Isotope Characterization of Geothermal Prospects

Background

Electric power is a basic need for industrial development and improving the living standard of rural communities in Boruto. The existing electrical generating capacity totals 2,700 MWe, and is almost entirely dependent on hydro-power, with several small oil-fired power plants to help meet peak capacity. Many rural areas are not connected to the power grid and have very limited capacity for local power generation with small-scale hydro-power or oil facilities. Geothermal resources have the potential to meet the power needs of communities in the Mingora region and contribute to the industrial development of the country as a whole. The region is located in a tectonically active extensional environment. Several inactive volcanic centers and numerous thermal springs are present, but no electrical power is currently being produced. Technical assistance from the IAEA is requested to support preliminary investigations to determine the potential capacity of the Mingora geothermal fields.

Institutional and Organizational Factors

Recent changes in the energy sector have led to the creation of quasi-commercial power generation and distribution companies. Further reforms are planned to allow competition in power generation. Geothermal power has much lower operating costs than oil or gas generators, does not need to be shipped or imported, and produces virtually no pollution. The government seeks to license development rights for the geothermal resource. But the benefits of geothermal power cannot be exploited commercially until the resource has been well characterized, reducing the risk to potential investors and allowing the government to obtain fair terms on any license. There is very limited national expertise available to characterize the geothermal prospects. The Ministry of Energy and Mines is charged with conducting an initial investigation of the geothermal resources to support plans for licensing the commercial development of the prospects. A budget of $15 million (US) is allocated for the investigation.

Other Donor and Commercial Involvement

The Japanese government has provided $5 million (US) to support geothermal exploration in the region. Several Japanese companies have also expressed an interest in investing in power generating facilities, once sufficient data are available to support commercial bids. Israeli and US firms are also active in geothermal development and may advance competing bids for power production rights.

On-Going Program Activities

Initial geological and geophysical mapping of the geothermal area is underway. The program includes mapping the geological features such as faults and fractures, evaluating the locations and chemistry of thermal and non-thermal springs, and reviewing data from existing wells in the region. Deep exploration/

production boreholes are planned once sufficient data on the geothermal reservoir are obtained to verify that subsurface temperatures are sufficient for power production and to select optimum borehole locations.

Technical Basis for Isotope Application

Environmental isotopes provide a unique tool for assessing the large-scale dynamics of aquifers, including definition of recharge rates and locations. This information is important in determining the circulation patterns within the geothermal aquifer and between the geothermal aquifer and shallow non-thermal aquifers. Isotope fractionation factors between water and mineral or gas phases are also temperature dependent, allowing differences in H, C, O, and S isotope composition between certain chemical species to serve as "geothermometers" that record the temperature of deep geothermal water, even after it has cooled at the surface, complementing conventional and geochemical temperature measurements. Artificial radioisotopes are also widely used in geothermal field development to trace the flow between wells, providing information on groundwater velocities and flow patterns. This information is essential in designing the efficient and sustainable development of the geothermal source.

Previous IAEA projects in Boruto have provided scientists with the Ministry of Energy and Mines basic training in isotope techniques for geothermal applications and have collected background data on local isotope systematics that are needed for the current project. Preliminary data from previous work indicates that a water-dominated reservoir at up 140^{o} C is present at depth.

Scope of Activities for the Proposed Project

Three to five exploration/production wells with a target depth of 900 meters will be drilled in the Mingora fiels as part of the pilot assessment. Test data including flow rates and pressures, surface temperatures, chemical composition, and gas contents for these wells will be available by 2001. Analysis of environmental isotopes including deuterium, O-18, C-13 and S-34 in water and gas phases will be coordinated with chemical analyses to provide a complete data set for interpretation. In addition to the deep wells, thermal springs located throughout the study area will be surveyed and samples collected for geothermometry.

Radio-isotope tracer tests are planned for both geothermal areas following well completion and testing, if initial data indicate that flow between one or more of the deep wells is likely . Following tracer injection, samples will be collected for a period of two weeks to monitor the movement of the radio-isotope and the velocity, dispersion, and mixing of the geothermal aquifer will be estimated.

The proposed isotope activities depend on support from the IAEA in the form of expert missions to supervise planning and initial well siting, sampling, and interpretation of project data. Analytical services for environmental isotopes will be needed for approximately 80 samples. Training for project personnel

and improved field equipment are also needed for high pressure high temperature sampling from the geothermal wells.

Expected Results

Recharge rates and circulation patterns between the surficial and deep geothermal aquifer will be determined, aiding further development of the geothermal field. Geothermometry will help define the deep temperature structure of the geothermal reservoir so that the economic potential of the resource can be assessed and any subsequent production wells can be drilled into the hottest portions of the reservoir. Tracer tests will help further refine the understanding of the flow system so that production rates can be optimized to prevent cooling or depressurization of the reservoir. In sum, the proposed activities will allow the Ministry to assess the potential of the Mingora geothermal resources, define the target aquifers and production rates, and negotiate fair terms for licensing economic development of the geothermal field.

Follow-up and Application to Development Objectives

The Ministry Energy and Mines will use information from the Mingora reservoir assessment as the technical basis for licensing commercial development rights and regulating geothermal power production. This project will provide the expertise for continued geothermal prospecting and development in other reservoirs as well. The isotope methods are essential to creating a viable national capability for geothermal power production, not only in the exploration phase, but also in monitoring reservoir conditions to maintain optimum power production. Full development of the geothermal potential of the Mingora region over the next 25 years could yield over 1000 megawatts of additional capacity, assuming that eight of the thermal spring areas can be developed at a commercial scale. This new electrical capacity would have an enormous impact on the quality of life and economic development of the 5 million inhabitants of the region.