Geothermal – Tulane’s Better Energy Alternative

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Executive Summary

Geothermal energy is an alternative source of heat and cooling that comes from within the Earth, using stable ground or water temperatures near the Earth's surface to control building temperatures above ground. A geothermal heat pump (GHP) system can reduce energy cost and usage by 40% to 70% and cut down carbon emissions by this same range. This system typically consists of the pipes buried in the shallow ground near the building, an indoor heat pump or exchanger, and an air duct system inside the building.

For Tulane University's Uptown campus, 4,000 pipes would be required to maintain the 6,000 tons of cooling capacity required to control the buildings' temperatures. These pipes would need to be installed 15 feet apart, requiring a total surface area of 60,000 feet, or roughly 245 sq. feet. Additionally, since the University is located in a southern climate, a 2000-ton capacity chiller is required to extract humidity from the buildings. The university already has a new 4,500-ton chiller that can be used (at half its capacity) and the required duct systems, so capital costs for equipment and installation would be reduced significantly.

The capital cost for constructing a geothermal system is $32 million, but if eligible for tax credits, the university could receive back as much as 54% or $17,280,000 of that cost. There are minimal operational costs involved with geothermal because the main parts of the system are protected below the ground. The equipment lifespan for this system would be around 50 years, and the payback period would be seven years. Tulane would save at least $400,000 or 33% of current HVAC maintenance costs, reduce energy consumption by 26,883,069.20 KWHs, reduce energy expenditures by $1,895 million, and reduce Tulane's emissions by 26% or 14,175 metric tons per year. Assuming Tulane qualifies for tax credits, the net present value for this project would be $80,675,000, and the discounted cost per reduction of CO2 is $113.83 per metric ton.

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Report

Geothermal energy is an alternative source of heat and cooling that comes from within the Earth. This heat can be recovered through pumps as steam or hot water; however, in Louisiana steam is not commonly used for climate reasons. Geothermal energy uses stable ground or water temperatures near the Earth's surface to control building temperatures above ground. Temperatures in the upper 10 feet of the Earth’s surface stay constant between 50 and 60 degrees Fahrenheit. This means that ground temperatures are warmer than outside air in the winter and cooler than outside air in the summer, allowing for the geothermal systems to work as both furnaces and air conditioners.

A geothermal heat pump (GHP) system typically consists of the pipes buried in the shallow ground near the building, an indoor heat pump or exchanger, and an air duct system inside the building. The GHP system uses these underground pipe loops to capture the fluid at this constant temperature and transport the fluid into the building to the indoor geothermal heat pump, which uses compressors and heat exchangers in a vapor compression cycle to concentrate the Earth’s energy and release it inside the building through a duct fan system. This process is reversed in the summer as heat is taken out of the building and put into the ground. The heat removed during summer can additionally heat water at no extra cost.

A geothermal heat pump works differently than ordinary furnace or air conditioning systems, and requires less maintenance because most of it is located underground. With a furnace, heat is usually created by burning fuel, but with a geothermal heat pump this is not required as the heat is extracted from underground and collected by the loops of pipes. Pipe loops can either be installed vertically or horizontally, depending on how much space is available. If these loops are immersed in water, then they are part of an open loop system. If these piped are not, then they are part of a closed loop system. The pipes in a closed loop system are either filled with water or environmentally-friendly antifreeze. Closed systems are more expensive to install but do not have the maintenance costs associated with open systems, as open systems often get clogged with silt and marine life, and require cleaning out.

Approximately 70 percent of the energy used in a geothermal heat pump system is renewable energy from the ground, according to Bruce Hoffman, local geologist and owner of Gulf GeoExchange and Consulting Services, Inc. Consumers who use geothermal systems can save money on heating and cooling costs and reduce carbon emissions since geothermal heating and cooling is much more efficient than traditional methods. According to the U.S. Environmental Protection Agency (EPA), geothermal heat pumps are the most energy-efficient, environmentally-clean, and cost-effective systems (in terms of maintenance) for temperature control. GHPs can save homeowners anywhere from 40% to 70% on heating and cooling costs over conventional systems. Tulane University would benefit from this system by saving a significant amount of money on energy consumption, and this option would also reduce the university's carbon emissions significantly, as explained further below.

To install a geothermal pump system at Tulane University's Uptown campus, exact measurements of the buildings as well as the university's annual energy consumption (to heat and cool the buildings) are required. Although these exact measurements could not be obtained, Bruce Hoffman was consulted for this project to provide some estimates. He assumed that Tulane's Uptown campus requires 6000 tons of cooling capacity. He also mentioned that underground pipes, indoor heat pumps/heat exchanger and the air duct system would be required to implement a GHP system, as aforementioned. This system must be complemented with a chiller that will help to cool the air and remove the humidity from the air in the buildings. According to Mr. Hoffman, a hybrid approach or a 1/3 to 2/3 ratio of chiller to geothermal energy is the best way to maintain energy levels. In Tulane's case, 4,000 tons of cooling capacity would need to come from the underground pipes, and 2,000 tons would need to come from the chillers.

For Tulane, the major costs of this operation would be installing the closed loop pipes underground in a few locations throughout the Uptown campus. The amount of cooling capacity tons needed would require 4,000 wells (or holes drilled) as well as an indoor heat pump. Each well needs to be 15 feet apart, which would require about 60,000 feet in surface area, or open fields roughly measuring a total of 245 feet by 245 feet. These wells can be constructed and installed simultaneously with the indoor heat pumps over the span of six months to save time and money, according to Mr. Hoffman. Also, Tulane already has an air duct system in place, as well as a new 4500-ton-capacity chiller that could be used as part of the geothermal process. This cuts down tremendously on the projected capital cost.

The cooling and heating capacity component of capital cost stands around $15 million, based on Mr. Hoffman's cost-estimate of $2,100 per ton of cooling and heating capacity with 6000 tons required for the campus. The cost of drilling (which is around $40,000 per site), labor, materials and incidentals should also be taken into account and increases the total capital cost to around $32 million. This estimate is high but provides cushioning for unforeseen costs.

Mr. Hoffman indicated that when the geothermal system involves the three components of heat pumps, underground pipes and air ducts, savings of 54% from the capital cost can be expected through energy efficiency tax credit, investment tax credit and modified accelerated depreciation tax credits. Essentially, the university would only pay 46% of the estimated $32 million capital cost, which would be $14,720,000.

It should be noted that there are virtually no annual or operational costs involved with this proposed geothermal system – with the exception of the chiller – because the main parts are protected below the ground. Nevertheless, the chiller maintenance costs are considered sunk costs, since the Tulane already purchased this equipment.

The payback period for installing a geothermal heat pump system is estimated to be seven to 12 years, which is impressive since the project duration or equipment lifespan for geothermal systems is around 50 years. Our team estimated that the payback time for this geothermal project would actually be seven years, because energy cost reductions are so high with this system. Chillers have a lifespan of 20-30 years, which is also beneficial to this option, since hypothetically, a purchase of only one new chiller would be necessary.

In terms of annual savings, Tulane currently spends $1,193,584.38 on its HVAC maintenance for the Uptown campus, according to its annual HVAC report. Since the geothermal system requires virtually no maintenance on its structure with the exception of the chiller, Tulane should expect to save at the very least 33% of this amount, or $400,000.

As for energy usage reduction, research indicated that Tulane used 67,207,673 kilowatt hours (KWHs) for 2008. Our team assumed that this number would be about the same for 2011, given the intentional reduction in energy usage in old buildings but added energy usage in newly constructed buildings. With the installment of this geothermal system, Tulane could expect to see a drop in energy consumption of at least 26,883,069.20 KWHs (40% energy reduction). This is a conservative figure, considering some facilities experience up to 70% reductions of energy usage.

To determine annual energy savings, it was assumed that Tulane spends annually around $6 million on energy usage for its Uptown campus. A low estimates energy-saving reduction of this would be roughly $1,895 million (a 31.5% reduction), as provided by the geothermal savings calculator on www.waterfurnace.com. A 31.5% reduction is conservative considering the average expected savings using geothermal systems is at least 40%.

With regard to carbon emission reductions, it is estimated that a geothermal heat pump will reduce Tulane's emissions by 14,175 tons per year, according to www.waterfurnace.com. In 2000, Tulane published its annual carbon emissions inventory at 52,982 metric tons. Assuming that the university emits around those same emissions now, eliminating those 14,175 tons is equivalent to 26% in CO_2 reductions.

Given the above-mentioned calculations, the net present value for this project would be $80,675,000, and the discounted cost per reduction of CO2 is $113.83 per metric ton.

In addition to the aforementioned financial benefits, there are several environmental and general benefits that would be realized by implementing geothermal energy at Tulane. Closed-loop geothermal systems do not harm the environment because the underground pipes are made of high-density polyethylene, a tough plastic that is extraordinarily durable and environmentally-friendly. In fact, the EPA now rates geothermal heat pumps as products with Energy Star ratings. Additionally, the geothermal components inside the buildings are usually small, require little maintenance, and are easily accessible. According to Mr. Hoffman, geothermal systems maintain 50% indoor humidity, which is very helpful in the state of Louisiana. Its pump systems are much quieter than regular air conditioning or heating systems, with virtually no sounds at all. Finally, geothermal systems are aesthetically pleasing, as the pipes are underground and the inside heat pumps can be hidden in utility rooms.

As for funding for geothermal implementation, Tulane could rely on its existing energy budget, as well as launch a two-fold energy campaign that fundraises the project while educating students, faculties, alumni, families and the community at large about Tulane's energy efficiency goals. This project, if implemented, will set Tulane apart from other universities and position it as a forward-thinking, environmentally-conscious university that will hopefully inspire other universities to follow suit. By installing a geothermal energy system, Tulane can improve upon its reputation and be seen as a positive driving force behind this not-so-eco-friendly city. Geothermal energy has great potential for the university, it should at least be considered as a more efficient and eco-friendly alternative energy source than the current heating and cooling system in place, and if accepted, Tulane should start implementing it by next year.