Oxbow's Miravalles III Power Plant: a Notable First Year for the First Geothermal B.O.T. Project in Latin America

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The Miravalles III Geothermal Project, Costa Rica

Introduction

The 27.5 MW Miravalles III geothermal plant in Costa Rica is the first geothermal Build-Own-Transfer (BOT) project built in Latin America. Miravalles III is the third power plant built to extract energy from the hot brine underlying the Miravalles Volcano geothermal area in the northern province of Guanacaste, near the border with Nicaragua. The Miravalles geothermal complex is operated by the Costa Rica national utility company, Instituto Costarricense de Electricidad (ICE), which also owns and operates the two earlier plants there. For Miravalles III, however, ICE – assisted by constitutional changes to allow limited IPP participation in the Costa Rica system – selected a BOT approach.

After a spirited bid competition, ICE in 1997 awarded the BOT contract for Miravalles III to a Costa Rica limited liability company, Geoenergia de Guanacaste, Limitada (GdG). GDG is a consortium consisting of Oxbow Power (a U.S. IPP with a long history of successful geothermal project development), Marubeni Corporation and Jose Altmann & Company of Costa Rica. GdG awarded the EPC contract to Mitsubishi Corporation, Mitsubishi Heavy Industries supplied the turbine and managed construction, and POWER Engineers of the U.S.A. served as MHI's

engineer for plant design, procurement, and field engineering. Oxbow will own and operate the plant for 15 years; then, ownership and operation of the plant will transfer to ICE.

Miravalles III achieved commercial operation in March 2000; in 2001, the plant passed its annual operation shakedown and clocked its first year of baseload operation. The plant reported consistent output at or above design capacity (27 MW net) and generated at an availability of above 99.5%. In addition to high availability, geothermal plants also have notable advantages in terms of environmental friendliness, use of a renewable and indigenous resource, and readiness for round-the-clock operations, indifferent to weather or faraway fuel sources.

ICE has been generating renewable geothermal baseload power at the Miravalles field since 1994. The current generation capacity of the field now totals 142.5 MW. Costa Rica, along with México, El Salvador and Nicaragua, occupy volcanically favored positions along the Pacific "Ring of Fire" and are exemplary leaders in geothermal resource development. These four nations account for approximately 14% of the world's installed geothermal generation capacity.

A Major Site for Renewable Energy Production

Miravalles III is the third in a series of geothermal power plants developed at the Miravalles field, an initiative carried out by ICE in conjunction with the Inter-American Development Bank. Miravalles I, with 55 MW of generation capacity, was commissioned in 1994, followed by Miravalles II (also 55 MW) in 1999. ICE also operates a 5 MW wellhead backpressure turbine about a kilometer north of the Miravalles I and II site. These plants are all owned by ICE and were developed by ICE.

The Miravalles III project is an exception to this ownership pattern, being an IPP plant operated by GdG, an affiliate of Oxbow Power of the U.S., under a BOT arrangement with ICE. This arrangement was made possible by recent legislative and constitutional changes in Costa Rica which permit limited IPP involvement in the national electric power system, in order to allow the national capacity to grow more rapidly than would have been possible with strictly internal investment by ICE.

The BOT tender process for the prospective Miravalles III project was conducted in 1996 and 1997, and the project was awarded to the Oxbow consortium in 1997. Engineering and construction began in 1999, and the plant began service in March 2000 with a formal dedication ceremony in July 2000.

A fourth Miravalles project – Miravalles V – is now being developed by ICE. This plant will be a 12 MW binary-cycle bottoming plant designed to recover additional energy from used geothermal brine – the spent fluids from ICE's steam separators – before the fluids are injected back into the reservoir. Miravalles V will not be an IPP plant, but will, like the plants developed before Miravalles III, be owned and operated by ICE. The winning EPC bidder for Miravalles V is Ormat International, a prominent developer, designer, supplier, constructor and operator of geothermal plants. Ormat manufactures modular binary-cycle energy conversion units suited to energy recovery from comparatively low–temperature resources.

One of the Most Advanced Flash Plants in Operation

After its negotiations with ICE were complete, GdG awarded the turnkey EPC contract to Mitsubishi Corporation. Mitsubishi Heavy Industries (MHI) of Nagasaki was engaged to provide the power plant's turbine and manage construction, and POWER Engineers of the U.S.A. served as MHI's engineer responsible for plant design, materials and equipment procurement, and construction support. (MHI and POWER were the EPC team for two previous Oxbow/Marubeni geothermal projects in the Philippines, the Mindanao I and Mindanao II projects (104 MW gross) completed in the period 1996-1998.)

On Miravalles III, MHI and POWER also worked with a Costa Rica engineering company, CLC Ingenieros Asociados y Cia, Ltd., for permitting support.

The tall structure in the background is the turbine housing and steam exhaust duct; the boxy component at the right is the electrical generator.

For Miravalles III, MHI provided the latest evolution of its line of top-exhausting steam turbines, a single-flash, single-unit power plant driven by 216,000 kg/hr of geothermal steam delivered to the plant boundary by ICE at a design pressure of 6 bars (absolute) and a temperature of 159° C. (320 °F.) The plant uses a direct contact condenser, a hybrid ejector/vacuum pump system for extraction of noncondensible gases, and a counter-flow high-efficiency film wet cooling tower. Excess condensate is returned to ICE for reinjection.

Output from the plant's turbine-generator at 13.8 kV is stepped up to 230 kV in the Miravalles III substation for interconnection with the ICE grid. Before its one-year maintenance outage, the plant logged 12 months of operation at an availability of over 99.5%.

A view from the Miravalles III 230kV substation.

Miravalles III Features Advanced Controls and Relaying Systems

The Miravalles III plant has a high-capacity distributed control system (DCS) supplied by a major manufacturer. The selection of this system, which is centered on a traditional utility-scale UNIX workstation, was mandated by ICE's specification for the project, and was perhaps a more complex solution to the Miravalles controls requirements than POWER Engineers would have chosen. The specification of such a system makes sense from ICE's historical perspective as a large utility company: a traditional utility thermal plant places high demands on a plant DCS because of the complexity and critical importance of combustion and boiler control, with many analog inputs. However, a geothermal power plant such as Miravalles III is comparatively simple from a controls perspective, since there is no boiler, wellfield controls are handled by a separate control system and much of the remainder of the controls duties are handled by the turbine-generator controls package and plant relaying.

POWER's controls engineering team, left to their own judgment in system selection, would probably have specified and designed a simpler system such as a PLC/DCS hybrid system based on an industrial PC with Windows or NT, and with current state-of-the-art plant interface software.

The use of a high-powered DCS for Miravalles III caused some complications during system implementation and plant construction and commissioning:

1. By the time the contract was signed, the UNIX hardware specified had become somewhat obsolete, and was less actively supported by the supplier than more current hardware.
2. The system was so small and remotely located that qualified supplier support for the system during programming and construction was difficult to obtain.

One of the great lessons that POWER's team took from the Miravalles III project was one of wariness about the technical and merchandise support that a small and remote project can count on. Integrating the big utility-scale DCS with the plant on time proved to be one of the engineering challenges of the project.

Relaying and Metering: A High-Tech Opportunity

The Miravalles project gave the engineering team the chance to design an exceptional degree of supervisory interaction between the control system and the distribution relaying. The POWER electrical team and the Schweitzer Relay project team worked closely together in designing the monitoring and protection system to allow the direct incorporation of signals from the plant's relaying and protection system into the DCS, and the ability to discern and modify relay settings through the DCS system. The result was an unusually advanced degree of plant control and monitoring, allowing a high level of direct interaction between the plant's relaying and protection system, the turbine governor and voltage regulation systems, and the balance of plant systems.

The Miravalles III protective relaying and metering system consists of leading-edge technology components. Schweitzer Engineering and Multilin microprocessor based relays are used for protection while Power Measurement and Electro Industries solid-state meters are used for metering.

The microprocessor-based relays perform three functions:

1. Protective relay trips, block close, and alarms
2. Control of automatic bus transfer
3. System metering and monitoring

Schweitzer mirrored bit communications between relays and relay logic functions allowed an automated fast bus transfer scheme to be implemented using two SEL-351 relays. The protective relay system provided advanced and redundant protection, comprehensive monitoring and diagnostics, and proved to be a cost-effective solution.

The complete protective relay and metering system communicates serially with two Schweitzer SEL-2020 communication processors that in turn communicate serially with the plant control system. The status of the complete plant electrical system is monitored by the operators from the plant control system consoles.

More Geothermal Power Coming to Latin America

New geothermal resource development now proceeding in Latin America and the Caribbean Basin includes projects in Nicaragua, El Salvador, Mexico, Chile, Guadeloupe, and a large ICE flash-plant project now beginning development at Las Pailas, a new resource in Costa Rica located to the north and west of Miravalles. ICE, GeothermEx and POWER are now doing the preliminary design and plant definition work for Las Pailas. ■