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2005—A Good Year for Cerro Prieto Geothermal Field

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Keywords

Steam, Cerro Prieto

ABSTRACT

During 2005, at the Cerro Prieto geothermal field a total of 52.2 millions tons of steam were produced at the wellhead. Of these, 49.9 million tons were used at the power station to generate 5,521 GWh of electricity; the largest amount ever in 32-years history of the field. The activities that allowed reaching the large steam production and electricity generation numbers are discussed.

The power plant was recognized as the "Best Power Plant" of the Northwest Production Management. This award is granted to the work center that for the goals execution and the improvements experienced. A special thing was the effort and work of the technical and administrative employees of Cerro Prieto for getting this goal in the year 2005.

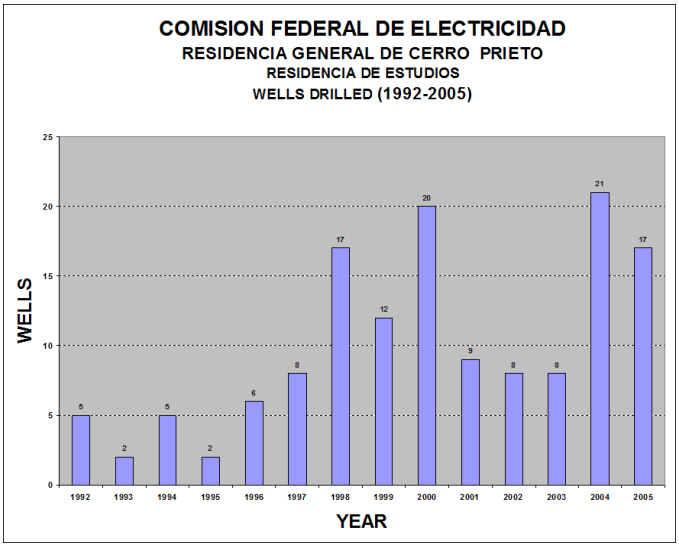

Figure 1. Drilling history of Cerro Prieto (1992 to 2005).

Introduction

The exploration of the geothermal field begun in 1961, with three wells, up to the 2005, in the field have been perforated a total of 350 wells. In the Figure 1, the drilling history of the field is shown.

At present, the installed effective generating capacity at Cerro Prieto is 720 MW. There are thirteen turbines installed in four separate buildings. That is, Cerro Prieto 1 (CP1) has Unit 1 to 5; Cerro Prieto 2 (CP2), Units 6 and 7; Cerro Prieto 3 (CP3), Unit 8 and 9; and Cerro Prieto 4 (CP4), Units 10, 11, 12 and 13.

Units 1 and 2 in power plant CP1, with a capacity of 37.5 MW each, started commercial operation on April 4, 1973. In 1979 Units 3 and 4, also with a capacity of 37.5, came on line. In 1981, the 30 MW Unit 5 was added.

Units 6, 7, 8 and 9, each with capacity of 110 MW, were installed in CP2 and CP3 between 1985 and 1987. CP4's Units 10, 11, 12 and 13, of 25 MW each, started operation in the year 2000.

From the beginning of their operation this power plants supplied base load to the Electric System of Baja California. In 2005, 55% of the electricity in the system energy was generated by the Cerro Prieto geothermal power plants.

The management of the complex field – power stations system is divided in two groups, one is the Gerencia de Proyectos Geotermoelectricos (GPG) and the other is the Gerencia de Produccion del Nor-Oeste (GPNO), both belonging to the Subdireccion of Generation of CFE.

Al the steam needed for Cerro Prieto power stations are supplied by the wells in the geothermal field.

Steam Production

In 2005, the steam production measured at the well head was 52.2 million tons; at average rate of 4.3 million ton/month (5,962 ton/h). Steam available to power plants was 51.0 million tons, with an average of 4.2 million ton/month, (5,824 ton/h). The steam supply to the power plants was 49.9 million tons,

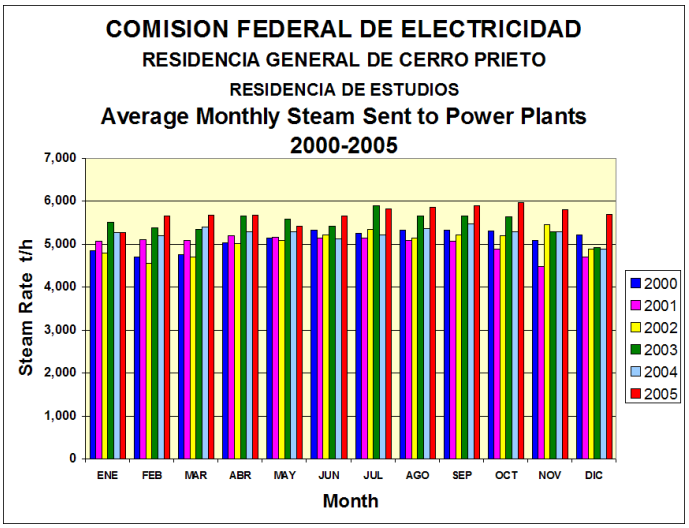

Figure 2. Monthly steam production at Cerro Prieto (2000-2005).

with an average rate of 4.1 million ton/month, 5,699 ton/h, (Jacobo, 2005).

Figure 2 shows the steam production rate for all the months of 2000 to the 2005.

Power Plants Results During 2005

The Cerro Prieto power plants reached the largest historical power generation of 5,521 GWh in 2005. It represents an increase of more than 10% above the previous annual record. It is equivalent to an average hourly generation of 630 MWh throughout the year. The high level of generation was attained in spite of having 180 days of maintenance in 2005.

The electricity generated by Cerro Prieto power plants represented 55% of the entire electric system of the of Baja California. The plant factor was 87.53% the best in the last 5 years. The unitary cost of production was the second lowest among the 8 power plants that generated more electricity in Mexico; it was only surpassed by a hydroelectric power plant.

Cerro Prieto power plants were available 88.64% of the time, which represents an increase of 5.5% with respect to that of the year 2004 (i.e. 83.14%). The unit 5 is being repowered for last 3 years; if it would have been on line, the overall availability of the plants would have been 92.84%.

The number of units shutdown, attributable to the power plant (unexpected and programmed trips, maintenances are not included), was 120 trips. In 2005, Cerro Prieto power plant had 82 trips. This value represents the smallest number of trips since CMC entered in operation.

Reasons Behind the Record Steam and Electricity Production in 2005

Good New Producing Wells

On average 162 production wells sent steam via gathering system to the power plants in 2005. Thirteen new wells were drilled, which supply 834 ton/h of steam (average of 69 ton/h per well). One should note that several wells of these wells were located in new areas. It was predicted that they would produce up of the 55 ton/h of steam, however they better producer (e. g. wells 319 with 103 ton/h; 416, 65 ton/h; well 401; 92 ton/h; well 315, 93 ton/h of steam. Other wells drilled in well-known areas, but they also produced more than expected (e.g. well 208, 72 ton/h; 422, 74 ton/h; 417, 79 ton/h of steam). The location of these wells is given in Figure 3. During 2005, ten wells were repaired, they produced 285 ton/h of steam. Figure 3 show the great steam producer wells location.

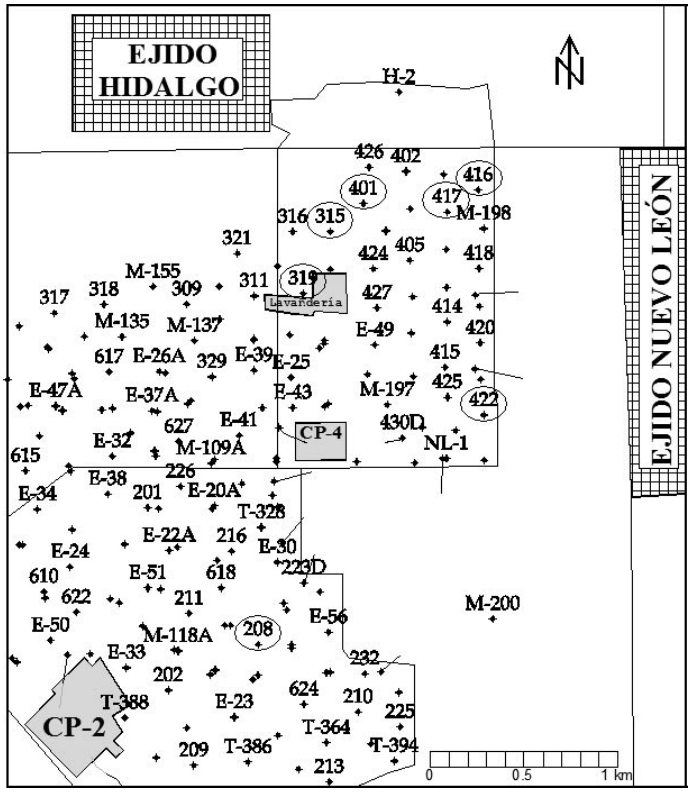

Figure 3. Location of the great steam producer in Cerro Prieto wells.

Improvements and Changes Made to Surface Installation

The steam gathering system in CP1 and CP2 that sends steam to power plant CP1 were modified in 2004. The effect of larger system supply was observed in 2005. Additional valves were installed in the main CP3 steam gathering system, which reduce of number of wells that have to be taken out of production if some repair needs to be made. This improved the steam usage in the field.

Reduction in Mineral Scaling

Mineral scaling is an old problem in Cerro Prieto; decrease in well steam production with decreasing is common occurrence. Silica scales deposit in different parts of the surface installation, like in the production orifice plates at the wellheads. Traditional orifice plates were modified. This modify was mirror finish and bevel angle on both faces of the orifice plate and stainless steel 316. A decrease in silica scaling was

observed and steam production increase. The new orifice plates were installed 20 wells.

An electromagnetic inhibitor to reduce the deposition of silica scales was installed in well 424, which showed a decline in steam production of about 1 ton/day. This required cleaning of the separator and pipe lines every 20 days; now that is needed only every 3 months.

Power Plants Maintenance

The units in power plant CP1 have accumulated, on average, almost 200,000 hours of operation. This has been achieved because of large investments made in the main and auxiliary equipments. During the last 3 years, the circulation water pumps in Unit 1 and 2 have been replaced; this reduce their unavailability because the failure to zero. In the 2006, the circulation water pumps are scheduled to be changed in Units 3 and 4, similar improvement are expected.

The cooling towers of CP1 were repaired in 2004 and 2005. The filler of the towers of Unit 1 and 2 was changed. This allowed generating power at nominal levels, even under severe summer conditions.

Availability of a spare turbine rotor allowed the substitution repaired rotor during each maintenance of the unit, this done, on average, every 16,000 hours. Usually the repair includes that of the last stage blades and of the diaphragms. The retired rotor is sent for repairs to make it ready for the next maintenance. This has allowed the CP1 units to generate more than the nominal capacity after maintenance.

In power plants CP2 and CP3 the four 110 MW units were maintained. The eight turbine rotors and turbine diaphragms of each unit were repaired during 2002-2005 period. This allowed to reducing the heat rate for the units to about 800 kJ/kWh. The program of rotor repair will conclude in 2006, with that of the two spare rotors.

The cooling towers of CP2 and CP3 were repaired 2003 – 2005. The filler of the cooling towers of units 8 and 9 was changed; that of Unit 72006 was made earlier this year (2006). The largest improvement was observed in Unit 9 since it gained around 4 MW with the repair of the filler. In addition, a new cooling tower was built for Unit 6, reducing its unavailability due to failure below 1%.

During the last four years (2002-2005), significant investments were made in improving the gases extraction systems, especially in the turbo compressors. This allowed to reduce the unavailability factor of the 110 Mw units; it has decreased for Units 6, 7 and 8.

Also in CP2 and CP3 digital registers and digital alarms systems were installed, which has improved the units operation and the analysis during the failures.

In power plant CP4, which started commercial operation in 2000, a strict maintenance program is fallowed; it is done every 2 years. The repair of the turbine rotors in the gland steam area has increased the availability of four 25 MW units.

Chemical are added to the water in the cooling towers to diminish the dirt in nozzles and filler, resulting in a decrease in the maximum cold water temperatures in the summer from 43° to 39° C. Thus, the units have been able to continue generating up of their nominal capacity, which was not possible when superior temperatures were above 40° C.

Future Plans

Presently, there are medium-term projects to increase availability and operative reliability of units at Cerro Prieto. They include:

- Repair and/or replacement of turbo compressors.
- Replacement of the turbine electro-hydraulic control with digital electro-hydraulic Controls.
- Replacement of turbine control system in the 37.5 MW units.
- The repowering of Unit 5 that will allow to generate again 30 MW, without additional drilling or repairing of new wells.

Conclusions

After 32 years (1973-2005) of continuous commercial exploitation, the Cerro Prieto geothermal field a record amount of steam and, as consequence, also attained a record in electrical power generation. This was possible because of:

- High steam production from new well
- Improvement in the steam gathering system
- Reduction of silica scaling in well and surface installations
- Appropriate and significant investment in power plants equipment cooling towers, water pumps during the last four years
- Replacement of turbine control systems
- Installation digital register and digital alarms systems in the plants
- Strict power plants maintenance program (major unit overhauls done every two years.

Finally, one should acknowledge that without the hard effort and especial dedication of the technical and administrative Cerro Prieto personal the achievements of 2005 would not have been possible.

Acknowledgments

The authors thank Marcelo Lippmann for his comments and suggestions to improve this paper. Also thanks to Cerro Prieto authorities to support preparation of this work.

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