NOTICE CONCERNING COPYRIGHT RESTRICTIONS

Recommissioning Non-Operating Power Projects The Bottle Rock Geothermal Case Study

Gary Snedaker

Integral Energy Management, LLC. (IEM)

Keywords

Bottle Rock, geothermal, Geysers, restart, integral, IEM, recommission

ABSTRACT

This paper is intended to highlight the successful recommissioning of the Bottle Rock Geothermal Power Project located in the Geysers area of California. This paper is focused on power block considerations and does not discuss steam field and resource issues. The repair and refurbishment of existing infrastructure presents an "opportunity to market" in half the time and at half the expense of green-field development. Even in cases of significant equipment degradation, out dated technology and with only partial regulatory compliance in place.

The Bottle Rock project was brought to market and producing electrical energy sales in eighteen (18) months at a cost of less than $600 per kW contract capacity and less the $250 per kW of the installed capacity. It is likely that the project could have been brought on line for 10% - 15% less had certain upgrades not been performed. However, the project may have then suffered repeated availability issues, required a larger staff and operated at a lower steam utilization efficiency.

The major benefits of revitalizing existing projects are installed infrastructure and any previous regulatory work. Additionally, the project is tangible in the eyes of investors, regulators and utilities, possibly gaining greater acceptance when seeking financing, permits or a PPA. The difficulties involved with a existing asset are dealing with the equipment selections, site layout and foot print as is. Often the equipment is not properly sized or configured for the current resource plan, may not be supported for parts and it is likely that something is not fully compliant with regulatory requirements. Replacement of usable equipment due to regulatory requirement can be difficult to swallow but, more difficult is the voluntary abandonment of usable equipment for the long term efficiency and viability of the project.

Background

The Bottle Rock plant was built by the California Department of Water Resource (DWR). The equipment is 1982 vintage which is when construction began. The plant was commissioned in June of 1986 and ran until September 16, 1990. At the time of commissioning, the plant was producing the full name plate value of 55 Mw. At the time of shut down, the plant was producing 12 Mw from diminished steam flow.

As Found Status

While there was some minor tending to the project site prior to the purchase of the plant in September of 2005, the facility was basically in an abandoned condition. Major systems and equipment will be detailed separately within this document. The buildings were not vandalized and the site maintained back-feed power from the 230 kV interconnection. Some interior lighting was still functioning, the domestic water system was partially operational, but there were certainly no communications, office equipment, HVAC systems, etc. The site literally still had 1991 newspapers on desks and expired food products in the kitchens from 1991 as well.

Multiple sets of design prints, but very few "as built" were on site. The steam field was partially mobilized because one well had been opened during the due diligence process and therefore the steam field office (0.2 miles away) did contain usable infrastructure.

Facility Purchased – Recommissioning Begins

The site was mobilized with a small crew at the steam field (provided by ThermaSource LLC) to perform road repairs, brush cutting and site preparation for drilling operations. The power plant was mobilized with the project manager, project engineer and a contracts person, on a ½ time basis. Local contractors were used to repair lighting, water systems, initiate phone service, etc. Site documents were gathered into

one "war" room to begin both the regulatory processes and development of bid packages for the equipment refurbishment and/or replacement. The first task was submittal of the sites LGIA (Large Generator Interconnect Agreement) as this had critical path potential with a possible time line of 20 months. Next were Power Purchase Agreement (PPA) solicitations and development of refurbishment bid packages for the major plant systems.

Regulatory

Although the facility was back-feeding from the grid, it was not considered interconnected for generation. The site did have to file an LGIA, as well as a system impact study and feasibility study. Fortunately, with existing equipment the site was able to provide submittals rapidly and the process was expedited. Still, most forms and submittals did not fit into the boxes allocated by the receiving agency which did cause constant interaction and generated a requirement for additional supporting documents. The facility did have to replace all protection equipment, utility communications and some sub-station and metering equipment. This process was originally the critical path for the recommissioning. It was later eclipsed by the control systems upgrade, but still was not fully complete until only six weeks prior to restart.

Air quality and use permits had been maintained during the dormant period making this an expedited process as well. Each aspect of the multiple permits required a separate Petition To Amend (PTA). Subjects requiring submittals included: noise, archeological and historic, traffic, ground water, wildlife, erosion, public health & safety, air quality monitoring, air quality emissions testing & control, steam field operations, gather system operations, and plant operations. The facility was required to make multiple system modifications, participate in public hearings and numerous technical submittals to support this process.

The California Energy Commission required volumes of technical data as well as public hearings. This process took approximately thirteen months to complete.

There were additional agencies and processes but the afore mentioned were the most intense. In all cases the agencies were overloaded with work but, generally supportive of the effort. In all the process took about ½ the time and resources that would have been required for a newly permitted facility.

Control System

The original Fuji supplied controls were a "hard board" configuration with EPROM driven loop controls. While the system appeared to be intact, individual components were missing or damaged. The equipment was no longer supported and documentation was sparse. The gas non condensable gas scrubbing system (Stretford) had separate controls located in another building, and the steam field data systems were located at the steam field office. Both of these systems were antiquated as well. Wood Group Controls located in Loveland, Colorado were chosen to supply an Allen Bradley- based system capable of controlling the power plant, Stretford, and actuated valves at each well. The most significant challenges were the lack of documented logic for the control of the existing equipment as well as merging the existing system with the new technology. At the plant site, all control communications are hard wired connections. In the steam field each pad has a "stand alone" PLC which the main plant communicates with via a secure wireless (radio frequency) connection. The control system ended up being the critical path and likely delayed the restart by about two months. The performance to date has been well worth the effort as the plant, steam field, and Stretford can be started and operated with a two- man shift.

Plant Instrumentation

This area goes hand- in- hand with the new control system and therefore Wood Group Controls was also responsible for ensuring proper communication with existing and newly installed instruments. The plant staff performed all the re-calibration and replacement of field instruments as well as a complete replacement of all local, analog gauges. Many tubing runs required replacement and numerous communication cables had to be pulled between the main building and the out buildings.

Steam Turbine

The turbine had a full set of spare diaphragms and a stacked rotor. While maintenance records were few and without detail, our best recompilation showed that each turbine set had about been in service 24 months, although neither had been refurbished. The spare set of diaphragms was in better condition, as it had been blast cleaned before storing. The set left in the unit was/is in poor condition. It appears that part of the damage is erosion, possibly from water- carry over caused by a large, single nozzle steam wash system installed just prior to the main separator. Corrosion also existed, probably due in part to normal operation but then sitting for 16 years through changing ambient conditions and exposed to the contaminants deposited on it. Of course there was deposition of boron, silica and other minerals. Further effecting both corrosion and deposition was the fact the steam washing system utilized geothermal condensate stored in a large open- top tank allowing it to oxygenate prior to being injected into the steam stream.

The turbine rotor repair and re-blading work was awarded to Turbo Care located in Perris, California. Due to the decline of the steam resource pressure, the new turbine steam path was designed for an inlet pressure of 63 psig and steam flow of just over 500,000 lbs/hour. The original design was for 100 psig at a flow of 978,000 lbs/hr. The turbine required on-site repairs to bearings, valves, oil systems, etc. The turbine protection and hydraulic control systems were upgraded and mostly replaced with new. All on-site work was performed by Thomason Mechanical Company (TMC) a division of Wood Group. The steam turbine restart was without incident or delay. The unit rolled up the first time with very low vibration and has been very reliable to date. This entire scope of work was accomplished in about twelve months as compared to the 30+ months required to manufacture a new steam turbine set.

Stretford & Abatement Systems

The Stretford system was the most degraded system at the facility processing hydrogen sulfide and sulfur during operation and then exposed to the elements over the years. All processing tanks and containments required re-coating. All rotating equipment and valves required major repair or replacement. Bottle Rock also has two steam stacking trains with abatement through chemical injection. The Stretford and Steam Stacking are specifically listed in the air permits and therefore, the repairs were subject to Lake County Air Quality Management District (LCAQMD) approval. The developers also worked closely with LCAQMD on a number of system modifications to improve performance. Each modification was subject to approval and public comment, including an open meeting with the public. Modifications included carbon filters for mercury removal, a skim line off the delay tank, and sparging headers in the oxidizer tanks. The Stretford is functioning well and to date has not had any significant operating issues.

Non-Condensable Gas Removal Systems

The steam/air ejectors required valve replacement; new instruments and some tubes were plugged and abandoned. The ejector venturis were resized for an inlet pressure of 73 psia from the original 108 psia. Two new vacuum pumps have been added to increase the steam utilization efficiency of the plant.

Balance of Plant Equipment

All plant equipment required comprehensive overhaul or replacement. The cooling tower was re-decked, the fan blades recoated and all rotating equipment rebuilt. The underground circulating water pipes required extensive repair. The plant fire equipment had been submerged in groundwater. This entire system required attention. Plant air compressors were replaced with new. Building systems, communications and basic infrastructure all had deficiencies.

Current Status

As of May 2007, the Bottle Rock plant is operating at approximately 10 Mw's. Two additional steam wells are anticipated by late June and two more by the middle of July. This should bring the plant output to greater than 22 Mw. Drilling and exploration will continue beyond this level. The plant reliability and performance to date is exceeding expectations.

A small series of photographs depicting plant equipment follows: