Colgate University’s Heating System: Examing the Sustainability of Woody Biomass

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1. Executive Summary

The seminar Environmental Studies 390: Community Based Study of Environmental Issues, taught by Professor Frey and John Pumilio, explored the sustainability of several programs at Colgate University. Our group examined Colgate’s biomass heating plant, focusing primarily on the source of our fuel. The research goal of this project was to analyze whether Colgate’s current use of wood chips as a primary fuel source is a sustainable method to produce heat for the university based on economic, environmental, and social measures.

Primary data were collected through research, interviews, and a student survey. Additionally, Colgate's experimental willow plot informed the focus and direction our study and recommendations. We determined several options to benefit the economic, environmental and social aspects of Colgate's use of biomass. The recommendations proposed in this study are for the administration, student body, Buildings & Grounds staff, as well as local farmers and residents. The aim of these recommendations is to help Colgate uphold it’s current and future commitments to sustainability initiatives.

Our research focused on assessments of biomass sourcing as well as sustainability studies analyzing the profitability and associated environmental impacts of using woody biomass as a fuel source. In addition, we investigated institutions similar to Colgate that had recently installed biomass facilities, looking primarily at their biomass sourcing policies. Interviews with biomass facility staff, Colgate faculty and staff, and local biomass experts allowed us to think broadly about the environmental, economic, and social impacts of Colgate’s facility.

Finally, we surveyed the student body to assess the current awareness of the biomass facility and willow plot and to examine whether Colgate students support the integration of sustainability into the academic curriculum.

The results of our study highlight the importance of biomass sourcing when considering the sustainability of this alternative heating fuel. We found that in general, biomass is more sustainable than fossil fuels based on economic, environmental, and social measures. The use of wood chips saves the university significant amounts of money in displaced fuel oil costs. However, we found that in order to fully analyze the sustainability of the system, the management practices in the sourcing of the biomass must be determined. Throughout our interviews and research, we were unable to determine the exact source of our biomass fuel.

The results of our survey of the student body indicate that the majority of Colgate students (75%) support the integration of sustainability into their academic curriculum. A smaller fraction is actually aware of the biomass heating facility and the willow plot.

We have come to a conclusion that incorporates several options to improve the economic, environmental and social implications of Colgate's use of woody biomass for heat generation. After considering our analysis of the research and data collected, we propose the following:

We recommend that Colgate focus on identifying and documenting its source of fuel, encourage campus-wide education initiatives regarding the biomass facility and willow plot, and implement region-wide programs to show the benefits of growing willow in enhancing the local economy, as demonstrated by an expanded and revitalized willow plot.
2. Introduction

2.1 Colgate’s Role in Sustainability

As defined by the students of Environmental Studies 390, sustainability is “a capacity to utilize resources and services ensuring economic, environmental, and social equity both locally and globally and with equal considerations of present and future generations.” This definition is particularly salient when considering the variety of initiatives at Colgate that have materialized in the past decade that focus on issues of sustainability. This definition further reflects the experiences and thoughts of a class comprised of environmental majos within a small liberal arts community.

Colgate officially became involved in sustainability efforts in early 2009, when the current president, Rebecca S. Chopp, signed the American College and University Presidents’ Climate Commitment (ACUPCC). This commitment required Colgate to take the necessary steps to reduce its carbon emissions and strive for carbon neutrality, as well as make sustainability a component of the academic curriculum. Further stipulations required that Colgate compile a “comprehensive inventory of all greenhouse gas emissions and update the inventory every other year thereafter.”\(^1\) It was discovered that the two greatest contributors to our emissions were air travel and fuel oil. Colgate received an equal or higher rating to that of its peer institutions, which may be attributed to the benefits of Colgate’s location which is conducive to the use of low carbon-emitting energy sources\(^1\).

2.2 Colgate’s Biomass Facility

We set out to examine the question of whether Colgate’s current use of wood chips as a primary source of fuel is a sustainable method to produce heat for the university based on environmental, economic, and social measures. Colgate utilizes three types of fuel: A) hydroelectric, B) fuel oil combustion and C) biomass combustion. In our study of sustainability on campus, we focused on the university’s heat processes, our source(s) of biomass, and how these sources are acquired. Fuel oil and biomass at Colgate hold an inverse relationship with one another. As greater amounts of biomass are burned, lesser amounts of fuel oil are necessary. Colgate’s biomass facility, installed in the early 1980s, burns locally sourced (within a 75-mile radius) wood chips\(^2\).

We conducted our study using interviews with professors and staff members of Colgate and other institutions and universities, research and review of literature, and direct, local observation of the biomass facility. We also conducted a survey of the student body to gauge awareness of Colgate’s use of biomass for heat and Colgate’s willow plot. Our group was further interested in the general opinion of integrating sustainability into Colgate’s


curriculum. Through these means, we were able to reach a conclusion on how Colgate can improve its economic, environmental and social sustainability. Colgate’s biomass facility is already more sustainable than any heating facility that burns fossil fuels. Wood chips are cheaper, more efficient and when managed properly, carbon neutral in terms of emissions. This study aimed to determine how to increase the sustainability of Colgate’s biomass facility, taking into account its 30 year old technology and the economic, environmental, and social issues in contemporary Central New York.

2.3 Connecting the Two: Sustainability and Colgate’s Biomass Facility

In order to fully examine the sustainability of Colgate’s biomass system, certain assumptions were made. The assumptions are as follows:

1) Any inefficiency of the boiler and the distribution infrastructure (i.e. loss of heat through pipes or poorly insulated buildings) generally does not play a significant role in the examination of the sustainability of the system.

2) It has proven to be difficult to find out information regarding the exact source of our wood chips. Because of the relatively little information about harvesting practices and type of land that our wood is sourced from, we cannot assume that our wood is grown and harvested in a sustainable manner.

3) The investment to move from our current woody biomass system to a completely new heating system is not an economically feasible option for Colgate University at this time.

In this report, we present an analysis of the data collected from background research, various interviews, and a survey of the Colgate student body. This report shows that our current use of wood chips as fuel is generally more sustainable than fossil fuels. However, it indicates that the current system does not place a strong emphasis on the source of our wood chips, which poses a major threat to the sustainability of the system. Additionally, the data shows that our current willow plot is faltering and is not a viable way to provide wood chips to heat our campus. Following our data analysis, we present options to improve sustainability of our current system and we make a single recommendation for the future of Colgate’s heating system.
3. Background

3.1 Biomass

3.1(a) Analysis of Sustainability

The term biomass is used to describe any biological material that can be used for energy\(^3\). It most commonly refers to low-value woody material, dead trees, downed logs, brush, stumps, tops, and limbs\(^4\). Biomass energy is the oldest form of renewable energy. However, globally, biomass energy contributes only an estimated 14% of the world’s total primary energy demand\(^5\). With increasing environmental concerns, many people have rediscovered the advantages of using biomass and it has recently become a popular form of energy. In the United States, all forms of biomass constitute roughly half of all energy consumed annually from renewable sources, therefore making biomass the most utilized source of renewable energy\(^5\).

In upstate New York, the most abundant source of biomass is wood. The increase in price of fuel oil coupled with growing environmental concerns about carbon emissions have resulted in general enthusiasm for woody biomass energy. It is generally less expensive per unit weight than fossil fuels. While the costs of fossil fuels are expected to keep rising due to availability and international forces, the cost of woody biomass is completely dependent on local conditions\(^6\). Using biomass energy thus enhances energy security by diversifying energy sources and utilizing the local economy. Biomass energy also strengthens the local economy by providing increased revenues for agriculture and forestry sectors in the area. An additional advantage of biomass energy is the ability to use the harvesting of woody biomass as a valuable forest management tool. The harvesting of biomass provides an economical way to remove undesirable species from forests and can enhance wildfire mitigation efforts in some areas\(^4\). Finally, woody biomass energy reduces carbon emissions by sequestering carbon dioxide as the trees grow, which is equal to the amount of carbon dioxide that is given off when the trees are burned. This net-zero carbon cycle can continue for as long as the sustainable management of the biomass source is ensured\(^6\). In contrast, fossil fuels do not have the ability to sequester carbon. Fossil fuels release carbon dioxide into the atmosphere that would otherwise have been stored for millions of years. For this reason, biomass energy is more ecologically sustainable than energy from fossil fuels. As long as proper management techniques are established, biomass energy has the potential to be carbon neutral.


Although there are clear benefits of using biomass as a source of fuel, there are also drawbacks to using biomass. Woody biomass has less energy per unit weight than fossil fuels. Coal has 13,000 BTU/lb and oil has 19,000 BTU/lb; however, wood only has 8,000 BTU/lb. Additionally, it is unclear whether biomass is truly ecologically sustainable. The rate of energy consumption in contemporary society is much greater than the current ability to grow biomass energy. In addition, there is not enough land space to completely depend on biomass as a source of energy. If we try to meet large energy needs with biomass fuel, we would likely deplete fuels and forests. It is imperative that when using a biomass system, the biomass production and harvesting is done in a manner that protects the ecosystem and preserves natural resources.

3.1 (b) Best Management Practices

In order to define biomass energy as ecologically sustainable, management practices must be examined and evaluated. The removal of biomass in a way that encourages “protection of soils, wildlife habitat, water, and other forest attributes” stimulates the growth of higher-value trees, provides a viable, sustainable energy source, decreases the risk of forest fires, and aids in local economic development initiatives. The Forest Guild Guidelines are grounded in Best Management Practices but with an intensified focus on a consistent, healthy forest supply for present and future generations. They outline methods of forestry that are ecologically, economically, and socially responsible.

Sustainable biomass removal guidelines address soil fertility maintenance, water quality and riparian zones, and harvesting processes—which should involve a professional forester, certified logger, low impact logging techniques, avoid recently harvested lands, and follow best management practices. In the absence of a comprehensive study detailing the effects of specific harvesting techniques and practices, the Forest Guild released a set of guidelines to aid in managing carbon emissions as well as biodiversity and long-term virility. These guidelines for carbon storage are: shift from even-aged to uneven-aged management of shade-tolerant trees, encourage advanced and rapid regeneration, maintain a reserve or trees, attempt to lengthen harvest cycles to increase the size of trees, and concentrate on long-term carbon holding species.

3.2 The History of Colgate Biomass

In October of 1973, OPEC halted its export of oil to the United States and other western nations. As oil prices quadrupled, rising from 25 cents to over a dollar in just a few months, the 1970s “oil crisis,” was born, plaguing all those dependent on oil, and especially establishments requiring large supplies of oil for heating purposes, such as Colgate. This oil embargo compelled America to consider alternative forms of energy, and potential oil-supply complications. In 1978, Congress enacted the Public Utility Regulatory Policies Act, which was an effort to develop alternative energy sources, giving rise to the biomass power industry. In the wake of this massive shift, Colgate switched from oil as its primary energy source, to biomass, and constructed a woody-biomass burner in the early 1980s,
which is still utilized today. While this heating system is now seen as an integral facet of Colgate’s sustainability initiatives, the reason for the conversion was for purely economic reasons.

3.3 Biomass Facility Processes

Colgate’s biomass facility works similar to a wood stove. Though Colgate’s biomass facility is more advanced, it operates with this same basic concept. The process includes nine steps: processing, delivery, storage, loading, gasification, combustion, ash collection, steam production, and re-introduction.

Fuel for the facility begins with the processing stage. Wood chips are pre-cut and collected from various sites of non-Colgate land within a 75 hundred mile radius of Colgate’s campus. These chips are transferred by delivery truck to Colgate and stored. Colgate’s storage garage has the capacity to hold two hundred tons of wood chips, which can be filled by nine delivery trucks and provides roughly two days of continual heating. The wood chips are then moved into the burner through a loading process consisting of a series of conveyor belts that grab the wood chips from the south west end of the storage garage. As the wood chips move along the conveyor, they are processed through a shaker that separates the bigger and smaller pieces, followed by the grinder that reduces larger chips to the 3 inch size requirement, and finally through the hopper that vibrates the chips to separate them. Throughout the process, the conveyor measures the resistance of the wood against a belt and regulates the speed at which wood chips enter the burner to maximize efficiency.

The wood chips are then transferred into the burner by a blower system. This process converts carbonaceous mineral chips into a gas mixture called synthesis gas, which is used as fuel and travels to the combustion chamber. The combustion chamber indirectly introduces the hot synthesis gas with water; the synthesis gas travels in three hundred small tubes that heats surrounding water in the chamber to produce steam.

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7 Picture: Seth Greene, Wood Chip Auger
8 Picture: Seth Greene, Wood Chip Boiler
The leftover biomass particles and ash collect at the bottom of the combustion chamber in a series of two steps. The first process is to re-inject some of the larger, unburned wood chips back into the burner. The second process is to re-inject some of the larger chip remnants in the ash, increasing the efficiency of the burner. The leftover ash then accumulates into a metal barrel. One truckload of thirty-three tons of wood chips after completing these processes results in only ¾ of a barrel of ash. These ash barrels are then collected by farmers and subsequently used as fertilizer for their soil.

The steam that is produced is sent around campus and is used for heating and hot water in all buildings. Eventually the water is recycled into the boiler and is thus re-introduced back into the system. The returning water travels through a water softener and a dealkalizer where it is treated chemically for cleanliness and then the cycle continues.

3.4. The Willow Plot

In 2008, Colgate became quite serious about wanting to supplement the biomass system with Colgate-grown willow (Salix sp.). The price of wood chips has continued to rise over the past decade from $20/ton (2002) to $33/ton (2008), and currently stands at about $40/ton (2011). As Colgate becomes increasingly more reliant upon wood chips for heat, and as the school continues to grow in size and student body, the need to supply a portion of the fuel from local Colgate-owned sources seems crucial to achieving economic and environmental sustainability. The planting of these short-rotation woody increases the carbon sequestration around Colgate at about the rate of 4.5-8 tons of carbon per hectare per year. A tract of land on Hamilton Street containing approximately 8 acres of suitable land was selected as the primary location for Colgate’s Willow plot after a thorough assessment of suitable Colgate-owned parcels. It was planted with approximately 60,000 willow cuttings, financed by the Class of 2008 class gift sustainability fund.

4. Methods

Performing an analysis of the sustainability of Colgate’s use of biomass demanded a mixture of data collection methods.

The primary source of information was collected through interviews with several individuals. Each individual was contacted via e-mail to determine an appropriate meeting time to conduct

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a 30-minute interview. During the course of the interviews, different group members posited predetermined questions to the interviewee whilst the remaining group members present took notes of the responses given. This method of collecting data provided various perspectives on the state of the Colgate willow plot as well as our use of wood chips as a fuel source.

A survey was also conducted in order to gauge the awareness of the biomass facility and willow plot amongst Colgate students. The survey was emailed to all students. It consisted of four questions: class year, whether or not students knew about the biomass facility, whether or not students knew about the willow plot, and whether or not students felt that sustainability in general should be factored into Colgate’s curriculum. The survey can be found in Appendix D. The last question was included in the survey to understand whether, in general, students felt that sustainability would enhance their liberal arts education. This survey allowed for a social analysis of the awareness of the biomass facility and willow plot, and whether sustainability is generally supported by the students.

The entire group conducted general research on the viability, history and sustainable management of woody biomass, with additional papers provided to the group by Timothy Volk, Professor Cardelus and John Pumilio. A review of this research informed the types of questions that were asked of interviewees as well as the direction of the project. Archived papers from Colgate students, the proposal created by the Class of 2008 class gift committee as well as the Stewardship Plan served as excellent starting points to glean a thorough understanding of our willow plot in particular.

5. Results

5.1 Biomass Facility Statistics

Colgate’s wood chip burning plant runs at 79% efficiency and provides the University with approximately 76% of its total heating requirements. The other 14% of heating is subsidized by #6 fuel oil to meet the needs of the University. The biomass facility is capable of providing heat for the University until the outside temperature reaches 32 degrees Fahrenheit, at which point, the biomass facility is running at its maximum capacity. All subsequent heating is then provided by the #6 fuel oil.

Based on the 2009 - 2010 Wood Fuel Reports, 23,898.13 tons of wood chips were consumed throughout the year. The resulting cost of the biomass was $955,925. To produce the same quantity of heat, the amount of #6 fuel oil that would need to be used is 1,289,646 gallons. With the average of #6 fuel oil being $1.3929 per gallon that year, the cost of this fuel would have reached $1,796,348. Aside from the negative environmental costs of burning #6 fuel oil, the avoided economic costs of burning biomass instead of #6 fuel oil was $840,423. For additional information, please see Table 1 and Table 2 in Appendix B and C.
Therefore, it would not be economically or environmentally advantageous to switch to another boiler or heating system, despite the boiler’s age, given that it is still very efficient. Systems such as wood pellet facilities or other forms of biomass facilities are expensive to install and are not significantly more efficient than the current system. The use of wood chips for fuel has a net production of less carbon emissions because of wood’s ability to sequester carbon. While fossil fuel oil emits carbon dioxide into the atmosphere without the ability to sequester it, woody biomass emits carbon dioxide into the atmosphere while sequestering it in the growing stage of trees.

Table 1: Total Fuel Avoidance

<table>
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<tr>
<th>Description</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Wood Fuel Consumption</td>
<td>23,898.13 tons</td>
</tr>
<tr>
<td>Wood Fuel Total Cost</td>
<td>$955,925</td>
</tr>
<tr>
<td>#6 Fuel Oil Displaced</td>
<td>1,289,646 gallons</td>
</tr>
<tr>
<td>Total Cost of #6 Fuel Oil Displaced</td>
<td>$1,796,348</td>
</tr>
<tr>
<td>Total Amount Saved</td>
<td>$840,423</td>
</tr>
</tbody>
</table>

Without data on the exact source of Colgate’s wood, it is impossible to quantify the exact carbon emissions that have been saved due to the use of woody biomass instead of fossil fuels. However, since fossil fuels do not have the ability to sequester any source of carbon while woody biomass can, it can be concluded that the use of wood chips in Colgate’s boiler also results in a net decrease of carbon emissions from fossil fuel emissions.

5.2 The Willow Plot

Colgate’s willow plot is somewhat limited in its ability to realistically supply usable biomass for energy purposes. Its total area encompasses only 8 acres. The plants are being grown at a density of between 4,000-8,000 plants per acre, on average, and it is currently estimated that the entire plot contains of 60,000 willow cuttings. Even if the plot was utilized maximally and 64,000 total willow sprouts were planted, the harvested biomass would not be sufficient to be the sole contributor to Colgate’s system. In fact, if the first harvest of willow from this plot would produce 3.7-5.1 oven dried tons per acre per year (odt/A/yr), this would mean a total of 29.6-40.8 odt/yr for the whole 8-acre plot. In the second and third harvest, if the yield were to increase to 12 odt/A/yr, this would produce a total of only 96 odt/yr. Over the entire 22-year cycle of the 8-acre Hamilton Street plot, only 2,360 tons of willow biomass are expected to be produced.

Colgate annually uses approximately 22,249 tons of wood chips to produce enough heat for the campus. Even if Colgate used all 485 acres of it’s potential willow plot locations, it could produce maximally 5,820 tons over a four year period, or 1,455 tons each year (if it’s yielding the maximum 12 odt/A/yr), which is only 6.4% of Colgate’s annual needs. Having a full-scale willow plot (all 485 of Colgate’ potential willow acres) would also only save the university a total of around $44,681 in fuel oil costs every four years, which

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doesn’t even come close to offsetting the costs of maintenance. A plot that size would cost the university approximately $252,409 over that same 4-year span ($63,102/yr) in maintenance, fencing, fertilizer, management, etc.\(^7\)

Colgate owns a total of 1,137 acres of total land (including campus), and even if every inch were converted for willow production, it would still take an additional 360 acres to be fully self-sufficient, as Colgate would need a total of 1,497 willow acres.\(^7\)

Unfortunately, the willow plot is actually struggling to remain productive because it has been grazed heavily by deer (\textit{Odocoileus sp.}) and other foraging species. The location of the plot is ideal for deer browsing, as there is dense tree canopy cover on all sides and no barriers preventing their entry into the field. The willow trees have yet to complete one uninterrupted growing cycle thus far, so they have not achieved a height tall enough to resist the harms of grazing.\(^12\)

The plot has additionally struggled due to an absence of management and oversight. The initial proposal created for the Class of 2008 sustainability fund gift outlined the need for management, yet this aspect of the proposal was never fulfilled. At present, the plot is partially managed by Sustainability Coordinator John Pumilio. Mr. Pumilio has extensive duties throughout the Colgate campus and lacks the support needed to maintain the willow plot himself, therefore there is a clear need for a dedicated manager if the plot is to succeed.\(^13\)

The current willow plot is too limited in size and scope to entirely replace fuel oil as a source of heating energy, and even maximal expansion of the plot still couldn’t produce enough to overcome this deficit. Due to constraints of time, money and management, the Colgate willow plot is instead intended as a community example for the production and harvesting of locally sourced woody biomass. The willow plot can also function as a source of student research, leadership, and stewardship. It will hopefully continue to be used to supplement the current woody biomass supply once the crops are in a proper and healthy rotation, but will never produce sufficient amounts of willow to become the main supply of wood chips.

5.3 Dr. Volk’s Information

One of the foremost experts in this region on willow as a biomass source is Dr. Timothy Volk of SUNY ESF. After reviewing some of his research on willow biomass harvesting and growth in the central-upstate region of New York State, we conducted a phone interview to discuss some questions pertaining specifically to Colgate’s willow plot and system for sourcing woody biomass. During the course of our discussion, Volk highlighted some of the issues that Colgate faces with its own willow plot, namely, the threat of deer grazing on new growth. He noted that in order for willow plants to succeed, there needs to be at least one year of uninterrupted growth for the shoots to achieve a height that deer are unable to reach the new growth. When asked about the most sustainable means of sourcing

\(^{12}\) Volk, T. (2011, Mar 1). Personal interview.


\(^{14}\) Trainor, C. (2010, October). \textit{The current status of Colgate University’s pilot willow plot and recommendations to improve the willow status.} Hamilton, NY: Colgate University.

\(^{15}\) Pumilio, J. (2011, Feb 4). Personal interview.
our wood chips, Dr. Volk discussed the importance of mixing the sources of our wood chips, from both private and public lands as well as from different species of tree. He agreed that our lack of available information on our current source of wood chips is problematic for evaluating the sustainability of our system, but that through introducing and familiarizing ourselves with best management practices and responsible harvesting, we can begin to take steps in the right direction.

5.4 Colgate’s Supplier of Wood

Through discussions with Pete Babich and John Pumilio, we were able to discover information about Mark, our supplier, and his integral part in our heating system. He is solely responsible for providing Colgate with its wood chip needs, and therefore must provide 3 truckloads per day, with additional requirements on Fridays to meet the weekend’s heating needs. He does not currently have a contract with Colgate. In unwritten terms, he is required to meet Colgate’s wood chips demand while receiving a flat rate salary. Any complications that may arise in the collection, chipping, or delivery process do not alter the payment price, and Mark is responsible for any additional costs he might accrue. For the past 20 years Mark has actively built a clientele base and network of connections through which he builds his supply to Colgate.

Given the intensity of his responsibilities, Mark is a very busy man and does not have much time to be interviewed. Additionally, we assume that the time requirements of his work preclude him from being able to consistently document his sources and their harvesting practices, at least in a way that is currently viewable to the Colgate administration. The demands placed on him by Colgate are so strict and inflexible that is impossible, given the current system, to expect sustainable harvesting practices to be placed high on his priority list.

5.5 CNY Biomass Study

The Central New York Biomass Crop Study was conducted by Cato Analystics, LLC. with the help of the State University of New York, College of Environmental Science and Forestry between October and December of 2009. The study looks at the viability of biomass cultivation on private farm land within a 25-mile radius of Morrisville, NY (approximately 8 miles from Colgate University). The area included 1.26 million acres and utilized satellite imagery in combination with tax roll information to estimate land area totals for biomass cultivation. Further, the study used questionnaires and interviews with farmers to determine their likelihood of moving to biomass cultivation and the needs and/or stipulations required to do so. The study found that there were significant amounts of land, approximately 120,000 acres, either currently available or easily convertible for biomass cultivation (cool/warm season grasses and willow). Even active farms with sub-standard tracts of land for commercial crops, are suitable for biomass cultivation. The study shows that not only is there an immense amount of land available for cultivation, but that land owners are generally receptive to bringing the land under control for biomass cultivation. The limiting factors are farmer’s expectations of economic return, security of purchasers

for said biomass and funding/support for new biomass cultivation on lands needing preparation/repair from years of inactivity. The study suggests that Madison County and the surrounding areas could greatly benefit from a return of inactive farmland to biomass cultivation, could secure the economic future for many farmers and decrease and secure the source of biomass for local institutions.

### 5.6 Survey of the Colgate Student Body

The questions in our survey asked for class year, whether or not the student knew about the biomass facility, whether or not the student knew about the willow plot, and whether or not the student felt that incorporating sustainability into Colgate’s curriculum would enhance his or her liberal arts education. Of the entire student body that received the email, 357 students responded. Of the respondents, 26.1% were from the class of 2011, 28.7% were from the class of 2012, 21.6% were from the class of 2013, and 23.6% were from the class of 2014. This shows a relatively equal distribution in class year of the respondents.

Of the student respondents, 67.8% knew that Colgate burned wood chips to heat the university instead of solely fossil fuels and 32.2% were unaware of Colgate’s use of woody biomass. Of the 354 students that answered the question on awareness of Colgate’s willow plot, 40.1% were aware and 59.9% of the students were unaware. The results of the final survey question suggest that overall, Colgate students believe that incorporating sustainability into the curriculum would enhance a liberal arts education. There were 356 respondents to the final question and 76.1% of them were in favor of incorporating sustainability into Colgate’s curriculum, while 24.4% of student respondents were not. We used a series of log-likelihood tests to ask whether the frequency of students knowing about the biomass facility was greater than 75%, whether awareness of the willow plot was greater than 75%, and whether incorporating sustainability into the curriculum was greater than 75%. We chose 75% as our awareness threshold because our group decided that 100% awareness would not be a realistic target. Furthermore, 50% awareness is equal to the awareness levels by chance alone. Therefore, we agreed on a target awareness level of 75%.

The results of the survey show that students are generally aware of Colgate’s biomass facility and willow plot. However, the awareness level of the biomass facility is significantly less than our target of 75% (G = 9.36, df = 1, p < 0.01). Additionally, the awareness level of the willow plot is also significantly less than our target awareness of 75% (G = 192.7, df = 1, p < 0.001). We found that the percentage of students that favored the integration of sustainability into the Colgate curriculum did not differ from 75%, meaning that three quarters of the student respondents supported sustainability in the curriculum (G = 0.242, df = 1, p = 0.623).

Because awareness of the biomass facility and the willow plot does not reach our awareness threshold of 75%, the results suggest that awareness should increase on Colgate’s campus. It is unreasonable to expect 100% knowledge about these sustainability initiatives on campus; however, a threshold of 75% should be achieved. Additionally,
because most respondents were in favor of incorporating sustainability into Colgate’s curriculum, the results of this survey also support a further inclusion of sustainability courses and activities around campus. Because 75% of Colgate’s student body supported incorporating sustainability into the curriculum, it is clear that sustainability is important for students at Colgate. Therefore, the results of this survey are in favor of increasing awareness of the student body and further incorporating sustainability into Colgate’s academic curriculum.

5.7 Stewardship Plan

Colgate University contracts with a forester, working with Colgate’s Environmental Council, every ten years to investigate and analyze Colgate’s forests and open lands. Our most recent stewardship plan was completed by Dr. Steven Bick of Northeast Forests, LLC. in 2007, an update is due in 2017. These lands include the campus tracts, the Hamilton Street tract, the Beattie reserve management units, the Bewkes property management units, the Parker Farm tract and the Bonney Hill tract. The plan specifies a set of management objectives and goals, as well as a system of classification according to which individual land management units are categorized. Each parcel and sub-tract is classified with a primary and secondary classification: a). preservation, b). research and teaching, c). recreation and aesthetics, and d). timber management. The plan does not yet designate biomass production as one of its classifications. Each tract is described in detail including its current use and purpose, what it could be used for in the future, and management practices over the next ten years.

The stewardship plan targets many tracts that are classified under timber management. These lands are targeted for sustainable growth and harvest of mature trees for timber products and chips for burning. This classification also includes several tracts in need of tree stand thinning to promote growth, which could also be used for commercial timber products and biomass sources. The plan further defines timber management with suggestions for the best management practices for water quality, certified logger training, contractual obligations and professional oversight. These policies should be applied to on and off campus harvesting operations. The plan calls for all timber harvesting activities to comply with New York State Forestry Best Management Practices for Water Quality Field Guide and to be built into all timber sale contracts. Next, loggers who work on Colgate property or for Colgate should have achieved Trained Logger Certification in New York State, this requirement shows support for sustainable management practices. Professional oversight by trained management professionals should be utilized during all planning and operations, minimal qualifications should include membership in the Association of Consulting Foresters or individuals who have achieved Certified Forester status from the Society of American Forester. And finally, all of these suggestions, along with many others, should be written into a contract between Colgate and the timber harvester/purchaser. This will ensure that best management practices and sustainable harvesting occur.
6. Summary of findings

Wood chips for Colgate’s biomass facility make up a significant portion of Colgate’s energy budget. Colgate’s wood chips are privately sourced within a 75-mile radius of campus. The sourcing and processing of the chips is the responsibility of one independent contractor. Colgate pays $40/ton of wood chips delivered to the biomass facility in tractor trailer loads. The exact procedures of the sourcing of Colgate’s wood chips are not attainable and it appears the chips come from private and public lands that are cleared for biomass production. Colgate’s current sourcing of biomass does not seem to take sustainability or best management practices into consideration. Colgate does not supply any of its own wood chips, either from forested Colgate property or Colgate’s Willow plot, located on Colgate’s Hamilton Street tract of land. Colgate’s willow plot is for educational and research purposes and could possibly serve as a resource to area farmers wishing to grow biomass for cultivation.

7. Conclusion

7.1 Current Sustainability Status of Colgate

As defined by our ENST 390 class, sustainability is “a capacity to utilize the recycled resources and services ensuring economic, environmental, and social equity both locally and globally and with equal considerations of present and future generations.” In examining the sustainability of Colgate’s current heating system, economic, environmental, and social aspects were considered. Economic analysis of the current system shows that Colgate has saved $840,423 in 2010\(^\text{15}\) by switching to biomass fuel, as opposed to fuel oil. Environmental analysis indicates that using wood utilizes the short carbon cycle. Trees used to produce woody biomass absorb carbon dioxide from the atmosphere equal to the carbon dioxide that is released when the tree is burned. In contrast, fossil fuel consumption emits CO\(_2\) that would have otherwise been trapped in underground deposits. Therefore, using woody biomass results in lower carbon dioxide emissions. Although we do not know the exact location of where our wood chips come from, because they are delivered three times a day, we know that they are sourced from local forests. In comparison to fossil fuels, using wood chips for fuel saves CO\(_2\) emissions from transportation. Finally, a social analysis of our current system suggests that in order to uphold the requirements of the ACUPCC to integrate sustainability into Colgate’s curriculum, there are ways for Colgate to increase awareness at the campus and town level, because at this point, the source of heat is generally unknown amongst students. With the current level of knowledge of the student body about our biomass facility, students are unable to place sustainability as a main priority in their daily functions and heating needs, as they do not understand the instability of a system dependent entirely on locally grown wood chips. With the current

\(^{15}\) Appendix C
status of the willow plot, there is little incentive for local farmers to grow willow and become an integral part of Colgate’s heating system.

The results of this study indicate that while the use of wood chips as fuel is more sustainable than using fossil fuels to provide heat for our campus, there are many ways in which we can improve the sustainability of our current system.

7.2 Presentation of Options

We recommend the following options to enhance the sustainability of Colgate’s heating system:

1. Institute a formal contract with our supplier
2. Implement a way to record information about the source of our wood chips
3. Revitalize Colgate’s Willow Plot
4. Expand locally grown willow operations
5. Increase awareness about Colgate’s biomass system and willow plot
6. Perform a comprehensive GIS analysis of suitable lands surrounding Colgate

1. Institute a formal contract with our supplier of wood chips

Colgate University employs one contractor to supply us with enough wood chips to sustain the campus heating system. Colgate’s agreement with our wood chip contractor has two basic tenets: 1) Do not let Colgate run out of wood chips and 2) Supply the wood chips at a flat rate of $40.00 a ton. This agreement is not recorded on paper, and there are no stipulations in the agreement regarding the sustainability of the sources used. This method for providing wood chips to campus has been successful for many years; however, in light of Colgate’s efforts to become a more sustainable campus, there are a few recommendations to be made regarding this system.

We suggest that Colgate follow previously established practices, such as those set forth in the Stewardship Plan, by creating a formal contract between Mark and the University. This contract would stipulate that either by his own hand or by a hired employee, there will be a record for each incoming shipment of the amount of wood, the location of harvest, the location of chipping, and the type of land - private or public. If Colgate is to compete with comparable facilities at peer institutions such as those at Middlebury, with a state-of-the-art, glass walled biomass burner located in the center of campus, there needs to be a transparent process for the collection of our wood chips. The evidence for Colgate’s sustainability efforts should be readily available for all to witness, imitate, and commend. To enhance Colgate’s involvement in the local community and initiatives for environmental improvements beyond Colgate’s borders, an arrangement for Mark to distribute Best Management Practices pamphlets, and a letter stating Colgate’s support of the guidelines, to his suppliers, should be enacted; it is our hope that distributing this information would have a positive impact in our efforts to reduce the environmental effects of harvesting woody biomass.
2. Implement a way to record information about the source of our wood chips

In order to continue supporting complete transparency in the collection process, we propose that a clipboard hang in the boiler storage facility, for each driver delivering a shipment of wood chips to sign. Performing this quick procedure would allow the university to have an accurate record of some of the basic information pertaining to each shipment. Each driver should record and provide the following information: the arrival date and time, the location of pick up, the approximate size of delivery, the harvesting methods utilized by supplier, and type of wood. If not all of the above factors are known, the driver should record all that he does know, and make a conscious effort to find out information regarding those factors in future deliveries.

3. Revitalize Colgate’s Willow Plot

We are in clear support of reinvestment into revitalizing the willow plot. The first step necessary is to hire a single manager or management group, in order to establish a foundation for stewardship. The absence of definite management may have been the missing link to the successful growth of willow during the past three years. We also recommend the encouragement of student organizations and class groups to become involved in the willow plot and contribute to its survival, a potentially indispensable teaching aid and an example of a truly liberal arts experience. Student involvement and stewardship alone will not control the deer grazing that has severely stunted the growth of the willow plot, therefore some sort of deterrent ought to be purchased and utilized. Finally, in order to revitalize the willow plot, we recommend an implementation of deer deterrents to decrease deer grazing of willow. A possible deer deterrent would be to install fencing to surround the plot and keep deer out.

4. Expand locally grown willow operations

We propose that Colgate should expand the willow plot in order to produce more locally grown wood to supplement our woody biomass fuel. In order to do this, we suggest that Colgate utilize its land that is currently being leased to farmers as locations for growing willow. By doing this, Colgate can expand its contribution to the supply of wood chips. Additionally, these plots can be used for educational purposes, both in Colgate academics as well as for locals. Therefore, we propose that Colgate work with local farmers to educate about growing willow and ensure successful willow operations. In doing so, Colgate will support the local economy and encourage local transactions while also increasing our local fuel supply.

To achieve this goal, there should be certain measures taken to revitalize our current willow plot, as shown in option 3, above. Revitalization of the current willow plot will provide a helpful example to farmers in the community on how to successfully grow willow and how to overcome the obstacles of growing willow in the area, such as the deer grazing. By revitalizing our own willow plot, Colgate will be able to support the expansion of locally grown willow operations and encourage the local economy.
5. Increase awareness about Colgate’s biomass system and willow plot

Based on the results of our survey, we have come to the conclusion that initiatives to increase awareness of Colgate’s use of biomass for heating would be extremely beneficial. Increased awareness of this environmentally conscious heating system distributed amongst students and faculty on campus, in the local community, and in all prospective students would help improve Colgate’s image as an institution striving to reduce their carbon emissions. Examples of information to be promoted to the community should include responsible harvesting practices and the best methods to promote regeneration, a general understanding about the biomass facility and burner, our source of wood, and the existence of a willow plot for educational and experimental purposes.

In addition, student and faculty education about our current energy system is key in order to raise awareness about the significance of sustainable energy and the benefits of using wood to meet Colgate’s heating requirements. By signing the ACUPCC, Colgate pledged to reduce carbon emissions and integrate sustainability into the university’s academic curriculum. Information available to students, faculty and staff about the source of Colgate’s heat and the potential to supplement the wood chips with Colgate-grown willow would, at the very least, provide a foundation for sustainable development in the coming years for our heating plant.

Student involvement in the willow plot is absolutely crucial for its success. Many students at Colgate are unaware of the biomass system as a whole, so familiarity with the willow plot encourages awareness both of the heating system and the plot itself. With stewardship on the part of students, the willow plot can be maintained, and without it the plot may falter. The top priorities in maintaining the plot are regular weeding, pest prevention, and protection from deer. Without any sense of designated management, student’s can act proactively to sustain the plot, while also utilizing it as an opportunity to learn about and research willow biomass sustainability.

6. Perform a comprehensive GIS analysis of suitable lands surrounding Colgate

We recommend that future researchers evaluating the sustainability of Colgate’s biomass system undertake a thorough GIS (Geographic Information Systems) analysis of the lands surrounding Colgate University. Suitable locations for sustainable logging and management, as well as potential locations for willow production should be evaluated within a 75-100 mile radius of Hamilton, NY. Previous studies were somewhat site-specific, and not nearly as broad as this comprehensive approach. One was based within a 25-mile radius around Hamilton University in Clinton, NY and the other main one was only within Colgate-owned parcels. This approach will allow for a more in-depth evaluation of the potential for sustainable biomass collection in the area surrounding Hamilton, NY. This could be used to highlight areas outside the currently-owned parcels that could be better utilized by Colgate, and can additionally serve as a reference for all woody biomass collectors/consumers in the area.
7.3 Rejected Options

There were some angles we considered regarding the sustainability of our heating system at Colgate and potential options that we rejected for various reasons. First, given the cost of renovation and the efficiency level of our current boiler, which at 79% is very high for boiler systems with a traditional efficiency span of 60% to 80%, it would be unreasonable and economically imprudent to suggest updating the current system. Likewise, it would also be imprudent to propose utilizing a new source of renewable energy altogether. The amount of infrastructure that would have to be reconstructed would be an unreasonable feet to suggest pursuing. Although the prestige of a state-of-the-art system with glass sides to enhance student awareness seems ideal, it is not a feasible or necessary option for Colgate at this time. Second, through our research we came to realize that it is impossible for the primary source of wood chips at Colgate to be from the harvesting of its willow plot. There is simply not enough land available to sustain a single willow plot large enough to support our needs, especially given the time it takes to plant, sustain, and complete a cycle of growth in a newly created plot. Lastly, we chose to shift our focus from the efficiency of the heating system in general to the source of our fuel, for the source rather than the transportation of heat on campus is the more pressing and potentially unsustainable issue.

8. Recommendation:

We recommend that Colgate focus on identifying and documenting its source of fuel, encourage campus-wide education initiatives regarding the biomass facility and willow plot, and implement region-wide programs to show the benefits of growing willow in enhancing the local economy, as demonstrated by an expanded and revitalized willow plot.
9. Reflection

According to Colgate University, “Our sustainability initiatives strive to reduce our ecological footprint, preserve nature’s resources, and contribute to a socially just, higher quality of life both locally and globally.” Colgate is dedicated to sustainability efforts in order to embrace the responsibility of addressing environmental issues. In doing so, Colgate strives to incorporate environmental education into the academic curriculum and stress the importance of sustainability at the Colgate community level and at large. It is clear that Colgate University is dedicated to sustainability. However, when we dig deep into the realms of Colgate’s heating system, questions arise concerning the true sustainability of the system.

The examination of Colgate’s use of wood chips for heat has suggested that while woody biomass is generally more economically and environmentally sustainable, our current system lacks important information that is imperative for an accurate analysis of sustainability at Colgate. Though Colgate is devoted to reducing carbon emissions and preserving natural resources, the current woody biomass system does not guarantee complete sustainability because it is difficult to access information about the harvesting practices and the sourcing of the wood chips. By implementing options such as a formal contract with our wood supplier and a system to record information about the source of the wood, Colgate will be able to accurately evaluate the sustainability of the system.

Although Colgate is dedicated to including environmental education in the academic curriculum, increased awareness of the biomass facility and willow plot is imperative to address the social aspects of the sustainability of Colgate’s biomass system. In light of the liberal arts curriculum Colgate students are prescribed, an increase in opportunities for hands-on learning or interdisciplinary experiences with our sustainability initiatives would be ideal. For example, allowing students to travel to the willow plot and participate in the maintenance or harvesting of the willow for an ENST freshmen seminar. As communities of the world are becoming more aware of the need for sustainable sources of energy, the chance for students to actively engage in dialogues about our own energy sources would be beneficial for their collegiate experience and beyond.

Colgate University has made an effort to increase campus sustainability by becoming a signatory of the American College and University Presidents’ Climate Commitment in 2009. In doing so, Colgate pledged to reduce carbon emissions and integrate sustainability into the academic curriculum. It is clear that Colgate is devoted to creating sustainability initiatives to enhance economic, environmental, and social aspects of the Colgate community. However, there are areas in which the university should consider in order to fully guarantee a sustainable system.

The next step for Colgate University would be to implement our options to find out the source of the wood. Additionally, the university should increase awareness of our current heating system and further incorporate sustainability into the academic environment by additional sustainability courses and activities around Colgate’s campus. In doing so, Colgate will be able to fully uphold its dedication to sustainability initiatives.
10. Acknowledgements

We would like to thank the following for their indispensable insight and guidance:

- Frank Frey, Associate Professor of Biology
- John Pumilio, Sustainability Coordinator
- Pete Babich, Associate Director of Facilities and Manager of Engineering Services
- Dr. Timothy Volk, Ph.D., SUNY-ESF Dept. of Forest and Natural Resources
- Catherine Cardelús, Associate Professor of Biology
- Professor McCay, Associate Professor of Biology and Environmental Science
Colgate’s Biomass facility process operates in nine steps: processing, delivery, storage, loading, gasification, combustion, ash collection, steam production, and re-introduction. The process moves left to right in this diagram, from the storage silo to the ash collection. One major step not shown is the transportation of the resulting steam used for heat from the boiler to buildings around campus.
### Table 1: Wood and Fuel Oil Usage 2009-2010

<table>
<thead>
<tr>
<th>Tons of Wood Chips Consumed</th>
<th>Actual Cost of Wood Chips Consumed</th>
<th>Adjusted Cost of Wood Chips Consumed</th>
<th>Total Gallons of #6 Fuel Oil Consumed</th>
<th>Cost of #6 Fuel Oil For the Month Per Gallon ($)</th>
<th>Total Cost of #6 Fuel Oil Consumed</th>
<th>Total Cost of Wood and Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>1,236.21</td>
<td>$52,248.40</td>
<td>1,500</td>
<td>1.3929</td>
<td>$2,089.35</td>
<td>$51,537.75</td>
</tr>
<tr>
<td>July</td>
<td>1,446.22</td>
<td>$58,848.80</td>
<td>2,666</td>
<td>1.3929</td>
<td>$3,713.47</td>
<td>$61,562.27</td>
</tr>
<tr>
<td>August</td>
<td>1,322.68</td>
<td>$50,867.20</td>
<td>1,100</td>
<td>1.3929</td>
<td>$1,532.19</td>
<td>$54,439.39</td>
</tr>
<tr>
<td>September</td>
<td>1,364.19</td>
<td>$58,967.60</td>
<td>3,800</td>
<td>1.3929</td>
<td>$5,293.02</td>
<td>$59,860.62</td>
</tr>
<tr>
<td>October</td>
<td>2,076.70</td>
<td>$84,268.00</td>
<td>11,025</td>
<td>1.3929</td>
<td>$15,356.72</td>
<td>$98,424.72</td>
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<tr>
<td>November</td>
<td>2,259.40</td>
<td>$88,376.00</td>
<td>15,736</td>
<td>1.3929</td>
<td>$21,918.67</td>
<td>$112,294.67</td>
</tr>
<tr>
<td>December</td>
<td>2,821.83</td>
<td>$116,473.20</td>
<td>49,610</td>
<td>1.3929</td>
<td>$69,101.77</td>
<td>$181,974.97</td>
</tr>
<tr>
<td>January</td>
<td>2,944.21</td>
<td>$117,968.40</td>
<td>62,123</td>
<td>1.3929</td>
<td>$86,531.13</td>
<td>$204,299.53</td>
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<td>February</td>
<td>2,844.69</td>
<td>$116,587.60</td>
<td>37,026</td>
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<td>$51,573.52</td>
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<td>2,489.79</td>
<td>$104,391.60</td>
<td>38,548</td>
<td>1.3929</td>
<td>$53,693.51</td>
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</tr>
<tr>
<td>April</td>
<td>1,816.26</td>
<td>$75,050.40</td>
<td>34,040</td>
<td>1.3929</td>
<td>$47,414.32</td>
<td>$120,064.72</td>
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<tr>
<td>May</td>
<td>1,275.95</td>
<td>$46,838.00</td>
<td>26,800</td>
<td>1.3929</td>
<td>$37,329.72</td>
<td>$88,367.72</td>
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<tr>
<td>Totals</td>
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<td>$970,885.20</td>
<td>283,974.00</td>
<td></td>
<td>$395,547.39</td>
<td>$1,351,472.59</td>
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</table>

Table 1 represents the total amount of wood chips and gallons of #6 fuel oil consumed with the respective costs.
## Appendix C

Table 2: Fuel Cost Avoidance 2009-2010

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>JUNE</td>
<td>1,236.21</td>
<td>$49,448</td>
<td>66,711</td>
<td>$92,922</td>
<td>($43,474)</td>
</tr>
<tr>
<td>JULY</td>
<td>1,446.22</td>
<td>$57,849</td>
<td>78,044</td>
<td>$108,708</td>
<td>($50,859)</td>
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<td>AUGUST</td>
<td>1,322.68</td>
<td>$52,907</td>
<td>71,378</td>
<td>$99,422</td>
<td>($46,515)</td>
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<tr>
<td>SEPTEMBER</td>
<td>1,364.19</td>
<td>$54,568</td>
<td>73,618</td>
<td>$102,542</td>
<td>($47,974)</td>
</tr>
<tr>
<td>OCTOBER</td>
<td>2,076.70</td>
<td>$83,068</td>
<td>112,068</td>
<td>$156,099</td>
<td>($73,031)</td>
</tr>
<tr>
<td>NOVEMBER</td>
<td>2,259.40</td>
<td>$90,376</td>
<td>121,927</td>
<td>$169,832</td>
<td>($79,456)</td>
</tr>
<tr>
<td>DECEMBER</td>
<td>2,821.83</td>
<td>$112,873</td>
<td>152,278</td>
<td>$212,108</td>
<td>($99,235)</td>
</tr>
<tr>
<td>JANUARY</td>
<td>2,944.21</td>
<td>$117,768</td>
<td>158,882</td>
<td>$221,307</td>
<td>($103,539)</td>
</tr>
<tr>
<td>FEBRUARY</td>
<td>2,844.69</td>
<td>$113,788</td>
<td>153,512</td>
<td>$213,826</td>
<td>($100,039)</td>
</tr>
<tr>
<td>MARCH</td>
<td>2,489.79</td>
<td>$99,592</td>
<td>134,360</td>
<td>$187,150</td>
<td>($87,558)</td>
</tr>
<tr>
<td>APRIL</td>
<td>1,816.26</td>
<td>$72,650</td>
<td>98,013</td>
<td>$136,523</td>
<td>($63,872)</td>
</tr>
<tr>
<td>MAY</td>
<td>1,275.95</td>
<td>$51,038</td>
<td>68,856</td>
<td>$95,909</td>
<td>($44,871)</td>
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<tr>
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<td>23,898.13</td>
<td>$955,925</td>
<td>1,289,646</td>
<td>$1,796,348</td>
<td><strong>($840,423)</strong></td>
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</tbody>
</table>

Table 2 represents the amount of gallons of #6 fuel supplemented by the wood chips. This table also shows the cost saved by using the cheaper wood chip fuel.
Appendix D: Survey for Colgate Student Body

Survey for ENST 390 class

1. What class year are you?

   2014          2013          2012          2011

2. Prior to this survey, were you aware that the majority of Colgate’s heat comes from burning woodchips (biomass fuel) instead of fuel oil and coal (fossil fuels)?

   YES          NO

3. Prior to this survey, did you know that Colgate has its own plot of land that is devoted to growing willow to supplement our wood chips?

   YES          NO

4. Do you think that incorporating sustainability into Colgate’s curriculum would enhance your learning as a liberal arts student?

   YES          NO
Appendix E: Survey Statistics

1.) Prior to this survey, were you aware that the majority of Colgate’s heat comes from burning woodchips (biomass fuel) instead of fuel oil and coal (fossil fuels)?

Null Hypothesis: The frequency of knowing about Colgate’s use of biomass is equal to 75%, and the frequency of not knowing is equal to 25%.

N = 357

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
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<tr>
<td>Observed</td>
<td>242</td>
<td>115</td>
</tr>
<tr>
<td>Expected</td>
<td>267.75</td>
<td>89.25</td>
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<tr>
<td>G statistic</td>
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<tr>
<td>p-value</td>
<td>&lt;0.001</td>
<td></td>
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</table>

The frequency of knowing about the biomass facility is statistically different than 75%. We can reject the null hypothesis.

2.) Prior to this survey, did you know that Colgate has its own plot of land that is devoted to growing willow to supplement our wood chips?

Null Hypothesis: The frequency of knowing about Colgate’s willow plot is equal to 75%, and the frequency of not knowing is equal to 25%.

N = 354

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>142</td>
<td>212</td>
</tr>
<tr>
<td>Expected</td>
<td>265.5</td>
<td>88.5</td>
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<tr>
<td>G statistic</td>
<td>192.68</td>
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<tr>
<td>p-value</td>
<td>&lt;0.001</td>
<td></td>
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</table>

The frequency of knowing about the willow plot is statistically different than 75%. We can reject the null hypothesis.

3.) Do you think that incorporating sustainability into Colgate’s curriculum would enhance your learning as a liberal arts student?

Null Hypothesis: The frequency of supporting the incorporation of sustainability into Colgate’s curriculum is equal to 75%, and the frequency of not supporting sustainability into the curriculum is equal to 25%.

N=356

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>271</td>
<td>85</td>
</tr>
<tr>
<td>Expected</td>
<td>267</td>
<td>89</td>
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<tr>
<td>G statistic</td>
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<tr>
<td>p-value</td>
<td>0.623</td>
<td></td>
</tr>
</tbody>
</table>

The frequency of supporting the incorporation of sustainability into Colgate’s curriculum is not statistically different than 75%. We cannot reject the null hypothesis.
References


Volk, T. (2011, Mar 1). Personal interview.