九大地熱・火山研究報告
第 11 号 (2002) 16-24 頁

COUNTRY REPORT - GUATEMALA

H. Fernando Navas A.

INTRODUCTION AND ACKNOWLEDGEMENT

There are about 20 Countries in the called Lava Fire Belt of the World, most of which are economically underdeveloped, that have the geological conditions to take advantage of such natural situation to assist their overall social and economic development by the use of geothermal energy.

Geothermal Energy is both, a renewable resource, and ecologically friendly as well. Considered to be of little ambiental impact, like hydro, wind and solar energies. Therefore the whole World needs to strengthen all efforts to benefit from this available energy. And in turn, to responsibly contribute to limit dangerous and unwanted results like contamination and global warming, usually associated to fossil fuel combustion.

The direct use, Geothermal technology for Electric Power Generation is being developed and produced for markets use, by developed Countries like USA, Japan and Israel. There are also several categories of these technologies or systems - dry steam; water dominated; 2 phase; and binary

Each Country site has different geothermal reservoir characteristics, after these have been properly evaluated and considered, decisions have to be made by its government and private officials to select the type and size of system to be used. This paper introduces a discussion for 2 different management issues: O&M and M&E. It presents a different angle for modern management of geothermal power stations in a Foreign Country.

This paper is special since is introduced under "Country Report", but is not a general presentation of the National Institution for Electrification of Guatemala, INDE; which will, I hope, also find a good use for these concepts and tools in the near future National geothermal projects, like Amatitlan, as well as any other National and private Institution that believes that modern tools of management can improve decisively over the daily, and long term optimization of results.

In my opinion enough good formal technical books have already been written about the background of geothermal power plants, general systems, geophysical models, techniques and locations, in multiple publications. Although not so for management issues.

For practical and obvious reasons, no consideration is to be given here to several shorter phases of a geothermal power plant development. Meaning, technical, legal and contractual aspects related to the exploration and drilling or procurement, construction, commissioning and acceptance of a new power station.

Acknowledgement is due here to Kyushu University professors, JICA and West JEC, who have provided support to all related activities in Japan.

---

8 Calle 17-15, Colonia El Maestro 2, GUATEMALA
Email: hfnavasjapon@hotmail.com

(Part A)

MODERN MANAGEMENT OF OPERATION AND MAINTENANCE OF A GEOTHERMAL POWER STATION IN A FOREIGN COUNTRY

ABSTRACT

After completing the expensive and scientific, first stage process of Research and Development (R&D) of new geothermal power conversion technology, It is surely an enormous effort and more investment required for the companies and organizations that are working in the following stage of manufacturing the final approved design for production. Both of these 2 stages are usually an important economic strength, limited only to developed Countries. Not only for the financial costs, but more importantly for the knowledge required as well. See Figure 3.

The Plan: When the final product is introduced and presented to the market, then we can enter the role of the developing Countries, that procure the new technology, with self means or loaned financing, and begin to try to maximize its exploitation, during the expected useful life of the equipment.

The Problem: That above is the ideal situation, but in reality, for most of the cases the new technology acquired, when operated and maintained, is neither maximum exploited nor used during the expected full time cycle of it.

The Result, consequently, the goods, products or services that the technology is supposed to provide in the underdeveloped Country falls short. Further is not economic to use, and ends being replaced before its expected life production is reached. That result is easily viewed and even recognized.

The Solution: This paper aims to present 2 tools for discussion, in the specific application of geothermal power plants, that convert heat energy into electrical energy: A) through the use of management techniques for attaining optimum technology transfer, considering the special coupling needs, due to cultural reasons, of the people that will do the daily routine work of O&M, operations & Maintenance. B) A Monitoring & Evaluation System M&E, for Optimization of long term Results, with control, and required adjustments.

This, of course can only be realized when the adequate policies and norms are already formally in place and, support by government and private high level decision makers.

A final comment to this part, about how to organize and manage a geothermal power station in a foreign country, is that it can also be implemented in present operations in Japan, where a plant manager of operations would be the responsible person to implement it, and most probably about 90% of the work will continue to be in the same manner as it currently is. But is precisely the little changes of 10% of the activities or less, that will be transformed into a better control of O&M, and Optimization of Results.

1. DEFINITION - Technology transfer

By technology transfer it can be said to be of either of 2 forms:

1. The knowledge of a process - i.e. mathematical, use of software, administrative tool.
2. Specific knowledge related to a new product developed- i.e. O&M recommendations, or service parameters needed to calibrate and adjust.

A buyer of technology should carefully include all contractual obligations from the seller to obtain a proper level of technology transfer, as well as be prepared to receive it by the qualified personnel also.

Failure to serious approach about this matter will invariably hinder and put limitations to the economic exploitation and maximum production of the system selected, therefore not reaching expected production, nor useful equipment life, nor quality standards, nor economies expected, as it would happen if the system is installed and operated by the manufacturing organization, or in a developed Country, where technology is understood and maintenance is well funded and performed.

Unfortunately, inn the developing countries this situation is too often still repeated after so many examples of previous experiences, sayings like "bad luck with our machine", or "do not know why it broke in just 2 years", or "the personnel did not understand", are all not acceptable.

Another typical form of negligence is when not enough attention is given to know and learn about the real quality of the technology system components, besides from the design.

2. ORGANIZATIONAL MATRIX OF A POWER STATION - Technical and Administrative

A safe and sure way to optimize the O&M Operations of a Geothermal Power Plant, is to use the tools developed for quality tackling of technical and administrative issues, or management techniques. This paper is for the presentation, based of an individual and independent management experience, to model a quite useful manner to systematically organize the Geothermal Power Plant.

For the systematic management and organization of each geothermal power plant, there are 4 defined areas of work, in order to have a smooth administration during routine Operations & Maintenance Operations O&M:

These groups have to work, following management planning and approval, which should be based on criteria of technology level (High Medium Low) in the power station and its specific technical requirements.

Of course, each of these groups will interact their

FOUR AREAS IN POWER STATION – ANY SIZE
From 100`s to 1,000`s of KW

- Area 1: **Geothermal field or Steam Generation** – Usually the largest area of land that includes the production and reinjection wells, separators, rock mufflers, control valves and transportation related piping.
- Area 2: **Energy Converting Equipment** – is the area where is located the selected technology to convert energy from thermal to electric. Including the turbines and generators, condensers, pumps.
- Area 3: **Switching Devices and Electric Power Substation** – is to receive and handle safely the gross electrical power produced by the geothermal power plant, as well as being the interconnection point with the high voltage grid.
- Area 4: **Controls and Auxiliary Equipment**: -

FOUR CATEGORIES OR GROUPS OF STAFF IN A POWER STATION
ANY SIZE

- **Management**
- **Administration**
- **Operations**
- **Maintenance**

activities in coordination with the other groups, as well as covering the 4 areas of the Geothermal Power Plant.

3. ADOPTION OF O&M - Norms, Procedures

Is necessary to have established a clear set of written regulatory norms, rules and regulations for daily routine and exceptional activities in each Geothermal Power Station. These are to be applied to all personnel categories, and may require special adaptations of activities and training for each group.

Based on the specified norms and regulations the personnel will carry out all daily actions. Including power delegation and decision making process, usually needed very fast, in exceptional situations.

For example of routine operations, logbook and forms, and that all plant generating and auxiliary equipment are responsibility of the operations shift, unless maintenance is working on any unit and has not returned the control to operations.

Maintenance for example, routinely has the workload divided in 3 levels of technology complexity - high, medium and low. All the low technology complexity work is to be done in house (70% of total), the medium complexity is to be handled with well coordinated local support and supply (25%); and all the high complexity is to be contracted outside, either the original manufacturer or suitable competitor (5 %).

After all, the manager is not necessarily on site physically 24 hrs/day. See Figure 2.

4. SET ALL OPERATIONAL PARAMETERS - Includes Quality, Safety and Environment

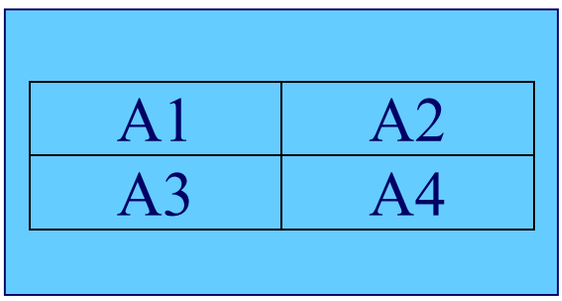
In addition to having clear rules for routine and exceptional activities of all groups of personnel for O&M operations, supervision or quality, reservoir and environmental issues should be addressed as special parameters to be complied with. This can be in a weekly manner. i.e. priorities, goals and expected situation of the period, warning signs, safety and prevention, emergency preparedness, etc.

For example, about environmental aspects, atmospheric discharges of uncondensed gases, or residual waters discharge, maintenance residues, training, plus an important coordination with accident and fire prevention. Parameters should be set and approved, for acceptable emissions of air, water, soil, residues, noise and vibrations.

Ecological protection in all the surrounding area. Animals, plants, landscape.

A final comment to this part, about how to organize and manage a geothermal power station in a foreign Country, is that it can also be implemented in present operations in Japan, where a plant manger of operations would be the responsible person to implement it, and most probably about 90 % of the work will continue to be in the same manner.

But is precisely the little changes of 10 % of the activities or less, that will be transformed into a better control of O&M, and Optimization of Results.



AREA **¥** **CATEGORY**	% or # hired people	**AREA 1** Wells & **Field**	**AREA 2** Energy Conversion & Generation	**AREA 3** Switchyard & Electric Grid Connection	**AREA 4** Controls for Automation & Auxiliaries
OPERATION	48% 12 p				
MAINTENANCE	40% 10p				
ADMINISTRATION	12% 3 p				
MANAGEMENT	8 % 2				

Fig. 1 Organizational Matrix for the Operation and Maintenance O&M Phase of a Geothermal Power Station

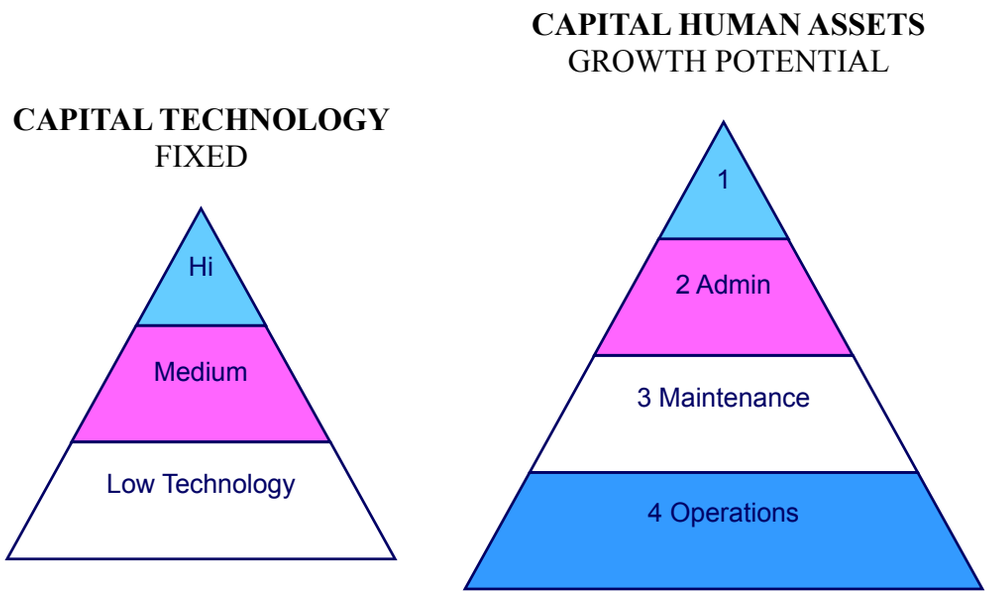


Fig. 2 The Operation & Maintenance O&M Technology Complexity Triangle

Phase	*R&D*	*EXPLOITATION*	*EXCHANGE*
	Research & Development	Procurement O&M	Monitoring & Evaluation
Main Characteristic	New Idea Design Working Model Prototype Manufacturing Marketing	Selection/Tech Specs Adoption Training Widely used Operation Maintenance	Overall Results Monitoring Evaluation Recycling Replacement

R&D — 99 % by developed Countries.
1 % by underdeveloped Countries.

Exploitation — **25 % efficiency** by underdeveloped Countries.
25 % never started to operate for lack of knowledge. High tech.
25 % stopped early for lack of maintenance knowledge. High + Medium tech.
25 % stopped early for lack of proper funding for corrective replacement.

M&E — Last phase should also be reflecting a clear definition of Indicators and Reports, including summaries of routine operational information M A M O, as well as indicators concerning the external factors of Reservoir and Environment

.

Fig. 3 Technology Development Process
Triangle for geothermal power conversion equipment

(Part B)

MONITORING AND EVALUATION SYSTEM (M&E) OF LONG TERM RESULTS OF A GEOTHERMAL POWER STATION

ABSTRACT

M&E is a sometimes forgotten cyclic management task, to evaluate and monitor the long-term macro or overall Results expected for a geothermal power station, in order to optimize them in a control closed loop like fashion. In a clearly different contrast with daily routine O&M operations.

Always, is more convenient that an independent entity be given this important responsibility assignment, in order to be out of management control that could prefer to skew or curve the findings, and likewise different from the group involved in daily O&M operations.

The Plan: The Monitoring and Evaluation tool is a management function that compliments the daily operational functions of quality production. Is not to be mixed, nor overlapped in any form. Its purpose is to Optimize the Results of the power station operation. Is easy to visualize as a closed control loop. Results can be defined of different nature as technical, financial, market, administrative / management.

Important parts of the M&E system are: The Evaluation chart, to compare to a given base; the properly defined Indicators, to measure the results consistently and systematically; and the defined Reports contents and periodicity.

The Problem: When M&E is not properly attended there is a risk to get too much involved in daily situations and missing the important macro view of the power station expected Results and timely adjustments.

The Result: This means that in consequence, no attentions is paid to problems that daily O&M will not be able to solve when they arrive, because these problems, are only visible in overall tendencies and projections of many months or years. As examples of technical aspects there are reservoir conditions, scaling in reinjection wells, and environmental issues.

The Solution: To present a technical tool that will assist and be the basic support to make the required timely management decisions based on M&E findings.

1. DIFINITION - M&E

○ The eyes for monitoring the Optimized Results are the Indicators.

○ Definition of Indicators for a geothermal power station. Table in next section

○ The Evaluation is a process to compare the real time obtained indicators with the expected levels, during a specific period. According to a table prepared early each year. And approved by the directors of the company.

○ Analysis is the next step to understand the reason for the deviations obtained. Suggest reasons for the found deviations, raise a flag if concern and attention is required.

○ A Reporting System needs to be established, defining the periodicity, and contents of each report. Monthly, Quarterly, Mid Year, Annual.

○ The M&E Reports for management, are definitely not like a public relations brochure, or a cosmetic look at the O&M operations, in fact is quite real and explaining the problems encountered.

○ Therefore is a management need to make corrections, steering, decisions, or praises if appropriate.

○ The reports will also include the timely measures already taken as well as adjustments required in

the future to continue the improving of results. Both, for daily O&M activities, as well as for long-term goals.

- It may be considered, and is more convenient to have the M&E Reports prepared by an independent source from O&M control, to avoid curving of findings, and be more objective.

2. ADOPTION OF M&E INDICATORS . Norms, Procedures

INDICATORS

DAILY **O&M** ROUTINE ACTIVITIES OR QUALITY CONTROL	OVERALL **M&E** **RESULTS**
Activities for 20,000 KW ❖ **O&M** A1. Separator A1. Well valves A2. Turbine A2. Generator A2. Condenser A2. Cooling tower A3. A4. All control and auxiliary equipment is checked and exercised periodically ❖ **M&E** ○ **Indicators & Reports**	**Optimized Results** are all met and satisfied ❖ TECHNICAL availability ❖ MARKET daily change ❖ FINANCIAL payments ❖ ADMINISTRATIVE / MANAGEMENT ❖
HRS / UNIT HRS / PERSON RESERVOIR Pressure Temperature Enthalpy Chemical ENVIRONMENT Water Air Gas Soil Noise Vibration MARKET INFORMATION	AVAILABILITY – to know generation POWER ENERGY INVOICE AGREED DISTRIBUTION CURRENT Owners Bankers Partners O&M M&E TAXES PERMITS AUTHORITY COORDINATION ANALYSIS OPTIMIZATION PERIOD REPORT

Additionally, any Indicator can be adjusted as necessary, every year, and have up to **6 dimensions** (period, time place, quantity, characteristic, description, cost) to make them more objective and easy to follow up.

FINAL CONCLUSIONS AND RECOMMENDATIONS

To strengthen the support for research and development of management tools and techniques, which are valuable for technology related projects, such as a Geothermal Power Station, as complement to engineering that alone does not guarantee optimal results.

Continue to develop the sound knowledge and techniques of management and administration of Geothermal Power Stations in accordance with the new tools and techniques available. For the optimization of overall results for new Geothermal Power Stations, and as well as for existing operations.

Compliment the expertise of engineering experience with management methods for optimization from administration and planning proven techniques. To assure optimized results, and less problems.

Test the above M&E, control loop, for optimization of results in a presently existing operation. Defining the appropriate indicators and reporting system.