PRESENT STATUS AND LEGAL ASPECTS OF GEOTHERMAL DEVELOPMENT IN GUATEMALA, CENTRAL AMERICA

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ABSTRACT

The Republic of Guatemala, as part of Central American isthmus is a little portion of the volcanic ring belt that surrounds the Pacific Ocean. This volcanic ring is a zone of intense volcanic activity and a high geothermal potential associated with it. Nowadays in Guatemala had been studied jive high enthalpy geothermal areas, all of them in different development stages, from preliminary prefeasibility to the development of a power plant that will be installed within the next months. Furthermore, according to an inventory ofgeothermal resources carried out in 1981, it had been identified at least 8 different areas that have the appropriated characteristics to be geothermal areas that are worth to be studied in detail. The geothermal exploration in Guatemala began in the 70's by the government agency Instituto Nacional de Electrificación (National Institute of Electrification -INDE-) through the Unidad de Desarrollo Geotérmico (Department of Geothermal Gevelopment -UDG-). Nevertheless, Guatemala is one of the lower electric service countries in Latin America. Thisfact, and the privatization boom that is happening throughout the world, has made the Government to take the decision of allowing private companies to participate in electrical generation projects. So, in the lastfew years private companies had begun to operate mainly in thermal and hydroelectric generation. The geothermal main activities include the building of the first geothermal power plant in Zunil by a private company. The Amatitlán geothermal field actually has two productive wells and the reservoir engineering confirm the economic feasibility of this project. Recently, the Parliament discussed and approved a new electrical law that changed dramatically the roll of private inversion on the electrical subsector in Guatemala. This article presents a broad description of the five main geothermal areas and a general perspective of fhe effects that this law will produce specially in the geothermal electric generation and the participation ofprivate companies inside this new law.

1.0 INTRODUCTION

The exploration and development of geothermal resources in the Republic of Guatemala, have been carried out by the Instituto Nacional de Electrificación -INDE- through the Unidad de Desarrollo Geottrmico, with the purpose to profit this resource as load energy for electrical generation.

Geothermal studies had been carried out since 1972 in different areas of the country, with loans of institutions like Interamerican Development Bank (IDB), Organization of Petroleum Export Countries (OPEC), and financial and technical aid of Japan Government, Latin American Energy Organization (OLADE), ROCAP/AID and the European Economic Community (EEC).

2.0 REGIONAL LEVEL RECOGNITION STUDIES

The first geothermal researches in Guatemala, were carried out in 1972 in Moyuta field. In this area there are geothennal manifestations that seem to indicate high probabilities to find out geothermal resources with adequate conditions for its exploitation for electrical generation. In 1976 the investigations were moved to Zunil field.

In order to obtain a national inventory of geothermal resources and to improve criterions to define the research priorities of the most attractive areas, UDG's personnel and BRGM of France, with INDE's and OLADE's funds, carried out regional exploration studies in 1981, in 13 different areas located in Guatemala volcanic province, that is located in east-west direction, from Mexico's border to El Salvador border, and from Motagua's fault system in the north to the Coastal Plain province in the south, covering about 30% of national territory **(Fig.** 1).

The geovulcanological, geochemical and geophysical studies indicated that there were another geothermal areas besides Zunil and Amatitlán that were been studying those days. That areas are San Marcos and Tecuamburro which had to be studied in a more detailed way

As a result of this study also there were identified another areas of geothermal importance, like Los Achiotes in Santa Rosa Department, Moyuta in Jutiapa Department, and Ixtepeque-Ipala in Chiquimula Department. In these areas the temperatures are between 130°C in Moyuta to 180°C in Ixtepeque. In a **third** category were classificated the geothermal areas of Palencia, Retana, Ayarza, Atitlán and Motagua, where the springs are limited or inexistents, and therefore the geochemical analysis are not reliable and are necessary additional detailed studies.

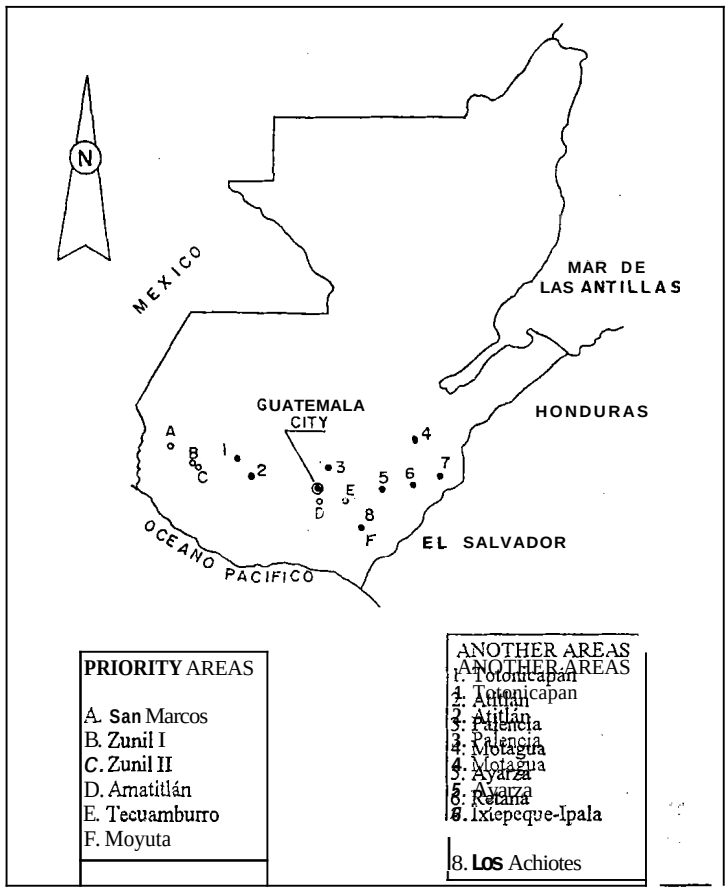

Figure 1. Geothermal areas of Guatemala

3.0 MOYUTA GEOTHERMAL AREA

Moyuta geothermal area is located in the eastern part of the country within the volcanic province, **in** Jutiapa Department (Fig. 2). The first preliminary studies (geology, geophysics and geochemistry) begun in 1972 **with** INDE's personnel, covering **an** area of about 1000 Km^2. In 1974 there were carried out prefeasibility studies, defining a 330 Km^2 area. In November 1975 **an** Italian company was contracted to make an evaluation of the previous studies and to complement them.

As a result of these geoscientific investigations, and with the information obtained from the drilling of 12 exploratory slim holes, there were identified three important areas, probably related with a geothermal reservoir. Then, a 10 Km^2 area was chose for further detailed studies.

The next **step** was the elaboration of a first hydrothermal model, that helped to select the targets for the drilling of two exploratory wells of commercial diameter. The registers obtained in both wells (797 and 1000 m depth), indicated a maximum of 114°C of temperature. This value **was** not adequate for the exploitation for electrical generation. For this reason, the exploratory activities in this area were suspended on March, 1976.

Nevertheless, the studies of Moyuta area, were not determinant to abandon completely the field. The necessity of additional investigations in order to profit the low enthalpy resources for industrial and agricultural use, and also for electrical generation using binary cycle systems were fulfilled with a Cooperation Project between INDE and Los Alamos National Laboratory, for a reevaluation of Moyuta geothermal system in 1990.

The reevaluation (focused on geochemical and geothermometrical aspects) established that there are another alternatives to drill new exploratory wells. The geochemical data suggests the existence of two different reservoir with temperatures of about 170° and 210°C. If the data are confirmed, Moyuta geothermal resources are adequate for the exploitation for electrical generation and alternate applications.

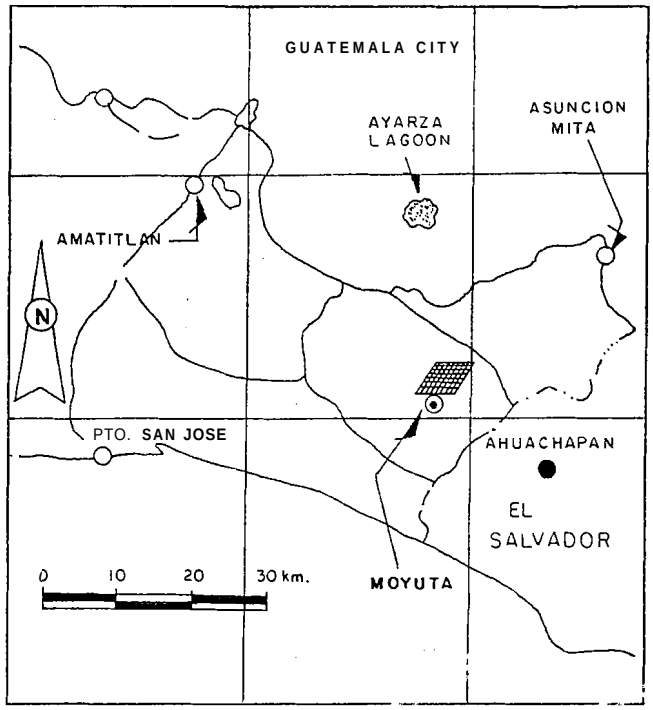

Figure 2. Moyuta Geothermal Area

4.0 ZUNIL I GEOTHERMAL AREA

Zunil I geothermal area is located 200 Km west of Guatemala city, in Zunil township of Quezaltenango Department (Fig. 3).

The first preliminary studies were carried out between 1973-1977, with technical aid of Japan Government, whom sent three missions.

From 1977 UDG of INDE with national geoscientific personnel accomplished geovulcanological, geochemical and geophysical studies in an 310 Km^2 area, in order to carry through the prefeasibility level study of this area. Additionally 18 exploratory slim holes were drilled. To agree with the obtained results, in 1979 a 4 Km^2 area was selected to carry out feasibility studies. This first evaluation stage was called Zunil I, because at that time the geoscientific studies showed that in the outskirts there were possibility to find geothermal resources; this area was named Zunil 11.

From March 1980 to October 1981 there were drilled in Zunil I field, six deep exploratory wells within an area of 1 Km^2.

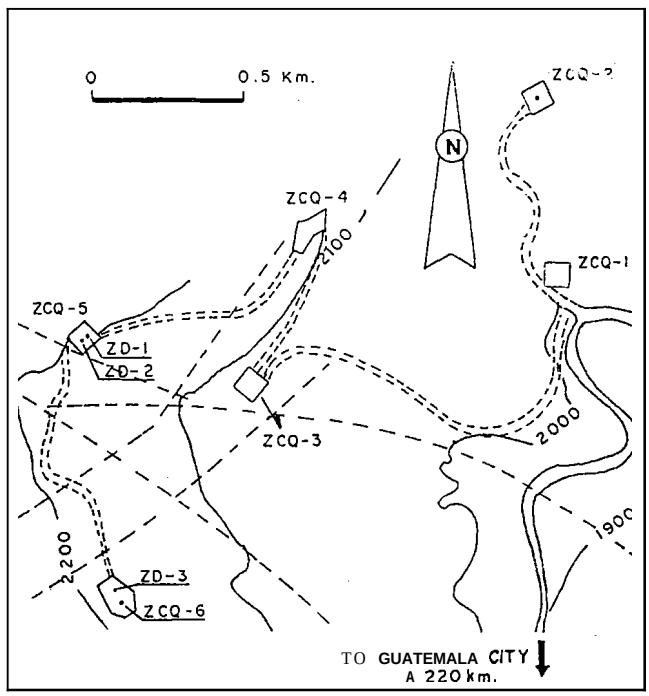

Figure 3. Zunil I Geothermal Area

Four of them are production wells. In May 1980 consultory services of an Italian Company were contracted with the purpose of evaluate the geothermal field and a geothermal power plant.

In March 1982 the Evaluation of Zunil I Field Potential Feasibility Report was edited in which it was sustained that there is a 15 MW potential for 20 years of lifetime. They recomnicndcd lo drill three additional wells in order to maintain the necessary vapor flow. Nevertheless because the low permeability of the reservoir, there were doubts about its capacity.

The additional studies confirmed the existence of a deeper geothermal reservoir within the granodioritic basement provoked by fault systems. Because that, the targets were relocated, recommending to drill them directionally to intercept the faulting to depths of about 2000 m.

The drillings were carried out successfully between 1991 and 1992, with a production above 12 MW for the first well and approximately 24 MW if three additional wells are drilled. According to the numerical simulation of the reservoir it is probable that this power can be maintained for 25 years.

As part of the process to stimulate the participation of private sector in electrical generation activities, in 1992 INDE resigned partially of IDB's loan destined to purchase the electromechanical equipment for the power plant and to invite interested companies to build and operate a geothermal power plant in Zunil I geothermal field.

After a bid at auction a contract was adjudicated and signed with ORZUNIL company in December 1993. In this contract the company binds to install a geothermal power plant of 24 MW.

This project has suffered some delays because interpretation divergences of the legal instrument. It is programmed that by 1998 the Zunil I power plant will begin it operation.

5.0 AMATITLAN GEOTHERMAL AREA

This geothermal area is located 24 Km. south of Guatemala city, in Guatemala Department,. behveen Amatitlán, Villa Canales and San Vicente Pacaya townships (Fig. 4).

The first studies in this area were carried out from 1977 by INDE's personnel. The studies were temporally suspended in 1979 because by then, the attention was focused in Zunil. In 1980 the studies were systematically renewed, in an 170 Km^2 area.

The prefeasibility studies include the drilling of ten exploratory slim holes, eight of them drilled by INDE and the other two by a foreign company.

With IDB and OPEC loans there were carried out prefeasibility studies in Amatitlán by an Italian company in January 1989. The final report recommended to continue the feasibility studies because the existence of a geothermal resource, commercially exploitable.

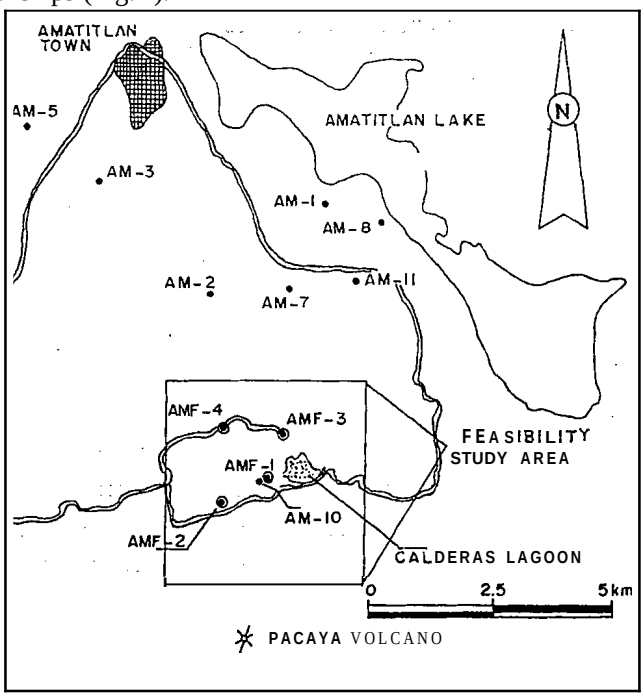

Figure 4. Amatitlán Geothennal Area

In 1991, with an IDB loan, there was contracted a Japanese company in order to make the feasibility studies. This works included the drilling of four deep exploratory wells of commercial diameter, from which the inforination obtained was used to elaborate a conceptual model of the reservoir and to foretell through numerical simulations of reservoir engineering, the potential of the resource.

This mathematical model was performed in a relatively small area, and indicates that the potential of the field could be greater with a minimum of 50 MW.

6.0 *SAN* MARCOS GEOTHERMAL AREA

This area is located 250 Km^2 to the west of Guatemala city, in the San Marcos Department. It covers an area of 85 Km^2 (Fig. 5).

In 1981 as part of the national geothermal inventory, San Marcos area was identified as a very important area. In the late eighties INDE carried out geoscientifk research in this area, mainly geophysics studies.

In September 1993, through a Cooperation Project (Geotergua) with the European Community, for the geothermal potential development of San Marcos area, were initiated the prefeasibility studies of San Marcos (geovulcanology, geology, geophysics, geochemistry, neotectonic, environmental impact) and actually the final report is on preparation.

According to the studies, the existence of a reservoir has been confirmed, **with.** temperatures adequate for its exploitation for electrical generation, with an initial minimum capacity of 24 MW.

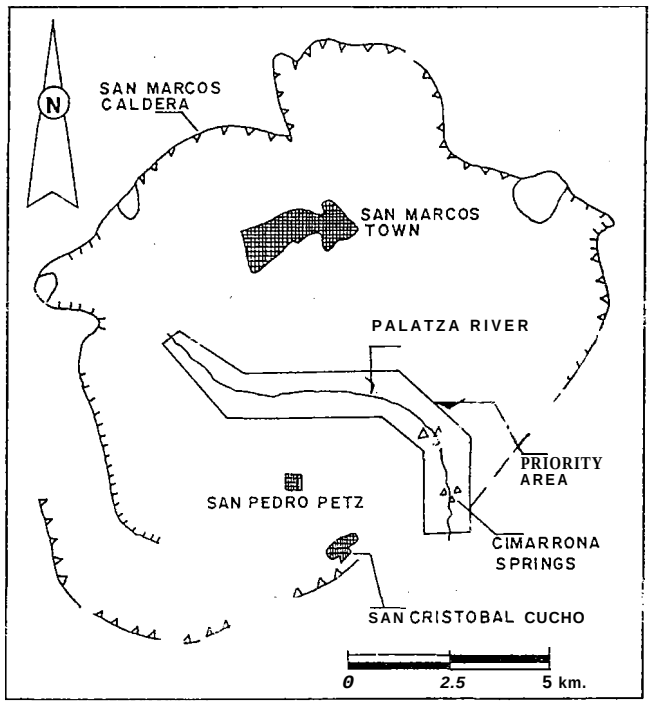

***Figure 5.** San Marcos Geothermal Area*

Moreover, taking as reference the conceptual model of the prefeasibility study, it has been performed a preliminary technical-economical evaluation of geothermal resource in this field. It were assumed the same parameters for three different plant types (condensation, backpressure and binary cycle). The analysis issues showed that the geothermal generation is lower cost than other energy alternatives used in Guatemala, 4.16, 4.37 and 5.23 US$ cents/Kwh for each plant type respectively.

It has been searched for a renew of the Cooperation to the European Community, in order to begin the next stage **of** development, that will be the drilling of three slim holes that will aid to confirm the surface studies and therefore to reduce the risks on future inversions.

6.0 TECUAMBURRO GEOTHERMAL AREA

This geothermal area is located some 70 Km. southeast of Guatemala city, in Santa Rosa Department, in slope of Tecuamburro volcano (Fig. 6).

The geothermal manifestations are present in a 400^2 Km area, most of them (fumaroles and hot springs) are located near Ixpaco lagoon, north of Tecuamburro volcano, and along Los Esclavos River east-northeast of this volcano.

Since 1984, INDE in collaboration with Los Alamos Laboratory, had been carried out geoscientific studies (geology, geophysics, geochemistry) that indicate the possibility of two different reservoirs, one of them of about 300°C.

In 1990 an exploratory well of small diameter was drilled, up to 806 m depth, with a measured temperature of 235°C.

The results indicate that the area could have an high potential for its exploitation in order to generate electricity.

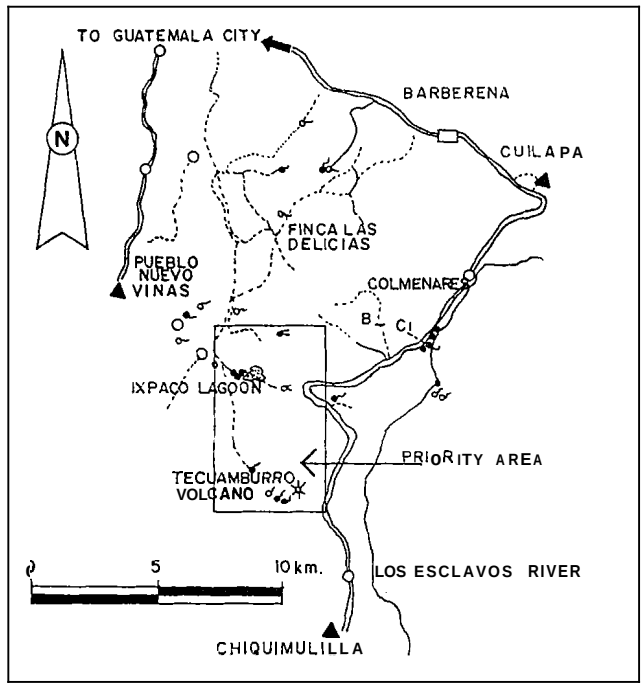

Figure 6. Tecuamburro Geothermal Area

7.0 ZUNIL II GEOTHERMAL AREA

This area is located to the east of Zunil I area, and Samalá River as natural border between both areas (Fig. 7).

The first geoscientific studies were carried out by a Japanese Company, beginning in 1989 covering an 150 Km^2 area.

The consultants performed a reinterpretation of INDE's data, choosing a 16 Km^2 area as priority area. In this area, additionally to the surface geoscientifk studies, three slim holes were' drilled of about 700-800 m depth. One .of this wells was successful and a short production test was performed that allowed to measure a 35 Ton/hour dry vapor production.

This fact probes the existence a shallow geothermal reservoir, located in granitic basement, similar to Zunil I, but shallower and with a different heat source, probably located near Zunil volcano to the southeast part of the area.

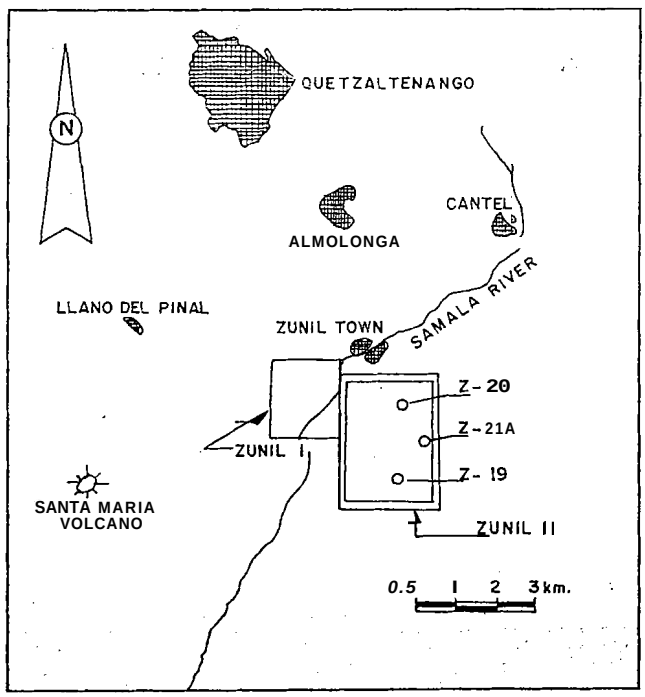

Figure 7. Zunil II Geothermal Area

The prefeasibility studies ended 1992, concluding that this area is a promissory one, and estimating a minimum potential of 40-50 MW.

8.0 PRESENT LEGAL STATUS

8.1. History

Until 1985, there were not any law that regulate the utilization of geothermal resource. In November 1985, it was emitted the "Law of Geothermics" in order to regulate the geothermal activities in the country.

In January 1986, the Law 20-86 was emitted as part of Government politics in order *to* promote the participation of private sector in the development of new and renewal energy sources. This law offers fiscal and tributary incentives in importation and tax payments to the companies that invert in energy projects.

In February 1995 the INDE's new law (64-94 Parlianient Resolution) was emitted and recently: on November 1996, the General Law of Electricity was approved by the Parliament. Both laws have the purpose to establish a coherent legal frame to allow the private sector participation in the electrification of the Country and at the same time, both take into consideration the development of geothermal resources for electric power generation. In the General Law of Electricity the shares and production percentage to the Government, that were originally considered in the Law of Geothennics were removed.

3.2. Law of Encouragement to the Developmen: of New and Renewable Energy Sources

As above mentioned, this law (20-86 Parliament Resolution) mas emitted in 1986 in order to promote the exploitation of renewable natural resources with energetical potential and the efficient use of this sources.

This law authorize any individual or legal person, national or foreigner, legally established in the country, to perform projects of new and renewable energy sources, naming the following incentives:

- Free importation of custom-house duties, related charges, freights and consular fees on fungible materials importation, machinery, equipment, necessary spares and accessories for the definitive use or consumption in the country where the project will. be carried out, whenever are not produced in the country or if the case, don't have the required quality.

- Temporal suspension regime, with any caution, of custom-house and freight duties, and other related charges, upon the machinery, equipment and accessories of foreign property that are destined for the projects.

- The sales tax (IVA) will be impute on a zero per cent rate.

- Any individual or legal person, addressed in the country, that inverts on projects, will be able to deduce up to 100% of its inversion value from the Income Tax.

- Deduction of 100% from the Income Tax on the amount from the donations destined to projects related to new and renewable energy sources.

8.3. INTERNAL LAW OF INDE

The Guatemalan Parliament, in order to accomplish the development and utilization of Natural Resources as electrical power generation sources, and taking in consideration that the previous legislation didn't satisfy the needs of the country, modified the INDE's law in February 1995.

The new internal law establishes that INDE is an autonomous and self financial institution, with its own patrimony, juridical personality and complete capacity to acquire lawful and to contract obligations in its own competence. Furthermore allows the participation of private sector in other things being equal.

Among the purposes and obligation of INDE are the obligatoriness to cooperate with the profit of hydraulic and geothermal resources for electrical generation. To carry out this objective, INDE must determine, technical, economical and juridically, the potential of the resources, in order that the studies be useful to new electrical generation projects and to dispose the reports to whom be interested, according to prices to be established. Moreover the Institution can subscribe contracts of bargain and sale of energy with private companies. In geothermal case, the contracts can include different operations, from exploration to exploitation of the resource, according to law requirements. Additionally, contracts to import or export electricity to other countries can be subscribed.

5.4. ELECTRICITY LAW

The purpose of this law is to re-establish the proceedings for the generation, interconnection, transmission and distribution services of electricity. The main objectives are:

- To supply the electricity demand with a rational and efficient use of energetic resources.
- To promote the free market.
- To prevent disloyal conipetence and to regulate trusts.
- To verify an efficient, secure and reliable operation of the national electrical systcni.
- To verify the protection of customer's rights and the accomplishment of their obligations.
- To maintain and to operate the installations in order to preserve the integrity of people, goods and environment.

The electricity service are based on principles of efficiency, quality, continuity, adaptability to technological improvements, and neutrality in customer service. The elements t: obtain this objectives are:

- To expand the electrical system.
- To regulate the companies of electrical subsector.
- To control, to inspect and to watch over
- The Government, through Energy Ministry, is able to authorize the concession of areas for exploration, development and exploitation of geothermal resources.
- Free access to transmission and distribution electrical system.
- Autonomy of Local Government and Government electrical companies.

It is important to take in account that this Electrical Law annuls the Geothermal Law for the utilization of geothermal energy for electrical use. Nevertheless, since geothermal resources are National property, Energy Ministry gives authorization for temporal studies in geothermal areas. In the case of geothermal power plants, the Government has not intermeddling and therefore there is conipetence in the free market.

9.0. REFERENCES

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