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OUTLINE OF MAHANAGDONG GEOTHERMAL POWER PROJECT

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ABSTRACT

Introduced here is the Mahanagdong Geothermal Power Project (3 x 60MW) in Leyte island of the Philippines which is one of the latest geothermal project and consists of Toshiba's three sets of steam turbine, generator and its auxiliaries.

The Mahanagdong Geothermal Power Project started in 1993 as a contract between PNOC-EDC (Philippine National Oil Company-Energy Development Corporation) and CECI (California Energy Company Inc.), and Toshiba joined to this project in 1994 as a turbine and generator supplier.
The special feature of this project is that this is the first BOT (Built, Operate & Transfer) contract for the geothermal power project in the world. The construction period of the project up to start of commercial operation for 3 units was 32.5 months, while the turbine and generator of the first unit was CIF in 16 months.

The Mahanagdong Geothermal Power Plant (containing three 60MW turbine & generator sets, total 180MW rated output plant) consists of two sites, i.e. Site A (2 x 60MW) and Site B (1 x 60MW).
This plant had achieved its rated output successfully in August 1997 at first, and now, electricity produced are mainly supplied to Luzon island and Cebu island via submarine cable.

1. INTRODUCTION

Recently, in Asian region, electrical demand has increased notably with its economic development, and the development of geothermal power in the Philippines is also prosperous.
Toshiba has been one of capable geothermal power plant supplier in the world, and their turbine, generator and other equipment are operating satisfactory not only in Japan, but also in USA, Mexico, the Philippines, Costa Rica etc. for many years. One example of Toshiba's remarkable supply experience in geothermal power station began at Geysers Power Station in USA. Toshiba supplied total 13 units of geothermal turbines & generators which include 7 units of the world largest unit capacity as 110,000kW ~ 124,000kW.
Based on these successful experiences, we, Toshiba always make best effort to supply economical and reliable units. The Mahanagdong Geothermal Power Project (3 x 60MW) located in Mahanagdong region of Leyte island of the Philippines which is one of the latest geothermal power project which consists of Toshiba's three sets of condensing geothermal steam turbine, generator and its auxiliaries.

2. APPROACH TO THE MAHANAGDONG GEOTHERMAL POWER PLANT

It takes one hour by airplane from Manila to Tacloban where is the largest city in Leyte island. This city is reminded as memorial place of miserable battles in the World War II. From this city it takes 2 hours by car to Ormoc City. This city is located close to the seacoast of the west side of Leyte island. Today's Ormoc City has lively, vivid and nice atmosphere surrounding by calm wind and palm trees. The power station is located in the mountain hillside of Tongonan region surrounding luxuriant tropical trees. The site is 23 km north from Ormoc city, and it takes 40 minutes by 4-wheel-drive car.

The Mahanagdong Geothermal Power Project started in 1993 as a BOT contract for 10 years between PNOC-EDC and CECI. PNOC-EDC developed this area from around 1990 for geothermal power resource and power plant, and is serving geothermal steam now. PNOC-EDC is purchasing electricity from several BOT contractors including CECI, and selling to National Power Corporation (NPC). BOT biddings of several geothermal power projects in Tongonan region were executed in 1993, and CECI was awarded for the Mahanagdong project. Toshiba joined to this project in 1994 as a turbine and generator supplier to CECI through Marubeni Corporation.

"BOT business" becomes well known wording recently. BOT business would become one kind of solution recently for developing industrial fundamentals or infrastructure quickly by pouring private capital. This Mahanagdong project is the first geothermal power project by BOT style business in the world.

The one of the key factor in proceeding BOT project smoothly is to care environmental affection. Namely, it is necessary to execute environmental assessment carefully and sufficiently, to take care of environmental measures for the surrounding circumstance, and to get public understanding about the regional environmental affection and measure. The Mahanagdong Project was well measured to the surrounding environment, got approval from the authority, and successfully passed various site tests regarding all environmental limitations.

The supply contract of turbine & generator was executed between the owner and Toshiba through international bidding procedure. We felt that this supply contract in BOT project seems to have relatively severe contractual conditions for supplier about technical requirement and commercial requirement such as delivery schedule and warranty condition rather than conditions in contract with power utility generally. We understood that generally such severe conditions might be one of the characteristics which is inherent in BOT projects.

3. FEATURES OF THE MAHANAGDONG GEOTHERMAL POWER PLANT

The Mahanagdong Geothermal Power Plant contains three sets of 60MW turbine & generator, total 180MW rated output plant, and consists of two sites, i.e. Site A (2 x 60MW) and Site B (1 x 60MW) which are located in approximate 5 km each other.
This plant has achieved its rated output successfully in August 1997 at first, and now, electricity produced are mainly supplied to Luzon island and Cebu island via submarine cable.

This plant was designed based on the following design conditions:

- Feature of steam to turbine:
  - Non-condensable gas contents in the steam to the turbine: Maximum 3.8 %wt in total (CO_2 98.16%, H_2S 1.56%, NH_3 0.27%)
  - Wetness in the steam to the turbine: Maximum 1.0 %
  - Geothermal steam wells were produced separately per site

This plant mainly consists of the following facilities and feature:

- Geothermal steam turbine (Toshiba):
  Single flush, single casing, double flow, condensing turbine, rated output of 60 MW (Maximum 66 MW), 540kPa(abs), 156.3degC, 3600 rpm, total 3 units
- Generator (Toshiba):
  Totally enclosed water to air cooled generator, rated capacity of 77.7 MVA, rated power factor 0.85, 13.8kV, 60Hz, brushless excitation, total 3 units
- Condenser:
  Bottom exhaust, indirect cooled tube type, one unit (*1)
- Non-condensable gas exhaust facility:
  Rotary vacuum pump 5 units, and steam jet air ejector 3 stages (for supplemental use) (*1)
- Cooling tower in the circulating water:
  Wet, fan induced cell type, longitudinal arrangement, wood casing, counter flow, splash fill, 7 cells (*1), 386m3/min (*1)
- Hot well circulating water pump:
  Vertical type, 3 sets (*1)

- Plant control:
  DCS control, each facility for Site A and Site B
- Steam piping line: Diffuser, Silencer, Steam purifier
- Electrical facility:
  Transformer, Diesel generator (for start-up use), SWGR, etc.
- Substation: Conventional type substation, 230 kV

- Turbine / generator auxiliaries (Toshiba):
  -Low pressure digital EHC (Electric hydraulic controller), AVR (Auto voltage regulator), SA (Surge absorber)
  - Main steam valve of poppet type with 1.02 m (40 inch) diameter at the inlet, 1 valve for one turbine
  - Governing control valve, Main oil tank, Oil purifier, Gland steam condenser & exhauster, piping & valves, etc.

  * 1) quantity associated with each one turbine

The plant flow description is briefly as follows; The geothermal steam produced in wells throws in-line-diffusers, steam vent silencers, steam purifier, then goes to turbine. The exhausted steam from turbine goes to tube-type indirect contact condenser. The condensate water is pumped-up by condensate pump, and [1)]goes to cooling tower for make-up of circulating water, and [2)]partially goes to blow down as pumped-up by condensate booster pumps and blow down pumps. The blow down water goes to re injection well. The circulating water between condenser and cooling tower is always pumped-up by cooling water pumps, and over flow water from cooling tower water basin is replaced to condensate make-up water from condenser. The non condensable gas is exhausted from condenser by vacuum

pump and/or steam jet air ejector, and goes to cooling tower to distribute to the at mosphere safely.

4.CONSTRUCTION SCHEDULE

Key construction schedule was as follows:

-BOT contract 1993
-Start of construction October 1994
-Start of installation of mechanical components
Nov.1995, Jan.1996 & March 1996
-Start of commercial operation
August 1997
-Completion of performance test
June 1998

The turbines and generators were designed, manufactured and tested at Toshiba factory in Yokohama, Japan, and shipped to Ormoc port in Leyte Island. After landed, the turbines and generators were transported by trailer slowly on the curved mountain road of 23 km. The turbine & generator on-base and erection was smoothly proceeded and executed mostly on-schedule. The construction at site was done mostly on-schedule.

5.COMMISSIONING

In August 1997, rated output was achieved. However, the performance test after commissioning was postponed up to May 1998, because of delay of transmission line and submarine cable completion.
After waiting for transmission line's completion, various plant performance tests were demonstrated and successfully finished.
Today, the Mahanagdong Geothermal Power Plant continues to supply electricity to Luzon and Cebu as one of the most important electrical supply source.

6.SUMMARY AND FUTURE VIEW

We had experience to supply geothermal steam turbines and generators to the first BOT geothermal project in the world. The Mahanagdong geothermal power plant was designed, manufactured and provided based on our plenty geothermal experience, as taking care of inherent characteristics of geothermal scaling, corrosive gases in the steam, etc.
Toshiba's design concept, performance and reliability to apply geothermal power plant to BOT project is same as the concept to apply to power utility.
However, in the contractual point of view, BOT project would have generally higher risk for turbine/generator supplier compared to conventional power utility's project, in the point of time schedule up to commercial operation due to short delivery and outside unknown factor, and point of owner company's proficiency in BOT project, etc.
In future, Toshiba will also continue to assist future BOT projects for power plant including geothermal power plant.
Also, Toshiba will continue to assist geothermal development in future by supplying geothermal power plant including FTK (Full Turn Key) job.