Trials and Tribulation of the Oregon Institute of Technology Small-Scale Power Plant

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ABSTRACT

This paper provides information on the trials and tribulations Oregon Institute of Technology (OIT) overcame to start producing power on their campus in Klamath Falls, OR. OIT started on their adventure in 2008 to develop a small-scale low-temperature geothermal power plant using its existing geothermal wells. The temperatures of the wells are 192ºF with a maximum flow of 950 gpm. During the course of developing the plant they have encountered many differ aspects of the project from drilling, water rights, Purchase Power Agreement (PPA), interconnection agreement, to incentive forms (Energy Trust of Oregon, Business Energy Tax Credit and Blue Sky grant) that they have never dealt with before. The power plant was completed in February of 2010 and interconnected into the grid in April 2010.

Introduction

The Oregon Institute of Technology is located in southern Oregon just to the east of the Cascade Range in the high desert country at an elevation of about 4,500 feet (Figure 1). The campus has been heated with 192ºF geothermal water since 1962, when the campus was relocated from the site of the WWII Marine Rehabilitation Center in the hills east of the city. This new site was selected based on a high angle normal fault, typical of the Basin and Range physiographic province of the West, running along the west side of the City of Klamath Falls, where many geothermal wells had been drilled for space heating of residences and schools. Three geothermal wells were drilled, one around 1,200 deep and the other two around 1,800 feet deep taping into an upflow zone of hot water in the fault system. The hot water, after running through a settling tank, gravity flows to each building on campus where the heat is transferred to benign cold secondary water through a plate heat exchanger. The heat exchanger is necessary as the geothermal water contains about 2.0 ppm of hydrogen sulfide that will attack solder and produced stress cracking in copper tubing. The geothermal water is then injected back into the reservoir through two wells that are around 1,800 feet deep. The geothermal water supplies all the heat and domestic hot water to the campus at an energy savings of around one million dollar annually. The present campus has about 828,092 feet of floor space with a student enrollment of around 3,000.

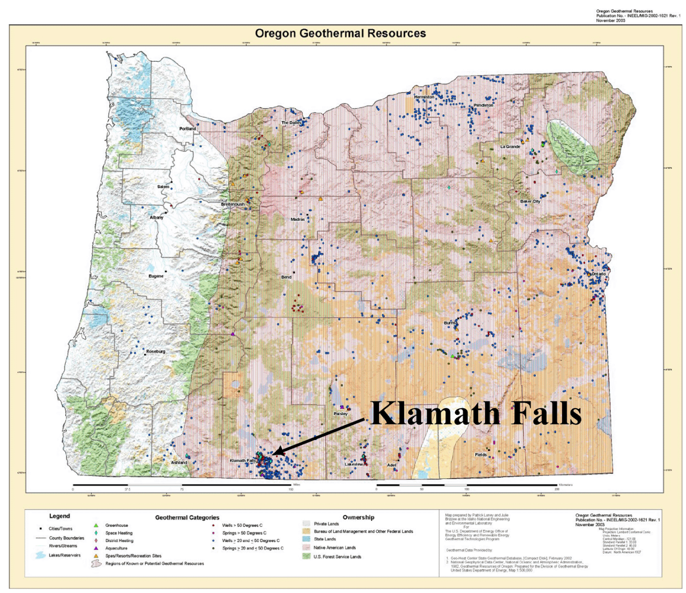

Figure 1. Oregon geothermal resource map courtesy of Idaho National Laboratory.

History of the Power Plant Project

In 2003 a proposal was presented to the Oregon Institute of Technology (OIT) Facilities Services to use some of the heat energy from the existing geothermal water to run a small binary (organic Rankine cycle) geothermal power plant. Systems West Engineers, Inc. was hired to evaluate the energy use on campus in 2005. Their conclusions were that there was sufficient energy to both run a 200 to 300 kW power plant and still heat campus (Systems West Engineers, 2005). They stated: "The existing geothermal system is capable of operating with a reduced supply of water temperature of 177ºF during most operating conditions with minimal upgrade of system piping and equipment." As a

Figure 2. Delivery of the UTC Pure Cycle© 280 kW binary power plant.

Figure 3. The 280 kW binary power plant with the turbine-generator set (covered). The condenser shell-and-tube heat exchanger is on top and the evaporator on the bottom.

Figure 4. The control panel for the 280 kW binary power plant.

result, a campus team was put together to write a proposal and obtain bids for a power plant and to provide the auxiliary equipment needed to complete the project.

In the latter part of 2006, there was only one company that we knew of that could provide a low temperature geothermal power plant in the 200 to 300 kW range, United Technology Corporation (UTC) of East Hartford, CT. We started looking into obtaining a UTC unit to use on our existing wells as they had recently provided a 200 kW plant to Chena Hot Springs, thus some historical operating experience was available. We started initial discussions then but did not really get into development discussions until later in 2007. Our Department of Justice had to review the contract and the Non Disclosure Agreement to make sure the language was suitable and passed legal sufficiently. The final contract was not signed until January 2009. During our discussions with UTC they recommended that we use stainless steel heat exchangers for the module. They said it would help improve the life of the unit and improve the long-term reliability but the additional cost would have increased by $50,000 and delayed the shipment of the unit by 3 months. OIT already has standard heat exchangers used for heating purposes and we have not seen any signs of deterioration so we elected to go with the standard heat exchanger design. The unit was delivered to our campus in March 2009. The plant was placed in the heat exchange building on the southeast side of campus (Figure 2, 3, and 4). The plant was dedicated in early 2010.

A wet cooling tower, controls, piping and circulating pumps were ordered separately, as they were not included with the UTC plant. The cooling tower uses water from the cold wells on campus located on the up-throw side of the normal fault (Figure 5). The cooling tower, at 827 nominal tons, is able to cool 1500 gpm of cooling water from 82°F to 70°F at 65°F entering wet-bulb temperature. We also elected to go with a non-chemical treatment for the cooling tower, since we would have to look at the disposal of the water if we used chemically treated water. We attached a Pulse Pure device to the cooling water entering the power module. It is a water treatment system that offers an alternative to treating the cooling tower water and it controls bacteria and formation of mineral scale. Approximately 12 gpm of makeup water is required to replace water lost through evaporation from the wet cooling tower. The tower was ordered in April 2009 and delivered in June of that year.

Figure 5. The building on the OIT campus housing the 280 kW power plant, with the wet cooling tower on the left.

While we were working on the power plant project we were notified by the state energy office that the power plant would require a SEED (State Energy Effeicient Design) Certification. The following components had to be analyzed for efficiency according to the program:

- Cooling tower design
- Sump heater
- Condenser water pump
- Variable frequency drives
- Digital controls for optimization and control under varying and operating situations

We were able to satisfy the SEED program in April of 2009.

There were several other permits and approvals that OIT needed to complete for the operation on the power plant. We had to get the normal building permits, which were issued by Klamath County. We also had to look at our water right certificates and Underground Injection Control permits. OIT has two certificates for water rights, which were approved in 1974 and 1991. The total amount of water available for geothermal heating from our geothermal wells is 1,095 gpm and the domestic water uses is 300 gpm from the cold wells. The certificates also specified how much irrigation water was available for use. The exiting water rights did not allow for power generation so OIT applied for a water rights transfer to include power generation as a use. OIT also applied for a limited use permit to cover us until the water rights transfer is approved. The water rights transfer is on hold at this time, which will allow us to make sure we have all the uses and places of use identified so we will not have to complete this transaction again in the near future.

OIT also currently has an Underground Injection Control permit, which allows the school to reinject the water back into the geothermal reservoir instead of disposing of the water on the surface. The City of Klamath Falls passed an ordinance in the early 1990s that requires geothermal water to be reinjected back into the ground it the system is pumped and no surface disposal is allowed unless the well is artesian. Once OIT decided to include power generation into a use for the geothermal water we were required to apply for a new Underground Injection Control permit. The permit was applied for and approved in 2010.

In order to generate power on campus while interconnecting to the utility system, approvals were required from OITs local utility, Pacific Power. Pacific Power had a specific procedure for obtaining this approval that involved completion of a Small Generation Interconnection Request. OIT applied for a Generation Interconnection Fast Track Study in Nov 2008. The study was completed in January 2009. This provided the information on what we needed to complete before we were allowed to be connected to Pacific Power. One of the outcomes of the study was that geothermal power generation was not eligible for net metering. We started working on the Purchase Power Agreement soon afterwards. Since OIT was not sure of how much energy would be going to the grid from the power plant we elected to go with a non-guaranteed power purchase agreement. The Interconnection and Power Purchase Agreements had to go through our Department of Justice, which slowed this part of our project. Unfortunately, the price we get for the power going to the grid is less than what we pay for electricity ($0.06/kWh).

While the plant was being specified, ordered and delivered, funding sources were investigated. The Energy Trust of Oregon provides resources and incentives to help install electric power systems. These incentives are based on a project's above-market costs. Our first application was submitted in early 2008 and was turned down due to the incompletion of the application. The Energy Trust recognized that we had a good project so provided assistance for us to hire consultant to help us through the process of developing the power plant mainly helping with the interconnection agreement and Power Purchase Agreement (PPA) and as a result provided an incentive of $487,000. The opportunity for a Blue Sky Grant through Pacific Power presented itself next. We submitted the grant application in May 2008 and received notification later that year that we were awarded $100,000. The State of Oregon offered a Business Energy Tax Credit (BETC) that can subsidize the project cost. We applied for the BETC in the middle part of 2008. Being a public Institution, OIT would not be eligible to get the full 50 percent on the credit but would get a portion using a pass-through option. The total amount received from the BETC after the project was completed was $254,148.

The geothermal power plant was designed to take approximately 15ºF off the top of the geothermal water as it was pumped from the well, and the remaining 192-15ºF = 177ºF temperature water used to heat campus. In warmer weather, when space and domestic hot water heating in demand is less, then a greater temperature drop is taken from the geothermal water for the plant. Approximately 600 gpm of geothermal water is used to operate the plant.

After the plant was operating, we were required to have an inspection from the Energy Trust. The outcome of the inspection is shown in Table 1.

Table 1. Inspection Summary for Energy Trust of Oregon.

Ambient air temperature:	37.9˚ Fahrenheit
Water flow through PureCycle Module:	448 Gallons per minute
Water temperature into PureCycle Module:	192.5˚ Fahrenheit
Water temperature from PureCycle Module:	154.0˚ Fahrenheit
PureCycle module power production :	213.0 kilowatts
PureCycle module power factor:	96.8%
Circulating water pump load:	7.7 kilowatts
Cooling tower fan load:	5.8 kilowatts
Net power plant production:	199.5 kilowatts
Well pump #2 load:	14.7 kilowatts
Well pump #5 load:	58.9 kilowatts
Well pump #6 load:	65.6 kilowatts
Total well pump load:	159.4 kilowatts
Net power delivered to PacifiCorp:	40.1 kilowatts
Water temperature to campus:	170.7˚ Fahrenheit
Well pump #2 flow rate:	88.8 gallons per minute
Well pump #5 flow rate:	389 gallons per minute
Well pump #6 flow rate:	314 gallons per minute
Total geothermal water flow:	792 gallons per minute

The Facilities Services people at OIT have since been doing some trouble shooting with the system to make it more efficient and still be able to heat our campus. They are no longer using Well # 2 as the power draw from the pump was more that it was producing. Well # 2 has a lower temperature (192ºF) that well # 5 (195ºF) or 6 (197ºF). They will still be troubleshooting it to see if they can optimize the power output.

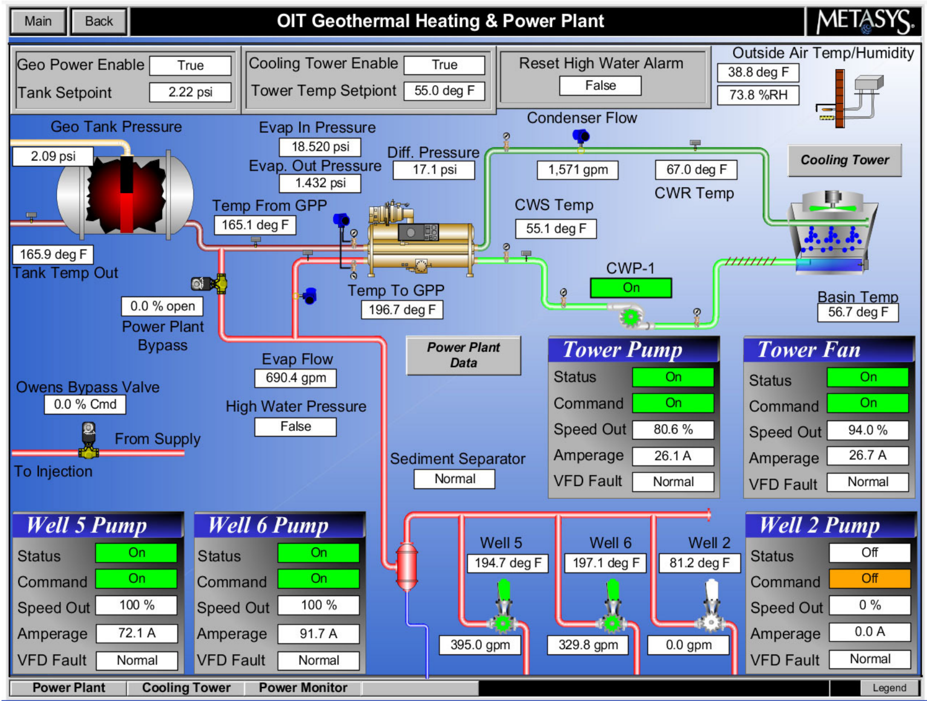

Figure 6. A screenshot of the control system for the UTC power plant.

Conclusions

The total cost for the power plant and auxiliary equipment was $1,100,000 and supplies approximately 10% of the campus electrical energy needs. Very few problems have been encountered during the approximately one year of operation; however, we are still learning how to operate the plant efficiently. We are very proud to be the first campus in the world to receive both geothermal heat and power from a resource directly under the campus. In the future, we hope to have an additional 2.0 MWe (gross) power plant online using a deep (5,300 feet) geothermal well drilled on campus in 2009. This unit along with the UTC plant will provide approximately 90% of the campus electrical needs.

References

System West Engineering, Inc., "Campus Geothermal System – Cogeneration Feasibility Study," 4 March 2005, Eugene, OR.