

DEVELOPMENT OF A GEOTHERMAL MASTER PLAN FOR NICARAGUA

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ABSTRACT

Nicaragua is endowed with a substantial geothermal potential that is connected with the active volcanic cordillera along the Pacific coast. Geothermal power generation began in 1983 with the startup of the Momotombo plant, which now has a capacity of 70 MW. A second geothermal field (San Jacinto-Tizate), discovered in 1993, has at least 25 MW of power potential confirmed by deep drilling. Two other areas have been investigated to the pre-feasibility level, and another 6 identified in a preliminary way. With the goal of orderly and efficient development of the geothermal resources of Nicaragua, a Master Plan is being prepared that will permit classification of the recognized geothermal areas in terms of development potential and planning of the successive stages of exploration and development. The Master Plan, in addition to being a planning instrument, will offer a basis on which to establish limits for exploration concessions and conditions for offering them to private companies; it will also serve as a presentation and promotional document for the country.

As the first step in this effort, all existing resource information is being evaluated and new exploration data are being gathered (geologic field investigations, remote imaging, hydrological and geochemical studies and geophysical surveys) to estimate the probable limits and develop a conceptual model of each prospect. Each model, in turn, will allow estimating the energy potential and will serve as a basis for planning the studies needed to reach the feasibility stage for each prospect.

Logistical and environmental impact aspects of each prospect are also being assessed. The logistical aspects, such as the area's accessibility, availability of water for future drilling, availability of land (given its present use), and other infrastructure data, are being defined and evaluated. The purpose of the environmental investigation is to identify the principal risks and their mitigation, and the social impact of geothermal development. The data obtained from these investigations are being reviewed and summarized for their inclusion in specific reports.

Based on the preliminary geothermal model, a technical-economic profile of each prospect is being prepared, taking into account logistical and environmental factors. The costs and time necessary to reach the feasibility stage are being estimated for each prospect, and an appropriate resource development strategy is being formulated. The Master Plan document will be a systematic presentation of all relevant aspects of each prospect (resource-related, logistical, infrastructure, environmental and economic), defining levels of priority and optimum development programs.

1. INTRODUCTION

Nicaragua is endowed with a substantial geothermal potential, connected with the presence of numerous active volcanoes located in a chain extending along the western margin of the country. Exploration and development of geothermal resources have taken place since the late 1960s, and have included the development and operation of the 70 MW Momotombo plant, which began producing geothermal power in 1983. Other fields have been explored or studied in varying degrees of detail, with the most extensive activity taking place at San Jacinto – El Tizate, where several productive wells have been drilled. In recent years, private developers have been granted concessions in several areas, and have conducted further investigations toward commercial development. The recent status of geothermal development in Nicaragua is summarized by Zúñiga-Mayorga (1998).

The country currently depends heavily on thermal plants supplied by imported oil for electricity generation. Exploitation of a even a small fraction of the estimated available geothermal power potential would have a significant impact in offsetting energy imports, and could potentially lead to net exportation of electricity. In addition, there is a growing awareness of the environmental benefits that could be achieved by the increased use of geothermal power, particularly as regards the reduction of greenhouse gas emissions.

In order to better plan and administer the development and exploitation of geothermal resources, the Government of Nicaragua has commissioned a study for the development of a Geothermal Master Plan. The necessary studies for the Master Plan are being carried out by GeothermEx, Inc. during 1999-2000. The main objective of the Master Plan study is to evaluate and classify the various geothermal resource areas according to their electric generation potential, and to plan for the exploration and development activities that will be undertaken in the future.

2. DISTRIBUTION OF GEOTHERMAL RESOURCE AREAS

For the purposes of the Master Plan, the geothermal potential of the country is being evaluated with respect to 10 areas of current or recent volcanic activity along the volcanic cordillera of western Nicaragua (Figure 1). Two of these areas have resources that have been confirmed by deep drilling (Momotombo, San Jacinto-Tizate). Several other areas appear to be highly promising, on the basis of various levels of exploration using geophysics, geochemistry, geology and volcanology (*e.g.*, El Hoyo-Monte Galán, El Najo, Masaya-Granada-Nandaime), whereas other areas are only now being seriously investigated.

Unlike most other parts of Central America, the volcanoes of Nicaragua are located in a major structural depression, known as the Nicaraguan depression. In this region, both volcanism and subsidence have occurred simultaneously over a long period of time; as a result, the geothermal systems are likely to combine geologic characteristics related to both processes. These may include a stratigraphy dominated by volcanic and possibly lacustrine sediments, along with lavas and pyroclastic rocks, and structures resulting from both regional extensional faulting and local volcanic stresses. The influence of geological setting on the most appropriate methods of investigation and exploitation of the geothermal resources may therefore be unique to Nicaragua, compared with neighboring countries.

Many of the volcanoes of the cordillera have been active in historic times, and a number have erupted over the past several decades. In addition to eruption hazard, the steep edifices formed by some of the volcanoes present potential landslide hazards. This was illustrated dramatically and tragically by the massive slide and mudflow that occurred at La Casita volcano in October 1998. The event, which was triggered by heavy rains from Hurricane Mitch and was non-volcanic in origin, destroyed two villages and caused the deaths of more than 2,000 people. Many of the volcanoes also host undeveloped forests and other environmentally sensitive areas. Thus, there are environmental and geologic hazard concerns that must be taken into account when planning for the development of the geothermal resources.

The location of the different geothermal areas with respect to centers of population is variable. Several areas (such as Masaya-Granada-Nandaime, Tipitapa, Chiltepe and Momotombo) are located close to Managua and other major cities, whereas other fields, though not remote, are less centrally located. Two areas, Cosigüina in the northwest and Ometepe Island in the southeast, are in relatively remote locations that could influence development. Field locations, as well as other local logistical and infrastructural conditions, will need to be taken into account for the adequate planning of orderly development.

3. OBJECTIVES OF MASTER PLAN STUDY

The objectives of the Geothermal Master Plan are:

- To evaluate and prioritize the geothermal areas of greatest geothermal electric power potential in Nicaragua.
- To consider not only the potential of each resource area but also the drilling, logistical, environmental and related parameters of the expected cost and feasibility of development.
- To present the assembled data and results of these studies in a clear and well-organized manner and format that will be useful to potential developers, investors and/or lending agencies.

This is being done on the basis of existing resource and exploration data, virtually all of which is available in the public domain, combined with a number of new geophysical,

geochemical, geological and volcanological field surveys, plus logistical and environmental evaluations.

4. COMPONENTS AND PRODUCT

The major components and product of the Master Plan Study will consist of:

- Collection and analysis of the existing body of resource and exploration data.
- Analysis, interpretation and synthesis of the available information from all media and methods to develop a preliminary conceptual geothermal model for each of the 10 study areas.
- Design and execution of additional field studies, to be carried out in areas not previously subjected to development, concession or pre-feasibility studies. These studies may include, as necessary, the exploration disciplines of geology, volcanology, geophysics, geochemistry, hydrology and environmental studies, which shall be designed to prove or refine specific aspects of the preliminary conceptual models.
- Analysis of the new information and use of the results to develop and/or refine the geothermal conceptual models of the different areas.
- Use of these models to estimate the potential energy reserves of each area, by employing a Monte Carlo probabilistic method.
- In coordination with the geoscientific evaluation, evaluation of the logistic and environmental impacts or constraints on development in each area, based on existing or newly collected data. As much as possible, the quantitative economic impacts of these factors will be emphasized.
- Development of Terms of Reference for feasibility studies in at least two areas determined to have the greatest potential for development, on the basis of the conceptual models.
- Combination of the key aspects of the conceptual models with environmental and infrastructure data to develop a technical-economic profile of each area. The existing level of exploration and understanding of each area is to be characterized, evaluating the nature, time and cost of additional activities that will be required to bring each area to the feasibility level.
- A report for each area that describes the work done, the results of data analysis, the conceptual geothermal model, the potential energy reserves, environment, infrastructure and the technical-economic evaluation of the area.
- A Master Plan document that will include the principal characteristics and conclusions related to each area studied, and categorize and establish priority levels for

the areas, with respect to the most important technical and economic factors. This information will be summarized onto a color map of the resources and potential for geothermal development of the volcanic region of the Nicaragua.

5. COMMENTS

The existing body of resource and exploration data is considerable. For example, a routine search of the GeoRef database for Nicaragua has returned over 850 citations, nearly 400 of which are related to geology and volcanology. Major exploration and resource evaluation projects were carried out in several regions and at various times during the 1970s and early 1980s (*e.g.*, Heilner and Braun, 1971; IECO, 1980; OLADE, 1981; ELC, 1982; OLADE, 1982a, 1982b). These were done with various objectives and in various formats that are inconsistently presented and difficult to use. As a result, it is difficult for the newly interested to take advantage of the work that has already been done. It is a major objective of the Master Plan Study to bring all of this prior work, and the new work to be done, into a clear, concise and well-documented format that will be useful for the further geothermal development of Nicaragua.

Work on the Master Plan started in 1999 and is scheduled for completion before the end of 2000.

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**FIGURE 1:
GEOTHERMAL PROSPECTS IN NICARAGUA**