THE 112.5 MW TONGONAN GEOTHERMAL POWER PROJECT

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ABSTRACT

Principal constraints to the design of a 112.5 MW power station are presented, together with a description of both power plant complex and fluid collection and disposal system.

INTRODUCTION

The development of the Tongonan geothermal power project is being undertaken by two corporations of the government of the Republic of the Philippines..

The National Power Corporation (NPC) is responsible for the development of the generating and distribution facilities. The Philippine National Oil Company - Energy Development Corporation (EDC) is responsible, in simple terms, for delivery of steam to the power station and for disposal of waste waters. This entails the drilling of production and reinjection wells, construction of pipelines and separator stations as well as the much earlier activities of exploration drilling and scientific work, well measurement and similar investigation activity.

With the exception of the NPC transmission system, KRTA ha8 had a continuing involvement in all project activities, from initial exploration through to the present stage of final design and letting of contracts. The work to date has been carried out largely as a Philippine/New Zealand Technical Co-operation Project.

PRINCIPAL DESIGN CONSTRAINTS

Four major factors have an influence on the design of this power station, namely the size and nature of the load demand, the characteristics of the geothermal resource, the engineering constraints and requirements of the site, and the environmental requirements' of waste disposal.

Size and Nature of Load Demand

The present generating capacity on the adjoining islands of Leyte and Samar is confined to a few isolated private utility diesel plants of low capacity in the larger towns or at industrial sites, and there is no interconnectinq regional power grid. A 3 MW geothermal pilot plant, the first commerical geothennal-electric plant in the Philippines, was commissioned at Tongonan in mid 1977. and supplies Ormoc City. The Tongonan Power Station will therefore, when completed, be the only significant power generating facility on Leyte or Samar for some years. In addition to the growth in urban and rural demand, the principal user will be the PASAR copper smelter planned to be operational in 1982/83. A maximum demand equivalent to installed capacity is projected to occur in mid 1985. Average 24 hour demand, equal to installed capacity, is projected for early 1986. No specific projection has been made for the date by which the continuous demand will not fall below the installed capacity but is not expected to occur until 1987 or later.

The combination of the industrial content of the load, the projected demand growth and the absence of alternative generating capacity on the associated grid, leads to three important considerations.

Firstly, thero is need for a high degree of reliability throughout the entire fluid collection and waste disposal system, generating plant and electrical system to maintain continuity of supply. In order to maintain standby generating capacity, the NPC load projections call for the commissioning of a further unit in rid 1984 when tho maximum demand is expected to exceed 70 MW.

Secondly, until operating as a base load station, the plant and fluid collection system will need to operate under a continuously fluctuating load while maintaining a reasonably rteady electrical frequency.

Finally, the absence fraa the grid of alternative generation makes the proviaion of a diesel generator for start up purposes essential.

Geothermal Resource

At the time of the decision to proceed in early 1978, the size of tho resource had been determined at 3000 MW years, i.e. 120-100 MW for a station life of 24 to 30 years. This set an upper limit on station size.

other design parameters sat by the geothermal resource are long-term enthalpy of the well fluids, and the well output/wellhead pressure characteristics. Early results suggested a design value of 1400 kJ/kg for average long-term fluid enthalpy. Subsequent well measurement data havo shown thia value to be conservatively low and a higher value of 1550 kJ/kg has been used for design of the fluids collection system.

In the unavoidable absence of long-term well output/wellhead pressure data, the choice of turbine operating pressure is largely a matter of engineering judgement.

The composition of tho resource fluids is such that they present potential problems of corrosion and mineral deposition.

Site

The outstanding features of the area in which the identified geothermal resource occurs is the rugged terrain and the presence of the Central Philippines Fault and its many branches and associated faults. Of seven potential sites initially identified, five were rejected after initial investigation on such grounds as inadequate area, liability to flooding, proximity of major faults, distance from the field, possible conflict with further development, or insufficient assessment of possible field subsidence. Neither of the two remaining rites could be considered ideal in either geological or topographic terms.

The final choice was for the site having lowest pipeline cost and lowest energy losses in the pipeline. The location and elevation of the power station site with respect to the wellheads, together with the need to pipe the two-phase fluids on a continuously decending gradient requires that the separator stations be located below the power station. Separated steam will be transmitted to the power station at a higher level.

Environmental Considerations

Aside from the social implications of tho project development and construction and the subsequent availability of reasonably priced electric power, the principal environmental consideration is the disposal of the geothermal waste fluids.

Discharge of the waste fluids from the separator stations into the adjacent Hahiao river or the more distant Bao river is unacceptable (except for short-term limited quantities) on account of both thermal and chemical pollution. Such discharge would seriously threaten fisheries and irrigated agriculture In the downstream areas. Chemical treatment is neither practical nor economic. Tests to date indicate that reinjection is a potentially economic as well as environmentally attractive disposal method for this project.

Discharge of hydrogen sulphide gas around the power station is not expected to present any significant environmental hazard.

An alternative scheme involving disposal to the sea in open channel. with a pumped rising main has been provisionally identified for the remote possibility that reinjection does not prove completely successful.

Present well measurement data indicate an approximate initial total (for full output) of 15 production wells and 4 reinjection wells.

Buildings comprise steam field workshop, administration offices and garages. Permanent housing for a total of approximately 120 key operating and maintenance staff of both NPC and EDC is being provided.

DESCRIPTION

Power Plant Complex (NPC)

The station is of 112.S MW installed capacity with three 37.5 MW turbine generators. The choice was based on the requirements for standby capacity, the proposed thing of further units in relation to projected maximum demand and the target generating capacity of the station.

Each turbine will be direct coupled to a 46,875 KVA, 0.8 pf, 13.8 KV, 3 phase, 60 Hz, 3600 rpm air cooled generator with brushless excitation. The generators will each be connected to the HT busbar through a 47 MVA, 13.8/138 KV transformer with switching at 138 KV for unit operation. A 4 MVA transformer 13.8/4.16 KV connected to the generator terminals will permit running the units while disconnected from the station 1.38 KV busbar system.

Turbines will be dual pressure,double flow with direct contact condensers and forced draft cooling towers. Turbine inlet pressures are 550 kPa and 112 kPa absolute. The pressure of 550 kPa, although it may be considered conservative, ensures long-tern operation of the turbines with diminishing well pressures. The turbines will operate initially only on high pressure steam at 608 kPa absolute. This arises from the decision to defer construction of the secund stage separator plant and low pressure steam lines until a teat programme has demonstrated that reinjection of the lower temperature waste fluids resulting from second stage separation will be successful.

A diesel yenerator will provide electric power at 4.16 KV for start up, sufficient for limited ancillaries of one turbine and restricted station services.

Non-condensable gas extraction plant for each turbine condenser will comprise 4 x 1/3 capacity (including standby) two stage steam ejectors and a two stage 100 percent capacity mechanical extraction plant. Extraction plant is designed for a non-condensable gas content of 1.3 percent by weight of high pressure steam.' The steam ejectors will be used for part load operation and the mechanical extractors for full load operation.

Each turbine has two 55 percent duty 700 KW hot well pumps to deliver approximately 13,500 tonnes per hour of cooling water to the cooling towers. Delivery of cooling water to the condenser from the cooling tower basin is achieved, without pumps, by the low condenser pressure of 96 mm Hg (12.5 kPa) absolute. Two bypass valves deliver cooling water from the hot well pumps to the condenser for start up and low load operation.

Competitive tendering has lead to the adoption of gas insulated switchgear which allows a very compact switchyard layout compared with conventional outdoor switchgear. The gas insulated switchgear will be housed in a small building to facilitate maintenance. in the wet and tropical conditions.

Other buildings comprise the power house building with turbine hall and loading bay, control room annex, and administration-workshop block. Civil works to the power station include roading and other concrete and aggregate paved areas, security fences, stow water and sanitary drainage systems, a complete water supply system and landscaping.

Provision for future expansion to include a fourth turbine generator was considered but not adopted. Future development elsewhere in the field is preferred.

Fluid Collection and Disposal System (FDC)

Fluid transmission from wellheads is by two-phase flow to separator stations at lower levels, with subsequent high and low pressure steam pipelines rising to the power station at a higher elevation.

Wells have been drilled in two areas (Mahiao and Sambaloran Valleys), which give rise to two pipelines routes and two Separator stations. Each route has provision for three pipelines, any one of which may be out of service while the others together maintain full steam supply to the power station,

Each separator station comprises several pairs (a first and second stage separation) of separator vessels. Target steam dryness from separator vessels is 99.97 percent, Steam scrubbing to remove silica in water carryover from the separators is achieved by the steamlines (250 and 420 metres) to the power station. Water carryover and condensate are removed by steam traps at an average spacing of 70 metres along each steamline. wastewater disposal from separator stations will be by reinjection in a closed system to wells close to. the station and within but near the postulated boundary of the field. Wastewater from the cooling tower will be reinjected in a separate well outside the field. A standby disposal system via cooling and holding ponds to tho river is proposed to cater for short-term or emergency conditions, but its need is to be reviewed. in the light of current injection test results prior to the system being committed to construction.

The power station and fluids collection system must be able to respond to any load changes while maintaining a reasonably steady electrical frequency. This is in contrast to base-load geothermal power stations which can operate at a steady base load adjusted to match the outputs of the geothermal wells.

Conventional turbine controls are satisfactory for the Tongonan system. The fluids collection system, however, has required more sophisticated control than is usual for a base-load station.

Six of the fifteen wells supplying the power station will have motor operated valves to bring the wells in and out of services by remote control from the power station, This should permit at least a 30 percent variation from full load without the need to blow off steam.

The two-phase system including the high pressure separators is designed to operate up to 2168 kPa absolute with a nominal working pressure of 552 kPa absolute. This is expected to permit a reduction in steam output of around 15 to 20 percent.

Finally for very large load reductions excess steam will be discharged to atmosphere through blow off valves at the separator stations. These valves will handle the full steam flow of 1035 tonnes per hour.

Other Design Considerations

The principal corrosion prevention measures to be adopted are:

(a) Avoidance of the use of unprotected copper, copper alloys or silver (in electrical contacts) in the vicinity of the power station, where they may suffer atmospheric hydrogen sulphide attack.

(b) The use of protected carbon steel or non-carbon steel where air ingress occurs, especially at vapour/liquid interfaces, such as in turbine condensers or in the cooling system.

(c) Care in the choice of turbine blade materials, manufacturing processes and stress levels.

(d) Cooling water treatment to control acidity caused by oxidation of sulphides and protection of concrete surfaces in contact with the cooling water against sulphate attack.

The principal deposition prevention measures to be adopted are:

(a) To minimise silica carryover to the turbines by careful design of the separator vessels and steam scrubbing system, plus a regular programme of maintenance to remove silica buildup on turbine blades.

(b) The adoption of valves with rotating spindles, and regular test facilities to detect any sticking of throttle and emergency valvae.

(c) *The* adoption of a closed circuit (air excluded) reinjection system with reinjection wells close to the separator station, plus a reinjection testing programme for the lower temperature wastewaters (100°C) from the proposed second stage separation, to ensure that excessive silica deposition will not *occur* in the reinjection system.

PROGRAMME AND PROGRESS

Due to the tight programme set at the time, a combined feasibility study and preliminary design was commenced early in 1978. A draft report was completed in October 1978 and the final report published in March 1979. At the same time design has proceeded to permit selection of Tenders for the turbines, generators and ancillary power station plant and piping, compensators, valves and separators for the fluids collection system. Orders have now been placed for much of this plant.