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El Salvador Country Update

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ABSTRACT

El Salvador, a country of 5.7 million inhabitants in the heart of Central America, is the smallest (21, 041 km^2) and one of the most densely populated countries in the region (277 inhabitants per square kilometer). Geothermal has been one of the main sources of electricity since the mid-1970's, when Ahuachapán power plant came on line. By the 1990's Berlín power plant started in operation. Today the country has a competitive electricity market, and geothermal sources provide 25% of the electricity needs.
The total installed capacity from geothermal resources in the country is at present 204.4 MW: 95.0 MW for Ahuachapán double flash power plant, and 100.2 MW at Berlín for single flash plant plus 9.2 MW from bottoming binary cycle.

The Geothermal energy production has increased from 410 GWh since 1995 to 936.4 GWh in 2002, 1,293 GWh in 2007 and 1,421 GWh by the end of 2008. Peak demand in El Salvador is 924 MW, yearly demand is 5,655 GWh, both with a growth rate around 5%/year. Today the country has a competitive electricity market, and geothermal sources provide 25% of the electricity needs.
The developing plans for LaGeo (2010 – 2015), are considering: 28 MW Unit 5 for Berlín, 5 - 9 MW, re-powering of Unit 2 of Ahuachapán, 50 MW Chinameca developments.

1. INTRODUCTION

The main use for geothermal energy in El Salvador is electricity generation. There are two geothermal fields in El Salvador that have operating power plants: Ahuachapán and Berlín (Fig. 1), both owned and operated by LaGeo which is owned by INE (Government Electric Utility) and Enel Green Power from Italy. Their combined installed capacity is 204.4 MW.

The main regional geological aspect for the geothermal potential in El Salvador is the subduction of the Cocos Plate under the Caribbean Plate, as part of the "ring of fire" around the Pacific Rim. The subduction zone causes a volcanic chain that trends WNW – ESE through the middle of the country. Areas of geothermal potential are found around the volcanoes: the heat sources are the magma chambers, the structures are calderas or grabens associated to volcanic activity (mostly quaternary, but some tertiary at the northern part of the country), and the reservoirs are formed by infiltration of rainwater into the high part of the volcanic craters.

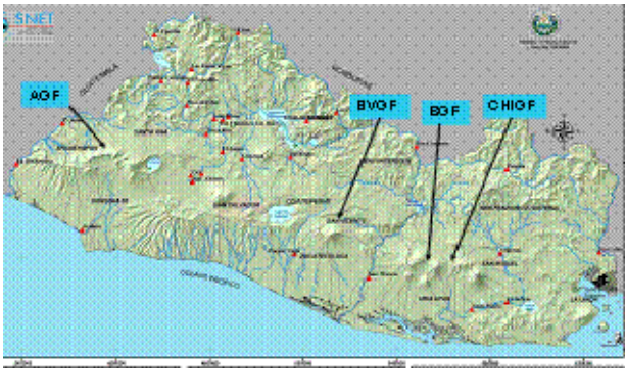

Fig. 1 – Map of El Salvador and geothermal field's location (modified from SNET 2008)

Temperatures of geothermal resources are 250°C in Ahuachapán, 300°C in Berlín, 230°C in San Vicente, 240°C in Chinameca, and there are several resources below 200°C all along the volcanic chain. Depths range from as little as 600m in the shallow areas of Ahuachapán, to about 2,800m in the deep parts of Berlín.
Work is currently under way to upgrade and expand both facilities, plus there is exploration and resource evaluation of other fields like Chinameca (CHIGF) and San Vicente Geothermal Field (SVGF).

2. AHUACHAPÁN GEOTHERMAL FIELD

The first exploratory well was drilled in Ahuachapán in 1968, under the auspices of the United Nations, and generation began in 1975. There are three condensing units installed in Ahuachapán: two 30 MW single-flash and one 35 MW double-flash units. Reservoir pressures dropped significantly during the first years of operation therefore just two units were operating and one was used as back up.

Since 1975 to 1999 the brine was disposed to the Pacific Ocean through a concrete channel (71-km long). However in December 1999 an injection pipeline was built in the Chipilapa area located at the east and 5 km. away, where 3 wells were available, but due to small injection capacity a pumping system was commissioned and put in operation in May 2004. In 2006 the second injection pipeline started operation and at present 100% of the waste water could be injected. The hydraulic connection between the Ahuachapán and Chipilapa reservoirs has been evaluated after 10 years of injection operation, and the numerical model forecast suggests that Ahuachapán could receive some pressure support from the injection, which could conduct to increase the energy production.
Studies are currently under way to upgrade Unit 2 to make the most efficient use of the increase in production, in the condensing units in order to reach the total installed capacity.

3. BERLÍN GEOTHERMAL FIELD

The exploration at the Berlin field commenced in early 1970 when well TR-1 was drilled. Later on in 1980 the drilling results of well TR-2 reported measured temperature over 280 ºC, unfortunately the civil war started and no more exploration works were done. The development was reinitiated during 1990-1992 and two back pressure units went on line (2 x 5 MW) using the already available wells and both were operated until 1999, when they were replaced by condensing type units (2 x 28.12 MW).
In order to achieve the steam requirements 20 wells were drilled (6 producers and 14 injectors). The wellhead units were decommissioned and sold in 2004.

During 2003-2007, with Enel partnership the third condensing unit (1 x 44 MW) went on line and 9 wells were drilled (5 producers and 4 injectors). The brine was injected by gravity to the northern part; but after 2005 the pumping station came in operation.

In order to improve the whole thermal efficiency a binary unit (9.2 MW) was commissioned as bottoming stage and at present is in testing period. This unit is operating with the hot separated brine and could be added to extract residual heat.

4. GEOTHERMAL-ELECTRIC PRODUCTION

Total geothermal production in El Salvador during 2008 (annual averages) of the Ahuachapán geothermal field (AGF) to Berlín geothermal field (BGF), can be summarized as follows:

Production wells in operation: 32
Injection wells in operation: 27
Production of steam: 13.1 million tons
Production rate of steam: 1,350 t/h
Average production per well: 33.1 t/h
Separated brine disposed: 38.2 million tons
Total geothermal-electric installed capacity: 204.4 MWe
Generation of electricity: 1,421 GWh
Gross specific consumption of steam: 8.2 t/MWh

At present the Ahuachapán geothermal field is generating about 80-85 MWe and injecting into the national grid 668.6 GWh that correspond around 12 % of the total electricity in the country. Even though Berlin geothermal field is generating about 95-100 MWe and injecting into the national grid 752.4 GWh that correspond at around 13 % of the total electricity in the country.

The installed capacity for both geothermal fields along the operational geothermal history is shown in Fig. 2.

The geothermal power generation for both geothermal fields along the operational geothermal history is shown in Fig. 3.

The geothermal net injection for both geothermal fields during summer seasons (june 2008) shows a peak of almost 26 % of geothermal resources contributing to the national electric grid. In the Figure 4 is shown the produced by source in GWh as an annual average 2008. Notice the imports only represents 1% of the total injection in 2008.

The distribution of the installed capacity, in the country for the year 2008 by source in MWe and percentage, is shown in Figure 5.

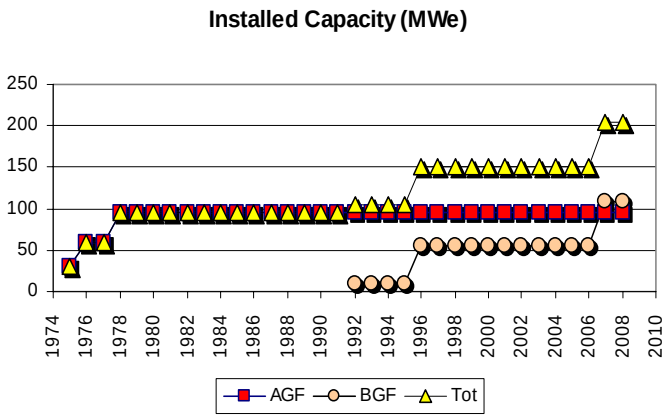

Fig. 2 – LaGeo´s installed capacity history

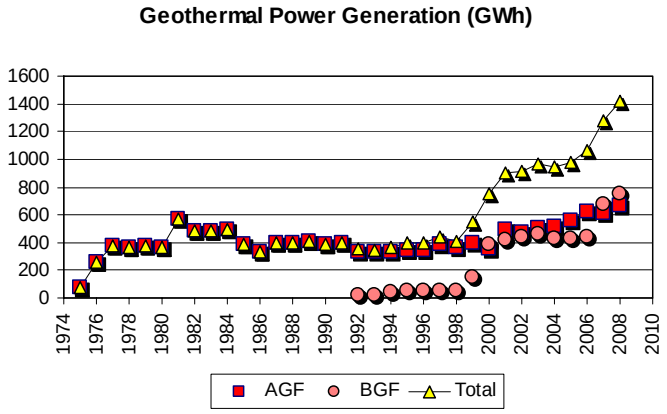

Fig. 3 – LaGeo`s power generation history

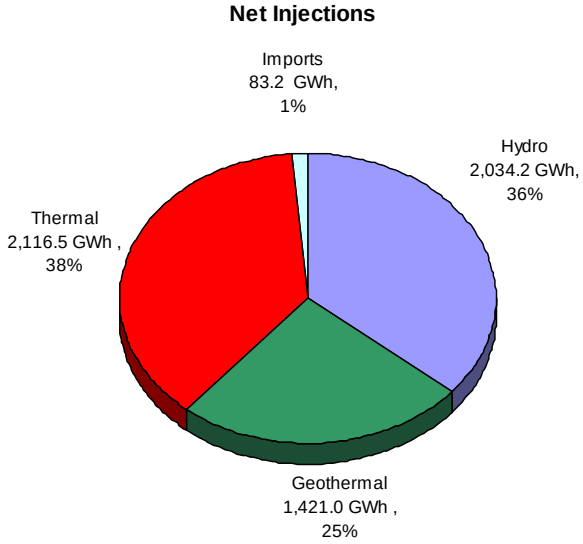

Fig. 4 – El Salvador net injection by source in GWh and percentage.

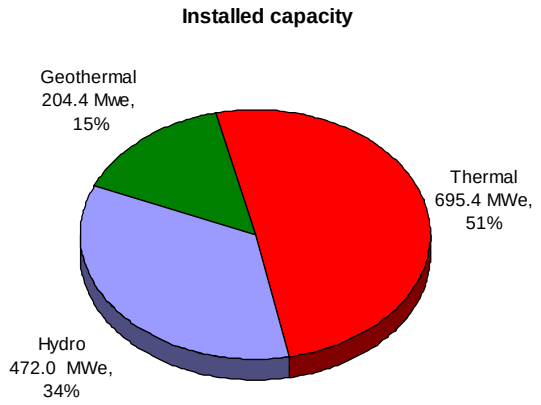

Fig. 5 – Installed capacity by source in MWe and percentage.

The annual electrical demand growing in the country and LaGeo's participation with the geothermal net injection during last years shows an increase. The geothermal power generation contribute to the national electric grid by year 2008 with a 25.0 % of the demand, as showed in Fig. 6.

The share of total electricity generated from geothermal resources locates El Salvador in the top 15 countries in the world (Earth Policy Institute 2007).

When the third generating unit came on line, Ahuachapán supplied 41% of El Salvador's electricity, a figure which to this day stands as a record, but a sharp drop in reservoir pressure caused generation to be scaled back from maximum.

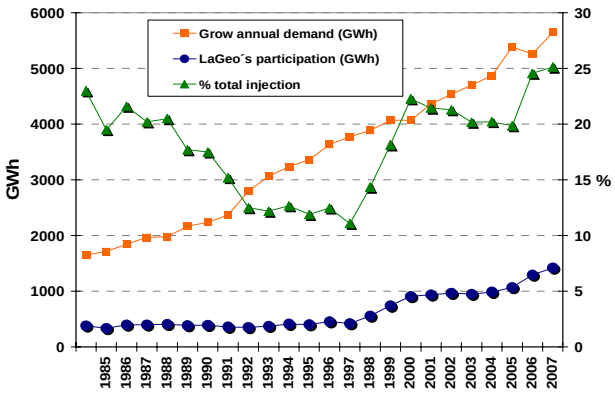

Fig. 6 – Annual demand, LaGeo annual generation, and percentage of total injection from geothermal resources

5. OTHER EXPLORATION PROJECTS

El Salvador's legislation mandates the electricity regulator, SIGET, to award concessions for areas with geothermal potential to interested parties, following a public tender process. At this moment LaGeo branch San Vicente 7 Inc. is the owner for both concessions San Vicente and Chinameca geothermal fields.

In San Vicente geothermal field, three exploratory wells were drilled during 2004-2007; with limits on the results, founding temperatures in the range between 150-250 °C, only the wells SV-1 and SV-1A shows good temperature conditions but lower permeability. At present the results are under evaluation and waiting for decision to continue with the feasibility study

Although in Chinameca geothermal field one well, the CHI-3, was drilled up to 1,869 m. The results suggest temperature over 240ºC with reasonable permeability at 1,400 m depth and waiting for discharge testing. Initial simulations indicate a potential of 3-5 MWe for this well.

Three additional wells are planned to be drilled in 2009-2010 to further confirm the extent of the geothermal resource and to assess the power potential to install 50 MW power plant which could be on line for year 2014.

6. LOCAL AND REGIONAL MARKETS

The local Salvadorean electricity market was liberalised in 1998. Distribution was sold to foreign investors, as was thermal generation. The system operation was separated from CEL and given to a private entity, the Unidad de Transacciones S.A. de C.V., or UT, whose shares are owned by a "club" of market participants. The transmission company was spun off from CEL, as was the geothermal generation.

The Wholesale Market has two components: the Contracts Market (MC), and the System Regulating Market (MRS) or spot market. Charges for use of the transmission system are determined by the UT (Market Administrator) based upon the costs of investment, operation and maintenance associated with each component of the system. In 2010 the model may change to a cost based market, as most other Central American countries.

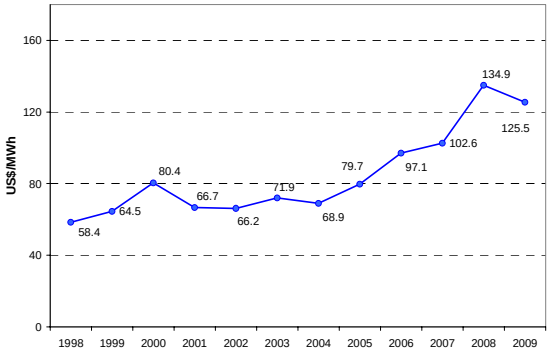

Fig. 7 –Annual average prices, El Salvador's MRS

In El Salvador, the price bid by the geothermal generator (LaGeo) has been historically the lowest of all (Fig. 7), so all of the available geothermal power has been dispatched first. Contracts with distribution companies and end users are typically of short duration (1 year), and referenced to the spot market price, so they are simply designed to ensure dispatch, not price.

Peak demand in El Salvador is 924 MW, yearly demand is 5,655 GWh, both with a growth rate around 5%/year. Geothermal accounts for 25% of the total electricity injected into the national grid.

LaGeo currently has sold 2 projects of carbon emissions reduction credits (CERs) registered (UNFCCC) which represents a saving of 220,000 tonnes of carbon pollution annually and profit of about US $3.5 million.

7. CONCLUSION

El Salvador has natural resources like geothermal which provide a quite good support to the national economy.

Over the past fifty years, El Salvador has developed its geothermal energy industry and today, almost 25% of electricity consumption in El Salvador is from geothermal resources.

El Salvador's small economy with scarce sources for electricity and abundant geothermal resources, make a special location where geothermal power can compete in price in an open power market. This explains a very large and growing share of geothermal in the national electricity mix.

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El Salvador's map http://www.snet.gob.sv/

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other		**Total**	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	**Capac-ity MWe**	**Gross Prod. GWh/yr**
In operation in December 2008	204.40	1,421.00	657.90	2,116.50	472.00	2,034.20					**1,334.30**	**5,571.70**
Under construction in December 2009			145.00	762.12							**145.00**	**762.12**
Funds committed, but not yet under construction in December 2009	83.00	654.37			310.30	1,087.29			250.00	1,533.00	**393.30**	**3,274.66**
Total projected use by 2015	287.40	2,075.37	802.90	2,878.62	782.30	3,121.49				1,533.00	**1,872.60**	**9,608.48**

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2009

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)
O = back pressure

3) Data for 2009 if available, otherwise for 2008. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1]	Type of Unit[2]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2009[3] GWh/yr	Total under Constr. or Planned MWe
Ahuachapan	UI	1975	1		1F	30	28		
	UII	1976	1		1F	30	28		
	UIII	1981	1		2F	35	28		
								669	
Berlin	BPI-II	1992	2	R	O	10			
	UI	1999	1		1F	28	28		
	UII	1999	1		1F	28	28		
	UIII	2006	1		1F	44	44		
	UIV	2008	1		B	9.4	8		
								753	
Total			9			204.4	192		

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

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2009 (excluding heat pump wells)

[1)] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)					
Production	>150° C	2+1				4.98
	150-100° C					
	<100° C					
Injection		2+ 4				12.41
Total		9				17.39