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El Salvador Country Update

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ABSTRACT

El Salvador, a country of 6.5 million inhabitants in the heart of Central America, is one of the most densely populated in the Western Hemisphere. Geothermal has been one of the main sources of electricity since the mid-1970's, when Ahuachapán power plant came on line. Today the country has a competitive electricity market, and geothermal sources provide 22% of the electricity needs.

1. INTRODUCTION

The main use for geothermal energy in El Salvador is power generation. There is some potential for direct use to dry grains and fruit, but none are as yet a significant economic activity. Geothermal power, on the other hand, has competed successfully in the local and regional markets for the last few years, and in fact geothermal generation has increased from 400 GWh in 1995 to 966 GWh in 2003.

There are two geothermal fields in El Salvador that have operating power plants: Ahuachapán and Berlín, both owned and operated by LaGeo, a spinoff privatised company of the government electric utility, CEL, now jointly owned by both CEL and Enel Green Power, of Italy. Their combined installed capacity is 151 MW. Work is currently under way to upgrade and expand both facilities, plus there are exploration and resource evaluation projects in at least four other fields: Cuyanausul, San Vicente, Chinameca, and Obrajuelo. The new projects would increase geothermal generation to 1350 GWh in 2006, or about 27% of the projected demand.

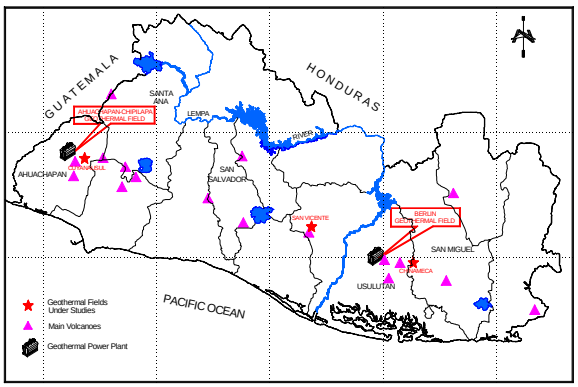

Fig. 1 – Map of El Salvador

The source of 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), and the reservoirs are formed by infiltration of rainwater into the high part of the volcanic craters.

Temperatures of geothermal resources are 230°C in Ahuachapán, 300°C in Berlín, 250°C in San Vicente, and there are several resources below 200°C all along the volcanic chain. Depths range from as little as 800m in the shallow areas of Ahuachapán, to about 2800m in the deep parts of Berlín.

2. A "STRATEGIC PARTNER" SELECTED FOR GEOTHERMAL

LaGeo, S.A. de C.V. (formerly called Geotérmica Salvadoreña) was separated from the government electric utility company, CEL, in November, 1999, and received the geothermal assets in Ahuachapán and Berlín in ownership. LaGeo´s shares were still 100% owned by CEL at this time.

In 2001, a process began to select a strategic partner for LaGeo that would invest in geothermal -wells, studies, power plants- then capitalise the assets in exchange for new shares. In June, 2002, Enel Green Power, a subsidiary of Enel S.p.A., of Italy, signed on as LaGeo´s new strategic partner. Enel´s obligations are to develop two projects: Berlín Third Condensing Unit, and Cuyanausul, both described later in this paper.

The process followed has been called "capitalisation with risk", where the strategic partner evaluates the resource, drills wells, constructs a power plant, then transfers ownership to LaGeo in exchange for a new emission of shares. The amount of shares received for the new assets is not a function of the dollar amount invested, but rather a function of the effective power contributed (within certain quality standards), and hence the development risk is on the side of the strategic partner, who is thus incentivated to be efficient.

3. 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 units, and one 35 MW double-flash unit. Reservoir pressure dropped significantly during the first years of operation, so normally only one single flash unit runs with the double flash unit, and the other single flash unit is kept on standby.

The separated water from the field was dumped into the ocean via a 71-km long canal, from the beginning of operations until May, 2004. In December, 1999, a reinjection pipeline was built to the nearby Chipilapa area, a subfield of Ahuachapán 6 km. away, and about 70% of the water was reinjected, and the other 30% was still dumped into the canal. In May, 2004, a pumping system was

installed just outside the flash vessels, so all of the brine is now injected into Chipilapa. The connection between the Ahuachapán and Chipilapa reservoirs has been evaluated, and numerical models predict that Ahuachapán will receive pressure support from the reinjection, which in turn would lead to an increase in production. Studies are currently under way to upgrade Unit 2 to make the most efficient use of the increase in production, and generate another 10 - 15 MW (approx.) in the condensing units.

Furthermore, since the speed of the fluid in the injection system can be controlled to prevent silica deposition, the reinjection system was designed so that a bottoming binary cycle plant could be installed between the flash vessels and the injection pumps, thus making use of residual heat in the brine. A 4.5 MW binary plant is scheduled for Ahuachapán by late 2005.

4. BERLÍN GEOTHERMAL FIELD

Exploration work in Berlín dates back to the early 1970´s, but the field was essentially abandoned from 1980 to 1992, during the civil conflict in El Salvador. In 1992, a 2 X 5 MW wellhead power plant was installed, which was operated until 1999, when it was replaced by a 2 X 28 MW single-flash condensing facility. The wellhead units were decommissioned and sold in 2004.

As part of the obligations of the Strategic Partner, Enel Green Power has drilled confirmation wells and performed a feasibility study to install a third condensing unit of 40 MW in Berlín. Permitting and preliminary construction for this new addition is currently under way.

As further study was performed on the Berlín geothermal fluid, it was estimated that a bottoming cycle binary plant could be added to extract residual heat and generate an additional 5.5 MW from the separated water. This binary cycle plant is scheduled for Berlín by late 2005, together with the Ahuachapán binary development.

5. CUYANAUSUL GEOTHERMAL PROJECT

Exploration work in the Ahuachapán-Chipilapa field concluded that there was potential for further growth to the East of Chipilapa, in an area called Cuyanausul. Development of this field was included as a requirement for the strategic partner in the process described in Section 2 of this paper.

As of this writing, the access road and a well pad for two exploratory wells were constructed in Cuyanausul, and drilling was scheduled to begin in July, 2004. If drilling results confirm the field´s potential, one or two 5 MW backpressure units would be installed while a condensing development is planned.

6. OTHER EXPLORATION PROJECTS

El Salvador´s legislation mandates the electricity regulator, SIGET, to award concessions for areas with geothermoelectric potential to interested parties, following a public tender process.

Such concessions were awarded in May 2001 to Orpower 7, a subsidiary of Ormat, for the San Vicente and Chinameca fields, to install 50 MW in each. Aditionally, in April 2004, LaGeo requested the concession for Obrajuelo geothermal field, to install a 10 to 20 MW power plant. This last concession process is ongoing as of this writing.

7. 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.

To participate in any phase of the MC, valid contracts are necessary. Contracts are not necessary to participate in the spot market.

Charges for use of the transmission system are determined by the UT based upon the costs of investment, operation and maintenance associated with each component of the system.

Dispatch is based on bid price, not variable cost, as in most other Central American countries. Geothermal then must compete with thermal generators, hydro, and imports for the baseload share of the market. In El Salvador, the price bid by the geothermal generator (LaGeo) has been historically the lowest of all, 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 830 MW, yearly demand is 4,400 GWh, both with a growth rate around 5%/year. Geothermal accounts for 22% of the total electricity injected into the national grid, but since 9% of the energy is imported, the geothermal share of local injections is actually 24%.

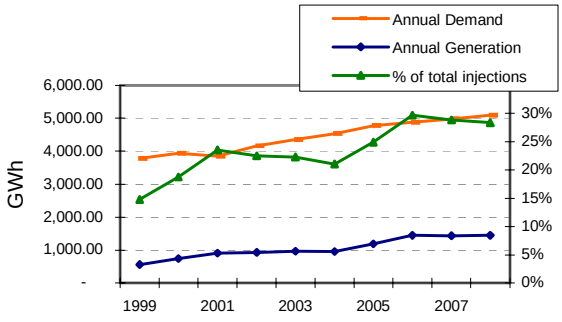

Fig. 2 –annual demand, LaGeo annual generation, and % of total injections

The Salvadorean grid is interconnected with the rest of Central America, and power trading is common from Guatemala to Panama. Each individual country has its own market, but a regional market is superimposed over the local markets to arbitrate price differences between the different countries. The regional market is price-based, like the Salvadorean local system, not based on variable cost.

There is a plan to build a 230 kV line through all six Central American countries to enable larger transactions and power projects. This project would be funded by the Interamerican Development Bank.

The international interconnections make it possible for geothermal generators to access the regional market, but they also increase the number of competitors.

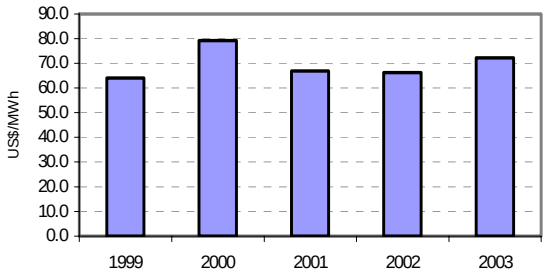

Fig. 3 –annual average prices, El Salvador's MRS

8. CONCLUSION

El Salvador´s small economy and abundant geothermal resources, together with scarce other sources for electricity, make it 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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Unidad de Transacciones (UT) Proyección de Demanda

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity)

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		**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 2004	151.2	967.4	472.5	1,652.1	428.2	1,459.0					**1,051.93**	**4,078.50**
Under construction in December 2004	50.0	320.2	50.0	174.8							**100.00**	**495.01**
Funds committed, but not yet under construction in December 2004	10.0	64.0	50.0	174.8	64.4	219.8					**124.40**	**458.60**
Total projected use by 2010	211.2	1,351.6	572.5	2,001.7	492.6	1,678.8					**1,276.33**	**5,032.11**

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2004

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 2004 if available, otherwise for 2003. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe	Annual Energy Produced 2004[3)] GWh/yr	Total under Constr. or Planned MWe
Ahuachapán	Ahuachapán Geothermal Field	1975	3		two 1F and one 2F	95 MW	501.7	4.5 MW
Berlín	Berlín Geothermal Field	1999	2		two 1F and	56 MW	465.7	45.5 MW
Total			5			151 MW	967.4	50 MW

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2000 TO DECEMBER 31, 2004 (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	4				
	150-100° C					
	<100° C					
Injection	(all)	1				
Total		5				

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

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000		280		1		1
2001		280		2		1
2002		270		1		2
2003		270		2		1
2004		270		2		1
Total		1370		8		6

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) US$

Period	Research & Development Incl. Surface Expl & Exploration Drill	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1990-1994	$13,509,139.10			$13,509,139.10		100%
1995-1999	$647,158.13	$121,736,862.73		$122,384,020.86		100%
2000-2004		$56,184,974.33		$56,184,974.33	100%	