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GEOTHERMAL ENERGY IN MÉXICO AND ITS RELATION WITH THE ENVIRONMENT

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ABSTRACT

The Comisión Federal de Electricidad (CFE), is the governmental company in charge of Generation, transmission and distribution of electricity in almost all country. In 2000, CFE produced 57.3 million of metric tons of geothermal steam. A total of 157 wells produced an annual average rate of 41.6 tons of steam per hour per well, reaching a generation geothermal electricity of 5,901 GWh, which represents 3.1 % of the total electricity produced in México. The places with geothermal fields are: Cerro Prieto I to IV, in Mexicali, Baja California Norte (720 MW); Los Azufres, in Hidalgo City, Michoacán (93 MW); Los Humeros in Puebla (42 MW) and Tres Vírgenes in Santa Rosalía, Baja California Sur (10 MW). Other projects are: In short term, Los Azufres II (100 MW); in medium term are La Primavera in Jalisco and Araró in Michoacán. CFE has studied some hydrothermal zones like Punta Banda in Baja California. Agree with its mission, CFE also has put in practice policies about its environmental behavior, because it knows that sustainability is not an aim, it must be a style life in all companies and countries in the world.

1. INTRODUCTION

The progress of any country can be measured behind its electrical installed capacity. So, México has many kinds of electrical power plants using different resources to produce electricity.

Comisión Federal de Electricidad (CFE) is the governmental company in charge of generation, transmission and distribution of this kind of energy in almost all the country. Luz y Fuerza del Centro (LFC), is the other company who produces less than 1 % of the electricity sold in the country. Private industry also generates electricity in co-generation facilities, for their own use, or for sale to CFE.

Environmental protection is one of the important aims in México. The application of renewable resources energy is used for generating electricity.
Following the environmental policies of México, CFE has decided its mission, vision and environmental policies.

Mission of CFE

To assure the electric power supply in appropriate conditions of technology, quantity, quality and price, using different resources of energy. To optimize the physical, commercial and human infrastructures, with careful attention to the clients, promoting the social development and protecting the environment where the electric power stations are.

Vision of CFE

- ✓ To keep us like the most important electricity company of México.
- ✓ To operate above the productivity, competitivity and technological international indicators.
- ✓ To be recognized by our clients like an excelential company, worrying for the environment and the service.
- ✓ To Promotion high qualification and professional development of our employers and directive people.

Environmental Policy of CFE

Agree with its mission, CFE has put in practice six policies about its environmental behavior:

- ✓ To take in all forms the environmental impacts of the actions in our company and to evaluate them for assuring the balance between internal and external costs and benefits.

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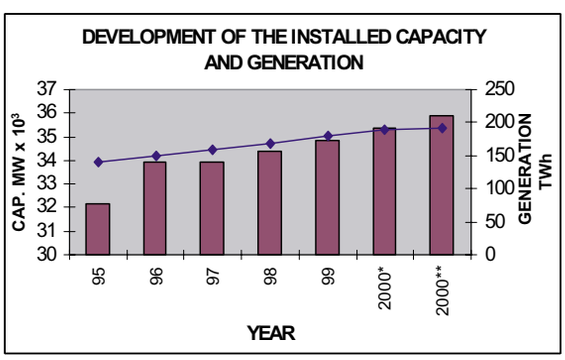
- ✓ To consider the national laws for environmental protection and to take them like a minimum value to take care of it.
- ✓ To support the environmental authorities to develop rules and environmental methodologies.
- ✓ To incorporate professional points of view about our environmental design and activities.
- ✓ To take the social people point of view, about the environmental development in projects of the company.
- ✓ To support education, investigation and technological development in the environmental area.

Development of the installed capacity and the generation

Throughout the years, the generation has increased to fulfill the fundamental aim of CFE, that it is to advance to take care of all the necessities of population, industry, agriculture, the commerce and services through electricity, in México.

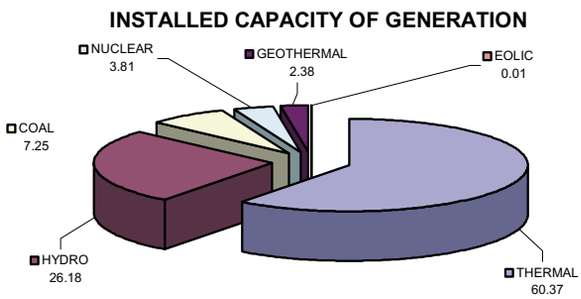


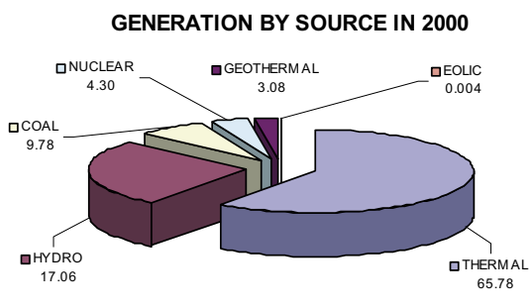
* Not included external energy production.
** Included external energy production (combined cycle plant Mérida III with 484 MW), since June of 2000.

The generation in México is constituted by 153 generating power stations of electrical energy, divided in 64 hydroelectric power stations, 81 thermoelectric, 6 geothermoeléctric and 2 eoeléctric ones with an installed capacity of 35,869 MW all together, to the closing of December of 2000.

The generation of electricity in CFE is made it by modern available technology in hydroeléctric, thermoelectric, geothermal, eólical and nuclear kinds.

In the year 2000, CFE counted with an effective capacity installed to generate electricity of 35,869 megawatts (MW), of which 9,389.8 MW are of hydroelectric, 21,657.1 MW correspond to the thermoelectric ones that they consume heavy oil, gas and diesel; 2,600 MW to carboeléctrics; 854.9 MW to geothermoeléctrics; 1,364.9 MW to the nucleoelectric and 2.2 MW to the eoeléctric.





2. GEOTHERMAL SITUATION IN MÉXICO

Comisión Federal de Electricidad has worried to develop power plants to generate electricity, alternating to fossil fuels, hydroelectric plants and the nuclear power stations. Considering the geographic and geologic location of México, more reasonable of the alternating sources of energy are geothermal and the eolic energy. México has one long history of advantage of geothermal to generate electricity; same that begins in the decade of fifties when it settled in Pathé, Hidalgo, the first geothermoeléctric plant in the American continent.

The geothermoeléctric capacity of México is of 865 megawatts (MW); it was generated 3,1% of the 191,197 GWh generated during year 2000. Cerro Prieto geothermal field is the second greatest one of the world and produces 60% of the electricity that is distributed in the network of Baja California, that is an isolated system of the Mexican National Electrical System.

Table 1

Power Plant	Capacity	Location
Cerro Prieto I	180 MW,	Mexicali, Baja California.
Cerro Prieto II	220 MW,	Mexicali, Baja California.
Cerro Prieto III	220 MW,	Mexicali, Baja California.
Cerro Prieto IV	100 MW,	Mexicali, Baja California.
Azufres	93 MW,	Michoacán, Cd. Hidalgo
Humeros	42 MW,	Puebla, Humeros
Tres Vírgenes	10 MW,	Sta. Rosalia, Baja California.

UBICATION OF GEOTHERMAL FIELDS IN MEXICO

Cerro Prieto

The Cerro Prieto Geothermal field, Located in the state of Baja California, 20 miles to border with the United States of America, is the largest known water dominated geothermal field in the world and one of the more thoroughly studied. It is contained mostly in sandstone's and shale's of the Colorado River Delta.

Cerro Prieto Power Plant has an installed capacity of 720 MW. At present, there are 13 units in operation housed in four power plants (Table No.1).

There are three reservoirs developed in sandstone and sandy shale units that are fed from depth by fluids rising from fractures, (Lippmann et. Al., 1991). The Alfa reservoir in the west part of the field is the shallowest and was the first to be exploited. It is found at depths between 1000 and 1500 m. the deeper Beta reservoir extends underneath the entire area of the Cerro Prieto (about 15 km^2) at depths between 1500 and 2700 m. with temperatures higher than those in Alfa reservoir. The deep Gamma reservoir is not exploited yet.

Tectonically, The Salton Trough-Gulf of California area is a zone of transition between the divergent boundary of the East Pacific Rise and the transform boundary of the San Andrés Fault System. The sediments at Cerro Prieto were deposited during Pliocene to middle Pliocene times (Halfman et. al.,

1984), classified like granodioritic basement.

Hydrothermally talking, minerals identified in Cerro Prieto are in equilibrium with hot fluids of the sodium chloride type with pH from neutral to basic. Several mineral assemblages have been defined. From them can be concluded that the temperature in the samples studied is close to 250 °C; it ends to increase as minerals like amphibole, biotite and muscovite form (Georgina I., Enrique P., Alfonso A., Ignacio T. And Julio A., 2001).

In 2000, on average there were 125 production and 9 injection well in service at Cerro Prieto; The number varied from 119 production and 8 injection wells in January and February, to 133 production and 10 injection wells in December (Residencia de Estudios, 2001).

The wells produced 46.7 millions metric tons of steam during the 2000, at annual average rate of 5,332 ton/h. This is 4 % higher than in 1999, when 44.8 million tons were produced. Steam production well averaged 42.7 ton/h, slightly better than in previous year (40.7 ton/h)(Quijano-León and Gutiérrez-Negrín, 2000). In addition 68.4 million tons of geothermal brine were produced, which were disposed by injection and evaporation (Residencia de Estudios, 2000).

The annual average specific steam consumption was 8.8 ton/h. This number considers only the steam available to the plants. That is, the actual steam arriving at the power plants facilities, and excludes the steam losses in the pipeline and valve system. During 2000, the available steam was of 44.9 million tons (Residencia de Estudios, 2001).

The exploitation for 27 years has been causing thermodynamic and chemical changes in the reservoir conditions, such us boiling, dilution and scaling and phase segregation. These processes affect the productivity capacity of the wells (Trhuesdell, et. al., 1995, 1997).

The steam production decline at Cerro Prieto has been attributed to five main causes: reservoir pressure drawdown, scaling in the bottom hole or main feed zones, scaling in the upper production casing, or scaling in the orifice plates on the surface piping and entalphy decrement (Arellano et. al., 1998). To recover lost steam production routine maintenance procedures include cleanout of the orifice plate, workover wells or drill new wells. In Cerro Prieto field are using new tools like chemistry, water isotope analysis, and electronic instruments (TPS), to understand the latest reservoir changes (Jesús de León V., Juán de Dios O. And Andres P., 2001).

The total electricity generated in 2000 was 5,103.67 GWh (Subdirección de Distribución, 2001). This amount is the highest in the history in Cerro Prieto; it is 9 % higher than what was produced in 1999 (4,670 GWh; Quijano-León and Gutiérrez-Negrín, 2000), because four additional units were placed on line in July 2000.

In 2000, the average capacity factor for Cerro Prieto was 88 % as compared 86 % in 1999.

Los Azufres

Los Azufres is the second of the four geothermal fields of México in commercial development, and it is located in central México, in the Michoacán State, within the Mexican volcanic Belt. The main features of the conceptual model are as follows.

Geothermal electric generation began in 1982. At this time there 11 power units: one 50 MW condensing unit, eight 5 MW back pressure units and two 1.5 MW binary cycle units, which totals 93 MW. Another 5 MW backpressure unit, formerly operating in Los Azufres, has been installed in the Amatitlan geothermal field, Guatemala.

The subsurface lithology can be grouped into two main units, the Mil Cumbres andesites and the Agua Fria rhyolites (López, 1991). Andesites contain the geothermal reservoir, while rhyolites act as a sealing cap in the south and middle parts of the field. The superficial limits of the reservoir were defined according to geophysical and reservoir engineering data. For the north zone, in 24.5 km^2 (Pérez-Esquivias, 2001), and the volume of the reservoir was calculated in 42.9 km^3. For the south zone the area was estimated in 12.3 km^2 and volume of 14.7 km^3.

On average, 20 production well and 6 injection wells were in operation during 2000. The number of production wells varied during the year, between 16 in September-November and 23 in August (Residencia de Los Azufres, 2001). Their depths range from 800 to 2500 meters.

Total steam production in 2000 increased to 7.6 million tons (i.e., annual average of 864 ton/h), in this is the highest recorded in Los Azufres since 1994.

Production of separated geothermal brine reached 4.51 million metric tons, which was reinjected into the reservoir using 6 wells. In 2000 it was almost 0.6 tons of brine per ton of steam.

Generation of electricity in Los Azufres amounted 586.1 GWh during 2000 (Subdireccion de Distribució n, 2001). That year, the annual average capacity factor was 73.5%. The total available steam at Los Azufres was 6.9 million tons. (Residencia de Los Azufres, 2001). The average annual specific steam consumption for the entire field was 11.8 ton/MWh.

Reservoir volumetric analysis and numerical simulation were used to investigate the potential for further development of the field (CFE, 1991; CFE, 1993); results are shown in next table.

Based upon those studies, the Comisión Federal

Type of assessment	North Zone	South Zone	Total
Volumetric Analysis (Mwe)	480	230	710
Numeric Simulation (Mwe)	145	160	305

de Electricidad decided to install 100 more MW of Geothermal generation in this field, which represent only the third of the total potential, assessed by the numerical modeling. This is the project known as Los Azufres II, consisting of four units of 25 MW (Units 13, 14, 15 and 16).

Because most of the power is installed at the south zone of the field, it was decided to install three of those power units in the north zone, and one at the south zone. With this, the total capacity in Los Azufres will increase of 93 MW to 193 MW.

Work started in December 2000, and was launched under a Build-Lease-Transfer contract, and should be finished by January 2003. The first one, Unit 13 is scheduled to be commissioned in October 2002, the second one, Unit 14, in November 2002, the third one, Unit 15, in December 2002, and the fourth, Unit 16, in January 2003. The typical steam required for those units are 7.65 ton/h, at 170 °C and 8.0 bar of absolute pressure, per MW. Eight wells are being drilled to supply the additional steam that the units will require. Three exploration wells will be repaired also to complete the steam.

Los Humeros

Los Humeros is another geothermal field system hosted in volcanic rocks. It is located in the central-eastern part of México, also within the Mexican Volcanic Belt.

The first power unit came on line in 1990. By December 2000 seven 5 MW backpressure units had been installed in the field. All units have been operated at 6 MW level for more than 4 years (1997-2000), increasing the total installed capacity at Los Humeros to 42 MW (Quijano-León and Gutiérrez-Negrín, 2000).

In 2000, an average of 12 production wells were in operation at los Humeros, ranging between 21 in January and 8 in December (Residencia de Los Humeros, 2001). Two injection wells were used throughout the year.

The total steam produced in 2000 was 3 million metric tons, at annual average rate of 342 ton/h (Residencia de Los Humeros, 2001). This number is quite lower than in 1999 (4.8 million metric ton; Quijano-Leó n and Gutiérrez-Negrín, 2000). The reduction was caused because units 4 and 5 were taken out of line to be repaired in May and units 3 and 7 in June. These four units did not go back on line during 2000, as repairs were not completed yet.

The average steam production per well was 29.5 ton/h, and it is the highest rate since 1994.

During 2000, the total available steam at Los Humeros was 2.52 million tons; the annual average specific steam consumption for the operating units was 11.9 ton/MWh, equal to 1999. That indicates that the field was very well operated, in spite of the problems with the power units.

Because most units were undergoing repair, the electricity generation during 2000 was only 211.5 GWh (Subdirección de Distribución, 2001), which is the lowest since 1994. The capacity factor was also low (57.5 %).

Las Tres Vírgenes

Las Tres Virgenes field, is located in the central part of Baja California Peninsula, about 46 kilometers northwest of Santa Rosalia.

Several exploitation studies as geological, resistivity, geophysical and geochemical studies had been carried out between 1982 and 1994, to confirm the existence of a geothermal system in the zone, in order to install geothermal power plants and satisfy the electrical requirements of the State of Baja California Sur. Las Tres Virgenes is situated inside of El Vizcaino Biosphere Reserve, and has an extension of 57 km^2 approximately.

This field is located in an isolated area of the distribution net, and at the moment the electric power is generated by means of diesel plants, that implies a very high cost for fuel and transportation.

Two condensing power plants of 5 MW each are already installed, giving 10 MW more to the total electrical capacity in México. It entered in operation last May 23rd and it is already providing energy to the electrical system.

The field is related to a quaternary volcanic complex, composed of three volcanoes aligned north south.

During the last years Comisión Federal de Electricidad (CFE) has carried out geochemical and isotopic studies to characterize the thermal springs and the water produced by the wells.

Nine wells have been drilled, 6 are producers and 3 reinjectors, their depths range between 1290 and 2500 meters.

Water produced by the wells has a sodium-chloride composition, characteristic of geothermal brine, completely equilibrated at a temperature of 280°C; this temperature is in agreement with the temperature estimated by geothermometry of gases. The low Cl/B molar ratio (approximately 12), and the low magnesium concentrations suggest that the water-rock interaction took place at high temperatures, and a deep circulation.

Las Tres Virgenes geothermal system is a dominant liquid reservoir.

The chemical composition of gases from fumaroles and wells is CO_2 is the predominant gas (>95%) that is expected in a geothermal environment. H_2 and H_2S are found in significant amounts.

At present the most important problem in Las Tres Virgenes is the silica and calcite scale in pipelines and wells. There is a highly saturation calcite index in the produce mixture, and, because the relatively low temperature of the resource there is deposition of calcite inside the well casing in the saturation point of the fluid.

This prorogues declination of the flow rate and total blockage of the well with time.

Besides at surface temperature, the silica deposits in the injection lines, increasing the frequency and cost of maintenance and in the worst place, scaling in the injector wells. We are focussing in solving these problems.

The studies of numerical simulation indicate the feasibility of operating without further problems during 25 years, with 20 MW in the southern area, but this expansion will require exploration toward other geologic structures such as Cerro Blanco fault and southeastern sector where evidence of high seismic activity is found.

3. DEVELOPMENT PERSPECTIVES

At present, Comisión Federal de electricidad is interested to re-initiate the exploration and development of different areas in México to increase the geothermal production. Three projects are activated to continue the friendly energy with environment.

La Primavera

La Primavera geothermal field is located in the western of México, in the state of Jalisco. It is about 11 kilometers west from Guadalajara City, and lies within a quaternary volcanic caldera at an average height of 1800 meters above sea level.

The Comisión Federal de Electricidad (CFE) started the prospecting works in the early 60´s. Four exploratory wells were drilled between January 1980 and August 1982, and seven more wells were drilled between January 1984 and January 1988, and in 1989 the activities in this field were stopped and since then

most of the production wells were kept closed or under flowing confition through ¼" pipes.

Taking into account the abruptness of the local topography, it would be expected to install 5 MW backpressure turbo gerator units. Preliminary reservoir assessment studies (JICA, 1989) have indicated the possibility to install at least 75 MWe for a 20 year period. Nowadays, CFE is interested to reinitiate this project to install 2 x 25 MWe turbo-generator units in the near feature.

CFE has carried out a complete and comprehensive program to restore the environmental impacts caused by the prior work.

Other programs are about to estimate the production parameter variation caused by the modification to the original pipe completion of the production wells, using Wellsim as the official wellbore simulator. As it knows, it internally incorporates five different two-phase flow correlations (Aziz, Duns, Hagedorn, Orkiszewski and Wellsim) for well simulations.

According to the results obtained through the simulation work done, the total mass flow rate is not drastically affected with respect to the modification studied. In this way, the drilled wells can be repaired with no substantive changes in their original production rates. However, it seems to be necessary that all wells would have to be opened before any further decision be taken (Sánchez-Upton, 2001).

Araró

The Araró geothermal zone is located in the northeastern part of the state of Michoacán, 40 kilometers south of Morelia city, within the Mexican Volcanic Belt. The main zone of hydrothermal manifestation is 6 km north of the Zinapecuaro town.

In the Araró geothermal zone, CFE has carried out several exploratory studies and drilled five shallow gradient wells as well as two deep exploratory wells. The reinterpretation of these results will give the conditions to define some characteristics of the subsurface geothermal system. It seems to be a fracture zone reservoir of a stock work type and fluid flow appears to be limited to a throttle, or narrow conduit, probably linked to the Araró Zimirao fault at more than 2000 m depth.

The total heat discharge in the Araró surface is estimated as 19.7 MWe by García y Tovar (1989), which is in the rank suggested by Hochestein (1993).

So, CFE is studying this zone to be sure about a geothermal potential of electricity.

Punta Banda

Deep submarine energy is related to the existence of hydrotermal vents emerging in many places along the oceanic spreading centers between tectonic plates. These systems have a total length of about 65,000-km in the earth's oceanic crust. Shallow submarine heat is related to faults and fractures in the sea bottom close to some coasts. Hydrotermal submarine reservoirs contain an essentially infinite energy potential.

This type of shallow subsea system was found offshore at Punta Banda in Ensenada, Baja California.

The ^{3}He detected in the Wagner Depression, is of magmatic origin and comes directly from the sea bottom carried by vertical submarine streams.

Natural chimneys photographed by Mercado (1990) at 2600 m depth in the Gulf of California, discharge spouts of waters at 350 °C. These plumes of warm water generate conditions in adjacent water to produce suspended materials as source of nourishment food different living organisms.

4. ENVIRONMENTAL PROTECTION

Comisión Federal de Electricidad In order to transform into facts the environmental commitment and policies, an Institutional Program of Environmental Protection settled down that contains actions relative to the quality protection of the air, water, ground and to the conservation of the flora and fauna in all the stages of each electrical project. Comisión Federal de Electricidad counts on the necessary infrastructure for the protection to the atmosphere that surrounds it and with specialized departments by Environmental engineering, ordered of the measurement of all the environmental aspects, supervising the fulfillment of the parameters marked in the effective rules and laws, in environmental protection matters.

✓ In Air Matter

Network of measurement of quality of the air

For more than 10 years it has been having installed

in the country, networks of measurement in several power stations to know the quality air in the surroundings of the same ones. During the period of operation of the measurement network.

✓ In the Matter of Water

CFE has made works to mitigate the environmental impact through several actions, as follows.

- Construction of separating graves of oil and water in each one of the pluvial water unloading, which operate in order to assure that by no reason fats and oils unload that by some contingency could arrive at these unloading.
- Black water plants to treat the sanitary unloading about CFE.
- Graves of neutralization that allows the appropriate processing of process waters, previous to its unloading. In these graves arrive the unloading from the plants of water processing, chemical washings of regenerative air preheaters and other effluents that by their composition could cause pollution risks.
- Brigade of fire-fighting emergency and for attention of spills of dangerous substances or oils, in case of a contingency that could affect the ecological surroundings.

✓ Residual Water Discharges

The residual water discharges are registered by the Comisión Nacional del Agua (CNA); same that fulfill the limits established in the Mexican Official Rule NOM-001-ECOL-1996. Inclusively, CNA has freed to CFE in several power stations of the accomplishment of the metal analyses of its discharges, by virtue of to have demonstrated through analysis, that it does not add in his unloading any of the polluting agents of that type established by the mentioned Official Rule.

✓ Remainders matter

- Procedures of control of the remainders that are generated by the activities of production and maintenance. In these procedures one settles down as remainders are the nondangerous and dangerous ones, and as it is the strategy of handling, segregation, temporary and final disposition, as well as the control necessary to fulfill the rules in the remainders matter.
- Temporary warehouses of storage of dangerous remainders.
- Zones of mud evaporation to wash the nondangerous materials that are impregnated by some dangerous substance to the atmosphere.

✓ Grounds Matter

- Studies to verify if impacts exist that could be significant to the environmental surroundings of the power stations.

✓ Special Projects

- Voluntary environmental audits, under the terms of reference of the PROFEPA, obtaining itself thus Certified from "Clean Industry" for 8 power stations and 22 more in process, Included Cerro Prieto and Los Azufres.
- Certification in the international Norm of Quality ISO 9002 for than 30 power stations, hoping more that for the 2003, all the institution is left registered letter in this norm.
- Certification in the international Norm of environmental Administration ISO 14001 of 16 power stations, 2 corporate areas and a laboratory of tests, being in process other 10 power stations.

✓ Legal Aspect

Comisión Federal de Electricidad has worried to count on the Permissions, Registries and Information that are due to obtain and/or to present/display before the Normative Dependencies. Between the most important permissions it is counted on the following ones:

- License of Operation and/or Unique Environmental License.
- Permission of generating company of dangerous remainders.
- Certificate of annual operation.
- Title of deep Well concession.
- Title of Allocation of residual water unloading.
- Permission of burns to sky opened for practices fire protective.

Flora Preservation and Ecological Restoration at Las Tres Virgenes Geothermal Field

Comisión Federal de electricidad developed and carried out an environmental program at Las Tres Virgenes geothermal field, Baja California, México, to mitigate and compensate for impacts associated with the exploration, development and exploitation of the area.

The field is located within the buffer zone of "El Vizcaino Biosphere Reserve", which extends over approximately 25,500 km^2. It is the largest ecological

reserve in México and one of the biggest in Latin America, and includes the "Vizcaino Desert" and the "ojo de Liebre" and "Guerrero Negro" marine lagoon systems. The Mexican Government created this reserve to protect this unique area, which includes major breeding and calving lagoons for gray and humpback whales. The on land reserve is a refuge for endangered mammals, as well as for several species of migratory and resident birds (Ortega Varela, 1996).

The program, which consisted mainly of flora transplantation and ecological restoration activities, is as follows.

After many actions and activities in the zone, a total of 2,430 plants of 16 species were saved from possible destruction and transplanted. Approximately one year later, 1815 plants were still alive in the restored sites, which means a rather high rate of survival (75 %), the rest were mostly small plants.

The plants were removed from construction areas (well platforms and roads) covering a total of about 29,225 m^2. They were successfully transplanted and used in the ecological restoration of a 30,000 m^2 area near the geothermal project (Ortega-Varela, et. al., 2001).

5. SUMMARY AND CONCLUSIONS

Year 2000 comparing with four years before for all operating geothermal fields in México is combined as follows.

Though during 2000, the number of production wells in service was the lowest since 1993, the amount of produced steam was the highest, as well as the annual average rate of production. This apparent paradox is due to a larger average production per well (41.6 ton/h), highest since 1993. This increase is the result of improved productivity attributable to a better operation of all the geothermal fields during 2000, in spite of problems with some of the units at Los Humeros.

Geothermal electrical generation in 2000 was the highest in México`s geothermal history. This can be explained by the commissioning of Cerro Prieto IV power plant in July 2000.

Another important 2000 highlight was the completion of the international bid for the construction and installation of Los Azufres II geothermal project. It is also a BLT (Built, Lease and Transfer) contract, which was won by the French Company Alstom. Construction activities started in November 2000, and should be finished by January 2003 (Cornejo-Castro, 2001). The project includes 4 x 25 MW condensed units in four different houses. This project will double the present capacity at Los Azufres.

Development of Las Tres Virgenes I geothermal project is finished right now, with a capacity of 10 MW, in 2 x 5 MW. With this, the total installed geothermal electrical capacity in México is 865 MW.

Comisión Federal de Electricidad CFE has made yearly an Institutional Program of Environmental Protection settled down that contains actions relative to the quality protection of the air, water, ground and to the conservation of the flora and fauna in all the stages of each electrical project.

CFE is making voluntary environmental audits, under the terms of reference of the PROFEPA, obtaining itself thus Certified from "Clean Industry" for 8 power stations and 22 more in process, Included Cerro Prieto and Los Azufres. Also, has made programs for certification in the international norm of quality ISO 9002 for 30 power stations, hoping more that for the 2003, all the institution is left registered letter in this norm, and Certification in the international Norm of environmental Administration ISO 14001 of 16 power stations, 2 corporate areas and a laboratory of tests, being in process other 10 power stations.

Cerro Prieto is the first geothermal field in LatinAmerica to get such certificate ISO 9001.

Concept	1996	1997	1998	1999	2000
Production Wells (annual average)	177	168	165	164	157
Injection Wells (annual average)	14	14	15	16	17
Steam Production (million tons)	56.2	53.3	55.5	56.3	57.3
Average steam Production rate (ton/h)	6,416	6,082	6,312	6,428	6,538
Average steam Production p/Well (ton/h)	36.2	36.2	38.3	39.2	41.6
Geothermal Electric Capacity (MW)	743	750	750	755	855
Electricity Generation (GWh)	5,737	5,478	5,657	5,619	5,901
Annual Average Capacity Factor (%)	87.5	83.4	86.1	85.4	84.5
Specific Steam Consumption (ton/MWh)	8.7	9.3	9.3	9.5	9.2

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