DESIGN AND CONSTRUCTION OF THE WEST FORD FLAT POWER PLANT AT THE GEYSERS

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ABSTRACT

The West Ford Flat 27 megawatt power plant is one of two Geysers plants constructed by Geysers Geothermal Company during 1987 and 1988. The project began in May, 1987 with the acquisition of a PG&E Power Purchase Agreement from SAI Geothermal. Construction commenced in April, 1988 and first electrical sales took place in December, 1988. The use of modular components, careful planning of the permitting and construction processes, along with aggressive expediting of equipment and materials, allowed GGC to benefit from electrical sales a full 11 months ahead of the contract expiration deadline.

INTRODUCTION

On May 18, 1987 Freeport McMoRan Resource Partners (FMRP), entered into an agreement with SAI Geothermal to acquire a Power Purchase Agreement (PPA) with Standard Offer Number 4 energy pricing. In acquiring this contract, FMRP, through its division, Geysers Geothermal Company (GGC), sought to construct and operate a 27 net megawatt (Mw) power plant supplied with steam from 240 acres of its existing leaseholds in the south-eastern Geysers in Lake County, California. Under the terms of the acquisition agreement, SAI Engineers would provide the engineering, procurement and construction advisory services.

Along with the power plant itself, GGC needed to complete improvement of a 0.7 mile access road, drilling of 5 production wells, construction of 3600 feet of steam gathering pipeline and construction of a two mile 230 kilovolt (Kv) transmission line to connect to Pacific Gas and Electric's (PG&E) transmission system. The project had to supply electricity by November of 1989 in order to preserve the Power Purchase Agreement.

Initial schedule assessment indicated first electrical generation could be achieved by March, 1989. The decision was made to go to a fast-tracked schedule, providing penalty-bonus incentives to key contractors and suppliers and compressing the permitting, design and construction schedules in order to achieve a December, 1988 first generation date. The goal was to qualify for a 10% Federal Energy Tax Credit prior to expiration of that credit on December 31, 1988. Although the credit was later extended through 1989, the three month acceleration of electricity sales compensated for the fast-track premiums.

PERMITTING

At the inception of the project in May, 1987 no use permits were in place with Lake County except for that for the steam gathering system. The time required to secure a use permit for a project of this scope was estimated to be twelve months. In order to meet the proposed schedule, construction work had to begin in April, 1988 as soon as the Lake County seasonal grading moratorium lifted. A detailed use permit application was submitted in July, 1987. The application included conceptual engineering and descriptions of the existing geology, water and air quality, cultural resources and socioeconomic conditions. Because consideration of the use permit application required completion of an environmental impact report, GGC made an effort to include as much background information as was available in the application in order to shorten the impact assessment period. GGC worked closely with the Lake County Planning Commission to expedite the impact assessment process. Inquiries from the Commission were responded to quickly and the scopes of various required studies were focused to provide for the shortest possible completion periods. Because of the atmosphere of cooperation and coordination between GGC and Lake County the use permit for the West Ford Flat Project was available to be issued concurrently with the opening of the grading season in April, 1988.

The acquisition of grading and building permits was also expedited. GGC set up a schedule of dates when permits would be applied for and when they were required to be issued for construction and submitted this to the Lake County Public Works and Building and Safety Departments in advance to allow the county to plan their design review work load. GGC then worked closely with SAI to complete the design packages to meet that schedule. As a result of this program construction was not delayed one day for any grading or building permits.

DESIGN CONSIDERATIONS

As the project began decisions on plant configuration had to be made quickly. Turbine-generator manufacturers were contacted to obtain preliminary pricing and delivery dates for one unit and two-unit configurations. The size of a single 27 net Mw unit would have necessitated a turbine pedestal design with the condenser under the turbine, while two smaller units would permit the use of a ground-level turbine exhausting upward through a crossover duct to a ground-level, modular condenser. An evaluation of the respective construction durations indicated that the two-turbine design would shorten the schedule by 2 1/2 months, providing a cushion against the November, 1989 PPA expiration date and an earlier production commencement to offset the premium of two machines over one. The two-unit plant also allowed for a higher availability; the individual turbine-generators were each designed to produce 17 net Mw during single-unit operation. The two-unit plant also has the advantage of increased availability of the hydrogen sulfide (H_2S) abatement system.

The successful bidder for the turbine-generators was Mitsubishi Heavy Industries, supplying two of their "Mod-10" frame machines capable of 14.35 gross Mw each at 115 psia inlet pressure. Each unit can go to 18 gross Mw at 165 psia inlet pressure during an outage of the other unit.

The plant cycle is typical of the current Geysers designs. Each unit is equipped with a 100% turbine bypass to route steam to the condenser for H_2S abatement during turbine outages. Non-condensible gases are removed from the condenser using two-stage steam jet ejectors. Each unit has two 100% condensate pumps and two 100% gas ejector trains, sized for predicted end-of-plant-life non-condensible gas concentrations.

There is a single primary H_2S abatement system and a single 4-cell cooling tower with three 50% circulating water pumps and two 100% component cooling water pumps. The cooling tower has a split basin and the circulating water system is designed to allow either unit to run off either side of the cooling tower for maximum availability and maintainability. The cooling tower fans have two operating speeds to allow for conservation of parasitic load during periods of cooler ambient temperatures.

Two methods of H_2S abatement were evaluated: the Stretford process and the burner-scrubber process. The Stretford process evaluated included a sulfur re-slurry mechanism that was guaranteed to reduce vanadium concentrations in the sulfur cake to non-hazardous levels. In the Stretford evaluation secondary abatement was assumed to be either a hydrogen peroxide addition with an iron chelate catalyst or an iron chelate addition only. The economics of the two processes were very sensitive to gas/condensate H_2S partitioning ratios and solids disposal costs. Neither process had a clear economic advantage over the ranges of partitioning ratios and disposal costs assumed; the Stretford was selected mainly to provide operating similarity to GGC's Bear Canyon Power Plant, which was under construction.

A Bailey Net 90 distributed control system (DCS) was selected for the power plant. The design criteria of one-person operation necessitated the consolidation of all plant information and controls in a central control room. The DCS is accessed by two display and keyboard stations which have interactive graphics and trending and archiving capabilities. There is also a mimic board which looks like a hard-wired board but which interfaces with the DCS and provides the operator with a quick overview of all plant processes.

The steam gathering system was designed in accordance with current Geysers practice. Three thousand feet of 20" and 24" pipeline brings the steam from the two drill pads to a 30" header entering the plant. Condensate from the pipeline is collected and routed to the power plant for disposal in the injection system. A 3000' 316L stainless steel injection line carries condensate to an injection well. Power and instrument air for the steam gathering system is supplied from the plant and the pipeline instrumentation and controls are tied into the plant distributed control system via a digital data hiway. This permits the power plant operator to control flow and pressure of the steam supply from the control room.

CONSTRUCTION

From the May, 1987 inception date to the April, 1988 opening of the grading season, efforts were focused on getting plant equipment specified and on order for the earliest possible deliveries. As site clearing and preparation began the effort shifted to the expediting of all construction activities.

The road improvement and site preparation were completed simultaneously. This effort was complicated by the concurrent start-up of a two-rig drilling program on the existing two pads in the project area. Careful planning allowed these efforts to proceed with a minimum of conflict or schedule impact.

The concrete, structural, mechanical and electrical work on the project was provided by The Industrial Company (TIC). A work force peaking at 180 people was employed on a six to seven day per week schedule. Daily coordination between various work groups was emphasized to permit many different simultaneous activities on the 3 acre site. A 2 acre laydown area adjacent to the site was fully utilized throughout the construction phase. A 100 cubic yard per hour concrete batch plant was operated adjacent to the site.

Early on in the design process the decision was made to utilize modular electrical switch gear structures to reduce on-site activity. While the use of this technique did reduce on-site electrical construction, serious delays were nearly incurred due to the size of one of the modules . Future users of modular switch gear units should exercise care to keep the size of each module within limits that do not require special permits for transportation.

The turbine-generators were on a 10-month delivery schedule. Being the first items ordered, the turbines and generators were on site prior to erection of the structural steel for the turbine building. This allowed a very quick setting of the turbine skid by using a 150-ton crane to pick the units right from the trailers to their foundations, avoiding time-consuming cribbing and jacking techniques. The generators arrived separately and were set on the turbine skid in the same manner. Coupling and alignment of the turbine-generators in place produced no significant delays.

The transmission line was constructed concurrently with the power plant. Completion by November, 1988 was required to allow 230 Kv backfeed from PG&E's system to the site to facilitate testing of electrical systems and establishment of circulating water flow. The 2 mile transmission line consisted of nine towers and a breaker/metering yard at the PG&E interface. The tie-in points for West Ford Flat and GGC's Bear Canyon Project were at the same location on PG&E's Unit 16 tapline. Though the entire transmission line route was over GGC leaseholds, considerable time went into securing surface rights-of-way from various lessors. The transmission line was routed along steep and varied terrain to take advantage of existing road access and avoid overhead clearance problems on drill pads. Inaccessibility of two of the tower sites necessitated helicopter assembly using a Sikorsky Sky-Crane. Because the helicopter was required for those two sites it was also used on several others to expedite assembly. A smaller helicopter was used to string the sock lines for pulling up the static and conductor lines.

START-UP

GGC contracted with Stone and Webster Engineering Corporation (SWEC) to provide start-up services for the power plant. Because of the compressed schedule there was considerable overlap between the construction, turnover, checkout and start-up functions. Coordination among the various parties, including GGC's operating staff, was required to keep these activities progressing. Rigorous tag-out procedures and daily communication meetings were the keys to the success of the start-up phase.

RESULTS

Due to the exceptional efforts of all of the participants, the West Ford Flat Project produced electricity only eight months after ground-breaking, 19 months after project inception. The plant maintained a capacity factor in excess of 92% in the first five months after start-up, including turbine inspection outages.