heavy wall pipe and acoustic insulation is used downstream of the vent valves to the rock muffler inlet.

2.2 Geothermal Fluid Reinjection

The original design of the Wairakei Power station located the station on the Waikato River to provide a plentiful supply of cooling water for the direct contact condensers, as well as a convenient discharge point for the separated geothermal water (SGW).

The current, more stringent consent conditions that were granted following the re-consenting of Wairakei in 2006 resulted in the implementation of SGW reinjection at Wairakei, which resulted in reduced heat and chemical loading on the river. The recently completed bioreactor project at Wairakei provided the means to comply with the more stringent discharge limits of H_2S into the river. The Te Mihi power station will have no geothermal discharges to the Waikato River.

2.2.1 Acid Dosing and 3.0 Bara LP Steam Turbine Operation

The thermodynamic/economic optimisation for the Te Mihi power station established an IP turbine inlet pressure of 5.20 bara and LP turbine inlet pressure of 1.14 bara. The LP flash separation is undertaken on the power station site at a corresponding LP separation pressure of 1.30 bara.

The amorphous silica saturation index for the Te Mihi LP SGW fluid at a 1.30 bara second flash pressure is 1.5 and accordingly the LP SGW discharge is acid dosed to inhibit silica scaling as the fluid travels to the reinjection sites.

High temperature acid dosing systems in geothermal applications can be problematic, both from corrosion and control perspectives. The acid injection duty for Te Mihi is not as onerous as for example Kawerau or NAP as the acid injection is undertaken downstream for the LP flash separators where the fluid temperature is lower and also the high velocity flow at the flash inlets is avoided. Analysis of the SGW fluid chemistry and scaling trials had indicated that for LP flash at 3.0 bara, the amorphous silica saturation index is 1.0 and acid dosing was not required. During the detailed design phase this was recognised as an opportunity to implement a risk mitigation operating option for the plant. Working closely with the turbine supplier, Toshiba, the design team implemented a 3.0 bara LP steam operating mode for the LP turbine. This required modification of the Digital Electrohydraulic Controller for the turbine and also modification of the relative position of the LP main steam stop valves and governor valves. With the additional 3.0 bara LP steam pressure mode the LP separation system is able to be operated at this higher flash pressure in the event of unavailability of the acid dosing system.

The LP governor valves are not able to drop the full 3.0 bara inlet pressure across them without damage so the upstream main steam stop valve is also modulated to share the total required pressure drop. This configuration required the spacing between the main steam stop valve and governor valve to be increased from 1.5 m to 4 m. The control changes included the additional modulating of the main steam stop valve and also modification of the effective IP/LP valve position ratio. In 3.0 bara operation mode LP steam is only admitted through the left of the two LP turbine steam inlet pipes.

The maximum load that can be generated in the 3.0 bara LP steam mode is only 70 MW (compared to rated 83.57 MW) due to the reduced steam flow from the higher pressure flash separation. As a further risk mitigation, a 400 NB branch nozzle has been provided for the 100 NB let down line from the IP steam line to the LP steam (which is used for warming through the LP steam system during start up). This provides the potential to be able to let down additional IP steam to the LP system to generate full load. The let down connection to the LP steam lines is adjacent to the LP wash water spray nozzles which could serve as desuperheating sprays if required.

The turbine is able to be started in either mode, and also change between modes during operation.

2.3 Steam Quality

Steam quality at the steam turbine inlets is managed by monitoring several process variables and integrating the operation of wash water injection and scrubbers where necessary.

Key components, as illustrated in Figure 2.3.1, are;

- Sodium monitoring system
- Wash water system
- Steam scrubbers
- Flow measurement of steam and wash water flows

Permanently installed, EPRI, single port, isokinetic nozzles are utilised to extract the sample steam which is piped to a local rack which has the facilities (condenser, cooling water, valves, drains) to allow a grab sample to be taken. An electrode type sodium analyser (using galvanically separated inputs for sodium electrode and calomel reference electrode with liquid junction in glass sleeve) is used to analyse the steam and monitor the sodium levels. One analyser is provided for each Unit and each analyser is capable of automatically cycling between IP and LP steam samples.

The IP and LP steam lines upstream of the steam scrubbers have the option of spraying wash water for steam washing. Wash water is not anticipated to be required to maintain the specified steam quality during normal operation, however if used the water injection mass flow rate is nominally set at 4% of the steam flow, with two spray nozzle injection points (of 2% each) approximately 100 m upstream of the scrubbers. Steam washing fluid shall preferentially be clean condensate taken from Contact's Poihipi Road power station shell and tube condenser, with alternate supplies available from the discharge of the hotwell pumps from each Unit and raw water.

The IP and LP scrubber demisters are of similar design. A single IP scrubber demister and two LP scrubber demisters are provided per Unit. The design comprises a first stage coalescer with second stage mist eliminator. The design results in highly efficient coalescing which is important when steam washing (that produces fine droplet distribution) is used. The coalescer stage uses a simple tube bundle design which provides good protection of the downstream scrubber baffles from any water slugs. Steam demisting is provided by a chevron baffle design which provides excellent demisting down to 5 micron droplet size.

Figure 2.3.2: View of IP and LP Steam Scrubbers.

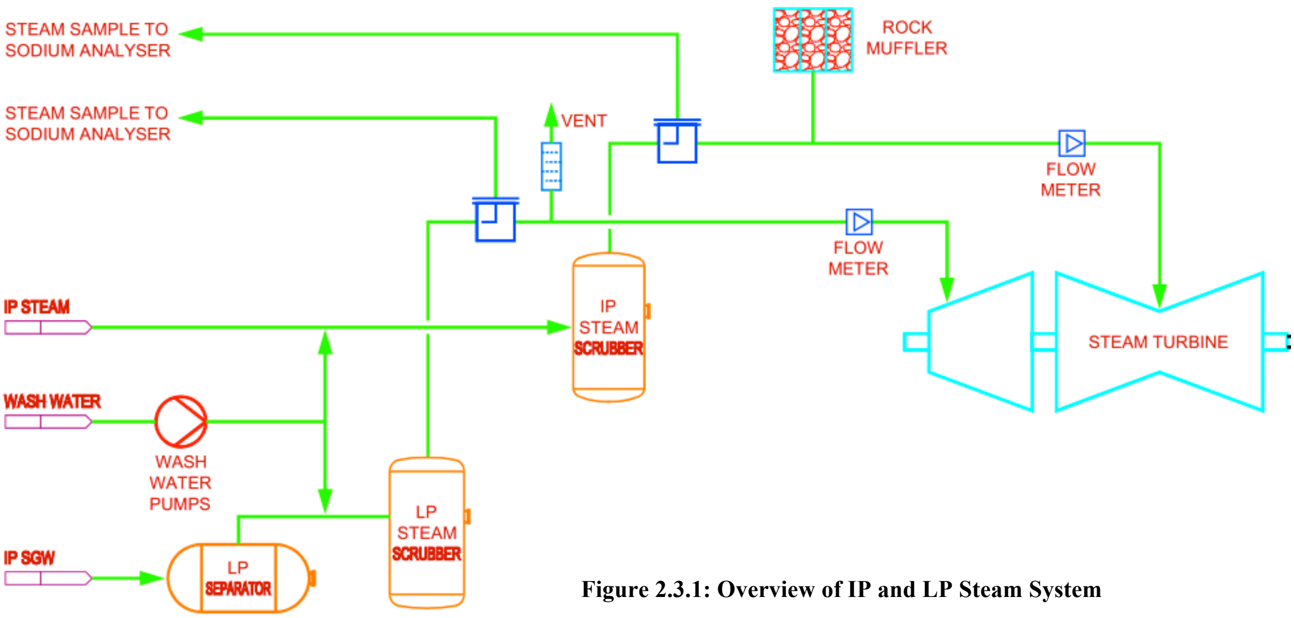

Figure 2.3.1: Overview of IP and LP Steam System

The IP and LP steam flows are measured using vortex flow meters located downstream of the steam scrubbers and vent valves, prior to the main steam lines entering the station.

2.4 Condenser Level Control

The main cooling water circuit follows the conventional arrangement for a direct contact condenser where the cold water from the cooling tower basin is drawn into the condenser by the vacuum condition in the condenser and the combined cooling water and condensed turbine exhaust steam is then pumped from the condenser by 2 x 50% can type hotwell pumps.

Hydraulic control valves are used for the condenser cooling water inlet and hotwell pump discharge due to the very large hydraulic forces and also the benefit of fast response for tight condenser level control.

Instead of a single control valve in the 2000 NB cooling water return line to the condenser, three separate 1200 NB control valves, mounted on the inlet nozzles at the top of the condenser, have been used on the three CW distribution risers. The three 1200 NB valves were more economic than a single 2000 NB valve and in addition this arrangement permitted the valves to be installed above cooling tower basin water level. Accordingly it was not necessary to provide cooling tower basin stop log gates or a syphon loop break in order to be able to isolate the control valve/s for maintenance. In addition the branch for the auxiliary cooling water circuit was able to be taken from close to the auxiliary CW pumps in the condenser pit. The only minor consequence of this arrangement was that it was not possible to locate a flowmeter for the condenser cooling water inlet flow with the required upstream and downstream clear pipe diameters. This value is instead calculated in the DCS by subtracting the measured auxiliary cooling water flow from the main cooling water flow from the cooling tower basin.

The primary control for the condenser water level is through the hotwell pump discharge control valves. A secondary control action is applied to modulate the condenser inlet CW control valves closed if the condenser level rises above the primary control range. Otherwise the condenser inlet CW control valves are set at fixed positions that correspond to the design cooling water flowrates for one or both hotwell pumps in operation.

The design flowrate for each hotwell pump is 2,900 kg/s with a minimum allowable flowrate of 1450 kg/s. Instead of a pump leak off system being used to maintain the minimum flow through the hotwell pumps, the control system ensures that the minimum flow is always available.

The non-condensible gas (NCG) extraction system comprises first and second stage steam venturi ejectors with direct contact intercondensers, and a third stage liquid ring vacuum pump (LRVP). Vacuum is pulled on the condenser using the LRVP which permits establishment of vacuum without increasing the condenser level from additional condensate from the ejector intercondensers. Condenser vacuum must be established before sufficient flow of CW into the condenser can be achieved to support minimum hotwell pump flow.

A coordinated (by the control system) start of one hotwell pump is then initiated. The weighted hotwell pump discharge valve is opened and then the condenser CW inlet valves opened to the one pump running position. The hotwell pump is then started against a closed discharge control valve when the condenser level is above the bottom of the control range. After the pump has run up to speed, the control valve is opened to the pump minimum flow position and then placed on auto to control condenser hotwell level.

When the turbine load reaches 50% the second hotwell pump is started using the same control strategy.

2.5 Site Testing of Options for Controlling the Ground Friction for Cooling Tower Basin

The level of friction restraint between the Cooling Tower Basin slabs and subgrade was a critical aspect of the basin design.

The design requirements for friction are for the cooling tower basins to have a specific range of coefficient of friction (0.8 to 1.0) for the interface between slab and subgrade. It was necessary to have sufficient friction during normal operation to provide lateral earthquake resistance but less than a maximum limit to ensure there is sufficient slip to allow the slab to be post-tensioned with the design level of pre-stress. The post tensioning is used to control cracking in the slab.

An important associated issue is that the surface must be uniform across the whole base of the slab and the potential for any long term bond between the slab and base must be minimised.

A series of friction tests were conducted to determine an appropriate value for the friction coefficient for the cases of compacted crushed rock (GAP 65) and the as-built blinding, and also to assess variability across different areas. The surface preparation for blinding concrete was required to be uniform across all pours with minimal raised ‘bumps’ or ‘dips’. Any ‘bumps’ that occurred were removed (scraped off) and ‘dips’ or holes were filled to be consistent with the surface of the surrounding concrete.

For each test a small block of concrete was cast onto the slab. The block was moved by pulling it with a crane and a 5 tonne digital load cell was used to determine pulling load.

Figure 2.5.1: Concrete Test Block on Crushed Rock

Figure 2.5.2: Test Block on Polyethylene

The results of the tests are summarised in Table 2.5.1

Block ID	**Friction Coefficient**	**Comments**
1	0.77	on polyethylene
2	0.82	on polyethylene
3	0.95	on polyethylene
4	> 3.6	poured directly onto slab block could not be moved at load limit
5 & 6	> 3.6	poured directly onto slab not tested based on Central W result friction coefficient from Central W results assumed
7	2.7	poured directly on Gap 65

Table 2.5.1: Results of Concrete Block Friction Tests

During the friction tests, the only blocks that were able to be moved with the load available were those on polyethylene. The friction results for these tests ranged between 0.77 and 0.95, noting that target range was 0.8 to 1.0. For the cases with crushed rock or concrete poured directly onto blinding, the friction coefficients were many times greater than 1.0 and if adopted would result in a risk that the slab would not slip as required during the post-tensioning procedures.

The cooling tower concrete basins for both Units were successfully constructed and post tensioned using the polyethylene layer over the blinding concrete, achieving a very efficient construction solution.

2.6 IEC 61850 and Profibus Networks

Extensive use was made of network communications technologies for the following reasons:

- Lower wiring costs.
- More flexible programming and fast configuration.
- Reliability.
- New capabilities that are not cost effective with hard wired systems.
- Higher performance with more data.
- Faster diagnostics.
- Reduced downtime.

The networks utilised included an IEC61850 network for the electrical protection and control of HV and LV switchgear (substation equipment), and a Profibus network for control of the LV switchgear.

At an early stage after contract award it was decided to investigate the benefits of using networked technologies for "smart" control and monitoring of electrical devices. A significant proportion of the devices being considered for procurement had IEC 61850 and Profibus capability and significant benefits could be obtained for very little additional cost.

The review concluded that IEC 61850 and Profibus were mature technologies and becoming the de facto standards for substation and process automation. There were some advantages in terms of the reduction in physical connections needed together with significant improvements in the amount of data that could be made available. There was little risk that the technology would become obsolete within the operational life of the power plant.

By way of background, IEC 61850 is an automation standard that was specifically developed for use in electrical substations. It has a number of mappings or protocols which can be used for communication between different types of equipment. For instance it has a process bus which can be used for fast communication between devices. This process bus is sometimes referred to as horizontal or GOOSE (Generic Object Oriented Substation Event) messaging and has specific features to ensure that no data packets are lost.

IEC 61850 also has a protocol that can be used for bulk information transfers typically between a device and a master controller. This type of communication is often referred to as vertical communications and uses client-server type messaging.

In addition to the above, IEC 61850 can also support HTML type services which can be used with devices that incorporate web browsers.

All of the IEC 61850 communication is via an Ethernet network and one challenge was to achieve the required levels of reliability. The Te Mihi application was different from many substation based applications because it was one network spread across 20 different areas rather than the usual substation application which would have far fewer different locations. It was important to achieve an architecture that allowed maintenance to take place in some areas whilst the rest of the equipment remained in operation. It was also important to ensure that all of the data could be communicated within the required timescales using conventional 100 Mbit/s network equipment.

Ultimately a MRP (Media Redundant Protocol) type configuration was adopted. MRP is a generic form of the Hirschmann Hiper-Ring which had already been adopted for the main control network architecture. MRP is a ring topology with the data having the ability to flow in either direction around the ring with the actual direction being controlled by a master device. MRP can tolerate one break in the ring and works quite well generally but is vulnerable if two devices are removed from the ring causing a gap to be formed. For this reason the main communication backbone was implemented using network switches with two switches per panel. With this configuration it was possible to take two devices within a panel out of service without affecting other devices or even to take a complete panel out of service without affecting the rest of the network ring. Refer to Figure 2.6.1 below for a diagram of a typical sub circuit.

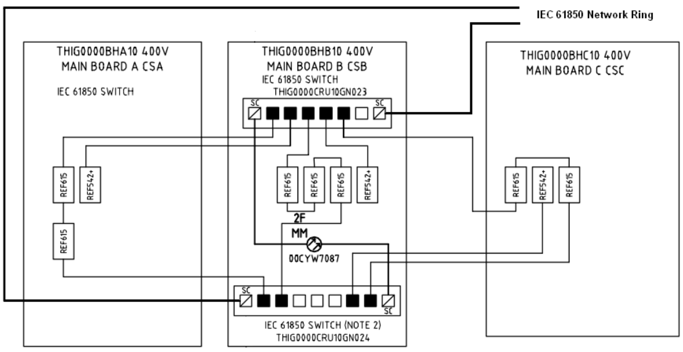

Figure 2.6.1: Typical Sub Circuit for the Network Ring

One of the benefits of adopting IEC 61850 was that it allowed the detailed definition of the interface between the electrical equipment and the DCS to be completed at a later stage than normal. This is because any additional signals or functionality required can usually be handled within the programming of the devices rather than with the addition of physical IO.

For instance it was decided at a late stage to use the synchronising functions of the SEL700G generator protection relay for synchronising the generator circuit breaker. This change had some impact on the IEC 61850 data but had little or no impact on the physical IO required.

For Te Mihi, IEC 61850 was used primarily as a communication interface between the equipment and the DCS and the results were quite encouraging.

To give some idea of the scale of the application we have managed to use IEC 61850 for all the HV switchgear including motor control, all of the protection and all of the LV feeder control. The final count was 54 devices altogether spread across 10 different types and from 3 different manufacturers. The only significant piece of electrical equipment where we did not use IEC 61850 was the generator circuit breaker where the required functionality was not available on the specific relay being proposed by the vendor at the time of order.

3. CONCLUSION

The construction of the Te Mihi power station in the west of the Wairakei geothermal field optimized the use of the geothermal resource and addressed some of the additional resource consent conditions relating to the continued operation of the Wairakei power station.

The Te Mihi power station project was the first significant infrastructure project to be consented under the Board of Inquiry “call in” provisions of the Resource Management Act and resulted in expeditious processing of the assessment of environmental impacts and resource use and subsequent granting of consents.

A number of challenges needed to be overcome with the design for the project in order to meet specific resource consent conditions. Foremost of these was the requirement to design for very low boundary noise limits and extensive mitigation measures were required to achieve a compliant design.

A high temperature acid dosing system was engineered to prevent precipitation of silica in the low temperature, double flashed, separated geothermal water. As a mitigation against the acid dosing system being unavailable, the control system for the turbine was also modified to permit operation at two LP steam pressures, 1.3 bara and 3.0 bara (acid dosing not being required in the 3.0 bara mode).

Site testing of the friction coefficient for concrete test blocks on the blinding concrete for the cooling tower basin permitted an efficient design to be developed for the basin which facilitated post tensioning to control cracking whilst requiring no separate lateral restraint for seismic loading.

Use of IEC68150 and Profibus communications networks for the MV and LV switchgear and protection significantly reduced control wiring and DCS I/O requirements, and permitted additional functionality to be inexpensively included.

ACKNOWLEDGEMENTS

We would like to thank Contact Energy and the partners of the MSP Joint Venture, McConnell Dowell, SNC Lavalin and Parsons Brinkerhoff for permission to publish this paper.

Don McKay was responsible for the concrete block friction design and Andrew MacLennan provided review of the IEC61850 content.