Clean Cole & Technology

Introduction

At Williams College we are trying to reduce our energy use and especially our greenhouse gas emissions 10% below our 1990-1991 levels. In this spirit we need to look for projects around campus that can significantly reduce greenhouse gas emissions while also saving the college energy. One of these projects concerns Cole Field House. Cole Field House serves as a medical center and a locker facility for almost 200 of Williams’s athletes every year, 160 or so in the fall and 40 in the spring. By

Why Cole?

Cole Field House is a unique building not only because of its past but also because it is not currently connected to the steam plant, which produces the heat and hot water for most of the school’s buildings. This means that Cole Field House must have its own means of producing heat and hot water. Cole Field House uses natural gas boilers to accomplish this heating. Because of this situation, we can monitor the energy use of Cole Field House easily and can come to conclusions regarding the feasibility and payback of projects easier than with other buildings that are connected to the steam plant. Furthermore, we can easily calculate the emissions directly related to Cole while other buildings require an analysis of square footage with regard to steam plant output and make assumptions of equal steam plant use per square foot.
Setting

Cole Field House is a very old building built without green principles in mind. Cole was built in 1926 but had undergone significant renovations, especially in 1973 and 1997, with a cost of $1,727,923 in 1997. Smaller changes have been continuing through the years, including sewer upgrades, shower installations, extra storage, and ventilation upgrades in the past 15 years.\(^1\) The building itself is 16,099 square feet. Cole Field House generally falls on an east-west axis, but the southern roof faces a South-southwest direction. Cole resides next to a steep hill that leads down to Cole Field, where soccer,
football, baseball, and softball teams all practice and/or play, and Poker Field, a large field used for Williams Ultimate Frisbee Organization and Intramural Soccer games.

**Current Natural Gas Profile**

**Table 1**

<table>
<thead>
<tr>
<th>Natural Gas Use (CCF (100 cubic feet²))</th>
<th>13,985</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost ($)</td>
<td>18,294.72</td>
</tr>
<tr>
<td>$/CCF</td>
<td>1.31</td>
</tr>
</tbody>
</table>

Table 1 shows the natural gas use and expenditures in 2007 at Cole Field House. These numbers stand out even more when we consider that Cole only uses the natural gas boilers for 10 months during the year and 6 months account for 12,781 CCFs, or 91% of the natural gas use with an average of 2,130 CCFs per month.

**Figure 2**

**Natural Gas Use per Square Foot at Cole Field House (2007)**

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Figure 2 shows the amount of natural gas used per square foot at Cole Field House. From this data we can estimate that the average natural gas use per square foot amounts to a monthly average of .073 CCFs per square foot in 2007. These numbers generally reflect the annual trend in natural gas use and can be accepted as an average yearly value. Therefore, the yearly average would be .88 CCFs per square foot.\(^4\)

**Discussion**

Based on current technology and the current energy profile at Cole Field House, it would make sense to implement new systems so that natural gas use would be curtailed. Projects for reducing natural gas consumption include extending the steam plant line, putting in a solar hot water array, and putting in a geoxchange system, all of which should drastically reduce natural gas use.

*Project 1: Steam Plant Extension*

Based on the economics principle of economies of scale, in which a larger producer can produce more at a cheaper cost per unit of output, the Steam Plant should be able to take on Cole Field House’s heating load for less cost and with more efficient use of natural gas. The Steam Plant currently heats 1,777,883 ft\(^2\), using 373,483 MMBTUs of natural gas and residual oil over the course of 2007.\(^5\) 1 MMBTU is approximately equal to 10 CCFs, so the steam plant uses roughly 3,734,830 CCFs over the course of a year, made up of 1,306,830 CCFs of natural gas and 2,428,000 CCFs of oil. By this metric, average natural gas use would be .73 CCFs per square foot. However, this fails to account for the natural gas used in the cogeneration plant, so it is probable that this value could in reality be even lower. By comparing this value of .73 CCFs per square foot of natural gas

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\(^4\) Monthly Metering, Sustainability at Williams

to the .88 CCFs per square foot of natural gas currently obtained at Cole Field House, it would make sense to extend the steam line, thereby saving .15 CCFs per square foot per year, which amounts to 2414.14 CCFs of natural gas saved. Therefore, our calculated payback based on natural gas would be $3,163.45 per year. Furthermore, saving 2,414.14 CCFs yearly would lessen Williams’s carbon emissions by 25,911 lbs.

While saving natural gas and carbon emissions would be advisable, we must also consider the initial cost of this project. The most recent Steam Line replacement project, on the North line to Poker Flats, cost the college $189,155.7 If we were to assume that

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this same cost would represent a lower boundary for the cost of extending the Northern Distribution Line to Cole Field House, then the payback on this project would be just under 60 years. Furthermore, extending the steam line to Cole Field House would also necessitate an increase in residual oil consumption. 1.366 CCFs per square foot of oil would be needed, so a total of 21,996 additional CCFs of oil would be used annually, amounting to about 15,000 gallons of additional oil purchases. This oil would cost the college around $2 per gallon, so the final expenditures would end up being much higher than the current system.

Project 2: Solar Thermal Panels for Water Heating

A very large quantity of natural gas goes towards heating water for showers, medical purposes, sewage, and laundry. Last year the college used 516 CCFs of water in Cole Field House. Assuming that 4/5 of this water needed to be heated, 412.8 CCFs of water was heated by the natural gas boilers. Since one CCF is equal to 748 gallons, Cole Field House used 308,774 gallons of heated water. Assuming 200 athletes use the facility each year, each athlete uses upwards of 1,500 gallons on average. Since each athlete uses the facility for around 84 days, each athlete uses 18.37 gallons per day. In the fall, this amounts to roughly 150 athletes using 2,750 gallons per day. 8.34 BTUs are needed to heat one gallon of water one degree Fahrenheit. If we assume that the water is raised from an average room temperature of 65° F to 100° F, we would be using 802,725 BTUs per day, which is equal to 6.7 CCFs of natural gas under ideal conditions. However, the current boilers are only around 80% efficient. So, actual daily CCF use for hot water heat would amount to roughly 8.36 CCFs in the fall.

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Most of this energy use can be prevented by putting in a solar hot water array. A solar hot water array made up of evacuated cylinders. A panel with 30 evacuated cylinders weighs roughly 175 pounds and is in a 5.5ft x 7.6ft rectangular shape.\(^9\) While the price may be up to $7,500 per panel, with tax incentives the price will normally decrease to perhaps $3,000 per panel. The Fort Hoosac system has two panels for 13 people. Assuming that the ratio of people to solar panels remains constant, Williams would need to acquire 23 solar panels for Cole Field House. This would cost roughly $69,000 after rebates and tax credits are accounted for.\(^11\) In addition to the panels, the college would need to put a storage tank in Cole Field House to hold heated water for peak use times, like at 5:00 when almost 130 athletes all get out of practice at the same time. A storage tank of around 2,000 gallons would be necessary for this. A storage tank of that size would cost somewhere in the neighborhood of $1,000, bringing the total

project cost without installation to about $70,000. Solar hot water panels have been shown to save up to 75% of the costs previously associated with heating water.\textsuperscript{12} If we can assume that this will hold true in Williamstown, then Cole Field House would only use 2.09 CCFs of natural gas in the fall daily, and the daily savings would be $8.21. Annual CCFs for water heating would decrease from 3850 CCFs to 962.5 CCFs, with an associated savings of 2887.5 CCFs and therefore $3,782 of yearly saving. At this rate, the payback would take roughly 18 and a half years. Since the panels are estimated to last between 30 and 40 years, the college would be able to take full advantage of the payback.

While we now have a calculated payback for solar panels, we must still place them somewhere. Unfortunately, the roof of Cole Field House does not face south. Also, the roof has a number of windows projecting from it, disrupting the surface and restricting the space available for solar panels. Finally the roof might not be able to support the weight of the solar hot water panels on its roof. Therefore, the solar array would have to go somewhere on the ground, perhaps on Poker Flats. However, this cannot be definitively determined until a structural engineer is able to look at the roof of Cole Field House to determine its stability.

\textit{Project 3: Geoexchange}

If we assume that all of the natural gas goes into either water heating or space heating, then there are 10,135 CCFs used in Cole Field House to heat air. In order to reduce the amount of natural gas used for space heating, the college needs to look into geoexchange as a source of heat. In order to construct a geoexchange system, the college would first need to invest in a geoexchange pump. Geoexchange pumps cost about

\begin{footnotesize}
www.dps.state.ny.us/07M0548/workgroups/WGV_California_Solar-Water-Heating_Study_Summary.pdf
\end{footnotesize}
$2,500 per ton of capacity. Because the capacity of Cole Field House is roughly 8 tons (based on an average electricity use of about 25 kw)\textsuperscript{13}, the college would need to invest in a geoxchange pump costing around $20,000. The college would then need to invest in eight loops, one per ton of capacity, which consist of 500 feet of pipes each and costing $1.25 per foot for a total of around $5000 depending on the type of pipe purchased.\textsuperscript{14} Finally, the college would have to drill holes between 150-450 feet deep, creating a vertical system. The college could not use a horizontal system because the rocky soil of New England provides too much of an obstacle for the 8 500 foot trenches that would be needed. A geological study must be done before drilling, but the price for drilling would

\textbf{Figure 5}

![Vertical Geothermal System\textsuperscript{15}](image)

\textsuperscript{13} Monthly Metering, Sustainability at Williams.
\textsuperscript{15} Geothermal Heat Pumps, Sustainability at Williams, http://www.williams.edu/resources/sustainability/green_buildings/geothermal.php
likely range from $1,500 to $1,800 per ton for a total of around $12,000. Furthermore, duct work would need to be done, but if we assume that the newly renovated ventilation system can readily accompany a geoexchange addition, then the total cost of the project would be $37,000.

Current geoexchange systems have been shown to decrease the use of natural gas systems by up to 55%. If this metric were to hold, then Cole Field House’s natural gas use associated with space heating would decrease from 10,135 CCFs of natural gas to 4,560 CCFs of natural gas over the course of a year. This would save the college approximately $5,974, for a total payback period of just over 6 years. Even if we assume that there is a lot of ductwork that needs to be done, perhaps even equaling the cost of the rest of the project, our payback would still be less than 15 years. The estimated lifespan of a geoexchange system is 30-40 years, so the college would be able to take advantage of the payback.

Recommendations

Cole Field House is an old building designed without green principles in mind. Therefore, no matter what courses of action are taken, the building will still not be green. However, in lieu of destroying Cole Field House and constructing a new building, which would easily cost millions of dollars, the college can implement some new technological systems to significantly increase the overall sustainability of the building.

The college should not extend the steam plant heating system. While the natural gas use would go down, more residual oil would be used and a new tunnel would have to

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be dug, costing hundreds of thousands of dollars and having a negative long term cash flow while increasing carbon emissions. However, by looking into solar hot water systems and a geoechange system, the college could potentially decrease its natural gas use by up to 60.5% with associated savings of $9,700 annually for a net payback of just over 10 years. In doing so, the college would also be decreasing its carbon emissions by almost 101,000 pounds per year, cutting the overall emissions associated with natural gas at Cole Field House by over one half. However, one must account for the current weakness of the economy. Therefore, if the college were not to support this project now in favor of conservation projects it would be understandable. However, as soon as the college is once again willing to spend large amounts of capital the school should definitely look into geoechange and solar hot water arrays, certainly for Cole Field House, but also for as many buildings as possible as a means of reducing natural gas use and consequently reducing carbon emissions.

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