STRATEGIES FOR SUSTAINABLE LONG TERM GEOTHERMAL DEVELOPMENT IN THE PHILIPPINES

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SUMMARY - PNOC-EDC has recently undertaken significant changes in approach to geothermal development in order to achieve sustainable long term development in the face of an urgent national need for power and the location of resources remote from power markets. These changes include expansion of corporate interest from steam field development into power generation based on BOT and BTO commercial arrangements, commitment to large Scale development, and management of resource risk based on historical experience in reservoir management and field operations.

INTRODUCTION

The Energy Development Corporation, a subsidiary of the Philippine National Oil Company, (PNOC-EDC), has been involved in the exploration for, and the development and production of geothermal steam fields for the past 17 years. In spite of this we have recently introduced significant changes in our approach to geothermal development to ensure that we can achieve long-term sustainable development through maintaining an adequate cash return fiom existing resources for further investment in ongoing resource identification and proving elsewhere.

Historically, we have been a steam field developer, obtaining since 1976 considerable geothermal experience over three broad phases of activity:

- surface exploration and initial steam field developments in which we explored some 30 prospects, drilled eight and developed two (1976-1983);
- operation of 2 x 112.5 MWe production fields at Tongonan and Palinpinon (1983-1993);
- development of 150 MWe at Bacon-Manit0 and an 80 MWe expansion of steam field capacity at Palinpinon (1990-1993).

We are now embarking on an ambitious fourth stage of activity in which we are developing 650 MWe of both steam field and power plant at Leyte for commissioning between 1996 and 1997 and 40 MWe at Mt. Apo by 1994. This takes us substantially outside of our past experiences in terms of our:

- proceeding in Leyte with a much larger single resource development than any we have previously undertaken. In this we are relying heavily on our long term experiences in reservoir management and production field operations, gained over the past 15 years, to minimize development risk
- entering into geothennal power generation, an area where we have no direct previous experience.

PNOC-EDC's whole approach to geothermal development has thus undergone considerable recent change and I would like in this presentation to review and discuss the major considerations which we have addressed in our forward development plans. Decision making with respect to resource development and steam field engineering issues have been taken almost entirely in-house, based on our experiences operating and developing production fields, whereas, decisions regarding power plant have necessarily led us to actively pursue commercial arrangements with foreign third parties.

MARKET CONSIDERATIONS

The Philippines has become critically short of power over the past several years due to the non commissioning in 1986 of a 600 MWe block of nuclear power and the dissolution for 6 years of the national Ministry of Energy. This has had major impact on industrial growth, development and modernization programs in the Philippines. In response, the national power utility of the Philippines, National Power Corporation (NAPOCOR), has now relinquished monopolistic control on power generation and the private sector is being actively encouraged by the Philippine Government to become involved in generation as a means to accelerate the availability of adequate power supplies.

This new commercial environment is advantageous to PNOC-EDC which has historically made significant early investments in exploring for and proving geothermal fields but has received only a limited return on these investments because resources have not been exploited as originally planned, due essentially to power plants not being built as and when programmed by government. PNOC-EDC is thus moving into geothermal power generation as well as steam field development in order to avoid involvement with any intermediate third party energy converter who may not be able to keep up with the development program.

FUNDING AND RESOURCE CONTROL

The major problem in developing and exploiting large geothermal resources is the amount of capital required for power plant (typically 3 to 4 times the cost of developing steam field systems). The Philippines, as with many countries, has had a problem with mobilizing this sort of capital from a single source - both from within the

multilateral aid agencies, who are facing very strong competing demands for their limited funding resources, and also from the private sector.

There is therefore a need to spread investment between a number of different parties by setting up several parallel steamfield/power generation projects within a single geothemal, resource. This, however, introduces considerable uncertainty and concern on how to control reservoir exploitation because a number of different operators would then be accessing a single resource with the likelihood for sustained and uncontrolled resource drawdown, such has occurred at the Geysers Field.

The solution to this which we have adopted for the Leyte program is for PNOC-EDC to retain overall control of the geothermal resources and "subcontract" power plant developers to convert steam on behalf of PNOC-EDC in the various reservoir sectors. By being the contracting party, it is then within PNOC-EDC's ability to control and balance mass withdrawal over the reservoir as a whole in order to optimize long term resource utilization.

This benefit has to be seen as the long term return on our investment in the steam field, rather than simply maintaining steam supply at all costs. It may, in individual circumstances, be preferable to allow one resource sector to be depleted while limiting reservoir pressure drawdown elsewhere in order to maintain a longer term operation there. Such decisions will need to be based on a combination of factors, balancing engineering, scientific and commercial issues.

COMMERCIAL CONSIDERATIONS

The development model that has been adopted by PNOC-EDC is thus one of vertical integration. We contract to sell wholesale electricity onto the grid rather than maintaining our traditional role as a steam supplier, and we then convert the steam into electricity using the most commercially advantageous method, which gives us a good financial return while still allowing us to protect our long term resource interests, Depending on a number of factors, mostly related to program and capital fund resources, our current developments are being undertaken as either BOT or BTO projects with the preference currently being for BOT for large projects (e.g. Leyte 650 MWe) and BTO for smaller projects (e.g. Mt. Apo 40 MWe).

By contracting out power plant operation to third parties through such commercial arrangements, PNOC-EDC is able to gain time in which to develop its own generation capability. It is our intention to develop in-house skills in this area over the next few years and we may well then contract back to ourselves the operation of some of the BOT projects.

DEVELOPMENT RISK

The main areas of development risk we perceive are those associated with the geothermal resource itself because:

the power market risk is low within the Philippine as the economy is poised for rapid growth as soon as power availability improves

our exposure to political and commercial risk is covered by our contractual relationships with BOT/BTO power plant operators and NAPOCOR.

In minimizing the resource risk we have relied heavily on our past experiences in operating and managing geothermal production fields. Resource development concepts which we see as being important in reducing risk include:

Resource Estimation

We estimate potential resource size prior to development using volumetric stored heat calculations, which include Monte Carlo methods for examining the uncertainty in variables such as resource size, reservoir temperature, porosity and recovery. Based on conservative input data and the ability to cross correlate these with earlier developments for which we now have substantial production histories and calibrated numerical models, we believe that this approach provides realistic estimates for sizing resource development.

Resource Optimization

Being both steam field operator and future owner of power plant, PNOC-EDC is in an excellent position to optimize power plant to the thermodynamic characteristics of a resource. Our studies confirm that we are able to increase generation capacity by 15 to 20% relative to our earlier developments, which were based on relatively low turbine inlet pressures (e.g. 0.5 MPa), and single pressure entry. Our current approach is now toward high pressure primary separation, with secondary flash and/or recovery of waste heat from reinjection brine lines.

Reservoir Pressure Decline

In order to reduce the rate of reservoir pressure decline with time, together with associated run-down in production well mass flow rates, we are placing considerable emphasis on:

- large diameter production wells to reduce the pressure drop between the reservoir and the surface fluid collection facilities;
- providing reservoir pressure support to production wells in high enthalpy production sectors by providing for some in-field injection;

Through this approach we also hope to minimize the effect of cool and/or supergene acid fluid intrusions into production well feed zones.

Reinjection

It is our experience that the whole process of reinjection poses the single biggest risk to geothermal development. Our areas of concern include:

Disposal Capacity

Liquid dominated volcanic geothermal systems typically produce 500 kg/sec of waste water per 110 MWe power plant. In Leyte we are looking at disposing up to 3000 kg/sec of waste brine and condensate from the 650 MWe developments. This is a large mass of fluid which has to be disposed of and reinjection is the only practical means

to achieve this.

In fractured volcanic rocks there is a high potential for premature return of cooled injection fluid back to production wells. This has been a significant, though manageable, problem for us at the Palinpinon field (as is discussed elsewhere in this conference by my PNOC-EDC colleague, Mr. D. Catigtig). We have found the most effective solution to this is to transfer injection away from the in-field hydrologic features such as faults or porous lithologies which give rise to the fluid returns. Almost invariably this requires moving to field edge injection sites to gain distance from the affected production sector, however, good permeability is difficult to obtain in these locations due to natural self-sealing at the boundaries of hydrothermal systems.

Silica Deposition

The high potential for scale to deposit from silica saturated two phase and brine flows in surface piping and plant, and within and around injection well bores, is a major operational problem and limits the amount of heat that can be extracted and thus the thermal efficiency of utilization of geothermal fluids. We are including in our future development program a variety of measures to minimize the impact of silica deposition:

- adopting a high primary separator pressure, balanced against reduced well deliverability, to reduce silica saturation to acceptable levels;
  dilution of silica saturated brines with both condensate and undersaturated brine;
  ageing and conditioning of waste brines in surface ponds and injecting "cold" after some silica deposition has been allowed to occur.

In addition we are examining methods of chemical pretreatment prior to reinjection. These include acidification of waste brine with C02 and/or mined acids to reduce the rate of silica polymerization and thus deposition, and inhibition with a range of proprietary chemicals. Such approaches to controlling silica deposition will be discussed in more detail elsewhere in this conference by Barnett and Garcia.

CLOSING REMARKS

I have spoken a lot today about change and strategy and how we expect these to lay the foundation for PNOC-EDC to achieve a sustainable, long-term geothermal development program. Our forward program over the next 5 years is large with 230 MWe of additional steam field to be commissioned during 1994, and a further 690 MWe of combined steam field and power plant by 1997.

We believe the strategy of moving into combined BOT type power generation and steam field development has fundamental advantages and is the only practical basis for achieving development at the pace which the Philippines requires. In particular it allows for:

- PNOC-EDC as the field d eveloper to control development risk, because our past experiences in developing and operating fields allows us to assess and handle this risk;
  PNOC-EDC as a power generator to gain a return on our large existing investment in wells, which in turn will allow for our continued investment in developing new geothermal resources elsewhere;
- the Philippines to rapidly increase much needed electrical generation capacity without increasing national debt.