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Geothermal Development in Honduras

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ABSTRACT

Honduras is a country with significant geothermal potential that currently is not being exploited as a source of energy generation. Considering the above, the paper describes an analysis of the potential utilization of geothermal resources in the country. Several aspects are taken into account, such as the existing legal framework regulating the energy sector, geothermal potential of Honduras and identifying markets for geothermal resources. High, medium and low temperature resources in different locations are considered. The use of different technologies for electricity generation and direct uses are identified.

The main on-going activities related to geothermal development in Honduras are described. They will serve as lessons learned for potential public and private investors in this field. Description of development activities and update mapping of geothermal resource potential nationally, the activity is implemented altogether with the IDB and JICA which aims to capture the majority of geothermal areas in Honduras who are still in the phase of recognition.

A development project feasibility study is also explained, "Geothermal Resource Utilization of Low and Medium Temperature for Industrial Utilization", which aims to promote the use of new alternatives for thermal energy generating using low and medium temperature geothermal resources for industrial uses in the northern part of the country. Development projects for electricity generation with geothermal resources are presented, indicating the level of progress and results of each project which is being implemented for electricity production and distribution of energy connected to the national grid.

1. INTRODUCTION

The world is moving toward an era of high costs of energy supply, which requires an adaptation of policies and country strategies. It has not only greatly increased the monetary costs but also environmental costs, and social and political impacts. This is the result of many factors: first, the enormous increase in global energy demand, driven by continued population growth and economic development, while the rate of discovery of new energy deposits has declined.

Environmental costs have also increased as the environment's capacity to absorb effluents and emissions has become saturated, largely from the processing and end use of energy. Environmental impacts include those caused by particulate matter, acid rain, and greenhouse effects resulting in climate change to which developing countries are most vulnerable because they lack the infrastructure and facilities to accommodate new circumstances; this results in costs in terms of public health, permanent damage to ecosystems, and risks to the safety of goods and people.

Honduras is also exposed to socio-political risks for its heavy reliance on imported energy, with obvious effects on the balance of payments and the risk of supply disruptions by geopolitical events. This situation will not change much, even when taking advantage of the full national energy potential.

Considering all the above, this paper presents the Honduras current status of using geothermal natural resources for the generation of electricity and direct heat uses. Highlighting these possibilities is important for promoting further development of geothermal resources in Honduras and, thus, taking advantage of the geothermal potential at different sites around the country.

2. BACKGROUND

The geothermal development in Honduras began in 1976 with a study carried out by the United Nations in conjunction with experts from several countries. Thanks to the support, a study of thermal manifestations was done, in which were identified the areas of interest for the development of geothermal energy in Honduras.

Through the years the government of Honduras requested various technical and financial supports to international organizations for further geothermal development, so that in 1985 USAID offered its collaboration for improving the status of geothermal development in the country. A deeper study was conducted through Los Alamos National Laboratory with the objectives: defining a master plan for national geothermal development; pose an alternative to geothermal power generation; and continuing investigations of the geothermal resource at a national level (Henriquez, 2011).

Geothermal research and wide recognition in Honduras were made at six sites (Platanares, San Ignacio, Azacualpa, Pavana, Sambo Creek and El Olivar).

According to the geological and geochemical results obtained, Platanares was selected based on the temperature gradient and three wells were completed to depths ranging from 428 to 679 m. The geothermal team, Los Alamos / USGS, presented a report to ENEE, recommending geothermal assessment feasibility levels in this area.

3. LEGAL FRAMEWORK

Honduras currently has a legal framework that involves different aspects such as environmental, economic, social, technical and others, particularly in relation to the exploitation of natural resources for power generation. Our main laws are: Law to promote electricity generation through renewable energy and Law of the electric subsector, both are focused on scaling up renewable energy using natural resources. The energy policy was created in the period of 2005–2010 but has not been approved yet, this policy has been implemented jointly to generate a positive impact on the development of the country, this implementation is now expected to encourage public and private investment.

4. ELECTRICITY GENERATION PROJECTS

Honduras is a country that through the years has made efforts to promote the development of energy production in a sustainable manner. These results have been beneficial to increase its installed capacity in renewable energy and diversify the energy matrix, such as entering and evaluating new power generation technologies such as wind, solar and geothermal.

Studies concluded that there is potential at six sites (Platanares, San Ignacio, Azacualpa, Sambo Creek, Puerto Cortes and Pavana) around the country for electricity generation (Table 1; Figure 1).

Table 1: Potential for electricity generation in Honduras, C.A. Hot spring (high temperature) (Source: Ministry of Energy, Natural Resources, Environment and Mining General Directorate for Energy data bank.)

No.	Project name	Location	Potential for electricity generation (MW)
1	Platanares	La Union, Santa Rosa de Copan	35
2	Azacualpa	San Pedro de Zacapa, Santa Barbara	20
3	Pavana	Choluteca, Choluteca	20
4	Puerto Cortes	Choloma, Puerto Cortes y Omoa, Puerto Cortes	20
5	San Ignacio	El porvenir, Cedros y San Ignacio, Fco. Morazán	20
6	Sambo Creek	La Ceiba	5

A map was created of hot springs with temperatures between 140-230°C to show the different sites with high-temperature geothermal potential in Honduras. The distribution of these hot springs around the country is shown in Figure 1, as well as the different projects for electricity generation.

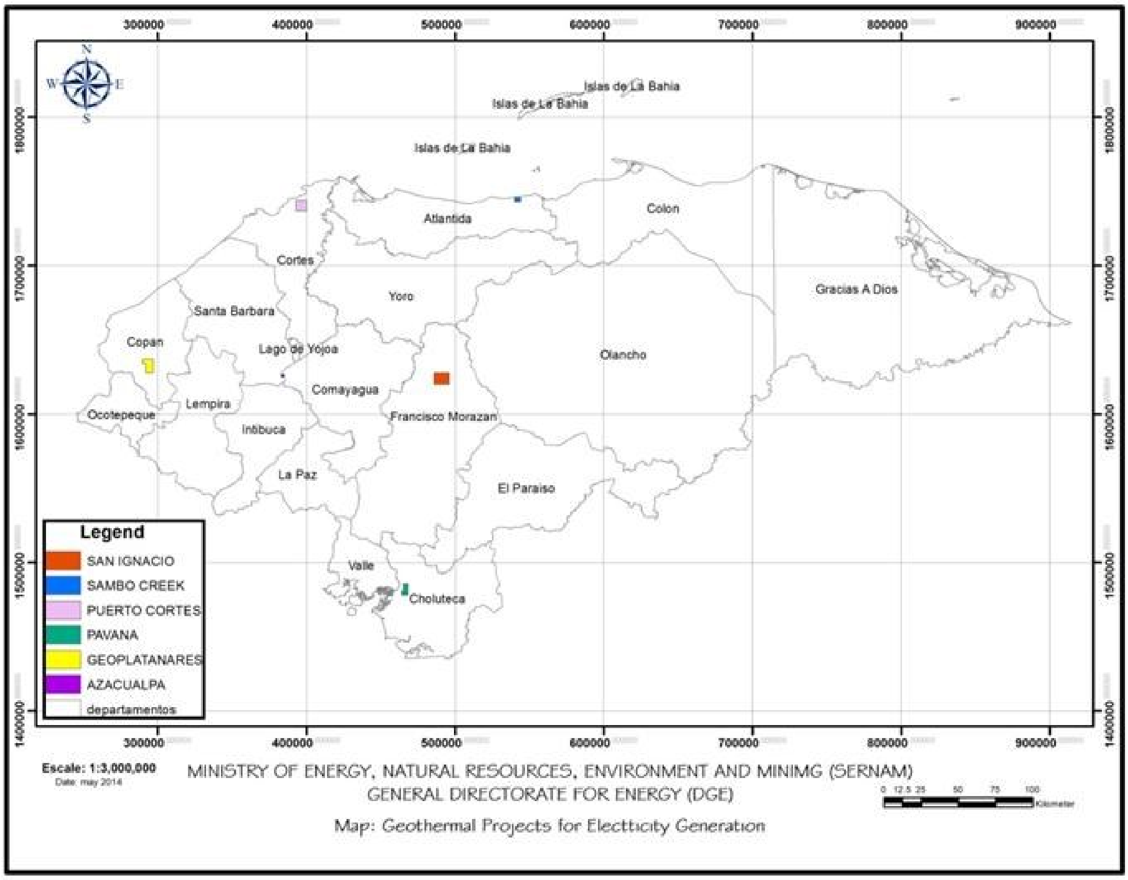

Figure 1: Hot spring sites (high temperature) for electricity generation in Honduras, C.A (Source: Ministry of Energy, Natural Resources, Environment and Mining) General Directorate for Energy data bank.

5. UPDATE MAPPING OF GEOTHERMAL RESOURCE POTENTIAL NATIONALLY

Honduras is carrying out several efforts for developing the geothermal energy potential through different actions, one of these, is the project update mapping of geothermal resource potential nationally. This activity is implemented together with the IDB and JICA which aims to capture the majority of geothermal areas in Honduras which are still in the phase of recognition. Moreover, the explorations nationally for geothermal resources have been few and insufficient development of topographic maps as they are currently undeveloped. Given these conditions, using remote sensing technology, satellite images and geographic information systems (GIS) together with geological and geochemical surveys in several selected geothermal areas to examine the information obtained. The main objectives and methodology of this project are:

5.1. Phase One (Data Collection)

5.1.1. Geological survey

In the study, the data collection was previously conducted before the field survey. They are satellite imagery collections, information collection of existing data regarding geothermal features; analysis will be done on interpretation work will be carried out on lineament extraction as a fracture, thermal anomalies, and distribution of alteration minerals, groundwater spring and others.

5.1.2. Chemical survey

Chemical data of geothermal fluids in Honduras obtained on the previous studies will be collected. Also the following items will be examined for evaluation of geothermal resources; origin of geothermal fluid, heating process, reservoir temperature and fluid flow pattern in prospective fields.

5.1.3. GIS

Various data must be collected like natural condition data such as topography, geology, geologic structure and distribution of possible geothermal areas, but also socioeconomic data like infrastructures, electric power development and its development plan.

5.2. Phase Two (Pre-Feasibility)

5.2.1. Selection of 6-8 prospect areas for geothermal development

Geothermal development prospect areas will be selected mainly through consideration about the updated and complemented information, together with consideration about the current situation of prospective areas such as environmental and social aspect, accessibility to the prospective area and activities of the private sector and so on. In these selected areas will be consider works on geological survey, geochemical survey, GIS and geothermal resource evaluation, (SERNAM, 2013).

6. GEOTHERMAL RESOURCE UTILIZATION OF LOW AND MEDIUM TEMPERATURE FOR INDUSTRIAL PROCESSES

There is a potential market for direct uses in Honduras, such as cooling, industrial processes and bathing, especially considering that Honduras has a lot of activity in manufacturing and tourism companies. Also, due to the weather and the high temperature, cooling is needed in various settings, such as supermarkets and other industries and residential areas.

This year, 2014, Honduras in collaboration with 4E-GIZ program has developed the project "Feasibility Study for the Development of Low and Medium temperature Geothermal Resource for Industrial Processes" in order to promote the use of new alternatives for thermal power generation using geothermal resources of low and medium temperature, potential sites were identified specifically in two areas in the north of the country (Valle de Sula and Sambo Creek).

6.1. Direct Uses Identified

Through technical visits with industrial companies, the potential market of direct uses of geothermal energy of low and medium temperature was identified, considering the geothermal resource as a sustainable economic alternative for the implementation of thermal systems in the industry. These applications include the use of geothermal resources of 60°C - 130°C (ADS Honduras, 2014).

6.1.1. Sector of Industry production or manufacturing

6.1.1.1. Drying of products using low and medium temperature (60°C - 90°C)

6.1.1.2. Preheating systems using heat exchangers, by raising the temperature to 60°C, 80°C, 90°C and 130°C

6.1.1.3. Absorption refrigeration systems and absorption cooling. Industries commonly use waste heat from a fossil fuel engine.

6.1.2. Sector of the tourism industry

6.1.2.1. Absorption cooling systems for offices, hotel rooms and other spaces.

6.1.2.2. Washing bedclothes or towels and washing kitchen utensils.

6.1.2.3. Natural thermal pools and spas.

6.1.2.4. Fresh water heating through heat exchangers for use in facilities such as hotels showers and sinks.

6.2. Geology of Valle de Sula and Sambo Creek

Honduras is located on the northwestern part of the Caribbean tectonic plate and moves eastward caused by the result of efforts of the oblique subduction to the northeast of the Cocos plate beneath the Caribbean plate. To the north, the northern margin collides with the North American plate forming a zone of tectonic and transcurrent fault system that extends from southern Mexico, through the central part of Guatemala, and continues through northern Honduras. Here is located the Motagua-Jocotan-Chamelecón-La Ceiba fault system, which is a set of transform faults with left displacement compression of about 4 cm/year. The relative movement of the northwestern margin of the Caribbean plate, or block Chortís, it has gone through outreach efforts in east-west direction forming a series of results oriented north and south, lined by normal faults with the same sense of direction (Figure 2).

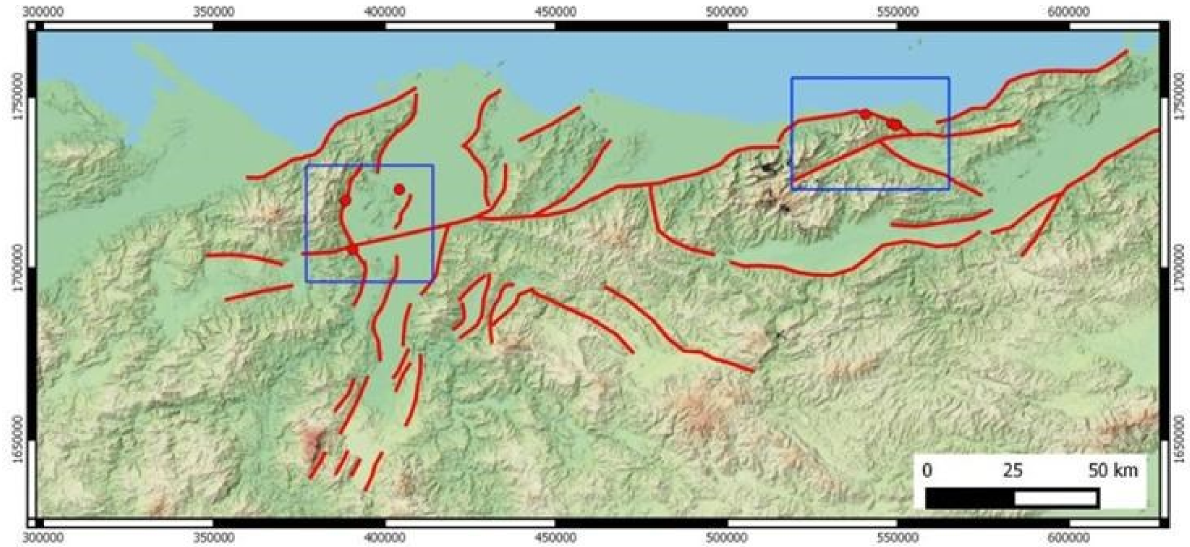

Figure 2. Regional structural map of northern Honduras on terrain relief image (Source: ADS Honduras 2014)

6.3. Geochemistry of Valle de Sula and Sambo Creek

The results of chemical analysis are presented in a HCO_3 - Cl - SO_4 ternary diagram (Figure 3) where you can see the classification of the hot springs. Red and blue circles represent hot springs areas Sula and Sambo Creek respectively, while the blue triangles represent samples from hot springs reported by LANL (Los Alamos National Laboratory) from Sambo Creek. All samples from hot springs Sula area plotted on bicarbonate waters and are interpreted as underground fresh water that occur in peripheral areas of geothermal systems. All samples from hot springs of Sambo Creek plotted within the area of sulfate waters that occur as the result of the interaction of groundwater with hot gases and vapors generated at greater depths, which amount and mixed with groundwater. None of the sites evaluated in the study presents typical high-temperature geothermal waters, (ADS Honduras, 2014).

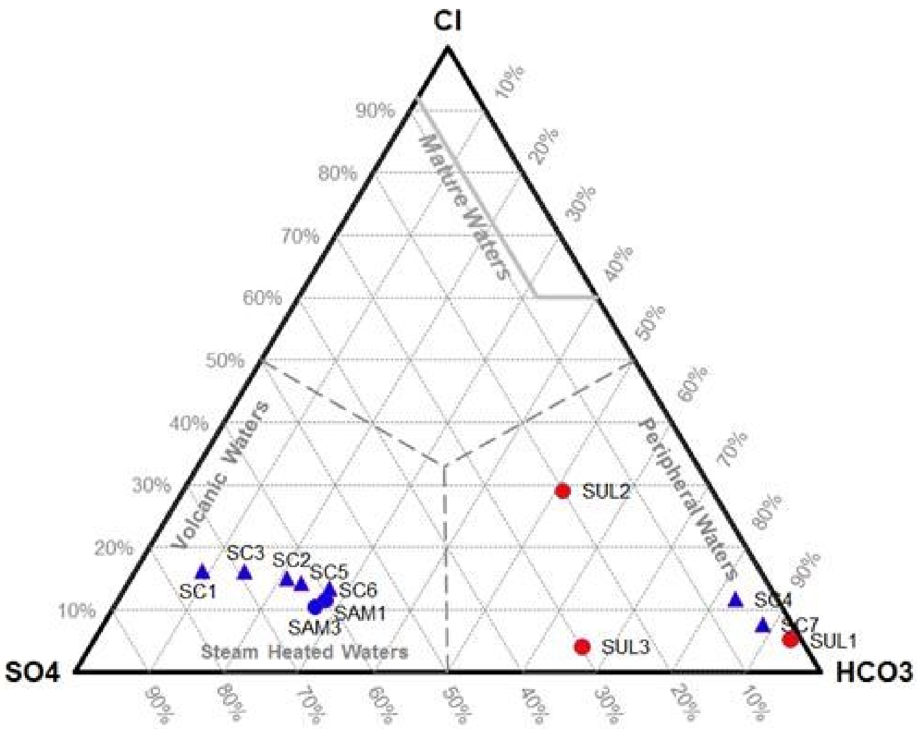

Figure 3. Ternary diagram Cl-SO4-HCO3 to samples of Sambo Creek (blue) y Sula (red) (Source: ADS Honduras 2014)

6.4. Geothermal Conceptual Modelling

Considering the information gathered and the results obtained, estimates are made, according to the conceptual model (Figure 4) the temperature of the reservoir in the Valle de Sula is in the range of 110°C-120°C, estimating a depth of 100-200 m; regarding the Sambo Creek area it is estimated by the conceptual model (Figure 5) that the temperature of the reservoir is in the range of 150°C-180°C, by estimating a depth of 500 to 1,000 m, (ADS Honduras, 2014).

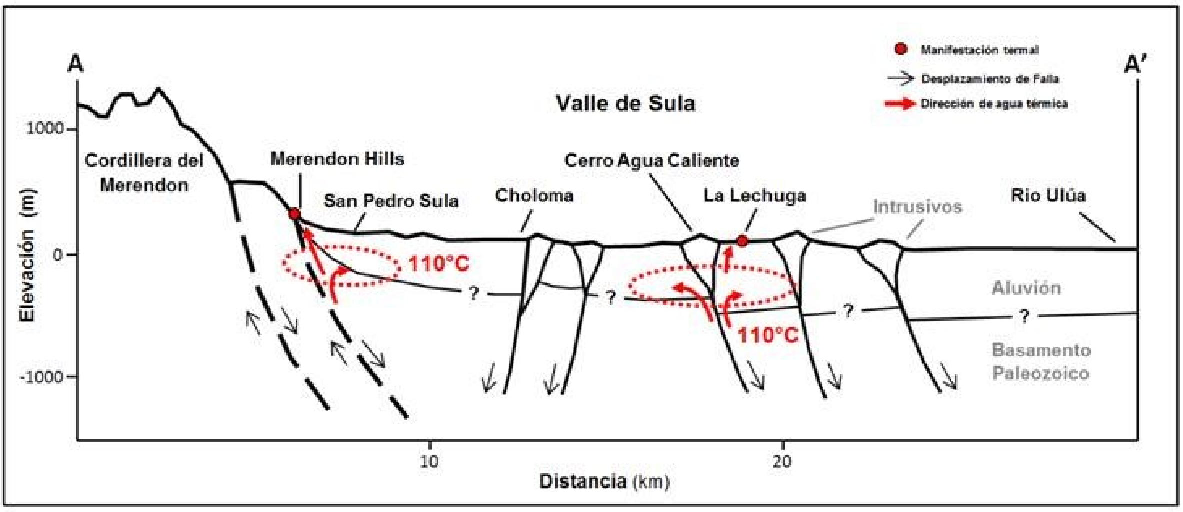

Figure 4. Geothermal Conceptual Model of Valle de Sula (Source: ADS Honduras 2014)

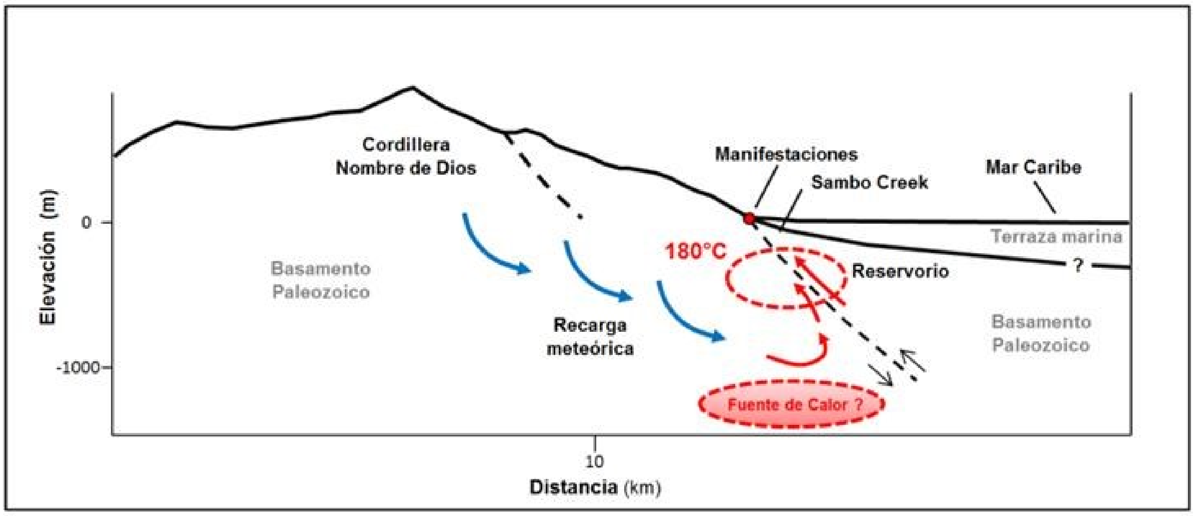

Figure 5. Geothermal Conceptual Model of Sambo Creek (Source: ADS Honduras 2014)

7. CONCLUSIONS

The manifestations of hot springs on the surface and some studies conducted show that Honduras has geothermal potential that could be used for different purposes. The Tertiary-Quaternary volcanism evident throughout the complex of igneous rocks, outcropping especially in the southern region, and the proximity of this same area to the subduction zone generated by the boundary of the Pacific and Caribbean tectonic plates, illustrate this possibility. The geothermal resources of Honduras have not yet been exploited, but there are different uses such as electricity production and several direct uses that have been mentioned herein which may develop in different parts of the country.

Sixty percent of the energy matrix of Honduras currently depends on fossil energy resources and only 40% on renewable resources. Thus, developing the estimated 120 MW of geothermal potential for the production of electricity will significantly contribute to the country's objectives with respect to increased electricity generation from renewable sources.

After considering some climatic aspects of the country like average temperatures and other factors, the market, and the low-temperature resource potential, it has been determined that space cooling by absorption systems is a viable option. Also geothermal energy could be used in several industrial processes and in bathing pools or spas.

Honduras currently has legal support to encourage and promote the use of renewable resources for power generation. Within the legal framework are: an energy policy including an exclusive section for the geothermal resource, a Promotion's Law of electricity generation through renewable energy, and the Law of electric subsector.

REFERENCES

ADS Honduras., 2014: *Study for the Development of Geothermal Resources of Low and Medium Temperature for Industrial Processes*. Ministry of Energy, Natural Resources, Environment and Mining.

Henriquez. W., 2011: *Analysis of the Potential, Market and Technologies of Geothermal Resources in Honduras*, United Nations University – Geothermal Training Programme, 2011.

SERNAM., 2013., *Data Collection Survey on Geothermal Energy Development in Honduras*, Ministry of Energy, Natural Resources, Environment and Mining.

STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014	0	0	958.6	4598.3	569.6	2738.5	0	0	226.3	166.5	1754.5	7503.3
Under construction in December 2014	35	0	0	0	37		0	0				
Funds committed, but not yet under construction in December 2014							0	0				
Estimated total projected use by 2020	70	0	990.1		1083.73	0	0	0	642.5		2786.33	

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2014

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status1)	Type of Unit2)	Total Installed Capacity	Total Running Capacity	Annual Energy Produced 20143)	Total under Constr. or Planned
						MWe*	MWe*	GWh/yr	MWe
La Union, Santa Rosa de Copan	PLATANARES	2018				35			
San Pedro de Zacapa, Santa Barbara	Energía Geotermica Azacualpa	2025				20			
La Ceiba, Atlantida	SAMBO CREEK					5			
Choluteca, Choluteca	Geotermico PAVANA	2025				20			
Choloma, Pto. Cortes y Omoa, Pto. Cortes	Planta Geotermica Pto. Cortes					20			
El Porvenir, Cedros y San Ignacio, Fco Morazan	Geotermico San Ignacio	2025				20			
Total						120			

1) N = not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash, 2F = Double Flash, 3F = Triple Flash, D = Dry Steam, B = Binary (Rankine Cycle), H = Hybrid (explain), O = Other (please specify).

3) Data for 2014 if available, otherwise for 2013. Please specify which.

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Valle de Sula, CORTES	I and C		80							
La Ceiba, ATLANTIDA	I, C and B		95							
Nationally	B						1.933		45	0.74
TOTAL										

I = Industrial process heat, C = Air conditioning (cooling), A = Agricultural drying (grain, fruit, vegetables), F = Fish farming, K = Animal farming, S = Snow melting, H = Individual space heating (other than heat pumps), D = District heating (other than heat pumps), B = Bathing and swimming (including balneology), G = Greenhouse and soil heating, O = Other (please specify by footnote).

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2014

Use	Installed Capacity[1]	Annual Energy Use[2]	Capacity Factor[3]
	(MWt)	(TJ/yr = 10^{12} J/yr)	
Individual Space Heating[4]			
District Heating [4]			
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	1.933	45	0.74
Other Uses (specify)			
Subtotal	1.933	45	0.74
Geothermal Heat Pumps			
TOTAL	1.933	45	0.74

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	2	1	1	2	2	5
2011	3	1	1	2	2	5
2012	3	1	2	2	4	7
2013	3	1	2	4	4	7
2014	4	1	2	4	4	9
Total	15	5	8	14	16	33

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

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development Incl.	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	1			1	50	50
2000-2004	2			2	50	50
2005-2009	10			10	90	10
2010-2014	7		2	5	80	20