NGAWHA GEOTHERMAL FIELD EXPANSION PROJECT. GEOTHERMAL FLUID CONVEYANCE SYSTEM

Kevin KOOREY[1]

[1]MB Century, Taupo, New Zealand

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SUMMARY - The geothermal fluid conveyance system for the Ngawha Geothermal Project conveys two phase fluid from three production wells to two separation plants. Steam and brine from these separation plants, supply two binary fluid power stations. The system also pipes cooled brine and steam condensate to reinjection wells.

1 GENERAL

The Ngawha geothermal field is the only high temperature geothermal resource in the north of New Zealand. (Figure 1). Hot springs near the Ngawha Village are used for bathing and the area was mined for mercury until 1934. The New Zealand government drilled a number of deep wells in the early 1980's but a planned 100MW power station was cancelled in 1983.

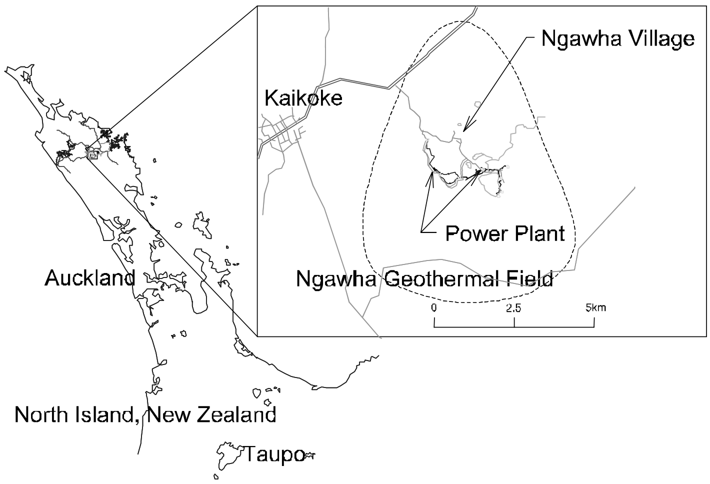

Figure 1 Location of the Ngawha field. Resistivity boundary between 500 and 700 meters depth shown.

Downhole temperatures up to 320C have been measured, but the wells used for production have feed temperatures of ~230C. Fluid enthalpy is correspondently 975 kJ/kg. Gas content 1.5 % of total mass which is a high faction of the flashed steam delivered to the power plants.

2 POWER STATION DEVELOPMENT

In 1994 the Tai Tokerau Maori Trust Board and Top Energy Limited were granted consents to extract 10,000 t/day (417 t/h). In 1998 two Ormat Energy Converters (OEC 1&2) were installed. These OECs use the heat from separated steam and water (brine) in an organic Rankine cycle (Daniel 2000). The power output of OEC 1&2 is nominal 9 MW.

Consents to expand the project where granted in 2006. These consents allow for extraction of 775,000 t/h month (~1076 t/h). The new consents also allow injection of surface water to maintain reservoir pressure. In 2008 a 3rd OEC (OEC3) was added. OEC3 is a 15MW unit.

3 GEOTHERMAL FLUID CONVEYANCE SYSTEM

The Geothermal Fluid Conveyance System (GFCS) for OEC1&2 and the expansion for OEC3 consist of the two phase piping from production wellhead to separation plant, steam and brine piping to the OEC interface points. The GFGS also includes the reinjection piping for the combined condensed steam and cooled brine from the OECs to the reinjection wellheads.

4 OEC 1&2 GFCS

The original GFCS for OEC1&2 consisted of wellhead separators (SP12 & SP9) on the two production wells NG12 and NG9. NG12 is close to OEC 1&2 but NG9 is 700m away and required long steam and brine branch lines. Transfer pumps on the brine branch lines where installed at the separation plants to overcome the pressures and elevations differences between the two separation plants.

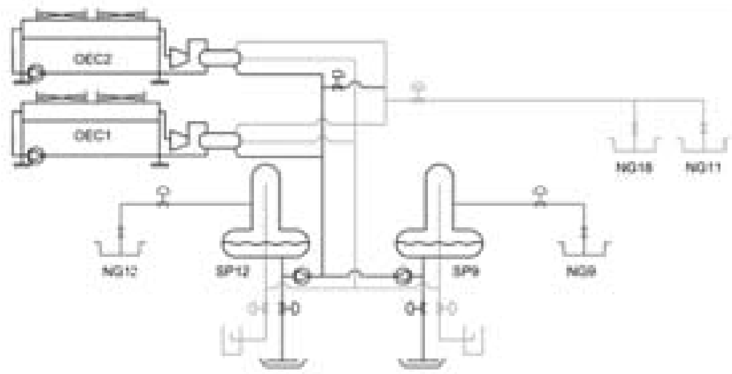

Figure 2 OEC 1&2 GFCS

5 EXPANSION PROJECT GFCS

A design build contract was let to MB Century for the GFCS to supply the new OEC3 as well as OEC1&2. This contract required a functional performance guarantee. The GFCS had to deliver the required pressure and flows and to the OECs given stated well output curves.

The new GFCS consists of a two phase main feed by three production wells, NG4, NG12 and NG9. Two separation plants are connected to the two phase main, the existing SP12 and the new SP2. These plants supply steam and brine to OEC 1&2 and OEC3 respectfully.

All the flow for OEC1&2 are now delivered via SP12. SP9 and the SP9 steam and brine branch lines have been decommissioned. The SP12 brine transfer pumps are no longer required. SP12 did not require modifications for the increased separation plant flow.

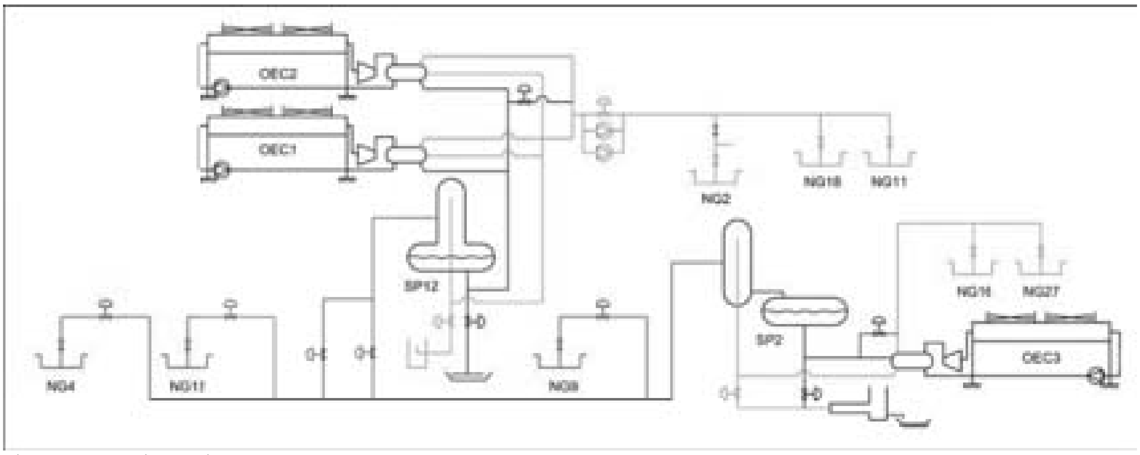

Figure 3 Expansion Project GFCS

Two phase main

The unusual feature of the new GFCS system is the two-phase main (TPM). All the production wells are connected to the TPM, which runs 3.2km from NG4 past NG12 and SP12 onto to NG9 then SP2.

SP2 is located at the end of the TPM, the separation plant and OEC3 receives all the fluid on the TPM at that point. On the other hand the take off for SP12 is located just down stream of NG12. The total output from NG12 and NG4 is more than required by OEC1&2 so the flow to SP12 must be regulated and the surplus passed onto SP2. OEC1&2 also require the ratio of steam to brine to be close to the plants design point.

The take off to SP12 has two branch lines with control valves. The steam branch line is teed off the top of the TPM and the brine line off the bottom. There is also an internal defector plate in front of the brine tee. Steam flow is regulated by the plant generation control. The flow of steam creates a pressure drop and draws brine into SP12. Brine flow is controlled by a flow control loop that uses a valve on the outlet of OEC1&2 and has an operator set point at the required plant flow. The control valve on the brine take off controls the brine level in SP12, when the level rises, the valve closes and more brine flows to SP2.

Flow into the TPM from the three production wells is controlled to regulate the steam pressure at SP2. For normal operation NG4 opens first and NG9 last. The wells will be fully open when the three OECs are operating. The pressure drop from SP2 back to SP12 varies with flow so the OEC1&2 operating pressure also varies.

The TPM mostly falls along its length from NG4. But there are two short up hill sections, one before the OEC1&2 pad and the other after SP12. There was concern that these two sections would cause slug flow or surging in the TPM. But the only problem found to date has been long period (~15min) surging and pressure build up across the second section when OEC3 is not operating and there is little flow past SP12.

The performance tests showed the pressure drop from the production wellheads to SP2 to be much as expected. Most of the pressure drop is across the wellhead piping where the small size of the master valve dominates.

SP2

SP2 is located at the end of the TPM. From SP2 separated brine and steam is supplied to OEC3. SP2 is sized for the design flow of OEC3 but can also handle for short periods the additional flow that is diverted from SP12 if OEC1&2 trips.

SP2 has a high brine level energy dump valves and steam vent valves. These discharge to a common cyclone silencer. The silencer has twin barrels 3.25m dia by 8.756m tall. Discharge from the silencer is to a large holding pond.

SP2 has a large (12m by 2m dia) brine accumulator. Under normal operation OEC3 controls brine level. If OEC3 does not require all the brine available the level rises to set point 1 where a valve open to by-pass brine direct to reinjection. Above set point 1, set point 2 will dump brine to the silencer and pond.

Reinjection

The original OEC1&2 reinjection piping to NG18 and NG11 has been retained. Decreasing injectivity of the wells and lowering of the OEC1&2 operating pressure required the reinjection pumps to be reinstalled as part of the expansion project.

A new rejection line has been built from SP2 to NG16 and NG27. NG16, one of the government wells, was deepened for the expansion project. NG27 is the only new well used for the project. There are interconnection loops between the two reinjection systems but these are closed under normal operation. The expansion project included connecting NG2 to the OEC1&2 reinjection line. While this well can used for condensate/brine injection it will mainly be used for surface water injection.

Staged Commissioning

The expansion project GFCS was commissioned in two stages. First the TPM from NG4 to SP12 was completed. OEC 1&2 was then run using NG4 and NG12 with SP9 decommissioned. NG27 was temporarily added to the OEC 1&2 reinjection line.

While the first stage operated the TPM, SP2 and the reinjection system was completed. TPM was then connected at SP12 and SP2 commissioned. OEC1&2 ran for some months using the completed CFCS before OEC3 was commissioned.

The OEC1&2 reinjection pumps where installed at the end of the project using planned shuts of OEC1&2.

6 GFCS DATA

3 Productions wells
5 Reinjection wells
3100m Two phase piping. 300, 450, 500 and 600NPS
5481m Reinjection piping 350,300,250 and 200NPS
4400m of optic fibre
13 Control valves
5300m of downhole and surface antiscalent tubing.

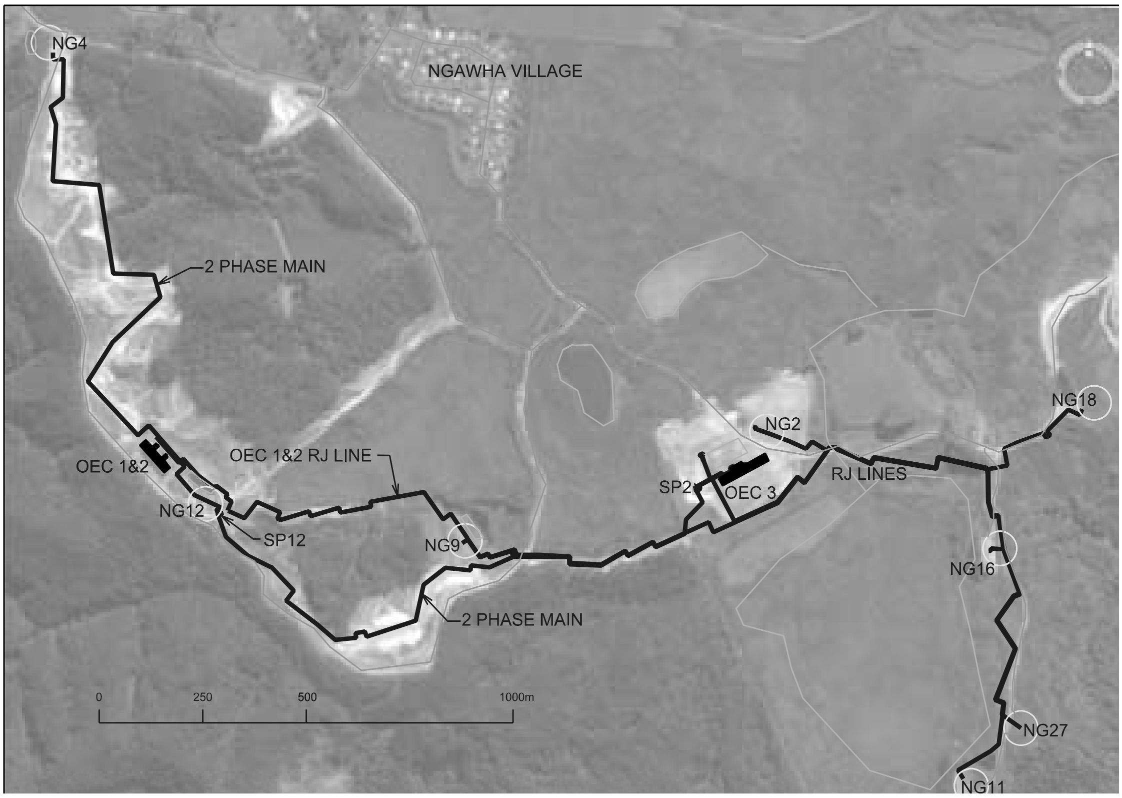

Figure 4 GFCS layout

7 ANTISCALENT INJECTION

The Ngawha production wells require antiscalent chemical injection to control calcite deposition in the wells. The MB Century armoured tubing system is used (Rock 2000. Robson et al 1990).

The expansion project GFCS contract including replacing the tubing in NG12 and NG9 and running new tubing in NG4. A new pump shed and tank system was installed next to NG12. Surface tubing has been run along the cladding of the GFCS piping to the wellheads.

8 SCADA

For the expansion project Top Energy installed a new SCADA system in the OEC1&2 control room. This interfaces with the PLCs that control OEC1&2. OEC3, the GFCS and the surface water injection. The plant can be operated remotely over the Internet.

The GFCS PLC is located in the OEC1&2 control room and has I/O cabinets at NG4, Antiscalent pump shed, NG9, SP2, NG16 and the OEC1&2 reinjection pumps. The cabinets are connected to the PLC with a twin optical fibre.

9 CONCLUSIONS

The use of a long two phase pipeline with slope changes and the two phase take off to SP12 was risk for the project owner and the contactor. While there are some flow instabilities the OECs can tolerate these. The concept has been a success.

10 ACKNOWLEDGEMENTS

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