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Geothermal Case Study

With the "double-aught" decade coming to a close many are looking back on the last decade: taking stock of what has or has not happened, and learning from those experiences. And in these past ten years many things have occurred: we have seen the beginning of the War on Terror, China rise to become a superpower once again, the election of an African-American man to the Presidency, a very serious economic recession, and a profound social change coming over America's youth. This social change manifests itself in many ways, and many of them have appeared spearheading new political movements such as nationalized health care or firearm control. Here, we will examine another movement which has been gaining both strength and scientific credibility: renewable energy, specifically geo-thermal power. In the past few years the terms "renewable energy", "fossil fuels", and "geothermal" have been thrown around with increasing regularity. The Merriam-Webster's Collegiate Dictionary defines fossil fuel as "a fuel (as coal, oil, or natural gas) that is formed in the earth from plant or animal remains. Geothermal is defined as "of, relating to, or utilizing the heat of the earth's interior". Renewable is defined as "capable of being replaced by natural ecological cycles or sound management practices", so renewable energy is energy derived from a naturally-replenishing and seemingly unlimited source, such as a rivers flow or, in our case, the heat of the Earth. According to the Geothermal Energy Association, "It is considered a renewable resource because the heat emanating from the interior of the Earth is essentially limitless. The heat continuously flowing from the Earth's interior, which travels primarily by conduction, is estimated to be equivalent to 42 million megawatts (MW) of power, and is expected to remain so for billions of years to come, ensuring an inexhaustible supply of energy."[1]

Geothermal power works on a relatively simple system: heat from the Earth's core is transmitted by way of conduction to mantle layer. The amount of heat applied to certain parts of the mantle turn the solid rock to liquid magma, which is then forced up toward the outermost layer, the crust, taking the heat of the core with it. This magma can erupt from below the crust and be expelled from the ground, becoming lava. Usually, however, the magma simply courses through the upper mantle and crust heating underground rock and water it comes in contact with to as much as 700°F[2]. Some of this heated water then rises to the surface to create what we see as geysers or hot-springs, while most of the heated water remains trapped underground. Any area where magma-heated water is trapped underground in some manner is known as a geothermal reservoir.

1 http://www.geo-energy.org/basics.aspx
2 http://geothermal.marin.org/pwrheat.html#Q3

Figure 1: Workers drilling a well to pipe into the geothermal reservoir

These geothermal reservoirs, also referred to as "hydrothermal resources", are one of many ways that we can utilize geothermal energy. The process is fairly simple: locate a geothermal reservoir, drill a well (which are sometimes a mile deep or more, pictured at left), and pipe the steam and hot water back to the surface to be used to drive turbines and generate electricity.

These geothermal reservoirs are seen in great number and size in Alaska, the Western States, and Hawaii, though heat from the Earth's crust and mantle is able to be utilized anywhere in the world. Also, these geothermal reservoirs are renewable in and of themselves: the source of the heat is the Earth's core, and even when the water and steam in a reservoir is completely depleted, all one needs to do is pump the cooled water or steam which has been condensed back into the reservoir area, and the water will be re-heated by the core for use again. Because of the relative simplicity of generation of power by way of geothermal energy, the unlimited power source involved, and the ability to establish a fully functional geothermal power plant nearly anywhere, the cost of energy produced from geothermal systems would cost one approximately $0.05 per kilowatt-hour.[3] The less expensive power feed has been predicted to lead to average home savings seen in the chart to the left, taken from http://www.thinkactgogreen.com/Heat%20and%20Cool.html

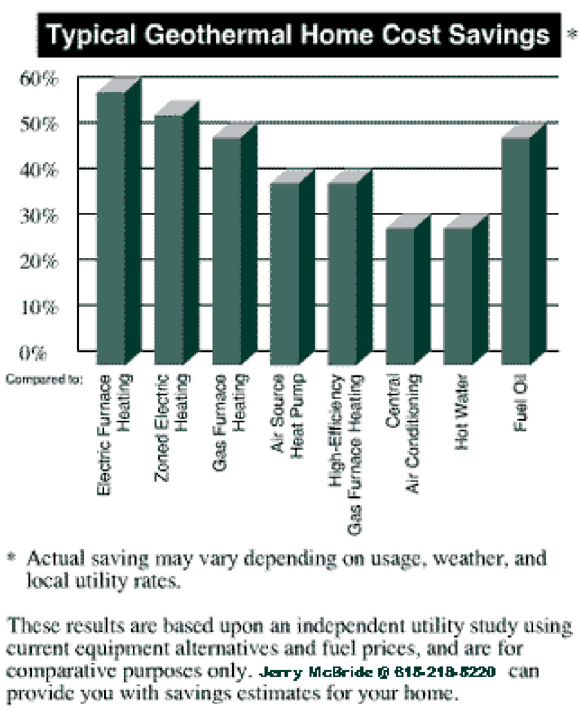

Figure 2: Geothermal powered home savings

[3] http://www1.eere.energy.gov/geothermal/faqs.html

The use of geothermal energy had been around since the early 19th century, where hot springs and geysers were used as an easy source of hot water for primarily hygienic purposes, usually therapeutic spas. It was not until 1864 when the water from hot springs was used to actually heat a number of buildings, in this case a few homes and a hotel. The first recorded system of building heating was actually physically piped into a number of buildings occurred in Boise, Idaho in 1892, where the district heating system was powered totally from hot spring water. Within the span of a few years, the same system had expanded to heat over 200 homes and 40 businesses. Today, this one district has expanded into four, and they provide heat to over five million square feet of space. Yet this was all local energy usage, the first actual geothermal power plant was built by one John D. Grant in 1922, where he drilled several wells, with the power generated from the first well to help build the second, third, and so on. By the end Grant's system was generating 250 kilowatts per hour, yet the plant was abandoned a few years later due to the ease of use and accessibility of coal power plants in the area.[4]

And back before the environmental damage caused by using coal was fully known and fossil fuels in great supply, such an action was considered the right decision. Now that coal is in a shorter supply and less favored as a power source, renewable sources of energy such as geothermal systems are becoming more mainstream. And as it becomes more and more common, it also becomes more efficient and cost-effective.

Figure 1: completed DeSepio building

A second way to utilize geothermal energy is with geothermal heat pumps which do not require steam but simply conduct heat between the earth and a building. The picture to the left is of the completed DeSepio Institute for Rural Health and Wellness, a new building at St. Francis University and one of the first to be heated and cooled by geothermal power alone. In an electronic interview (that is, the questions were asked and answered via email) with one of the chief engineers on this project, James M. Vizzini of CJL Engineering, was able to shed some light on the

[4] http://www1.eere.energy.gov/geothermal/history.html

reasons driving the large construction project. The first question asked was simply "Why geothermal?", which he answered, "Efficiency in terms of utility use and the ease of which the equipment is to maintain." And while there were most likely several factors contributing to the choice for geothermal power, Mr. Vizzini stated that the final decision was "purely economical", and that "Funding came from several sources. However, the PA Energy Harvest Grant funded a portion of the well-field construction in particular. This grant is now called the PA Comprehensive Energy Grant." There are, of course, other grants supplied to the University, such as a "$75,000 grant will help the university pay for a 44-well geothermal heating and cooling system for the planned DiSepio Institute for Rural Health & Wellness, university spokesman Amanda Stoehr said."[5]

The St. Francis geothermal project was finished recently, but when asked about the history of the endeavor, Mr. Vizzini said, "[The] Project started approximately 5 years ago with the plan to have an institute for rural health and awareness. Facilities personnel were pleased with the existing geothermal systems installed on campus. CJL performed energy models to confirm annual utility costs and expected system payback to confirm that such a system did indeed make financial sense." Yet the decision to expand the St. Francis geothermal system is driven by more than simply economics, the geothermal systems installed are safe, easy to maintain, and better for the environment, fitting nicely with the University's efforts to "go green". When questioned about maintenance and power generation safety Mr. Vizzini stated, "These systems, when installed properly, have historically been the most reliable of the ones we see. The main concern would be if any of the wellfield piping would ever develop a

Figure 2: pipe "loop" ready to install

[5] http://tribune-democrat.com/local/x519150546/Cambria-Somerset-get-energy-grants

leak. All piping was tested and is on polyethylene material. So on paper, the underground portion of the system should be good for 50+ years." (pictured above: the piping Mr. Vizzini is referencing, known as a "loop", these pipes circulate water (sometimes mixed with an anti-freezing agent) to absorb and transmit heat into the building in winter and out of the building in summer. Pictured below: one of several loops being laid out and soon to be installed.)

Figure 3: Pipe installation in progress

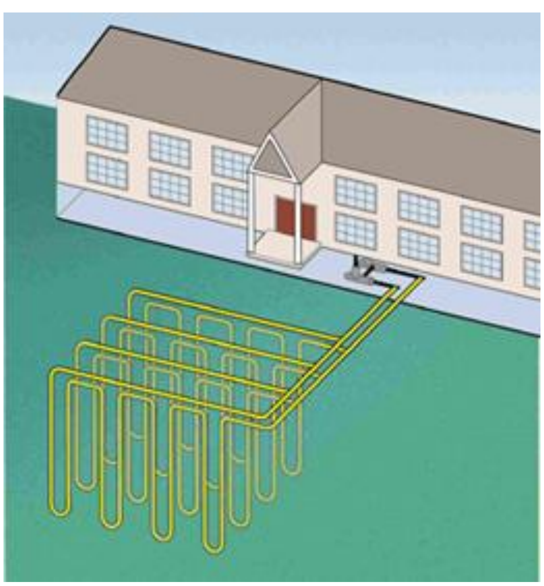

Figure 4: simple wellfield diagram

Pictured left is a simple diagram of the type of well field being used, and to its right is a photograph of the well field being drilled near the DeSepio construction site. The physical plant director of Saint Francis University at the time of the installation, Bernie Geishauser, was quoted saying "There will be forty-four wells, each bored to a depth of 354 feet. Each well will then have a closed loop piping system placed in it. Water is then circulated through this piping to either heat or cool the building, depending on what the building needs at that time.". The drilling of one of the forty four geothermal wells in the DeSepio well field is pictured below

Figure 5: Drilling of a well-field, equipment shown to scale

With construction of the DeSepio geothermal system complete, expectations of students and staff is high. When asked about the probable direct and indirect benefits of this system, Mr Vizzini said that the direct benefits would be, “Lower utility and maintence costs.” and that indirectly, “Reputationally … This system has been the subject of a few seminars. … if it gets folks to come to SFU, it is helpful in the exposure of the Campus.” Aside from reputation or politics, the installation and maintenance of a geothermal system is a definite stride toward a more efficient and environmentally friendly campus, and has up to the time of this writing been a total success and met and even surpassed all of its physical, financial, and maintenance goals.

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Figure 6: Anonymous. "A Typical Geothermal Well-Field." American Well Technologies. Date of creation not given. 19 December 2010. http://www.americanwelltechnologies.com/page3.html

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The author would like to thank Mr. James M. Vizzini, PE, Managing Partner of CJL ENGINEERING, Johnstown Office, for his time, assistance, and willingness to be electronically interviewed and quoted; without which this case study would not have been possible. The Author would also like to thank Dr. Alice Walters and Director Gwendolyn Andersen for their continued aid and support in this study.