GROUNDED IN SAVINGS AND COMFORT

BURNSIDE ROCKET TAKES OFF WITH GROUND-SOURCE HEAT PUMPS

When designer-developer Kevin Cavenaugh began planning the Burnside Rocket building in Portland, a ground-source heat pump system was one of his top priorities. While the high-efficiency heat pump, also known as a water-source heat pump, would help the building use 50 percent less energy than a typical commercial building, it would also earn points toward LEED® Platinum certification, qualify for state tax credits and Energy Trust of Oregon incentives, increase leasable space with smaller mechanical rooms and align with the developer's green ethic. With a payback under 10 years, it was an investment Cavenaugh considered a no-brainer.

Adding water to the mix

Cavenaugh hired geothermal system specialist John Lower of Total Energy Concepts to design and install the system. Working with licensed mechanical engineer Dan Wehage, Lower proposed a closed-loop system with vertical heat exchangers that required drilling 21 bore holes 165 feet deep. Because of the small site (just 38 feet x 100 feet), a horizontal system that doesn't require drilling was not an option.

When the gravelly soil below the site prevented the driller from using a standard drilling rig, the driller switched to a rotary rig that allowed them to advance the well casing while drilling. With drilling still slow and difficult, it became clear it wouldn't be cost-effective to drill 21 bore holes, but they kept going in hopes of hitting water. At 280 feet they reached an aquifer that delivered 68 gallons per minute and the plan switched to an open-loop system served by an extraction and injection well.

The new plan added a step that wasn't in the original plan: securing water rights from the Oregon Water Resources Department, followed by permits from the Oregon Department of Environmental Quality, Multnomah County and the City of Portland. With help from hydrologist Roger Smith of RNSA Groundwater Consulting, water rights and permits were secured, but the process delayed the project by several months. In spite of the delay, it was worth the wait for Cavenaugh. Today, the aquifer serves all the building's water needs, so the building has no city water bills except for a fire line. And Cavenaugh learned to involve an experienced hydrologist at the very beginning of a project to save time, avoid costly drilling surprises and move swiftly through the water rights and permitting process.

> **The idea that green is more expensive doesn't roll anymore. I spend more upfront and save money over time. I don't perceive that I paid more for the ground-source system.**
>
> Kevin Cavenaugh, principal
> Cavenaugh & Cavenaugh, LLC

AN EFFICIENT, COST-EFFECTIVE SYSTEM

Six WaterFurnace water-source heat pumps, sized to meet the needs of the areas they serve, provide heating and cooling for the building's tenants, which include restaurants and offices. The systems use water from the extraction well as a heat source in fall and winter and as a heat sink during the cooling season. Most of the water is re-injected into the well, but some is piped directly to the restaurant for drinking water. Hot water is pre-heated with heat recovered from compressors running the HVAC system and is stored in electric tank water heaters.

The water-source systems have very small mechanical space needs, which increases leasable space. Cavenaugh and project architect Francis Dardis further streamlined the footprint by using hollow-core concrete slabs to distribute conditioned air instead of using ductwork. The building's concrete structure serves as the finished surface, reducing the need for additional floor and ceiling systems, and small floor plates limited the need for interior walls.

How it penciled out

A combination of energy and water cost savings, financial incentives, tax credits and other benefits made the system pencil out for the Burnside Rocket building. The $309,839 system costs were offset by the following:

Energy cost savings

Energy Trust estimates that the water-source heat pump system delivers energy cost savings of approximately $6,300 each year compared to a conventional system.

Incentives and tax credits

The project qualified for $7,175 in Energy Trust incentives and a $61,066 grant from the Green Investment Fund, a competitive grant program that supports innovative green building projects in Portland.

A $60,000 Oregon Business Energy Tax Credit further offset the net system cost. (A federal investment tax credit is now available to provide additional tax benefits.)

Property tax exemption

The value that the ground-source heat pump system adds to the building is exempt from assessment for property tax purposes under the Oregon alternative energy system property tax exemption (ORS 307.175). Cavenaugh estimates property tax savings of $11,000 per year.

Water cost savings

Because the well provides all the water for the building, the Rocket is not connected to the city water system and has no water utility costs.

BUILDING

- 16,500-square-feet, 4 stories
- Restaurant and open office spaces
- 38 ft x 100 ft site
- Completed May 2007

HEAT PUMP SYSTEM

- 6-ton WaterFurnace ground-source heat pumps with dual speed compressors and desuperheaters—16.6 EER cooling, 5.4 COP heating
- 3-ton WaterFurnace ground-source heat pumps with single speed compressors—15.3 EER cooling, 4.7 COP heating
- Heat recovery ventilators
- Variable flow well pump

FINANCIAL ANALYSIS

Costs	
Ground-source heat pump equipment	$173,057
Design & engineering	$68,625
Drilling	$62,407
Permits	$5,750
	$309,839
Offsets	
Green Investment Fund grant	($61,066)
Oregon tax credit	($60,000)
Energy Trust incentives	($7,175)
	$128,241
Annual Savings*	
Energy costs	$6,300
Property taxes	$11,000
	$17,300

** Water and avoided maintenance costs not included*

Increased operating revenue

Rocket tenants have full-service lease agreements where utilities are included, so Cavenaugh realizes the full benefits of the building's low operating and maintenance expenses for higher profits. This allows higher profits than the triple net lease model, which passes operating costs to tenants.

Maintenance cost savings

According to Lower, maintenance savings alone can pay for the cost of a water-source system in less than 10 years because there's no need for a boiler and cooling tower. While boilers and cooling towers have high maintenance costs, water-source equipment requires only occasional filter cleaning.

Durability

Ground-source systems are guaranteed for 10 years, but an Environmental Protection Agency study has shown that they typically perform for 30 to 70 years.

HIGHEST-EFFICIENCY HEATING & COOLING

Today there are more than 600,000 ground-source heat pumps installed in the United States, with 40 to 50 percent of those in commercial applications. According to a 2008 U.S. Department of Energy report, this proven technology has the potential to dramatically reduce U.S. energy consumption and greenhouse gas emissions and could reduce U.S. utility costs by up to $38 billion a year.

Ground-source heat pumps, also known as geothermal heat pumps, use the ground, groundwater or surface water as both a heat source and a heat sink. With a reversible refrigeration cycle, ground-source heat pumps provide heating and cooling by moving refrigerant around a closed loop, transferring heat between an indoor coil and another coil where heat is absorbed or rejected.

Because the temperature of the earth and subsurface aquifers is relatively constant year-round, ground-source heat pumps use 40 to 70 percent less energy than conventional systems. While conventional furnaces and boilers burn a fuel to generate heat, ground-source heat pumps use electricity to simply move heat from the earth into buildings, allowing for higher efficiencies.

Types of systems

The type of heat pump system used depends on the type of soil on the site, available geothermal resources and specifics of the application.

Closed-loop designs use the earth as the heat source and sink via horizontal or vertical ground-coupled heat exchangers. Horizontal loops require more land area, but are usually less costly to install because they don't require drilling. Vertical systems use heat exchangers that consist of polyethylene u-tube pipes in boreholes that are typically 150-250 feet deep. Closed loops can also be located in lakes, ponds and other bodies of surface water.

Open-loop systems can be a viable option with an ample supply of groundwater. A plate heat exchanger typically transfers heat between the groundwater and a common water loop inside the building; zone heat pumps exchange heat with the common loop. Surface water from lakes and streams can also be used in an open-loop system, but applications are usually limited to warmer climates or to cooling-only applications in colder climates.

Water heating

Ground-source heat pumps can be equipped with desuperheaters to provide highly cost-effective water heating. A desuperheater permits heat that would normally be transferred from the air conditioning compressor to the ground to be used for water heating.

Key Benefits

- Energy and maintenance cost savings
- Water cost savings (water-source systems)
- Low life cycle cost
- LEED Energy & Atmosphere points
- Smaller mechanical rooms
- Quiet operation
- Increased leasable space

Considerations

The installed cost of a ground-source system can be higher than conventional space conditioning equipment, but this depends on factors such as the particular geothermal resource used. For new commercial applications, the installation cost of a well-designed ground-source system is often competitive with the cost of most conventional alternatives. However, even when there are higher first costs, the life cycle cost is usually lower than other alternatives due to substantially lower energy and maintenance costs.

Given the potential for dramatic savings, a building owner should always ask the design team to consider a ground-source heat pump before the project budget is finalized. Spending more time upfront can pay big dividends later.

RESOURCES

Energy Trust incentives
www.energytrust.org/newbuildings

Green Investment Fund grants
www.portlandonline.com/bps/gif

Oregon Business Energy Tax Credits
www.oregon.gov/ENERGY/CONS/BUS/BETC.shtml

Federal tax benefits
www.energy.gov/additionaltaxbreaks.htm

U.S. Department of Energy
www.eere.energy.gov/buildings

Oregon Water Rights
www.oregon.gov/OWRD/PUBS/aquabook.shtml

Oregon injection well registration
www.deq.state.or.us/wq/uic/forms.htm

International Ground Source Heat Pump Association
www.igshpa.okstate.edu/index.htm

Geothermal Heat Pump Consortium
www.geothermalheatpumpconsortium.org

WHAT TO PLAN FOR WHEN CONSIDERING A GROUND-SOURCE HEAT PUMP SYSTEM:

Start early: The earlier a system is considered, the less expensive it will be.

Hire an experienced designer/engineer: Since ground-source systems are not one size fits all, an experienced, knowledgeable team will design a system that makes sense for your site and the needs of the building. If you're considering a water-source heat pump, involve a hydro geologist that knows your area.

As with any HVAC system, proper assessment of the building's peak heating and cooling loads is critical to the system design. Proper sizing ensures maximum energy efficiency, proper humidity control and longer system life.

Plan for site work and permits: Because ground-source systems require site work, it's imperative that the project schedule allows for any drilling or excavation that must be done prior to construction. Water-source systems can add the most time to a project schedule since drilling must happen at the beginning in order to apply for water rights and get necessary permits from applicable jurisdictions (usually city, county and state). An experienced ground-source heat pump consultant and hydro geologist can expedite this process.

Apply for tax benefits and incentives: In Oregon, projects installing ground-source heat pumps are eligible for Oregon Department of Energy Business Energy Tax Credits and Energy Trust of Oregon incentives. Federal tax credits and other tax benefits are also now available. Projects planned for Portland may qualify for a grant through the Green Investment Fund.

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