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LESSONS LEARNED FROM GEOTHERMAL DEVELOPMENT IN MEXICO

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ABSTRACT

Several countries of Central America and Mexico have a long experience in developing and operating geothermal power plants. Beside the specific technical subjects learned during all those years, there are some general experiences that can be learned from the Mexican experience. First, there is a need for technical and financial support that helps in overcoming the obstacles for the exploration of new fields. Second, the geothermal projects should be actively promoted by government agencies and developers. Third, the geothermal industry requires highly qualified technical staff and training of young professionals should be a priority. Fourth, the development of new capacity requires a well defined and fair regulatory framework, including environmental aspects, like development of geothermal projects in protected areas. Finally, it is necessary to have a positive relationship with local communities where the geothermal projects are located and to inform society of the benefits of this type of energy.

This moment is an opportunity to further develop the geothermal resources of the region, considering the high prices of oil and gas and the concern with global warming. The Central American countries and Mexico must encourage the technical cooperation among them and a common human resources training program.

1. INTRODUCTION

The first geothermal power plant in Mexico and the American Continent was installed in Pathé in 1959. It had a nominal capacity of 2 MW and remained in operation during 10 years. Later, in the 60's, exploratory activities were carried out in Cerro Prieto; the first geothermal plant was commissioned in 1973. At present CFE has a total installed capacity of 953 MW; last year 7 299 GWh were generated.

Mexico has a long and rich experience in resources exploration and assessment, as well as in design, construction and operation of geothermal facilities. The experiences learned from that historic record are discussed here in two different sections: a) overall experiences and b) specific technical experiences.

2. OVERALL EXPERIENCES

The most important experiences that can be drawn from Mexican geothermal fields are the following:

- During the early stages of geothermal development, surface exploration and exploratory drilling, there are strong technological and financial barriers. Usually an amount of 7 to 10 million dollars have to be expended prior to be able to estimate the actual potentiality of the reservoir. In the worst case, the whole investment can be a loss.

  Before the 90's, CFE had every year a specific budget for exploratory activities, including drilling. The budget was assigned by the Ministry of Finances as part of the investment budget given to CFE. In those cases that drilling was not successful, the expended money was considered as a loss in the accounting. This practice changed completely when the Federal Government decided, as a general policy, to finance infrastructure projects with external credits labelled for each specific project, and to use IPP, BOT and EPC contracts. None of these modalities are viable during the exploration stage. As a matter of fact, CFE has not carried out exploratory drilling during the past 10 years. New capacity has been developed in operating fields.

  To overcome this obstacle, it is necessary to establish some kind of financial support for this early stage of exploration of geothermal resources. Our countries have limited or extremely limited financial resources. So, private investment, strategic alliances or soft loans from international cooperation banks or agencies could be the solution.

- Our experience with CFE's Programming Division is that the geothermal projects are not taken into account in the strategic planning of new capacity, except if there is an active promotion by the Geothermal Division. It is worthwhile to mention that this is the case for other type of renewable energy projects. There are several reasons to explain why an active promotion is necessary. In Mexico, geothermal projects are rather small as compared to the demand and planners tend to ignore them. The location of the resources does not necessarily coincide with the demand and the transmission line may be an economic overburden for the project. The time to plan, explore and develop a geothermal project is longer than that required for a fossil fuel project.

  The promotion of geothermal projects among government officials, financial institutions, investors, the community, etc., should be encouraged in order to increase its participation in the energy portfolio.

- The exploration and development of geothermal projects requires quite a lot of skilfulness and creativity. The whole cycle of fossil fuelled power plants can be considered as a closed system from a technological point of view. It is totally designed and control by men; operators must apply the manual and that is all. Uncertainties are rather related to the markets: availability and price of the fuel and customers demand. On the contrary, the steam supply part of the geothermal cycle is an open system. It was designed by "mother nature" not by men. During the exploitation, the reservoir interacts with its physical environment in a rather complex way.

  It is, therefore, necessary to have well trained and highly qualified personnel. Geothermal engineering is not a common subject in the curriculum of the majority of the universities. That means that the geothermal companies and the worldwide geothermal community have to organize themselves periodic courses.

- A well defined regulatory framework, including the environmental issues and the rules for the development of geothermal projects in protected areas, is essential. The investment in geothermal projects is a long term investment and should be guaranteed by appropriate laws. Even in cases like Mexico, where the electricity utilities are government own, a regulatory framework is essential, because the clients and minor players in the industry deserve protection and the public utilities should be managed with autonomy from central government.

  The environmental issue and regulation has been considered in another paper in this meeting.

- Many of the geothermal fields in Mexico and Central America are located in rural areas where native or needy communities live. Our experience in Mexico is that, as a rule, these communities are favourable for the project, because it represents the opportunity to have better life standards, like access to roads, clean water, and electricity. Nevertheless, it should be paid attention to this relationship. The policy in CFE is to assign some amount of money to built basic infrastructure; to aloud the communities to make use of wasted heat and to sign service contracts for general maintenance of the field and reforestation.

  CFE has in each geothermal field a plant nursery and an annual program of reforestation, which is administrated by the local community. We have had demonstrative pilot projects for timber drying, fruit drying, greenhouses to produce flowers, mushroom nursery, silica recovery for road pavement and brick manufacture, etc.

- It should be not taken the acceptance of geothermal projects by society for granted. This was probably true in the past, but not anymore. Social opinion is now strongly oriented in favour of the environment preservation and infrastructure projects are seen as a threat. The people must me informed about the advantages of geothermal projects as compared to other options. They should be also illustrated in order to be able to rationally evaluate the necessity of power plants and their benefits, as well as the fact that geothermal projects make use of indigenous resources and are benign to the environment.

3. TECHNICAL EXPERIENCES

In the previous section I have discussed the most significant general experiences in the development and operation of geothermal projects in Mexico. Now I will discuss few specific technical subjects which were selected according to my personal experience and may be considered somehow arbitrary. It is impossible to talk about the many technical challenges of a geothermal project.

- Noise abatement in surface installations and power plants is required by environmental regulations. In Mexico the maximum allowed noise level is 68 dB during day and 65 dB during night, measured in the limits of the confinement of the equipment which is the source of noise.

  We have experienced difficulties to properly isolate the sources of noise in wellheads and production separators when the flow conditions change with time. The steam to water ratio changes with time in several wells. It is usual that the steam fraction increases to almost dry steam. In those cases, the isolation and mufflers designed for the original conditions is no longer suitable. There are few cases that behave in the opposite way, the water fraction increases.

From time to time, it is necessary the change the isolating devices and mufflers to adapt to the new flow conditions, which represents expenses and undelivered steam during equipment reconditioning.

- Reinjection is mandatory in almost all fields to avoid surface and groundwater pollution. Cerro Prieto in Mexico is an exception. Around 70% of separated water is evaporated in an artificial pond with an area of 7 km^2, which is possible because of the climatic and soil conditions there.

  It is commonly stated that reinjection also helps in supporting reservoir pressure. But this is a rather ambiguous sentence. It is well known that the larger fraction of the thermal energy of a reservoir is in the rock and the water acts as an energy carrier to the surface. Therefore, it is wise to replace the extracted mass of water in order to sweep heat form the rock. Now, the relation between mass, temperature, enthalpy and pressure is not unique for any reservoir, it depends on the type of reservoir. In a confined liquid dominated reservoir, pressure is a function of the hydrostatic head and, even if pressure is sustained, the total reservoir enthalpy (rock and water) will decline because of colder reinjection. In an unconfined liquid dominated reservoir, if water is reinjected in the deeper parts, the situation is the same as the previous one. But, shallow reinjection in the "steam cap" will inevitably cause the pressure to drop, because pressure is a function of temperature. The fluid enthalpy most probably will rise, because of water boiling, but at the expense of rock enthalpy, because heat is transfer from rock to fluid. The same situation applies in a steam dominated reservoir. The point is that reinjection will always cause "damage" in the reservoir and reinjection engineering should be oriented to minimize it, in order to extend the reservoir life.

  This is not an easy task. I think it is the most challenging operation in a geothermal field. The effectiveness of reinjection depends on how and where in the reservoir take place. In Mexico, separated water is reinjected cold and at atmospheric pressure, with no wellhead pumping, making use of the topographic relief. This has advantages and disadvantages. The main advantage is that reinjection piping is simple and easy to move to different reinjection wells. We use high density polypropylene piping that lies on the ground. The main disadvantage is silica scaling especially in Cerro Prieto, where separated water at atmospheric pressure is conveyed to the evaporation pond by a network of canals; and from the pond is conveyed to the reinjection wells by polypropylene piping. A large amount of silica is deposited in the canals and the pond, which has to be removed by dredging to the final disposal sites. In other fields, silica is deposited in the piping and is removed by running "pigs" from time to time.

  Cold reinjection may also cause a higher temperature drop in the reservoir as compared to hot reinjection. We have not noticed such an effect in Los Azufres and Los Humeros; but in Cerro Prieto there are evidences of reservoir cooling in the western area, which is the most exploited and where reinjection takes place.

  CFE is considering changing to hot reinjection. I do not foresee mayor problems in Los Azufres, Los Humeros and Tres Virgenes; but in Cerro Prieto silica can be a real problem for two reasons. First, the separated water chemistry, which is high in silica and chloride; second, in many wells there is double flashing, so that the temperature of the separated water is well bellow the saturation point for amorphous silica.

- Well testing and well production history, including chemistry, should be the priority of reservoir engineers. Because reservoirs are complex and heterogeneous it is necessary to understand the way each reservoir portion responds to exploitation. There are now new excellent tools and software to facilitate these tasks.

- Drilling has a large economic impact during all the development stages of a geothermal project. Therefore, it is always desirable to introduce new drilling techniques to save costs and prevent formation damage.

- Formation logs are expensive and originally designed for oil reservoirs, which are hosted in sedimentary rocks. We have run a limited number of these logs in Tres Virgenes, where there is little or no relation of surface structural features and structures in the granitic rock that hosts the reservoir, with encouraging results. More research and field application of these tools is essential to better understand the reservoir geomechanics and to be on target when drilling.

- The discovery of new fields in the deeper part of the crust or with little or no surface expression depends entirely on the ability to construct realistic structural conceptual models. Seismic and electric tomography should play an important role to achieve these goals. Geothermal reservoirs are 3-D structures and exploration methods should be capable of investigating this type of situations.

4. DISCUSSION AND RECOMMENDATIONS

The present oil and gas prices, as well as the adversities caused by global warming, are a favourable opportunity to develop geothermal projects in Central America and Mexico. For many years several countries of the region have been exploiting their geothermal resources and have accumulated a lot of experience. This platform should be used to launch a new making use of the experience. Several initiatives have been proposed in the last years. This workshop and previous similar events organized with the sponsorship of the Government of Iceland in cooperation with governments of the region are an example.

The Japan bank of International Cooperation (JBIC), through the Official Development Assistance (ODA), is considering the establishment of a program to support the development of geothermal projects, based on long term soft loans given to the qualified governments in Central America. This financial support is intended to overcome the exploratory economic barrier. That is, the main purpose is to facilitate the exploration, including drilling, of new fields. Once the resource has been probed, the field can be developed by private, public or mix investment. This program is the result of a three year feasibility study carried out by the JBIC. The study concluded that geothermal energy is the best alternative for the region and discussed the different barriers that oppose to the development of this energy and the way to overcome them.

Parallel to this exploratory program, the government of Mexico, through CFE, and the government of Guatemala have presented to the Japan International Cooperation Agency (JICA) a request for a three year technical assistant program for training of human resources in the region of Mexico and Central America. The request is been evaluated by JICA and, if approved, will be initiated next year, being either Guatemala or Mexico the host country.

I believe that technical cooperation between CA and Mexico is of great importance and will redound to their advantage. A regional training program to prepare young professionals will be of great benefit for the geothermal industry in the region.

On the other hand, there are several initiatives in the international community to promote the development of these indigenous energy resources and to financially support the earlier stages of exploration. Let us take advantage of this situation.