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COSTA RICA COUNTRY UPDATE

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ABSTRACT

Exploitation and development at the Miravalles geothermal field have continued since the first unit of 55 MW was put on line in March 1994. During that same year, a 5 MW backpressure unit went into operation, and in 1998 a second condensing unit of 55 MW was installed. The energy produced by these plants represents about 20 percent of the nation's total energy consumption. During 1998-1999 the drilling campaign to obtain the steam required for a third unit of 27.5 MW was completed; this unit will be on line in May 2000. Finally, a portion of the heat available in the water that is currently injected will be used to operate a second-stage flash unit of 19 MW. The total installed geothermal capacity at Miravalles will therefore be 162.5 MW.

Feasibility studies of the Tenorio geothermal project are now underway, and the first of four deep wells in the Tenorio field has been completed. In addition, a pre-feasibility study of the Rincón de la Vieja geothermal project has been successfully completed.

1. USE OF GEOTHERMAL ENERGY IN COSTA RICA

Of the numerous geothermal areas that exist in the Republic of Costa Rica, three that are located in the volcanic cordillera of Guanacaste Province in the northwestern part of the country have been studied in detail. These are the areas of Miravalles, Tenorio and Rincón de la Vieja (see figure 1). Despite an abundance of zones with attractive geothermal resource potential, the use of geothermal energy has to date been limited to the utilization of high-enthalpy resources for electric power generation. This is due the country's tropical climate and incipient stage of industrial development (table 1).

Because Costa Rica has favorable climatic and topographic conditions, the country's principal energy source is hydroelectricity, which supplied 81 percent of the national electric energy consumption in 1998 (see figure 2). Recently, the level of generation from non-contaminating renewable resources has been expanded by the start-up of wind-power plants. Two more plants of this type are due to begin operation shortly.

2. MIRAVALLES

At present, all of Costa Rica's geothermal power generation is concentrated at the Miravalles geothermal field, where two single-flash units of 55 MW each are installed and have been in operation since March 1994 and October 1998, respectively (table 2). In addition, a small backpressure unit of 5 MW capacity was put on line in 1995 to take temporary advantage of the excess steam supply available. The information obtained from investigations carried out during field development indicates that the limit of possible expansion of the production area has effectively been reached in the northern, western and southern sectors of the field. At present, studies are being undertaken in the eastern sector of the developed area to confirm that the productive area of the field extends farther in this direction. By the middle of the year 2000, the installation of a 27.5 MW plant will complete the development of the area where exploitation is now concentrated. When this unit is in operation, the total installed capacity of the Miravalles field will reach 142.5 MW.

With the start-up of the third (27.5 MW) unit, the development of the known production area based on utilization of primary steam will have been completed. Additionally, studies of the use of a portion of the heat available in the waste brine from the plants, which is systematically reinjected at a temperature of 167°C, have been successfully completed. An additional unit of 19 MW will be installed to make use of low-pressure steam to be obtained from a second-stage flash of part of the waste brine; it is anticipated that this plant will begin operation in 2003.

A total of 45 wells have been drilled to supply the steam needed by the Miravalles plants (table 3). Two additional wells, now being drilled, are intended to obtain reserve steam for the system. Of the 45 wells drilled, 25 are in use as producers and 11 are used for reinjection of residual water. Another four wells of lower permeability are used to monitor the evolution of reservoir pressure, and three wells drilled at the periphery of the field are available as reserve wells for the reinjection system. Finally, two wells of very low permeability are effectively unusable for any purpose.

The 25 steam production wells have a production capacity of 153 MW, while the output of the four units operating at full load is 142.5 MW, leaving a reserve steam supply that is reasonable to cover the natural evolution of the reservoir. It is worth noting that four of the production wells located in the eastern sector of the field produce acid fluids, with pH in the range of 2.2 to 3.5.

Because the fluids produced from the reservoir tend to react within the wellbore to form and deposit calcite at the depth of flashing, a sophisticated system to inhibit calcite formation has been installed in all of the production wells. After six continuous years of operation of the calcite scale inhibition system, it can be said that the results have been totally satisfactory, having completely controlled the formation and deposition of the mineral.

Taking advantage of experience gained in the use of the calcite scale inhibition system, a system for neutralizing the fluid produced by the acid wells has been designed and perfected. This system, based on injection of a 50% solution of sodium hydroxide, allows the fluid pH to be raised to

between 5.5 and 6. Testing has confirmed that the process is technically and economically feasible for the conditions under which it will be applied at Miravalles.

The implementation of the neutralization system will allow the production of the four wells that produce acid fluids, equivalent to 23 MW, to be recovered. Well PGM-19, the first of the acid wells treated with this system, was placed in commercial production and integrated into the Miravalles system in November 1999. The steam production from the other three acid wells will gradually be integrated into the production system during the second half of year 2000.

Since the construction of the first two 55 MW plants, a change has taken place with respect to the source of financing used to cover the costs of studies, field development, and the purchase of plants and gathering systems. This change is due to modifications in the loan policies of the development banks, with which the development of this energy source has traditionally been financed. As a result, the construction of the third unit of 27.5 MW, which will begin operation toward the middle of 2000, was undertaken by means of a concession based on the BOT model. The BOT contract foresees the exploitation of the plant by the concessionaire during a period of 15 years; at the end of that time the installations will become the property of the Instituto Costarricense de Electricidad (ICE), which is the public institution charged by law with the generation of electricity in the republic of Costa Rica. It will be ICE's responsibility to supply steam for the plant during the period in which it is operated by the concessionaire.

3. TENORIO

Pre-feasibility studies of the area on the slopes of the Tenorio volcano at the headwaters of the San Lorenzo River were completed at the beginning of this decade. Based on the promising results of these studies, it was recommended that the investigations be continued and that four exploratory wells be drilled to confirm the existence of a reservoir that is economically exploitable for electricity production.

The Tenorio - San Lorenzo area (figure 3) is characterized by the presence of intense volcanic activity that has lasted since early Pleistocene time. This activity has created important volcano-tectonic collapse features, which are related to a shallow magmatic system that has given rise to an attractive thermal anomaly. The zone where the exploratory wells have been sited is located within a Pleistocene volcanic caldera, characterized by the existence of important geophysical anomalies that are associated with the largest geochemical manifestations in the study area.

It should be noted that the start of the feasibility-stage work for this project suffered a delay due to the creation of a national park that included a significant part of the area of geothermal potential identified in the pre-feasibility studies. It was not until mid-1999 that, having completed the Environmental Impact report and obtained the work permits from the Ministerio de Ambiente y Energía (Ministry of Environment and Energy), the construction of the drilling pads and the drilling of the first of the four programmed wells could begin.

Although good indications had been found during the pre-feasibility studies, the first of the exploratory wells was drilled to a depth of 2178 meters with poor results. No significant permeability was found in the volcanic units drilled, and the thermal gradient is lower than was anticipated.

In spite of these results, it has been decided to continue the drilling and eventual testing of the exploratory wells. If positive results are obtained from the new wells, the work will extend until the second half of 2000 and the feasibility report can be presented at the end of the same year. Should the existence of an exploitable geothermal reservoir be confirmed, it is foreseen that a power plant would be placed in the Tenorio field during the first part of 2006.

4. RINCÓN DE LA VIEJA

The geothermal area known as Rincón de la Vieja is found in the extreme northwest of the Guanacaste volcanic cordillera (figure 4), where zones that have been the subject of geothermal investigations are located along the southern flank of the Rincón de la Vieja volcanic massif. The principal zone of interest covers an area of approximately 10 km by 20 km, aligned along the axis of the cordillera.

The first studies carried out in the Rincón de la Vieja field concluded in 1976 with the presentation of a report at the pre-feasibility level. This report described three areas that are possible geothermal prospects, where high-temperature thermal manifestations coincide with other anomalies of geothermal interest. Subsequently, much of the area of geothermal potential identified in these studies was incorporated into the newly formed Parque Nacional Rincón de la Vieja (Rincón de la Vieja National Park). As a result, it became necessary to reassess the pre-feasibility according to these new prevailing land-use restrictions, and so an updated pre-feasibility study was completed during the second half of 1999.

Based on the results of the updated study, two areas, Borinquen and Las Pailas, have been proposed as being the most promising for drilling exploratory wells and carrying out feasibility studies. In both cases, Environmental Impact studies must be completed and the appropriate permits obtained from the Ministry of Environment and Energy before any activity associated with the drilling of exploratory wells is begun. Due to these limitations, it is estimated that the drilling operations for the five wells proposed cannot be initiated before the second half of 2001.

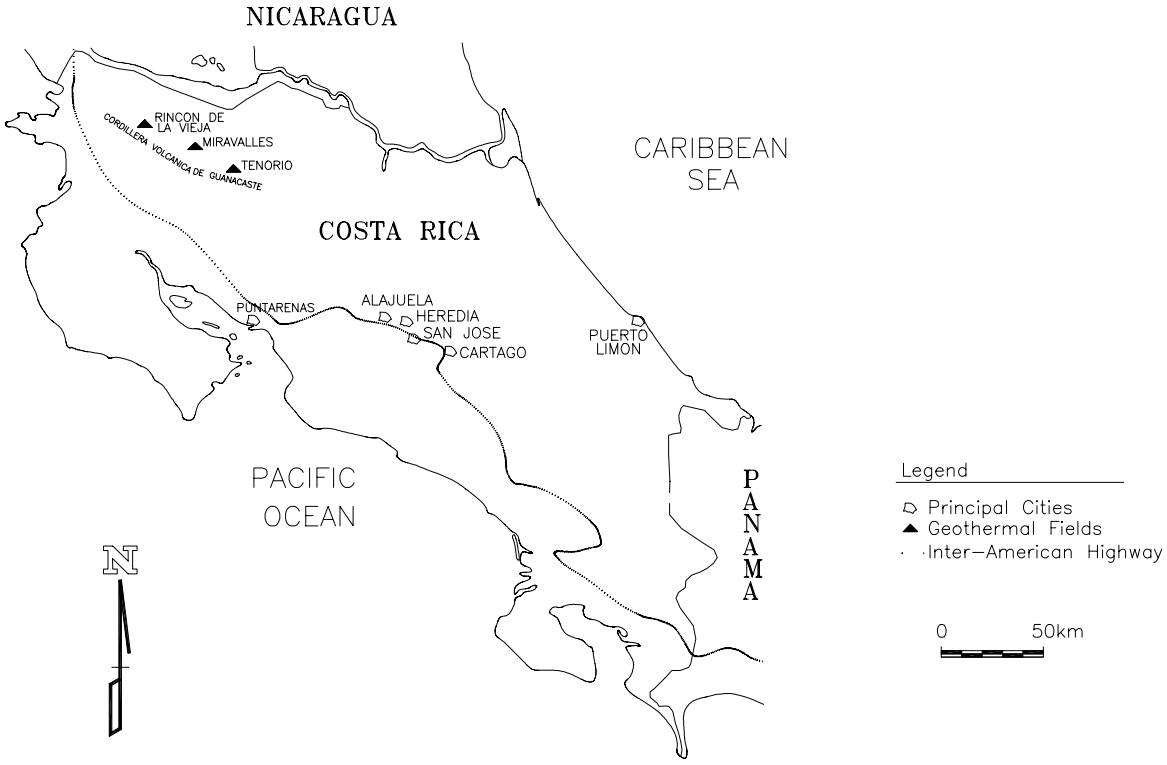

FIGURE 1: LOCATION OF GEOTHERMAL PROJECTS

Table 1. Present and Planned Production of Electricity

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (Wind Power)		Total	
	Capa-City Mwe	Gross Prod. GWh/yr	Capa-City Mwe	Gross Prod. GWh/yr	Capa-City Mwe	Gross Prod. GWh/yr	Capa-City Mwe	Gross Prod. GWh/yr	Capa-City Mwe	Gross Prod. GWh/yr	Capa-City Mwe	Gross Prod. GWh/yr
In Operation December 1998	115	592	288	450	1053	4687	-	-	24	65	1480	5794
Under Construction January 2000	27.5	229	72	112.5	184	725	-	-	40	108	323.5	1174.5
Funds comitted, but not yet under construction January 2000	19	158	36	56	55	217	-	-	-	-	110	431
Total projected used by 2005	161.5	979	396	618.5	1292	5269	-	-	64	173	1913.5	7399.5

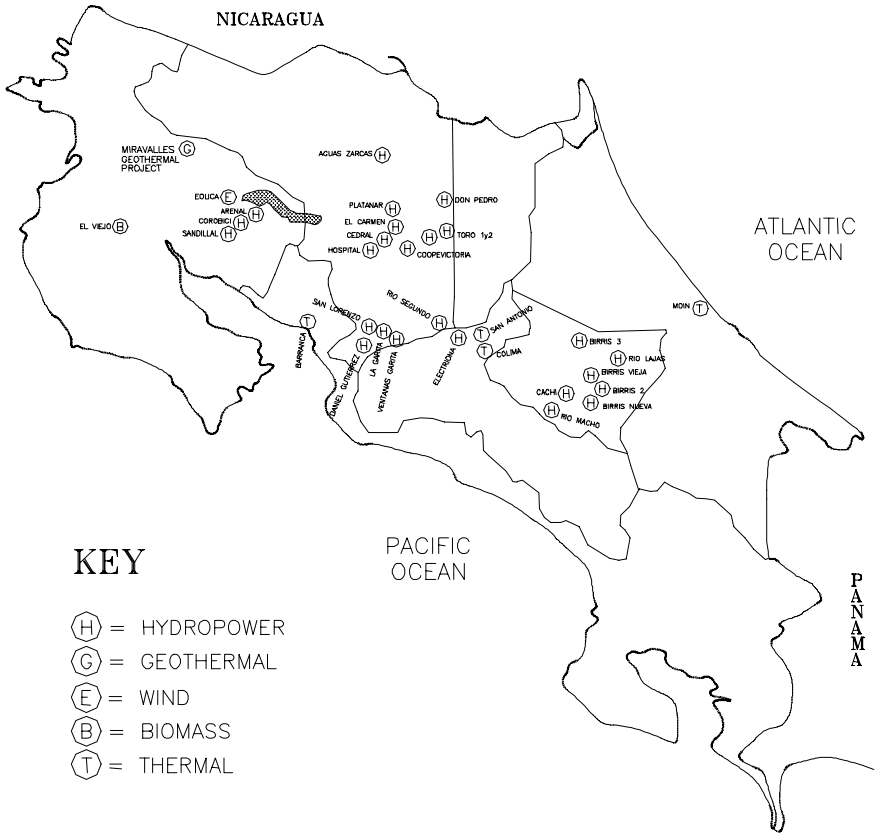

FIGURE 2: NATIONAL ELECTRIC ENERGY GRID
PRINCIPAL PLANTS IN SERVICE AS OF DECEMBER 1998

Table 2. Utilization of Geothermal Energy for Electric Power Generation as of December 31 1998

Locality	Power Plant Name	Year Commis-sioned	No. of Units	Status[1]	Type of Unit[2]	Unit Rating MWe	Total Installed Capacity MWe	Annual Energy Produced GWh/yr[3]	Total Under Constr. or Planned Mwe
Miravalles	Miravalles I	1994	1		1F	55	55	451	
"	Boca Pozo	1995	1		1F	5	5	39	
"	Miravalles II	1998	1		1F	55	55	71	
"	Miravalles III	2000	1	N	1F	27.5			27.5
"	Miravalles V	2003	1	N	1F	19			19
Total						161.5	115	561	46.5

1) N = Not operating (temporary), R = Retired; operating unless otherwise indicated
2) 1F = Single Flash B = Binary (Rankine Cycle) D = Dry Steam
2F = Double Flash H = Hybrid O = Other
3F = Triple Flash
3) Data for 1998

Table 3. Wells Drilled for Electrical, Direct and Combined Use of Geothermal Resources from January 1, 1995 to December 31, 1999

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other	
Exploration[1]	(All)	15	-	-	-	4.309
Production	>150° C	10	-	-	-	17.433
	150-100° C	-	-	-	-	-
	<100° C	-	-	-	-	-
Injection	(All)	6	-	-	-	10.010
Total		31	-	-	-	31.752

1) Thermal gradient wells only

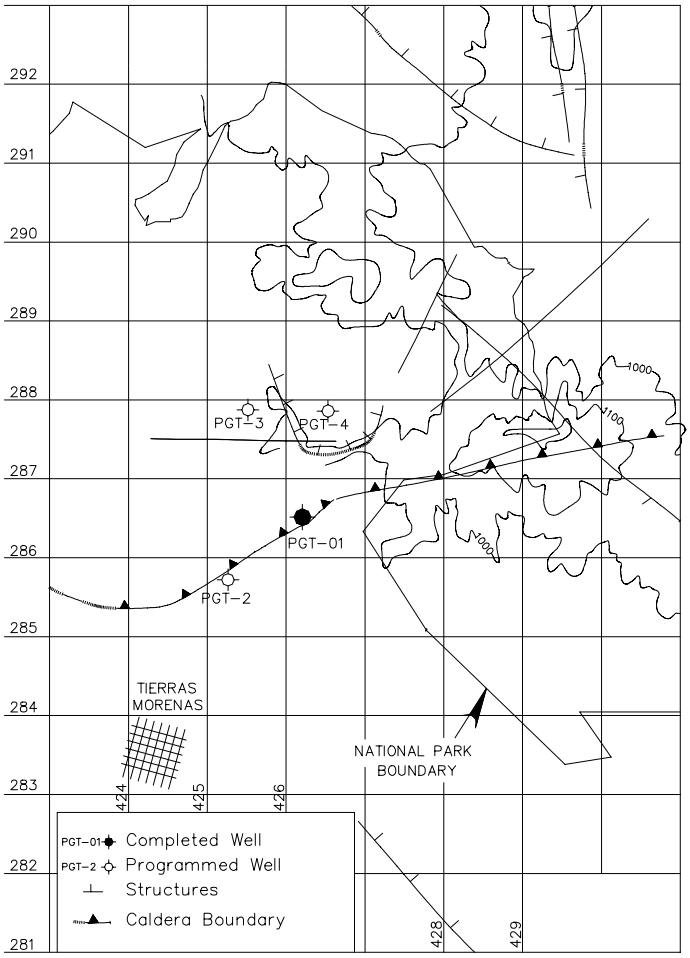

FIGURE 3: TENORIO GEOTHERMAL PROJECT

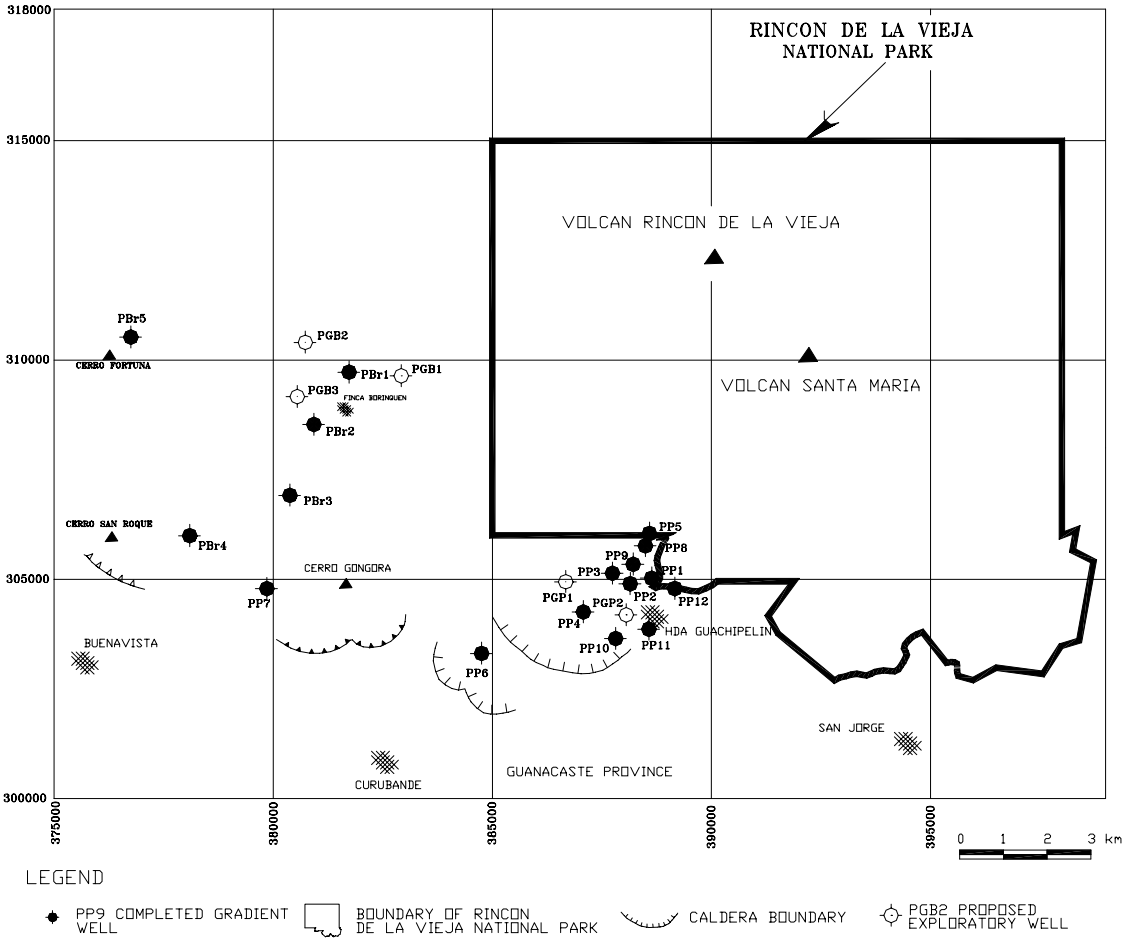

FIGURE 4: RINCON DE LA VIEJA GEOTHERMAL PROJECT