Geothermal Energy at Boston College

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Introduction

Boston College's Central Heating Plant (Figure 1) provides 3 million square feet of steam to 22 buildings on campus using oil and natural gas. According to the Environmental Protection Agency, geothermal ground-source heat pump systems, or GHPs, are one of the most energy efficient, environmentally clean, and cost-effective space conditioning systems available (Lloyd), but may be costly to implement and would be subject to BC's five-year payback period mandate. The purpose of this study is to conduct the initial research to determine the practicality of geothermal energy as a renewable heating and cooling source on Boston College's campus.

Research Questions:

- **Is geothermal a viable heating and cooling source in Massachusetts?**
- **Could a geothermal well be compatible with the topography at BC?**
- **What are the environmental, social, and financial incentives and disincentives involved with implementing?**

Methods

Literature Review:

- Mechanics, variations, benefits, and drawbacks of geothermal
- BC's 2008 geothermal feasibility study
- Case studies of Massachusetts universities with geothermal

Interviews:

- BC's Energy and Sustainability Departments regarding the topography and current state of energy usage at Boston College
- Massachusetts Clean Energy Center about financial incentives available to colleges
- Drilling, installation, project management, and engineering professionals regarding their experience and their recommendations specific to BC's campus
- Project manager for Boston University's geothermal system at its new Data Sciences Center (Figure 2)

Figure 1: BC's Central Heating Plant powered by natural gas and oil (BC)

Figure 2: Drill rig at BU's new Data Sciences Center (BU)

Figure 3: Geothermal wells at Harvard est. 2007 (Harvard)

Results

How does it work and why do we need it?

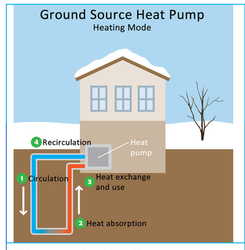

Figure 4: GHPs use the earth as a heat source in the winter and heat sink in the summer (EPA)

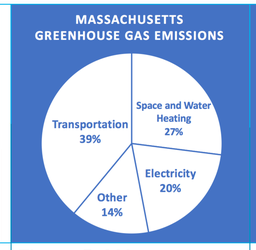

Figure 5: MA greenhouse gas emissions breakdown (MassCEC)

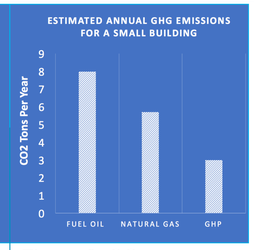

Figure 6: CO_2 emissions by energy source. GHPs use 65 to 80% less electricity than traditional electric heating (MassCEC)

Can it be implemented at BC?

- The ground beneath the frost layer remains an almost constant 55º, cooler than Boston's summer air and warmer than its winter air
- Boston's bedrock makes drilling more efficient because it provides a stable borehole for wells
- **Harvard University** has at least 7 buildings that utilize ground source heat as of 2007, and has reported a 20-50% reduction in energy costs over its conventional systems
- **Boston University** established its first 6-well geothermal building on Comm. Ave in 2009 and is currently in the process of drilling for its 31-well Data Sciences Center to be completed in January

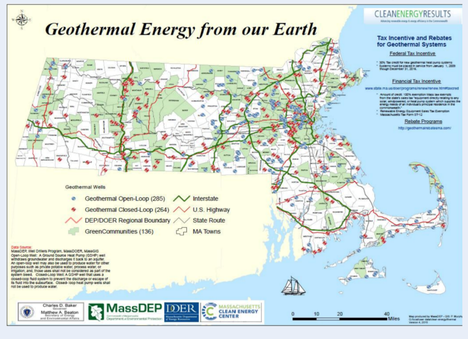

Figure 7 shows that as of 2015, there were 549 geothermal wells in MA indicated in red and blue, notably concentrated around the Boston area (Mass CEC)

What would it look like and where could it go?

- Lower campus is on filled reservoir, and the water table is less than 5 feet below the surface in many places. Water is more conductive than soil, so this would prove to be advantageous for closed-loop, vertical geothermal wells. Because they require little maintenance, have no moving parts, and are sealed, they could be paved under the mod parking lot
- Wells are relatively out of sight (Figure 3) at about 6 inches in diameter.
- One reason that BU chose to use geothermal was because the boilers needed are smaller than conventional ones, reducing the necessary building size to house the equipment and freeing up roof space to be used as a green roof

Pros and Cons of Geothermal

- ✓ Minimizes maintenance and operations costs
- ✓ Reduces heating costs by 20-50% vs. oil (MassCEC)
- ✓ Hedges against fluctuating natural gas and oil prices
- ✓ Extends system lifespan to about twice that of a conventional system (Lloyd)
- ✓ Eligible for MassCEC financial incentive
- ✓ Eligible for Department of Energy's alternative energy credits (MassCEC)
- ✓ Aligns with BC's commitment to investigate "economically feasible sources of on-site renewable energy such as geothermal" (BC's Institutional Master Plan)
- ✓ Aesthetic benefits of no cooling tower and less noise pollution (Harvard)
- ✓ Provides new research and service-learning opportunities
- ✓ Encourages interdisciplinary collaboration among faculty
- ✓ Fosters campus-wide ethic of environmental stewardship
- ✓ Reputational gain as a leader in sustainability
- ✓ Appeals to current and prospective students, parents, and donors
- ☹ Costs 30-40% more to install than conventional (BU)
  - ☹ Ex: A 1,500 foot well cost Harvard around $80,000, or $50 per foot (Harvard)
- ☹ Payback ranges around 5-15 years depending on type of well and environmental factors (Report on Geothermal Study BC)
- ☹ Operates on electricity
- ☹ Requires complex design and installation to ensure high quality
- ☹ Requires compliance with state's geothermal well regulations
- ☹ Disruption to school functions
  - ☹ Ex: BU's geothermal project will begin drilling 31 1500' deep wells in the summer and is expected to end in January

Discussion and Recommendations

My hope is that this research can provide the introductory data necessary for administrators to seriously reconsider undertaking a geothermal project. After conducting this study, my opinion is that geothermal is in many ways attractive and practical particularly for our school's topography.

BU's project manager says geothermal has potential to one day be the dominant heating and cooling method, especially as the world's finite fossil fuel reserves make the resource more difficult to obtain. He admits that there are great benefits from ground-source systems, but the driving force for most universities is to be a leader in the renewable energy field.

BC states in its Institutional Master Plan that it is devoted to the investigation of renewable sources of energy, and I believe that as a Jesuit institution it is our responsibility to continue this investigation.

I recommend conducting a net present value financial analysis over the projected life of the system rather than a simple payback. Open dialogues should be held with Harvard, BU, MIT, and another colleges about lessons learned from their geothermal programs. Lastly, a revolving green fund should be established for projects with a longer payback that align with Boston College's mission.

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