Ngapuna geothermal power plant feasibility study

(Version prepared for EECA)

Prepared for

Pukeroa Oruawhata Trust and Rotorua District Council

By

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Summary

This study was commissioned by the Pukeroa Oruawhata Trust (the Trust) with funding from the Energy Efficiency and Conservation Authority (EECA) to consider the feasibility and economics of the generation of electricity from the geothermal resources available at Ngapuna, in the vicinity of the wastewater treatment plant in Rotorua. The project is intended to be implemented as a joint venture between trading businesses owned by the Trust and the Rotorua District Council (RDC).

The Ngapuna project is seen as a potential commercial opportunity in its own right, and as an example of small scale electricity generation that could potentially be replicated elsewhere in the Rotorua area at locations where a similar geothermal resource is available.

However the Ngapuna project has a number of unique features, based in particular on its close integration with Rotorua District Council's wastewater treatment plant, that add to its commercial and environmental attractiveness. These include:

- The opportunity to embed (in whole or in part) the electricity generation, by selling to the wastewater treatment plant, and utilise the existing network connections
- A source of cooling water in the treated liquid effluent; avoiding the cost, power consumption and noise associated with cooling towers
- The availability of geothermal fluids at a temperature in excess of 200°C at the shallow depth of around 250 metres, and
- Its "green" attributes, which are of value to the RDC.

Preliminary work carried out indicates that it is likely that the project can obtain the required consents and approvals for taking the geothermal fluids and construction and operation at the site, though this can only be confirmed on completion of the full consent process. Careful geothermal system design, along with reinjection of all fluids will be required to mitigate potential impacts on other geothermal resource users; in particular the geothermal tourist facilities of Rotorua.

A significant concern with any development in Rotorua is the potential effect especially on the Pohutu geyser and associated tourism and commercial interests. This study has drawn on initial consultation with Environment Bay of Plenty and the use of their Rotorua reservoir model which has been developed and maintained by Industrial Research Limited. A preliminary assessment carried out using this model shows "negligible" effect on the geysers and the possibility of an "up to 8% decrease" in geothermal flows around the Kuirau Park area over 30 years, though detailed geothermal system design may reduce this effect.

Environment Bay of Plenty has indicated that "based on the rules alone (assuming that all environmental issues are addressed and suitably avoided, remedied or mitigated), the proposal would probably receive a positive recommendation".

Further detailed modeling work is planned, addressing potential issues of subsidence, hydrothermal eruption, reinjection and effects on existing bore users: in preparation for a consent application and in order to develop a full business case for the development.

Based on a nominal fluid flow of 1,420 tonnes per day of fluid, fully reinjected, the output of the binary cycle generation plant is likely in the range 1,050 to 1,250kW, after the deduction of "parasitic" power and that required for pumping the geothermal fluids. This range is based on budget offers received from two manufacturers of binary cycle units; similar in technology to Bay of Plenty Electricity's TG1 and TG2 plants at Kawerau, but on a smaller scale.

This generation, for an assumed 95% of the year, will supply all the electricity requirements and export between 350 and 550kW. The plant is connected to Unison Networks Limited who feed the wastewater plant at 11kV and these existing electricity systems can be used for export with the addition of appropriate meters, and perhaps some additional protection.

The capital cost of the project is assessed at between $6.8 and $8.2m with this range based primarily on the differing costs of the two generation units offered, which also have significantly different efficiency and outputs.

Income streams are from the embedded sale of electricity and export of the surplus, and from the avoided lines charges associated with the reduced peak demand. A number of other revenue opportunities can be explored and the optimisation of the generation plant and negotiations around the price for this and the pumps in particular have the potential to improve financial outcomes further.

Generation is expected for 95% of the year, allowing for maintenance and downtime. Based on the electricity price path in the report and a range of other assumptions, including that two production wells and pumps are required (one set may suffice), the project return is seen as commercially satisfactory in the context of an infrastructure development.

Overall, the project is seen as providing acceptable returns for an infrastructure development, despite its small scale, which reflects the benefits associated with its location and linkages to the wastewater plant, and relatively low risk excepting with respect to a resource consent given the Rotorua location.

Contents

1. Introduction 1
2. The site 1
3. The Ngapuna geothermal resource 2
4. Resource-related considerations 4
5. Other considerations 5
5.1 The site, environs and access 5
5.2 Historical use and development 5
5.3 Impacts on existing users 5
5.4 Archaeological issues 5
5.5 Ecosystems 5
5.6 Noise 5
5.7 Emissions to air 5
5.8 Potential conflicts 5
5.9 Use of "surplus" heat 6
5.10 Carbon emission reductions 6
5.11 Electricity connection 6
5.12 Regulatory and legislative requirements for small generators 6
5.13 Electricity markets 6
5.14 Electricity sales and pricing 7
5.15 Cooling water supply 7
6. Resource consents 7
6.1 The ability to obtain consents 7
6.2 Environment Bay of Plenty's comments 8
7. The generation plant 8
7.1 The generation plant 8
7.2 Alternative technology – steam turbine 9
7.3 Balance of system/plant items (provisional) 9
8. Electricity sales and connection 10
8.1 Forecast wholesale electricity price path 10
8.2 Electricity sales and revenues 11
8.3 Other potential revenues 11
9. Operation and maintenance 11
10. Financial assessment 12
10.1 Financial assumptions 12
10.2 Capital costs 12
10.3 Revenues 13
10.4 Operating costs 13
10.5 Financial outcomes 13
11. Risks and opportunities 13
12. Non-financial benefits 13
13. Commercial structures 14
14. Development timescales 14
15. Next steps 14
16. Conclusion 14

1. Introduction

East Harbour Energy, a consulting business with considerable geothermal experience and expertise, has been commissioned by the Pukeroa Oruawhata Trust (the Trust) in association with the Rotorua District Council (RDC), to carry out a study covering the feasibility of binary cycle generation at the Council's wastewater treatment plant close the shore of Lake Rotorua.

This feasibility stage of the study is based on previous work by East Harbour on geothermal developments, quotations from key equipment suppliers, a preliminary modelling exercise covering the geothermal resource by IRL using the Environment Bay of Plenty model, and preliminary discussions with a number of potential stakeholders such as DOC. The costs of this feasibility study are supported by EECA.

The report is intended to identify any "show stoppers" for the development, assess the financial and commercial feasibility, and recommend a path forward for the project.

2. The site

The geographical location of the wastewater treatment plant and the proposed generation plant is shown in Figure 1, and the indicative location of the wells and generation plant at the site in Figure 2.

Figure 1: Extent of the Rotorua geothermal field as defined by electrical resistivity surveys, and areas of surface geothermal activity (from EBOP Environmental Publication 2005/12)

Figure 1 also shows the "exclusion zone" around Whakarewarewa, within which no extractive geothermal development is possible. It is hoped that the generation plant can be located within the boundaries of the wastewater treatment plant, on part of the area currently used for composting, but alternatively the "grey" area just to the north, which is the heavily modified site of a former rubbish dump, is available subject to agreement; given that it is officially "reserve".

The wells themselves, and connecting pipework, may be outside this area depending on the detailed system design.

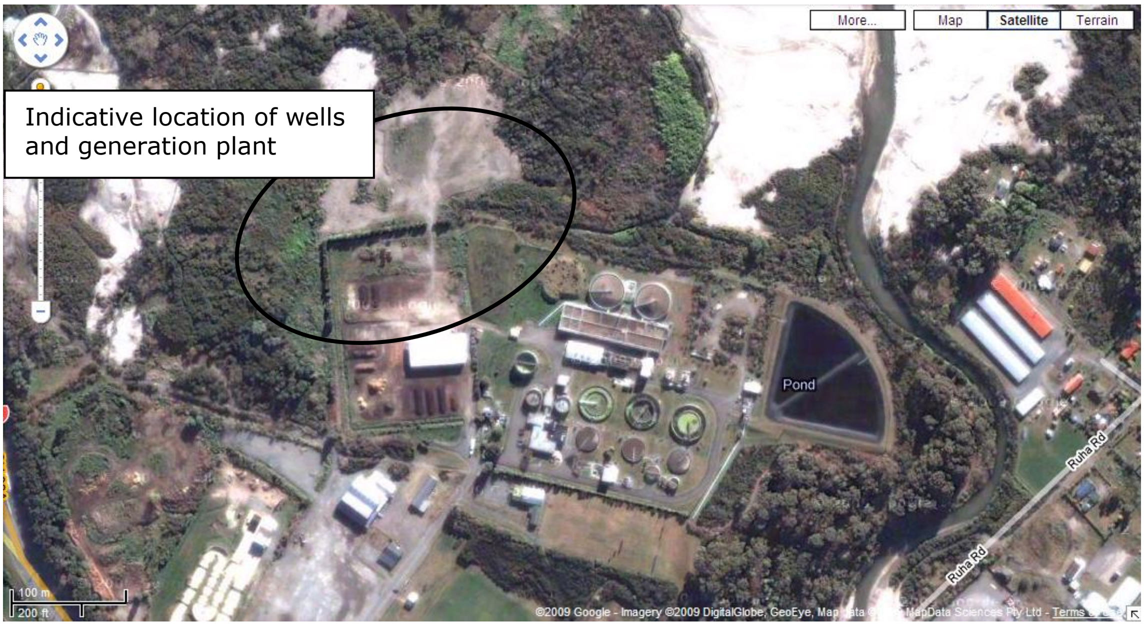


Figure 2: Indicative location of the wells, generation plant

3. The Ngapuna geothermal resource

The initial assessment of the geothermal resource draws heavily on Environment Bay of Plenty's Environmental Publication 2005/12 June 2005 "Rotorua Geothermal Field Management Monitoring Update: 2005" and the subsequent preliminary modelling related to this project by IRL using the EBOP field model.

The Rotorua field concept is one of upflow near the Ngapuna fault (refer Figure 3) with this flow spreading out from this: some to the south to Whakarewarewa, and some across the field towards Kuirau Park then Ohinemutu.

There is a very large flow of fluid in the Sulphur Point area, which is believed to flow mostly through the Ngapuna area but also in considerable volumes directly into the lake, suggesting this could sustain a significant level of production. However issues to be considered include the impact on other users of the fluids, the overall heat take (noting that there will be no net fluid extraction) in relation to the overall resource and current usage, and potential for issues such as subsidence.

The preliminary modeling exercise carried out indicated that these effects were likely to be minor, and manageable. To confirm this, and to design the production and reinjection wells to minimise impacts a full modeling exercise will be required; this is planned for the next stage of the project.

There is a 240m deep monitoring bore (M9) at the wastewater treatment plant with a measured well temperature of 210°C near its base. The reservoir at this depth is in ignimbrite which should mean a relatively productive resource, though the actual well performance is one area of current uncertainty, as shallower rhyolite reservoirs are generally used for production in Rotorua.

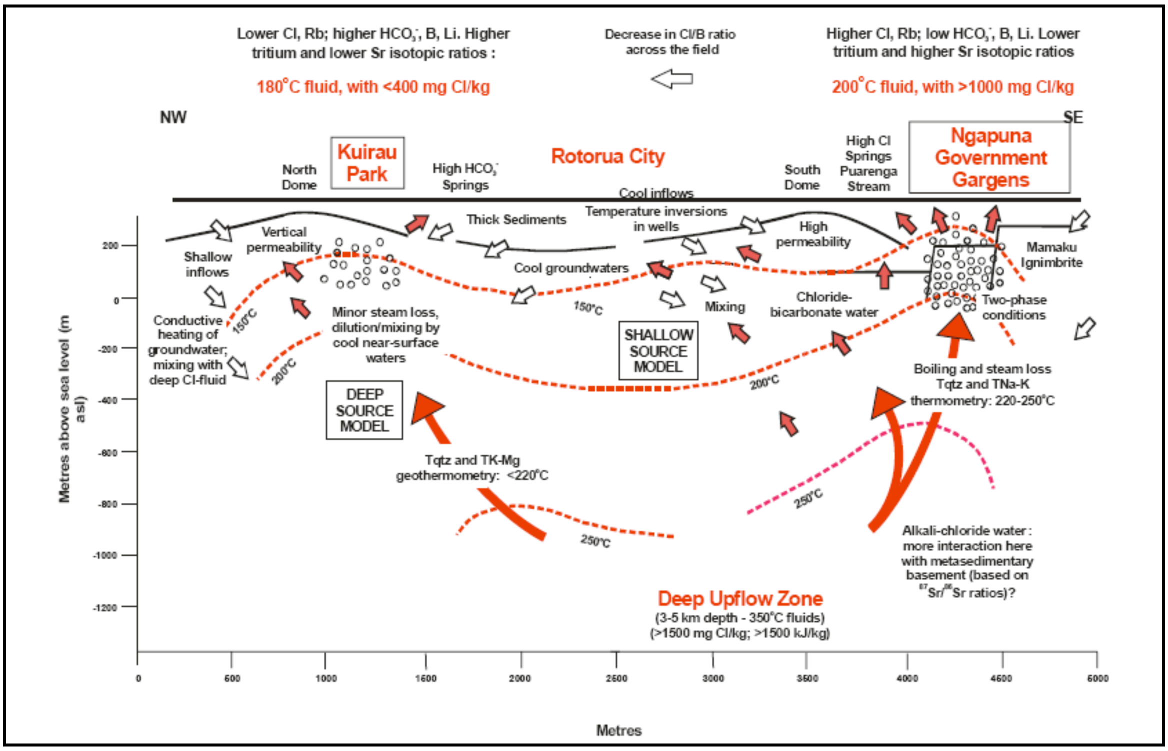


Figure 3: Inferred hydrology of the Rotorua Geothermal Field (from EBOP Environmental Publication 2005/12)

Interim conclusions, from the preliminary modelling exercise

The preliminary modelling exercise was limited to a single chosen scenario with no chance to optimise the configuration and depths of wells, and therefore the impacts and outcomes. A full modelling exercise covering a range of scenarios is planned for the next stage; focussed on optimising the system to minimise potential impacts and costs, and proving the resource itself.

Specific points from the preliminary modelling report are as follows:

1. The impacts of the development may be (over 30 years as modelled by IRL):
    - Very minor on Whakarewarewa which "will not be noticeable" (this was a key point of concern)
    - Potentially there may be up to an 8% outflow reduction at Kuirau Park, which could be of concern to EBOP. However IRL suggest that there may be options for lessening this impact
    - There may be potential impacts on nearby users, which will need to be considered
    - Subsidence should not be an issue ("will not be noticeable" say IRL) as the modeled pressure drop is very low.
2. Further IRL modelling is required to test different arrangements of production and reinjection to optimise outcomes and reduce possible impacts. IRL advise that "what has been modelled so far is probably one of the "worst case scenarios" in terms of impact so the potential impacts may well be reduced.
3. Temperatures of a little over 200°C should be available beneath the site, at a depth of around 250m:
    - The absence of a highly permeable Ryolite layer in this location (most production in Rotorua is from Ryolite formations) means that two production wells may be required (this taken as base case in considering the economics)
    - Further work is required on well productivity; one well may be adequate, but this may not be able to be determined until the first well is drilled and tested.
4. Reinjection will be required, most likely to a depth of around 350m. One well should be adequate.

Alternatives to the nominal 1,420 tonnes per day of fluid chosen were not covered by the IRL modeling. Options in terms of sizing can be considered at the next stage of the modeling work but there does not at this stage seem to be a case for considering a larger development, excepting as a potential subsequent development stage.

4. Resource-related considerations

4.1 Risk of scaling

Some wells in the Rotorua area are subject to silica scaling and GNS Science has undertaken a range of studies covering this. Further work is required but East Harbour's initial assessment for the Ngapuna site is that the reinjection of the fluids may have to be at the relatively high temperature of 100°C to prevent scaling; and this figure was specified for generation plant quotations.

There are no particular concerns about well acidity.

4.2 Consenting issues

Consenting issues are dealt with in more detail in Section 6 of this report. From a resource perspective the field management focus in Rotorua is centred on the preservation of the geyser activity at Whakarewarewa which draws in numerous tourists and supports the regional economy.

The overall Rotorua field management regime gives a high degree of protection around a 1.5 km radius of Pohutu geyser (refer Figure 1). Ngapuna is some distance outside this exclusion zone but is also situated in an area of significant field upflow so development in this area remains sensitive. Very careful consideration will be applied to the assessment of the effects, and communication with potentially affected stakeholders.

4.3 Reinjection or surface disposal

This is a standard issue facing geothermal developers, but there are very few recent or potential developments that do not include reinjection which is useful for pressure maintenance in reservoirs. Reinjection is considered a non-negotiable requirement for this development.

4.4 Field potential

Clearly the Rotorua geothermal field itself is of some scale: NZ Geothermal Association have assessed it at 35MWe, or 18MWe after environmental limitations are taken into account, but given historical use now with only 3MWe available for long-term sustainable use. Current management practices appear to have re-established a sustainable situation. With full reinjection the only effect on the field from the project is the heat take (a very small proportion of the total) and the effect on current field use and life at the size envisaged is expected to be very small, if assessable at all.

4.5 The extraction rate

A nominal extraction rate of 1,420 tonnes of hot fluids per day (all reinjected) was selected for the feasibility assessment and preliminary modeling exercise The temperature of the fluids at the nominal extraction depth of 250 metres is expected to be around 210°C.

This proposed extraction rate compares with a total current withdrawal across the whole Rotorua geothermal field of 9,700 tonnes/day (a 15% increase) but given full reinjection will not increase the current net take which, after reinjection, is around 970 tonnes/day, with a maximum allowable (in theory) of 4,400 tonnes/day.

4.6 Subsidence

Subsidence is an issue at a number of geothermal fields, including at Wairakei where reinjection has historically not been the practice. At Ngapuna all fluids will be reinjected and while this is an area that will require more detailed assessment for consenting purposes it is not expected to be a material issue for the proposed development.

5. Other considerations

5.1 The site, environs and access

Figure 2 shows the proposed site of the power station and the general area for the supply and reinjection wells. The area is heavily modified and of little ecological value, having been the site of a rubbish dump and part of the wastewater treatment plant.

The plant itself may be able to be located within the current boundaries of the wastewater treatment plant, and area that is already "industrial" in use, and this would reduce interconnection costs, is likely to provide better foundation conditions, and would mean no encroachment on the reserve. If, as expected, the plant is operated and maintained (except for specialist work) by waste water treatment plant staff the closer location will also be of benefit. Failing this the bare land outside the plant to north is proposed as the site, though foundation conditions are likely to be poorer and this is closer to the lakeside which is an important bird habitat.

Access to either site is excellent with no issues seen in terms of delivery of large loads associated with the power station or drilling and other specialist equipment.

5.2 Historical use and development

Previous site use is understood to have been as a rubbish dump and no issues are seen.

5.3 Impacts on existing users

Existing uses at Ngapuna are the wastewater treatment plant, some wooden buildings housing sports and other clubs to the South-West, and to the South Council playing fields. To the North along the lakeshore are a number of public walkways. The generation plant will be of a height and scale similar to the wastewater treatment plant and shielded from public view by this facility and from the walkways by the relatively dense stands of (predominantly) Kanuka.

Given the very low emissions, and appropriate attention to noise no significant impacts on existing users are seen.

5.4 Archaeological issues

These have not yet been specifically reviewed for this project, but any such impacts seem unlikely.

5.5 Ecosystems

An informal preliminary discussion with DOC indicated that they consider the site highly modified and see few issues with respect to the development as outlined.

5.6 Noise

The plant itself will generate some noise, but its enclosure within a building along with acoustic treatment is expected to be adequate to meet planning/consenting requirements. Noise will be the subject of specific consideration as part of the planning and consenting process.

5.7 Emissions to air

It is proposed that the geothermal fluids will be pumped to maintain them in a liquid phase throughout the system, without flashing off steam; though this is not necessarily the final design concept. In this case the only emissions to air will be small discharges of gases, including potentially hydrogen sulphide. With a cooling tower these gases would normally be dispersed in the "plume" of water vapour created, though this option is not available in this case.

This aspect requires further work/consideration but is seen as manageable/consentable.

5.8 Potential conflicts

The significant take of geothermal fluids for the station is likely to be seen as potentially affecting existing geothermal field users, and some parties who have lost geothermal facilities in recent years, and cause significant public/stakeholder interest and concern. This will be in part mitigated by the status of the participants in the venture, the close relationship with EBOP, and the range of project benefits; requiring careful planning and development of mitigation and communication strategies. These will be developed and initiated in the next stage of the project.

No other conflicts are seen.

5.9 Use of "surplus" heat

The requirement to reinject fluids at or above a specified temperature (provisionally 100^{o}C) means that heat cannot be extracted from these fluids without impacting on the efficiency of generation of electricity.

There is however potentially, at a cost in terms of generation efficiency, useful low grade heat available from the cooling water if a use can be found. As currently specified the return temperature is 30^{o}C.

5.10 Carbon emission reductions

The actual reductions in carbon emissions from this project will be a function of the carbon emissions from alternative electricity generation that is displaced. Wind and geothermal generation are 'must run' or base load operated whenever possible and while hydro has a firming function it is operated to minimise spill with generation in the long term maximised. This leaves the avoided generation coal, or more likely CCGT (gas combined cycle) plant emitting around 400 tonnes CO_2/GWh.

The project will generate around GWh pa which based on displacement of CCGT generation avoids 4000 tonnes of CO_2 per year. The benefit of this is essentially built into the electricity revenue streams, based on electricity pricing forecasts (refer Section 8).

5.11 Electricity connection

The generation plant will connect to the grid via the wastewater treatment plant's current connection requiring in terms of new equipment only electricity cabling and appropriate metering, plus potentially some additional protection; thus avoiding a range of costs associated with development on a greenfields site.

5.12 Regulatory and legislative requirements for small generators

The regulatory environment for the connection of small generators to the local network has been assisted by the Electricity Governance (Connection of Distributed Generation) Regulations 2007. The purpose of these regulations is to enable connection of distributed generation (in this case to the local Unison 11kV network) where connection is consistent with technical and operational standards. The other relevant regulatory and legislative requirements relate to electrical safety issues outside of those required by Unison's connection and operation standard.

Electrical matters are discussed in Section 8 of this report.

5.13 Electricity markets

For a broad description of New Zealand electricity markets refer to "Assessment of the Kawerau Geothermal Power Station Proposal" prepared in July 2005 by Concept Consulting Group (http://www.mightyriverpower.co.nz/content/597/9%20-%20Economics%20Assessment.pdf). This gives:

- An electricity industry overview including a history of reforms that have led to its current structure (including the separation of monopoly elements which are regulated and competitive elements which are left to the market)
- A description of the supply features (updates of the current supply mix can be found in MED's Energy Data File)
- An overview of the electricity market
- Views on the outlook for electricity

Importantly the Ngapuna generation will feed directly into a host site and the electricity will be largely used there, with the balance exported via distribution network to the market, or sold to the Regional Council for use in their other buildings and facilities.

The plant will reduce peaks in demand from the wastewater plant and this will mean a direct cost saving that has been factored into the financial assessment. The network company will also receive benefits from this distributed generation (which have not been factored into the assessment) that they may be prepared to pass through as financial benefits to the venture, but stand to lose revenues from lower imported volumes and lower peak demand, meaning that negotiations will be required to monetise the overall benefit, if in fact this is possible.

Because owners of small generators are not set up to be independent market participants, they must inevitably reach an agreement with the major generator/retailers to purchase the electricity produced. The retailers of electricity may recognise benefits associated with distributed energy that they are prepared to pay for, especially where this is of a baseload nature, and scheduled outages can be programmed for periods outside the retailer's peak demand time.

5.14 Electricity sales and pricing

Electricity used by the wastewater treatment plant is (provisionally) to be sold to it from the generation facility business at a discount to the contracted price; the detail of this arrangement yet to be discussed/agreed.

Electricity exported may be sold on a number of bases, including into the spot market under an arrangement with a generator/retailer, to a specific customer, or on a contracted fixed price basis (though this price may change with the season). The option selected will depend in part on the risk profile adopted, and the detail of the arrangements possible.

5.15 Cooling water supply

The proposal is to use the treated effluent from the wastewater treatment plant to cool the condensers; eliminating the need for cooling towers and associated pumps. This will require only a small proportion of the available water which is pumped up to local forests for disposal.

This effects a material saving in capital costs and in the power required to run the pumps while eliminating a source of noise and vapour. The water specification has yet to be analysed for any issues, but appears to be satisfactory and its temperature varies between 18 and 20^{o}C, winter and summer.

6. Resource consents

6.1 The ability to obtain consents

The proposed development is not a "prohibited activity" and would be assessed by both the Regional Council and Rotorua District Council as a "discretionary activity" requiring a resource consent. The consent may be granted or refused, and if granted, conditions may be imposed by the consent authorities.

The next stages of the project will include a full "assessment of environmental effects" and the development of a strategy for consultation and the consent process itself. A wide range of issues will have to be addressed, and technical studies carried out, including the following:

- Site and construction management during the construction phase
- Reservoir management for the life of the project
- Noise. An "on-the-ground" survey will be required to establish the background levels, along with full specialist consideration of mitigation measures and the resultant impacts of the noise from the plant
- Ecosystems
- Landscape and visual
- Efficient use of the geothermal fluid resource; a consent requirement that must be addressed in detail and demonstrated in the consent application
- Discharges. The discharges, in this case only gaseous, must be shown to have no more than minor adverse effects on the environment and this may be addressed by considering the location of the discharge, potential for treatment prior to discharge to the environment or an alternative methodology that reduces, mitigates or avoids the discharge
- Affected parties – a wide range of parties will need to be consulted from early in the process under a defined strategy including the relevant consent authorities and local tangata whenua

- Term of consent – The Rotorua Geothermal Regional Plan restricts most geothermal consents to ten years and this may impact on the viability of the project when the capital investment required is considered. A thirty-year term would seem appropriate.

The project is believed to be consistent with the purpose of the Resource Management Act 1991 as set out in section 5 in that it will involve the sustainable use of a natural resource, enabling people of the Rotorua community to enjoy economic and environmental benefits while adverse effects on the environment are avoided, remedied or mitigated.

6.2 Environment Bay of Plenty's comments

EBOP agreed to the use of their geothermal reservoir model in a joint modelling exercise. Their comments on the results of the initial modelling exercise were contained in their letter of 21 September (Attachment 2) which advised that "there are six key points to consider, as well as more general considerations in the Resource management Act 1991:and included the following statements:

- There are no rules that prohibit this activity
- There must be full reinjection of the geothermal fluid except where this is technically not feasible or potentially dangerous
- The cumulative net mass (all users) that can be extracted from the Rotorua geothermal field cannot exceed 4,400 tonnes per day
- The use of geothermal fluid must be efficient
- All significant surface features must be protected
- Protection of the environment with particular regard to issues raised in Part 2 of the Resource Management Act 1991".

They advise that in terms of the resource consent process:

- Early and ongoing engagement with Iwi and Hapu is strongly encouraged
- Based on the rules alone (assuming that all the environmental issues are addressed and suitably avoided, remedied or mitigated) the proposal would probably receive a positive recommendation
- Consent is highly likely to be considered through a fully notified process

The planning, consultation and consenting processes will be advanced cooperatively with both EBOP and RDC and in close consultation with all potentially affected parties and stakeholders.

7. The generation plant

The initial, very high level, assessment of the potential and economics of the Ngapuna development were based on nominally 250kW UTC machines. While these remain an option they are of relatively low efficiency and have a maximum fluid temperature of 165^{o}C, though this can be worked around at a cost.

7.1 The generation plant

For this study East Harbour prepared an outline plant specification, based on the nominated geothermal fluid (1420 tonnes/day at 210^{o}C and a reinjection temperature of 100^{o}C), and cooling water (seasonal temperatures between 18 and 20^{o}C); requesting proposals and costs for the supply of generation units. This was expected to provide a range of costs and performances from which an optimal solution could be selected (though considerable subsequent negotiation was expected).

Two responses were received at this stage of the process, offering binary cycle plant, designed for geothermal applications. Based on these responses the output of the binary cycle generation plant is likely in the range 1,050 to 1,250kW, after the deduction of "parasitic" power and that required for pumping the geothermal fluids. The range of outputs reflects different efficiencies and is almost directly proportional to the costs of the unit. In each case however further clarification of the offers is required and it is believed that a range of options to optimise outputs in relation to capital and operating costs and outputs may be available.

7.2 Alternative technology – steam turbine

This initial feasibility assessment has been made using binary cycle generation plant, which is seen as the most likely option in the case of Ngapuna. A possible alternative however is to flash the steam in the well and pass it through a turbine before reinjecting the condensate.

This option may be considered in the next stage of the project.

7.3 Balance of system/plant items (provisional)

Geothermal heat supply: The two production wells (or potentially one well depending on the permeability of the structures, which is yet to be determined) will be drilled to nominally 250m, cased and lined. The well is expected to be drilled with a truck mounted rig and the operation can be accomplished within the footprint of the site.

Pumping: A down-hole pump will be installed at the bottom of each well to maintain pressures throughout the system; with VSD's to manage variations in geothermal system flow rates. Quotations from Schlumberger for this application were received. The wells and pumps will require periodic maintenance and total pumping power is around 75kW.

Cooling water supply: The water supply from the wastewater treatment plant will be supplied via a bypass from the plant's discharge systems (indicated in Figure 5) and a pressure reduction valve. The water will pass once through the generation plant condensers and be returned to the wastewater treatment plant. The supply temperature for the wastewater is between 18 and 20°C (winter and summer), and the chemistry appears to be satisfactory.

Civil works: The unit location is expected to provide relatively poor foundation conditions and is likely to require pre-loading and compaction before the concrete floor is poured on a hard fill pad to support the generation plant and the building in which it will be housed. Additional site works related to access have been allowed for in the assessments.

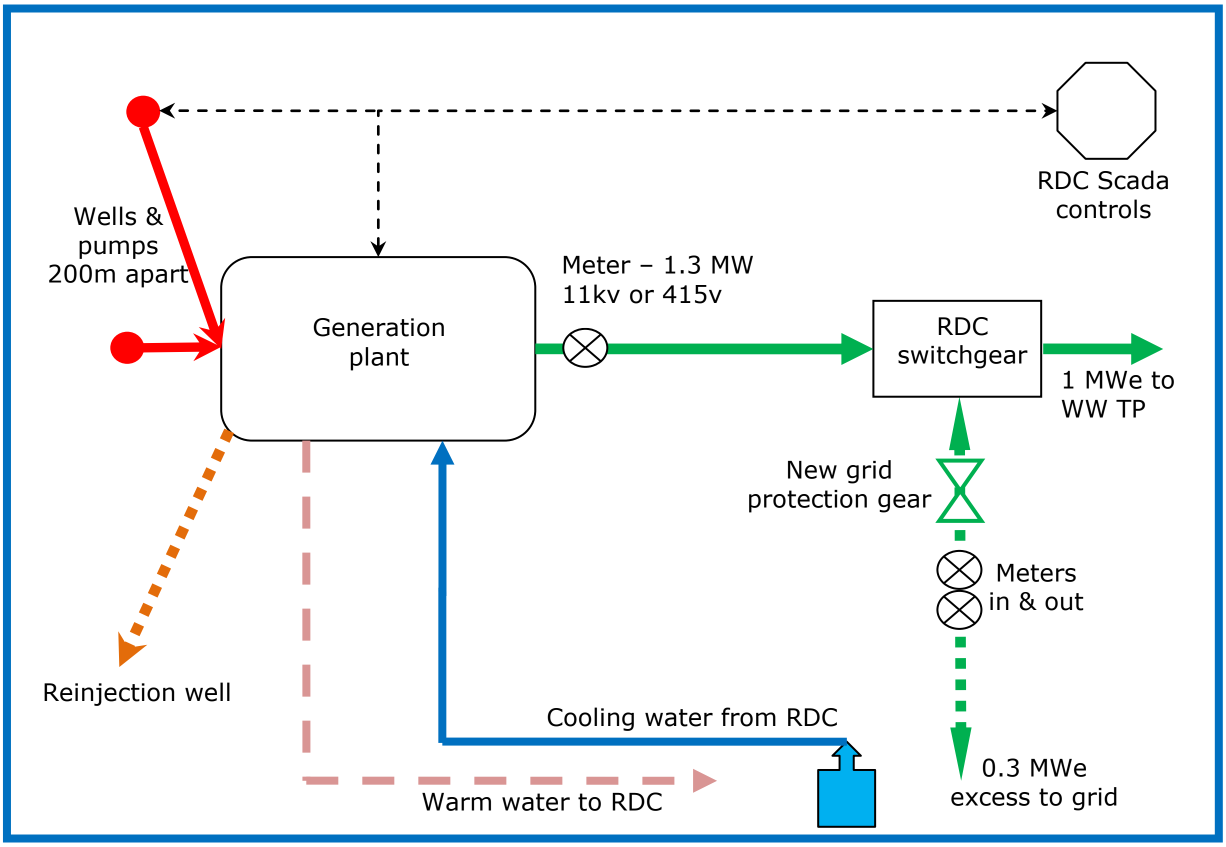


Figure 4: System schematic

The building: This is required to both protect the generation plant and also to attenuate the noise the unit produces. The building is expected to be of relatively simple/light construction with sound attenuation treatment to a specific design.

Balance of mechanical plant: This includes organic working fluid storage and transfer facilities, fire fighting facilities and interconnecting pipework.

Electrical, control and instrumentation: Includes site cabling, interconnection to the wastewater treatment plant's 11kV system, metering, cabling to the cooling water supply pumps and the well pumps and connection to the wastewater treatment plant control room and Scada for control and monitoring (Refer Figure 4).

8. Electricity sales and connection

8.1 Forecast wholesale electricity price path

Current electricity pricing

RDC have used a mix of contracts and hedges for securing power supply. Their current contract is a 1.3MW hedge at around $80/MWh which expires in 2011 with the remaining volume on spot. They advise that they will review before the expiry date whether to hedge again or risk remaining on spot.

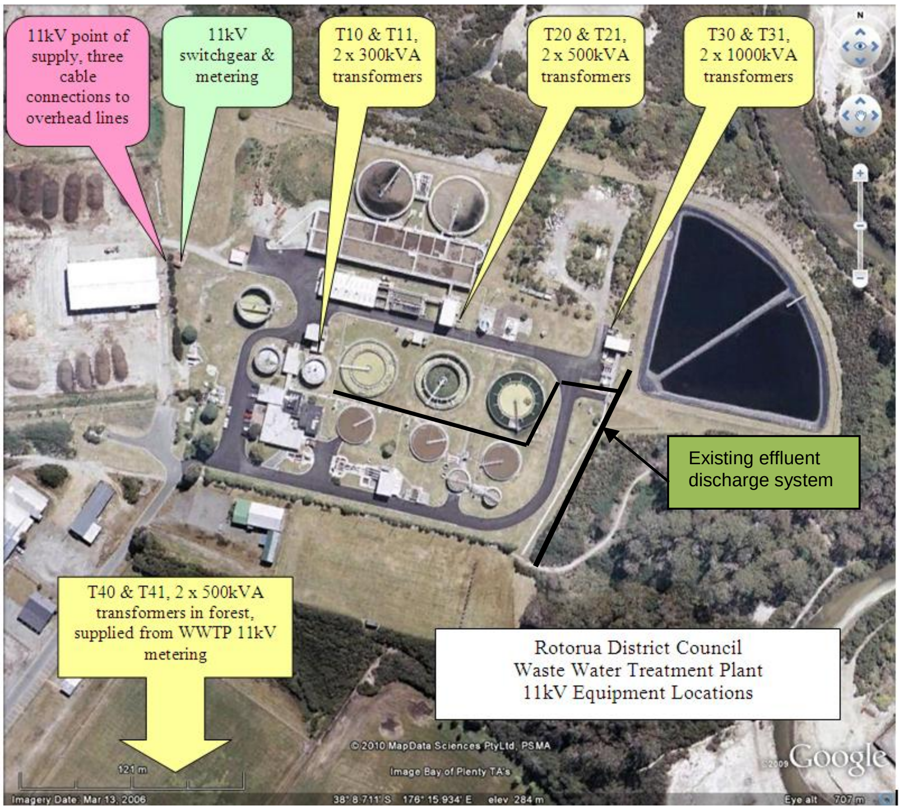
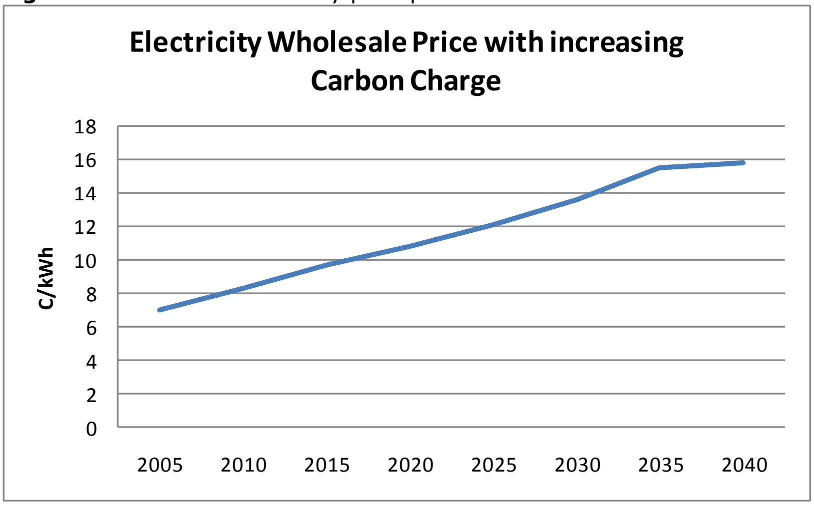


Figure 5: Site showing electricity and water connections and provisional facility location (need add mark-ups)

East Harbour's electricity price forecast (updated March 2010)

The electricity demand set out in the reference case of Energy Outlook 2009 has been modelled, including a 10% security margin, to give the price path shown in Figure 6, for wholesale electricity.

Figure 6: Wholesale electricity price path



Forecast electricity prices

The forecast price path correlates well with current (2010) prices (including that RDC is currently paying), which we expect to increase in line with the path shown; assisted by the impact of a carbon charge on thermal generation from mid 2010, unless the new ETS scheme is modified.

This path has been used in the project financial model as the basis for all electricity revenues.

8.2 Electricity sales and revenues

The generation plant is assumed to generate between 1,050 to 1,250kW, after deduction of all site parasitic power. This is base load and an assumed availability of 95% has been used in the modeling to give a total generation of between 8.5 and 10GWh per year.

Of this, an average of around 700kW is expected to be used in (sold to) the wastewater treatment plant with the balance sold on the market, under an arrangement yet to be considered.

8.3 Other potential revenues

Other potential revenue streams for the generation plant, which may be reflected in financial returns include:

- Heat sales. This has been previously discussed, but as initially offered the binary cycle plant has a pass out temperature of 30^{o}C which seems unlikely to be useful – this could be increased, but only at the cost of lost generation
- The sale of power to other RDC facilities on a basis that avoids at least a portion of normal lines charges
- Financial benefits to Unison/Transpower - reflecting any financial benefits from the presence of the embedded generation in their network can be identified and secured. An assessed figure approaching $100,000 pa has been included in the modeling reflecting the value of reducing peak loads
- Further savings which may be able to be negotiated with Unison in relation to lower system losses, increased network security and perhaps deferral of work or system upgrades; though such negotiations are challenging.
- The benefit to RDC of increased security of supply and potential elimination of need for diesel backup
- The benefit to RDC of the "green attributes" associated with this geothermal generation.

9. Operation and maintenance

The plant will be base-loaded, running at constant load unless there is some technical problem or if there is a local power outage when it can be run at lower load to provide power to the wastewater treatment plant. The generator is synchronous so can run in isolation from the grid.

A range of routine checks and maintenance activities will be required and these will be performed by wastewater treatment plant staff (or local contractors) with assistance as required from the manufacturer via remote monitoring. The generation plant Scada will monitor the power unit and fault condition alarms for the generation plant, well pumps and ancillary equipment, and is expected to be connected into the wastewater treatment plant Scada systems. It is envisaged that these services will be performed for an agreed fee under a Service Level Agreement.

Planned maintenance may be undertaken by wastewater treatment staff, or outside contractors, in accordance with the manufacturer's recommendations. Maintenance costings assume a higher figure than the rather low ones provided by Turboden. Planned maintenance is likely to require an annual shut and more major periodic refurbishments (every say five years) and initial commissioning and acceptance will be supervised by manufacturer's staff.

The geothermal systems, including pumps, will require periodic maintenance.

10. Financial assessment

A standard DCF model was used to calculate the project performance and returns, based on the following:

10.1 Financial assumptions

Expenditure phasing: We have assumed all capital expenditure occurs in 2011 and 2012, with revenues from 2012.

Discount rate: This has been taken as 11% nominal, being the rate discussed with the Trust during the Ohinemutu exercise. This is considered a typical rate for a utility investment (power companies for example use figures around this though are considered unlikely to invest in a project of this scale).

Exchange rate: We have assumed a rate of US$0.68 against the NZ dollar which is a little lower than current rates, with most purchasing to be carried out in 2011 or 2012.

Inflation: Taken as 3% for the project lifetime.

Project life: We have assumed a project life of 30 years, being a reasonable design life for such plant based on a resource that has an expected life that is essentially unlimited. We have allowed for regular pump replacement or refurbishment (an annual cost of $30,000) and assumed a significant refurbishment of the generation plant in year 20.

Carbon cost: Refer discussion re: electricity price path.

Contingency: We have allowed between 15% and 25% by expenditure category.

10.2 Capital costs

These are summarized below and have been based on the highest priced/most efficient offer received, Schlumberger's pricing for geothermal pumps and East Harbour's institutional knowledge and work on similar projects for the balance of the plant.

i.	Planning and consenting, (assuming no appeal process)	$200,000
ii.	Generation plant, cooling water supply, electrical, controls, siteworks and buildings	$5,950,000
iii.	Geothermal supply and reinjection systems including wells, pumps and distribution piping	$2,000,000
	Total capital	$8,150,000

The use of the lower cost plant reduces the capital cost by around $1.3.

10.3 Revenues

The revenues modeled comprise the electricity revenues referred to in Section 8.2 (initially around $900,000pa, and rising in line with the price path assumed) plus the benefit of peak-lopping referred to in 8.3 ($90,000 pa).

10.4 Operating costs

Plant operating costs have been based on East Harbour's experience, industry-standard costs, and the manufacturer's advice. A number of assumptions have been made with respect to the costs associated with the support to be provided by the wastewater treatment plant staff and a nominal figure for land-lease costs has been included in the financial model. In total a figure of around $200,000 pa for operation and maintenance costs has been allowed.

10.5 Financial outcomes

Modeled in accordance with the above assumptions, costs and revenues, the project at Ngapuna shows a nominal IRR of above 12% nominal, and an NPV of above $1.5m. Using the alternative machine, with its lower output and lower cost has a negligible effect on the return from the project as modeled.

A number of opportunities to both improve financial outcomes, and also potential to reduce returns. A sensitivity assessment shows that project's financial outcomes are most sensitive to capital cost increases and the electricity revenue path, though a 10% variance in either of these still leaves a satisfactory project return. If one well only is required the return improves by 0.5%, while an appeal to the environment court with respect to the resource consent (adding a cost assumed to be $200,000) has a negative 0.3% impact.

11. Risks and opportunities

The following risks and uncertainties are recorded; the key ones having been discussed in the text above:

- The long-term sustainability of the resource at satisfactory temperatures
- The potential for subsidence or hydrothermal eruption caused by extraction of fluids and consequential reservoir changes
- Impacts on the current usage of geothermal resources in the Ohinemutu and wider Rotorua area
- Inability to gain a resource consent for:
    - The geothermal fluid take
    - A development without closure of other bores in the area
- Chemicals composition in the fluids, and potential for deposition issues and corrosion
- "Normal" project related risks associated with capital and operating costs, exchange rates and electricity revenues (price path, contractual relationships)
- Risks around operational reliability and performance of the generation units
- Counterparty risks with respect to major equipment items
- A range of options for improving the economics of the project as discussed in Section 8 above.

12. Non-financial benefits

Non-financial benefits from the project include:

- Carbon emission reductions
- The "greening" of Rotorua with its attendant marketing benefits
- The potential availability of hot water for use in the wastewater treatment plant
- The added interest/attraction of the development for visitors and stakeholders
- The establishment of a leadership position in this technology in New Zealand
- A basis for further geothermal projects.

13. Commercial structures

The Trust and the RDC are working to form a joint venture company owned by their trading businesses under which they will develop and operate the project.

14. Development timescales

Given the prompt decision to proceed with the project, and a resource consent secured without significant issues or an appeal to the environment court (which could add indicatively a further 12-months to the timescale), the plant could be running in late 2012 as shown in Figure 12. The longest lead-time item is the generation plant at 12-14 months, as quoted by Turboden, which may be able to be reduced by negotiation.

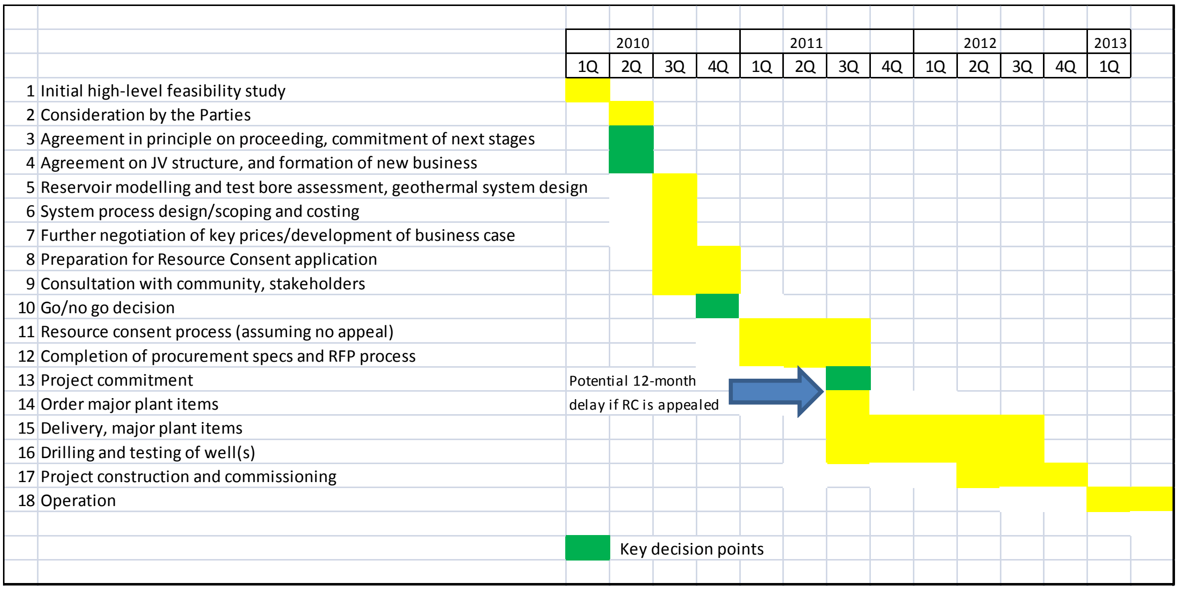


Figure 11: Indicative project development timescale

15. Next steps

The project economics are seen as satisfactory and the risks generally moderate (the major one being consenting). The next steps are seen as:

- Progressing the JV arrangement between the Parties
- Carrying out further geothermal resource modeling to ascertain potential impacts and mitigation measures, and to provide the scientific basis for geothermal system design
- Proceeding with the preparation of the resource consent application
- Further development of the system specifications and costings, and progressing system optimisation and plant selection
- Progressing discussions with electricity companies, in particular the network company.

16. Conclusion

On the basis of the assessment outlined in this feasibility study the Ngapuna geothermal project offers an economic geothermal development at relatively low risk for the Trust and the Regional Council as joint venture partners.

The scale is relatively small, driving higher system costs, but this is compensated for by the benefits associated with the location and linkages to the wastewater treatment plant. Overall economics appear to be satisfactory and the major risk seen is the ability to get a resource consent in the somewhat sensitive Rotorua environment.

It is therefore recommended that the project proceed through the next set of planning stages in accordance with the steps outlined above.