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GUATEMALAN GEOTHERMAL ENERGY

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ABSTRACT

For the past 26 years, Guatemala has conducted geothermal feasibility studies and research projects in different geothermal areas. This year (1998) the first geothermal plant at Amatitlán, will start operating on October 28th, with a pilot power unit of 5MWe. This will be followed by Zunil I, a power plant of 24 MW, scheduled to start operating in April, 1999. Other fields are open to private investors following guidelines of the new regulatory framework.

1. INTRODUCTION

Geothermal potential in Guatemala has been under research for 26 years. These studies are centred in 13 areas around the country. While studies in some of them are advanced, others are in various preliminary stages. The Zunil field and Amatitlán have completed feasibility studies and are ready to start production (West Japan Engineering Consultants et al., 1995).

The signing of the final peace accord on December 1996, ended the country's 36 year-civil war. As part of the peace process, the government is committed to increase spending on infrastructure expansion and social and economic development programmes. The Guatemalan population is increasing its demand for electricity. In order to increase the generation, transmission and distribution of electrical energy, the government set up a new legal framework in November 1996, known as the General Electricity Law. The main objectives of the law are to a) promote free competition in the electricity sector without privileges and distortions, b) regulate development of the generation, transmission and distribution of electricity and c) promote legal certainty for investors.

According to the law generation is free, although for exploitation of the geothermal resources the authorization of the Ministry of Energy and Mines is required. These authorizations could be temporary (one year) and for generation projects could, with Ministerial accord extend up to 50 years. The accord is granted by the Ministry after an application is presented. If more than one party expresses interest the bids will be evaluated in order to select one.

Results of 26 years of research have determined the Guatemalan geothermal potential along the Central American volcanic belt in 13 areas located in the southern part of the country from the Mexican border to the west to El Salvador in the east (INDE, 1997). These areas are shown in Figure 1.

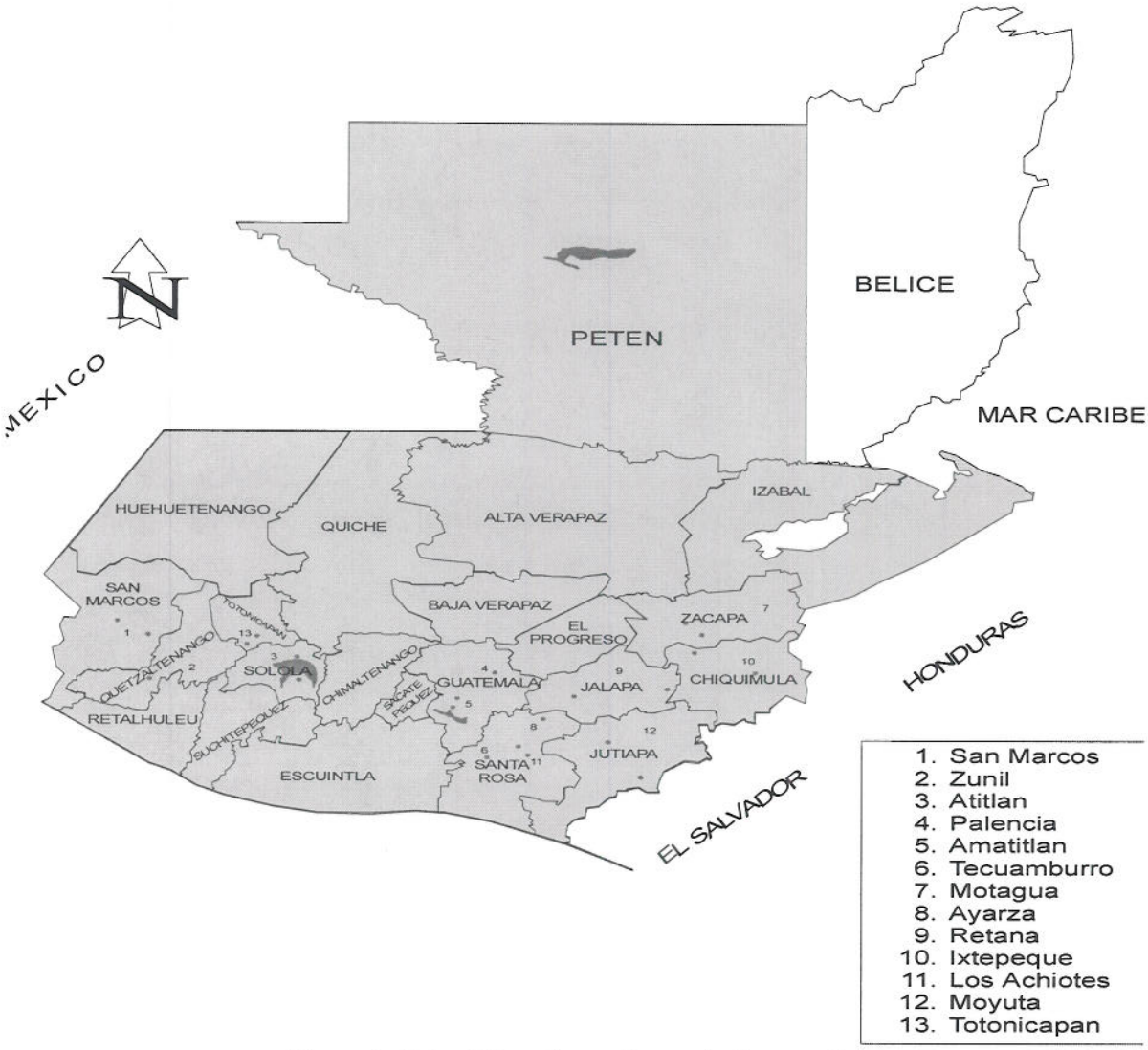

Figure 1: Potential geothermal areas in Guatemala

2. GEOTHERMAL AREAS OF INTEREST

In 1981 in a regional study, OLADE identified 13 geothermal areas in Guatemala. These are San Marcos, Zunil, Atitlán, Palencia, Amatitlán, Tecuamburro, Motagua, Ayarza, Retana, Ixtepeque (Ipala), Los Achiotes, Moyuta and Totonicapán. Seven of these have been subject to more detailed studies in different stages (INDE, 1997). Figure 2 presents an overview of this.

3. AREAS WITH PRE-FEASIBILITY AND FEASIBILITY STUDIES

The areas at this stage of study are four, Moyuta, San Marcos, Tecuamburro and Zunil II.

3.1 Moyuta geothermal area

The Moyuta geothermal area is located in the eastern part of the country. The area was one of the first studied. Results of geoscientific studies and the 12 slim holes drilled indicate that there are three

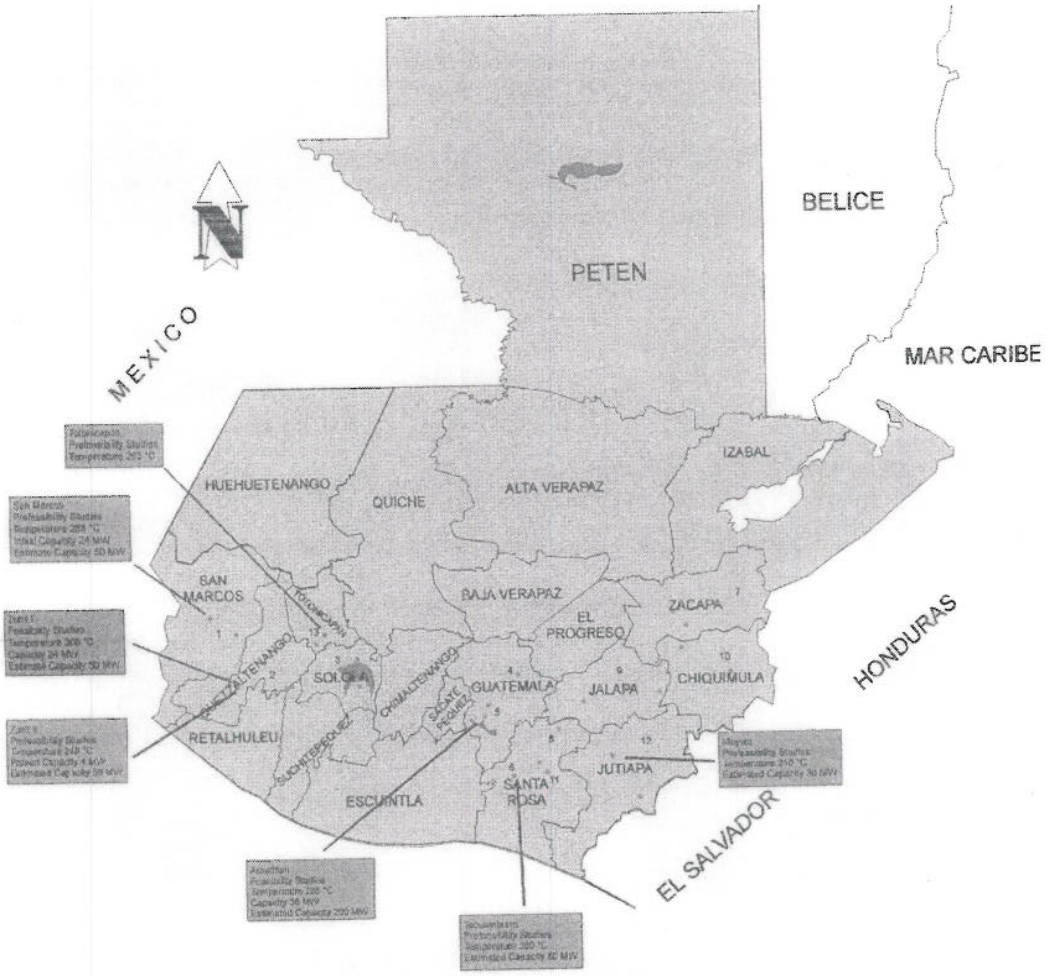

Figure 2: Geothermal areas where detailed geothermal studies have been conducted in Guatemala

important sites with possibilities of geothermal reservoirs. In response to these studies, the first geothermal model was drawn and two exploratory wells were drilled at 797 m and 1000 m depth with highest measured temperature of 114°C. In 1990, a reevaluation of the area was done in cooperation with the Los Alamos National Laboratory. Subsequently, they concluded that there are other sites in Moyuta where it is possible to find geothermal resources with high temperature. Capacity is estimated at 30 MW with a temperature of 210°C.

3.2 San Marcos geothermal area

The San Marcos geothermal area is located 250 km west of Guatemala City, covering an area of 85 km^2. A prefeasibility study of the area was realized in cooperation with the European Community, and the project was called GEOTERGUA. As result of the studies, the existence of a geothermal reservoir with temperature of 255°C and initial capacity of 24 MW was estimated.

3.3 Tecuamburro geothermal area

Tecuamburro geothermal area is located southeast of Guatemala City. Feasibility studies were conducted in 1994, and one slim-hole well was drilled to 806 m depth, with 235°C temperature. The capacity is estimated to be 30 MW.

3.4 Zunil II geothermal area

Zunil II geothermal area is located 2 km east of Zunil I. 16 km² have been selected for research. Two slim and 1 commercial size wells have been drilled; one of them had 35 Ton/hr of dry steam and a measured temperature of 260°C. The prefeasibility studies (Cordon y Mérida et al., 1993) of the area confirmed the existence of a geothermal reservoir with an estimated potential of 40-50 MW.

4. GEOTHERMAL AREAS READY TO START PRODUCTION

4.1 Orzunil I (Zunil geothermal project)

Geothermal exploration at Zunil started in the 1970's. Prior to deep geothermal drilling, many slim holes were drilled. At present, 9 deep geothermal wells have been drilled, 3 of which are directional (Figure 3). Of the deep geothermal wells, seven are productive. Their characteristics, based on various tests, are given in Tables 1-2.

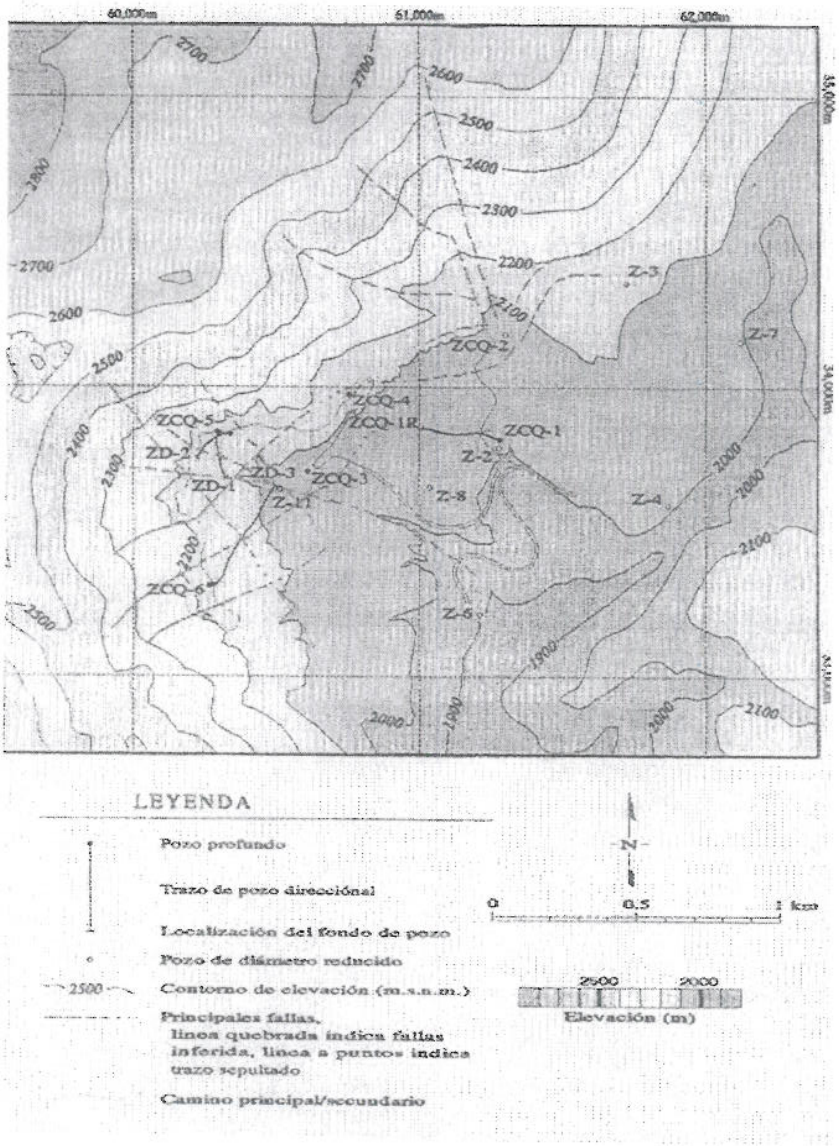

Figure 3: Geothermal well locations at Zunil (Cordón Y Mérida et al., 1993)

Table 1: Production characteristics of Zunil wells
(Atmospheric pressure at Zunil is 11 psi = 0.78 bar)

Well	Date	WHP (bars-g)	T_{max} well (°C)	$T_{bottom\ hole}$ (°C)	Enthalpy (kJ/kg)	Mass flow (tons/h)
ZCQ-3	15/05/84	4.20	271	264	1520	17.1
ZCQ-4	27/03/84	8.96	255	255	2795	8.8
ZCQ-5	03/09/85	4.89	276	276	2795	8.4
ZCQ-6	01/06/84	4.75	288	288	1150	17.0
ZD-1	16/10/92	9.58	297	291	1380	80.7
ZD-2	16/10/92	10.27	294	289	1470	53.4
ZD-3	01/03/93	3.93	290	287	2040	9.1
					Total	**194.5**

Table 2: Summary of well characteristics at Zunil

Well no.	Depth (m)	Depth of producing aquifers (m)	$T_{aquifer}$ (°C)	T_{max} for well (°C)
ZCQ-3	1040	700	265	
ZCQ-4	1020	400,700	249	265
ZCQ-5	1080	900[a]	255	291
ZCQ-6	1140	950	290	
ZD-1	1516	750, 1500	296	Deeper aquifer
ZD-2	1784	850, 1450	293	
ZD-3	2370	1100	292	

In 1993, INDE contracted Ormat to construct and operate a 24 MW power plant at Zunil which should have started operation in August 1995. Due to different situations, the start-up of ORZUNIL has been delayed, but the problems have now been clarified and a new date for initiating operations has been set for April, 1999. INDE will be responsible for operating the wells, the steam supply system and providing steam to the power plant, as well as reinjecting waste fluid. The intention is to connect the directional wells (ZD-1, 2 and 3) plus well ZCQ-3 and 6 to the power plant. The layout of the geothermal power plant is shown in Figure 4.

The plan is to convey the geothermal water from the wells to the power house at 9.2 bars gauge (180.8°C) and mix it with condensed steam at 170.5°C at a ratio of 66/34 so the final mixture will reach a temperature of 177.3°C. Subsequently, the mixture will be cooled down in a preheater to 112°C.

Actually, Ormat has contracted a company to drill two reinjections wells close to ZCQ-2 (800 m deep), a well that has proven its permeability. The infrastructure for the pipe lines in the area is under preparation. However, ORZUNIL will have to make their best efforts to initialize the operation by the proposed date.

4.2 Amatitlán geothermal power plant

Amatitlán geothermal field is located 30 km south of Guatemala City, on the outskirts of Pacaya volcano, which is constantly erupting. 10 slim holes and four exploratory wells called AMF have been drilled in the area (1992-93); two of them AMF-1 and AMF-2 are productive with a potential of 6 and 7 MW, respectively. Wells AMF-3 and AMF-4 did not response to production. Their characteristics are summarized in Table 3.

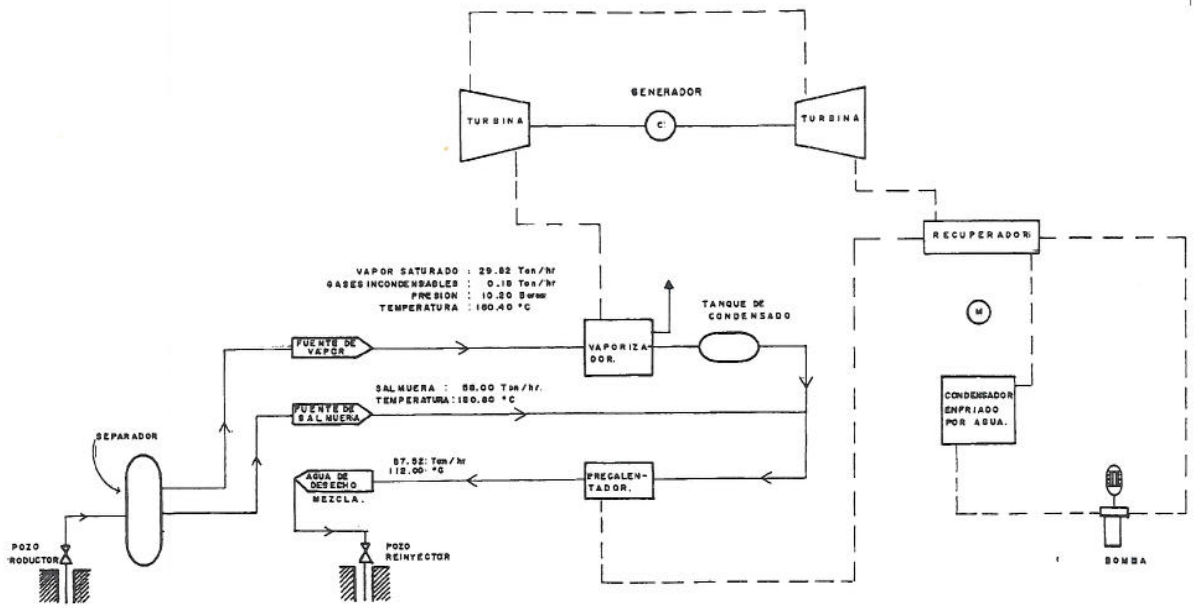

Figure 4: Layout of Orzunil power plant

Table 3: Production characteristics of Amatitlán wells

Well	Date	Depth (m)	T_{max} (°C)	WHP (kg/cm²)	Enthalpy (kJ/kg)	Qt* (tons/h)	Qa* (tons/h)	Qv* (tons/h)
AMF-1	8/7/94	1,581	280	11	1250	165	125	40
AMF-2	23/8/94	1,502	295	8	2080	80	25	55
AMF-3	20/5/94	1,500	231	0				
AMF-4	1/9/94	2,058	240+	35**				

* Calculated at separation pressure of 7.03 kg/cm² ** Static wellhead pressure
\+ Maximum temperature at 1750 m during drilling.

Chemical and isotopic data indicate that the thermal fluid is a mixture of magmatic water and deeply circulating meteoric water originating from high altitude precipitation. The chemistry of the production wells is in Table 4, and Figure 5 shows the locations of the AM and AMF wells series in Amatitlán.

Table 4: Chemical characteristics of AMF wells (mg/l)

	AMF-1	AMF-2		AMF-1	AMF-2
Date	6/07/94	23/08/94	SO_a	28	27
WHP (kg/cm²)	11	8	Cl	4,049	3,797
H (kJ/kg)	1250	2080	SiO_2	567	935
X (vapour)	0.26	0.67	B	43.28	63.19
pH	7.01	6.51	Fe	0.13	0.29
Ca	79.21	62.10	F	1.03	0.96
Mg	-0.16	1.22	As	7.59	7.75
Na	2,298	2,188	TDS	7,610	6,950
K	495	448	CO_2*	5,510	17,200
Li	15.70	12.55	H_2S*	79.7	233
HCO_3	38	39			

* Concentrations in ppm-weight in the steam.
Samples taken under flowing conditions, 20 days after the initialization of production tests

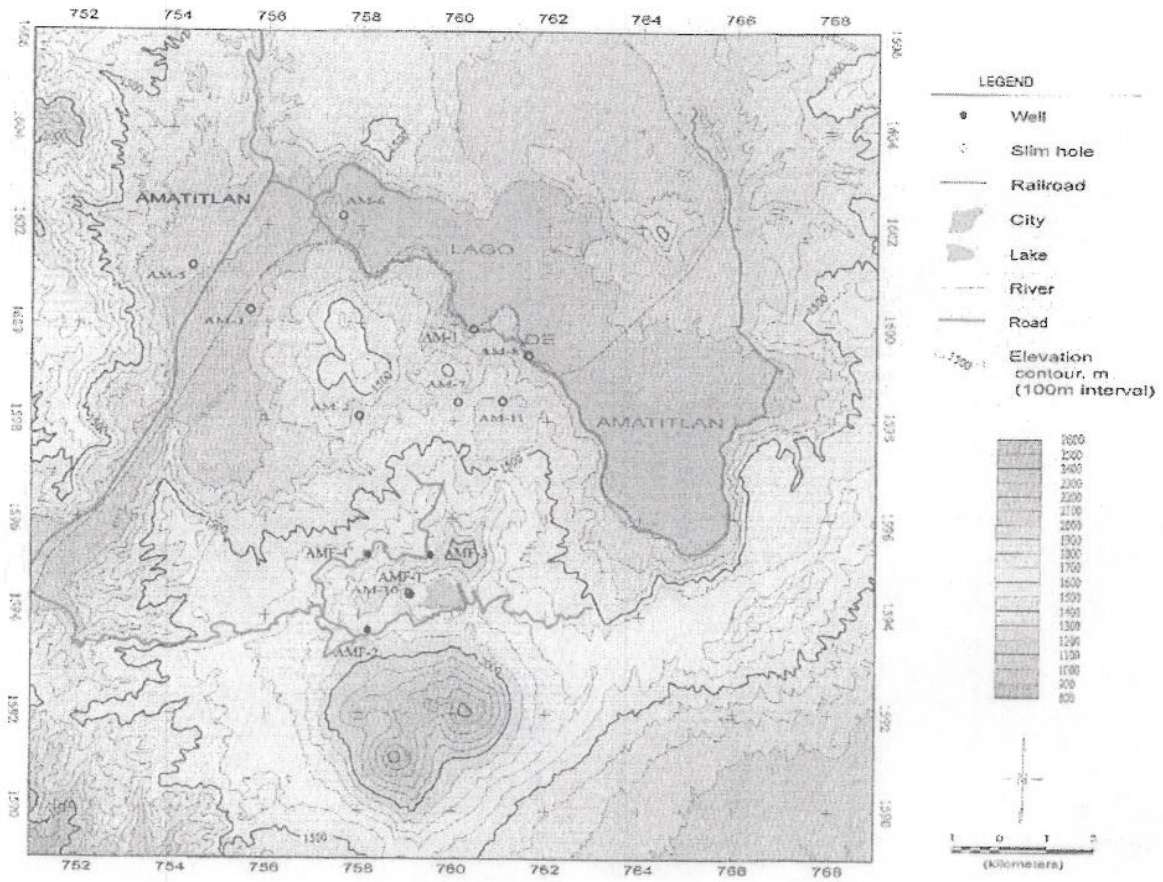

Figure 5: Topographic map of Amatitlán showing location of wells

The geothermal power plant at Amatitlán is ready to start operation. It will be the first of this type in the country. The power plant will be a backpressure turbine of 5 MWe installed under a three year contract with ICA (Civil Engineers Associated) and CFE (Comisión Federal de Electricidad) from Mexico who will provide electricity to the country national grid, evaluate the potential of the geothermal reservoir and the behaviour of the two production wells in the area.

The steam will be provided by the two productive wells AMF-1 and AMF-2. INDE will buy the electricity that is produced and ICA & CFE will maintain the plant, monitor the field and production wells, and evaluate their capacity for three year term.

The layout of the power plant is shown in Figure 6.

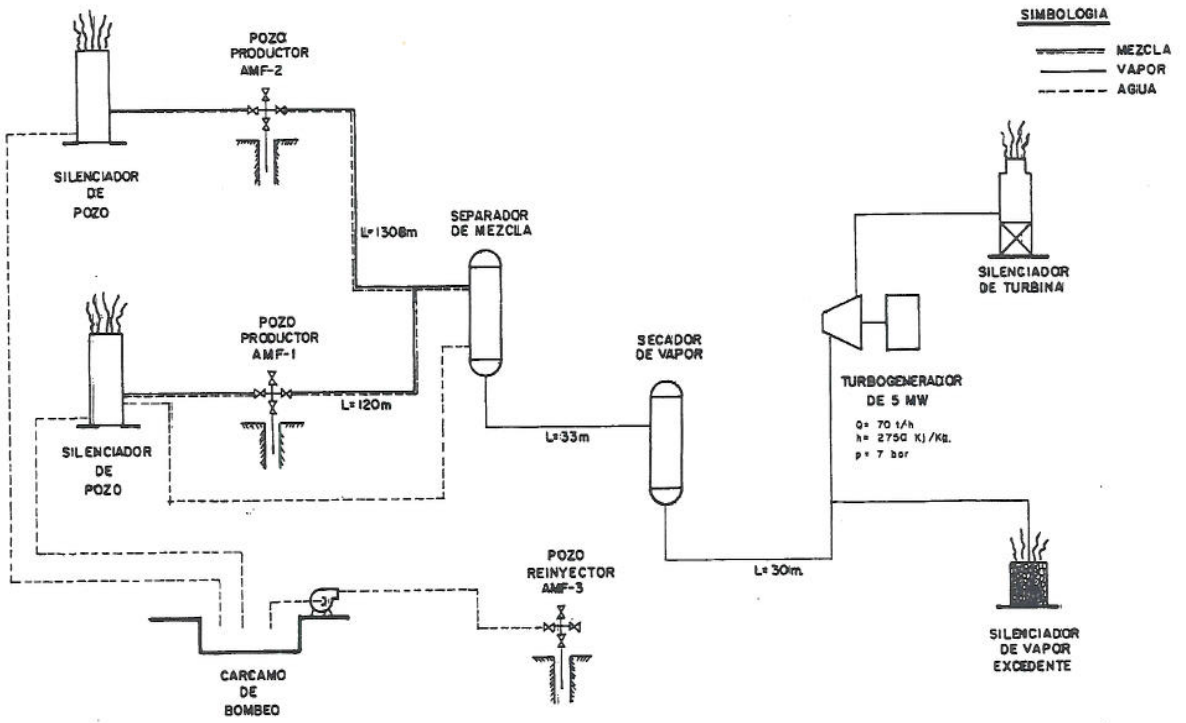

Figure 6: Layout of the Amatitlán power plant (West Japan Engineering Consultants Inc., 1995)

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