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GEOTHERMAL POWER PLANT DESIGN WITH OPERATION AND MAINTENANCE IN MIND

David Gonsalves[1] Lauri A. Knox[2]

[1] Stone & Webster Engineering Corporation, P.O. Box 5406, Denver, CO 80217
[2] Geothermal Resources International, Inc., 1825 S. Grant St., Suite 900, San Mateo, CA 94402

ABSTRACT

Many more geothermal power plants are expected to be built in the United States in the near future. The owners and designers of these plants are increasingly realizing the importance of operations and maintenance to successful plants. Various design features can contribute to plants that will operate well and be easy to maintain. These include the design process itself, built-in operation and maintenance features and incorporation of user friendly controls.

INTRODUCTION

The geothermal power industry is maturing rapidly in the United States. Today, a number of firms are engaged in designing, building and operating geothermal power plants in California, Utah and Nevada. Many of these plants are in the early planning stages, and many more are expected to be built.

Plant owners and designer engineers within the industry are increasingly realizing the benefits of developing superior operating plants that make maximum economic use of the geothermal resource. An important contribution to achieving this goal can be made by designing with operation and maintenance in mind.

Various design features can contribute to superior plant operation. These include the design process itself, built-in operation and maintenance features and incorporation of user-friendly controls.

THE DESIGN PROCESS

Designing for superior plant operation starts during the design process by considering operation and maintenance requirements throughout the conceptual phase, detailed design phase, and construction phase followup.

Conceptual Phase

During the conceptual phase, the plant owner and the design engineers work together to define the basic design parameters for the plant. The major thrust of this phase is to develop a plant that will be compatible with the geothermal resource and that will return maximum net revenues to the owner. At this stage, neither the owner or the design engineers is usually concerned with operation and maintenance. Actually, this is the most critical phase of a project in terms of operation and maintenance and therefore a high priority should be given to O&M. The following are some of the aspects that should be considered during this phase to ensure future reliable operation and ease of maintenance:

1. Basic Cycle Selection - Will the cycle be easy to operate and maintain? Is it compatible with other O&M objectives?

2. Reliability & Efficiency Objectives - Are these economically reasonable to achieve? High reliability and expected capacity factors may require redundant equipment and higher levels of instrumentation, maintenance and staffing requirements. These may require higher capital investment but over the years should quickly pay off with the higher revenues that can be generated.

3. Operation Staffing Plan - What is the number and level of operators that are expected to operate the plant?

4. Maintenance Plan - What are the plans for the preventive maintenance program? How will spare parts be handled? Will major overhauls be done by company people or contracted out?

5. Design Criteria, P&ID's, Basic Layout & Electrical One Lines - Are these basic design documents developed with operations and maintenance input?

6. Control Philosophy - Is this written and clearly understood by the design engineer? Is it compatible with the operation and maintenance plans and objectives?

Since the conceptual phase sets the stage for the remainder of the project development, it is imperative that clearly defined O&M criteria and objectives be established.

Detailed Design Phase

During the detailed design phase, the owner's role shifts to that of a reviewer and approver, and the design engineers concentrate on production. Usually, schedules and budgets become more important as the design engineers push to procure equipment and to produce construction plans and specifications. During this phase, it is critical that operation and maintenance aspects not be forgotten. In this regard, both the owner and the design engineers should consider the following:

1. Frequent Reviews Against O&M Criteria and Objectives - These reviews can be ongoing throughout the detailed design phase and formal O&M reviews to ensure that the O&M criteria and objectives established for the plant are being implemented. For example, if the criteria is established that all valves be accessible from fixed platforms or ladders, the reviews should examine the piping and layout plans with this in mind.

2. Access & Maintainability - Design engineers are concerned with constructability aspects of the design. Their focus is on installation of equipment and the sequencing necessary to build the plant. They may forget to think about how to remove a particular component later for maintenance.

   During operation, maintenance people are concerned with the ability to quickly access the equipment to be maintained with minimum interferences. Equipment needing frequent disassembly, such as strainers, filters and certain equipment subject to rapid scaling or corrosion, requires special attention, such as crane access, laydown areas and the like.

3. Difficulty of Getting Design Engineers to Think Operation and Maintenance - Most engineers working for design engineering firms have spent little if any time operating or maintaining the plants they design. Even those with O&M experience tend to forget this experience in the intensity of the design effort. Firms with an in-house O&M department attempt to overcome this deficiency by imposing operational design reviews. Owners would be wise, however, to bring their plant O&M staff into the design review process.

Construction Phase Followup

After completion of the detailed design phase, the next step is construction of the plant. During this phase, the owner and the design engineers should be involved as follows:

1. Design Followup - The design engineers and the owner's representatives should observe the construction work in progress to assure the plant is built as designed. Also, things that might prove to be troublesome to O&M are very often not apparent until during construction. Examples are field run piping blocking access to equipment, valves and instruments; and tripping hazards. These should be corrected during construction and not left for the plant operators and maintenance people to contend with.

2. Baseline Data - Valuable baseline data can be obtained during construction. Initial alignment of equipment, foundation loadings, relay settings, instrumentation calibration and the like should be formally recorded, documented and collected. This data can form the baseline for operating data and plant maintenance records. Pictures and video tapes can be taken, edited with text and filed for future reference.

3. O&M Orientation - As soon as possible during construction, the owner should establish the nucleus of the operation and maintenance staff on site. These people should participate in witness testing, system walkdowns, documentation efforts and initial operations and checkout. This orientation is extremely important to get the plant up and running quickly after construction. They can also contribute to safety programs and organize spare parts, preventive maintenance, and records management programs.

BUILT-IN OPERATION AND MAINTENANCE FEATURES

As with most other plants, the design of geothermal power plants, is primarily concerned with production, in this case of electrical energy. Much effort is expended to design a plant that will make maximum economic use of the capital financial resources and of the geothermal "fuel." Operation and maintenance also use financial resources, which are usually considered small in relation to the initial financial resources needed to build the plant. What is forgotten is that the superior plant operation needed to produce maximum revenues can be achieved only through the efforts of operators and maintenance people.

During the design of the plant, operation and maintenance features can be built-in by applying conservative approaches to the basic design, keeping the design as simple as possible and by providing little extra features that make a big difference for O&M.

Conservative Approaches To The Basic Design

In order for geothermal power plants to operate at high availability and capacity factors, the basic design needs to be conservative. Geothermal fluids all tend to cause scaling and corrosion to some extent. Also, geothermal reservoirs degrade with time. Conservative design means to use the minimum geothermal fluid consistent with the plant's economic factors and to select equipment that will not be pushed to

design limits and that has reasonable margins for the varying fluid conditions and for wear, scaling and corrosion. This includes:

1. Lower than normal cleanliness factors used to size heat exchangers and condensers
2. Larger corrosion allowances for piping and vessels
3. Larger turbines
4. Wider range control valves
5. Extra cooling tower cells
6. Redundant equipment for high maintenance services.

Keep It Simple

A good rule of thumb to follow in designing geothermal power plants is to keep the design as simple as possible. From an operations and maintenance standpoint, the simpler the better.

Piping systems should be as simple as possible. Each valve, drain, expansion joint, instrument connection and the like becomes a potential maintenance problem.

Automation and sophisticated controls should be applied only when the benefits greatly outweigh the potential for operator errors that can cause outages or for increased maintenance.

Little Extras

Little extras that can make big differences in operation and maintenance are often overlooked in plant design. These include installed monorails, hoists, lifting and handling lugs, clean water sealing systems, dust & H_2S filtering systems in electrical equipment and control rooms, vibration monitoring equipment, well designed laboratories, and the like. These little extras usually do not increase initial capital costs significantly, but they do require that design engineers take the time to see that they are implemented. Other examples are good lighting, well thought out control room layout, conveniently located utilities such as service water and compressed air for pneumatic tools, process fluid sampling taps, extra space for laydown areas and motor-operated isolation valves on large piping.

USER-FRIENDLY CONTROLS

"User-friendly" is a very popular term these days. Plant design engineers must understand, however, that operators, maintenance people and plant engineers are the users and that each has unique needs; therefore, the controls must be truly user-friendly to each and contribute to a reliable, well-maintained plant.

Operators and Their Needs

Operators are the people who run the plant. They start it up, shut it down, and vary equipment operation to produce the maximum output for varying conditions of the geothermal fluid and the environment. They keep the plant in a safe mode at all times, respond to emergencies and keep all discharges within environmentally acceptable and regulatory required limits. They operate the plant both from the control room and out in the plant.

Operators usually man the plant round the clock, and therefore, they need clean, pleasant, comfortable surroundings in which to work. They also need to know at all times the status of all equipment, how the equipment is performing in a gross sense, and how it changes with time (trends). They must be alerted immediately if something goes wrong. In emergencies, operators must also be able to determine quickly what action to take with as little confusion as possible to minimize errors.

These needs can be accommodated by a well designed control system and can be incorporated in the control philosophy and design criteria during the conceptual phase.

Maintenance People and Their Needs

Maintenance people need to be able to schedule preventive maintenance, usually with the plant running. This means that the control system must have on-line diagnostic capabilities and the ability to segregate and service subsystems without shutting down the total system. Other needs include room to work in and around panels and equipment, adequate test equipment, communication channels to the field and above all, good documentation. This includes up-to-date software, drawings, calibration records, parts lists and the like. In addition, maintenance people need specialized training to maintain the control system and have ready access to equipment service representatives.

Plant Engineers

The plant engineers include the plant manager and his technical staff. These people are primarily interested in overall results of operations. Their needs regarding the control system include the ability to easily access the data files of the control system, obtain operating logs, reports, trends, and the like. In addition, they need to be able to adjust the controls as conditions change. Like the maintenance people, they need good documentation. Incorporation of their needs also contributes to truly user-friendly control systems.