THE NAGQU, TIBET, BINARY GEOTHERMAL POWER PLANT, AT 4500 METRES ABOVE SEA LEVEL

GUSTAVO CUELLAR
United Nations/DTCD, New York

WU FANGZHI
Geothermal Development Company of Tibet Autonomous Region, Beijing, China

DANIEL ROSING
Ormat Inc., Sparks, Nevada, USA

SUMMARY

Nagqu town, known as the gateway to northern Xizang (Tibet), with a population of 15,000, has a serious requirement for electric power, which at present is being supplied by small diesel generators.

The existence of a geothermal reservoir close to Nagqu town led the Xizang authorities to carry out exploratory drilling in the area. It was found that the local geothermal resource is reliable and wellbore ZK 1303 was already put into use for heating purposes in Nagqu township in 1985.

The United Nations, through its Department of Technical Cooperation for Development, within its programme for developing Geothermal Resources in Tibet, in 1990 allocated funds for the acquisition of a 1 MW capacity binary cycle power plant, to be erected in Nagqu in conjunction with the government of the PRC.

The Ormat 1 MW air cooled binary power plant module which was then purchased, Will utilize geothermal hot water at a temperature of 110°C to generate electricity in one of the highest power stations in the world. It is planned to be operational in June/July 1992.

The power plant design had to be adapted to the special conditions of the site - i.e. high altitude, low temperature, remoteness of the site and long overland transportation. The thin air at the site similarly affected the size of the air cooled condenser and difficult working conditions on the site through long periods of the year required special planning.

The Nagqu geothermal resource is typical of those in Tibet. It is hoped that the erection of this 1 MW binary cycle power plant in Nagqu will lead to further development of the geothermal resources in Tibet.

1. INTRODUCTION

Nagqu Prefecture s located in the North Tibet Plateau at an average altitude of above 4500 m above sea level; it has a total area of 400,000 km^2 and a population of 200,000. This means that population density is less than 1 person per square kilometer. The administrative office of this prefecture is set up in Nagqu town which is a political, cultural, economic and traffic center of the North Tibet Plateau. Close by the Qinghai-Xizang highway and petroleum pipeline, Nagqu town has made much progress during the last years. Its permanent inhabitants have increased up to about 20,000. This town begins to take shape, in which two elementary, one middle and one pedagogical and a nurse's school have been established, animal husbandry, handicraft and the country fair trade have developed also in some extent. Nevertheless, the problem in the local energy enterprise still remains unsolved, due to the past socio-historical and natural factors. There are only 10 diesel generators with a total nominal capacity of 1.68 MW. The electricity from these units can only satisfy the lighting needs of the local organization and some inhabitants, lasting only 4 to 5 hours every night due to high production cost. The others have to light their houses with candles or buttered lamps. This shortage seriously restricts the further progress in local economy. For this reason, the energy problem in Nagqu must be solved as a strategical one, and the Government of Xizang Autonomous Region has invested RMB 6 millions for Nagqu's geothermal exploration and drilling. This has yielded some positive results. Recently the UNDP provided financial support the construction of a 1 MW geothermal binary-cycle demonstration unit in Nagqu town, which is greatly welcomed by the local inhabitants. We hope the combined investments from UN and Chinese Government may reap rich fruits.

The United Nations, through its Department of Technical Cooperation for Development (UN/DTCD) as Executing

Agency for technical cooperation projects in developing countries, has been involved in supporting geothermal activities in PRC since 1982, considering its enormous geothermal potential for power generation and for a wide spectrum of direct industrial applications.

According to the government request to install 1 MW capacity binary cycle power plants in Nagqu, based on the critical electricity shortage as well as the preliminary resource information available, DTCD did select and purchased the most appropriateand technologically advanced equipment through an international competitive bidding. The power plant is in process of manufacture and its operation is scheduled to start June/July 1992.

The site is being prepared by the Chinese Government who will also be responsible for the power plant erection and whose experts will undergo training in operation and maintenance.

Additional expertise is being provided to further strengthen the Government experts' self-reliance in the field of resource utilization by means of on-the-job and overseas training and providing the appropriate high technology equipment.

2. PREPARATORY WORK

In order to prepare for the construction of the 1 MW power plant, the Chinese government, with the help of experts provided by the UN, performed the following preparatory work and reached the following conclusions:

- The local geothermal resource is reliable. A total of 18 drilled holes have now been completed in Nagqu town by the Geothermogeological Brigade of Xizang Bureau of Geology Mineral Resources. These boreholes cover an area of about 10.1 km^2. Four wellbores (ZK 1005, 1004, 1203 and 1303) may be used for test production. These wells were completed with a diameter of 9-5/8", and all discharged about 200 t/h; the measured maximum temperature was 115.8°C, while the wellhead temperature was 110-113"C. The total flow from these four wells during discharge testing was measured as 1051 t/h. Based on a preliminary calculation of the potential power generation, a total of 3-4 MWe might be installed, if the binary cycle units were adopted.

- The geothermal reservoir has good potential for exploitation. The wellbore ZK 1303 was put into heating use since September 1985. The heating period in Nagqu town lasts as long as 9 months every year, and the average flow from ZK 1303 was 120-150 t/h, and its temperature, pressure and discharging flow remained basically unchanged, while the multi-well discharging test was carried out in 1988. The pressure in ZK 1303 recovered rapidly (only 7 months), although this test lasted as long as 6 days. This characteristic was confirmed by some Aquater experts during their investigation on site in 1989. The Chinese and Italian experts were of the same view that the pressure of the fluid within the drillhole might recover rapidly so long as drillholes were located in the upwelling pathway of the deep fluid.

- An ideal cooling condition exists in Nagqu. For example, the multi-annual mean air temperature is -1.9°C, the extreme maximum air temperature was 22.6°C (on July 15, 1972), while the minimum was -41.2°C (on January 16, 1968). According to the calculations of the Chinese and American experts, the specific consumption of hot water may be 0.25 t/kWh, if the air cooling system were adopted. This advantage may be greater in a cold winter.

- The partial environmental change may not exert significant impact to human activity, because the Nagqu Prefecture is vast in territory and sparsely populated. Furthermore, the geothermal field to be developed is located just within a saline-alkali depression, with a capacity of about 3.4 x 10^7 m^3. This figure means that this depression might be all filled only after 15 years, if the hot effluent were 250 t/h. The evaporation and seepage have not been taken into account in this rough estimation. In fact, the local annual evaporation loss was as high as 1800 mm. The future project activites will involve the evaluation of waste waters reinjection, to minimize the environmental concerns and optimize reservoir behaviour.

- The power generation unit is relatively compact and easy to move. The main equipment of this unit may be assembled with two standard containers. This unit could easily be removed to another geothermal field (for example, Yangbajain or Yangyi), whenever the resources of Nagqu were unfavorable or the production wells were affected by accident or failure.

- The Nagqu geothermal power generation unit has considerable demonstration significance. Several tens of geothermal fields with the same or similar dimensions and parameters as Nagqu occur in the Tibet plateau. It is expected, on the one hand that the selection of the Nagqu geofield may reduce the local shortage of energy source; on the other hand, this may spread Nagqu's experience over other areas covered by the regional electrical networks. Thus, it is worth putting some human and material resources on the construction of the Nagqu geopower plant.

The geothermal resources in Tibet have undergone extensive analyses by the Chinese government, with the help of leading experts from Iceland, Italy and the USA.

The Chinese govemment and related departments of the Tibet Autonomous Region began a series of explorations into geothermal energy in the area in the early 1980's.

3. THE POWER PLANT

In December 1990 a binary cycle power plant rated at 1 MW was ordered by the United Nations, and is due to be shipped to China in December 1991.

The UN Department of Technical Cooperation for Development (DTCD), after extensive surveys with the Government of China, issued specifications for the power plant to be provided, taking account of the special site conditions. These detailed specifications for all items of the equipment to be provided and ensuring the supply of adequate engineering and training services for the end user, were then issued through the UN's international competitive bidding process before the supplier was chosen.

Taking into account the conclusions shown above, in item 2, Preparatory Work, and the results of the surveys, all of which were reflected in DTCD's technical specifications, the Nagqu power plant has been designed for the design point parameters shown in Fig. 1, i.e. an average air temperature of -1.9°C and a flow of geothermal hot water at 110°C, with a flow rate of 300 tons per hour.

In view of the environmental conditions and the fact that the Nagqu river remains frozen for several months of the year, it was decided that the power plant should be air cooled.

The special site conditions mentioned below affected all stages of the design. The mechanical equipment on the vaporizer and all joints and attachment points required the use of special materials capable of withstanding the extremely low temperatures. These factors also had to be taken into account in the design of the condenser fans and motors.

All of the electrical and control equipment was designed and chosen to operate at the extreme temperature conditions and the high altitude at the site. Among others, these factors also dictated the conditions at which the electrical equipment is to operate.

In order to maximize quality control and to minimize work at the site, the power plant will be tested in the factory prior to shipment and is expected to arrive at the Nagqu site in April 1992. By that time erection and commissioning will be easier to perform as the environmental conditions will allow the work to progress more easily.

Figure 2 below shows a perspective view of a 1 MW air cooled station layout.

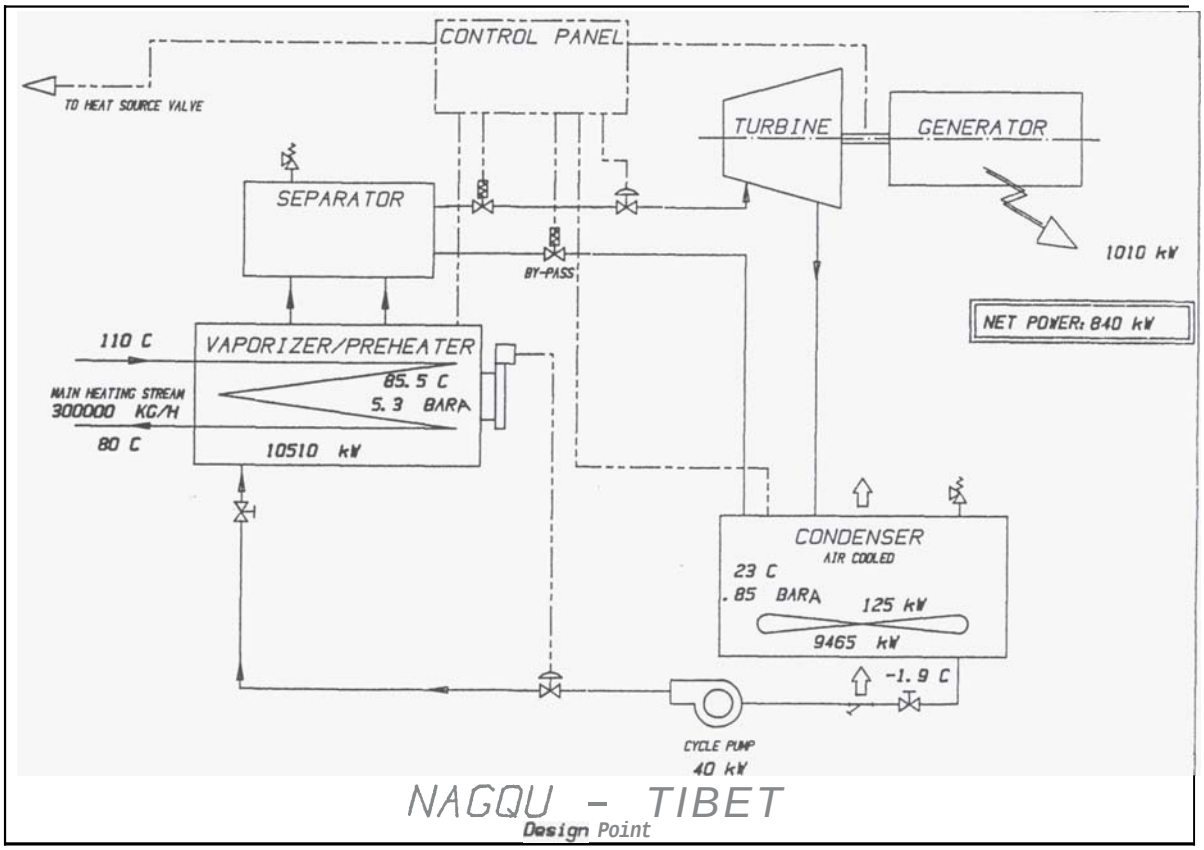

Figure 1- Nagqu Geothermal Power Plant - Heat Balance Diagram

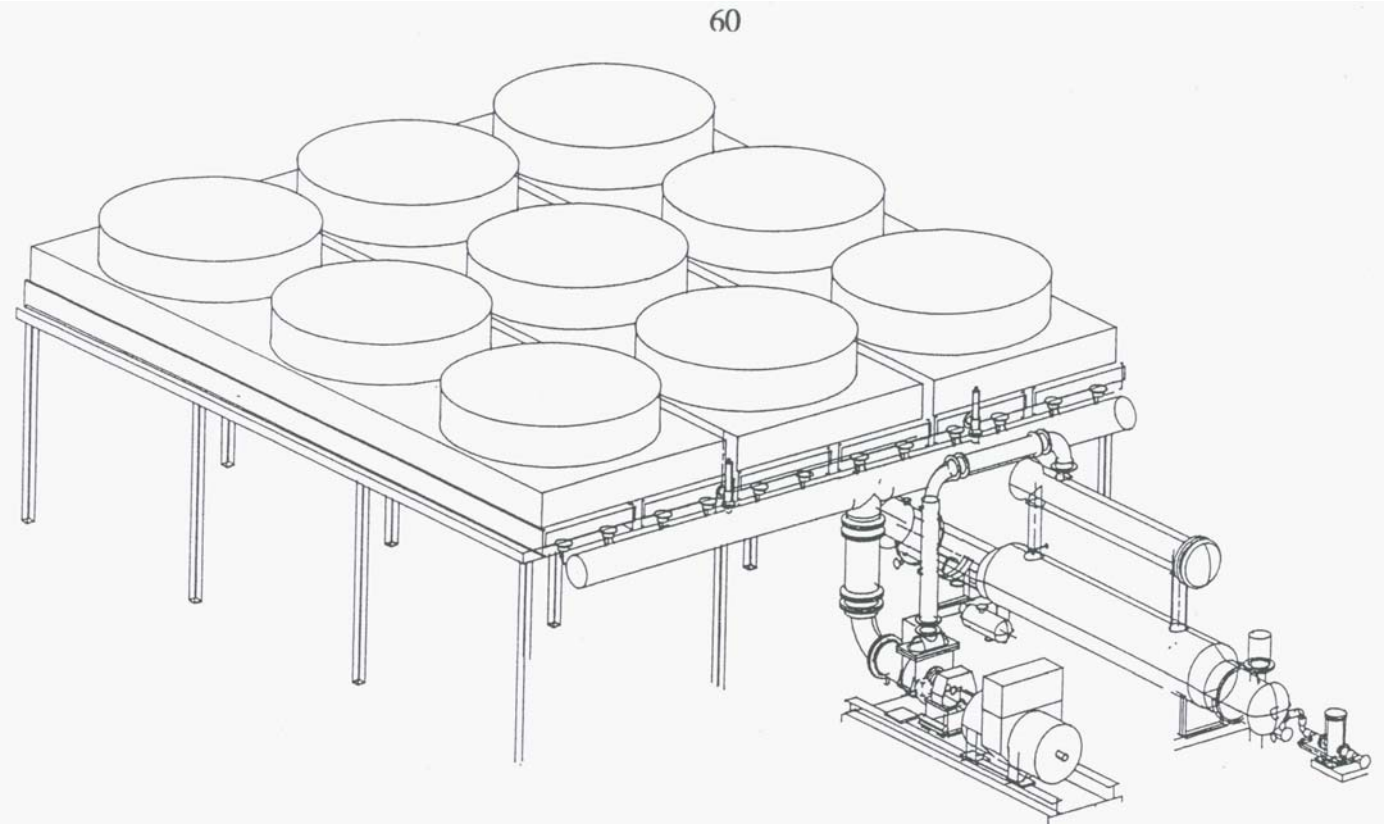

Figure 2- Air Cooled 1 MW OEC Power Plant Layout

4. SPECIAL CONDITIONS

As described above, because of the high altitude and the temperatures the equipment will have to withstand, the electrical and control equipment and the mechanical equipment had to be specially designed and chosen, keeping in mind the rigorous environmental conditions at all times.

The air-cooled condenser had to be sized and especially adapted for the thin air at the site and will be double the size of the condenser for a similar power plant which was erected in Kawerau, New Zealand. (A photograph of this power plant is shown in Fig. 3).

The long overland transportation of the equipment from the port of arrival in China also called for special design of the equipment packaging for overland transport.

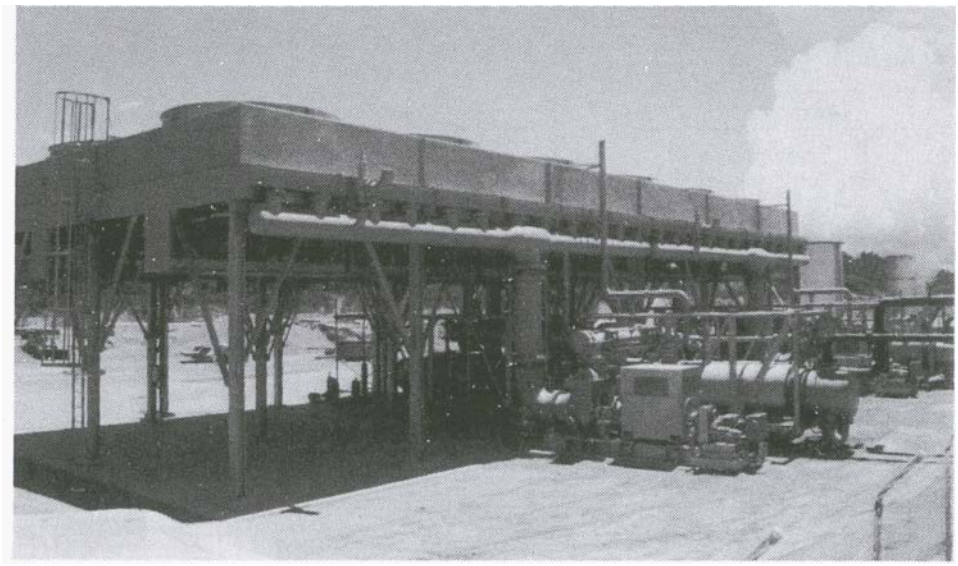

Figure 3- Tarawera Ormat Installation - TOI, Kawerau, New Zealand, operated by by Bay of Plenty Electricity

5. CONCLUSIONS

The nature of the geothermal resources in Tibet indicate that the modular binary cycle power plant is the most suitable form of power generation from these resources in Tibet.

The Nagqu power plant will supply the minimal electric power needs of Nagqu township, but could also be an example for the generation of electricity in other locations in Tibet.

After taking into account all of the special site conditions and with the good cooperation between the UN, the Chinese project management team and Ormat, it is envisaged that the binary power plant will supply reliable power to Nagqu town on schedule. Also, with the geothermal potential that exists in Tibet this power station could be the first in a series of geothermal-based binary power plants in the region and will promote local economic development, using an indigenous resource.

6. REFERENCES

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Note

This paper represents the opinions of the authors and not necessarily those of the organizations they represent.