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STATUS OF GEOTHERMAL ELECTRIC POWER DEVELOPMENT IN MEXICO

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Status of Power Plants On-Line In the State of Baja California, in the Mexicali Valley, the Comisión Federal de Electricidad has in operation a 150000 kW Geothermal Power System, named Cerro Prieto I, that includes a liquid dominated reservoir, production wells, pipeline gathering system, a power plant and an evaporation pond for brine disposal purposes. The power plant has four 37500 kW units in operation. The first unit began commercial operation in April 1973, followed by a second unit in September 1973. Two additional units were placed in operation later in 1979, increasing the plant capacity from 75000 to 150000 kW. From April 1973 to April 1981, these four units have generated 5191 million kWh.

Status of Power Plants Planned and Under Construction In addition to the four Cerro Prieto I operating units, a fifth 30000 kW unit is under construction, and it will begin to operate in July 1981, increasing the total capacity to 180000 kW.

This year will also begin the construction of two geothermal power plants with a generating capacity of 220000 kW each. These new two plants, Cerro Prieto II and Cerro Prieto III, are scheduled to initiate commercial operation in 1983 and 1984 respectively. With such plants operating on line, the total Cerro Prieto's generation capacity will reach 620000 kW by 1984.

As part of the exploration programs for this year, two deep wells will be drilled 7 kms., north-east from the Cerro Prieto I Power Plant, in order to define the reservoir boundary in this direction. If the results are successful, the proven capacity of the Cerro Prieto Geothermal Reservoir will be increased to a minimum of 1000 MW.

In the central part of México, in Los Azufres Geothermal Field, CFE is planning to install five portable non-condensing turbine generators 5000 kW each, scheduled to begin commercial operation in the first quarter of 1982. Preliminary engineering for the construction of a 55000 kW power plant in this field has begun. The total reservoir capacity has been estimated between 300000 and 600000 kW.

Forecast of Geothermal Generating Capacity for the Year 2000 Important efforts during the last 6 years have been made by Comisión Federal de Electricidad towards the diversification of its energy sources for power generation. In 1979 58000 GWH were generated, from which 17800 GWH were produced by hydroelectric plants, 39200 GWH by fossil fuel plants and 1000 GWH by geothermal power plants. The latter figure represented 1.78% of the total electrical energy generation for 1979. To support México's National Industrial Development Plan, where a yearly increase of 14.2% in power supply is expected, CFE is planning the construction of power plants whose power output should be 550000 GWH per year by the end of the century. From such power generation, 80000 GWH will be produced by hydroelectric plants, 270000 by fossil fuel plants, 140000 by nuclear plants, 40000 by coal power plants and 20000 by geothermal power plants. This latter figure will represent 3.6% of the total power generation. This fact implies the need to install geothermal power plants at a rate of 200 MW per year and consequently, the drilling of nearly 40 production geothermal wells per year once the reconnaissance, prefeasibility and feasibility stages of each project have been accomplished.

Technical Features of the Plants and Resources The 150000 kW Cerro Prieto I Geothermal Power Plant is operated with the separated steam produced by 30 wells. The plant requires a total amount of 1580 metric ton/hr of steam assuming a plant factor of 100%. In order to produce this amount of steam, the total steam and water mixture production should be 5000 metric ton/hr. Turbines of Units 1, 2, 3 and 4 of 37.5 MW capacity each, are single cylinder, double flow, impulse and condensing type. The inlet pressure is 6.3 kg/cm<sup>2</sup> abs, and the exhaust pressure is 0.108 kg/cm<sup>2</sup> abs.

In the actual exploited area, the average reservoir temperature is 290°C, the brine's dissolved solids before flashing are 15000 mg/kg. The gas content in the separated steam is 1.7%.

Unit No. 5 will be driven by low pressure steam obtained from two additional flashed stages of the brine, that at the present is discharged to the evaporation pond. The

turbine is single-cylinder, double-flow, mixed pressure and condensing type. The steam required to operate this turbine will be 143 metric ton/hr at 4.3 kg/cm<sup>2</sup> abs and 136.4 metric ton/hr at 2.1 kg/cm<sup>2</sup> abs. To obtain this amount of steam 3200 metric ton/hr of brine are required.

The Cerro Prieto II and Cerro Prieto III Power Plants under construction will be supplied with the steam produced by 50 wells. Each plant will consist of two 110000 KW units. Each generator will be operated by two 55000 kW tandem compound turbines, double-flow, mixed pressure, condensing type.

The turbines of the five portable units that will be installed in Los Azufres Geothermal Field are single-cylinder, non-condensing type; the inlet pressure will be 10.2 kg/cm<sup>2</sup>. Each plant will be operated with approximately 70 metric ton/hr of steam.

In Los Azufres Geothermal Field, steam and water mixture is produced in some wells, and in others only dry steam is produced. The average reservoir temperature is 300°C and the total dissolved solids are 6400 mg/kg at atmospheric pressure.

Constraints on Development At present the main technical obstacle for the geothermal energy development in Mexico is the difficulty to evaluate the total potential of geothermal reservoirs, that leads to the adoption of conservative evaluation methods in the selection of power plant sizes.

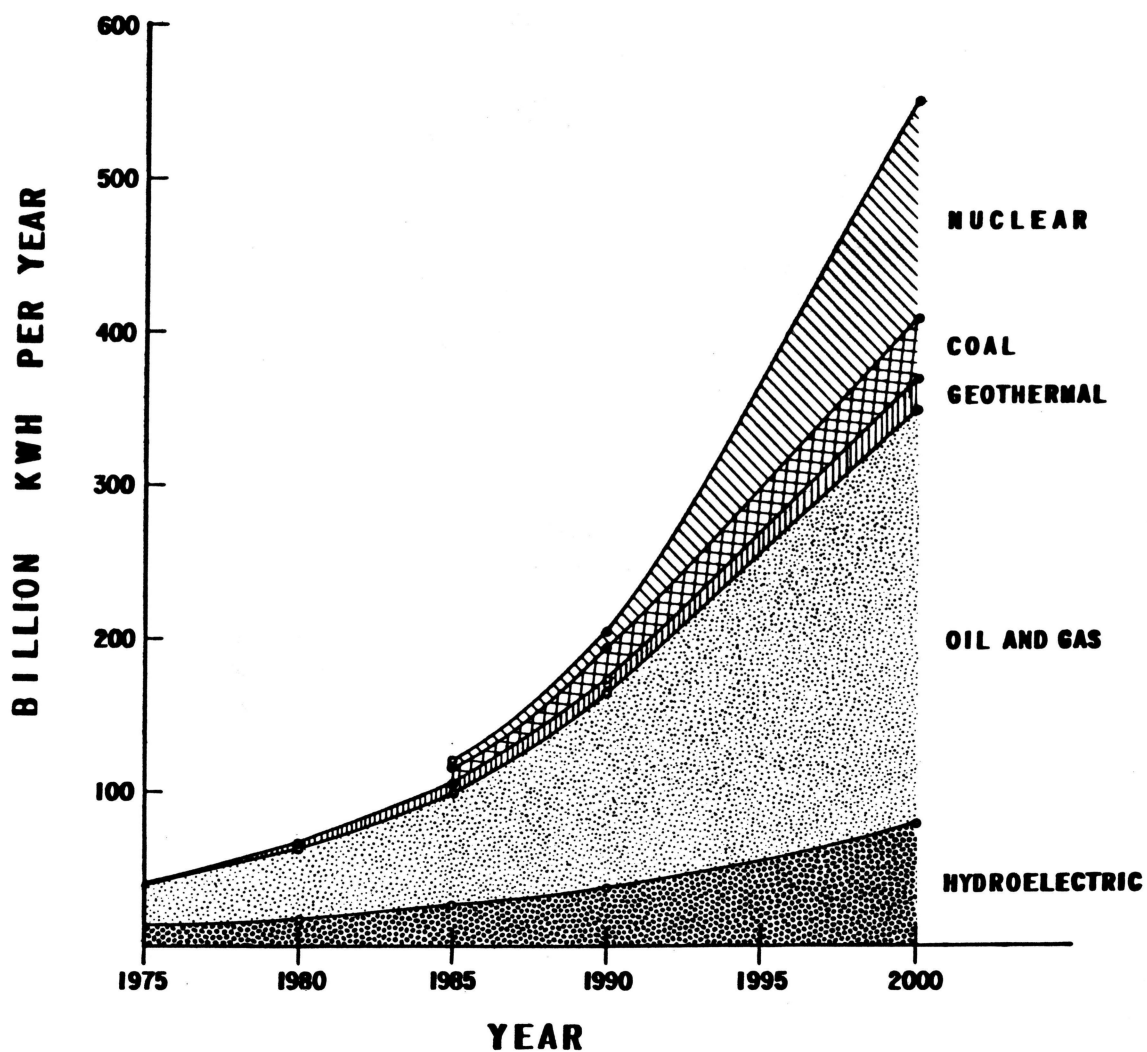
Some other problems that require additional research are those regarding well completion in high temperature reservoirs, associated to cement degradation and casing corrosion problems.

Another potential constraint for Mexico's geothermal development could be the environmental impact caused by geothermal fluids in liquid dominated reservoirs. The general recommended solution in these cases seems to be brine reinjection. Regarding the environmental impact originated by hydrogen sulphide discharge to the atmosphere, though problems have not yet been presented that could stop the geothermal development, some studies and surveys are conducted in Cerro Prieto, using dispersion models and direct measurements of H<sub>2</sub>S, to estimate the level of this gas at the atmosphere when new geothermal plants begin to operate. The possible process that could be used to reduce H<sub>2</sub>S discharge is also studied.

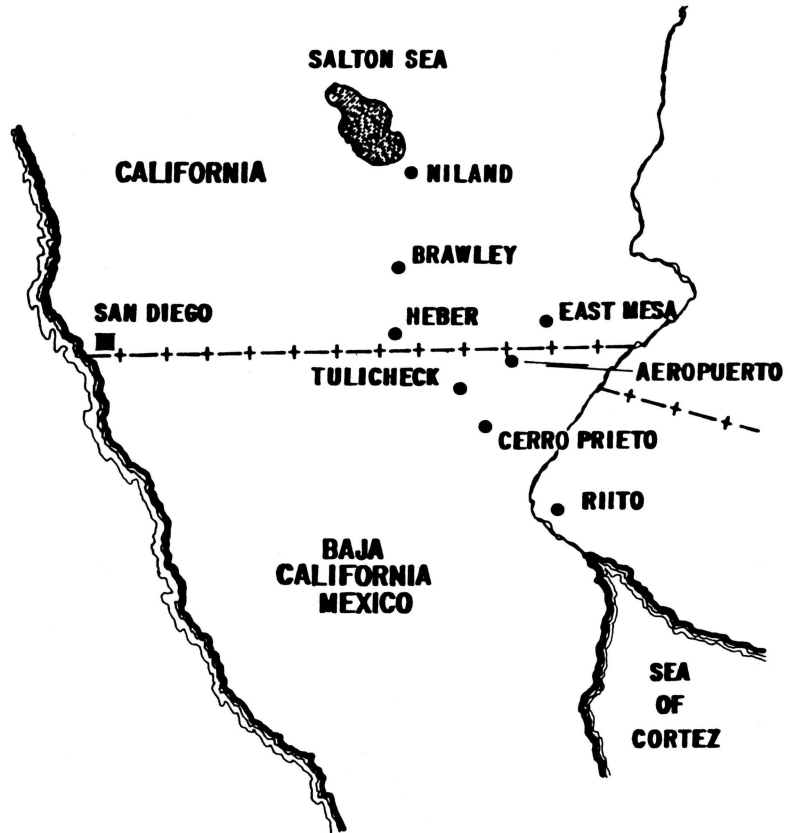
Another problem that must be studied and solved to facilitate Mexico's geothermal development, is that related to the land extension required for well drilling, above all, when these wells are located in agricultural zones. A potential solution to this problem is to improve the directional drilling technology for geothermal wells.

Finally, it is necessary to train the human resources that will be capable to cover the different stages of exploration, evaluation, project engineering, construction and operation of geothermal power systems that will allow to reach the goal of 4 million kW and so generate 20 thousand million kWh annually towards the end of the century.

ELECTRICAL GENERATION FORECAST  
BY TYPE OF SOURCE IN MEXICO



GEOTHERMAL RESOURCE AREAS

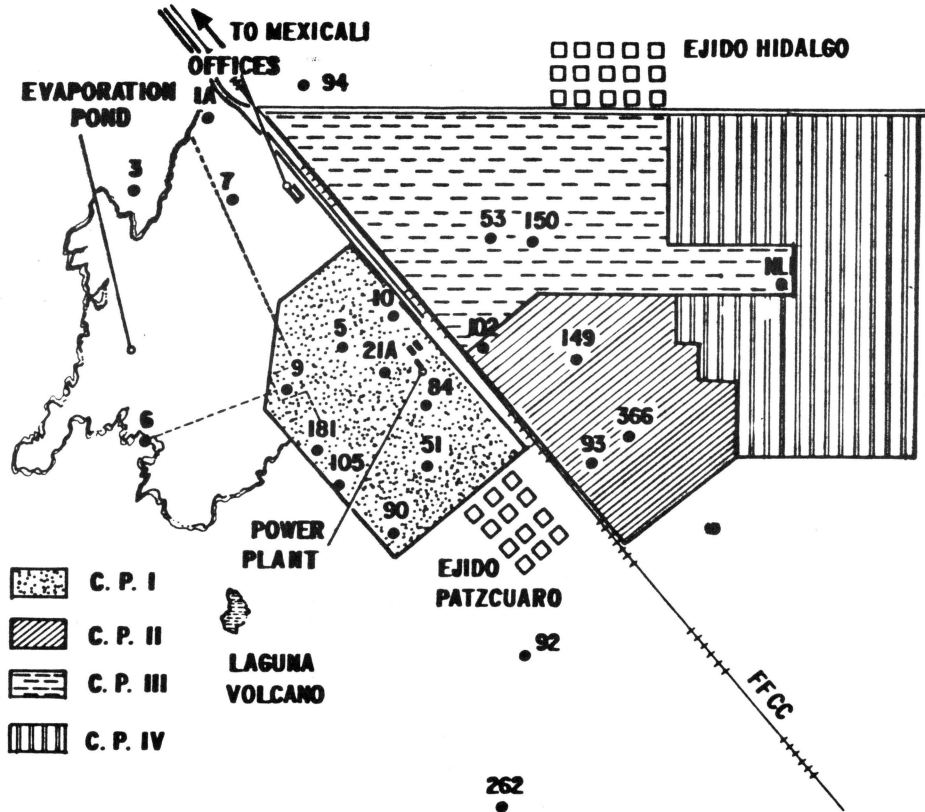


STATUS OF GEOTHERMAL POWER PLANTS IN MEXICO

| NAME                            | DATE OF INITIAL OPERATION | CAPACITY MW | STATUS (16-JUNE-81)           |
|---------------------------------|---------------------------|-------------|-------------------------------|
| PATHE, Hgo.                     | Nov. 1959                 | 3.5         | OUT OF LINE                   |
| U1 CERRO PRIETO I               | Oct. 1973                 | 37.5        | ON LINE                       |
| U2 CERRO PRIETO I               | May. 1973                 | 37.5        | ON LINE                       |
| U3 CERRO PRIETO I               | Jan. 1979                 | 37.5        | ON LINE                       |
| U4 CERRO PRIETO I               | Mar. 1979                 | 37.5        | ON LINE                       |
| U5 CERRO PRIETO I               | Jul. 1981                 | 30.0        | UNDER TEST TO BEGIN OPERATION |
| U1 CERRO PRIETO II              | May. 1983                 | 110.0       | UNDER CONSTRUCTION            |
| U2 CERRO PRIETO II              | Sep. 1983                 | 110.0       | UNDER CONSTRUCTION            |
| U1 CERRO PRIETO III             | Jan. 1984                 | 110.0       | UNDER CONSTRUCTION            |
| U2 CERRO PRIETO III             | May. 1984                 | 110.0       | UNDER CONSTRUCTION            |
| 5 PORTABLE UNITS<br>LOS AZUFRES | Jul. 1982                 | 25.0        | UNDER CONSTRUCTION            |
| U1 LOS AZUFRES                  | Apr. 1984                 | 55.0        | UNDER PROJECT                 |
| U2 LOS AZUFRES                  | Feb. 1987                 | 55.0        | UNDER PROJECT                 |
| U3 LOS AZUFRES                  | Dec. 1988                 | 55.0        | UNDER PROJECT                 |

NOTE.- THIS PROGRAM DOES NOT INCLUDE ALL THE GEOTHERMAL PROJECTS  
BUT ONLY THOSE APPROVED BY C.F.E. TO DATE.

CERRO PRIETO GEOTHERMAL DEVELOPMENT AREAS



-  C. P. I
-  C. P. II
-  C. P. III
-  C. P. IV

| AREA | NO. OF WELLS | M w/WELL | Mw. |
|------|--------------|----------|-----|
| I    | 30           | 6        | 180 |
| II   | 25           | 8.8      | 220 |
| III  | 25           | 8.8      | 220 |
| IV   | 40           | 7.6      | 380 |

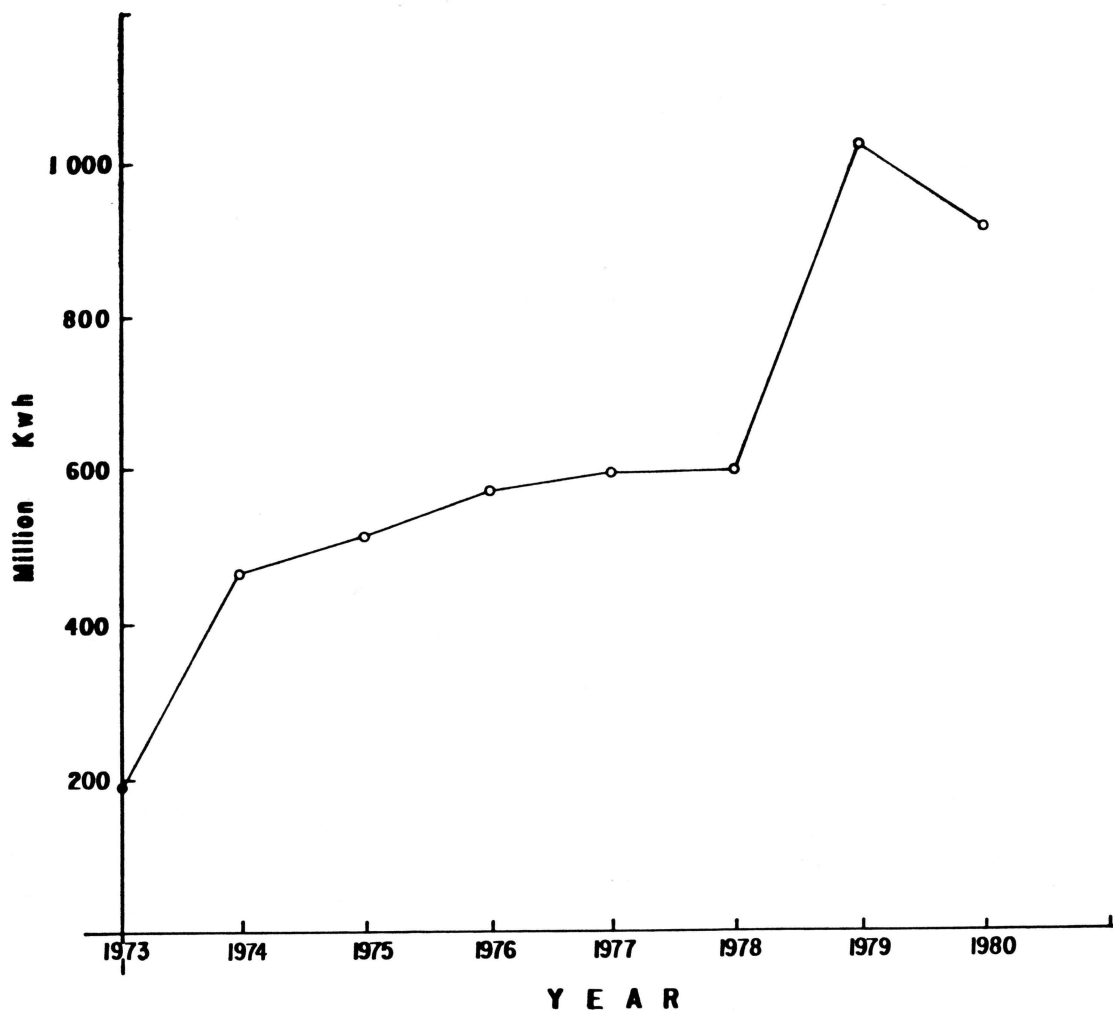
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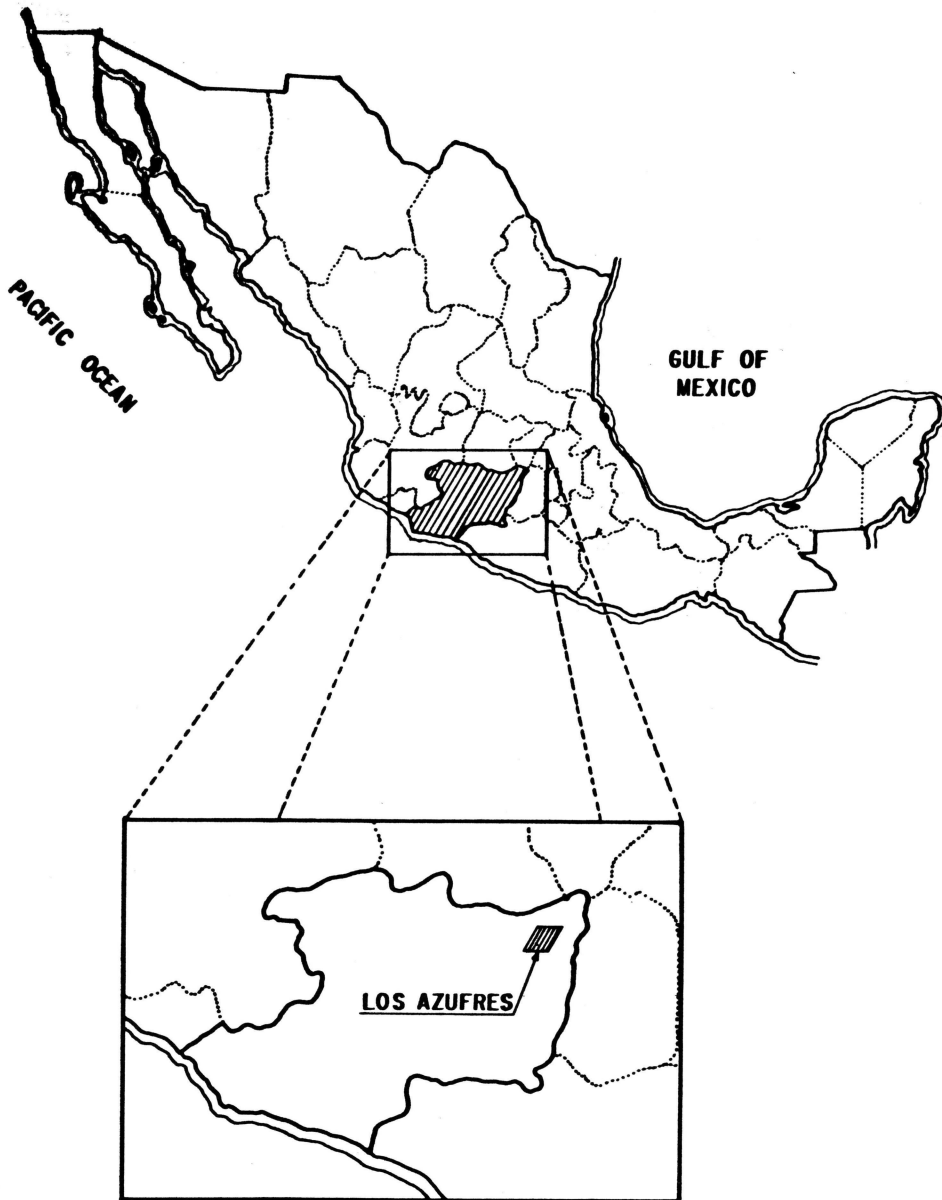
## ELECTRICAL GENERATION IN THE CERRO PRIETO GEOTHERMAL PLANT

| <b>YEAR</b>  | <b>GWH</b>  | <b>CAPACITY</b> | <b>PLANT FACTOR</b> |
|--------------|-------------|-----------------|---------------------|
| <b>1973</b>  | <b>193</b>  | <b>75 MW</b>    | <b>0.63</b>         |
| <b>1974</b>  | <b>463</b>  | <b>75 MW</b>    | <b>0.70</b>         |
| <b>1975</b>  | <b>518</b>  | <b>75 MW</b>    | <b>0.79</b>         |
| <b>1976</b>  | <b>579</b>  | <b>75 MW</b>    | <b>0.88</b>         |
| <b>1977</b>  | <b>592</b>  | <b>75 MW</b>    | <b>0.90</b>         |
| <b>1978</b>  | <b>598</b>  | <b>75 MW</b>    | <b>0.91</b>         |
| <b>1979</b>  | <b>1018</b> | <b>150 MW</b>   | <b>0.82</b>         |
| <b>1980</b>  | <b>915</b>  | <b>150 MW</b>   | <b>0.72</b>         |
| <b>TOTAL</b> | <b>4876</b> |                 |                     |

ELECTRICAL GENERATION IN THE CERRO PRIETO I GEOTHERMAL PLANT



LOS AZUFRES GEOTHERMAL AREA



TECHNICAL DATA OF LOS AZUFRES GEOTHERMAL FIELD (Sept. 1981)

|  |                              |
|--|------------------------------|
| <b>DRILLED WELLS</b>                     | <b>17</b>                    |
| <b>PRODUCTIVE WELLS</b>                  | <b>12</b>                    |
| <b>INJECTION WELLS</b>                   | <b>4</b>                     |
| <b>PRODUCTION DEPTH RANGE</b>            | <b>600-1500m.</b>            |
| <b>AVERAGE STEAM PRODUCTION PER WELL</b> | <b>64.5 METRIC TONS./Hr.</b> |
| <b>RESERVOIR TEMPERATURE</b>             | <b>250-300 °C</b>            |