Big Iron in Nicaragua: A Muscular New Geothermal Plant!
The San Jacinto-Tizate Geothermal Project

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ABSTRACT
Nicaragua is now the host country for a large geothermal power plant, the 72 MW + San Jacinto-Tizate Power Plant, developed, owned and operated by Polaris Energy Nicaragua, S.A., a subsidiary of Ram Power, Inc. of the U.S. The new flash steam plant is located in northwest Nicaragua, near the city of León, approximately 90 km northwest of Managua. The plant is a monument to the patient aspirations of the developers and the plant hosts, since the recent completion and commissioning crowned a complex multi-year development cycle in which small, comparatively simple pioneer units cleared a commercial and political space for a large and highly evolved development. The long-studied San Jacinto-Tizate (SJT) resource, in the project’s first course, provided flash steam for two skid-delivered backpressure units. This initial phase eventually yielded to staged installation of two new condensing flash units, each of 36 MW capacity, with a dessert course of a binary bottoming cycle now getting the finishing touches.

At its current capacity of 72 MW, the plant is the largest in Nicaragua. As of 2013, it supplies the country with 12 percent of its total electricity needs. Further development of other area resources will be central to improving Nicaragua’s industrial and gross domestic product (GDP) growth, in concert with a transition to indigenous and lower-carbon-intensity energy production. In this paper, we present a review of the San Jacinto-Tizate project and its benefits to Nicaragua.

Nicaragua’s Economy and Geothermal Potential

One of the key contributors to a country’s economic growth is access to, and economical use of, energy resources. Table 1 shows that a typical industrialized nation such as Germany may use around 150 GJ per capita per year; Nicaragua’s usage is around 25 GJ per capita per year. The efficiency of utilization is also a factor. Due to Germany’s higher level of technology, transport, and efficiency measures, each unit of energy is far more productive (5x) in generating GDP. Unearthing new sources of energy for Nicaragua, and subsequent more efficient use of those resources, will contribute to the country’s economic well-being.

Nicaragua’s Economy and Geothermal Potential

Table 1. Comparison of Nicaraguan economic and energy statistics with Germany and the U.S. (adapted from world bank, 2010).

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<th>Nicaragua</th>
<th>Germany</th>
<th>U.S.</th>
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<tbody>
<tr>
<td>GDP per capita</td>
<td>$1,097</td>
<td>$40,873</td>
<td>$46,436</td>
</tr>
<tr>
<td>(current US$ - 2009)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Energy usage per capita (kg oil equivalent/year)</td>
<td>621</td>
<td>4,027</td>
<td>7,759</td>
</tr>
<tr>
<td>GDP per unit of energy use (US$ per kg of oil equivalent)</td>
<td>1.8</td>
<td>10.1</td>
<td>6.0</td>
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Nicaragua is a country with great human potential, but one that has been stricken with devastating calamities such as an earthquake which destroyed much of the capital city of Managua in 1972, the civil strife in the 1980s, and Hurricane Mitch in 1998. With a population of around six million, it is one of the poorer countries in the Western Hemisphere, with GDP three orders of magnitude less than an industrialized nation such as the U.S.

So a particularly grave challenge is Nicaragua’s need to import costly fossil fuels to meet the country’s energy needs. Oil consumption was estimated at approximately 11 million barrels per year in 2009. As of 2010, Nicaragua’s nominal installed capacity of 750 MW and annual generation of around 3,000 Gwh was primarily dependent on thermal systems (80%), with hydroelectric and geothermal making up the balance. Spot market prices for suitable fuels over a recent three-year period have ranged from 80-160 $/MWh (Arguello, 2010); a level at which geothermal power could realistically be competitive.

The great promise for Nicaragua is the availability of hydropower and geothermal resources which can supplant the costly diesel and fuel oil generation. Nicaragua is located on the circum-pacific “Ring of Fire,” the gigantic volcanic activity zone where
many of the world’s geothermal power generation resources are found. Zuniga (2003) reports on prospects at a variety of geothermal fields, with overall potential in excess of 1,000 MW. With this considerable baseload potential, in addition to considerable hydropower potential and some wind, Nicaragua has the capability of transforming its energy economy to improve both economic and environmental sustainability. Recognizing this, the Nicaraguan government in 2010 developed a national energy plan with the target of covering 90 percent of its generation mix with renewable by 2017, with contributions from hydropower, wind, and geothermal (PRONicaragua, 2010).

The San Jacinto-Tizate (SJT) geothermal area is a promising site with a resource capacity estimated at over 200 MW (Long, 2010). Figures 1 and 2 show the location of the project in western Nicaragua. Polaris Energy Nicaragua S.A. (“PENSA”) has operated a geothermal plant with output of 10 MW at that location since 2005. Ram Power Inc. (“Ram”) and PENSA merged in 2009, and this site was selected as a prime candidate for upgrade and expansion of the generation assets.

Backpressure Units Pave the Way for Big New Flash Units

As recently as four years ago, the existing 10 MW plant at SJT consisted of two 5 MW backpressure turbines. While these comparatively simple backpressure units are easily deployable and a good initial step to provide swift revenue, they were sensibly regarded by PENSA as an exploration phase and reservoir proving tool only. The high temperature and high pressure steam obtainable from “flashing” the geofluid to clean steam (6 bar at San Jacinto) and brine allows a condensing steam turbine to offer almost double the power output of a backpressure unit connected to the same resource. Recovery of the steam in a condenser also allows injection of water back to the reservoir, helping sustain the reservoir pressure.

PENSA originally investigated the feasibility of replacing the existing low-efficiency backpressure turbines with several refurbished marine turbines. These are available relatively inex pensively, but are less efficient than modern machines engineered and built for geothermal service. However, after PENSA’s merger with Ram Power in 2009, a new and formidably sophisticated 38.5 MW Fuji turbine owned by Ram became available for the project. Fortunately, the new turbine had a design basis that made it suitable for optimal use of the San Jacinto-Tizate resource.

After evaluation of this more efficient candidate machine, PENSA decided to employ it for the first phase (35 MW net) of the project. Then a second, identical 38.5 MW turbine was added alongside the first. After completion of the second phase, the two original backpressure units were freed up for relocation to other PENSA projects in Nicaragua, where they can repeat their pioneer service in providing generation during the initial well proving and wellfield development stages.

In readiness for the big flash units being installed at SJT, the SJT gathering system was expanded to accommodate the increased steam demand by drilling additional production and injection wells and constructing new wellpads and additional steam separators and demisters.

The turbine is a top exhaust, double-flow design, exhausting to an innovative advanced direct contact condenser (ADCC). The ADCC is supplied by SPX/Yuba and uses stainless steel fill to increase the efficiency of heat transfer in a manner analogous to cooling tower fill. The condenser also integrates the non-condensible gas removal system condensers into the package. The two stage ejector arrangement is mounted directly to the condenser and the intercondensers are integrated into the condenser body and also implement stainless steel packing making the system both compact and relatively efficient. The plant design was performed by POWER Engineers, Inc. and incorporates a mirrored arrangement of the turbines within the powerhouse to allow the generator pull space to be shared between the two units, resulting in a more compact powerhouse design. The circulating water system, using Torishima hotwell pumps, is a “slide-along” design that results in similar equipment and piping arrangements for the two units, resulting in lower engineering and construction costs.

Figure 1. Location of the San Jacinto project, in western Nicaragua close to the city of Leon (Weller).

Figure 2. The San Jacinto project site. Photo by Juan Escalante, plant manager.
A Highly Evolved Plant Development for Aggressive Resource Use

The plant has many features which render it state of the art for geothermal flash plants. One key aspect of geothermal projects is that custom site-specific engineering and careful equipment selection inevitably result in better project value, because inefficient units will require additional costly wells drilled up front to achieve the same generation. In addition to the more efficient and proven Fuji turbine, the project incorporates (Long, 2010):

- directional drilling of the production wells, which allows for fewer wellpads and gathering system infrastructure work, while minimizing land usage;
- variable frequency drives for brine injection pumps, allowing power savings for different injection lineups;
- a counterflow, low-clog film fill cooling tower, improving plant efficiency and reducing land usage;
- an advanced direct contact condenser, which results in lower cooling water requirements and a more compact arrangement;
- asymmetric steam ejector lineups, which allow tuning of the gas removal system to save steam when there are variations in non-condensible gas content in the resource;
- current construction and design of a bottoming binary unit to extract additional heat from spent brine from the flash separators.

The sum of these upgrades, when combined with the lower drilling costs for the more efficient plant, resulted in an estimated savings to PENSA of $25 million over the original plant design using the marine turbines. The reader is encouraged to consult Long (2010) for a more detailed description of the project technical and financial aspects.
Many international financing organizations have been brought together to contribute to the success of the project. These included the International Finance Corporation (IFC, associated with the World Bank), the Inter-American Development Bank, Central American Bank for Economic Integration, Deutsche Investitionen- und Entwicklungsgesellschaft mbH from Germany, Nederlandse Financierings-Maatschappij voor Ontwikkelingslanden N.V. from the Netherlands, Oesterreichischesche Entwicklungsbang AG, and Soiete de Promotion et Participation pour la Cooperation Economique from France. As such, the project is a high profile example of financing of geothermal projects in the developing world.

What Geothermal Means to Nicaragua

The San Jacinto-Tizate geothermal power plant provides a wealth of benefits to the country of Nicaragua including:

- An overall large increase (~12%) in the electrical capacity of the country, with corresponding potential for industrial and economical development that typically is driven by access to power at reasonable rates.
- A significant shift in the percentage of the country’s generation to a cleaner, renewable source, improving air quality and reducing net carbon emissions per MWh.
- A decrease in Nicaragua’s reliance on and vulnerability to uncertain world oil markets, displaces the demand for approximately one million barrels of imported diesel oil per year.
- A shift in the significant percentage of the country’s generation base away from its reliance on hydroelectric resources, which are vulnerable to seasonal variation, acute drought and long-term climate change.
- A successful template for implementation of a power project navigating through Nicaragua’s regulatory and commercial environment. Given the high potential value of geothermal projects to the country, it is hoped that a stable and encouraging political environment is maintained so that more development can continue to benefit the country. Successful management of a complex and international financing package, providing a deserving outlet for financiers specifically interested in sustainable energy projects in the developing world. Integrated the Phase I funding efforts led by Central American Bank for Energy Integration (CABEI) and FMO-Netherlands with the Phase II funding led by the IFC. Phase II funding included IFC, IDB, FMO, CABEI, Proparco – France, OeEB – Austria and DEG – Germany. The Phase II financing was awarded the 2011 Central American Financing Deal of the Year. The overall structure combined a truly international development which may serve as a model for future emerging market programs in the geothermal industry. Employment during construction, including building up of contractor expertise in project execution in Nicaragua that will ease development of future projects.
- Employment during construction (which consisted of around 50-100 personnel) and continued employment for the life of the plant (which should be 25-30 years or more). Jobs will also be created for local contractors which will be engaged in various upgrade and maintenance projects associated with the plant and steamfield throughout its life.
- An excellent ‘living laboratory’ for technical education and research, especially in sustainable energy and development. By taking steps to maximize knowledge transfer, the project structure will contribute to the skills development opportunities available in the surrounding communities, and will develop valuable geothermal experience in the workforce that will contribute to smoother execution and skilled operation of future Nicaraguan geothermal projects in the years ahead. As the reservoir is used and expanded over time, the geofluid composition and conditions may change, requiring additional well drilling or modifications to plant equipment to accommodate the new “fuel.” Because of this evolution of a geothermal project over its life cycle, owners and operators of geothermal power plants find it helpful to have a capable local workforce to perform plant upgrades and additions, resulting in a symbiotic relationship between the San Jacinto-Tizate plant and the surrounding community.
- Potential, strong collaboration between Nicaragua’s educational institutions the next generation of geothermal engineers. A large and modern geothermal plant offers a prime educational opportunity for students interested in green technology, providing future skilled graduates that will be available to strengthen other aspects of Nicaragua’s society.
- A springboard for future geothermal development in Nicaragua, with the ultimate potential of being able to export power to the Central American transmission system (SIEPAC).

Summary

The San Jacinto Tizate project – a new and sophisticated flash plant soon to be paired with an advanced ORC bottoming cycle – is a key example of Nicaragua’s commitment to sustainable principles and wise use of its resources, as well as to the evolution of high-performing geothermal technology. By adding 12%
to the country’s installed generation capacity with clean, baseload power, the project will improve both local and regional economics, and provides a blueprint for additional successful developments of this nature.

The careful engineering and wise investments into efficient technologies demonstrate Ram and PENSA’s long-term commitment to the success of the project. We hope and believe that additional geothermal projects in Nicaragua can be executed in a similarly successful manner.

References


