Feature Story

Renewable to the Core:

OIT taps campus geothermal resources

Tonya Boyd, Assistant Director, Geo-Heat Center, Oregon Institute of Technology

For more than a century, Oregonians have been harnessing the state's geothermal energy potential to heat buildings, melt snow off sidewalks, grow plants in greenhouses and more. Located 25 miles from the California border, the community of Klamath Falls, Ore., sits atop a particularly abundant supply of geothermal resources. (Nearly 600 wells are already used to heat 1,000 homes.) It was, in fact, these resources that prompted Oregon Institute of Technology (OIT) to move its Klamath Falls campus to the northern part of the city in the early 1960s, specifically so the school could tap hot water from the earth's core to heat campus buildings.

Today geothermal district heating serves 16 buildings totaling approximately 818,200 sq ft of floor space at OIT. The university is the only completely geothermally heated campus in North America. Building on its experience with geothermal, the school has been establishing itself as a leader in the field of renewable energy - in its academic offerings, research and development activities, and green building initiatives. Now OIT is well on its way to becoming not only geothermally heated but also geothermally powered. When this is accomplished, OIT will become the first university in the world to supply all of its heating and most of its electricity with geothermal resources found on its own property.

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Produced From Three Wells

OIT's current location on the northern edge of Klamath Falls was selected after the university had carried out

Courtesy Geo-Heat Center, Oregon Institute of Technology.

OIT's deep well (OIT Well #7) was drilled in early 2009. The drill rig is visible in a parking lot on the southeast corner of the campus and visible from the Martha Anne Dow Center for Health Professions at the top of the photo, and Snell Hall and the Residence Hall to the right. The white building in the bottom of the image is the heat exchanger building. To its left is the housing for OIT Well #2.

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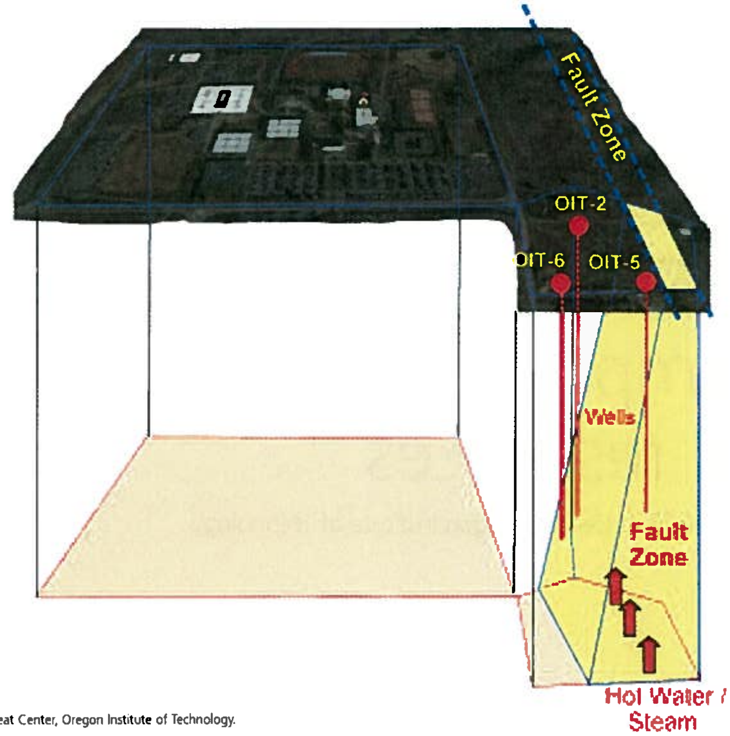
Figure 1. Geothermal Wells at the Oregon Institute of Technology. Geothermal water is produced from three wells drilled along a fault line in the southeast corner of campus.



Source: Geo-Heat Center, Oregon Institute of Technology.

studies of local hot wells, hot springs, faults and other factors and had consulted with the state engineer's office and local well drillers. The first well on campus was drilled in 1959, with five others to follow through 1963.

Today geothermal water is produced from three wells drilled along a fault line in the southeast corner of campus (fig. 1). The well water temperature can vary between 192 and 196 degrees F depending on the pumping rate and location of the well. Normally only one of these wells is used, with two required during extreme cold weather (below 0 F). The third well is used for standby and allows maintenance to be performed without interrupting usage. (Of the additional three wells drilled on campus, one is no longer used as it does not produce anything, and two provide domestic water, at a lower temperature of 70 F.)

The water is pumped individually from each well, with a maximum total flow from all the wells at 980 gpm. The water is then collected in a 4,000-gallon settling tank in the Heat Exchange building before it is delivered to each campus facility via gravity through the distribution system according to the demand on the system.

The settling tank provides the necessary head for the gravity flow systems and allows the fine-grained sediment from pumping to settle out of the water. Past pipe failures in the direct-buried distribution system – mainly from the ground water attacking the piping exterior through the insulation – spurred construction of a concrete utility tunnel in 1980. As new extensions to the tunnel are added, corrugated galvanized steel culverts are used instead of concrete.

In the original design, the geothermal water was used directly in each building's mechanical system. This once-through approach eliminated the need for circulation pumps in the buildings but caused a number of problems due to the corrosive nature of the water, including failure of the tin/lead solder connections and 1 percent silver solder and control valves; wall thinning; and perforation of copper tubing.

To address these problems, the geothermal water was isolated from the building heating systems using plate heat exchangers. The type selected consists of 316 stainless steel plates and Buna-N gaskets. The heat exchanger for campus swimming pool failed due to the chlorine in the pool water, and thus had to be replaced with titanium plates.

The original discharge temperature of the waste effluent was initially quite high at 135 F in winter and 170 F in summer when it was delivered to a drainage ditch. This discharge method presented a safety hazard and was stopped when a city ordinance was put into effect in 1990 requiring all geothermal water produced to be returned to the reservoir.

As a result, two injection wells were drilled in 1990 approximately 2,050 ft from the production wells. These injection wells can now handle up to 1,400 gpm. The elevation difference from the heat exchange building to the injection wells is 4,424 ft at building ground level to 4,301 ft at the injection well ground.

To reduce the effluent temperature, Purvine Hall was designed and constructed in the 1980s to use the effluent from the rest of campus. The effluent's temperature as it enters the building is around 155 F, and it leaves at approximately 130 F. The main components of

Temperature Reading: Geothermal hot water and its uses

- High-temperature geothermal – Water greater than 300 F, which is used for power generation.
- Low-to-moderate geothermal – Water at temperatures ranging from 75 F to 300 F, mostly used for direct-use applications like space heating, greenhouse heating and aquaculture pond heating. The heat from the water can be used directly without any mechanical boosting.
- Normal ground temperature – Ranges from 45 F to 75 F depending on the location in the U.S. Florida, for example, can have a groundwater temperature as high as 75 F. This temperature can be used for heating but would require mechanical boosting in the way of a heat pump system.

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this building's heating system are a 4,000-gallon storage tank, circulating pumps and heat exchangers. On the building heating side, space heating is accomplished by 54 variable-air-volume terminals equipped with hot water coils.

The newest additions to the OIT geothermal system are sections of sidewalks, stairs and handicap ramps equipped with a geothermal snow melt system. In 2009, approximately 37,000 sq ft of sidewalk and driveway systems were installed in front of the administration building, Snell Hall. The pipes in the concrete are 5/8-inch- to 3/4-inch-diameter cross-linked polyethylene tubing placed 8 to 10 inches apart. The system should be able to maintain a slab surface temperature of 38 F at minus 5 F air temperature and 10 mph wind when the entering 50/50 propylene glycol/water temperature is 144 F. Each major area has a separate plate heat exchanger, and the system will activate when the outside air is 30 F. The total amount of geothermal snow melt system installed on campus to date covers around 40,400 sq ft.

At peak use, OIT's geothermal heating system provides 16 million Btu/hr or a capacity of 3.8 MWt. The campus uses approximately 64.4 billion Btu of geothermal heating annually, saving the university around $1 million each year in heating costs as compared to natural gas.

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Tradition of Sustainability

OIT's 50-year track record of utilizing geothermal energy is only part of the university's tradition of sustainability. It was the first university in the nation to offer an undergraduate degree in renewable energy engineering and is home to the Geo-Heat Center and Oregon Renewable Energy Center (see sidebar). OIT has also instituted green building and energy conservation initiatives.

In the past five years, five new campus buildings have been constructed (increasing total building space by 23.6 percent) that are designed to meet LEED® (Leadership in Energy and Environmental Design) Silver certification standards. Two of the facilities designed to LEED standards, Wing 1 and Wing 2 of the Martha Anne Dow Center for Health Professions, are designed to use a mixture of supply and return water. Purvine Hall, the building on the end of the system, was designed to only use the return water from the campus. Although no campus buildings are currently equipped with energy or Btu meters for measuring electrical or heating use, there are plans to evaluate installing them in the future.

OIT also maintains a focus on energy conservation. The Klamath Falls campus has instituted aggressive conservation measures, including programs in 2000 and 2002 to upgrade inefficient lighting systems. As part of these efforts, light fixtures were replaced or renovated with high-efficiency electronic ballasts and T5 and T8 fluorescent tubes; and occupancy sensors were installed in offices, classrooms and restrooms. As a result, campus electricity consumption was reduced by 25 percent. Fixtures continue to be upgraded as resources become available.

All new buildings at OIT must meet the requirements of the State Energy and Efficiency Design (SEED) program. SEED was established in 1991 by Oregon law, directing state agencies to include energy conservation measures in new and renovated public buildings. The new Martha Anne Dow Center for Health Professions has carbon dioxide monitors for HVAC control, reflective roof surfaces and innovative surface water detention features that capture and treat 90 percent of water runoff. A new residence hall, the Village for Sustainable Living, includes low-flow fixtures and bicycle storage units and was built using renewable construction materials.

OIT's various energy-saving measures are moving OIT toward its goal of becoming carbon-neutral. (The university's target date for achieving carbon neutrality, originally set for 2017 per a 2007 strategic plan, is currently being re-evaluated.)

Next-Generation Projects

Toward its goal of becoming the first geothermally powered campus, OIT has launched a plan that comprises five new geothermal projects. These projects include installation of a small 280 kW

Sustainable R&D at OIT

Furthering its commitment to sustainable energy, OIT has established two centers for renewable energy-related research and development on the Klamath Falls campus:

- **Geo-Heat Center** – Opened in 1975, the Geo-Heat Center is a national resource for the development of direct heat utilization of geothermal energy. The center provides information developed through firsthand experience with hundreds of projects and through extensive research to individuals, organizations and companies involved in geothermal development. Its resources are available to the public through U.S. Department of Energy grants. (http://geoheat.oit.edu)
- **Oregon Renewable Energy Center** (OREC) – OREC was established by the Oregon State Legislature in 2001 to integrate renewable energy technologies into energy systems for practical use by businesses and consumers. The center conducts applied research in areas such as low-temperature waste heat recovery, hydrogen fuel cell cars and wind energy aerodynamic modeling. Its many activities include an online lecture series on biofuels, wind and solar energy, financing options for energy conservation and renewable energy, and more. (www.oit.edu/orec)

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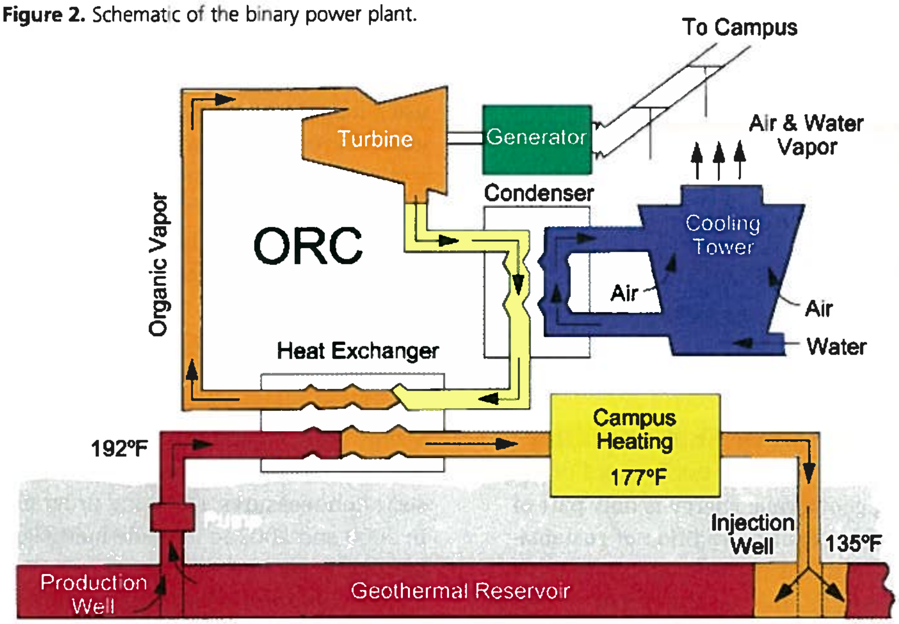
Figure 2. Schematic of the binary power plant.



Source: Geo-Heat Center, Oregon Institute of Technology.

binary power plant using existing well water, drilling a deep well predicted to produce high-temperature hot water and building a large binary power plant to use the energy from that deep well. In addition, the plan calls for construction of geothermally heated incubator greenhouses and aquaculture facilities on campus.

All of these projects will serve as teaching laboratories, primarily for students in OIT's renewable energy engineering program, with real-time monitoring available for students at OIT and other universities. The projects will also be demonstration sites for geothermal energy investors and developers.

Small Power Plant

The 280 kW (gross) binary power plant was installed on campus in 2009 – the first combined geothermal heat and power plant in Oregon (fig. 2). The turbine generator binary system arrived in late March, and the cooling tower was delivered in May. The system was to be fully operational by the end of December. It uses low-temperature geothermal water from OIT's original wells. The school is planning to take 15 F off the top, and the remaining 177 F water will still be adequate to meet campus heating needs. The maximum flow required for the power plant is 600 gpm. In summer and warmer periods, when campus heating demand is less, the reject temperature can be reduced to as low as 150 F.

This unit will use a single-cell wet cooling tower with 70 F cooling water and produce an average net output of 85-140 kW depending on outside temperature and humidity. This plant will provide approximately 10 percent of the campus electrical energy demand and is expected to save $50,000 annually.

Deep Well Drilling

To produce additional electrical energy for the campus, OIT in early 2009 drilled a deep (5,308-ft) geothermal well to intersect the high-angle normal fault on the east side of campus. The geothermally heated fluid 'upwelling' along the fault is already tapped by existing geothermal wells. Based on analyses of surface water geochemistry of the existing wells, researchers had predicted that approximately 300 F geothermal fluids existed at depth. However, the well was found to produce 196 F water at 1,500 gpm with a drawdown of 24 ft. OIT is in the process of obtaining the water rights to produce 2,000 gpm from the deep well for the big power plant.

Large Power Plant

After establishing the water rights for the deep well, OIT will design a 0.8-1.0 MWe power plant (gross) to use the fluids from the well. It will probably be a binary type – i.e., an organic Rankine cycle using a secondary low boiling point hydrocarbon – supplying 0.6-0.8 MWe (net) to meet around 50 percent of campus electrical energy requirements. This is expected to save the campus approximately $250,000 per year. This larger-scale power plant will be designed, ordered and installed through a competitive solicitation that should take approximately six months to a year. The plant will be ordered and on site sometime in late 2010 or early 2011, and operational soon after that.

The total cost of the deep well and 1.0 MWe power plant will be around $9 million. However, the 150 F wastewater from the power plant could either be used as a preheat for a concentrated solar project on the north side of the campus, sold to adjacent property owners or used to supplement existing and new OIT heating demands. This would generate additional income or savings, along with the sale of excess electrical energy to the grid.

Incubator Greenhouses

OIT is also proposing to construct two geothermally heated greenhouses on campus, each at 6,000 sq ft. Different heating and cooling systems would be provided to each greenhouse as a research and demonstration project. All heating and cooling in the greenhouse would be monitored and controlled by computer.

The greenhouses would serve as incubator facilities where interested investors/developers could test the feasibility of growing their crops in a controlled environment utilizing geothermal energy. The facility would also provide research projects for OIT students and local agricultural programs at the community college and rural high school.

These facilities would require around 140 F hot water for heating and 60 gpm, which could easily be met by existing geothermal wells, mainly by cascading the effluent water from the campus heating system.

Incubator Aquaculture Ponds

Additionally, OIT is proposing to construct two geothermally heated outdoor aquaculture ponds and a covered

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nursery tank facility on campus. Each pond would be 100 ft by 30 ft, and the covered facility would be a 6,000-sq-ft greenhouse. Different heating systems would be provided to each pond as a research and demonstration project. The covered facility would consist of a series of fiberglass tanks heated by the geothermal water. All heating systems would be monitored and controlled by computer. Various fish species, hard-shell aquatic species and even various algae could be tested.

Effluent water from the campus geothermal heating system at around 140 F and 150 gpm would be required, which could easily be met by cascading. The facility would provide an incubator facility for potential developers and investors and would also be used as a laboratory for campus students.

Ready to Lead

The OIT campus was built at its present location mainly to take advantage of the geothermal energy provided by water moving up along the high-angle normal fault on the east side of campus. The school has certainly capitalized on these geothermal reserves, utilizing geothermal hot water from three (soon to be four) wells to heat – and now power – campus buildings. By putting renewable energy technology to work on campus, in addition to fostering a strong academic focus in this area, OIT is well-positioned to be a leader in renewable geothermal energy utilization.

Tonya Boyd, assistant director, Geo-Heat Center, Oregon Institute of Technology, is an engineer-in-training and has been with the GHC since 1995, when she started as a research assistant. She is primarily responsible for the technical assistance program and the center's Web page. She has been active in the Geothermal Resources Council and is presently on the GRC board of directors. She also is a member of the International Geothermal Association. Boyd has received training as an installer and designer from the International Ground Source Heat Pump Association. She has participated in many geothermal conferences and workshops as a speaker and organizer and is currently evaluating papers for the 2010 World Geothermal Congress. She holds a bachelor's degree in civil engineering from OIT. Boyd can be reached at toni-boyd@oit.edu.