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GEOTHERMAL ACTIVITY AND DEVELOPMENT IN NICARAGUA – PRODUCING AND DEVELOPING

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ABSTRACT

The high cost of oil derivatives has compelled Nicaragua to look for viable alternatives to generate electricity. A very interesting option has been the exploitation of the country's abundant renewable energy resources (hydraulic, wind, biomass and geothermal). Nicaragua has plenty of geothermal resources, which have been used since 1983. This document is a summary of the plans, activities and results related with the utilization of geothermal energy in Nicaragua.

1. INTRODUCTION

Electricity generation in Nicaragua has been highly dependent on imported oil derivatives (fuel oil, diesel) (Figure 1), unfortunately in Nicaragua's territory has not been found any oil reservoirs with the size to consider them as commercially exploitable, so a possible solution to reduce the consumption of oil derivatives is to utilize renewable resources such as: geothermal sources, wind, hydraulic, biomass (what in a long time could mean a reduction on energy prices).

The plan of Nicaragua Government is to convert the actual energy matrix in a very dramatic way, so the energy generated using renewable resources would represent 98% of the energy matrix (Figures 2).

Even though Nicaragua has significant renewable resources, they have been scarcely used because of some obstacles, such as:

- Preliminary studies are expensive and require long time to be finished;
- The initial investment involves high risk and requires a long time to be recovered;
- The required technology and civil work are highly expensive;
- Funding sources are limited.

The Nicaragua Government is absolutely interested to exploit the renewable resources available as energy source, but one of its main goals is to make possible the development of electricity power plants with geothermal energy as a main source.

In this document, the executed actions will be described, results and plans applied to develop the utilization of geothermal energy as a substitute for oil derivatives.

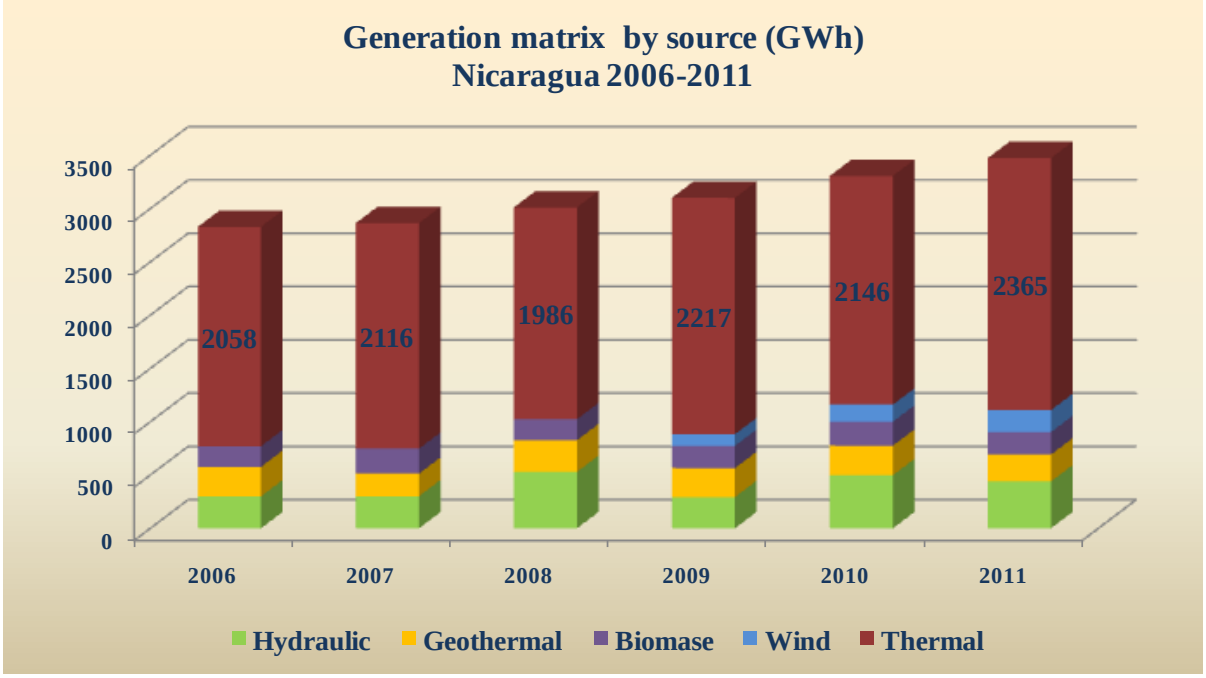

FIGURE 1: Electricity generation in Nicaragua by energy source

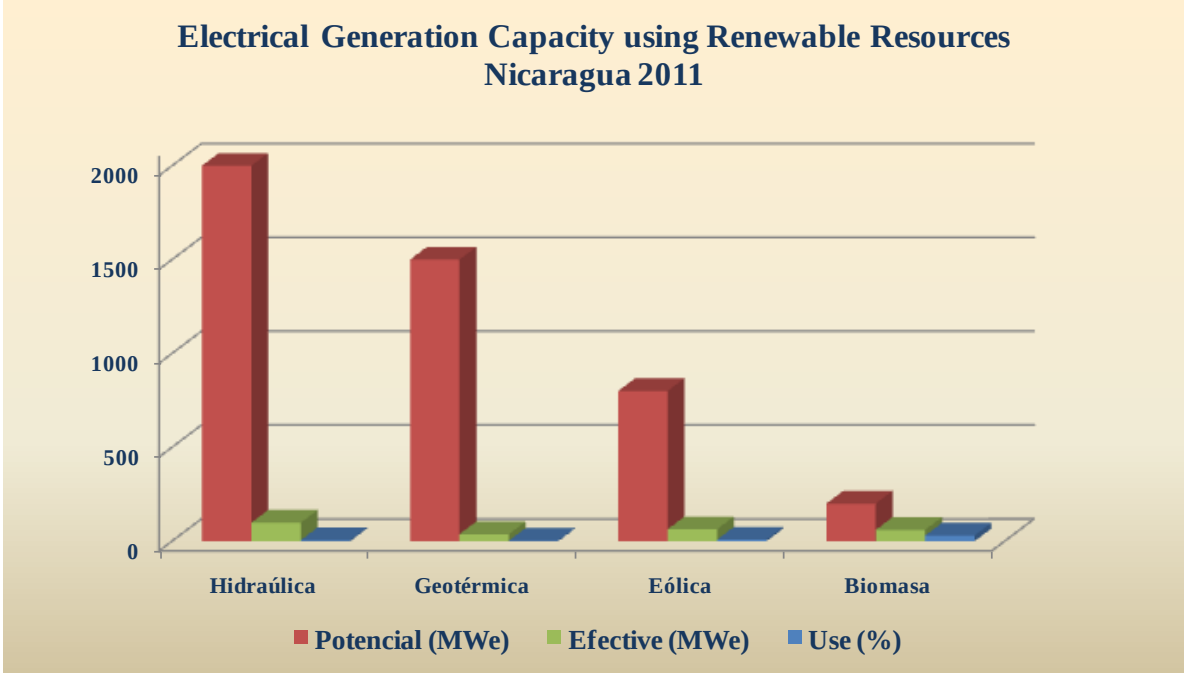

FIGURE 2: Electrical generation capacity from renewable energy sources in Nicaragua

2. GEOTHERMAL DEVELOPMENT BACKGROUND

The exploration of geothermal resources started in the period between June 1969 and February 1971. The Nicaraguan Government hired Texas Instruments (North-American company) to be in charge of the first investigations about the existence of geothermal resources. Those researches were funded by the United States Agency for International Development and were designed to locate the first areas with geothermal potential. That investigation included: geological mapping emphasizing on the areas

with hydrothermal alterations, geophysical measurements (resistivity, MT and gravimetry) and geochemistry. With the information collected from this study, it was possible to select two areas: San Jacinto Tizate and Momotombo.

The United Nations Development Programme continued with the studies in the Momotombo Volcano. These studies were a reassessment of the geophysical and geological surveys carried out previously. Furthermore, it helped to complete the geochemical investigation. The results obtained pointed out that Momotombo Volcano had a reservoir suitable to be exploited for power generation, and it had the capacity to support a 35 MWe Power Plant.

In august 1975, the "Empresa Nacional de Luz y Fuerza" (ENALUF) hired California Energy Company, Inc. (CECI) to continue the development of the Momotombo Geothermal area. CECI was in charge of the drilling of 28 geothermal wells in Momotombo. Furthermore, CECI carried out geophysical investigations in San Jacinto Tizate, El Hoyo Volcano.

In 1977, ENALUF carried out the "Master Plan for Electrical Development 1977-2000". the consortium IECO-LAHMEYER was chosen for ENALUF to carry out the studies needed to elaborate the ENALUF Master Plan. The ENALUF Master Plan comprised an assessment of the geothermal resources in Nicaragua. Its main objective was to deepen the studies carried out previously in order to confirm the potential to generate energy for each geothermal area. The studies were mainly focused on geological, geochemical, geophysical and hydrological studies. The areas chosen to be under study were:

- Chiltepe Peninsula and Mombacho Volcano;
- The semi-actives and dormant volcanoes located to the east of the Nicaraguan Depression;
- The volcanic axis located to the east of Managua and Cocibolca lake;
- The area between the towns of El Rama and Nueva Guinea.

In the period between 1980 and 1986, the Nicaraguan Institute for Energy (INE, institution that was created after the triumph of Sandinista Revolution in 1979) drilled 4 commercial sized geothermal wells in Momotombo's Geothermal Area.

In 1983, INE installed the first 35 MW steam condensation turbine in Momotombo (it is called the first unit), that fed with 5 production wells. In 1989, it was installed the second turbine with the same characteristics as the first unit.

In the period between 1993 and 1995, Intergeoterm, S.A. (Consortium ENEL Nicaragua – Russians companies) drilled seven production wells in San Jacinto –Tizate geothermal area, the depth for those wells ranged from 550 to 2000 m.

2.1 Nicaragua Geothermal Master Plan (NGMP)

In 1997, INE through a loan granted by the Inter-American Development Bank (IDB) started a public bidding process to select the company to carry out the study "Nicaragua Geothermal Master Plan".

In 1998, the Nicaraguan Government created the National Energy Commission. This institution continued with the necessary actions to carry out the Master Plan. The scopes for this study were as follows:

- General definition of the area and its geographic borders;
- Studies of the existing geoscientific data;
- Carrying out of new and additional geoscientific research (geological, vulcanological, geochemical, geophysical studies);

- Synthesis and interpretation of data;
- Definition of a geothermal model for each area;
- Assessment of the energy potential for each area.

After the public bidding CNE defined that the North American company GeothermEx was suitable to carry out the NGMP.

3. GEOTHERMAL DEVELOPMENT

The NGMP made possible to identify 10 areas as suitable for geothermal development, all of them were distributed along the Pacific volcanic range that goes from Chinandega Department to Rivas Department. Volcán Cosigüina, Volcán Casita–San Cristóbal, Volcán Telica–El Ñajo, San Jacinto–Tizate, El Hoyo–Monte Galán, Volcán Momotombo, Managua–Chiltepe, Tipitapa, Masaya–Granada–Nandaime and Isla de Ometepe were the geothermal areas assessed in the NGMP and the potential of geothermal energy reserves for Nicaragua was estimated as 1519 MWe (Figure 3).

FIGURE 3: Areas that have been identified as suitable for geothermal development

4. GEOTHERMAL FIELDS UNDER EXPLOITATION

This section presents a summary of the activities carried out on the geothermal fields that have reached the exploitation stage.

4.1 Momotombo Geothermal Field

4.1.1 Location

The Momotombo Geothermal Field is located at the extreme SE of the Marrabios Cordillera, some 40 km NW of Managua, on the shores of Lake Managua and on the S slope of Momotombo Volcano.

4.1.2 Drilling

The wells on this field have been drilled in two different periods, as follows:

- 1974-1997: 43 commercial sized wells were drilled under Nicaraguan government responsibility;
- 2000-2002: 3 commercial sized wells were drilled under ORMAT company responsibility.

The drilled wells are categorized as follows:

- Amount of drilled wells: 46
- Amount of active production wells: 10
- Amount of active reinjection wells: 6

4.1.3 Exploitation

In the period from 1983 to 1994, the Momotombo field was exploited for the Nicaraguan Government, which was represented by the Nicaraguan Energy Institute (INE). Then from 1995 to middle of 1999 it was exploited again by the Nicaraguan Government represented by Nicaraguan Electricity Company (ENEL) and from middle 1999 to the present time by Ormat Momotombo Power Company.

This geothermal field is currently managed by ORMAT Momotombo Power Company, which got the concession for exploitation after the signing of a contract with ENEL. This concession will finish in 2013.

4.1.4 Generation details

The initial generation system was composed by two single flash turbines with condensation of 35 MW each one (the first unit was installed in 1983 and the second one in 1989), later on, at the end of 2002, ORMAT installed a binary cycle system composed by two turbines with a nominal capacity of 4 MWe each one, so the current installed capacity is 78 MW.

Currently, just one of the single flash turbines is running because the steam flow is not large enough to impulse both units. Furthermore, the active turbine is generating at an operation level below its nominal capacity (around 70% of nominal capacity). The binary cycle turbines are running at full capacity, so the current average generation for Momotombo Power Plant is 28 MWe.

4.1.5 Problems found during the operation of Momotombo Geothermal Field

- Natural cold water is flowing in the Momotombo's reservoir because of the reservoir drawdown caused by the exploitation. This phenomenon has a cooling effect on the reservoir that can be easily observed because many geothermal wells stopped its production. This problem has not been solved yet.
- Calcite scaling on production Wells. It was solved with calcite chemical inhibitors.
- Silica scaling on binary plant heat exchangers. It was solved with silica chemical inhibitors.

4.2 San Jacinto-Tizate Geothermal Field

4.2.1 Location

The San Jacinto-Tizate Geothermal Field is located in the Marrabios Cordillera some 75 km NW of Managua and approximately 20 km NE of Leon, on the E end of the Telica Volcanic Massif.

4.2.2 Drilling

The wells of this field have been drilled in two different periods, as follows:

- 1992-1995: 7 commercial sized wells were drilled under Nicaraguan government responsibility.
- 2007-2011: 9 commercial sized wells and 6 sidetracks were drilled under Polaris Energy Nicaragua S.A. (PENSA) responsibility.

The drilled wells can be categorized as follows:

- Amount of drilled wells: 16
- Amount of sidetracks: 6
- Amount of active production wells: 11
- Amount of active reinjection wells: 3
- Amount of temporary reinjection wells: 1 (SJ-6)

4.2.3 Exploitation

This geothermal field has been commercially exploited only by Polaris Energy Nicaragua S.A. PENSA started to exploit this field in July 2005. Its initial production was 5 MWe.

4.2.4 Generation details

The initial system was composed of 2 back-pressure turbines with a nominal capacity of 5 MW each one. This configuration prevailed up to 2011 when the first single flash turbine with condensation system of 36 MW was installed (it's the first stage of a project to increase the exploitation capacity to 72 MW), so, at the end of 2011 the nominal installed capacity for this field increased to 46 MW.
At the end of 2011, only the backpressure turbines were running at full capacity. The single flash turbine was under tests, so the average capacity at the end of 2011 was 9.3 MW.

5. BEHAVIOUR OF ENERGY GENERATION FOR GEOTHERMAL POWER PLANTS

The historical behavior of energy generation using geothermal resources is presented Figure 4. It contains the installed capacity and the net electric generation (Momotombo + San Jacinto).

6. GEOTHERMAL AREAS UNDER EXPLORATION

6.1 Casita-San Cristóbal Volcano

On March 6th 2009, the Ministry of Energy and Mines granted Cerro Colorado Power the concession for exploration of geothermal resources at Casita-San Cristobal Geothermal Area.

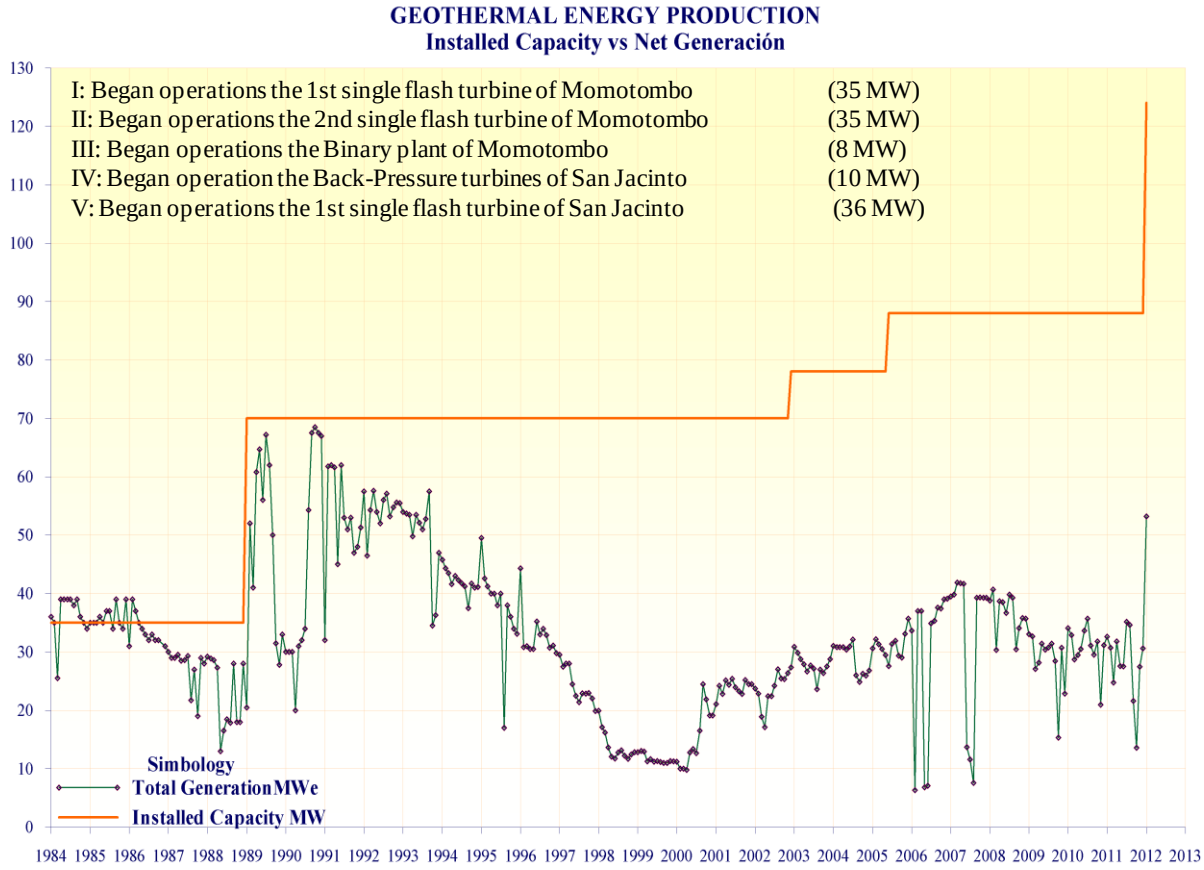

FIGURE 4: The history of geothermal electricity generation

Some activities have been carried out since the concession for exploration for this area started:

- Construction of the access road;
- Drilling of a 800 m depth slim hole well;
- At the end of 2011 was done a production test for the slim hole well, apparently they got very promising results.

6.2 El Hoyo Monte Galán

In March 2006, INE granted to GEONICA the concession for exploration of EL Hoyo –Monte Galan Geothermal area. The project involved an operative plan for two years with the aim of integrating all the surface geoscientific techniques, drilling of gradient and deep wells that would help them to understand the details of the lithological units and to carry out chemical tests that would let them characterize the deep geothermal fluid. All these activities would help them to gather the information required to define a geothermal conceptual model for El Hoyo Monte Galan system.

The exploration activities were delayed, because there were legal issues stated in the act 217 “Ley General del Medio Ambiente y los Recursos Naturales" that prevented to carry out exploration and exploitation activities of renewable and non-renewable resources located in protected areas. This legal issue was overcome in September 2006, after the publication of the Law No. 594. In that legal document was established the procedure that has to be followed in order to carry out exploration and exploitation of geothermal resources located in protected areas.

In the period from May 2007 to May 2008 GEONICA carried out the activities regarding to geothermal prospection for this area, such as:

- Geological mapping and location of alterations;
- Geochemical sampling;
- Geophysics (MT, Gravimetry and Aeromagnetic soundings);
- Measurement of the baseline for CO_2 and H_2S content in the air in the area.

Other activities that have been carried out are:

- Drilling of 3 shallow wells that were used to supply the water required for drilling operations;
- Selection of the drilling targets;
- Construction of access roads and concrete platforms for drilling purposes;
- Environmental management plan for El Hoyo-Monte Galan Area.

The drilling operations have been under the responsibility of Santa Barbara Drilling company. This company has drilled 2 vertical commercially sized geothermal wells, HMG-1 and HMG-2.

The well HMG-1 was drilled from April 2009 to July 2009, to the depth of 2000 m. At 650 m, a thermal inversion was found, which showed a very low permeability.

The well HMG-1 was drilled from October 2009 to January 2010. The depth of the well was 1623 m. It showed very good permeability but the formation temperature was not suitable for energy generation purposes.

Considering the high costs that represent a failed geothermal well, GEONICA asked permission to MEM to drill slim hole wells instead of commercial sized wells. The request was accepted and under those conditions three additional slim hole wells were drilled, but the geothermal reservoir has not been intersected yet. GEONICA plans to continue the exploration of this area by drilling 3 new slim holes.

6.3 Managua-Chiltepe

Activities that have been carried out at the Managua-Chiltepe area include:

- Selection of drilling targets;
- Environmental management plan for Managua Chiltepe Area.

In March 2009 a slim hole well was drilled to 1000 m depth. The objective of this well was to complete the surface studies and to get more information about the geothermal reservoir. The results were not encouraging, so GEONICA started the arrangements to quit for the exploration concession.

The administrative resolution "DGCA No. 012-2011" was issued in March 2011. In that document, the request to quit the exploration concession was accepted, so the legal rights that GEONICA had over Managua-Chiltepe geothermal area were suspended. From that time Managua-Chiltepe was free again to be explored.

Currently MEM is under negotiations with Albanisa regarding the continuation of exploration of this geothermal area.