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# Nicaragua Country Update

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**ABSTRACT**

Geothermal exploration began in Nicaragua at the end of the 1960s, focusing on the Momotombo and San Jacinto geothermal fields, demonstrating the large geothermal potential in the country.

Medium and high-temperature resources are associated with the Maribios range, an active quaternary volcanic chain of the Nicaraguan depression.

The commercial exploitation of Momotombo started in 1983 when the first 35MW unit was installed to operate. A second unit of 35 MW was installed in 1989.

In August 1999, Ormat International Inc, won a 15 year build-operate-transfer contract to exploit the geothermal resource and improve electricity output at the Momotombo geothermal field; affected by the decline of pressure in the last two decades.

A geothermal master plan for Nicaragua was completed in November 2001.

In November 2002, the country's geothermal law was approved by the National Assembly.

In November 2002, a 7.5MW Ormat binary energy converter came on line, raising generation capacity at Momotombo.

In the past three years, the international atomic energy agency conducted isotopic studies around Mombacho volcano and Tipitapa area.

In October 2003, the government of Nicaragua granted an exploitation geothermal concession to San Jacinto power to develop the San Jacinto geothermal field to achieve 66MW. According to a generation license given to San Jacinto power, two backpressure turbines will be installed in 2004.

## 1. INTRODUCTION

Nicaragua is the Central American country with the greatest geothermal potential, on the order of several thousand megawatts (MW). Reserves that can be estimated with a higher degree of confidence total about 1100MW (klein, 2001). Medium and high-temperature resources are associated with volcanoes of the Nicaraguan depression, which parallels the pacific coast.

Geothermal exploration began in Nicaragua at the end of the 1960's, showing the large geothermal potential of the country and giving priority to the Momotombo and San Jacinto-Tizate fields. Studies increased after 1973, at a time when the oil crisis had a large impact on Nicaragua's economy.

During the 1993-1995 period, seven exploration-production wells were drilled in the San Jacinto-Tizate geothermal area with total depths between 724 and 2235meters, encountering temperatures from 264 to 289ºC. The production test demonstrated the commercial viability of the field with a proven capacity of 25 MW.

A Geothermal Master plan for Nicaragua was completed in November 2001, it assessed the geothermal resource potential of identified fields and prospects in the country (klein et al, 2001; Henneberger et al, 2002) (Fig 1).

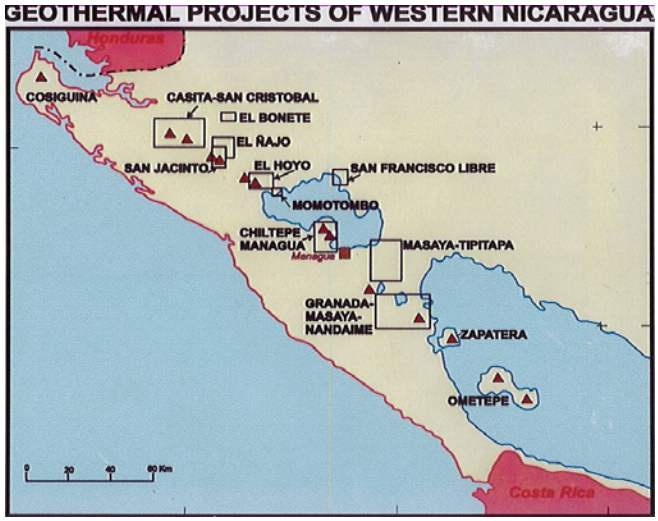


**Fig. 1 Location of the Geothermal Areas**

The three most promising geothermal areas are:

El Hoyo-Monte Galan. Located west of Momotombo, this field has an estimated capacity of 200MWfor 30 years.

Managua-Chiltepe. This is an area with a great geothermal potential, located 18km NW of Managua, Nicaragua's capital. It is estimated that the geothermal fluids could generate 150MW per 30 years.

Masaya-Granada-Nandaime. This area which includes several volcanoes and geothermal prospect areas is near the northwestern shore of Nicaragua's Lake. It could produce 200MW for 30years.

From 2001 to 2004, the International Atomic Energy Agency (IAEA) conducted isotopic studies around Mombacho volcano, south of the town of Granada; and at Tipitapa, an area near the shore of Managua's lake at the East of the capital. The ultimate goal of IAEA's assistance is to improve geothermal resource management and increase the sustainability of geothermal reservoirs.

## 2. NICARAGUA'S GEOLOGIC SETTING

Nicaragua is located in the middle part of the block Chortis, which is a unit of the continental crust that belongs to the

Caribbean plate. The geothermal resources of Nicaragua are situated in the SW sector of the country to the interior of a wide subsidize zone well-known as the Nicaraguan depression, parallel to the Pacific coast and the Mesoamerican trench. The Nicaraguan depression is flanked to the SW by the plateau and the relieves of the Pacific coast consist in a sequence of neritic sediments, composed mainly for clastic-volcano, deposited in the eldest Eocene and the superior Miocene, to the NE by the altiplane of the interior, where volcanic and sedimentary formations of the Tertiary show up (Oligocene to Miopliocene). (Fig 2)

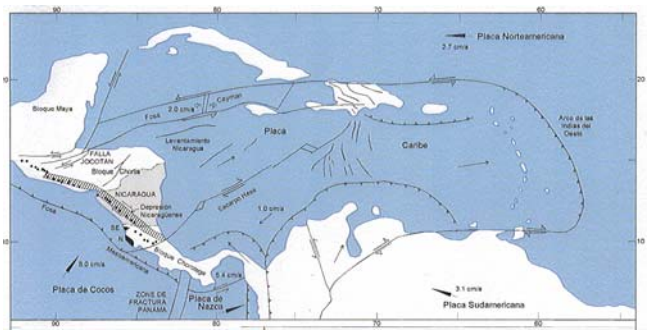


**Fig 2. Tectonic scheme of the Central America and the Caribbean Region. Central American Volcanic Arc.**

The Nicaraguan depression is in part occupied by the Managua and Nicaragua's Lakes, and includes a Quaternary volcanic mountain range, that is a segment of the Central American volcanic arc, originated through the subduction processes of the Cocos plate along the Central America trench. The volcanic mountain range extends with direction NW-SE from the Cosiguina volcano to the Concepción and Maderas volcanoes in the island of Ometepe (Nicaragua Lake) (Fig 1).

### 3. PRESENT PRODUCTION OF ELECTRICITY

In December 2003, the total installed capacity of the country was 692.56MW, from which 77.5MW was the geothermal electric installed capacity at the Momotombo geothermal field. The installed capacity for each type of power plant is presented in Table 1.

**Table 1. Total electric installed capacity in Nicaragua in 2003**

| Type of plant | Capacity (MW) | Percentage |
|---|---|---|
| Hydroelectric | 104.40 | 15.07 |
| Geothermal | 77.50 | 11.19 |
| Thermoelectric | 497.80 | 71.88 |
| **TOTAL S.I.N.** | **679.70** | **98.14** |
| Isolated Systems | 12.86 | 1.86 |
| **NATIONAL** | **692.56** | **100.00** |

Gross generation of electric energy in Nicaragua in December 2003 was of 2771.68 gwh, from which 270.70 gwh were produced in the Momotombo geothermal plant. Electricity generated for each type of plant is shown in table 2.

**Table 2 Total electric energy produced in Nicaragua in 2003.**

| Type of plant | Electric Energy (GWh) | Percentage |
|---|---|---|
| Hydroelectric | 297.39 | 10.73 |
| Geothermal | 270.70 | 9.77 |
| Thermoelectric | 2,172.73 | 78.39 |
| **TOTAL S.I.N.** | **2,740.82** | **98.89** |
| Isolated Systems | 30.86 | 1.11 |
| **NATIONAL** | **2,771.68** | **100.00** |

For the purpose of electric power generation using geothermal energy, Table 3 shows the present and planned generation plants.

**Table 3 Utilization of Geothermal Energy for Electric Power Generation**

| Power Plant Name | Year Com-Misio-ned | No. Of Units | Sta-tus [1)] | Total Insta-lled Capacity MWe | Annual Energy Produced 2004[3)] GWh/yr | Total Under Constr. Or Planned MWe |
|---|---|---|---|---|---|---|
| Momo-tombo | 1983 | 1 | | 35 | | |
| Momo-tombo | 1989 | 1 | | 35 | | |
| Momo-tombo | 2002 | 1 | | 7.5 | | |
| San Jacinto Tizate | 2006 | 3 | N | | | 66 |
| | | | | **77.5** | **270.7** | **66** |

The total investment in geothermal during the period 2000-2004 is shown in table 4.

**Table 4. Total investment in geothermal**

| Period | Research & Development Incl. Surface Explor. & Explora-tion Drilling Million US$ | Field Develop-ment Including Produc-tion Drilling & Surface Equip-ment Million US$ | Utilization: Direct Mi-llion US$ | Utilization: Electrical Million US$ | Funding Type: Priva-te % | Funding Type: Public % |
|---|---|---|---|---|---|---|
| 2000-2004 | $1.7 \times 10^6$ | $33 \times 10^6$ | | $34.7 \times 10^6$ | 5.0 | 95 |

Table 5 below shows the professional persons assigned by sectors to geothermal activities

**Table 5. Allocation of professional to geothermal.**

| Year | Professional Person-Years of Effort | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 2000 | 8 | | | | | 7 |
| 2001 | 8 | | | 12 | 3 | 7 |
| 2002 | 8 | | | | 3 | 7 |
| 2003 | 8 | | | | 3 | 7 |
| 2004 | 8 | | | | 3 | 7 |
| Total | 40 | | | 12 | 12 | 35 |

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

## 4. CONCESSION AREAS

Currently, INE has granted Concessions for geothermal exploration and/or exploitation in Momotombo and San Jacinto-Tizate. The Momotombo geothermal field was granted to Ormat International Inc and San Jacinto Tizate to San Jacinto Power.(Fig 1)

## 5. MOMOTOMBO GEOTHERMAL FIELD

The Momotombo geothermal field lies on the northwestern shore of Managua's Lake and on the southwestern slope of the active Momotombo volcano, which is located in the central sector of the Nicaraguan depression at the SE extremity of the Marrabios mountain range. The cone of the Momotombo volcano grew over oldest lavas formations, that are shown in the relieves of the hill la Guatusa, situated closely to the South East and to the East of the Momotombo volcano, and partially over the volcanic structure of the Monte Galán caldera that is located in the north west base of the volcano. Around the volcano either at the north zone or in the South West are shown a wide formations of tuffs and pumices generally known as; escudo ignimbritic de Malpaisillo(fig 3).


**Fig. 3 Geologic scheme of the Momotombo Area (Geothermex)**

In 1983 a 35 geothermal flash power plant was placed online. A second identical unit was installed in1989, bringing installed capacity to 70 MW. The first wells at the field were completed in early 1970s. Since then, 47 wells have been drilled for the purposes of exploration, injection and development. The depths of these wells vary from 313 m to 2983 m intersecting three different geothermal reservoirs: one is shallow (300m-800m), another is intermediate (from 800m to 1700m); and one is a deep reservoir (1700m-3000m). Locations of wells and the geothermal reservoirs are shown in Fig 4.

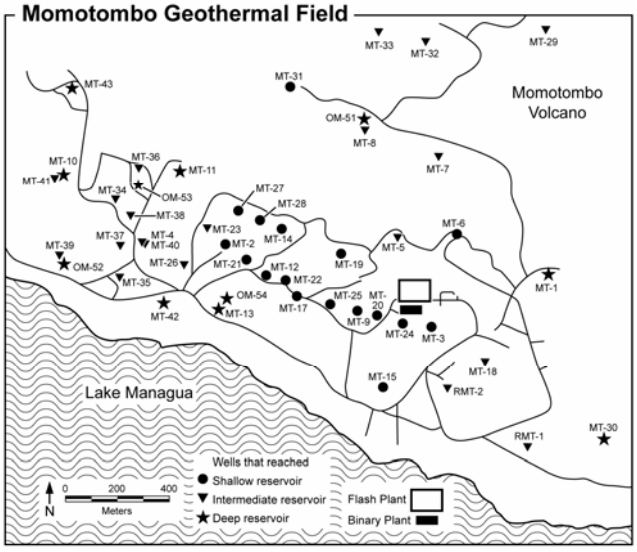


**Fig. 4 Location of wells and power plants**

The field now has 12 production wells and four injection wells (table 4 show the characteristics of the producing wells).

**Table 4 Characteristics of the producing wells**

| Well | Depth. meters | Pw | Vapor Flow | Water Flow | Total Flow | Enthalpy | Injected Water Flow |
|---|---|---|---|---|---|---|---|
| | | Bar g | T/hour | T/hour | T/hour | Kj/Kg | T/hour |
| MT-02 | 490 | 6.80 | 11.90 | 116.60 | 128.50 | 861.00 | 115.90 |
| MT-23 | 823 | 6.40 | 12.10 | 100.30 | 112.40 | 877.00 | 99.63 |
| MT-26 | 640.1 | 5.80 | 10.60 | 147.20 | 157.80 | 797.00 | 146.60 |
| MT-27 | 442.3 | 6.40 | 23.90 | 215.00 | 238.90 | 858.00 | 214.75 |
| MT-31 | 201.4 | 6.30 | 32.90 | 217.60 | 250.50 | 956.00 | 211.00 |
| MT-35 | 1295.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MT-36/ MT-43 | 1653/ 2495.7 | 5.40/ 5.50 | 19.50 | 34.60 | 54.10 | 1410.00 | 25.38 |
| MT-04 | 1435 | 9.30 | 16.20 | 75.40 | 91.60 | 1022.00 | 54.59 |
| MT-42 | 2093 | 5.70 | 9.00 | 56.80 | 65.80 | 731.00 | 55.89 |
| OM-53 | 2053 | 5.50 | 66.60 | 127.00 | 193.60 | 1377.00 | 108.90 |

In 1999, Ormat International, Inc won a 15 year Build-Operate-Transfer (BOT) contract to exploit the geothermal resources and improve electricity output at the Momotombo geothermal field; where the enthalpy and pressure of the producing wells have declined rapidly, affecting the steam output of the wells and the plant's electricity production. In early 1999, only 12 MW were being generated. Since then, the company has drilled four deep wells (Om-51 to Om-54), and of these only Om-53 was a good producer (9 to 11MW). Mineral scales have been cleaned out of eight production and four injection wells, using mechanical methods, in addition, chemical-scale inhibition systems have been installed in five wells.

About 83 percent of waste geothermal fluids are being injected back to the reservoir at this time (see table 4). These efforts have increased and stabilized the electrical output of the flash plant at around 29MW. In November 2002, a 7.5MW Ormat binary energy converter entered online, raising generation capacity at Momotombo to nearly 35 MW.

## 6. NICARAGUAN'S GEOTHERMAL LAW

In November 2002, the country's geothermal law was approved. It designates the Comisión Nacional de Energia (CNE) as the organization in charge to propose the Nicaraguan President new areas for geothermal exploration and development. Once the president has approved and declared such areas for exploration or exploitation, the regulatory entity Instituto Nicaraguense de Energia (INE) is assigned to issue request for bids.

According to this Law, INE will open an international geothermal bidding in year 2004, to explore and exploit two geothermal fields: Hoyo Monte Galán and Managua Chiltepe.

### 6.1 Main issues of the Law.

6.1.1 Governing Law

Law for Exploration and Exploitation of Geothermal Resources, No. 443, effective 20 November 2002 – published in the Gaceta No. 222 dated 21 November 2002.

Regulation to the Law No. 443, Decree No. 003-2003, effective 13 January 2003.

Presidential Decree on "Declaration of Areas for Geothermal Resources", effective 10 November 2003 – published in the Gaceta No. 220 dated 29 November 2003.

Law No. 479 – "Reform to the Law No. 43 – Law for Exploration and Exploitation of Geothermal Resources", effective 10 October 2003 – Published in the Gaceta No. 192 dated 10 October 2003.

6.1.2 Competent Authority

Instituto Nicaragüense de Energía (INE)

6.1.3 How to obtain a Concession for Exploration and Exploitation of Geothermal Resources.

International Bidding Round.

6.1.4 Signatories of the Concession

President of INE´s Board of Directors and a representative authorized by the concessionary.

6.1.5 Effective Date of the Concession:

Exploration: date of the awarding of the concession.

Exploitation: date of the signature of the Contract.

6.1.6 Legal Pre-requisites of the Concession

Non-Nicaraguan entities should register a society in Nicaragua and appoint a resident agent for legal purposes.

6.1.7 Granted Area

Exploration: Up to 100 square kilometers.

Exploitation: Up to 20 square kilometers.

The area will be specified in the contract, considering results related to the feasibility study, as well as capacity and extension of the geothermal reservoir.

6.1.8 Period of the Concession

Exploration: 2 years from the awarding of the Concession.

Exploitation: 25 years from the signature of the contract.

6.1.9 Guarantee

Concessionary shall deliver a guarantee for accomplishing to INE, which shall be for an amount corresponding to ten percent (10%) over the field investment.

6.1.10 Commercial Discovery

Contractor's decision once he has development at least one productive well.

6.1.11 Entitlement of Production

The holder of an Exploration Concession will be the owner of the power produced from the geothermal steam.

6.1.12 Production Valuation

Upon tons of steam produced.

## 7. NICARAGUA'S ENERGY POLICY

In March 2004, the president of Nicaragua approved by the decreto No 13-2004, the first energy policy for the country, with a principal objective of developing the Nicaragua's energy sector. The decreto, prioritizes the use of renewable energy resources within the national development plan.

## 8. CONCLUSION

The approval of the Nicaraguan's geothermal law and energy policies, put the foundations to attract local and foreign private investment in geothermal projects. In addition, the economic development of Nicaragua and the rest of Central America, could be improved with the integration of electricity markets in central America and Southeastern Mexico with the implementation of the Sistema Eléctrico para America Central (SIEPAC) and the Plan Puebla Panama. These two initiatives will lead to growth in electricity demand, as well as in increased exploitations of indigenous renewable energy resources, taking advantage of economies of scale. Thus, the country will become more attractive to the private sector. The final result will satisfy energy needs of Nicaragua, and improve the country's standard of living and its environment.

## REFERENCES:

Nicaragua´s Geothermal Master Plan. Geothermex Volume VII. Evaluation of the Momotombo Area.

Statistics Department INE.