The Don A. Campbell Geothermal Project

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Keywords

ABSTRACT

The Don A. Campbell Geothermal Project in Mineral County, Nevada, reached firm operation in December 2013 and has since been providing more than 16 MW (net) of base-load renewable power to the Los Angeles Department of Water and Power and Burbank Water and Power in southern California. The successful development of this project, ahead of time and below budget, and the plant’s performance exceeding its design, can be attributed to multiple factors, including: a rigorous and regimented exploration and development campaign that resulted in successful resource discovery, confirmation and development; streamlined permitting through close cooperation with all local, state and federal agencies while designing and siting all facilities to minimize environmental impact; power plant engineering tailored to the specific resource characteristics so as to maximize power generation and efficiency; creative business development that identified new customers and a new transmission path to deliver the power to them; fast-tracked engineering, procurement and construction capable of meeting a challenging deadline; and a user-friendly and highly automated power plant design that allowed for swift start-up and commissioning and high availability while lowering operation and maintenance costs. This project also marks several “firsts” for Ormat and for the U.S. renewable energy industry as a whole, on both technical and commercial fronts, to include: (a) the first project to wheel renewable energy over NV Energy’s statewide high voltage transmission system, including the newly constructed 231-mile 500 kV One Nevada Transmission Line, from northern Nevada to serve load in the large population center of southern California; (b) the first geothermal project to be included in the resource portfolio of LADWP – the nation’s largest municipal utility; (c) one of Ormat’s first large utility-scale binary geothermal power plant to utilize a low temperature 260°F geothermal resource; and, (d) the first geothermal project to be developed in Mineral County, Nevada, bringing major economic benefits while protecting the environment.

Introduction to Ormat

Ormat Technologies, Inc. began focusing on the benefits of clean, reliable energy almost five decades ago. In the early 1970s, Ormat commercialized the Organic Rankine Cycle technology for the application of remote power solutions, manufacturing small (by today’s standards) power units in Massachusetts. This technology was adapted and well received by the then-booming pipeline industry in North America. This industry was using the technology for reliable remote operation of gate-valve power shelters in very remote areas and under extreme environmental conditions. In the early 1980s, Ormat ventured into geothermal, commercializing low-temperature geothermal resources to generate electricity in the U.S. The first installation of the Ormat Energy Converter (OEC) in 1984, at the Wabuska facility outside of Yerington, Nevada, is still in operation today, proving the reliability and dependability of Ormat’s technology. As low-temperature geothermal power generation began to grow in the U.S. in the early 1990s and Ormat’s technology was proving to be the primary choice, Ormat began to expand the application for its OEC to offshore platforms and waste-heat recovery installations. In the late 1990s, Ormat expanded to owning and operating geothermal projects that generate revenue through electricity sales. Ormat’s stance as a primary geothermal developer and the major supplier of ORC technology grew quickly in the new century. Today, with over 626 MW of geothermal and Recovered Energy Generation power plants, and with over 1,750 MW of installed OEC capacity worldwide, Ormat

1 Formerly referred to by Ormat as the Wild Rose geothermal project, until it was renamed in memory of Don A. Campbell, a long time Ormat employee and a pioneer in the exploration, development and reservoir management of geothermal resources
has firmly planted itself in the development and support of clean energy, and has been able to prove, where many have failed, that there is a long-term, reliable solution for the world’s energy crisis.

**Identifying, Exploring and Developing the Geothermal Resource**

The Don A. Campbell geothermal energy facility is located on federal lands managed by the Bureau of Land Management in Mineral County in western Nevada, approximately 26 miles north-east of the town of Hawthorne. Referred to by the BLM as the Deadhorse Wells property, the project is in the general vicinity of numerous operating geothermal projects (Figure 1). Nevertheless, this geothermal system is entirely “blind,” with no apparent surface thermal features or related mineralization.

Ormat’s geologists identified this property as potentially housing a subsurface geothermal resource using data from mineral exploration campaigns that took place in the area in the early 1990s. This data included summaries of an aeromagnetic survey and exploration drilling. The aeromagnetic survey delineated a large magnetic-low anomaly along gently northward sloping alluvial fans. The magnetic anomaly trended NE-SW, with a length of about 4 km and a width of about 1.5 km, and the anomaly was inferred to correlate with strong argillic alteration observed over depth ranges of ~50 to 500 ft. Summaries of several exploration wells drilled by mineral companies indicated strong flow of 140°F to 190°F fluids and 203°F vapors at shallow depths over an area of approximately 46 square kilometers (Figure 2). All wells were completed in alluvial sands and gravels that exhibited propylitic alteration within 100 ft. of the surface, with an assemblage of secondary minerals that included argillite, pyrite, chalcedony, and chlorite. Much to their chagrin, the mineral prospectors did not find sufficient indications for precious metals like gold and silver to exist in commercial quantities. Nevertheless, and although nil Au-Ag values were present, the coincidence of propylitic alteration in young Quaternary rocks with very anomalous shallow temperatures and the presence of hot fluids and steam suggested a possible commercial-grade geothermal system at depth. This led to Ormat nominating this property to the BLM in 2001 and in August 2007 Ormat secured site control through the BLM’s competitive geothermal lease auction.

![Figure 1. Location of the Don A. Campbell plant (formerly the Wild Rose project) in relation to operating geothermal projects. Source: GeothermEx.](image)

![Figure 2. Map illustrating location of mineral exploration holes (1990-1992), aeromagnetic contours (1990), and summary of shallow 2-meter temperature survey (2011). Black triangles are shallow 2-meter temperature probe sites.](image)

Immediately after obtaining site control, Ormat embarked on a 4-year structured exploration campaign, starting with pre-drilling exploration surveys; followed by shallow exploration drilling; then full-size and deep core drilling that served to discover and delineate the resource. The exploration program concluded with a 29-day multi-well production-injection flow test that allowed confirmation of the geothermal reservoir and selection of the MW capacity of the initial plant. The pre-drilling exploration surveys included water sampling; surveying existing well temperatures, water levels and depths; mercury soil sampling; geologic mapping; multispectral and thermal imagery analysis; shallow 2-meter temperature surveying (Figure 2); detailed gravity surveying; controlled-source audio-frequency magnetotellurics (CSAMT) surveying; magnetotellurics (MT) surveying; and ground magnetic surveying. Ormat synthesized all of data to generate a geological model that was used to select...
the initial temperature-gradient core holes. During the summer of 2010, five temperature-gradient holes were drilled vertically to 500 ft. Core samples were analyzed, and temperatures and water levels were monitored over a period of several months. Anomalous high temperatures up to 267°F were encountered at depths within 200 ft. of the surface, and argillic and siliceous alteration was observed in the core samples. The results of this drilling campaign were integrated with the other data for selection of a first deep exploration drilling target. That first target was drilled as a full-size well, and it encountered total loss of circulation at 1,245 ft. depth while drilling in silicified and fractured alluvial sand and gravel. The well was flow tested in mid-November 2010, and results indicated commercial fluids at temperatures around 266°F contained within a fracture system. Fluid samples were also taken, and geothermometers calculated from the reservoir fluid chemistries indicated a 300°F temperature of source fluids at depth. The results of the first deep test well were synthesized with other data, and a site was selected for a second full-size well. That site, located approximately 1.5 km to the southwest of the first deep well, also encountered a total loss of circulation, at 1,256 ft. depth in silicified and fractured alluvial sand and gravel. Flow testing the well indicated commercial temperatures similar to the first well, which were also likely predominately contained within a fracture network.

Next, two deep core wells were drilled, one to 4,000 ft. and the other to 2,663 ft., in order to delineate the resource area. Then, in January 2012, the third full-size well was drilled in the northeastern part of the field. This well experienced a total loss of circulation at 683 ft. within silicified and fractured sand and gravel, and it encountered maximum temperatures near 266°F. The results of this well were integrated with the other datasets into GIS and 3D software for analysis. Figure 4 summarizes the temperatures measured through the various deep exploration wells. Finally, in the spring of 2012, a long-term (29-day) multi-well production-injection test was conducted. The purpose of the test was to test the capacity of the geothermal reservoir by producing and injecting to create a significant reservoir pressure drawdown. To aid in this, pressure changes due to pumped production from a single full-size well were monitored at two locations. Injection into two wells provided information about the injection capacity of these wells and the permeability of the formation. A tracer test conducted in conjunction with the injection established the degree of connection between production and injection areas. The data gathered from the test was used to generate a 3-dimensional numerical reservoir model that showed a significant geothermal system containing both the ability to receive injection and to recharge production at high rates. Combining the output from this model with Ormat’s proprietary thermodynamic simulation tools predicted that the reservoir could support sustained production of at least 16 MW (net) of electricity generation. Development drilling then took place, consisting of 4 more production wells and one more injection well. All wells exhibited very high permeabilities, and the production wells measured fluid temperatures slightly above 260°F. By the end of 2012, Ormat completed drilling all wells needed to support a commercial power plant. All full-size and deep core wells drilled throughout the exploration and development process have successfully penetrated the underground resource and all have been placed in commercial use as either production, injection or observation/monitoring wells.
Permitting

Permitting for any geothermal project is a lengthy and detailed effort, and it can present many challenges in the project’s development. Permitting can potentially cause delays in the development schedule, cost overruns and in some cases even prevent development altogether. Permits are required before the start of any work that may affect the natural state of the environment at the site. The Don A. Campbell project is located entirely on public land, therefore the permitting process, as defined by the National Environmental Policy Act, is both time and resource consuming. Typically, a full project Environmental Assessment under NEPA takes between 12 and 18 months to complete. An EA is required before wells can be drilled and any power plant facility (power block, substation, pipeline, generator tie line, etc.) can be built. If the EA determines that the proposed project cannot be developed without creating significant environmental impacts, additional public and agency involvement are required in development of an Environmental Impact Statement.

Having said that, the remarkable aspect of permitting the Don A. Campbell project was how unremarkable it was. The proposed project site was similar to many other geothermal projects developed in the state of Nevada, in that it was located on remote and mostly uninhabited public land (Figure 6). Careful analysis and planning early in the development cycle enabled a streamlined and uneventful permitting process. The process started with Ormat doing its own environmental surveys and analysis of the project to rigorously evaluate the project for environmental constraints. This evaluation revealed no Threatened and Endangered species, and it allowed early identification of potential for cultural sites that could be avoided through careful project siting and design. The analysis also revealed the need to carefully site transmission infrastructure to avoid damage from infrequent but severe flooding in ephemeral drainages in the area.

Then Ormat submitted an Operations Plan for exploration drilling to the BLM, based on the drilling targets selected by Ormat’s exploration team. Thanks to the early analysis described earlier and close cooperation between Ormat and the BLM, the exploration EA was completed in approximately 1 year.

As exploration drilling progressed, Ormat began the permitting process for developing the power plant itself with its related facilities. On the federal side, this included preparation of a Utilization Plan for the proposed power plant and pipelines, and a Plan of Development for the proposed generator tie line route—a 20-mile 120 kV transmission line connecting the plant’s substation with the point of interconnection to the electrical utility’s grid. These documents were the basis for the preparation of the Utilization EA and granting of a generator tie line right of way. Here, too, thanks to the work done early on and the close cooperation between Ormat and the BLM, the Utilization EA and the POD were completed in just one year.

Ormat’s development and construction teams worked with multiple federal, state and county jurisdictions to obtain all additional required permits, and all were obtained in sufficient time to allow construction and operation to begin on or before schedule.

Power Plant Technology

In any project, once the geothermal resource parameters (temperature and flow, among other properties) are determined...
with confidence (through individual well flow test and a long-term multi-well interference test and the generation of a 3-dimentional numeric reservoir model), an appropriate conversion technology can be chosen to best utilize the resource and to maximize power plant efficiency and performance. Resource temperature is a major driver in the selection process. Higher-temperature resources are viable to be flashed to produce steam, which generally is able to produce power at a higher efficiency using either a steam turbine or a condensing Organic Rankine Cycle. However, there is not an easily defined temperature limit, and in many cases all available technologies need to be considered. Lower resource temperatures almost always favor the ORC process, which can extract heat from liquid-dominated streams for power generation. At the Don A. Campbell project, the resource temperature was estimated to be around 260°F. At this temperature the geothermal fluid would be kept in a liquid form as it would not produce sufficient steam for a steam turbine or condensing ORC. ORC technology was the clear choice for this project.

Furthermore, given the location of the project (in the high and dry Nevada desert where water is scarce) and the strict environmental requirements, air-cooling as opposed to water-cooling was the natural choice.

The choice of an equipment supplier for the Don A. Campbell project was also clear, since Ormat designs, engineers and manufactures its own ORC power block, the Ormat Energy Converter. The OEC has been used in geothermal applications for decades and has been proven to be reliable and dependable, with over 1,750 MW of installed capacity worldwide. Ormat OECs are still operating today in geothermal applications after 30 years in the field.

Ormat’s OECs are designed and manufactured to match the specific geothermal resource conditions. Each is unique, implementing decades of design experience and success. Each OEC undergoes a strict thermodynamic design process to maximize the power output of the cycle while minimizing the equipment cost. As the OEC is a modular system, it can be used by itself or in combination with other OECs. This modular approach also offers a unique potential to further maximize the energy output potential. Ormat is the only company today with a vertically integrated approach that applies this level of optimization when it comes to geothermal power plants.

The design of the Don A. Campbell project consists of a single air-cooled OEC, in an Integrated Two Level Unit configuration. The ITLU includes two impulse axial full-flow turbines spinning at 1,800 RPM and directly coupled to a single water-cooled generator rated at 25 MVA / 20 MW (gross). This was selected as the most cost-effective solution that optimizes generation of at least 16 MW (net), on a yearly average basis.

Exporting Geothermal Energy from Northern Nevada to Southern California

Early in 2012, Ormat bid the Don A. Campbell geothermal project into the rolling 2012 Renewables Portfolio Standard Request for Proposals issued by the Southern California Public Power Authority. SCPPA is a joint powers agency comprised of eleven municipal utilities and one irrigation district. SCPPA’s members deliver electricity to over 2 million customers in the southern California basin, spanning an area of 7,000 square miles, with a total population that exceeds 5 million. On December 31, 2012, a power purchase agreement was executed between an Ormat affiliate and SCPPA, with two SCPPA members committing to taking the power to serve their loads: the Los Angeles Department of Water and Power – the nation’s largest municipal utility – taking 85% of the plant output, and Burbank Water and Power taking the remainder. For both utilities this agreement marks the first time they have added geothermal energy to their resource portfolio. For LADWP, adding this resource is of specific importance as it supports its strategic decision to completely phase out coal-based generation – historically its main source of base-load power – between 2015 and 2025. Geothermal resources are the ideal renewable alternative to coal as they are also base-load resources, yet produce negligible emissions, and they are also more reliable and more flexible.

But how do you deliver renewable energy generated in northern Nevada to customers in southern California? The Don A. Campbell is located within the service territory of Sierra Pacific Power Company, the main investor-owned utility that provides electricity and natural gas to customers in Reno and the rest of northern Nevada. Therefore, interconnecting to SPPC’s high-voltage transmission grid was the natural choice. Ormat filed an interconnection request with SPPC in October 2010. SPPC then carried out several interconnection studies, and in October 2012 a large generator interconnection agreement was executed. SPPC completed construction of all required interconnection facilities – including a new 120 kV switching station named Excelsior - and network upgrades by the end of 2013. Ormat built a 20-mile 120 kV generator tie line from the power plant to Excelsior. SPPC’s transmission grid has several interties with neighboring grids surrounding northern Nevada, such as PacifiCorp in Utah; Bonneville Power Administration in California and Oregon; and, Idaho Power. However, SCPPA wanted the power delivered closer to where its load is, in southern California. SCPPA’s sister company – Nevada Power Company2 – had multiple high-voltage interties with southern California electric utilities, such as the Mead 230 kV intertie with LADWP south of Las Vegas, but SPPC and NPC did not have a physical interconnection between them. Not until the One Nevada Transmission Line (ON Line) was placed in service, ON Line is a 231-mile 500 kV transmission line connecting the Harry Allen Substation north of Las Vegas in NPC’s balancing authority area with the newly constructed Robinson Summit Substation 20 miles west of Ely, in SPPC’s balancing authority area. This line is jointly owned by NPC, SPPC and Great Basin Transmission, LLC, an affiliate of LS Power, a power generation, transmission and investment group. By connecting northern and southern Nevada’s transmission grids for the first time, ON Line significantly increases the ability to obtain energy independence for Nevada by enabling SPPC and NPC to share renewable resources, and more cost effectively dispatch their generation fleet to serve customers statewide, thus maximizing efficiency and improving reliability.

In addition, as demonstrated for the first time by Ormat through the Don A. Campbell project, this line also allows tapping into the abundant geothermal resources of northern Nevada to serve the main population centers of California. NV Energy started construction of ON Line in 2010 and completed it by the end of

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2 Both SPPC and NPC are affiliates of and do business as NV Energy
2013, just in time to allow the Don A. Campbell plant to wheel the geothermal energy it generates all the way to the Mead 230 kV intertie, where LADWP and BWP import it to serve their loads in the Los Angeles basin. Ormat filed a transmission service request to NV Energy for service from Excelsior to Mead in May 2011. After conducting multiple transmission studies and resolving some regulatory issues that surfaced through the analysis of this first-of-its-kind request, a transmission service agreement was executed in March 20143.

Construction, Commissioning and Operation

Construction of the power plant and above-ground pipelines began in the spring of 2013, after the power purchase agreement obtained the necessary regulatory approvals. Construction started first with building the power plant pad, followed by setting foundations for all major equipment at the power plant. All of the major pieces of equipment for the Ormat OEC were manufactured by Ormat. As the components (air coolers, heat exchangers, and turbines) arrived on site they were set on their respective foundations.

With most or all of the major equipment unloaded at the site, the central effort of mechanical and electrical construction could commence. This process usually takes a couple of months as piping is fitted, valves and instruments installed, and then all process-air and electrical connections are made and tested. A project of this size requires miles of electrical cables and process-air lines. There are hundreds of connections to be made, and they all must be confirmed and tested prior to start-up of the power plant. Construction of the Don A. Campbell had to be rapid and efficient, since the PPA required the plant to reach firm operation by December 31, 2013. Moreover, being placed in service by that date was a critical deadline to qualify for a major financial incentive from the U.S. federal government – the 1603 Program: Payments for Specified Energy Property in Lieu of Tax Credits. By mid-November 2013 – only 8 months from the start of mechanical construction - commissioning started and the plant was synchronized to the NV Energy grid. Just one week later the plant was already generating at its full capacity, and by December 6, 2013 – more than 3 weeks ahead of schedule - the plant successfully passed a rigorous 5-day capacity and reliability test, as required by the PPA, and firm operation was achieved. Since then, the Don A. Campbell plant has been performing beyond its design, producing more than 16 MW (net) of clean, renewable energy.

Economic Benefits to a Rural Nevada Community

While some northern Nevada counties, such as Washoe and Churchill, have been benefitting from geothermal development and operation for many years, Don A. Campbell was the first such development in sparsely populated Mineral County; and the economic benefit this project brings to the county and the state is quite significant. The project created an estimated 138 full-time jobs during construction, and 7 long-term full-time operational jobs. Beyond those direct employment benefits, the total amount Nevada is projected to gain from the power plant during its life cycle is $102 million, which includes employee wages, a capital investment worth $84 million dollars, and $8 million combined from property taxes.
and school support taxes. Ormat worked closely with the county and the state throughout the development of the Don A. Campbell project and has enjoyed widespread support for it.

**Summary**

The successful development of this project, ahead of time and below budget, and the plant’s performance to date exceeding its design, can be attributed to multiple factors, which include: a rigorous and regimented exploration and development campaign that utilized state-of-art technologies and resulted in successful resource discovery, confirmation and development; streamlined permitting through close cooperation with all state and federal agencies while designing and siting all facilities to minimize environmental impact; power plant engineering tailored to the specific resource characteristics maximizing power generation and efficiency; creative business development that identified new customers and a new transmission path to deliver the power to them; fast-tracked engineering, procurement and construction capable of meeting a challenging deadline; and a user-friendly and highly automated power plant design that allowed for swift start-up and commissioning and high availability while lowering operation and maintenance costs.

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