A Proposal For Geothermal Heating & Cooling at the University of Richmond

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Abstract

Ground source heat pumps (GSHPs) offer a more efficient and environmentally responsible alternative to traditional heating and cooling systems. Using the earth's constant subsurface ground temperatures to generate heating and cooling, GSHPs allow for a decrease in fossil fuel dependence and greenhouse gas emissions. Higher education institutions, such as the University of Richmond, have a responsibility to model sustainability for their students when expanding and developing their campuses. Environmental, educational, and economic factors must be evaluated when considering new and replacement heat and energy installations. The viability of a GSHP installation on the University of Richmond's campus should weigh current costs versus future benefits. To investigate the potential benefits of a GSHP installation on campus, the study employs both archival research and expert interviews to seek a well-rounded evaluation of the implications of geothermal energy on the University of Richmond campus. In addition to environmental incentives and economic benefits, the study explores various social and educational benefits also associated with a GSHP installation on campus.

Introduction

Climate change has become an unavoidable issue on both a domestic and international level. While the earth's climate has naturally fluctuated in temperature for millions of years, current research shows that anthropogenic impacts are leading to an unprecedented spike in global temperature (McElroy 2016). The greenhouse gas emissions from fossil fuel combustion are largely responsible. By shifting away from our global dependence on fossil fuels, society can mitigate its effect on the environment (McElroy 2016). One way homeowners and businesses can mitigate their effect on climate change is by changing the way they heat and cool their buildings. Traditional Heating, Ventilation, and Air Conditioning (HVAC) systems run on oil or natural gas, contributing to emissions and running up energy costs. GSHP systems provide an alternative that utilizes the earth's subsurface ground temperatures to effectively heat and cool buildings.

The history of geothermal energy in the U.S. goes back as far as the early 1800s, when the first of the European settlers moving west discovered the hot springs of the Yellowstone area. Entrepreneurs built spas and hotels around the springs, advertising the natural pools, as well as pumping the water to heat their buildings. The first regional geothermal heating system was created in Boise, Idaho in 1892, initially reaching town buildings and eventually developed to heat over 200 homes in the vicinity (OEE&RE, 2013). From there, interest in geothermal energy increased, as it proved successful in areas with few other options. The first GSHPs for residential use, along with the first commercial groundwater pump, were both developed in 1948. Since then the technology has improved through the investment of gas and electric companies developing their own systems. In 1994 the U.S. Department of Energy launched an effort to reduce greenhouse gas emissions by accelerating the use of geothermal heat pumps, further boosting the industry and development (OEE&RE, 2013).

There are several different types of GSHPs that have been developed, each with their own advantages and disadvantages. GSHPs can be categorized as closed or open loop systems.

In an open loop system groundwater or surface water, in a lake or pond, is used as a heat carrier. The water is extracted and passed through the heat exchanger of the heat pump before being returned to the source. In a closed loop system the heat transfer liquid is completely enclosed within the circuit and has no direct contact with the ground, so heat transfer occurs through the piping material (Omer, 2008). Closed loop systems can be configured in a horizontal, vertical, spiral, or lake/pond system. Horizontal loop systems are usually laid out in a parallel pattern no more than a few meters underground and are ideal when there is ample space available. Vertical loop systems consist of a bore-hole field with piping going down 45-75 meters deep, depending on the application (Self, 2013). Spiral loop arrangements are laid in shallow trenches similar to that of horizontal systems, but consist of multiple overlapping loops, making them more space efficient than a traditional horizontal layouts (Self, 2013).

This paper explores the analysis regarding the installation and application of geothermal systems on college campuses, specifically at the University of Richmond. Using the research behind this paper, we discuss the installation of a GSHP at the University. The paper will begin with a literature review, which explains the integration and contrast between our research sources. These resources include reports, scholarly articles, and news articles from universities across the country. The pros and cons of GSHPs and Geothermal energy are discussed, along with how our sources are linked to one another. Next, we delve into our research methods as well as the background behind the study. The results and discussion of our research belong in the next section, which offer a series of recommendations on building geothermal systems at site-specific areas at the University of Richmond. In addition, an economic analysis on the installation and use of geothermal systems is reviewed and discussed. Finally, we share our conclusions on the instillation of a GSHP at the University of Richmond.

Literature Review

In order to broaden our knowledge about the application of geothermal energy we conducted research through a variety of literature, utilizing multiple different frameworks for analysis. The key aspect of our project focuses on the application of geothermal energy on college campuses. We therefore concentrated our efforts researching information about geothermal heat pumps on university campuses across the nation. Through our research, we discovered *Going Underground on Campus: Tapping the Earth for Clean, Efficient Heating and Cooling*, a 2011 report written by three professionals (Stan Cross, David Eagan, and Paul Tolme) credentialed and experienced in the fields of environmental leadership and sustainability. Stan Cross is the Education Director of the Environmental Leadership Center at Warren Wilson College. David Eagan is an Outreach Specialist at the University of Wisconsin-Madison as well as the editor of the Climate and Sustainability Series for Campus Ecology. Finally, Paul Tolme is an environment, science and outdoors writer and former Ted Scripps Fellow in Environmental Journalism (Cross et al. 2011). The report includes statistics, graphs, images, and analysis regarding the utilization of geothermal heat pumps on 160 college campuses in 36 states. The analysis of geothermal heat pump application is conducted geographically, emphasizing the highlights, challenges, and takeaways from each University being analyzed. Taking each location, the authors analyze each University using an environmental and sustainability framework in order to evaluate the efficiency of their geothermal systems. This report offered critical information for the project as it provided background for geothermal application on college campuses. The authors stress the cleanliness and efficiency of geothermal application, which relates to the project's goal of highlighting the importance of geothermal energy as an alternative source for heating and cooling. The authors agree that geothermal application can increase the response to climate-action on college campuses across the country (Cross et al. 2011). Equally relevant to the project, the correlation between increased climate-action and the application of geothermal energy was essential for our research.

Outside of the report we also used a collection of scholarly sources on geothermal energy and its applications. In one of these scholarly sources, a group of engineering professors from the University of Tennessee write a peer reviewed paper on the application of geothermal heat pumps on their agricultural campus. The professors offered excellent analysis of their geothermal system due to their educational background in engineering. However, this paper was difficult to comprehend at times where the analysis became too advanced for someone outside of the engineering field to understand. Although it was too advanced at times, their conclusions based on their analysis were important to our overall research. Birchfield et al. (2014) discussed the challenges the University faced since installing a system on campus. They concluded that further installation of geothermal heat pumps was not economically feasible due to high installation costs and a lengthy payback period (Birchfield et al., 2014). The engineering challenges that the University faced offers insight into difficulties that other Universities may experience when attempting to install a geothermal heat pump. Lund et al. (2005) offered background on the direct application of geothermal energy on a worldwide scale. The article delved into both large and small scale applications of geothermal energy, including geothermal heat pumps for heating cooling. The authors of the article stated that the geothermal heat pumps are the most globally used application of geothermal energy (Lund et al. 2005, 711). This article was important to our research because experts on geothermal energy clarified that geothermal heat pumps were a viable development on a global scale. Therefore, we were able to use this information to focus our application of a viable geothermal heat pump to the scale of the University.

A variety of other popular sources published on the internet were also valuable in our geothermal research. Many Universities that use geothermal application on campus have written articles on the benefits that they have provided since instillation. In almost all of these articles the environmental and economic benefits are primarily highlighted. These highlights are important for our research because they explain the benefits and impacts that come with installation. The campus' carbon footprint in each case was reduced millions of metric tons, and thousands of dollars on heating and cooling is saved each year. Although the authors writing these articles are not as credentialed as the intellectuals writing scholarly reports and papers, these articles stress the array of benefits that come with using geothermal heat pumps on college campuses. This includes reduction of carbon emissions, money saved on energy costs, and diminished dependence on fossil fuels.

Methods/Background

For initial data collection we conducted a review of current information and research on GSHP system implementation on college campuses. We expanded our search to general information on the different types of GSHPs, their costs, and implementation parameters. To fill in gaps in the available research we interviewed several consultants. Jesse Warren of the Office of Sustainability at the University of Virginia provided us with insight into the planning, installation, and maintenance necessary for their geothermal heat pump system. A local geothermal business owner, Kylie Draucker of DeltaTemp, shared her expertise and experiences with geothermal installations in the Richmond area. Andrew McBride, the Associate Vice President for Facilities and University Architect at the University of Richmond, along with George Souleret, Director of Utilities and University Engineer, shared their past experiences with attempting to implement a geothermal heating system on campus.

Results/ Discussion

Potential On-Campus Installations:
We investigated three potential areas where geothermal heating could be incorporated into future development. These were selected based on the proposed potential sites within the 2011 University of Richmond Master Plan. The three options included: a pond system utilizing the Westhampton Lake to help heat and cool the Tyler Haynes Commons, geothermal heat pumps incorporated into the new construction projects upcoming on the south campus (UFA and Gateway areas), or a retrofitted system for the buildings on the Westhampton Green.

Westhampton Lake:
From our research, Westhampton Lake would be best suited for a spiral, closed loop pond system. The spiral allows for more efficiency than a traditional horizontal loop, therefore requiring less area (Self, 2013). Pond systems are required to be at least 1.8m below the surface of the body of water (Self, 2013)**.** DeltaTemp consultant Kylie Draucker estimated a large residential home would require about .5 acres of pond and a commercial would require approximately ten times a residential purpose due to the need for greater temperature variance. Based on our research the Tyler Haynes Commons (THC) would require about 5 acres of water at a depth of 1.8m or greater. We also estimated the capacity needed in the lake for geothermal based on the THC's square footage. A geothermal system usually requires approximately 12-20 BTUs (a measure of how much heat is needed to heat a building to a specified heating temp) per square foot. This would estimate the requirement for THC to be 1,320,000 BTUs on the upper end. Looking at a system size in tons, one ton is approximately 12,000 BTUs- putting the

estimate at a 110 ton system (Geothermal Sizing). For space needed, typically 200 ft per ton of piping is needed, converting this to square feet and estimating area this would end up at only half an acre of necessary capacity estimated for THC (Geothermal Sizing). The Westhampton Lake sits at an area of 14.35 acres with an average depth of about 2.4 meters (Souleret, 2017). The deepest part of the lake lies closest to the Commons and using either estimate would have sufficient area to sustain a geothermal heat system for the Tyler Haynes Commons. While the lake has the capacity to support a geothermal heating system in theory, the University has not seen fit to invest in this area in the past. Aside from the economic setbacks discussed later on, sediment build up and summertime drought conditions threaten the stability of the system. Another issue would be the lake maintaining necessary temperatures. "Summertime water temperatures crept up to unusable conditions, since the source is mostly drainage from 1632 acres west of here," Souleret said of past issues with a lake based system, "Drought conditions mean that no fresh water comes in to replenish losses from evaporation." This could pose serious issues for the functionality of a lake based geothermal system, making it a less reliable option.

Westhampton Green:

The Westhampton Green area provides an opportunity to retrofit a geothermal system to the Modlin building or Keller Hall. The green itself potentially provides enough space for a more economical horizontal loop option running underneath the lawn. Most issues with retrofitted systems have to do with insulation and roofing issues in older buildings that fail to contain the heat (Draucker, 2013). To properly predict the success of a geothermal system for Modlin and/or Keller, these features would need to be assessed, as they may create a higher BTU requirement due to excess heat loss from old insulation or windows. If the system is designed properly, retrofitted systems are just as reliable as new construction, with the piping warrantied for up to 50 years and the furnaces usually lasting for 20-30 years. This would be by far the most economical option, but would need to be designed properly to ensure there are not later issues with the retrofit.

South Campus:

The south campus could provide an opportunity to implement a horizontal loop system for the Gateway apartments or future new construction, as indicated by the Master Plan. For a larger investment, there could also be potential for a vertical loop system in the area. After consulting with DeltaTemp and conducting further research, the 55-year lifespan of the underground piping for these systems make putting them under a parking lot or sports field a more feasible and economical option than we originally believed (Draucker, 2013). For a more economical horizontal loop system more space would be required, but this would also help to avoid rock-drilling costs that a vertical system would require. The horizontal system could be placed under the IM fields and fitted to new buildings proposed on the master plan, or the adjacent Gateway apartment complex. Another option for new construction in the area would be a vertical system under the buildings themselves. This would save space, as campus is always changing. However, to ensure stability the filing process of vertical wells would take six months to a year, extending construction times. The upside of vertical wells is that if there is an issue with one, the entire field doesn't need to be dug up, merely the one well area.

Economic Analysis:

When addressing the economics behind the installation of a ground source heat pump (GSHP), the question of whether or not the investor believes they will get a full return on their investment becomes a top priority. To help break the concept down further, ROI (return on investment) can be understood as "payback." The term payback, in our application of the word, is a period of time, usually in years, correlating with the duration you will have to wait until you finally get your money back from the initial investment. Therefore, with a GSHP, you are spending money now to save money later. Unfortunately, a major challenge and pushback for GSHP installations stems from an investor's inability to evaluate current costs versus future benefits. GSHP manufacturers usually stand by a payback period of three to five years, but it all depends on the parameters of your GSHP system. In his book, *Geo Power: Stay Warm, Keep Cool and Save Money with Geothermal Heating & Cooling*, Donal Lloyd (2015) provides three models to help better understand a few of the varying "payback" scenarios associated with a GSHP installation. Although the three models come from residential installation examples, their application can still apply similar payback trends for college and university campuses.

In the first model, you spend $28,000 for GSHP system; $8,000 more than the $20,000 cost of a natural gas boiler and full AC unit. You will save $2,500 every year by not buying gas, but it takes $200 of electricity per year to run the GSHP. Here, Lloyd leaves you with the question every investor wants to know: So, what is the payback? Evaluating the model's numbers, you have $2,300 in energy saving per year ($2,500 - $200). Then, take the $8,000 additional cost for a GSHP system and divide it by the $2,300. The result is a three-and-a-half-year payback on our original investment. Not bad at all! Lloyd also makes note that if you factor in a federal tax credit, the initial cost may even be lower than a standard HVAC system. For example, at the time the book was written, GSHP installations received a 30% federal tax credit. If you perform the same calculations, you have a scenario where, with a federal tax credit, the GSHP installation costs less than the standard HVAC installation, and that's before acknowledging the yearly savings you acquire for the duration of the GSHP system. Using the same numbers and the 30% federal tax credit, you have $28,000 GSHP cost x .30 = $8,400 tax credit. Then, $28,000 - $8,400 = $19,000 cost with a 30% reduction. As you can see the cost of the GSHP installation ($19,000) would be lower than the actual cost of the HVAC installation ($20,000). Strictly looking at the payback on additional costs, you can see the relatively quick return on your investment, and possibly a situation where your initial investment costs less than a common HVAC installation. Unfortunately, federal tax credits for GSHP installations were terminated at the end of 2016. Leading proponents for geothermal heating and cooling, such as the Geothermal Exchange Organization (GEO), are determined to reinstate a federal tax credit. In their January Newsletter, GEO stated, "Our fight for the federal tax credits isn't over. The

GEO Board of Directors is intent on maintaining and creating U.S. jobs by reinstating the tax credits for GSHPs, and extending them on a timeline matching solar through 2021" (*GEO Industry News*, 2017). GEO builds on their advocacy for the reinstatement of a GSHP installation federal tax credit through a strong relationship with the International Ground Source Heat Pump Association (IGSHPA), who provides training and technical research for GSHP systems. Together, IGSHPA works to strengthen the industry from the bottom up, while GEO serves to change legislation and regulations, benefiting the industry from the top down.

Now let's look at Lloyd's (2015) second model where he evaluates the payback on a retrofit. The example goes something like this: You are replacing your home's ancient oil burner with a GSHP. For this installation, you need both air delivery (for air conditioning) and hot water delivery for your existing radiant floor heat. You paid $4,000 the previous year for heating fuel. A new high-performance boiler and separate AC would cost about $16,000 when installed. Comparatively, final GSHP installation costs total $34,000 because of the vertical boreholes you must excavate in your backyard for a closed-loop system. In the model, Lloyd also includes a received tax credit for $10,200 the following year. After installation, the cost to operate the GSHP system is $300 per year. So, what is the payback? The following calculations must be made: First, $34,000 - $10,200 tax credit = $23,800 GSHP cost. Second, $23,800 - $16,000 = $7,800 added cost of GSHP system. Then, $4,000 - $300 = $3,700 yearly savings in fuel costs. Finally, you calculate $7,800 divided by a $3,700 yearly operating costs savings, giving you a 2.1-year payback. It's interesting to note that even without a federal tax credit, the model's payback would be 4.9 years. Regardless of whether or not you receive a federal tax credit for your GSHP installation, in this particular model, you are still saving over $74,000 on fuel costs alone over a 20-year span.

Lloyd's (2015) third, and final, model looks at the payback on the total cost of a GSHP system. In this model, you have a GSHP system, including installation, that costs $30,000, and your net fuel savings per year are $1,900. You will receive a federal tax credit of $9,000 (30% of $30,000). In comparison, a standard oil furnace with full AC option would cost about $22,000. Now, let's consider what the payback would be on the entire investment and not just the additional cost: $30,000 - $9,000 = $21,000 system cost, and $21,000 divided by $1,900 gives you an 11-year payback on the entire investment. This particular model employs a very conservative approach where the entire cost of the GSHP system is paid back. Obviously, this isn't the case for most, if not all, investments. If you applied the same payback concept to a standard $22,000 HVAC system, it's important to realize that you never truly have a payback because there are no savings. You continually pay for fuel costs on a frequent basis. Lloyd (2015) emphasizes that, with this particular model, after 20 years the savings will have paid for the cost of the GSHP plus $17,000 more. For example, $1,900 x 20 = $38,000 in fuel savings (over the course of 20 years), and $38,000 - $21,000 system cost = $17,000 in the bank!

After observing the three models, dealing with payback on the additional cost, payback on a retrofit, and payback on the total GSHP cost, a better understanding of current cost versus future benefits can be observed. When you start thinking long-term, you will see that GSHP systems have the potential to save a lot of money. The added cost will always be paid for over a relatively short time period, especially if you have federal, or state, subsidies on initial installations. That being said, we know federal tax subsidies for GSHP installations were terminated with the ending of 2016. One in-state program, Virginia Energy Efficiency Rebate Program, provides a rebate of 20% of the total cost of equipment and labor for energy efficiency measures and equipment not to exceed $2,000 residential or $4,000 commercial. Despite the current status of both federal and state subsidies, payback on initial GSHP installations remains insignificant, depending on the parameters of your system. Lloyd's (2015) models are helpful in understanding how payback will work for several prevalent situations, but they are still just models. To further assess and validate the economic feasibility of a GSHP system paying for itself over a period of time, the next section of this paper will employ several college and university examples.

In 2006, Allegheny College in Pennsylvania installed a vertical closed-loop system, providing heating and cooling to three buildings. The installation totaled 45,000 square-feet, including the LEED Certified North Village Phase I with 30 boreholes and 500 feet of depth. Recently, a similar system was added to North Village Phase II, a 75,000 square-foot residence hall. The loop field supporting this building consists of 48 wells at a depth of 500 feet. Finally, a third vertical closed-loop system was installed in collaboration with a renovated 14,000 square-foot 454 House, housing the Admissions and Public Affairs offices. This system has 17 wells also at a depth of 500 feet. Remarkably, North Village Phase I's three buildings use 80% less fossil fuel energy during the heating season compared to the campus average. More importantly, "When natural gas savings are added to the electricity savings from geothermal cooling – compared to conventional HVAC – the extra costs for the geothermal system will be paid back in 4-6 years, according to estimates by Ken Hanna, Director of Physical Plant" (Cross et al., 2011, 34). Similar to Lloyd's (2015) models, a 4-6-year payback for Allegheny College parallels a very successful installation and GSHP system operation on the campus. It's also important to note that our three proposed on-campus buildings for GSHP installation have the following square-footage: 1) Tyler Haynes Commons: 66,000 SF; 2) Modlin: 70,740 SF; and Keller: 20,152 SF. With a total square-footage of 156,892, compared to Allegheny College's total of 134,000 SF, a future GSHP installation of comparable size could result in the same payback and successful operations.

Similarly, starting 2006 and ending in 2008, Lipscomb University in Tennessee began the installation process of three vertical closed-loop systems, destined to serve eight buildings on campus. The first loop field, installed in 2006, has 144 boreholes drilled 300 feet deep. The loop heats and cools the 77,000 square-foot Ezell Center, directly correlating with the with the parameters, and GSHP installation potential, of the University of Richmond's 66,000 SF Tyler Haynes Commons, or 70,740 SF Modlin Center. The new Village Apartments, consisting of four structures and totaling 48,000 square-feet, are supported by a 46-borehole system, all drilled 500 feet deep. The third loop, comprised of 70 boreholes, drilled at a depth of 500 feet, supports an "interconnected trio of buildings" (Cross et al., 2011, 35): The Burton Health Science Center

(44,000 square-feet), the Thomas James McMeen Music Center (10,000 square-feet), and the Willard Collins Alumni Auditorium (15,000 square-feet). “The cost of the Ezell Center geothermal system was $1.2 million, with $500,000 covered by a U.S. Department of Energy grant. The Burton and Village systems cost $750,000 and $430,000 respectively. At the Ezell Center energy use is around 65% less than if heated and cooled with conventional HVAC, cutting utility bills by an estimated $70,000 per year” (Cross et al., 2011, 35). Cross et al. (2011) also states, maintenance calls to these specific buildings are a fraction of those for other campus buildings. Less maintenance correlates with less money spent on repairs. Therefore, GSHP systems can save on ways outside of direct energy savings and CO_2 emission cutbacks. The most remarkable part of Lipscomb’s GSHP system revolves around the university’s payback. Originally, they anticipated a payback of several years, but because of spiking energy prices, the payback was only 16 months! On their website, the U.S. Department of Energy (2017) states, “The Geothermal Technologies Office (GTO) partners with industry, academia, and research facilities to further the development of geothermal energy technologies. Competitive solicitations issued as Funding Opportunity Announcements (FOAs) are the principal mechanism used to contract for cost-shared research, development, and demonstration projects.” Furthermore, the University of Richmond can learn from Lipscomb University, advocating for federal economic support through the U.S. Department of Energy.

Warren Wilson College in North Carolina represents another school pioneering in ground source heat pump application to heat and cool campus buildings. In 2004 and 2007, the college installed three vertical closed-loop systems, operating to provide heating and cooling for three campus buildings. The colleges 6,800 square-foot LEED-Gold certified Orr Cottage receives heating and cooling from a four borehole GSHP system, drilling 300-350 feet deep. Second, the renovated 27,750 square-foot Jenson building utilized a 14-borehole GSHP system, drilled at a depth of 300 feet. Finally, the renovated 5,155 square-foot Lauren administrative building utilizes a four borehole GSHP system, with a drill depth of 300 feet. Combining their geothermal system and “very tight building envelope and efficient lighting,” the Orr Cottage now uses 56% less energy than the industry standard (based on ENERGY STAR *Portfolio Manager*). Furthermore, the building will avoid 1,650 tons of greenhouse gas emissions during the 50-year lifespan of the GSHP system. “Based on energy savings alone, the building’s total ‘green’ investments, costing an additional nine dollars per square foot, are expected to be paid back within 12 years by deferring roughly $5,000 annually in energy costs” (Cross et al., 2011, 37).

Strategic Plan & Educational Exposure

Vice President Andrew McBride and University Engineer George Souleret from the University of Richmond’s Facilities Office both stated that a geothermal heat pump system is not currently viable on campus. In 2014, engineers from the University of Tennessee’s Agricultural campus also noted that the instillation of a GSHP on their college campus is not economically viable (Birchfield, 2014). In both situations, the professionals decided sticking to the current HVAC systems is more affordable than installing GSHPs. However, as institutions of higher learning, Universities should use their positions in society to drive positive change. So although the short-term economics for Geothermal development may not be attractive, our unique position as an institution of higher learning should also factor into decision making.

One of the most excellent aspects of the University of Richmond is its Strategic Plan. The Strategic Plan is an agreed upon set of goals developed in order to ensure that, as an institution of higher learning, we focus our resources toward a higher standard of efficiency. American Universities across the nation are in an important position when it comes to the future of sustainability on college campuses. Due to large amounts of capital and intellectual leadership, American Universities have the ability to influence the creation of sustainable development on their campuses. The combined operating budgets for Universities in the United States is a sum of about $200 billion, larger than all but 20 national economies (Finlay, 2012). Using their significant resources and influence, American Universities are able to promote sustainable development. The University of Richmond's Strategic Plan was created in order to efficiently utilize our resources and improve life on campus. As the University of Richmond, our school seeks to improve the standards of all different areas of life, in order to improve the Richmond experience and better our surroundings, both in the present and future. "The future health and vibrancy of the University — like all institutions of higher education — rest on our shared commitment to steward our vital resources: the environment on which we all depend, funds for our needs and aspirations, and the faculty, staff, student, and alumni relationships that form the core of our educational model. Responsible stewardship will enable us to better support our academic aspirations and will enrich our intellectual community. In response to emerging environmental and financial challenges, we will imagine and implement new approaches to our work that support the sustainability of our mission and serve as a model for other institutions." ("Stewardship in a Changing World", 2017).

The vision of the Strategic Plan reads, "The University will be a leader in higher education, preparing students to contribute to, and succeed in, a complex world; producing knowledge to address the world's problems; and modeling the way that colleges and universities can effectively meet the challenges of our time." ("Mission, Values, & Vision", 2017). Not only does our education at the University of Richmond impact the way we students view environmental impacts, it also allows us to realize our abilities to prevent the effects of environmental impact. By installing a geothermal heat pump at the University, students would be exposed to alternative energy sources. The educational exposure facilitated by the instillation of a geothermal system could potentially drive economic, environmental, and social change on campus. By installing a geothermal heat pump the University could save thousands of dollars in the long-run, at the same time as reducing the amount of carbon emissions the school releases annually. In addition, exposure to alternative forms of energy and their effect on campus could stimulate change in the way students view our environmental impact.

The University's Strategic Plan (2017) also attempts to create the driving force needed on campus to facilitate the accountability of our ideas and actions. Under the values section, ethical engagement is discussed, "The University of Richmond values integrity, responsibility for the ethical consequences of our ideas and actions, and meaningful engagement with our local and global communities. The Strategic Plan has potential to create a more responsible student body. By collaborating on ideas for the University, our community has the ability to improve the campus for the future. The aim of our project is to educate the University community on the benefits of installing a geothermal heat pump on campus. Even if the economic costs of the system outweigh its benefits, members of the University community may believe the educational benefits of the system do outweigh its economic costs.

Geothermal energy use at the University of Richmond can bring more than just economic and environmental benefits. The installation of geothermal heat pumps on college campuses creates climate action opportunities including: reducing current operational costs and creating positive returns on clean energy alternatives, protecting against the uncertainty of current energy sources (higher costs, increased regulation, etc.), developing new research and service opportunities, preparing students for sustainability and climate related decision making, and developing a campus-wide ethics for environmental sustainability (Cross et al., 2011). All of these opportunities are important for students living on college campuses across the nation.

Taking the initiative to increase sustainable development on campus creates a sense of a sustainable well-being on campus. If visible investments in sustainability are not made, students will tend not to pay attention. However, sustainable development would spark a different type of reaction by grabbing the attention and curiosity of students. It is vitally important to expose college students to sustainable energy use because it will have future impacts on their lives. Using geothermal applications campus could create educational exposure for students living at the University of Richmond. This becomes especially important since many University students will become leaders of the US economy later in life, and their exposure to sources like geothermal energy will have implications on the decisions they make regarding energy use (Cross et al., 2011). The educational exposure could have economic, environmental, and social impacts on Richmond students. By being exposed to alternative energy sources, students are better equipped to make climate-related decisions later in life, thereby affecting generations to come. In addition, if the installation is viable in the lake, it adds an interesting aspect that makes our campus more attractive to prospective students and their parents. By making our campus more eco-friendly it becomes a talking point for admission officers, which can in turn attract more environmentally responsible students to our campus. The culmination of this situation could be a student body more actively engaged in the environmental impacts and implications of our campus.

Conclusion

The use of geothermal energy for heating and cooling on college campuses is valuable due to the environmental, economic, and social impacts that it has on these locations. Geothermal heat pumps offer the advantage of reducing the carbon footprint of college campuses while saving costs on energy usage. The environmental implications of these installations reduce universities' dependence on fossil fuels as their main source of energy. Institutions of higher learning have an important responsibility to maintain their environmental integrity by doing all that is possible to reduce their impact. The University of Richmond should consider the instillation of a GSHP on campus due to the fact that it is a socially viable development on campus. By exposing future generations of Richmond students to geothermal energy, we hope to increase the permeability of alternative sources of energy in mainstream circles of energy usage on university campuses across the nation.

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