INTERNATIONAL SUMMER SCHOOL
on Direct Application of Geothermal Energy

Under the auspice of the
Division of Earth Sciences

The Ngawha Geothermal Project

Presenter: Roger de Bray, Chief Executive

Background

Top Energy is an Electricity Utility which traditionally was a pseudo Government agency, a "Power Board" which supplied electricity to a local geographic area. It bought electricity from the State owned National Grid which had been generated by State owned Generators.

The Government set out to reform the industry in 1990 and required a commercial style of ownership including the appointment of "commercial" rather than "elected" directors, be established by each Power Board.

In 1993 Top Energy was formed as a corporate entity. Today, Top Energy has a variety of activities which include :

- Ownership of a 4500 kilometre electricity network with a value of e40million
- A construction division servicing both on the Top Energy network and others which turns over e5million
- Ngawha 10 MW geothermal generator value e15million
- Business services operation which employs 40 people on three sites.

As part of the reform process Top Energy was prohibited from owning a generator or a retail business but has an exemption for the Ngawha generator.

The Company shares are held in Trust for the benefit of local consumers and dividends are paid to consumers annually.

History

The Bay of Islands Power Board was established in 1940 when the first connection to the National Grid was made. A local generating company had been producing hydro power in the area from 1920.

The establishment of a joint venture to develop Ngawha was established with local Maori interests in 1991.

While the land involved is in private ownership, there is a process in New Zealand law which protects the rights of indigenous people in all areas including those of natural resources and particularly where there is cultural use. In the case of Ngawha, the local natural springs have been used by Maori for their medicinal properties for hundreds of years.

Demographics

The Top Energy area is large geographically, with 8000 square kilometres . Population is relatively sparse with only 5 customers supplied from each kilometre of line and a total population of 55000.

The area has a poor economic base with a low household income by New Zealand standards and a high dependence on Government support in term of benefits. Unemployment is the highest in the country. A side product of this is the low energy consumption per household with most using fires and wood for heating. The area has no reticulated gas.

The economics of the area are supported by tourism, dairy farming and a growing volume of timber. There is no significant industry aside from those involved in processing this produce.

Total electrical consumption in the area is approximately 250 GWH annually with a peak load of 50MW.

Statement of Corporate Intent

This is the central document which defines the Companies activities and objectives. It is agreed between the Trust who owns the shares and the Directors who appoint management and govern the company.

The document has a number of points which influence the Ngawha project.

The Power Board, pre 1993, had a clear objective to provide good quality and reliability of electricity at lowest cost. When the Government reformed the Electricity Industry it prohibited network owners from selling electricity and this activity was taken over by a small number of larger national entities. As a result companies like Top Energy could no longer influence the price to the public. To deliver benefit to consumers the objectives were changed to maximising the returns as dividends.

To do this, an objective to maximise the benefits from the Ngawha investment was included and an overlay of objectives requiring a contribution to economic development and employment growth was added.

Included also was the requirement to distribute dividends to shareholders and we now do this annually.

Electricity Generation in New Zealand

The Ngawha project needs to be viewed with some understanding of the sources of Electricity generation in New Zealand.

The generation is dominated by hydro resources. This generation takes place in both North and South Islands of New Zealand which are connected by a high voltage direct current link. This is necessary because most of the electrical consumption takes place in the north while most of the hydro generation takes place in the south.

It is also notable that the dominant hydro resources do not have big storage relative to other hydro systems like Canada. Storage in New Zealand is about 6 to 8 months duration.

Other generation is combined cycle gas and some geothermal. Because price is relatively low in international terms it is difficult to establish economically viable alternatives to hydro and there is not a great amount of new investment in generation. Market prices are on average e0.025 per kilowatt hour.

Ngawha Geothermal Resource

The Ngawha Geothermal field is situated in the Far North of New Zealand and is not widely known outside the geothermal industry. It covers an area of some 25 square kilometres and is unusual in that it has an impervious rock cap approximately 500 meters thick which means there are few surface features.

The Government decided to explore the field in the 1980s and drilled 13 exploration wells on private land in the area. As a result of this, a 100MW station was planned and proposed. In 1987 the Government decided not to proceed and withdrew from the area.

It is interesting that this project did not propose reinjection of fluid and was of a scale which we now know would have significantly impacted the resource within 10 years.

There are a number of ways of estimating heat content of geothermal resources and these vary significantly. We estimate a heat content of approximately 4000PJ of heat contained in the resource. With extraction being possible of some 25% of this, the heat value would approximate e2billion.

The heat flows into the resource from the core of the earth have been modelled at Ngawha and this gives rise to top limit of sustainability of 25 MW.

Geothermal Field Characteristics

The Ngawha field is not typical for New Zealand. It has lower enthalpy and does not have the high steam content of most New Zealand resources.

The geothermal resources produce a mixture of steam, gas and geothermal fluid at approximately 200 degrees celsius and 22 bars. Steam proportion is only 10% by weight. Approximately 1.2% of the mass is non condensable gas, mainly carbon dioxide and some hydrogen sulphide.

The fluid in common with many geothermal fields has a high chemical content. However in the Ngawha case this includes Boron, present as a sulphate. This compound is an effective herbicide and as such no fluid can be discharged to the watershed. As the field is at the head of a river system which supplies both irrigation and drinking water to the east coast of the area, this results in a tightly controlled 100% reinjection process with close environmental monitoring by local government agencies.

Revenues and Costs

The slide shows a breakdown of the capital costs for the 10MW net binary plant installed at Ngawha. The costs do not include the purchase of approximately 500 hectares of farmland above the resource. This purchase was made on the basis of securing the future access to the resource.

The steamfield development involves the use of two production wells and two reinjection wells.

There were no new wells drilled. The wells drilled by the Government were acquired with some difficulty together with the land in which they were drilled.

The project would not have been viable if the wells were not available as this would have added some e4million to the cost with the attendant risks of not striking the required production zones.

The average revenue for electricity in New Zealand is currently e0.025 per kilowatt hour. The plant operates 24 hours with availability's of 95% to 97%.

Output with fine tuning has reached 110% of specified manufacturers output.

Costs are those projected for the 2002 year and are in line with prior years experience. We are depreciating the plant over 25 years.

To give some idea of returns we have quoted a profit as earnings before interest and tax. This avoids the influences of shareholder investment and funding costs in getting an understanding of the returns. The returns shown are in fact marginal as a justification for investment and the decision was made on the basis of the future expansion prospects of the project.

Binary Plant Process

The Binary Plant process is generally well understood by the Geothermal Industry. It is typically used on lower quality resources particularly where there is not significant steam available to drive conventional turbines or after the fluid is spent of high quality steam.

At Ngawha, a mixture of fluid steam and gas is taken from two production wells at a rate of 10000 tonnes per day. The steam is separated from the fluid for transmission to the plant and then both are put through a series of heat exchangers which transfer the heat to a fluid used in the turbines, isopentane. This fluid is selected for the temperature and pressure characteristics which allow for most efficient heat transfer. From the heat exchangers the spent fluid travels in a pipeline for about 3 kilometres before being reinjected into the resource.

The isopentane at high temperature and pressure, passes through turbines of a normal configuration. One high pressure and one low pressure turbine is mounted at either end of a conventional electrical generator.

The spent isopentane is then cooled in air condensers prior to being recycled through the process.

Build Programme

The programme seems very long and in part this is due to the difficulties in getting the consents and satisfying the legal requirements. The process of dealing with both Maori and private interests was very slow.

In 1993 Top Energy applied for consent under the Resource Management Act to build the plant. This act is a complicated piece of legislation designed for environmental protection. In addition we were the subject of a claim for ownership by the Maori (indigenous) interests on the basis of their long cultural use of the resource. It is notable that this consent process cost approximately e300000.

It took two years to acquire both land containing the wells and to deal with the Governments claims to ownership of the wells and the information relevant to them.

In 1996 a programme of monitoring was commenced which was required by the consents granted and provided a baseline against which to measure any future changes. This continues today and is comprehensive with a cost of approximately e100000 annually.

The process of build and test for the plant was completed in 6 months following delivery, and production commenced mid 1998.

Cost Influences

The revenues and costs of the project were influenced by a number of factors:

1. The position of the generator at the end of the grid furthest from existing generation provided a cost advantage due to the reduction of transmission losses. This increased generator revenue by approximately 7%.
2. The exploration and well drilling risk had been largely offset by using existing wells.
3. Top Energy had a local commitment to maximise the use of local resources for the economic benefit of its owners.
4. Top Energy had the balance sheet strength to build the plant without external funding. External project funding would have been expensive both due to the risk and the evidential requirements of funders.
5. With land ownership and local government relationships we could assume sole field use rather than competitive exploitation.
6. The supply point for the Top Energy network was close to the generation point which reduced connection costs.

Background to the Decision

While the decision was economically marginal, it has been noted other influences were taken into account. These mainly were relative to the potential shortages in electricity availability.

The reliance nationally on hydro generation with low storage levels.

There has been a history in recent years of electricity shortages in years when weather has been dryer than usual. These took place in 1991 and 2001.

The national supply of inexpensive natural gas is predicted to run out in 2007 with resulting increases in generation costs.

The climate has been changing with impacts on rainfall and temperature. Cooling water has restricted thermal generation in summer and rainfall has been unpredictable.

The National Grid has capacity constraints where it crosses Auckland City and the volume of power available off the Grid can potentially be restricted in the longer term.

Project Expansion Potential

Modeling

The marginal nature of the current project was known from its beginning. One reason for making the investment was the belief that economics would improve with further expansion.

The initial step in evaluating expansion is an improved understanding of the geothermal field based on a period of use. Ngawha had not been tested under load to any degree. Accordingly, a full geothermal reservoir model was prepared and the performance of this model against actual results for the changes made by exploitation has been checked. As a point has now been reached where the actual performance is very close to that shown by the model, a projection into the future can be made. These projections show that the field will sustain a plant of 25MW indefinitely.

The modeling however also shows changes in well performance taking place due to changes in chemistry. These changes need to be clearly understood to evaluate any future well drilling programme and to decide how the field may be planned.

Cost Implications

Also included in any future evaluation are the financial variables that with drive the economic results.

The price of electricity will determine the revenue. This in the New Zealand environment where there is a competitive market with a relatively small number of participants is difficult to quantify. We do know prices are rising and expect this to be a continuing trend.

The plant purchase for expansion will be predominantly in $US. When we built stage one, this rate against the $NZ was 0.67. Today it is 0.48 and has been as low as 0.40. At these prices the plant capital cost will be unsustainable. Our evaluation shows that expansion cannot be considered unless electricity prices rise to e0.03 and the NZ$ to 0.6US$.

Secondary Heat Use

The use of geothermal resources is more efficient if direct heat can be used rather than generating electricity. There are a number of issues which determine the use of heat remaining after generation. This heat is in two forms.

- Fluid after the heat exchangers

There are two constraints which influence this heat.

The tonnage of fluid which can be taken is restricted to 10000 tonnes per day. This total amount must be returned to the resource by reinjection. This reduces the potential to divert spent fluid which at this point is 100 degrees Celsius.

The chemical composition has two effects. The first is the presence of Boron which makes the fluid toxic to vegetation and animals. Fluid cannot be discharged to the watershed. Secondly the presence of silica in the fluid restricts the temperature at which fluid must be reinjected to about 97 degrees. Any lower temperature results in the deposition of silica in the reinjection wells and will reduce their capacity over time to accept the fluid.

- Condenser air

Very substantial quantities of warm air are discharged from the top of the air condensers. However the temperature is only about 40 degrees and velocity about 8 metres per second. The uses to which this can be put are very limited.

Chemical Extraction

The problems of the chemical content being the issue of deposition and toxicity have already been covered.

- Opportunities for extraction

Boron is used for a variety of preservative products. A typical example is the use of boric salts in timber treatment. Calculations have shown that Ngawha is the fourth largest boron deposit in the world and values warrant extraction. However, extraction is traditionally by evaporation which is not an environmentally acceptable process in New Zealand. The resulting fluid at ambient temperature represents a reinjection problem.

Silicates are the basis of the reinjection deposition problem. They can be extracted with attendant lowering of the reinjection temperature. They do not have a ready market and are of low value. The most likely commercial opportunity would be to extract both silica and boron in a combined process.

Carbon dioxide is released from the resource. This has a potential negative impact with

New Zealand's intent to ratify the Kyoto protocol for green house gas emissions and tax such emissions. Carbon Dioxide is also a medium used to improve plant growth and used jointly with low grade heat in a hot house project has potential.

Rare elements exist in the fluid but not in quantities to make extraction viable.

Risks and Management

Geothermal Risk

Geothermal risk is probably the most significant. Information particularly in an undeveloped field is not precise and based on estimates and extrapolation.

Sustainability is difficult to establish with reasonable certainty. It is interesting that prior to exploitation Ngawha had been the subject of extensive study by geothermal scientists. Projections led to plans for a 100MW power station. Today with estimates based on four year use at a modest level of extraction has resulted in a well substantiated estimate of 25MW. The error of 400% is enough to destroy the economics of any project. The message is err on the side of conservatism.

Chemistry can be researched quite definitively but despite this at Ngawha we have had significant unforecasted problems relating to chemistry of the geothermal fluid. We have overcome these by chemical treatment and innovative cleaning processes

Well performance is difficult to predict. If new wells are to be drilled there is substantial risk that even with the best information, well performance will fall short of expectation or worst not produce resource. With existing wells they can perform differently under long term load from predicted results. Lack of production results in a need to drill new wells at a million euro each. Again the message must be to estimate conservatively giving room for less than expected output without destroying project economics.

Build Risk

This is in theory at least a much more controllable and predictable risk but action is required to exert the control.

Delivery will need definition and late delivery will impact the start of revenue streams. The cost of delay can be calculated and at least part should be passed to suppliers who do not meet deliveries.

Contract risk exists in my view mainly because the owner does not insist on complete definition of what he is buying and the performance he expects. Define all aspects and control deviations from specification firmly. Experienced project management is vital and its costs will be repaid several times over.

Cost risk relates to variation of actual costs from those used to evaluate and justify a project. Risks should be managed and controlled. Allow adequate contingencies and control their use. Pass on risks like currency. We justified Ngawha on a $US exchange to $NZ of 0.68. At the point of ordering the plant we bought the currency. At the time of delivery the exchange rate had dropped to 0.57. The potential increase in cost was several million dollars. Currency speculation is not our business. Variations are always a problem and must be controlled or they can inflate costs dramatically.

Financial Risk

The viability of any project in a financial sense is a matter of defining and control of revenue and costs at every stage. Small variations in each area can add up to a significant over all variation in returns to owners.

Political and Social Risk

These issues vary from country to country. In our case as an Electricity Utility, we are a logical target for political interference and control. We are after all a monopoly in our core activity. Projects have a definite environment risk. Local authorities will take an interest and attempt to control activities and minimise any perceived or actual environmental risk.

Thank you and good luck with your projects.