Environment, Sustainability, and Culture at Thetford Academy:

Suggestions for Moving Forward

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Advisor

Nicholas Reo

Contributors

Frohman Anderson '14

Amelia Antrim '14

Louis Concato '14

Natalie Flowers '14

Sophie Hasson '15

Emily Lacroix '15

Jillian Mayer '14

Andres Ramirez '14

Sam Rauschenfels '14

Varun Ravishanker '14

Katherine Rohn '14

Alex Rowe '14

Nelson Santry '14

Jessica Tarbell '14

Melina Turk '14

Diana Wise '15

Rett Young '14

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Jenna Muscoe
Len Whitaker
Jordan Glidwell
David Cornwell
Jean Hamilton
Chris Schmidt
Gary Engler
Dustin Burnett
Michael Berger
Sarah Alexander
Tracy Dustin-Eichler
Emily Horne

Chapter One: Thetford Academy and the Environment: Introduction to Sustainability Recommendations

1.1 Introduction

Throughout the spring of 2014, the students of Dartmouth College's Environmental Problem Analysis and Policy Formulation class worked in conjunction with the faculty, staff, students, and administrators of Thetford Academy (TA) for the purpose of addressing current environmental issues and opportunities. Four teams were tasked with finding ways to improve campus sustainability and better utilize the natural resources and surroundings available to students and the local community. The four groups focused on (1) alternative energy and energy efficiency, (2) a maple sugaring operation, (3) improving the TA food system, and (4) an outdoor leadership program. After analyzing current practices and systems in place at TA, the teams formulated recommendations for use at TA.

TA, located on 284 acres atop Thetford Hill, is Vermont's oldest secondary school, having been founded in 1819. TA is an independently governed private school with a public mission, serving both a local students as well as students from other Upper Valley communities. The TA campus includes a variety of wooded and open areas that provide ample opportunities to the student body and the local community. With 65 employees and approximately 300 students in grades 7-12, TA is a close-knit community dedicated to education; the school hopes to become more sustainable, as well as utilize the natural resources available on the TA campus.

The goal of this project was to bring new, sustainable programs to TA. With this goal in mind, many obstacles needed to be considered, especially in a high school setting. A primary obstacle was determining what 'sustainability' meant to each of the individual subgroups, as sustainability does not have one clear-cut definition, and thus what it means to be "sustainable" varied based on the parameters of the issue being considered. A key obstacle that each group encountered was the issue of trade-offs, whether they be economic, educational, time management, long-term vs. short-term goals, or using local vs. regional vs global resources. Each project considered existing and future constraints and included further questions for TA faculty and community members.

Alternative energy and energy efficiency

When considering TA's energy use, the goal was to recommend viable options for alternative energy sources that would be both efficient and feasible for implementation at TA. Currently, much of TA's energy is generated from fossil fuels, which is neither environmentally sustainable nor economically beneficial, since reliance on fossil fuels precludes TA from adjusting its fuel mix in the event of rising fuel prices. Taking into account TA's need to diversity their energy portfolio, the recommendations made to TA were to increase the efficiency of existing infrastructure, implement biomass heating, and, if choosing to implement alternative energy systems, use solar power. Carrying out these recommendations will not only decrease the school's carbon emissions, but will also establish TA as a model for high school environmental sustainability.

Maple sugaring operation

A maple sugaring facility offers an enriching educational experience for the student body and allows engagement with community members. Furthermore, maple sugaring bring the school one step closer to self sufficiency by utilizing existing resources.TA has prime access to a maple sugar stand across the road from the school. The stand contains over 200 tappable on-site maple trees. The stand also features a level clearing at the bottom of the access road, serving as a possible site for the sugaring house. TA will require a stand management plan in order to ensure tree health and overall maintenance of the operation. Finally, leadership and ownership from students, faculty and community members will ensure the sustainability of the operation. The recommendations contained in this report serve as a framework for future development of the sugaring facility.

Food systems and sustainability

Evaluating the TA food system requires careful consideration of inputs and outputs of the system as a whole. Looking specifically at inputs, sustainable food sourcing was discussed while taking locality, cost constraints, and resource depletion into consideration. Focusing the attention to the food system outputs emphasizes the potential benefits that implementing a composting program could have. Implementing a composting program will allow TA to close the food loop so that the food wastes exiting the system could be turned into a viable product that can be put back into the system in the form of compost. Lastly, discussions regarding the broader image of the food system led to an in-depth look at the TA culture as a whole, and the recommendations of various initiatives that serve to shift the culture of TA to that of one that is more environmentally conscious.

Outdoor Leadership

By capitalizing on its surroundings, TA has the unique opportunity to create an Outdoor Leadership program. Outdoor leadership engages the student body by enforcing communication, leadership and small-group behavioral skills. Furthermore, the program enhances judgement in the outdoors, teaches outdoor skills and raises environmental awareness. The activities proposed emphasize personal safety, environmental stewardship in order to create an overall quality educational experience for the participants. The proposed Outdoor Leadership Program includes six potential options for implementation, these programs focused on outdoor survival, wilderness first aid, cross country skiing, hiking, and an outdoor ropes course. The aim of this is to expose students to TAs surrounding environment and to introduce them to important leadership and communication skills that can be applied to other areas of their lives.

Overall, TA has many opportunities for infrastructure and culture changes that will contribute to the goals of sustainability and environmental awareness within the school.

Many of the recommendations in this report allow for students to engage with the natural world in new and interesting ways with interdisciplinary and experiential learning applications. Furthermore, these projects engage students with community members and create a sense of ownership and leadership in the natural environment. Opportunities explored throughout the project take advantage of TA's beautiful settings and rich surroundings. This report provides guidelines and recommendations for several different areas of improvement that strive to foster an environmentally aware community through program implementation with minimal environmental impact.

Chapter Two: Efficiency and Energy Production Alternatives

Amelia Antrim, Emily Lacroix, Katie Rohn, Louis Concato, Rett Young, Sam Rauschenfels

2.0 Executive Summary

Currently, Thetford Academy has a large carbon footprint due to their electricity and energy consumption. Though the school is relatively small, the heavy reliance on oil and propane for heating is costly and irresponsible. Substantial annual electricity demand could be reduced through infrastructural improvements and partially offset by implementing renewable energy systems on campus. After conducting on-site and regional research, there are numerous solutions that apply to an institution of this size and location with reasonable capital investment.

Energy Efficiency

The school's current energy efficiency has been measured by examining the campus infrastructure, analyzing electric bills, and communicating with school administrators. Our research is intended to distinguish existing components that support their sustainability from those that do not, so that TA may establish uniform efficiency and minimize preventable costs. This assessment analyzed three main appliances that contribute to the school's heating and electric costs and carbon footprint: lighting, windows, and insulation. Initiatives for efficient lighting have been taken and must be continued when changes are necessary. Almost all windows are high performing, but adequate maintenance is required. Differences in the age of buildings on campus have created discrepancies in the age and type of insulation, which can lead to significant heat loss.

Heating

TA presently consumes over 20,000 gallons of propane and 10,000 gallons of fuel oil per year for a campus comprised of four main buildings. Numerous schools across Vermont have switched to pellet boilers for heating. Following the regional trend, TA would also benefit from such a switch. This modification would save TA approximately $20,000 on heating costs per year, and the school would see a return on investment in under seven years. Converting to biomass as a heating source also helps protect TA from the instability of rising oil prices. Furthermore, this decision would create local jobs and spur regional economies because of the vast biomass resources within New England.

Electricity

Within the past decade, Vermont has experienced significant growth in residential utilization of solar energy. TA could install a solar array on campus without compromising a significant portion of their property. Depending on the size of the array, initial installation costs would be under $130,000, with total expenses nearly halved with state benefits, and have a return on investment of under 20 years. With a large enough array, TA could produce 100% of their electricity in the summer months. As an alternative to direct ownership, TA could enter into a power purchase agreement with a local solar provider and incur no upfront costs. Under such an arrangement TA would enter into a long term agreement to purchase the energy generated at a fixed price, and could eventually purchase the system outright at reduced cost.

Additionally, wind energy has seen similar growth in recent years. Numerous companies have engaged in large wind farms across the state. Smaller turbines may be less frequent and less productive, yet the installation of a turbine on Thetford Hill would provide the school with a steady source of electricity. Also, electricity production would increase in the winter when TA’s electricity demand is greatest. Unfortunately, permitting and capital costs may be prohibitive.

Energy Literacy & Learning

Clean energy technologies are rapidly growing: their presence and importance are becoming commonplace around the country and around the world. Regardless of TA’s choices to adopt cleaner, more efficient forms of energy, we urge that the aforementioned sources--and many others--should be intertwined to the curriculum. Numerous energy-education programs and activities are easily accessible to TA, creating great potential for the school to develop a learning environment surrounding this increasingly important topic.

Final Recommendations

Once considering the contents of this report, we recommend the installation of a pellet boiler when an upgrade in heating is next required. Although this recommendation does not require immediate action, it should be seriously researched prior to installation. TA is moving in the right direction regarding electricity consumption. Still, electricity demand at TA can be reduced by installing and maintaining the most recent appliance technologies, specifically for lighting, windows, and insulation. Affordable, carbon-free electricity can also be produced on the campus by installing a solar array.

2.1 Introduction to Energy and Efficiency

The goal of this report is to assist Thetford Academy in finding ways to improve their energy consumption and enhance their sustainability. We organized our ideas around the central theme of energy efficiency. This pertains not only to appliances—lighting, windows, insulation, etc.—but also to feasible alternative sources of energy. Overall, TA is efficient with regard to appliances, through their use of LED lighting and double-paned windows. However, there is room for improvement, specifically by switching to more effective window frames and additional glazing options on windows. We narrowed our alternative energy focus to three opportunities: biomass (namely pellet stoves), solar, and wind energy. These three were chosen because of their low carbon emissions as well as their successful implementation in many nearby institutions. Each alternative energy source is examined in terms of the opportunities offered within the state of Vermont.

Pellet stoves would provide TA with a good alternative to fuel oil and propane as a heating source. They are a feasible and sustainable option for TA due to their price stability, local sourcing, and minimal carbon footprint. Solar panels would provide TA with a relatively easy alternative to electricity from the VT grid. Wind turbines were explored as an alternate option for electricity generation, yet due to low wind speeds in Thetford and the long payback period, we find wind to be a less feasible option for TA. Investment on any of the aforementioned options is highly dependent upon the rate of return.

An important component of achieving change is building awareness and understanding of the issues. As a result, we feel strongly that these energy changes should be used as an educational opportunity so that their impact may stretch beyond Thetford. Witnessing and understanding these shifts in energy sourcing is crucial in shaping future generation's understanding of the impacts of our energy practices.

In sum, we recommend that TA continue to improve energy efficiency through lighting, window and insulation upgrades when buildings are renovated. We recommend the installation of a pellet boiler when existing oil boilers are retired. If TA strongly desires sources of renewable energy, we would suggest solar panel installation over the construction of a wind turbine, as we find solar to be more feasible and economically efficient than wind. Finally, we advocate integrating energy education into TA curriculum to improve students' energy literacy.

2.2 Energy Efficiency

Energy efficiency at TA is an important aspect of the school's improvement because it focuses on small, low-cost investments that can reduce long-term energy costs and the institution's carbon footprint. Modifications to TA's current appliances, including lighting, insulation, and windows, can greatly impact energy costs without having to consider the large-scale and long-term installations required of many alternative energy systems. Current energy efficiency at TA varies based on the age and structural layout of each building.

Over the past several years, TA has demonstrated determination in decreasing their electricity use. During the 2012-2013 school year, the school participated in Vermont's Whole School Energy Challenge, a program sponsored by Efficiency Vermont in partnership with Vermont Energy Education Program (VEEP) and the Vermont Superintendents Association's School Energy Management Program (SEMP). The program had three main goals: 1) to form a "Green Team" a collaboration of faculty, students, and staff, 2) to benchmark the school's energy use and assess opportunities for energy savings, and 3) to create and execute an action plan to save money through equipment upgrades, operations and maintenance, and student action (Efficiency Vermont, 2014). As a result of their participation in the Challenge, TA reduced their annual electrical energy usage from 499,444 KWH to 412,994 KWH, a decrease of 17.3 percent that saved approximately $8990.80 in electrical costs (Vermont Energy Education Program, et al., 2013).

This section examines the school's physical plant, including lighting and insulation, and identifies where there is room for future improvement. Energy efficiency projects achieve long term benefits with short term actions.

Lighting Systems at TA

Currently, TA has moderately energy efficient T8 and T5 fluorescent light bulbs installed in its newer buildings. Additionally, much of their lighting system is equipped with timers and sensors. The computer system that controls the lighting is complex and can be confusing to operate. As a result, the lights may not always be set for maximum efficiency. Due to difficulties in programming sensors and dimmers, lights are often left on in unoccupied classrooms (B. Hyde, personal communication, April 18, 2014).

Sustainable Lighting

Lighting typically represents 20 percent of the total energy usage in a K-12 school (California Energy Commision Public Interest Energy Research, 2004), indicating there is great potential for reduction in electricity costs by improving lighting options in school buildings. There are several popular ways to improve lighting efficiency, specifically in municipal buildings such as schools. A great way to assess different lighting options is to work with a lighting designer. Efficiency Vermont's RELIGHT program offers financial incentives to customers hoping to hire a lighting designer, substantially reducing the cost (Project Green School, n.d.).

Beyond TA's already installed timers and sensors, one relatively easy way to improve lighting efficiency is "daylighting," or using the natural light of the day to illuminate classrooms and other building spaces. Daylighting makes for pleasant and attractive spaces and has been shown to improve student concentration, mood, and well-being, in addition to reducing energy costs. Daylighting is a great option in schools, as students are known to need lesser levels of light for academic performance. The Illuminating Engineering Society of North America (IESNA) has released recommended light levels for different ages and activities (Fig. 2.1.1). Because younger eyes need less light than older people, daylight can provide most of the light necessary for classroom activities throughout the day. In conjunction with daylighting, some dimming fixtures can be programmed to auto-adjust based on ambient lighting, using electric lighting as a supplement to the natural light coming into the room (Project Green School, n.d.).

Insulation and Windows at TA

Overall, TA has a good handle on energy efficiency, yet there is still room for improvement, especially in regards to insulation. Considerable development has been made to the TA campus in recent decades, which has made the school increasingly efficient. However, many of these developments are undermined by lack of insulation and updates in older buildings; one of the building's has not had its insulation updated since its construction in 1958 (B. Hyde, personal communication, April 18, 2014). Because the insulation is outdated, it is likely the material may be decayed. Frequent inspection is beneficial and necessary because of the importance of insulation for heat conservation and also the periodic improvement in technology.

Almost all the windows at TA are double-paned and were installed during or after the 2008 renovations. Since that time there have been no noteworthy issues involving heat leakage, other than in the "annex" hallway that is likely due to a lack of wall insulation. Window efficiency could be increased by upgrading to triple-paned windows, which are most effective at reducing heat loss, especially when reinforced with pockets of gas between layers (Efficient Windows Collaborative, 2013). There are many ways in which window efficiency can be increased according to the Efficient Windows Collaborative for the state of Vermont. Double-paned or tripled-paned windows are the most effective at reducing heat loss. Two factors—U-factor and the Solar Heat Gain Coefficient (SHGC)—are important for selecting the most effective windows. The former is a heat rate measured in Btu/hr-sf-°F; a lower U-factor implies the window has a higher resistance to heat flow and is a better insulator. The SHGC is the amount of solar heat a window transmits, measured between 0 and 1. These two factors are important because the recommended values vary depending on climate. According the March 2013 report, a U-factor less than 0.22 and an SHGC between 0.41-0.60 is preferable. Additionally, glazing and tinting can help reduce certain solar radiation that would otherwise enter the window and will enable TA to achieve appropriate U-factor and SHGC levels. (Efficient Windows Collaborative, 2013). However, given that nearly all of the windows in TA are already double-paned, a more effective way to improve performance might be to evaluate building insulation.

Sustainable Insulation

The school contains various types of insulation in each of the buildings. The blown and spray foam insulation in the Science, Annex, and Anderson buildings are presumably the most efficient. However, the Styrofoam insulation in the roof of the Art/science building may be improved. Re-insulating TA's campus with the most cost-effective and efficient insulation will benefit energy efficiency efforts. The increased ability to retain heat during winter months may extend the life of the gas and oil boilers on campus.

In order to improve insulation, it is essential to understand where the deficiencies in insulation occur. Blower door testing and infrared camera analysis, which locate areas of low insulation effectiveness, should be used to target areas for insulation improvement. Spray foam has become popular recently, because of its ability to expand and fill structures completely. Certain types of foam are especially carbon conscious by recycling plastic waste to be used as insulation. Building Energy VT's Heatlok Soy brand can "reduce excess waste and energy consumption in buildings by up to 50 percent.” Companies such as VFI Inc. specialize in residential, commercial, and industrial spray foam insulation and energy efficiency contracting. (Building Energy Vermont, n.d.; Vermont Foam Insulation, n.d.).

Case Study

Craftsbury Academy, Craftsbury, VT

Craftsbury Academy is a small school with 158 students in grades 5-12. One challenge Craftsbury faces is its historic buildings. Similar to TA, these buildings are difficult to update for maximum sustainability and modernity while simultaneously maintaining important historic features. Craftsbury Academy reduced their electricity consumption by upgrading many of their lighting systems. The school increased its use of daylighting and borrowed lights for common areas and hallways. Any additional lighting in the building is supplied by super T-8 full-spectrum fluorescent lights with sensors. Craftsbury was unable to replace their window sashes on their historic double-hung windows due to historic codes. Instead, the window sashes were rebuilt and reglazed with low-emissivity glass (Ceraldi, et al., n.d.). Low-E glass reduces the heat energy lost through the windows, improving its insulating properties (Efficient Windows Collaborative, 2014).

The school also installed exterior storm windows with bronze weather stripping. Additionally, Craftsbury installed “Ecco” shades that are drawn down at the end of every school day. The shades provide a higher R-value for additional insulation against overnight heat loss. (Energy Star, n.d.). Craftsbury estimates the solar energy gained during the day through the windows is equivalent to the heat loss when shades are up. The Academy also improved other aspects of general insulation, adding Borate dense pack insulation to many of their walls, rough cut board sheathing, and adding pack around window frames. This improved insulation of the windows and walls has resulted in immense savings in heating costs at the school. The school’s first year energy savings after the renovations amounted to ~46 percent, or $29,120 in saved costs (Ceraldi, et al., n.d.).

Recommendations for Efficiency

After analyzing the infrastructure of TA, we recommend three options for improving energy efficiency: replace future bulbs with LED lights, continue to upgrade windows with double- and triple-paned models, and ensure that the computer system that controls heating and lighting is being run efficiently. First, using as much LED lighting throughout the buildings will allow the school to minimize the energy needed to light the school. While it is difficult to reduce using lights throughout the day, LED models will ensure that a more sustainable level of energy is maintained. Second, the double- and triple-paned windows are the best models for retaining heat, which is particularly useful for Thetford’s cooler climate. Third, proper use and understanding of the computer system will prevent unnecessary additional energy use from lighting and heating systems being in use either at night or on school breaks when it is not necessary.

2.3 Alternative Energy: Biomass Heating

Vermont, due to its great potential for wood chip and pellet production and a favorable regulatory environment, leads the nation in biomass heating and has a well-established biomass market. In fact, over 20 percent of Vermont students already attend a school that utilizes biomass heating (Biomass Energy Resource Center, *Vermont Fuels*, n.d.). Following the example set by other Vermont schools, TA could realize significant environmental and economic benefits by replacing the current oil-burning heating system with a wood boiler system.

Economic Benefits/Risks

Installing a wood boiler system at TA would be of economic benefit not only to the school, but to surrounding communities as well. Although the installation of a wood boiler system entails significant upfront capital costs, the long-term savings tend to be substantial (Biomass Energy Resource Center, *Vermont Fuels,* n.d.). Oil, gas, and propane are expensive and volatile in pricing. Biomass, in contrast, costs on average 30-50 percent less than fossil heating fuels and tends to be much more price stable (Biomass Energy Research Center, 2007, *Wood Pellet Heating*). Many schools have been able to pay back the initial costs of boiler installation with the money saved on fuel purchases in only a few years (see case studies), and there are several Vermont state initiatives aimed at helping schools finance the installation of biomass heating systems. For example, pending a favorable life cycle cost assessment, the Vermont Department of Education offers grants covering up to 50 percent of project costs for schools installing biomass heating systems. Bonds, loans, leasing and third party financing are options as well (Biomass Energy Resource Center, n.d., *Vermont Fuels*).

Furthermore, shifting energy costs from oil — sourced from out of state multinational corporations — to Vermont-grown wood keeps money within the state, bolstering the state economy (Biomass Energy Resource Center, n.d., *Vermont Fuels*; Lorber, 2013). Increasing demand for biomass in the state could lead to more job creation and further strengthen the VT economy (Lorber, 2013). Dartmouth College Forester Kevin Evans offered an example of this occurring in northern NH, where his town “talked about a pellet boiler [which cost] $40,000 with five local logging firms in town, [and has] forty to fifty people who work in the woods,” versus a gas boiler which might only supply one local job “in the form of a delivery man.” Evans concluded that in choosing to install a pellet boiler system there are often economic benefits as well: “it’s not always about what is better for the environment” (K. Evans, personal communication, April 21, 2014).

Cost Analysis of Biomass Systems

In terms of heating potential, one ton of wood pellets, which costs approximately $200, is equal to 120 gallons of heating oil or 170 gallons of propane. That is the equivalent of paying $1.67 per gallon for heating oil or $1.18 per gallon for propane (Maker, 2004). In reality, TA spent $3.029 per gallon for heating oil and $1.49 per gallon for propane in 2013 (L. Lanteigne Magoon, personal communication, April 23, 2014). Biomass has great cost-competitiveness potential (Fig. 2.2.1, Fig. 2.2.2).

There are several techniques for analyzing the cost effectiveness of biomass systems. One is the payback period, or the number of years it takes to recover the initial investment. This is a very simple analysis which does not take into account several factors, including the cost of capital, or the interest rate one would pay for a long-term loan, as well as the magnitude of expected future energy savings and the costs of future equipment replacement for both the biomass system and the alternative fuel system to which it is being compared. Another method is first-year cash flow analysis, a determination of whether the project's cash outflow in the first year, which is typically the first year's loan payment, is greater than the first-year fuel savings, as well as any other savings that the project generates. If this figure is positive, the project is definitely cost effective. If the figure is negative, the project may still be cost effective if the competing fuel price inflates faster than the wood fuel price, and/or if the fuel cost savings in the years after the loan has been paid off are "dramatic enough to offset the short-term negative cash flows" (Maker, 2004).

The third and most robust method is life-cycle cost analysis, in which all costs and all benefits are analyzed for each year of the project's entire life. This type of analysis "accounts for future changes in fuel costs of the biomass fuel and the competing fuels. It also considers the cost of financing; looks at differences in maintenance, repair, and replacement costs of the competing options; and takes into account the future value of the dollar" (Maker, 2004). Life-cycle cost analysis must be compared to the life-cycle cost of not installing the wood system "by characterizing the 'do-nothing' option in the same way that the wood system installation was characterized" (Maker, 2004). A preliminary life cycle cost assessment is generally done during the planning stages, and a final one is completed once actual construction bids and other costs are finalized.

Key parameters for a life-cycle cost analysis of a wood-chip heating system are:

- ❏ initial system equipment/installation costs (including any building construction)
- ❏ costs for system design and project management
- ❏ the life of the basic wood-chip system equipment and any required building construction
- ❏ future wood-chip system equipment replacement costs
- ❏ salvage value of existing equipment no longer needed after the new system is installed
- ❏ costs associated with the backup fuel system
- ❏ annual wood-chip system maintenance and repair costs
- ❏ the projected volume of wood chips required annually

- ❏ the projected volume of backup fuel required annually
- ❏ the projected electric use and first-year costs associated with running the system
- ❏ the current price of wood chips, backup fuel, and electricity (energy and demand)
- ❏ annual fuel price inflation rates for wood chips, backup fuel, and electricity
- ❏ timing and amount of financing costs (principal and interest)
- ❏ amount of financial incentives such as grants that will offset the installed cost
- ❏ annual general inflation rate
- ❏ the owner's discount rate for the investment

(Maker, 2004)

Environmental Considerations

Installing a wood boiler system at TA would benefit the environment by reducing the school's carbon footprint and decreasing sulfur emissions. Biomass is a renewable resource - when wood is harvested, unlike oil, it has the ability to grow back and sequester carbon released during combustion relatively quickly (Biomass Energy Resource Center, *Vermont Fuels*). The burning of both wood pellets and wood chips have lower global warming potential (GWP) than the burning of fossil fuels. Of the different forms of biomass, pelletized fuels do have greater GWP. However, their GWP is still significantly less than that of fossil fuels (Itten et al., 2011). Furthermore, combusting wood releases less sulfur, a major cause of acid rain, into the atmosphere than combusting oil (Biomass Energy Resource Center, *Vermont Fuels*; Itten et al., 2011).

While there are several environmental concerns associated with biomass boiler systems, simple actions can be taken to minimize these impacts and ensure the environmental benefits of replacing oil and gas with a wood boiler system outweigh the harms. One environmental concern associated with biomass boilers is the production of particulate matter (PM), an atmospheric byproduct of combustion that can be inhaled and negatively affect respiratory health (Biomass Energy Resource Center, *Particulate Matter*, 2011).

PM emissions can be minimized in these systems in a variety of ways. First, selecting an automated feed system for wood boiler installation will help maximize boiler efficiency, thereby limiting emissions. Fuel type and storage method will also have a great impact on the system's discharge. Wood chips must be dry and clean of any leaves or dirt. To prevent this contamination, chips should be stored off of the ground in a covered container. PM emissions from pellet boilers largely depend on pellet-grade: higher quality pellets, as defined by the Pellet Fuels Institute (PFI), will emit less PM. Utility, the lowest grade pellets, have a maximum ash content of 5.0 percent; Standard, 2.0 percent; Premium, 1.0 percent; and Super Premium, 0.5 percent. Finally, installing PM controls equipment such as mechanical scrubbers or fabric filters can significantly decrease emissions (Biomass Energy Resource Center, *Particulate Matter*, 2011).

Deforestation and unsustainable forestry may also be of concern in switching to biomass boiler systems. However, the wood used for wood chips and pellets is often low-grade wood from low-value boles, crooked or diseased trees, mill residues, furniture makers, or other secondary sources, and would otherwise go unused (Biomass Energy Resource Center, *Vermont Fuels*; Jensen, 2013; Vermont Bioenergy Initiative, 2013). Evans emphasized the value of wood as a local resource in VT and NH. He agreed that biomass burning could become unsustainable if forests were overcut, but he believes that we are currently nowhere near an unsustainable level of extraction. In fact, utilization of low quality wood may improve overall forest health. New Hampshire and Vermont may serve as a "region of the country that can afford to fill the harvest need" (K. Evans, personal communication, April 21, 2014). Thus, TA is regionally well-suited to install a biomass boiler system. With wood in great abundance in the state of Vermont, the likelihood of over-harvesting as a result of increased demand is low.

Wood Chips vs. Wood Pellets

Municipalities, such as schools, generally install either wood chip or wood pellet boiler systems when transitioning to biomass heating systems. Wood chips are best suited for heating medium to large sized buildings such as schools or community centers (Vermont Bioenergy Initiative, 2013), and tend to be cheaper than pellets (Biomass Energy Resource Center, *Vermont Fuel*s). A woodchip boiler will also release more PM than an oil or gas boiler. For a 200,000 square foot school, a wood chip system will release approximately the same amount of PM as five home wood-stoves over the course of an entire winter (Biomass Energy Resource Center, *Vermont Fuel*s). In general, wood chip systems are best for high-energy demand buildings, but they require more maintenance than pellet boilers (Biomass Energy Resource Center, *Wood Boiler*, 2011). Fully automated wood chip systems require approximately thirty to sixty minutes of operator workload daily and are appropriate for about 50,000-500,000 square foot facilities. Semi-automated wood chip systems are a good match for smaller facilities such as rural schools (10,000-50,000 sq. ft.), but require sixty to ninety minutes of daily operator workload (Biomass Energy Research Center, *Wood Boiler*, 2011).

Wood pellets are made from wood chips and shavings that are compressed under high heat and pressure into uniform pieces. A natural lignin within the plant allows the material to harden while cooling to create the pellet structure (Vermont Bioenergy Initiative, 2013). Wood pellet boilers are practical for a wider variety of energy demands, take up less space, require less daily maintenance, and are often cheaper to install and easier to operate than wood chip boilers. Some reports approximate daily operation time for ash removal to take twenty to thirty minutes per day for a pellet boiler (Biomass Energy Research Center, *Wood Boiler*, 2011). However, local case studies have indicated that much less time is actually required for boiler maintenance (R. Hutchins, personal communication, April 11, 2014).

The System

According to the Biomass Center's pellet guidebook, typical wood pellet heating systems include:

> a fuel storage silo with an auger system that delivers the wood pellets from the silo to the fuel hopper. The wood pellets are fed from the fuel hopper through the fuel feed system into the combustion chamber at a rate determined by the control settings. A combustion fan supplies air to the combustion chamber and the exhaust is ducted to the chimney through a port at the rear of the system (Biomass Energy Resource Center, *Wood Pellet Heating*, 2007).

Main system components include:

- ❏ Storage Silo
- ❏ Fuel Conveyor/Auger System
- ❏ Fuel Hopper and Feed System
- ❏ Combustion System (Boiler)
- ❏ Electronic Controls
- ❏ Connection to Existing Chimney
- ❏ High Temperature Chimney (if there is not an existing chimney to connect to)
- ❏ Plumbing Connections (to the building's hot water heat distribution system)

(Biomass Energy Resource Center, *Wood Pellet Heating*, 2007)

Optional system components:

- ❏ Ash Removal System
- ❏ Automatic Soot-Cleaning System

(Biomass Energy Resource Center, *Wood Pellet Heating*, 2007)

Complete wood pellet systems generally cost between $75,000 and $100,000 per MMBtu of heat output, and the cost components can include:

- ❏ System equipment and installation
- ❏ Complete fuel storage and handling system, including installation and any optional system components
- ❏ Construction (such as building additional boiler room space or a new boiler house, if required)
- ❏ Site costs (possibly including driveways for fuel deliveries)

- ❏ Chimney equipment and installation, if required
- ❏ Emissions permit or control equipment, if required
- ❏ Professional fees (such as those for engineering)
- ❏ Connection of controls and piping to the existing system

(Biomass Energy Resource Center, *Wood Pellet Heating*, 2007)

Resources

There are several Vermont-specific resources that could help TA in its transition to wood-pellet heating. First, state aid is available to help fund the initial costs of boiler installation. Vermont Fuels for Schools is an initiative of the Biomass Energy Resource Center (BERC) in collaboration with the Vermont Superintendent Association's School Energy Management Program (SEMP) and in cooperation with the VT Department of Education, Department of Public Service, and Department of Forests, Parks and Recreation, with funding from the US Department of Energy. Vermont Fuels for Schools provides educators with information and support needed to successfully implement biomass burning heating systems and replace current oil burning systems. SEMP, in collaboration with Vermont Fuels for Schools, performs free site visits to assess whether a transition to biomass boiler systems at Vermont schools is feasible. The initiative has also designed a life-cycle cost analysis tool (LCC) for schools to use in determining their eligibility for state aid (Biomass Energy Resource Center, *Vermont Fuels*).

Local energy installation companies could also assist TA in a transition to biomass heating. For instance, Froling Energy, a company based out of Peterborough, NH, calculates the energy savings of a new biomass system based on the school's historical data and "real-life" efficiencies, accounting for the fact that equipment is not always run at maximum efficiency. The company bases their estimates on the payback costs of a boiler and the installation costs of the boiler and can provide feasibility and sustainability studies to its customers (Froling Energy Services, 2013).

Case Studies

Mascoma Valley Regional School District, Canaan, NH

Other VT and NH schools have recently made the transition to pellet boiler stoves from oil-burning systems with great success. Mascoma Valley Regional School District replaced the oil-burning heating systems in all five of their schools with Okofen or Froling pellet boilers in the summer of 2013. Before the boiler installation, the district, consisting of five schools in total, used approx. 62,000 gallons of oil for heating in the 2012-2013 winter, spending approximately $207,000 on oil for the season. In the 2013-2014 winter season, over 80 percent of the heating for the district came from pellet boilers. The district spent approximately $93,000 on wood pellets and $8,000 on oil to supplement the pellet heating system. Maintaining and installing the pellet systems has been a very easy process, according to Roger Hutchins, Mascoma Valley Regional High School's head of facilities. During the coldest weeks of the winter, the high school's pellet boiler ash bucket needed to be emptied only once a week, a five to ten minute task. The pellets are sourced from Lyme Green Energy, a local company. The pellet boilers were installed as part of a larger energy-saving plan implemented by Johnson Controls, and the installation costs of the pellet boilers are being paid back over time with the money saved in heating fuel costs. When asked about his least favorite part of the high school's new boiler system, Hutchins had a difficult time responding. Finally, he admitted when the boilers were first installed, the buildings were a little bit drafty, for controlling the new heating system required some adjusting to (R. Hutchins, personal communication, April 11, 2014).

The White Mountain School, Bethlehem, NH

The White Mountain School also replaced their oil-burning heating system with three Okofen pellet boilers. The installation cost approximately $128,000. Prior to the installation, the school spent ~$72,000 on oil each year. Since switching to pellets the school has saved over $40,000 each year, using only 150 tons of pellets to heat the school each winter (Jensen, 2013).

ROI: Wood Pellet Boilers

As the cost of oil is rising, pellet boilers have become a more popular options (Bean Foster, 2013). Pellet boilers require slightly more maintenance than oil heating systems, but are superior to wood chip boilers in terms of cost of labor, as pellet boilers must be filled once per day (Bean Foster, 2013). Nonetheless, pellet boilers are generally considered to be very cost-effective once installed; generally, "cost about half of what oil costs to produce the same heat, and 40 percent of what it costs to heat with propane" (Bean Foster, 2013). TA currently runs its heating system on propane and oil; the New Hampshire Office of Energy and Planning reports that propane currently costs $3.821 per gallon (NH Office of Energy and Planning, 2013), while oil, TA's more frequent fuel choice, oil (B. Hyde, personal communication, April 18, 2014), currently runs at $3.807 per gallon. Pellet boilers are delivered and thus priced in different units, with one ton of "bulk delivered pellets" costing approximately $243 (NH Office of Energy and Planning, 2013).

To compensate for the disparity in purchase units across fuel types and allow consumers to more accurately compare their fuel options, price of fuel is often measured in dollars per million BTU (British thermal units) of heat. Bulk-delivered wood pellets in New Hampshire currently cost $14.71 per million BTU, as compared to $41.84 for propane and $27.84 for oil (NH Office of Energy and Planning, 2013). When measured in uniform units, the price differential between pellets and oil/propane is striking; per heating unit, pellets are currently 47.2 percent cheaper than oil and 64.8 percent cheaper than propane.

The current heating system at TA consists of three boilers: two installed in 2008, one approx. 15 years old, and one approx. 20 years old, and a propane boiler installed in 2008 (B. Hyde, personal communication, April 18, 2014). TA used an average of 25,965.35 gallons of propane over winters 2011-2012 and 2012-2013, during a period spanning from August 22, 2011 to May 10, 2013. During the same period of time, TA purchased 21,414.9 gallons of fuel oil, or 10,707.45 gallons per year. Given current fuel oil and propane prices, and assuming stable prices over this two-year period, fuel costs were approximately $40,763.26 for oil per winter, and $99,212.27 for propane per winter, approximately $139,975 was spent on heating fuel per winter (L. Lanteigne Magoon, personal communication, April 3, 2014).

With fuel oil valued at 138,690 BTU per gallon, 10,707.45 gallons of fuel oil is equivalent to 1,693,051,240.5 BTU of heating energy purchased per year to heat TA, while 25,965.35 gallons of propane, valued at 91,333 BTU per gallon, provided an average of 2,371,493,311.5 BTU per year. Thus, in an average winter, TA requires approximately 4,064,544,552 BTU of heating fuel to heat the campus. At 16,500,000 BTU per ton, TA would require approximately 246.34 tons of pellets to heat the campus per winter. At $243/ton, heating solely by pellet stove, excluding cost of labor, would cost approximately $59,859.66 per year — $80,115.34 and 57 percent less per year than the current mix of oil and propane, excluding labor costs. Annual maintenance is estimated at about $2,000 per year for pellet boilers, so even including labor costs, the school would save approximately $78,115.34 per year (Yellow Wood Associates, Inc., 2011)

Assuming that implementing pellet boiler installation to replace a gas or oil boiler would cost approximately the same at TA as it did at White Mountain School, a pellet boiler would cost approximately $128,000 to install. Given this cost, replacing all four boilers with pellet boilers would cost approximately $512,000. The 15- and 20-year-old boilers are scheduled to be replaced within the next several years (B. Hyde, personal communication, April 18, 2014).

Assuming that a single pellet boiler would displace one fourth of TA's oil and petroleum usage, we can assume that the school would save $19,528.84 per pellet boiler installed per year. At a cost of $128,000 per boiler, each boiler would take 6.55 years to pay for itself, with a 15.3% return on investment. Additionally, industry experts predict that as the price of heating oil rises, the gap in price between oil and wood pellets will increase (Geiver, 2012).

Recommendations

Because pellet stoves burn more cleanly, require less maintenance, have lower installation costs, and have a greater ROI, we recommend the installation of pellet boilers--when required--as a replacement for oil or gas-burning boilers at TA.

2.4 Alternative Electricity

State and nationwide electricity production have seen dramatic changes over the past three decades through the increased use of nuclear, hydro, and wind. However, our nation still heavily relies on fossil fuels to meet electricity demands. Solar and wind energy will not entirely offset these demands, but utilizing alternatives will increase TA's resilience and lock-in stable, affordable electricity rates. Though solar and wind may have longer payback periods, they provide significant stability to the uncertain market for fossil fuels. Climate change, dwindling fossil fuel resources, and high transportation costs are all vulnerabilities associated with TA's current energy practices. It is unlikely that TA, or any school, can immediately overhaul their energy portfolio, but taking steps towards clean and efficient energy use will produce immediate and continued benefits.

Electricity costs are subject to frequent change as a result of off/on peak hours as well as changes in production methods and prices. For the calculations conducted in this report, we will use a price of $0.09 per kWh to account for some of these uncertainties, as it seems to be a reasonable estimate based on Green Mountain Power reports.

Net Metering

Net metering, generally speaking, is a policy that allows residential and commercial consumers of power to sell unused, sustainably-generated electricity back to the grid. If an establishment participates in net metering, and is generating more power than it is consuming at a given time, the establishment's electricity meter will run backwards to credit the establishment for electricity generation, and the establishment is only billed for its net electricity usage — that is, electricity usage from the grid minus the power sold back to the grid (Solar Energy Industries Association, n.d.).

"In order to net meter, customers must first apply for and receive a 'Net Metering Certificate of Public Good' from the Vermont Public Service Board (PSB). Net metering in Vermont is generally available to systems up to 500 kilowatts (kW) in capacity. An additional meter must be installed to record each system's output. Customers retain ownership of the renewable-energy credits (RECs) associated with the electricity generated by PV systems" (DSIRE, 2014, *Green Mountain Power*).

2.4a Solar Power

Solar energy in Vermont is an expanding industry. In recent years, a variety of installers, nonprofits, electricity providers, and local governments have created plans and projects throughout the state that are focused on making the transition away from fossil fuels affordable and reliable. While the benefits of solar energy are clear, paying for the initial setup and installation of the power collection system can be difficult due to the potentially high costs and infrastructure changes. Additionally, the town of Thetford has recently partnered with Strafford in organizing a large shift towards residential solar energy in the project titled “Solarize Thetford-Strafford.” In considering solar power, TA has the opportunity to be consistent with the town’s efforts and support the shift towards reducing greenhouse gas emissions. Presented in this section is an overview of options that TA might consider when weighing the costs and benefits for a solar power system.

Projects and Programs

The United States Federal government provides a variety of incentives for renewable energy projects, which include tax credits, grants and loans (DSIRE, 2014, *Financial Incecntives*). Currently almost all national energy exemptions and credits are residential or tax-based, and TA would not necessarily qualify for these programs.

The state of Vermont itself does offer a variety of programs that TA may qualify for. The first program of interest is Green Mountain Power’s (GMP) solar power credit program, which offers producers of solar power a credit for the energy they produce (DSIRE, 2014, *Solar*). The program pays customers for the solar energy produced by their solar panel systems, according to the value of the power and the amount produced. It does require an application process and the installation of a power meter to directly measure the amount of power outputted by the customer’s system (Green Mountain Power, 2014, *FAQ*).

Of the programs offered by the state of Vermont, one of the most helpful with upfront installation costs would be the state’s Small-Scale Renewable Energy Incentive Program (SSREIP), which provides qualified projects with funding based on a competitive application process (DSIRE, 2014, *Small-scale*). For a school such as TA, up to $12,500 or 50 percent of the system’s total installed cost may be paid by the program. The funds typically apply for systems up to 10 kW, although larger systems may qualify under a “public good” exceptions program. Again, as of the writing of this document, there are still funds available through the program’s application process (Vermont Energy Investment Corporation, 2014).

A related program, Vermont’s Clean Energy Development Fund (CEDF) provides grants through a competitive process to clean energy projects that demonstrate community good. As a school, TA would be eligible to apply. The CEDF may provide funds of up to $125,000 with a 50 percent match of provided funds expected from applicants (Vermont Public Service Department, 2014, *Clean Energy*). As a note, the website states that organizations qualified for funds from the aforementioned SSREIP will generally receive funds from that program unless a “convincing” argument to receive funding from the CEDF is made (Vermont Public Service Department, 2014, *Community Solar*). Both programs are good options, and the particular solar system/project/etc. undertaken by TA would dictate which program would be the best fit.

Various schools throughout Vermont have been progressively installing solar panels for greater energy efficiency. Many of the schools have used the proximity to such projects as educational tools on clean energy for students and faculty, as well as the surrounding community.

Case Studies

College of St. Joseph's, Rutland, VT

First, GMP has recently been committed to solarizing Rutland, VT, and through these projects has demonstrated the benefits and reliability of solar power. The company works on a performance-based incentive and operates in the residential, industrial, commercial, nonprofit, governmental and schooling sectors. The incentive is offered for participants in a net-metered photovoltaic system. The Vermont Public Service Board offers certificates for various applicants to be eligible for net metering. Participating customers then have ownership over their Renewable Energy Credits.

Within the past year, GMP submitted a proposal to solarize the College of St. Joseph's in Rutland, VT. The college is a similar size to TA, made up of 320 students. The project proposed to install solar panels on the roof of the college's athletic building, with GMP both owning and operating the system. In January of 2014, the project was completed with a capacity of 98 kW. The arrays were installed by Positive Energy of Poultney, VT (DSIRE, 2014, *Green Mountain Power*).

The partnership functions under GMP's credit system so that the college is credited by GMP for 10 percent of the solar system's output. The energy that the college's arrays produce are also used by other local GMP clients through electric grid distributions.

According to the college's President, Rich Lloyd, the solar system "will serve as a physical symbol of the connection [the school is] making to the GMP Energy Innovation Center and will serve as an educational tool for [their] students and visitors" (Green Mountain Power, 2014, *College*). The project has since been titled "College of St. Joseph Farm." Other colleges that have partnered with GMP on solar projects include Castleton College, Community College of Vermont, and Green Mountain College (Green Mountain Power, 2014, *College*).

Camels Hump Middle School, Richmond, VT

Camels Hump Middle School installed their solar array in the fall of 2011. The school now has 507 roof-mounted solar panels, and it now represents one of the greenest public schools in Vermont. Collectively, the panels generate roughly 135,000 kW per year, accounting for about 25 percent of the school's electricity needs. The panels generate enough electricity to cut about $25,000 per year from the school's electric bill. ReKnew Energy Systems, located in White River Junction, VT, installed the system.

Funding for the project came from a collection of grant money that totaled $500,000, eliminating any costs for the local taxpayers. In fact, according to school principal Mark Carbone, many of the school's energy efficiency projects have been created with reducing taxpayer expenses as a primary goal . A large portion of the funding for the solar arrays has been accumulated through the work of Senator Bernie Sanders, (Vermont Progressive Party-VT), who has helped fund similar installations at other Vermont Schools. Other major funders of the projects include the State of Vermont and GMP (Solar Schools Program) (Mallery, 2012).

CHMS has taken the solar installation into the classroom as an opportunity for students to explore how it functions and its efficiency. This past year, the fourth grade Science class and eighth grade Design and Technology class teamed up to conduct experiments on solar energy, exploring both sustainable technologies and the scientific operations of energy and matter that play a role in the function of solar machinery.

Crossett Brook Middle School, Duxbury, VT

A similar solar project was recently completed in January at the Crossett Brook Middle School in Duxbury, VT, which serves 260 students. As a 157 kW installation of 140 panels, the project marks the largest school solar system in the state of Vermont. The pair of solar arrays is now responsible for roughly one-third of the school's power, and the project dynamically involved both Waterbury Local Energy Action Partnership (LEAP) and SunCommon installers. The array is located on a hill next to the school and complements existing roof-mounted panels the school installed previously (Valley Reporter, 2013).

Green Lantern Capital helped fund the project by eliminating the CBMS' upfront cost and instead having the school pay monthly with a credit system, reducing 10 percent of those costs. According to school principal Tom Drake, "the financing option made it an easy budget decision and [they are] already incorporating the project into [their] curriculum. Our goal is for Crossett Brook to be a leader when it comes to sustainability science education." (Courrégé Casey, 2013).

Teachers make use of the installation in their own backyard by designing curriculum to examine the way it functions and the ways in which it influences the school. The new sustainability program at CBMS has worked to create a curriculum for the middle school students to learn about alternative energy (Valley Reporter, 2013).

CBMS school posts their energy savings on a website so that students, parents and faculty can understand the quantitative effects of the solar installation. Students also use the online data for school projects about clean energy. The website includes information on the amount of CO_2 emissions avoided, gallons of gasoline saved, the amount of trees CO_2 conservation offsets and much more. This is another way the school has made use of the program as an education opportunity not only for the students, but for the entire community as well (DECK Monitoring, 2014).

Governor Shumlin (D-VT) identifies the project as "one more example of Vermont's leadership in developing renewable energy resources and in driving math and science education in [Vermont] schools. Moving forward, [they will] be working to strengthen

Vermont's solar programs so that every Vermont school can follow Crossett Brook's lead." (Valley Reporter, 2013).

Middlebury College, Middlebury, VT

With a student body just under 2,500, Middlebury College is one of Vermont's smaller colleges. What they lack in size, however, is compensated for by their diligent efforts at improving campus sustainability. Currently, there are two two solar array systems fully equipped with GPS solar trackers (correspondence Jack Byrne, April 21, 2014). The field was established under a purchasing power agreement, which helped compensate for the costs of the 143 kW and 500 kW systems. The boards are outfitted with four-by-five panels each and attached to ground mounts, covering nearly two acres of land. Middlebury annually accrues $5,000-6,000 from the arrays (correspondence, Jack Byrne, April 21, 2014). Though the system is well-maintained and strongly supported by a large network, the production and success of the project clearly demonstrates the potential for significant solar energy production within Vermont.

From information received from the school, TA used a total of 406,652 kWh of electricity from 2011-2012 and 491,286 kWh from 2012-2013. Of both totals, approximately two-thirds of the energy was consumed during peak hours and the highest demand was seen in winter months. Figures 2.4.1 and 2.4.2 show electricity production from the 143 kW array: between March '12 and June '13 the panels produced 353,096 kWh of electricity. At TA during that same period the school drew 574,815 kWh of energy--over 61% of the energy could have been produced via solar energy. During summer months when students are not in school, the electricity demand declines dramatically (Fig. 2.4.3). August 2012 at TA withdrew a mere 17,727 kWh of electricity while the Middlebury array produced 29,371 kWh. State and federal legislation requires electrical companies to purchase excess electricity at a higher price than they charge (J. Byrne, personal communication, April 21, 2014); $.09 per kWh of energy in Vermont . Thus, the school would have been able to fulfill their electricity demand for August while also making a profit of at least $1,048. (AllEarth Renewables, Inc., 2014; Vermont Electric Co-op, Inc., 2012).

Fig. 2.4.1 Time-lapse night view of Middlebury College's solar array (AllEarth Renewables, 2014)

Return On Investment

In the state of Vermont, ROI for investment in solar energy is estimated at 5.6 percent per year, making Vermont 22nd out of the 50 states and Washington, D.C. This calculation is based on a combination of the cost of solar energy — a function of sunlight intensity, efficiency of solar array, and installation cost — conventional electricity rates, and state and federal solar incentives, which include tax credits, rebates and other incentives (Cost of Solar, 2013).

However, because TA presents a special case being both a non-residential establishment and a combination between a public and private academy, a more accurate assessment of the cost of solar at TA should take into account a more detailed and tailored set of factors.

TA consumes an average of 37,414 total kW per month, with an average of 23,853 kW during peak hours, and 13,519 kW during off-peak hours, which typically span from 11 PM to 7 AM (L. Lanteigne Magoon, personal communication, April 3, 2014).

If TA does not participate in a group net metering project in the future, one advantage solar has over wind power is that solar power generation is concentrated during daylight hours, which coincide with hours of operation and thus hours of peak energy consumption for the academy. If TA either cannot sell its power back to the grid, or must sell the power back to the grid at a highly discounted rate at off-peak hours, solar may be an advantageous option for electricity generation.

However, if net metered, Green Mountain Power, TA's electricity provider, provides a performance-based incentive for installed solar power. This broad-based incentive applies to Commercial, Industrial, Residential, Nonprofit, Schools, Local Government, State Government, Federal Government, Agricultural, and Institutional establishments, and thus would apply to TA. This incentive allows a $0.06/kWh credit in addition to the net metering discount (DSIRE, 2014, *Green Mountain Power*). Because, on average, only 20-40 percent of solar-generated electricity goes back onto the grid, possibly because solar's peak hours often coincide with peak electricity consumption hours, this incentive provides a useful method of increasing ROI on solar panel installation (Solar Energy Industries Association, n.d.).

One option for solar is to use a power purchase agreement with a local solar company. Under this process, the company installs the solar panel for TA, paying for purchase and installation of equipment for Thetford. TA would then enter into a long term agreement to purchase electricity from the system at a predetermined price, and after a certain number of years Thetford would have the option to buy the equipment at a discounted price and begin saving money directly. Several local renewable energy companies provide an option for this plan. In some cases, such as with the Valley Community Loan Fund, TA would automatically own the solar panel after a certain number of years at no additional cost. These plans would allow TA to install solar panels at a highly discounted rate, leading to a higher return on investment. Even if Thetford never owns the panels, this method could provide a cost-free way to be more sustainably powered.

Because TA has similar sunlight patterns to nearby Thetford Elementary School, it can be assumed that cost savings would be comparable to those presented by the committee at Thetford Elementary School, who are currently working to install solar panels.

According to an online solar energy calculator based on location, a quality solar panel system of size 36kw, which is what TA would aim for to offset 10% of their power bill, would generate 41,218 kWh of electricity per year in Thetford, VT, provided that the system was installed in an unshaded region (Solar Estimate, 2014). Such a system would have a gross cost of approximately $125,965, but with a 30% federal tax incentive, the net upfront cost of the system would be about $88,175. Assuming 41,218 kWh of electricity generated per year, and assuming that all solar electricity generation would occur during daylight, which also happen to be peak hours, TA could save $3,759.17 per year through solar panel installation of this size. Given the cost of $88,175, return on investment for solar panels would be 4.3% per year, leading to a 23.5 year payback period.

Additionally, the state of Vermont allows a solar incentive of up to $12,500 per solar electric system installed for consumers in a "special category" outside of residential establishments. If TA were approved for this special category and received the highest possible incentive, solar panel installation could cost as little as $75,675, leading to a 5% return on investment of and a 20.1 year payback period.

Recommendations

Solar power offers a dependable, low-maintenance source of clean energy. It is a project that is suitable for TA's size and energy demand, and there is ample space for the project on campus. As Thetford and Strafford attempt to solarize the residencies of the towns, applying the same approach to the schools would further their attempts at reducing fossil fuel emissions and bolster this unity. Vermont's rapidly expanding solar industry continues to provide affordable and reliable opportunities for institutions such as TA, which can save money on energy bills and facilitate clean energy goals.

2.4b Wind Power

Wind turbines operate by capturing the kinetic energy in the wind as this energy rotates their blades. These blades connect to a shaft, which in turn rotates an electric generator that creates electricity. Wind is one of the largest sources of renewable energy in the United States, making up 3% of total electricity usage, which is the equivalent of approximately 12 million households (US Energy Information Administration, n.d.).

The effectiveness of turbines as a major source of clean energy varies tremendously by location. Ideal locations for wind are flat, uninterrupted, high-speed wind areas; this is the reason that wind farms are often located on plains or in offshore regions. One challenge in turbine installation is choosing appropriate locations that make the large cost of installation worthwhile. Another challenge to wind power generation is the problem of storage and distribution; since wind is generated relatively evenly throughout the day, power generation may not correspond to the timing of power consumption, leading to a problem of how to store the energy that is not used, and how to retrieve sufficient energy during times of high demand. For these reasons, wind turbines are often installed in large wind farm projects in ideal locations, equipped with storage and distribution infrastructure (US Energy Information Administration, n.d.).

Thetford, Vermont is situated 600 feet above sea level making it a suitable location for wind power, relative to the Upper Valley (Town of Thetford, 2014). Studies have been conducted to test the forgone energy lost from decreased air density, however a 10% reduction is only seen at 3,500 feet (Rashford, 2010). For TA, residential turbines may have the greatest impact on electricity costs while having the least public opposition. Recent development in turbine technology has made low-to-moderate wind regions more suitable for harnessing energy.

Zoning

A major concern often raised about wind turbines is the visual disturbances, particularly in relatively pristine locations such as Thetford. TA falls within the Thetford Hill Historic Preservation, which strictly regulates any of TA's development plans in order to preserve the historic appearance of the area.

Since most turbines exceed 35 feet in height, Section 3.02 of Thetford's zoning laws would apply and require that the turbine be set back from property lines a distance at least equal to its height. Regulations that may apply to the development of a wind turbine include noise regulations, which stipulate that noise shall not exceed 60 dBA during daytime hours, and may not exceed 50 dBA between 7:30 pm and 7:30 am. However, this is unlikely to be a problem as relatively large wind turbines generally produce around 40 dBA. Additionally, noticeable ground vibration is prohibited beyond the boundary of TA's property (Thetford Development Review Board, 2011).

Additionally, given the location of TA within the historic district, development on TA land, particularly development such as a wind turbine that would be visible from nearby properties, is subject to a variety of regulations through which the outcome of the project would be at the discretion of the Thetford Development Review Board (DRB). The DRB mandates that "consideration shall be given to the impact of the proposed development on historical structures on the site or on adjacent properties" (Thetford Development Review Board, 2011). Thus, this development will likely be subject to a public hearing as well as review at the discretion of the DRB, leading to potential hurdles in approval for turbine development and installation.

Public Support

Wind energy is not new to Vermont: in 2011 the New York Times featured an op-ed, titled *The Not-So-Green Mountains*, which criticized a wind project in the Lowell Mountains. Green Mountain Power was in the process of installing 21 new, large turbines along extensive ridgelines (Wright, 2011). Within a week of printing, numerous letters were submitted to the editor, with a majority contradicting the original article. One of these letters even came from a Dartmouth Physics professor, Tim Smith, who lauded the Lowell residents for "saying yes to energy in their backyards" (Smith, 2011). More notably was the response from Dorothy Schnure, an employee for GMP. She highlighted the extensive support of Vermont residents for the development of wind power; "75 percent of voters in the town of Lowell supported the project, and 90 percent of Vermonter support wind, 74 percent strongly" (Schnure, 2011).

Furthermore, the Castleton Polling Institute released results that indicated additional support of wind development. As of February 2013, roughly two-thirds of respondents supported the installation of wind turbines along ridgelines in Vermont. Surprisingly, however, when the phrase 'in your community' was included in the question, the percentage *increased* from 66% to 69%. These results were consistent across all demographics including political preference, education levels, and sex: "actual opposition to wind averaged just 19 percent" (VPIRG, 2013). This overwhelming support for wind energy development could be used to TA's advantage in garnering support for any future wind energy projects.

Climatic Advantages

Though other regions in Vermont possess greater wind resources, there is still an opportunity to harness substantial carbon-free energy in Thetford. While researching the production potential for TA, we discovered two, significantly different wind averages largely because long term climatic data specific for Thetford, VT was unavailable from government websites.. Many sources identified Thetford as a moderate wind location, with average wind speeds ranging from 6-12 miles per hour (mph). Other, less reputable sources reported average winds upwards of 17 mph (USA.com, 2014). The difference between these two values is an average (or sustained) wind speed versus an instantaneous ‘peak’ wind (or gust) speed. Average wind speed that relates to electricity production is measured by averaging wind speeds over a certain time period--typically two minutes--while instantaneous wind averages do not account times when the wind decreases (Matthews, 2007). For this report, and for future considerations into wind energy, TA’s location should be considered a moderate wind site, with an average wind speed around 8 mph.

Based on data from 2012 and 2013, electricity consumption significantly increases from December through March (Fig. 2.4.3). Fortunately, the spike in electricity consumption is complemented by a rise in the average wind speed during these months. Figure 2.4.1 shows that the average wind speed in Thetford increases to over 8 mph from November through May. Utilizing this additional wind could reduce electricity demand during the coldest winter months when power plants are already stressed for production.

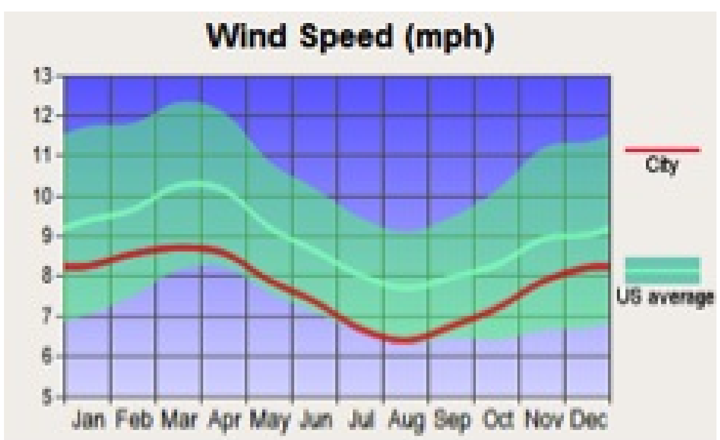


Fig. 2.4.2 Thetford, VT annual wind speed (City Data, 2013).

Vermont Elementary Projects

A number of elementary schools across Vermont participated in the *Vermont Small-Scale Wind Energy Demonstration Program*, which began in 2003. By 2007 there were 19 total turbines installed and being continuously monitored by the program, however it was concluded in 2011 due to lacks in funding (VERA, 2011). These locations were comprised of family-owned farms, elementary schools, and colleges located in every corner of the state. Inadequate machinery, personnel, and funding led to issues in turbine functioning and transmission of data. In spite of this valuable information was still obtained from the installation of these turbines, discussed below. The Vermont Small-Scale Wind Program provided each site with a 10 kW Bergey XL-S residential turbine to record wind energy information., and will also be discussed in later sections.

Fig. 2.4.3 Bergey 10 XL-S Residential turbine

Case Studies

Addison Central School, Addison, VT

The Addison turbine was installed in 2004 and operational with continuous data reported from 2006 through early 2011. Figure 2.4.10 clearly shows a spike in average wind speeds around the winter months, similar to what would be experienced in Thetford. Unfortunately, average daily kWh production was not listed on the monthly data reports, however the final summary states that the school “has been an excellent energy producer since its [...] wind turbine was installed.” Administrators at the school were unable to be contacted for further questions, however the principal has expressed consistent interest in utilizing the turbine as an educational tool (VERA, 2011).

Danville School, Danville, VT

Danville’s wind turbine was the first in the program to be installed in July 2003. Of the four elementary schools, Danville had the most recorded data on kilowatt hour production, and substantial wind data from 2005-2007. Unfortunately, severe weather broke off part of the turbine in the winter of 2008 which ceased all meteorological data from being recorded; “likely resulting from excessive ice accumulation” (VERA, 2011). Monetary constraints made it clear that lowering and repairing the tower was not realistic, however the school chose to keep the turbine on campus to be used as “an excellent educational tool for renewable energy and technology curriculum” (VERA, 2011). This is a maintenance issue that could easily occur at TA. Average kWh production and wind speed from the Danville School turbine are shown in figures 2.4.11 and 2.4.12, respectively.

The turbine was clearly unable to produce for a single family home, however it demonstrated the possibility of harnessing wind power. The school is located atop a hill similar to TA, and though the turbine stood at 90 feet tall there were few complaints of visual interference. One drawback of the turbine, however, was that it shut down when it stopped spinning regardless if it occurred momentarily; some electricity was not produced despite gusts of wind. It was directly in the view of many local residents, including the relative of a school employee, yet no substantial complaints of visual interference arose. The turbine was included into the school curriculum, and the science department still studies it. Elementary school students learn about wind power by trying to mimic the turbine's processes and production. The electricity that was produced had always been sent back to the grid, making roughly $50 profit per month/year (correspondence Marvin Withers, April 29, 2014).

Dover School, Dover, VT

Dover School’s turbine was installed in 2005 and has sporadic data that does not include much of 2008-2010. However, average wind speed was recorded before and after this gap, as seen below in figure 2.4.13. The increase in wind during winter months is evident in the Dover data, which could result in similar benefits at TA. There were problems with data recording because of communication errors involving nearby telephone lines as well. The school principal who was involved with the project has since left, and no administrators were able to respond for questioning (VERA, 2011).

Mount Holly School, Mt. Holly, VT

The turbine at Mt. Holly unquestionably provided the most reliable data regarding wind speed. Each year from 2005-2011 the wind speed dropped to almost 4 mph but then increased to over 8 mph in the winters (Fig. 2.4.15). These average wind speeds are lower than TA’s location, but demonstrate a common trend throughout Vermont. Data on average daily kWh production was much less reliable, but in 2010 and 2011 a notable amount of electricity was produced (Fig 2.4.14). Currently, the turbine is still used as an educational tool, supplementing other activities such as garden beds already occurring on campus

(VERA, 2011).

Turbine Models

Xzeres Skystream

As a leading residential wind turbine, the Xseres Skystream 3.7 is rated at 2.4 kW with a 12-foot rotor diameter weighing only 170 pounds. The turbine is designed to generate energy even at very low wind speeds, and as it is designed as a residential turbine, prides itself on sleek, unobtrusive design and quiet operation, which would be important for a turbine in the historical, residential area of Thetford Hill. The turbine comes with a 5-year limited warranty (Xzeres, 2013).

Additionally, the turbine comes with Skyview performance monitoring software for Windows PCs, which could either be used simply to evaluate performance or could be involved in a physics, engineering, or environmental experiential learning project with interested TA students.

Figure 2.4.4 A Skystream 3.7, a popular option for small-scale wind power, installed in a rural residential location (Control Alt Energy, n.d.).

With this very small turbine, TA could generate approximately 300 kWh of energy per month with an average wind speed of 5 mph (USA.com, 2014) at 9.33 cents per kWh (Green Mountain Power, 2014, *New England Comparison*). Assuming that Thetford was consistently using energy and used all energy outputted by the turbine, after the cost of implementation this turbine would save TA $27.99/month, or $335.88/year. However, with a cost of $12,000-$15,000, this popular turbine would take between 35.72 and 44.66 years to pay for itself, with only about a 2.2-2.8 percent yearly return on investment. Because there are some functions of a school that run at all times, for example the computer system controlling the heat and lights (B. Hyde, personal communication, April 18, 2014), it is not unreasonable to assume that the building may be using this power at a nearly constant rate as it is generated.

However, if the case arises that the school is not using the electricity as it is generated, Vermont Net Metering laws would allow TA to sell unused power back to the grid, which is important for a location such as a school with regular off-peak hours at night and over vacations when the power from the turbine may not be used. Net metering laws allow customers to generate power and sell it back to the grid. If either an individual customer or group of customers who elect a group net metering option uses more electricity than they generate, the customer will pay the utility only for the difference between the amount generated and the amount used. If the system generates more electricity than the customer used in a month, the energy provider gives credit for the excess kilowatt hours towards the next bill for the customer or group of customers. Net metering is restricted to renewable forms of energy in Vermont, including solar, wind turbines, and fuel cells fueled by renewable sources (Vermont Public Service Department, 2014, *Net Metering*).

Additionally, either solar or wind power could be applied to the Vermont Group Net Metering option; for example, if a larger turbine were used to generate more power, and other community members in Thetford wanted to establish a Group Net Metering project with TA, these community members could help pay for the implementation of the turbine and thus benefit from a reduced electricity bill corresponding to the energy sold back to the grid from the turbine. In these ways, even if TA were not continuously using the energy generated by an installed wind turbine, the school could still be reimbursed for the power generated while also promoting clean energy sources.

Bergey 10 XL-S

This model, which was used in the Vermont Small-Scale Wind Program, is noticeably different in design from most turbines on the market. It features a 23 foot rotor diameter atop a tower ranging from 80-160 feet, and projects an estimated 13,800 kWh of electricity annually with an 11 mph wind (Bergey, 2013). Figure 2.4.2 shows additional estimated generation at various wind speeds, with the lowest of 8 mph. This significantly smaller design guarantees electricity production at almost any wind speed at TA but it will not significantly contribute to reducing campus electricity consumption. Despite this relatively low performance, a Bergey XL-S turbine would be an essential educational component, and optimal for demonstrating TA's commitment to sustainability.

With an installation cost of around $28,000 total, it is slightly above similar sized residential turbines (Event Horizon, 2013). If the turbine was able to produce approximately

13,000 kWh per year, a load that the turbine can produce, TA would save roughly $1,242 per year on electricity costs. Figure 2.4.8 shows estimated production at various wind speeds with uncertainties provided. This would also result in a payback period just over 20 years (see Fig. 2.4.9).

NPS 100

A final, more extreme option for wind power with the highest potential output is the NPS 100. While this turbine stands significantly higher than the previous two options, it has a rating of 100 kilowatts and can "begin making power at wind speeds as low as 3 meters per second (6 mph)" (NPS, 2014). Additionally, the model comes in an Arctic option, which may be of interest given the complications surrounding cold temperatures for residential turbines. This model also feature a direct drive; by eliminating the gearbox the process of delivering electricity directly to the buildings is made simpler. Fewer moving parts reduces operating costs and the frequency of maintenance required. With a lifespan estimated at 20 years, this would undoubtedly provide TA with stable electricity and, at the same time, demonstrate strong dedication to energy efficiency and sustainability (NPS, 2014).

A NPS100 turbine was installed on the campus of McGlynn Middle School of Medford Massachusetts, which included a complete education package. This included online monitoring and control for school and public access, as well as a wind power curriculum set (McDermott, 2009). Since its installation in January 2009, the turbine has produced 421,115 kWh and upwards of $58,956 at a price $0.14 per kWh. Figure 2.4.5 shows the online dashboard for public access featuring rotor speed, wind speed, energy production, turbine angle, and air temperature. This figure was viewed on May 29, 2014 just after noon; with a comparable wind speed to TA's campus, the turbine was generating 4.8 kWh of electricity with an 8.9 mph wind (Medford Energy Committee, 2014). McGlynn's average wind speed for the month of May fluctuated around 10 mph (Fig. 2.4.6), which if reached at TA could result in ~20 kWh of electricity per day (Fig 2.4.7; Medford Energy Committee, 2014).

Fig. 2.4.5 NPS100 Turbine; 21-foot blade model (NPS100, 2014)

If TA were to install a NPS100 Arctic turbine on campus, the 21 meter blade model could generate an estimated 4.1-10.5 kW daily with wind speeds of 8.9-11 mph, and 77-145 MWh annually, provided optimal conditions and maximum capacity (Northern Power Arctic, 2014). These estimates may be misleading because Northern Power Systems produces for a large European market, therefore they must supply information to a much larger scope of climates. A hypothetical NPS100 turbine in Vermont, however, would cost around $550,000 to install before $328,625 of Investment Tax Credits and Modified Accelerated Cost-Recovery System in savings. With an 11 mph average wind speed, the turbine would produce 114,000 kWh/yr, have a 10.7% internal rate of return, and a payback period under 9 years (Hudson, 2009).At a price of $0.933 per kWh, TA could save an estimated $10,636.2 on their electricity costs per year. Although wind speeds and turbine production are immensely uncertain, the Arctic turbine's height (compared to other proposed turbines) will be advantageous because it will avoid topographical interferences that may prevent electricity generation. In addition, the turbine will remain operational at temperatures up to -40° Celsius, eliminating many maintenance issues seen with smaller, residential turbines (Northern Power Arctic, 2014). Conversely, zoning complications and public opposition likely will become amplified with the increased height of this model.

Recommendations

Due to the relatively low wind speed of Thetford compared to areas in which wind power is prevalent, the high rate of varied topography, and potential hindrances from historical regulations in Thetford, we do not recommend wind power as a cost-efficient alternative energy option for TA. The Skystream 3.7 turbine's 5-year warranty is far outpaced by the 36-45 years which it may take to pay for the turbine's installation at this location. The NPS100 Arctic model is better suited for producing electricity in the climate and topography of TA, and it has a shorter payback period than many other recommendations (see Fig. 2.4.9). Yet, it comes as a much more difficult option regarding public opposition and zoning complications. The Bergey 10 XL-S model will provide an insignificant amount of energy over the course of the year, but is a smart decision towards promoting sustainability. Ultimately, we believe that solar is a much more feasible and efficient source than wind in Thetford, and should therefore be pursued as a more immediate source of alternative electricity production.

2.5 Energy Literacy & Experiential Learning

Since TA is a teaching institution above all else, energy efficiency and renewable energy plans ought to go hand in hand with educational initiatives surrounding the production and use of energy. Not only would such curricular additions enhance students' understanding of any infrastructure projects the school undertakes, even in the absence of capital projects, teaching students about energy, efficiency, and clean technologies will prepare TA graduates to become leaders in a rapidly growing field. In fact, it is vital that the young people of today are informed as much as possible about the consequences of energy use and the options that exist for reducing them. Furthermore, many components of energy education could enhance existing subjects such as chemistry, physics, and environmental science. Furthermore, existing courses such as math, business, and accounting could examine calculations of return on investments, annual energy production, and other important estimations. An energy curriculum for TA could take many forms - a dedicated week or day for all students, an afterschool program, incorporation into existing classes or clubs, etc - and ultimately administrators and teachers will have to decide what the best approach is for TA. Fortunately, there are extensive resources for them to draw upon.

Energy education can begin at any age. At the earliest stage, activities as simple as drawing in coloring books with windmills can increase awareness of alternative energy. As students advance, it's appropriate to introduce basic energy literacy and the idea of energy conservation. At the high school stage, students should be taught about various energy sources, climate change, and energy efficiency. Multiple excellent sources for curricular program development already exist, including: the Vermont Energy Education Program, the U.S. Department of Energy's Energy Education and Workforce Development Program, the National Renewable Energy Laboratory's education website, NREL.gov/education, and the Union of Concerned Scientists' Guide to Teaching Renewable Energy. Each contains numerous resources for integrating energy, electricity and environmental information into education, and all three offer free PDF documents of curricular material targeted at each level of pre-university education.

An especially effective approach for teaching students about energy is through science projects. There are many such projects that relate to energy and the environment, and by getting students actively involved in their own learning they are likely to leave a lasting impact. Common projects include performing an energy audit; building a potato battery, solar cooker, or solar hot water heater; and creating biofuels. Each of the three aforementioned sources also provide a number of projects for students to undertake.

For students at TA, performing an energy audit as a method of alternative energy education would be especially productive because it simultaneously creates opportunities for TA to maximize its energy efficiency. As we outline in this paper, there are several avenues through which the school could make small adjustments in energy efficiency. For example, replacing fluorescent lighting with LED lighting, replacing doors, and sealing insulation leaks. A student-run energy audit would allow students an opportunity for hands-on learning while simultaneously identifying problem areas in which TA could improve upon efficiency.

In sum, the more educated students are about energy issues, the more critically they can think about energy programs within TA and their own energy consumption. Regardless of the alternative energy or energy efficiency paths that the school chooses, the process can be enhanced by an educated and interested group of teachers and students. Here, we will present sources from which teachers can obtain energy literacy training and lesson plans to help students think critically about energy and sustainability-related issues.

Resources for Energy Literacy Training and Lesson Plans

Vermont Energy Education Program (VEEP)

In order to undertake these projects, students must first have an understanding of how energy works. The Vermont Energy Education Program (VEEP) was founded in 1979 by Vermont Departments of Public Service and Education in response to call for more energy education curriculum in VT public schools for this purpose (Vermont Energy Education Program, 2014, *What is*). VEEP can be used at any school in Vermont to teach students about energy and how it functions, in addition to energy conservation. VEEP consists of three core programs: (1) VEEP educators giving in-class presentations, (2) energy literacy education for teachers and other educators, and (3) a whole school energy challenge. VEEP stresses seven principles of energy literacy, which seek to explain to students what energy is, how it is harnessed and used by humans, and what dictates energy consumption rates. VEEP then also teaches climate literacy, which allows students to understand how energy consumption relates to climate change and consume climate news and literature in an educated and critical way. Given these two pieces, students would then be able to understand what energy is, what factors contribute to conservation, and why energy conservation is important both directly for sustainability of energy sources and also in the broader context of climate change.

Depending on the choices made by TA in terms of what to implement for energy efficiency improvements or alternative energy, VEEP provides several educational program guidelines that could help students understand and actively participate in the implementation, care, and maintenance of these systems. For example, if TA is interested in implementing solar panels to contribute to the school's energy profile, VEEP presents a Solar Challenge, which challenges students at different grade levels to model and experiment with different components of solar panel modeling and installation. For example, high school students grades 9-12 are challenged to develop computational models that estimate the amount of energy converted from one source to another in a solar panel, and determine where energy is lost (Vermont Energy Education Program, 2014, *Solar*).

TA could pursue the programs presented by VEEP if either certain members of the faculty or staff are already well-versed in this particular sector of energy and climate change, or could have faculty or staff undergo the VEEP teacher training program, which costs $25/teacher. Each teacher is then provided with a 2-3 day training as well as materials to consult and follow-up information.

USDE Energy Education and Workforce Development Program

Similarly, the U.S. Department of Energy has an Energy Education and Workforce Development program, which includes many resources from energy literacy training to specific lesson plans. Similarly to the VEEP program, the Energy Education and Workforce Development program presents energy literacy training; this program presents this training in the form of a free document. Unlike VEEP, which is targeted specifically at schools, this document is targeted more toward adult individual literacy and self-training. However, the program also includes a “Green Your School” program. This program encompasses many outlined programs and challenges that schools can participate in to increase their energy efficiency or transition to alternative energy.

In addition to general literacy training, this program includes a comprehensive compilation of suggested projects and lesson plans for teaching students at all grade levels K-12 about different aspects of alternative energy and energy conservation. For example, students grades 5-12 are encouraged to calculate the size of their energy footprint, and analyze their energy efficiency of their homes. This newfound awareness of energy efficiency could educate students to take initiative within TA on their own energy efficiency projects, or to simply be aware of their actions on a day-by-day basis, such as turning lights off when leaving rooms. Additionally, should TA choose to pursue a solar project, the Energy Education and Workforce Development provides an entire 9-lesson course on understanding photovoltaics (US Department of Energy: Energy Efficiency & Renewable Energy, n.d.).

NREL Educational Resources

The National Renewable Energy Laboratory hosts an entire website devoted to educational resources for energy, environment and clean technology topics. The website contains comprehensive lesson plans and activities divided by age group and topic focus. Topics covered include energy efficiency, biomass, solar, wind, hydrogen, transportation, buildings and renewable energy in general, and the concepts most emphasized are energy literacy and techniques for conservation. A number of experiments and projects accompany each lesson. Helpfully, in addition to lesson plans and project ideas, the site also includes teachers’ guides for each topic. (NREL, 2012)

UCSUSA

The UCSUSA includes a variety of education programs that deal specifically with alternative energy. Activities include a game that helps students distinguish between renewable and nonrenewable energy sources, as well as understanding how energy is used, and encouraging students to think critically about what a sustainable future means and looks like to them, and how they can take steps to get there. Once students have gained a deeper understanding of different types of energy improvements and their advantages and disadvantages through other literacy programs and activities, such thinking exercises allow students to critically consider what energy efficiency and sustainable energy sources mean to them, and what tradeoffs they are willing to make to help realize this future (Union of Concerned Scientists, 2003).

2.6 Conclusion

Both energy efficiency and alternative energy solutions allow TA to join many other schools in Vermont and the rest of the country in reducing fossil fuel emissions. Short term investments can establish long-term decreases in both the school's energy bills and its carbon footprint. It is clear that TA possesses the resources and determination to apply cleaner energy to its educational environment and can use these changes for experiential learning.

Pellet stoves will apply the most immediate return to both TA's budget and to the environment.

Solar power is becoming incredibly popular throughout the state of Vermont. While many of the current programs are designed for residential installations, the growing sector is providing greater resources and incentives that make initial costs less daunting.

Wind energy has grown immensely in recent decades across the globe: although this option may not be monetarily feasible at the moment, it should be considered in the future because of TA's location and climate. As technology develops, more productive wind turbines may become more attractive for schools and buildings in the future via government stimulus.

Many local schools have successfully used these options of cleaner energy to educate future generations. While some schools are able to use the existence of their own onsite renewable energy forms as part of the classroom curriculum, others have created experiments to simulate the processes. TA's range of curriculum and after-school clubs, as well as the broad student interest in hands-on activities, makes the school an ideal environment for clean energy experiential learning.

Through the analysis of energy efficiency, alternative energy options, and education, both short-term and long-term advantages are identified should TA choose to become more engaged in cleaner energy.

Study Limitations

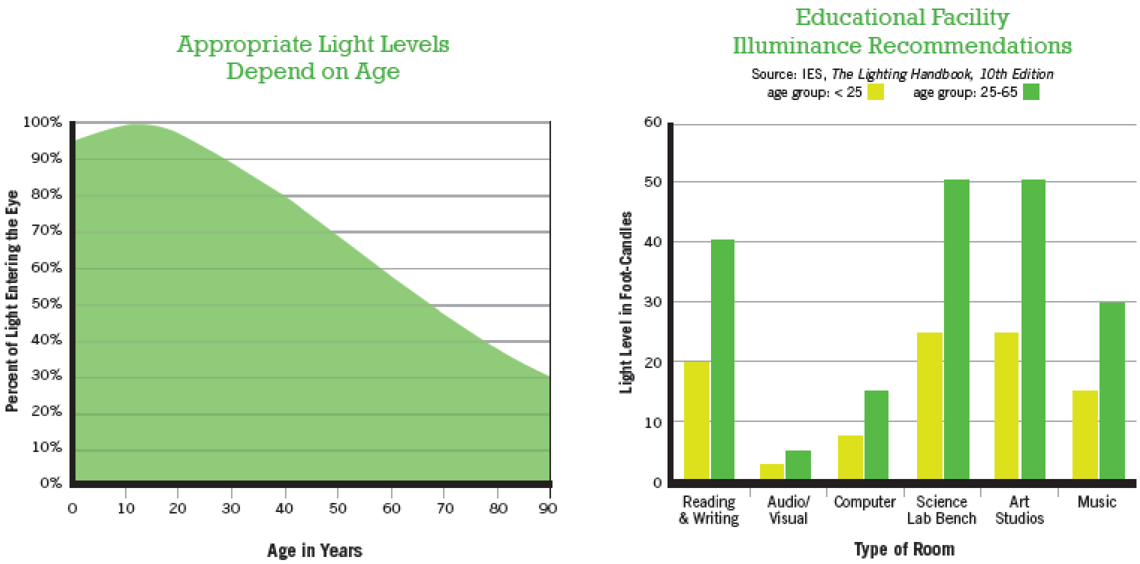
Given the time constraint and lack of necessary funding to produce a complete report, this document likely lacks the necessary information required for immediate action. As a result, our goal is to provide TA—students, parents, and faculty alike—with a comprehensive analysis of alternative forms of energy that have been implemented in areas similar to TA. It is also our understanding that future groups will work with TA, and we hope that this report can be used as a stepping-stone for prompting sustainable development in Thetford.

One of the most significant factors that limited the specificity of our energy efficiency calculations was the lack of a complete energy audit for each of the school's buildings. Though many of the renovations took place within the last decade, there may still be inefficiencies that were not corrected. We were informed during one of the tours that there was significant leakage of heat between the boilers in the gymnasium and the separate science building. Evaluating similar leaks from windows, doors, and other areas should be a priority from an efficiency perspective. The inexplicit recommendations provided in our report shed light on TA's energy inefficiency, but we do not have the information or ability to analyze how to amend these problems. For example, installing triple-paned, rather than double-paned windows, may be a cost-effective possibility for windows on different sides of buildings. In addition--specifically pertaining to energy efficiency--there are many other ways to reduce consumption through behavioral changes. Dartmouth's 'turn off the lights' campaign was largely successful, simply by placing stickers above outlets across campus encouraging students to turn switches off whenever leaving a room. Also, educating students *and* faculty that appliances continue to draw energy while plugged into outlets, though they may be turned off, can be effective in decreasing annual electricity consumption. These and many other efforts are inexpensive, effective ways to reduce energy costs and minimize TA's carbon footprint.

As we came closer to finalizing this project, we identified many other alternative energy and energy-efficiency solutions for TA. For example, Dartmouth utilizes a co-generation power plant that produces heat and electricity from burning fuel oil. Though the campus requires immense amounts of fossil fuels, the dual production does notably increase Dartmouth's the sustainability. Though we did not explicitly research this possibility for pellet boiler systems we advise future research by TA faculty, Dartmouth students/faculty, or energy consultants into applying a cogeneration system on-site at TA.

Finally, there is considerable uncertainty surrounding the public support for changes in energy production in any town, which we do not identify as seriously as needed in this report. Specifically for TA, the historic district poses an even larger problem than usual in terms of installing various types of alternative energy sources. However, we hope that at least one of the three aforementioned options takes hold, given the overwhelming support for renewable energy sources in Vermont and across the country. Our research of similar efficiency-projects in Vermont displays that these changes are feasible and beneficial in numerous ways. Such projects can be included into curriculums and after school activities in addition to the environmental focus. This dual benefit will likely be instrumental in gaining support of community members who are not directly involved with TA.

2.7 Figures



Advancing age reduces maximum pupil diameter and increases absorption by the lens, and combined these effects significantly reduce the amount of light entering the eye. When considering this fact for K-12 schools, where most occupants are less than 25 years old, the IES light level recommendations are notably lower than if the space was primarily occupied by adults.

Fig. 2.2.1 - Adapted from Efficiency Vermont,.... School-age children require less lighting to perform the same tasks as older eyes. Furthermore, not all school activities require the same lighting levels. Electricity consumption may be decreased by lowering lighting levels throughout the day and for specific activities, such as using computers or participating in music class (Project Green School, n.d.).

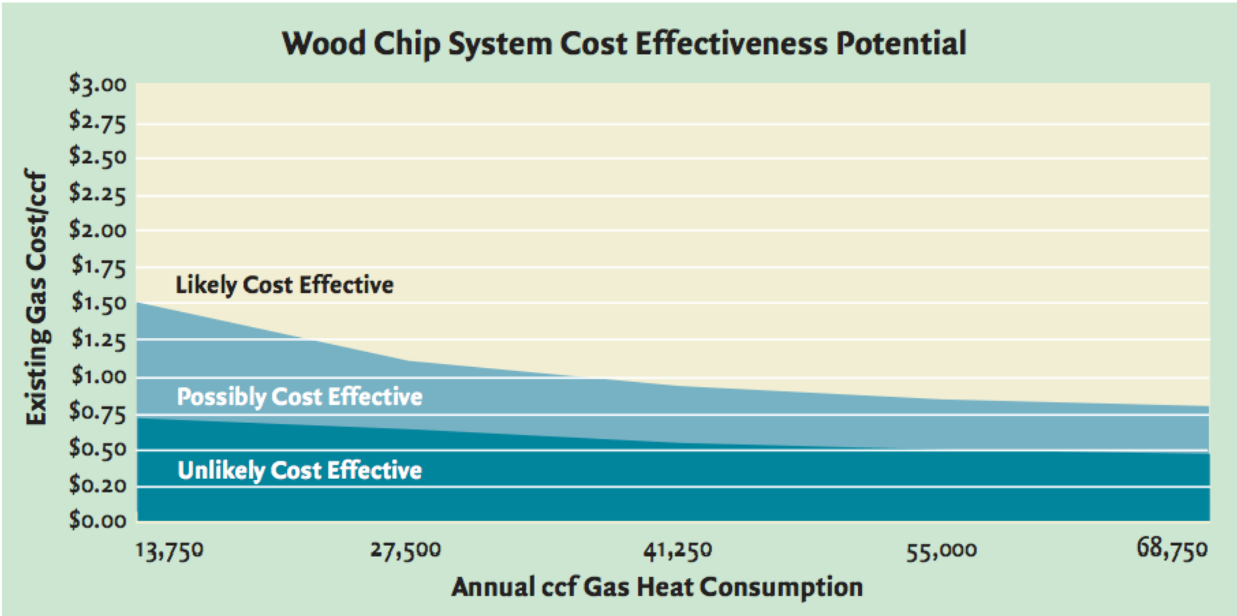


Fig. 2.3.1 Based on TA's current propane consumption, installing a biomass boiler system to replace current gas burning will likely be cost effective (Maker, 2004).

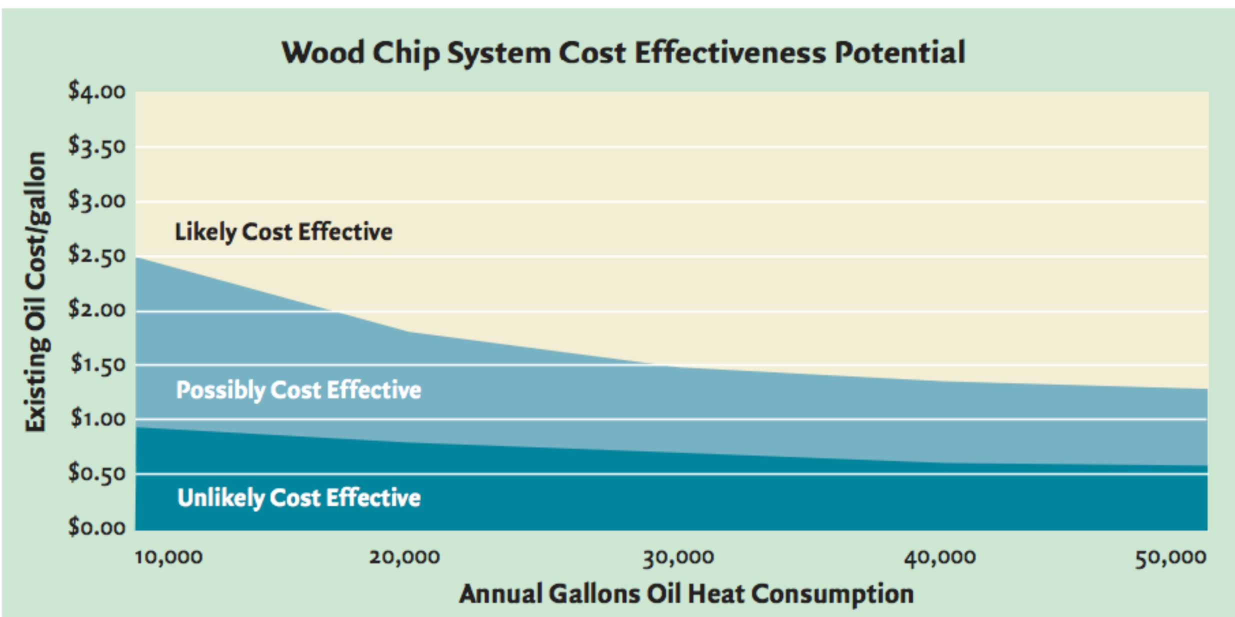


Fig. 2.3.2 Based on TA's current oil consumption, installing a biomass boiler system to replace current oil burning will likely be cost effective (Maker, 2004).

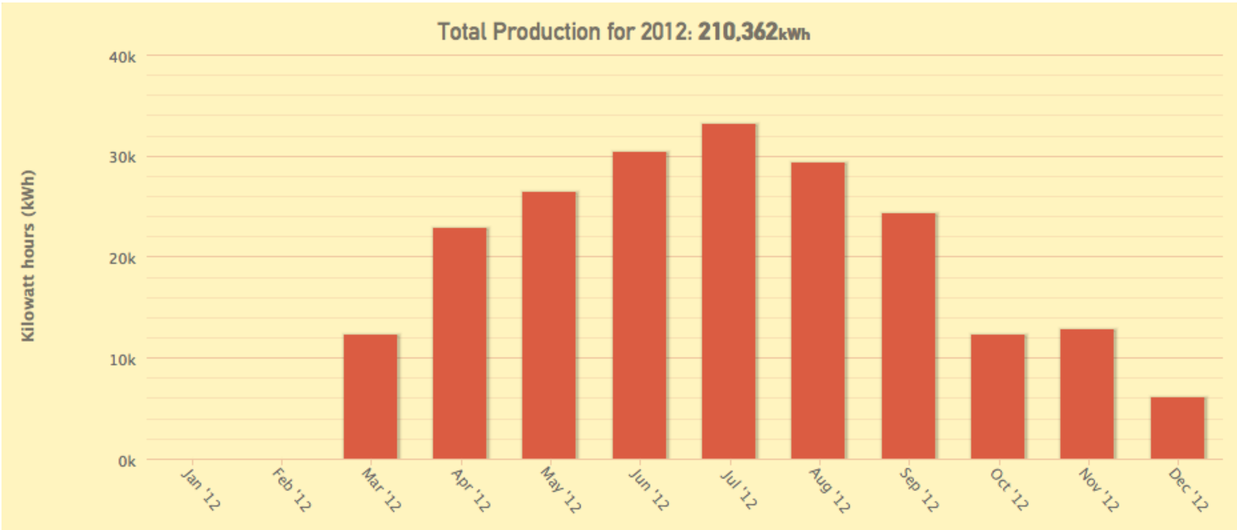


Fig. 2.4.1 2012 kWh production, Middlebury 143 kW array

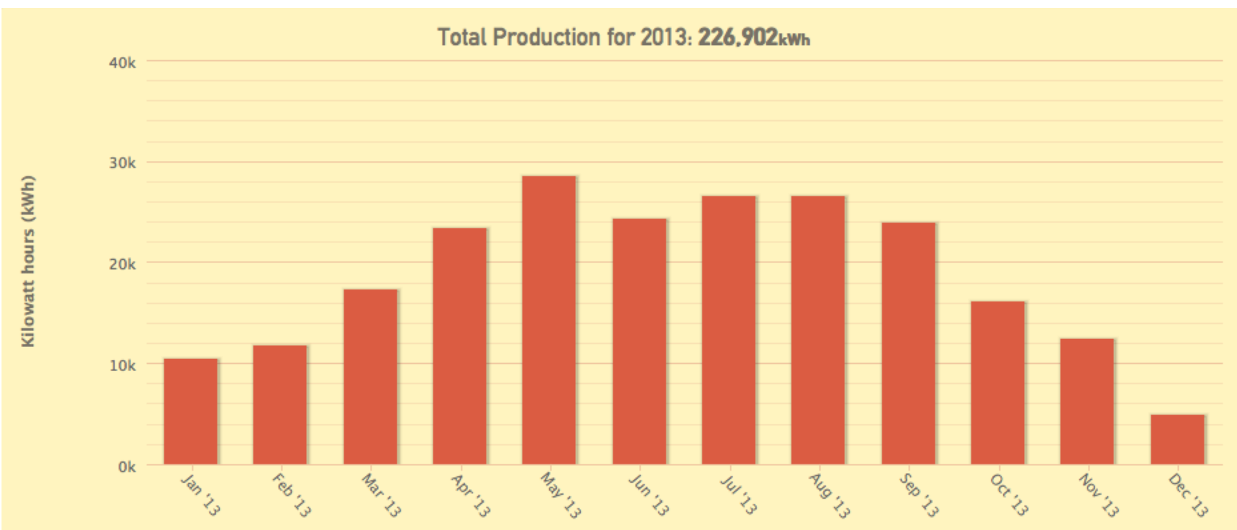


Fig. 2.4.2 2013 kWh production, Middlebury 143 kW array

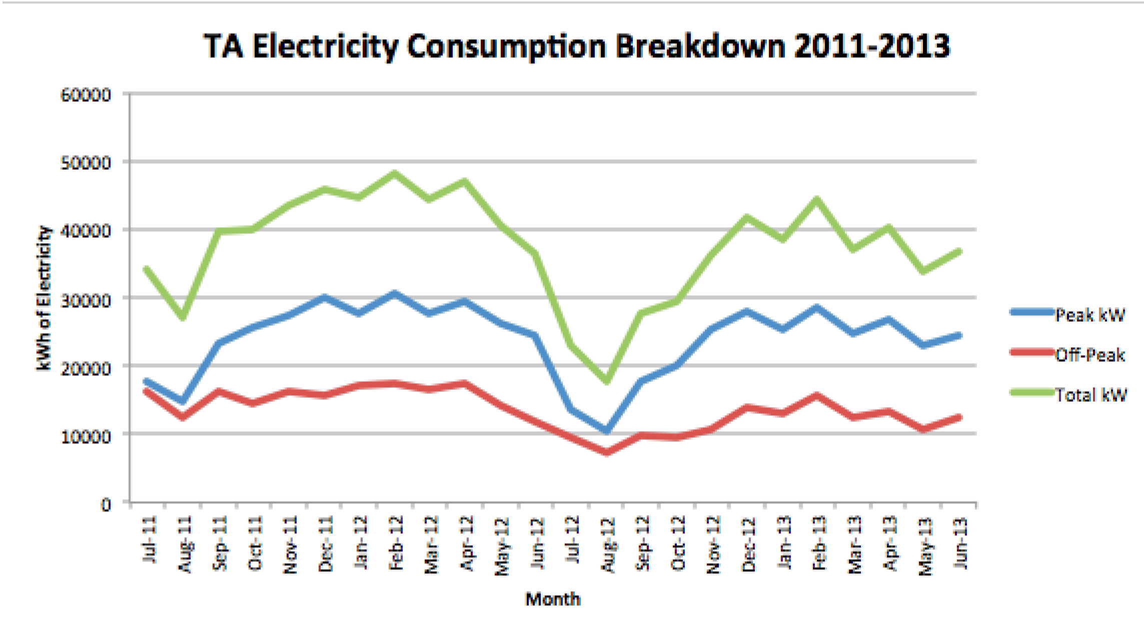


Fig. 2.4.3 TA Electricity Usage Breakdown Summer 2011 Summer 2013

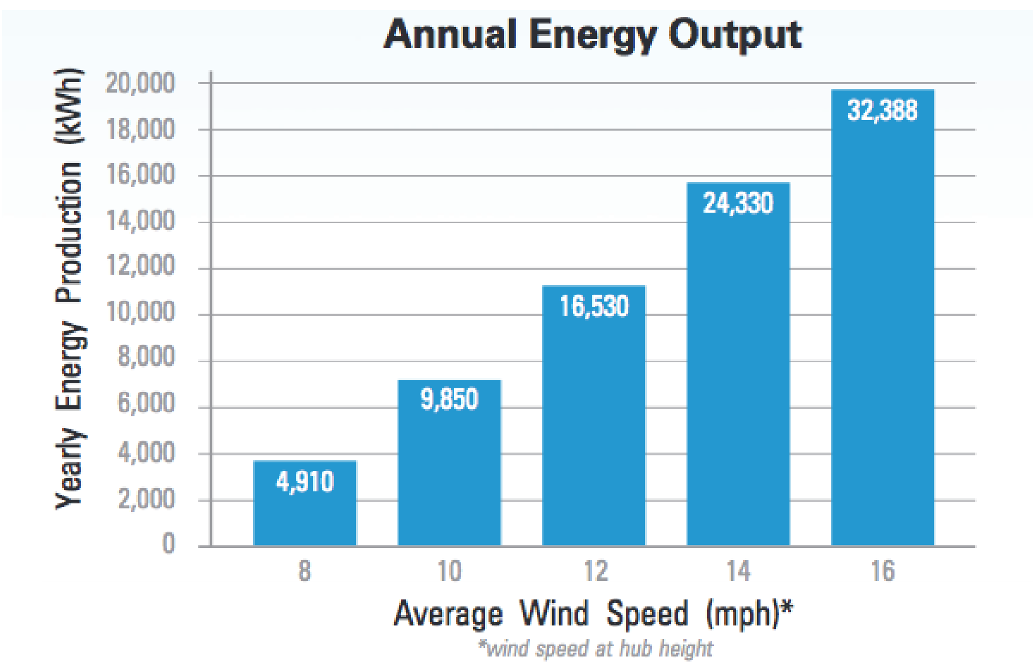


Fig. 2.4.2 Projected turbine production of Bergey 10 XL-S model (Bergey, 2013).

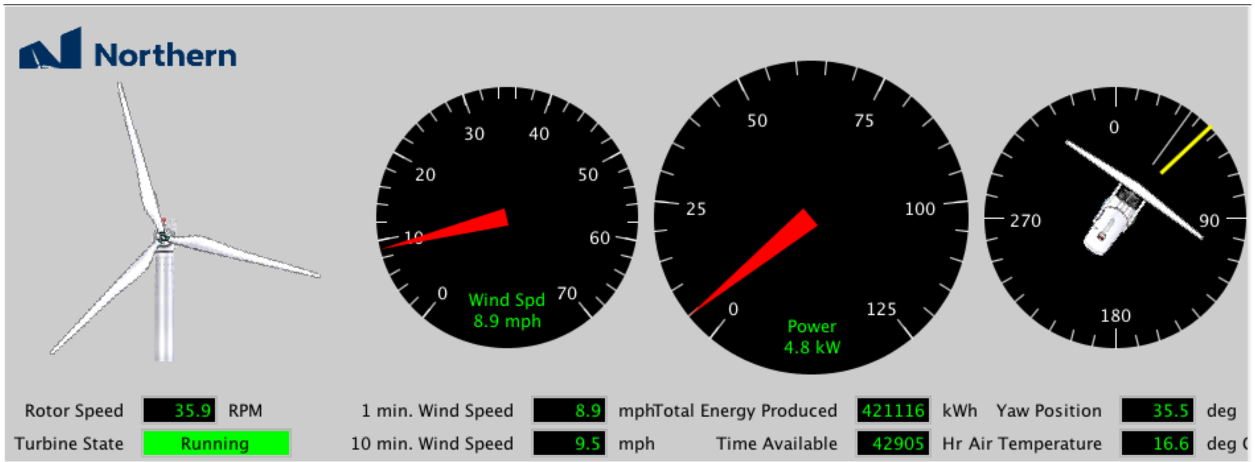


Fig 2.4.5 McGlynn Middle School NPS100 Turbine production; May 29, 2014 (Medford Energy Committee, 2014)

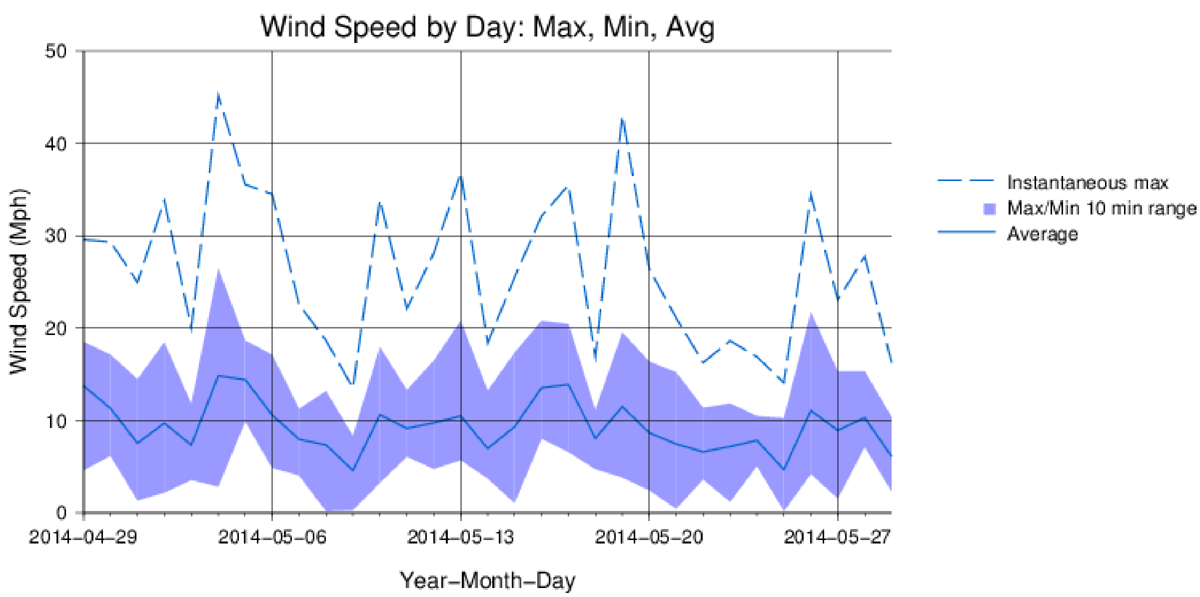


Fig. 2.4.6 McGlynn NPS100 Turbine 30-Day Wind Speed (Medford Energy Committee, 2014)

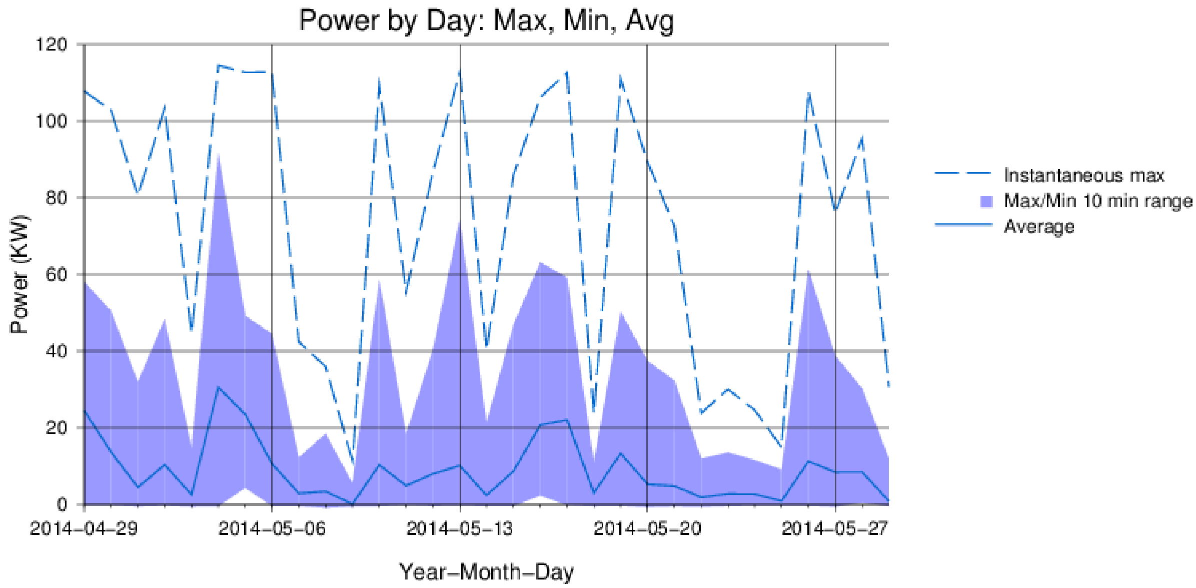


Fig 2.4.7 McGlynn NPS100 Turbine 30-Day Power Production (Medford Energy Committee, 2014)

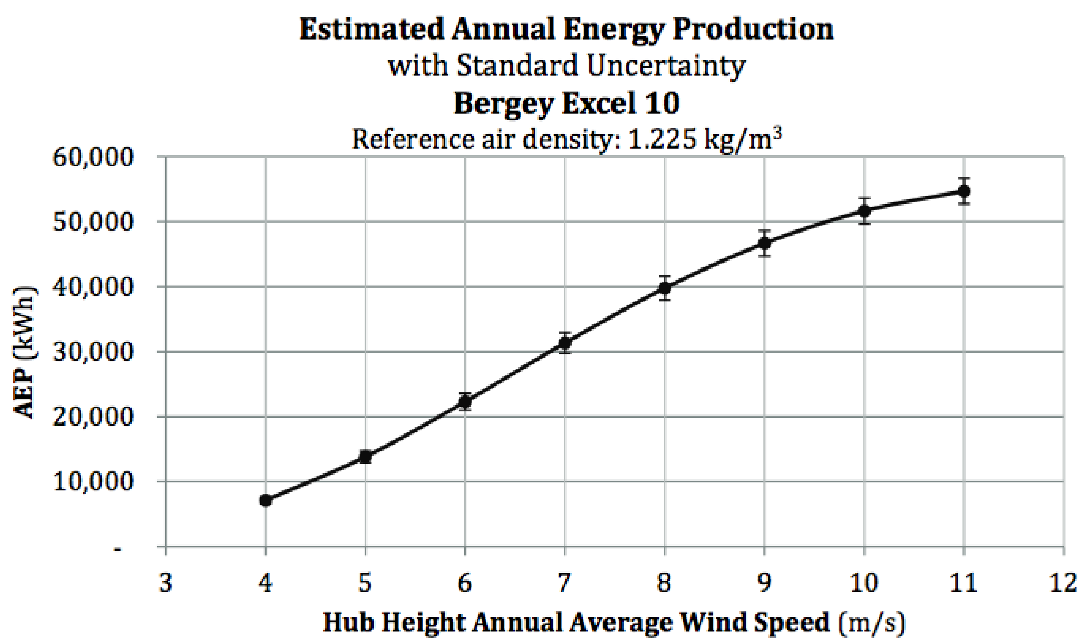


Fig. 2.4.8 Estimated annual production from the Bergey 10 XL-S model.

Energy Source	Initial Cost	Annual Return	Power Rating	Avg Wind Speed	Annual Production	Payback Period
Pellet Stove	~$128,000	~$19,528	N/A	N/A	N/A	~6.55
Solar	~$125,000	~$3,759	variable	N/A	~41,218 kWh	~20.1
Wind (NPS100)	~$550,000	~$10,260	100 kW	11 mph	~114,000 kWh	~53
Wind (Bergey XL-S)	~$28,895	~$1,242	10 kW	11 mph	~13,800 kWh	~23
Wind (Skystream	~$15,000	~$307.8	2.4 kW	11 mph	~3,420 kWh	36-45

Fig. 2.4.9 Comparison of Recommendations for TA Energy

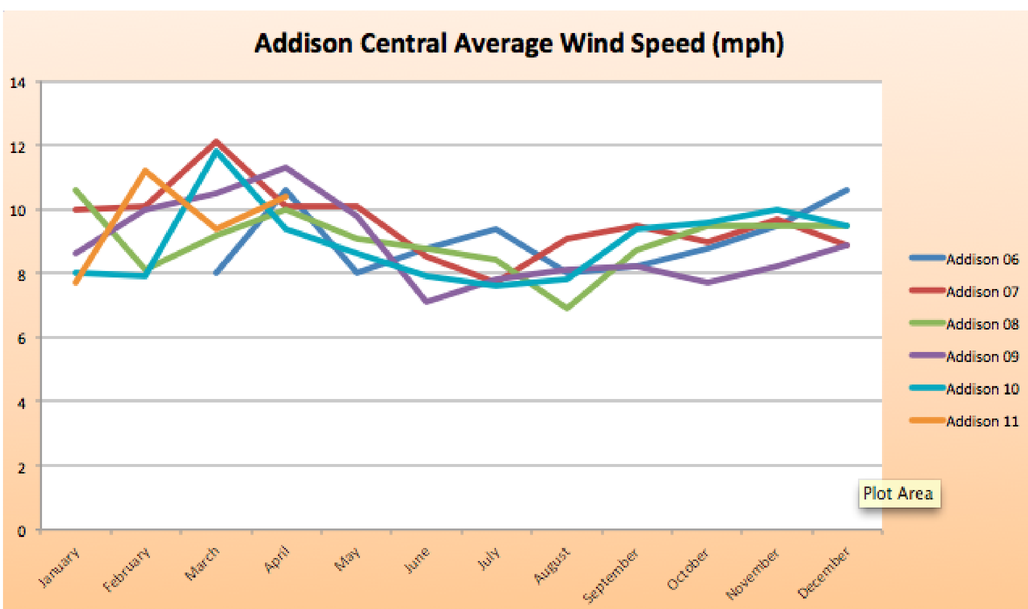


Fig 2.4.10 Addison Central School wind speed, VERA (2011) program data

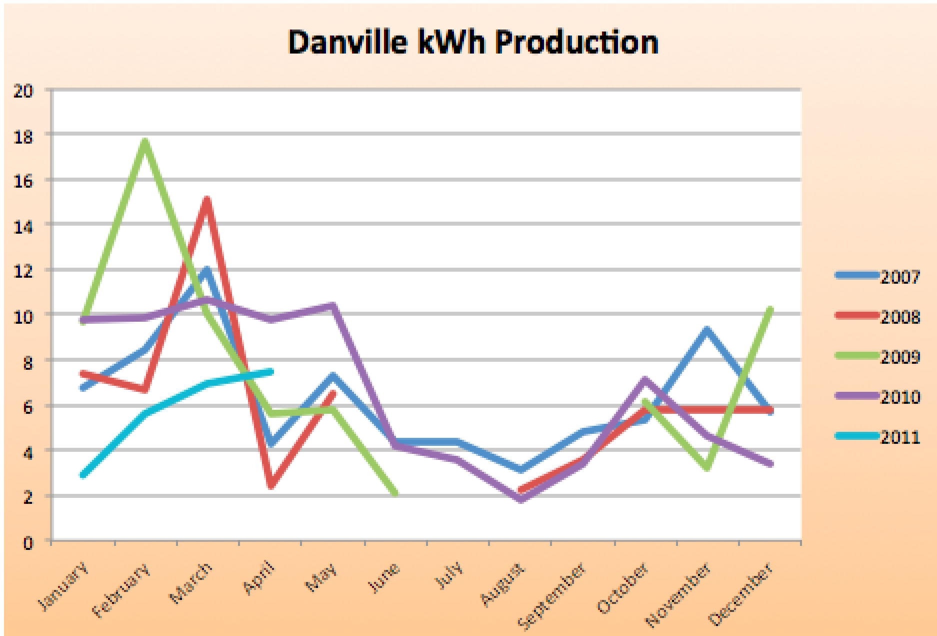


Fig. 2.4.11 Danville School kWh Production, VERA (2011) program data

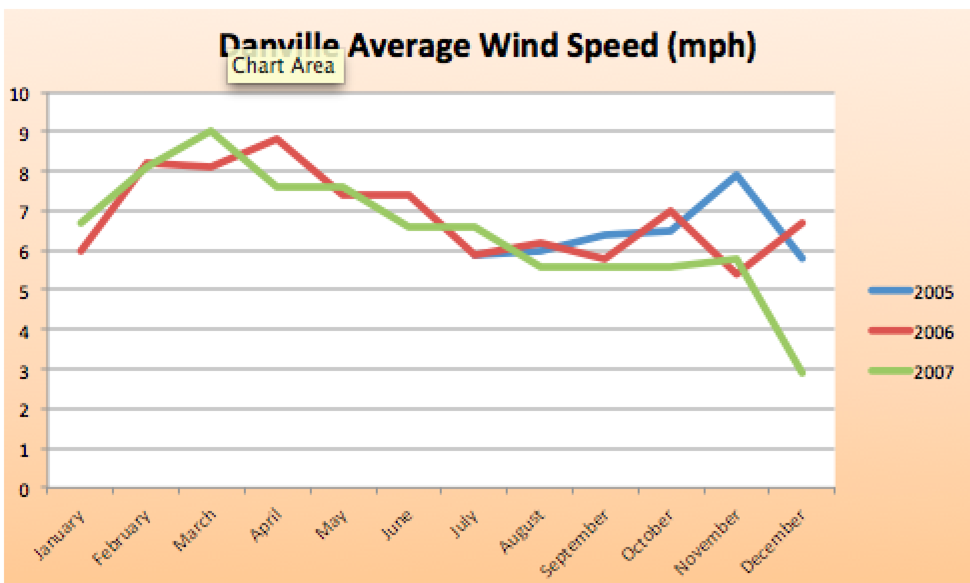


Fig. 2.4.12 Danville School Average Wind Speed, VERA (2011) program data

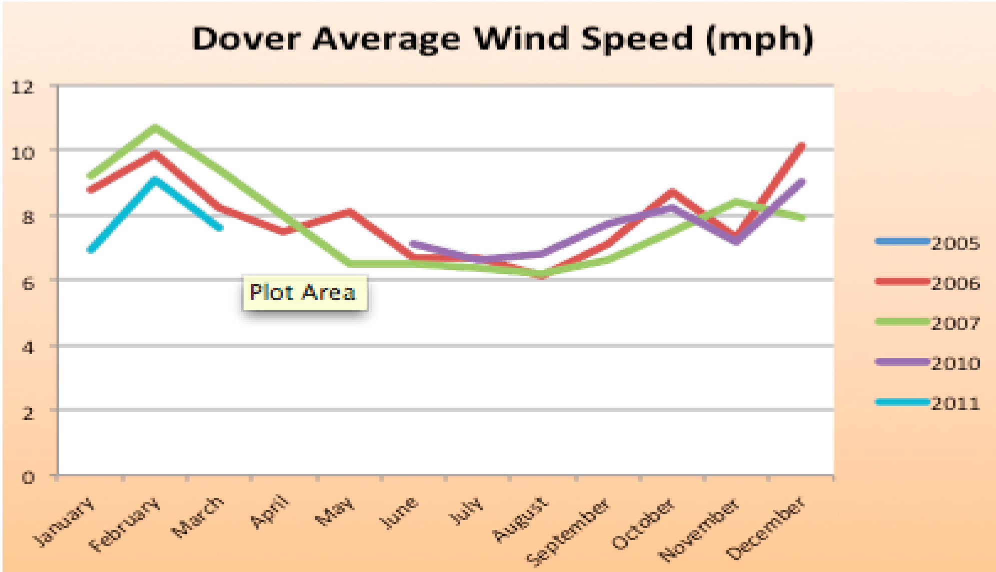


Fig. 2.4.13 Dover School Average Wind Speed, VERA (2011) program data

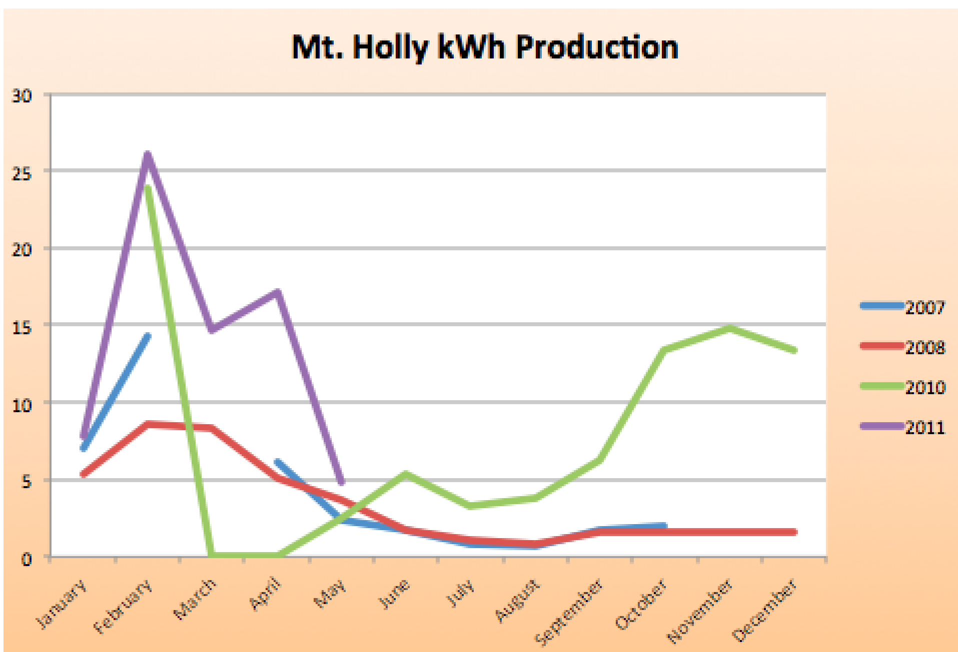


Fig. 2.4.14 Mount Holly Average kWh Production, VERA (2011) program data

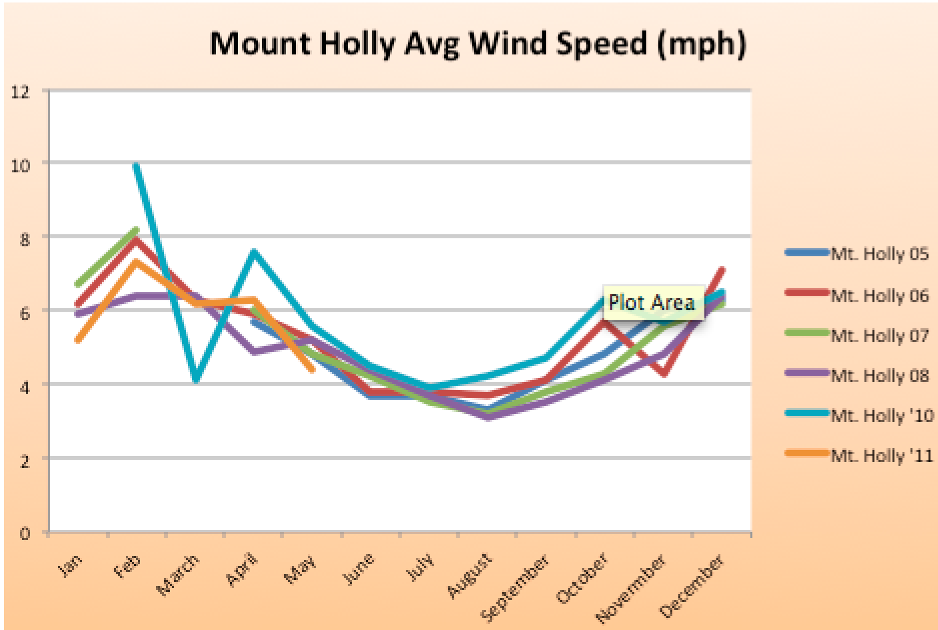


Fig. 2.4.15 Mount Holly Average Wind Speed, VERA (2011) program data

Chapter Three: Food Systems and Sustainability: Closing the Loop

Sophie Hasson, Jillian Mayer, Alex Rowe, Jessica Tarbell, Diana Wise

3.0 Executive Summary

This report aims to minimize the environmental impact, or create sustainability, from Thetford Academy's food system. An introduction describes our definition of a food system, in which we consider growth to decomposition of food products, and several considerations taken towards increasing sustainability at Thetford Academy. The current food service program includes breakfast and lunch service which is used by some of the 300 students. Recommendations are given in four areas:

- ❏ Currently, most of Thetford Academy's food is sourced through Reinhart Foodservice or Upper Valley Produce. All meat and dairy are sourced through Reinhart. It is recommended that some of these products should instead be purchased through Black River Produce. Black River Produce is a Vermont company that processes and distributes fresh animal products from local farms. All of their meat is certified grass fed, antibiotic free, and hormone free.
- ❏ In the 2012-13 school year, Thetford Academy's food service program ran a deficit of $19,127. Also, on average only 82 of the 300+ students are purchasing a lunch meal every day. In order to decrease this deficit is is necessary to increase student participation in the lunch program. Cooking more food at Thetford (as opposed to heating frozen and pre-packaged foods) must be made a priority. Additionally, by requesting student opinion on previously served meals and future meals the school can be sure to match student desires.
- ❏ By 2020, Thetford Academy will be required to implement a composting program. Composting also closes the food loop by turning waste into a viable input. Plans for an on site, 5-bin composting system alongside the maintenance building are described in detail. The structure of the program is based on, and is very similar to, an existing composting system at Thetford Elementary School. This plan requires staff and student involvement for success.
- ❏ Less concretely, the culture surrounding sustainability mindsets and their connection to food systems was investigated. Currently, there are several classes that expose students to the outdoors and environmental issues, but most students have not embraced environmentalism nor are they concerned with food systems. Suggestions to shift the culture include revitalizing the Environmental Club, conducting social media campaigns, a local foods night, a program called Thetford On Purpose, and implementing more information about food systems into classes.

Thetford is in the heart of a productive farming community. The students at Thetford Academy deserve to understand the food system, eat high quality food that is grown all around them, and to participate in moving towards a sustainable future. The above suggestions are a few ways to begin improving the campus knowledge and interaction with the food system.

3.1 Introduction: Food Systems Sustainability

As we began thinking about ways to make Thetford Academy's high school food system more sustainable, we were immediately faced with a fundamental question: what *is* sustainable food? We took a systems approach to this question, remembering that food does not exist only within the kitchen. A food system includes all actors (farmers, distributors, policymakers, consumers, scientists) and processes (farm inputs, harvesting, transport, processing, certification, marketing, distribution, consumption, and waste) involved in getting food to plates. Ideally, food systems should create a "loop," wherein all nutrients and energy that go into food production eventually reenter the system to create more food (Stokoe, 2014). There are many points of entry and departure for food, energy, and waste within food systems. Closing the food loop should be the ultimate goal of any food sustainability initiative.

In this report, we have outlined several ways that TA can begin closing this loop. First, we discuss TA's food sourcing options. Currently, TA sources the majority of its food from Reinhart Foodservice, a massive national-level distributor. We explore the possibility of sourcing TA's most resource-intensive foods (animal products) from regional distributor Black River Produce. We examine the complex environmental implications of alternative sourcing and compare animal welfare, labor practices, and the economic viability of the two distributors. Another point of entry into the food system in which TA is embedded is investigating and managing post-consumer waste. Food compost programs will give TA the opportunity to turn waste nutrients to soil capable of growing more food products. Properly composted food waste can be used at TA or sold to the surrounding community. As additional incentive, the Vermont legislature recently passed House Law 485, mandating that all recyclable and compostable materials be diverted from landfills from 2020. We believe a compost system modeled after that at Thetford Elementary School (TES) will allow TA to return vital nutrients to the energy system long before 2020, moving TA closer to creating a self-sustaining flow of energy through its food system. In the final section of this report, we explain the importance of student, staff, and faculty involvement in creating a cultural shift towards responsibility, cooperation, and environmentalism at TA. If the attitudes, behaviors, and values of the students and staff do not reflect a commitment and passion for environmental sustainability, neither alternative sourcing nor composting programs will be effective. Making sustainability sustainable is vital.

Food sustainability is a process. Analyses and suggestions enumerated upon in this report are only some of many ways to heal our food system and close the food energy loop. Exploring alternative sources of cafeteria food and implementing compost programs, coupled with a cultural shift towards sustainability, represent three of many paths TA should take. By engaging with many points of entry into the food system, TA has the opportunity to begin closing the food loop, thereby becoming a leading institution in sustainability nationwide.

3.2 Thetford Academy Sourcing Summary

TA works with three distributors. They are, in order from most to least products ordered, the Burlington division of Reinhart Foodservice, Upper Valley Produce out of White River Junction, VT, and Luckyday Company LLC out of Plainfield, VT.

Reinhart delivers two to three times a week. Deliveries are divided into three categories: dry goods, frozen goods, and refrigerated goods. Dry goods include sugars, sauces and condiments, spices, cereals, chips and snacks, kitchen wear, disposable cooking and serving equipment, and cleaning products. Frozen goods include meats, breads, french fries, pizzas, vegetables, juice concentrates, and cookie dough. Refrigerated goods include dairy, meat, juice, salad dressing, and eggs. Reinhart is a national company that distributes food and equipment to foodservice providers that sell directly to consumers. The origins of their individual products are unattainable given our limitations, but they come from farms all over the US, and potentially beyond. Reinhart is a massive organization that is convenient because of the diversity of their product catalogue, everything from aprons to feta cheese, and the guarantee of next day delivery.

Upper Valley Produce delivers two to four times a week. Deliveries include fresh fruits and vegetables, yogurt, and occasionally fresh herbs. A regional distributor, Upper Valley Produce forms the link between farmers and retailers. They are much smaller than Reinhart; the majority of their product is turned over on a daily basis. The vast majority of their products come from Vermont, New Hampshire, or Quebec.

Luckyday Company delivers once every four weeks. Deliveries include non-perishables - flour, rice, vegetable oil, canned goods; frozen goods - beef, chicken, vegetables, and freezable cheeses. These are all bulk goods with essentially indefinite shelf lives.

3.3 Sourcing Alternatives

In this section, we weigh the pros and cons of TA's primary food distributor, Reinhart, against those of a local/regional distributor, Black River Produce. We focus on meat and dairy sourcing because the New England region supports a large number of these farms, and because these products tend to be more resource-intensive than non-animal products. Since energy systems are complex and product supply chains are rarely transparent, this section is meant to be used as a tool for guided decision-making rather than direct consulting. While we ultimately conclude that switching to meat and dairy products from Black River Produce might allow TA to support local and regional farms and corporate transparency, the environmental impact of the switch is contentious. Should TA choose to source their meat and dairy from Black River Produce after weighing the pros and cons, in section D we identify alternatives to all meat and dairy products that TA ordered between August and November 2012. These alternative products to be newly sourced from Black River Produce are labeled "tier 1," "tier 2," or "tier 3," depending on the ease of switch. Tier 1 products will be the easiest to re-source from Black River, considering quantity, preparation needs, and other factors. Tier 3 products will be the hardest, and may require a radical shift in food preparation or presentation. We gently recommend switching meat and dairy sourcing to Black River Produce, but leave the final social, economic, environmental, and ethical cost-benefit analysis to TA.

Food Sustainability at Thetford Academy

According to the Sustainable Food Purchasing Policy Project, sustainable food purchasing seeks to address the following issues: labor issues, animal welfare, hormones and non-therapeutic antibiotics, genetic modification of crops and livestock, toxicity, water conservation and quality, soil conservation and health, global warming, protection of wildlife, local economies, food quality and safety, and diet-related health concerns (Sustainable Food Policy Guide). There are numerous views of how to approach these goals, all claiming different metrics towards judging "sustainability." One of the largest groups of sustainable food activists is food locavores. Food localism is an approach focused on the number of miles food travels from farm to plate ("food miles"). While buying local is certainly trendy among environmentally-minded consumers in America's middle class, professor and writer James McWilliams has elaborated on where locavores "get it wrong" in his book *Just Food* (2009). According to McWilliams, extreme localism is neither physically nor morally feasible, and the answer is much more complex than locavores claim. A "systems thinking" method is a more comprehensive view of the food system. Tracking biogeochemical cycles (water, carbon, nitrogen, phosphorous, etc.) in which our food systems are embedded allows researchers to determine the environmental "footprint" our food system leaves on the earth. The larger the footprint, the less sustainable or eco-friendly the food system. Like the locavore argument, the larger footprint-tracking method of sustainability has several limitations, including its erroneous privileging of zero greenhouse gas emissions and its inability to incorporate key variables like land degradation (McWilliams, 2010)..

Most environmental scientists and food justice activists agree, however, that the factory-farm meat and dairy industries are environmentally unsustainable, detrimental to human health, and economically exploitative. There is also a large body of literature arguing that regional, and not necessarily local, food sourcing may offer the best alternative (McWilliams). Currently, TA receives the majority of its meat and dairy from Reinhart Foodservice, the fifth largest foodservice distributor in the US, that sources from hundreds of farms, factories, and brands all over the country (Reinhart Foodservice L.L.C., 2014). Our alternative distributor, Black River Produce, is a Vermont-based foodservice distributor that sources from local and regional farms and cooperatives (Black River Produce, 2014). Both of these sources have advantages and limitations, as outlined in this section.

After researching food webs, energy systems, and Reinhart and Black River Produce, we conclude that there is no clear-cut answer to food sourcing. Since claims of “sustainability” are elusive and dubious in the complex food system in which TA is embedded, we do not feel confident proclaiming Black River Produce more sustainable than Reinhart or vice-versa. The product supply chains are vast, and often, in the case of Reinhart, well hidden. Even if we could trace every ingredient to its farm, and its food/fertilizer/transportation to their sources, evaluating every link in that energy web is not feasible. Therefore, in the following paragraphs, we have briefly outlined the pros and cons of each distributor. This section is meant to be used as a decision-making tool for Thetford; we have outlined the major differences in the companies and left it to TA to make final decisions. Additional considerations include contract and policy barriers, physical limitations (storage and cooking facilities may need upgrade), staff education, and budgetary constraints (Sustainable Food Policy Guide).

After considering all options, should TA choose to switch its most resource-intensive products - meat and dairy - to the regional distributor, we outline the Black River Produce alternatives to each product currently sourced from Reinhart. It is our hope that after reading this section of our report, TA will be able to make an informed decision about their meat and dairy sourcing, whatever they decide.

Reinhart Analysis

Reinhart Foodservice LLC is the fifth largest foodservice distributor in the US, with 33 distributing locations, spanning from the midwest to the east coast.

Pros:

1. Products are prepared to be served immediately (i.e. already sliced, cooked, washed, etc)

2. [Probably] lower prices*
3. Three sustainability initiatives:
    a. The “Engines that Can” program mandates reduced-emissions vehicles for transport;
    b. The “Enlightening Ideas” program switched the company to fluorescent light bulbs, redesigned warehouses to be energy-efficient, and introduced a recycling program for food packaging; and
    c. The “Green Disposables” program sells recycled and compostable cups, lids, and cleaning products to customers.

Cons:

1. Food has traveled from all over the country; “food miles” high
2. Extreme lack of transparency; impossible to track products back to farms and therefore impossible to make inquiries into labor practices, animal welfare, resource use, etc.
3. Sustainability initiatives are modest and brief; little information is provided beyond that outlined above (Reinhart Foodservice L.L.C., 2014)

Black River Produce Analysis

Black River Produce (BRP) is a family owned food distributor founded in the 1980s. Based in Vermont, BRP sources 23% of its products from farms within a one-day driving radius from its North Springfield headquarters. BRP services customers in Vermont, New Hampshire, and parts of New York and Massachusetts.

Pros:

1. Local
    a. 23% of products locally sourced; keeps local farms in business
    b. New meat process facility opening to process local meat; fills market void and opens wholesale market to local farmers
2. Ethical animal rights; all meat certified grass fed and antibiotic- and hormone-free
3. Farms chosen on basis of animal welfare, farm economic viability, and food safety
4. Transparent supply chain; all ingredients traceable to farm

Cons:

1. No explicit sustainability initiatives
2. Cannot compare prices to Reinhart, but probably higher
3. Smaller product catalog
4. Unclear whether regional food sourcing is more environmentally sound than national sourcing is (Black River Produce, 2014)

Alternatives at Black River Produce

Should TA choose to source their meat and dairy products from Black River Produce after considering the advantages and limitations, we have identified alternative BRP products in the table below. In the following table, we list all meat and dairy products ordered from Reinhart between August and November of 2012, and their viable BRP alternatives. The "tier" classification refers to the ease of switch from Reinhart to BRP sourcing. Tier 1 products have a BRP alternative with comparable size and preparation needs to equivalent products at Reinhart. Tier 1 products are also exclusively locally or regionally sourced. Tier 2 products are products that will be more difficult to source from BRP, given their quantity and/or preparation requirements. Tier 2 products may not be exclusively regionally or locally sourced. Tier 3 products require significant onsite preparation, or come from the same distributor as those from Reinhart. Products listed after Tier 3, without at "tier" classification, do not have a viable BRP alternative. The table also lists the name, source (smaller distributor or farm), quantity, and order frequency of Reinhart and Black River alternatives when applicable. BRP prices are included, but Reinhart prices were not disclosed.

Table 1: Sourcing Alternatives
(Black River Produce, 2014)

Tier	Reinhart Product	Source	Quantity[1]	Order Frequency 8/24/12-10/30/12	BRP Product	Quantity	Price/Quantity	BRP Source
1	Plain Cream Cheese	CSTONE	100/1 oz	16	Cream Cheese	100/1 oz	$21.80	Green Mountain Farms
1	Chick Brst (Frozen)	HORMEL	10#	3	Chix Breast B/L FRZ	10# AVG	$60.00	Murrays
			2/5#	3				
1	Feta Cheese	VILFRZ	9#	3	Feta	8# Bucket[2]	$35.85	Maplebrook
1	Ranch Dressing	KATKIT/KENS	4/1 gal	3	Salad Dressing Ranch	1 gal	$17.50	Drew's
1	Cheddar Shredded Cheese	GLCHSE	5#	2	Cheddar Shredded White/Yellow	5#	$18.90	Biery
1	Eggs		15/doz	1	Eggs White LG VT	15/doz	$42.00	Maple Meadow
1	Cottage Cheese	CABOT	5#	4	Cottage Cheese	5#	#10.45	Paul Marks
1	Whole Milk	HOOD	4/1 gal	3	Milk Whole	4/1 gal	$16.35	Hatchland Farm
			5/8 oz	3		No size equivalent		
1	Beef Ground	BFC	2/5#	3	Beef Ground	4/2.5#	$41.50	NE Raised[4]

1. # represents lb.
2. Also comes in 2/3# and 3# block ($25.45, $14.60)
3. No products that adhere to the 2014-2015 state nutrition regulations
4. Other alternatives at farms that are not distributors: PT Farm ($47.15) & Boyden Farm ($49.60)
5. BRP sources product from the same Reinhart distributor
6. Requires additional onsite preparation

1	Chicken Breast Tenders	BKBUSH	2/5#	6	Chix Breaded Tenders Retail	12/CS (10#)	$69.40	Bell & Evans
1	Chicken Breast Patty	BKBUSH	2/5#	12	Chix Breaded Retail Patties	12/CS (10#)	$69.55	Bell & Evans
1	Turkey Ground	JENIEO	2/10#	1	Turkey Ground	10# AVG	$49.00	Misty Knoll
1	Sausage Links	NCSH	10+#	1	Sausage (Maple, Bkfst)	5#	$24.35	VSC
2	Ham Sliced[6]	HORMEL	12/1#	1	Ham Uncured ABF B/L 1/2	4/4# AVG	$103.20	VSC
2	Grated Parmesan	ARTHUR	5#	2	Parmesan Shredded	4/5#	$22.55	Milano's
2	Butter	OASIS	30/1#	1	Butter N/Salt Solid	36/1#	$97.45	Cabot Creamery
			17#	1				
2	Caesar Dressing	KENS	4/1 gal	1	Salad Dressing Ceasar	6/1 L	$38.20	Drew's
1	Turkey[6] Breast Slices	HORMEL	6/2# (1 oz SL)	2	Turkey Breast Bnlss Frozen	1/6#	$39.90	Stonewood
2	Chicken Diced[6]	SBROOK	10#	12	No diced products—See Chicken Brst Frzn			
2	American Cheese	GLCHSE	4/5#	1	American Slices White	4/5#	$67.40	IPAP
3	Shredded Mozzarella[5]	JACOBO	5#	4	Mozzarella Shredded	5#	$18.75	Jacobo
3	Pulled Pork[6]	CSMRKT	2/5#	6	Pork Shoulder	30# AVG	$115.50	VSC
3	Sharp Cheddar[5]	CABOT	2/10#	1	Cheddar Sharp Sliced	4/2.5#	$58.00	Cabot
			50 ct/.75 oz	5				
3	Sour Cream[5]	CABOT	5#	3	Sour Cream	5#	$7.90	Cabot
---	1% Milk	HOOD	50/8 oz	30	NONE			
---	Chocolate Skim Milk	HOOD	50/8 oz	52	NONE[3]			
---	String Cheese	FRIGO	96/1 oz	6	NONE			
---	Margarine		900 ct	1	NONE			
---	Salami Genoa SL	HORMEL	6/2#	1	NONE			
---	Sausage Patty	HORMEL	10/1#	2	NONE			
---	Cooked Meatballs (.5 oz)	TYSON	2/5#	1	NONE			
---	Cooked Ham[6]	HORMEL	12/1#	1	No precooked ham products—see Ham Sliced			
---	Bacon Bits	REDBIT	10#	1	NONE			

Conclusion

While localism may be a trend among environmentally-minded consumers in the US, the environmental science behind the movement is controversial. Currently, TA sources the majority of its packaged and prepared food from national distributor Reinhart Foodservice, privileging price, convenience, and breadth of product catalog over supply chain transparency, regional industry, and animal welfare - three pillars of regional distributor Black River Produce. Note that in this list of pros and cons, we did not mention environmental sustainability. Food chains and energy webs are extremely complex, and there exist studies supporting both the energy efficiency of large-scale farming *and* that of local/regional farm systems. After weighing the pros and cons of all options, if TA decides to switch any of its food sourcing to Black River Produce, we recommend starting with the most resource-intensive foods: meat and dairy. The New England area is well-suited to producing these products, and we can say with relative confidence that if TA can source their meat and dairy from BRP, they should for environmental, economic, and ethical reasons.

Furthermore, it is our informed opinion that combining Black River Produce sourcing with other food sustainability initiatives outlined later in this paper - namely composting and educational outreach programs - will increase TA's environmental viability more so than switching their food sourcing alone.

Whether TA decides to remain a customer of Reinhart or chooses to switch certain products to Black River Produce, open communication with any food distributor is key to a successful and sustainable relationship. As Farm to Institution New England's (FINE) toolkit entitled "A Toolkit for Institutional Purchasers Sourcing Local Food From Distributors" reminds us, "as institutional purchasers continue to communicate their desire for local, regional, and sustainably produced foods, traceable to their source of origin, regional distributors will continue to work them into mainstream supply chains. As more requests are made for reports that track and report institutional purchases of these foods, distributors will continue to improve their reporting capabilities" and, hopefully, their sustainability, animal welfare, nutritional value, and food safety practices (FINE, 2012). Should TA continue to purchase from Reinhart, administrators might consider joining the chorus of sustainability- and ethically-minded institutions demanding transparency in product supply chains. If TA chooses to switch to BRP, open communication may continue to incentivize company policy improvements.

3.4 Balancing the Budget

School food service programs are not designed to make money. They do not run like businesses. Instead, they are designed to meet strict state and federal nutritional requirements in serving students that are interested in purchasing food. While the traditional model is legally sufficient, it results in mediocre food quality and costs that are higher than revenues. A school cafeteria cannot be viewed entirely as a business. Providing free and reduced price meals is required; sale prices cannot be adjusted to match demand, and the consumer base is static with one annual turnover. However, the most successful school food service departments balance the traditional model with a business mindset. They try to tackle the school lunch "trilemma" - balancing cost, nutrition, and student participation (Sacheck et. al. 2010). Finding the sweet spot in the trilemma is not simple, but an investigation into TA's current practices suggests that the most important change TA can make is in improving student participation in the school lunch program.

The following analysis of the 2012-13 school year food service program finances excludes costs and revenues related to vending machines. Total revenue for this academic year was $128,769 while total costs were $147,896. The food service program ran a deficit of $19,127. This $19,127 is money that the school is losing from classrooms and student activities. Were this a business, running a large deficit would clearly be unacceptable, so why should it be accepted in school? To eliminate - or at least decrease - this deficit, it is necessary to find the source of the budget gap. Food sales were $94,854 while employee salaries plus food costs were $117,360. Clearly, this is an unsustainable practice. For a 175 day school year, the program lost $109.30 per day. To be self-sufficient, TA food service must be asking: How can we make $110 more every day?

That year, 14,398 student lunches (82.3 per day) and 605 adult lunches (3.5 per day) were purchased. In any given year, there are approximately 300 students at TA, the majority of which are required to be on campus during a daily lunch period. Currently, only 27% of the market is being captured. There are 220 students that could potentially be purchasing a meal every day, but choose not to. This is problematic for two reasons: financial and academic. The lunch special at TA costs $4. If costs and a la carte sales were static, selling 23 extra lunches every day (just 8 every lunch period) would close this budget gap. Of course, costs are not static, but the first step is to increase revenue by $110 a day and 23 more lunches a day will achieve this. Many students that do not purchase the school meal eat chips, snacks, or nothing for lunch. There is a strong correlation between proper nutrition and academic achievement. Students that do not receive proper nutrition learn more slowly, test worse, are more frequently tardy and absent, have more disciplinary rates, and lower grades than students receiving proper nutrition (Center for Ecoliteracy).

To reach this goal, one mantra must not be forgotten: Put kids first! If the students' desires are met, higher participation rates will follow. On May 22, 80 TA students filled out a paper survey and then spoke in small groups with Alex Rowe. The principal topic of discussion was, “What would you change about lunch at TA?” Suggestions ranged from more comfortable benches to free seconds. Students enjoy the caesar salads and dislike frozen quesadillas. It is also apparent that students want healthy foods in general. There were many calls for more fresh fruit and when one girl exclaimed, “The salad bar is amazing!” all of her friends nodded in agreement. A group of senior girls begged for soy milk and occasional tofu dishes while one group was just hoping that more food could come from local farms. Specifically, one student was appalled at the lack of local corn in the fall considering all of the surrounding corn farms and another said, [What’s important to me is] “the fact that the food is not frozen and shipped in from somewhere far away.” One creative student hoped the beige walls could be painted; some student art is featured, but perhaps a student driven mural would make the cafeteria a ‘cooler’ place.

For TA to sell more meals, there must be a greater variety of freshly prepared foods. The eighth grade students with four years left at TA were already tired of frozen pre-packaged quesadillas and pizzas that “taste like cardboard.” Fresh fruits and vegetables were praised. Homemade muffins, a recent addition to Thetford’s repertoire, received high praise. Two big lessons should be taken away from the student input: more cooking should be done at Thetford, and the food service program should be continually seeking student input.

Experimentation and creativity will be necessary to create more food in-house. Some new recipes and a la carte items will flop. Students can be fickle, and a delicious meal may sell much better the second time it is served. With time and patience, excellent recipes will be found that can turn a profit and improve a student’s day. Student engagement will be crucial as the food service program evolves. When trying a new recipe, bring students into the kitchen to taste test it (Sacheck et. al. 2010). Ask them to be honest, and they will tell you whether they would buy that item or not. After new lunches are served, or biweekly if new menu items are not being added, students should be polled. It is impossible to know how the students truly feel about everything unless they are asked.

Other suggestions for student involvement include ‘contracting’ the culinary arts classes to try recipes for the cafeteria and hiring student interns in the school kitchen. These types of initiatives allow students to take ownership over the food program. If a class develops a recipe that is served at lunch, those students will be more likely to purchase that meal and encourage their friends to do the same.

Buying and preparing more fresh food can be more expensive, though this is not necessarily true. Because of the rich farm networks in Vermont, purchasing local produce is cost effective for some items (Vermont FEED). Because of increased participation rates, schools that serve more nutritious foods cooked from scratch make more money than schools that do not. Additionally, students eating more nutritious meals are less likely to be absent or require nurse visits, habits which both cost schools more money (Center for Ecoliteracy).

In looking to reduce the deficit and food costs, it is crucial to purchase the maximum amount of USDA commodity foods. These government provided reduced cost items are essential to balancing cost in a public school (www.fns.usda.gov/fdd/schoolscn-usda-foods-programs). TA already uses USDA commodities, but this practice can be expanded. A school in Maine has found that the more commodity foods they ordered, the more that were offered to them. Because this team jumps on any commodities available, the USDA calls them to offer extra foods at the end of the year (Sacheck et al., 2010). Purchasing all available commodity foods can present a challenge to the kitchen staff. They must be flexible in their menu planning and creative in using these foods. Again, patience and practice will be necessary when the kitchen begins purchasing all available commodities, but the financial gain makes this option too important to forego.

By making more meals in-house, engaging students in the meal creation process, and gathering student feedback, TA can increase student participation in its meal program. Relying less on frozen foods will allow the kitchen to be more flexible, which can lead to more menu diversity, and the ability to incorporate a wider variety of commodity foods, thus lowering food purchasing costs. It is important to remember that significant improvement is attainable. Only eight more meals per lunch period need to be sold. If these steps are followed, TA will not just have a happier lunchtime, but they will be on the way to closing the $19,127 gap.

Suggestions from Thetford Academy Students
• Get rid of the quesadillas • Pizza is undercooked and “tastes like cardboard” • Fewer frozen & canned foods • Frozen fruit is served at a temperature that is too cold to eat • More variety of drink options • Larger repertoire of recipes -- 6 years of the same foods is a lot! • More vegetarian options -- would love to see almond or soy milk and tofu • Less chili • Pasta, pizza, and quesadillas are not always fully cooked • Local corn in the fall, and more local foods in general • Offer hummus as an a la carte option • More vegetables • Healthier snacks

3.5 Strategic Plan for Implementing a Compost Program

Introduction to Composting

In an attempt to close TA's "food loop," we recommend implementation of a composting program that will minimize landfill waste while creating a meaningful educational experience for the students. According the Environmental Protection Agency (EPA), food waste is the largest contributor of waste being deposited into municipal landfills, accounting for 21% of total wastes, which is equivalent to 35 million tons annually. Additionally, when we consider wood and yard trimmings, biodegradable materials that could otherwise be composted are responsible for 38% of current landfill deposits (Reducing Food Wastes for Businesses, 2014). Within the past few years Vermont legislature has sought to combat these figures via the passing of House Bill 485 that will prohibit the disposal of recyclable and compostable materials in state landfills by 2020 (Gerlat, 2012). With this new law taking effect in the coming years, it would be in TA's best interest to begin a composting program so adequate time will be allotted for program growth and adjustment so that TA's initiatives can be fully compliant with House Bill 485 by 2020.

Putting this system into effect is important, not only from a legal perspective, but for reducing TA's impact on the environment and the food system. Composting preserves the nutrients that would otherwise be lost to a landfill, allowing the nutrients to be reintroduced to the system. The best solution for food decomposition is degradation via the aerobic decomposition that is facilitated by composting: a process that releases heat and carbon dioxide as byproducts. Handling food waste properly is important, for organic wastes that are deposited into landfills breakdown anaerobically, releasing methane, a greenhouse gas 25 times more potent than carbon dioxide. In addition to becoming a more sustainable institution, TA will benefit from a composting program both economically and educationally. Economically speaking, diverting food waste from the landfill will reduce hauling and tipping fees incurred via waste removal. If TA implements an on-site program, the school will also benefit from the mature compost created, by either using the compost on school property or selling the finished product to local community members. From an educational standpoint, TA students will learn what can and should be composted, how to maintain and facilitate successful composting, and they will be able to see the closing of the "food loop," encouraging students to be more environmentally conscious.

After considering the options available to TA that would result in compliance with House Bill 485, we recommend implementing an on-site composting program, similar to the program established at Thetford Elementary School (TES). Since its implementation in 2011, the TES composting program has been successfully maintained and has resulted in usable end products that have since been integrated into the school's on-site gardens. While other composting methods have been considered, modeling TA's new program after the one that has been proven successful at TES seems to be the most effective solution. This program will require additional labor and effort from the students, staff, and faculty alike, but maintaining this program on campus, and having the ability to incorporate student involvement into many parts of the process will have far reaching educational impacts. Not only will the students learn firsthand how to compost food and other biodegradable wastes but they will also be able to see the entire process and see how their actions can make a difference on a large scale.

The Decomposition Process

Composting is the natural degradation of organic materials by aerobic decomposition. This process yields water, carbon dioxide, and heat, which is preferable to the methane that would be produced if this same organic matter were to undergo anaerobic decomposition in a landfill. Properly maintained compost will undergo three phases through the decomposition process: the mesophilic stage, the thermophilic stage, and the maturation phase (Trautmann, N., & Olynciw, E., 1996). The mesophilic stage refers to the early decomposition carried out predominantly by microorganisms that rapidly break down easily degradable compounds, resulting in an initial increase in compost temperature. The mesophilic stage is relatively short, only lasting a few days. The thermophilic stage is marked by relatively high temperatures that may persist for long periods of time, ranging from several days to several months, depending on the composition of the compost. The high temperatures of the thermophilic stage facilitate the degradation of fats, proteins and other complex carbohydrates. Lastly, the maturation phase, or “curing,” refers to the last stage in which microorganisms are allowed to breakdown the remaining organic material; this phase could last for several months (Trautmann, N., & Olynciw, E., 1996). Throughout these phases the maintenance of the compost is important, as a well-maintained compost pile will not produce foul odors and will result in a faster, more efficient process. To properly maintain a compost pile the most important factors to monitor are frequent aeration, the carbon to nitrogen ratio, and the moisture content.

Aeration is a highly important aspect of maintaining efficient compost, as it is the availability of oxygen that prevents the formation of methane via anaerobic decomposition. In order to meet the demand of oxygen throughout this process, it is recommended that the composting materials be ‘turned’ (or aerated by other means), every 3-5 days in the early stages of decomposition, and in later phases, maturing compost needs to be turned at least once a week.

Secondly, to ensure effective decomposition, close attention should be paid to the carbon to nitrogen ratio (C:N). This ratio refers to the amount of organic “green” materials being deposited into the system relative to the non-organic “brown” materials being inputted. While all organic things have a specific C:N, “green materials,” which are comprised mostly of food scraps, provide the nitrogen while the brown materials add carbon. The ideal ratio is 25- 30 units of carbon to 1 unit of nitrogen, and because the carbon content of the brown materials is much greater than the nitrogen content of food wastes, this equates to approximately 2-3 times more brown material than green material (Home Composting Made Easy). Green matter includes most food wastes, fruit/vegetable peels, and grass clippings. To offset the generated food wastes, carbon-rich materials will need to be added, which include non-glossy newspaper, brown paper towels, manure, dried leaves and sawdust.

Lastly, the moisture content of the compost will also be important to facilitate microbial activity. Compost should feel wet to the touch but should not be overly saturated (Compost Cornell). Ideally, compost should have the consistency of a wrung sponge. To maintain proper moisture content, composting should take place in shade, where it will be kept out of direct sunlight.

The finished, mature compost will be dark brown in color, and have a crumbly texture and earthy odor. Compost is considered mature when initial materials (i.e. food wastes) can no longer be identified and pH has been neutralized (Coughlin et al., 2002). After mature compost has been allowed to rest during the curing phase, this finished product can then be used as soil conditioner, sprinkled over lawns, or mixed into potting soil (using a 1:4 ratio of compost to soil). The use of the end product is essential to closing the food loop since this process preserves and reintroduces soil nutrients that would otherwise be lost.

Implementing a Composting Program: Getting Started

Faculty Involvement

To ensure a successful program on TA's campus, the most vital element will be the interest and involvement of faculty and staff. Due to the high turnover rate of high school students, the longevity of any program will depend upon the continued momentum provided by the static members of the TA community. With a stable and consistent group of faculty working together with the students, a composting program will not only have a smoother implementation but a greater chance for survival as students graduate and new students arrive.

Most importantly, there is an eminent need for a core group of faculty advisors to serve as leaders within the school and as a contact for any outside assistance. It is essential for this group to play an active role in the program to maintain consistency and continuity despite the constant influx of new students, and loss of interest as heavily involved students graduate (Buxton, C., personal communication, 6 May 2014). The faculty advisors will be responsible for the maintenance of the composting-site, providing supervision and guidance to involved students, determining when decomposing material is ready to move on to the next stage, enabling and encouraging communication between all parties involved in the decomposition process, and deciding how the finished products will be used. The time commitment of a faculty advisor will be significantly larger during the implementation of the program and during initial operation, but this time commitment should decrease once the program is running successfully and the students have adopted their roles in the process. A group of faculty backing this program is recommended, rather than having one advisor for the program, to ensure its longevity. There will be greater chances of success with multiple members of the faculty so that the time commitment and responsibilities would be shared among several members of the TA community (Hayashigawa, J., personal communication, 22 May 2014).

For this program to be successful there also needs to be a considerable amount of support from cafeteria staff, which would encompass lunch monitors as well as kitchen staff who handle pre-consumer waste. The role of the lunch monitors is especially crucial as they will be responsible for helping the students with the transition to the new program by ensuring the correct food wastes are being collected for compost and that undesired items are not contaminating the collection bins. This position will be most important in the early stages of this program, since separating food wastes from other wastes in the cafeteria will be a new concept for many students and require some initial prompting. Once this program has been fully established and TA students become accustomed to separating wastes in the cafeteria, the responsibilities of cafeteria staff will be lessened.

Lastly, student involvement and education is essential. Students would need to be aware of the types of foods that can and cannot be composted by the school's program. Student's primary responsibility would be to compost when possible, while being cautious not to include certain items that could interfere with compost efficiency. Educating the students on the composting process, and encouraging participation will be invaluable in creating an effective and lasting program.

Food Waste Collection

Kitchen

Food wastes from the kitchen will make up the majority of pre-consumer wastes which include fruit/vegetable peels, unused food products, etc. After reviewing TA's current ordering forms, it has become apparent that much of the food that is entering the kitchen arrives pre-cut and ready to be used. While there are obstacles (such as time constraints, cost constraints, and limited staff) that necessitate this sort of ordering, if this were to shift in a way that incorporates more fresh produce it would certainly create more pre-consumer wastes.

Kitchen waste would also include any food leftover from breakfast and lunches that cannot be used for any other purpose. Another source of kitchen food wastes would be any foods that cannot be used for food preparation, i.e. food products that have passed their expiration date, stale bread products, and unused meat products.

Cafeteria

Cafeteria waste will comprise a large part of the collected food wastes. Cafeteria wastes will include any and all uneaten food that students wish to dispose of at the end of the breakfast/lunch period. These products will be collected as students are disposing of other wastes in a separated waste collection bin that will ask students to differentiate between compostable materials, recyclable materials, and municipal solid wastes.

In order for the collected wastes to be used for composting, it is important that the students understand what is being collected and which products will hinder the decomposition process. While the students are currently using paper plates and compostable plastic ware, these products cannot be collected for on-site composting. These products require composting in a commercial facility that provides much more heat than an on-site program could produce. Recommendations on the ordering of cafeteria products cannot be made at this time since the ideal composting program for TA will not be able to accommodate the decomposition of the compostable plastic ware or the paper plates that are currently being used and thrown away.

Classrooms

Because classroom waste will be minimal, the main obstacle regarding their compost contribution will be the collection process. It is not expected that classrooms will generate enough food waste to warrant compost collection on a daily basis, but rather, the collection will occur as needed. To accomplish this, each classroom would have a supply of brown paper bags that can be used in the event of food waste collection. After waste is collected in the paper bags, the bags would be taken to the cafeteria where they would be added to the larger cafeteria collection bin.

Since food waste is not usually generated in classrooms, the largest contributor of classroom waste is expected to be from the culinary classrooms. These classes would follow a similar procedure as the other classrooms by filling brown paper bags with compostable materials as needed and transporting wastes to the cafeteria. To ensure that the hassle of transporting food wastes from the classroom to the cafeteria is not preventing compostable materials from being added to the larger collection bins in the cafeteria, faculty should allow for time at the end of class for a student to deliver the bag to the cafeteria.

Using brown paper bags to collect classroom wastes is advantageous to the composting process since these bags will be composted along with the food wastes. The bags are also ideal because they will contribute to the amount of carbon entering the system. Once food scraps are collected, the whole bag should be added to the collection bin so that the paper can lend its carbon to the compost. Adding items as large as whole paper bags may slow decomposition, but they will break down eventually. If the addition of whole paper bags presents a problem, especially in the winter months as the environmental temperature drops, tearing the bags as they added to the collection bin could assist the decomposition process. Not only would tearing the bags allow more oxygen to come into contact with the contents of the bag, but also the bag itself would decompose more rapidly due to the increase in surface area.

The goal of classroom composting is to make this process as easy and accessible as possible so that more students and faculty would be willing to comply (Gernhard, J., personal communication, 31 March 2014). To seamlessly integrate compost collection into a classroom setting would require minimal time commitment and small changes to current behaviors. Using the paper bag collection system would inflict little change within the classroom; the only changes that would be made would be that food scraps are deposited into a paper bag rather than the trash bin, and a student would be delegated to transport the bag to the cafeteria before the end of the class period. While a similar system could be run using small plastic containers in the individual classrooms, using paper bags as needed is recommended since plastic containers would need to be cleaned after each collection, for minimal use in classrooms would result in bins that attract pests and produce foul odors. The process of cleaning the bin and returning the bin to its respective classroom would require more time to participate in composting, thus making compliance less likely, especially in classrooms that do not generate a substantial amount of compostable wastes.

Other Sources of Compostable Waste

The implementation of an on-site composting program will allow for waste reduction in areas not specifically related to food, specifically by employing the carbon-rich materials on campus to maintain the carbon to nitrogen ratio. Maintaining this ratio is necessary for sustaining an effective program because it will result in minimal odors, faster decomposition, adequate moisture content, and a viable end product (Home Composting Made). For compost, good sources of carbon are sawdust, dried leaves, and some paper products. Incorporating other wastes generated on the TA campus will not only provide the compost with great sources of carbon, but it will allow TA to better dispose of wastes in areas other than the kitchen and cafeteria. Other on-campus wastes that could be diverted to a composting system include sawdust from the wood shop, dried leaves and cut grass (grass is a green material and would contribute nitrogen to the compost), and used paper towels from the restrooms.

Restroom paper towels could play an important role in providing adequate carbon to the system. While dried leaves are an adequate source of carbon they are only readily available for a small period of time during the school year, whereas a school the size of TA would generate a continuous supply of paper towels that could be used year round (Buxton, C., personal communication, 6 May 2014). An additional benefit of utilizing used paper towels is that the paper towels would otherwise be thrown away since it is not always possible to recycle paper towels since many are made from already recycled materials (Waldstein, 2011). Using paper towels for compost will further divert waste from the landfill and contribute to decreased hauling and tipping fees.

Beginning the Collection Process

To ease into the implementation of a new program, TA could take a similar approach to that of TES, where food waste collection began before the composting program. In beginning the food collection process early, TA will be able to work out the food collection process, and the students will be more aware of the types of wastes that can be composted (Buxton, C., personal communication, 6 May 2014). One benefit of starting this process sooner than the composting program is that there will be less chance of unwanted materials ending up in the composting bins. While these unwanted products, which include eating utensils, milk cartons, metals, and plastics, will not terribly hinder the decomposition process, they will make the end product less desirable since these items will not break down and will remain intact amid the mature compost. What is especially beneficial about early stage food collection is that students and faculty will become accustomed to separating waste into trash, recyclable, and compostable materials. Having this system in place before TA begins composting will increase the likelihood of more waste being collected once sorting becomes more of a habitual behavior.

The primary reason for beginning food waste collection early is that in starting this process, and continuing to do this daily for long periods of time, TA will be able to gauge how much food waste is being generated. While this amount will fluctuate based on a variety of factors, collecting food wastes over a long period of time will allow for more accurate information regarding the average amount of daily waste (Hayashigawa, J., personal communication, 22 May 2014). Knowing the amount of waste that the school produces is important for the carbon to nitrogen ratio since the amount of food inputs must be matched with certain ratios of other materials, and knowing how much food waste will be contributed will allow TA to quantify the amount of other materials that will be needed (these ratios will be discussed in depth in a later section).

If TA begins the food waste collection process before the implementation of the composting program, the next step will be to decide what is done with the collected wastes. The collected food wastes could be donated to local farms/community members that either maintain their own compost or use the food wastes to supplement the diets of farm animals. In donating the collected scraps to community members TA will be fulfilling a public service in addition to the diversion of wastes from the landfill.

Based on the size of the TA student body and given the fact that not all students eat meals on campus, we expect a similar output, especially since high school students are more likely to consume larger portions of their meals than their elementary school counterparts. On an average day, up to two five-gallon buckets of food waste are collected from the TES cafeteria (Hayashigawa, J., personal communication, 22 May 2014). Given our assumptions, a similar sized composting program would be sufficient.

The Composting Site (modeled after TES)
Location

An ideal location for a composting site must meet several requirements in addition to taking into account the numerous outside factors that must be considered. Primarily, the site for setting up composting bins would need to be large enough to accommodate at least a 5- bin system, and have additional space in the event of program expansion. The system currently functioning at TES is a 5-bin system requiring a considerable amount of space, including additional space for the turning of the piles and for the storage of carbon materials. The size of individual bins can vary based on the amount and rate of food waste being generated by the school, but bins smaller than one cubic yard each are not advisable. Since one cubic yard would be able to accommodate a typical household, for a school, the bins could be built larger, but should not be more than four feet tall since this high would make it difficult for students and faculty to manage the bins (Coughlin et al., 2002).

The location should be away from direct sunlight for a majority of the day, due to the fact that maintaining adequate moisture within the bins is necessary for decomposition and being in direct sunlight for prolonged periods of time could lead to excess drying. For this reason, the bins would also need to be close to a water supply so that water can easily be supplemented when needed (especially important during the warmer months of operation). Lastly the composting bins would need to be near enough to the cafeteria collection bins so that the addition of food wastes to the bins does not present an obstacle sizeable enough to hinder compliance. The transportation of food wastes from the cafeteria to composting site should not be a time consuming or a laborious task if TA hopes to maintain the momentum of this program. The ease of this process will become especially important during the winter months, as this will require those involved with the compost to be outside during the transportation of wastes and during the maintenance of the bins.

Aside from the actual maintenance of the composting bins, another important factor to consider is the visibility of the program. The location of the composting site can also vary based on the level of transparency TA wishes to convey with this program. For education and awareness on campus, having a highly visible system would be advantageous as students, and campus visitors, will be able to see the functioning system and this may act to foster interest in the program and sustainability overall. However, maintaining a visible system would mean a high level of commitment from all actors involved since a visible program would need to be well kept to deter foul odors and unwanted pests.

After assessing the TA campus and speaking with Casey Huling and Len Whitaker a potential location for the site has been proposed. On TA's campus an ideal location for a 5-bin system would be by the maintenance building, since this is both visible to the campus and also located near the dumpsters where all other wastes are taken (Huling, C. and Whitaker, L., personal communication, 21 May 2014). Currently, the area behind the maintenance building is not being used for a functional purpose. Ideally, this location would provide the bins with some sort of shade during the day so that the bins do not experience excessive drying. Of the two locations, the most ideal would be to place the bins along the side of the maintenance building for accessibility. Having the bins located alongside an existing structure would make it easier for students and employees to maintain during the winter when snow plowing becomes a factor. Additionally, constructing the bins here may help protect the bins from the environment so the bins last longer. A roof should also be constructed over bins to provide shade and prevent rainwater interference. This structure can be built from the existing maintenance building (Hayashigawa, J., personal communication, 22 May 2014). Because this location is on the TA campus and near neighboring forest, bins must be well maintained to prevent intrusion of nearby pests.

Fig 3.5.1 Recommended location for TA compost site (Campus Tour, 2014).

Fig 3.5.2 The Current Location

Fig 3.5.3 TES Composting System

5 Bin System

Due to the observed success of the TES composting program, the proposed system for TA would be very similar, with few exceptions for design and maintenance of the bins. This system is ideal for a school setting because working with a bin system means that the compost itself is contained during the mesophilic and thermophilic stages, which will prevent unwanted pests and odors. Additionally, using a 5-bin system provides sufficient storage for compost at all stages of decomposition, the process allows enough time for the compost to enter the maturation phase.

Much like the TES composting system, the bins would be arranged in a series. The first bin in the succession is the "active bin," named for having the most active contents. The active bin will be the only bin where new materials are added to the system. Food wastes will continuously be added to the first bin until the first bin is full. When the first bin is full, turning must take place (Buxton, C., personal communication, 6 May 2014). The bins will then be turned in a progression whereby the contents of the active bin will be deposited into bin 2, the contents of bin 2 will be deposited into bin 3, the contents of bin 3 with be deposited into bin 4, the contents of bin 4 will be deposited into bin 5, and the contents of bin 5 will be moved into the "curing" pile. The curing pile rests directly on level ground so that microorganisms and worms may further degrade the composted materials into mature compost. Materials should be left in the curing pile for at least one month before being used (Refer to HighFields Compost Management Sheet in Appendix 2).

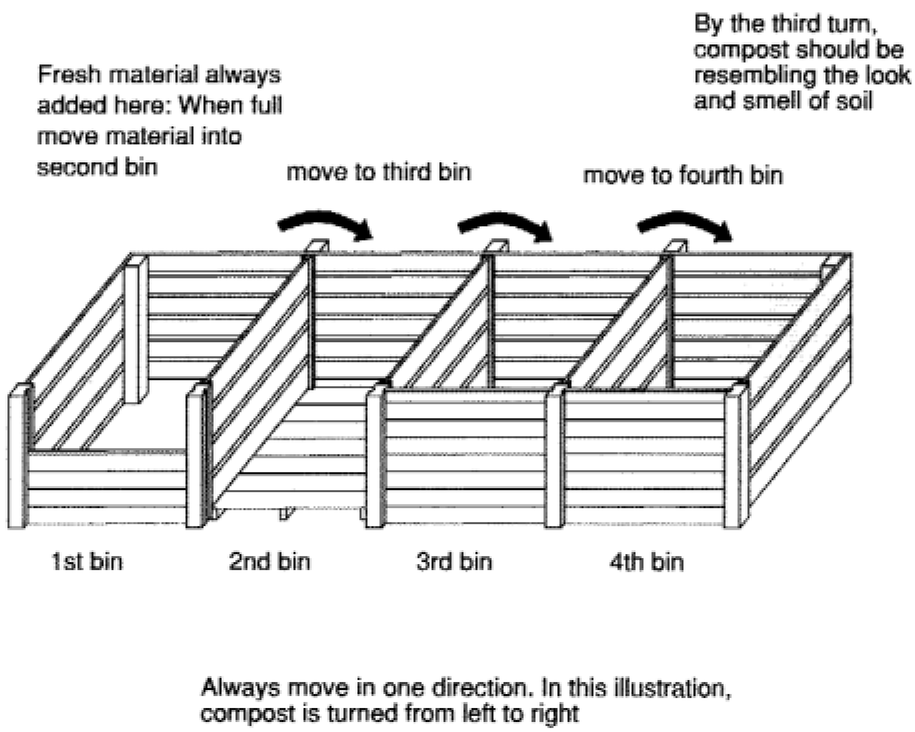


Fig3.5.4 Diagram depicting the function of a bin sequence (Coughlin, P., Alexander, K., & Enkler, M., 2002)

The bins would be constructed out of wood, since they would need to be sturdy, low conductors of heat to insulate the compost, and have the ability to absorb excessive moisture to prevent the compost from undergoing anaerobic decomposition (Dunn 2007). These bins could be constructed on-site, however, the size of the individual bins could be adjusted to accommodate the amount of food waste being generated. These bins would be slightly raised and have a closed bottom, meaning that the compost will not be resting directly on the ground. While having the bins closed and off the ground would inhibit the introduction of naturally occurring microorganisms and worms, the composting process should not be hindered by their absence since a majority of the composting that will be occurring inside the bins will be the high temperature degradation of the thermophilic stage. Additionally, having the bins slightly raised will allow for some aeration to occur even when the bins are not being manually turned. The design of the bins also includes insulation panels that will be installed on the outer walls of the bins, but not in the communal walls shared between bins. Insulated walls will assist in the decomposition process by ensuring high internal temperatures during the colder months of the year (Hayashigawa, J., personal communication, 22 May 2014). Lastly, to ease the process of transferring the piles from one bin to another, the TES bins are built so that the front facing walls of the bins can be removed. Having this feature will greatly improve accessibility to the compost at the bottom of the bin as well as decrease the amount of labor and time it will take to turn the piles from one bin to the next (Hayashigawa, J., personal communication, 22 May 2014).

TA could modify the bins from the TES system to better suit the needs of the school. One recommendation is that the size could be modified based on the actual output of school waste. While TA's enrollment is approximately 100 students greater than TES, the output of waste could vary greatly based on the number of students who chose to eat on campus since there are more options available to high school students, and based on the amount of uneaten food by the individual students since appetites and preferences will vary between the two age groups.

Maintaining A Successful Compost Facility

How the Compost will be Collected

A suggested method for collecting food wastes would be for the school to implement visual aids to assist the students in determining which wastes should be thrown away, recycled, or composted. As shown in the figure below, Dartmouth College has had success with this sort of visual display since it shows the proper categorization of the exact items a student will have to sort. Using this sort of system in the school cafeteria will help to prevent unwanted materials from being composted as well as encourage students to compost the proper materials. Having a visual display is especially beneficial for items that are often sorted incorrectly such as plastic utensils and used paper plates that cannot be recycled. However, given the size of the TA student body, it will probably not be necessary to have a large sized collection bin in the cafeteria since two or three 5-gallon buckets will suffice for daily collection.

Fig 3.5.5 Waste Collection bins at Collis, Dartmouth College

Once compostable materials have been collected, a pair of 7th or 8th grade students, along will a faculty advisor, will transport the 5 gallon bucket(s) to the composting site. At TES, transportation is accomplished using a wagon, and depending of the amount of waste generation, using a wagon may also be ideal for TA (Hayashigawa, J., personal communication, 22 May 2014). The students who are responsible for transporting the wastes to the compost site will also be responsible for adding the collected materials and proportionally correct amount of carbon materials to the active bin under the supervision of the faculty advisor. This task would be most efficiently completed by a pair of 7th or 8th grade students who will be assigned to this duty on a weekly basis. Given that there are 40 weeks in a typical school year, this program will require the participation of at least 80 students, excluding students involved in the turning of the piles.

What to Collect

The on-site composting system will be able to accept all food wastes, with slight variations depending on the state of the compost (i.e. if the compost is too wet, TA may wish to restrict the amount of liquids being collected). While it may be contested that on-site compost should not include meat and dairy products to avoid unwanted odors and attracting pests, properly maintained compost will not have these complications. Pests are attracted to compost when they see it as a viable option for food, which will happen if the compost is degrading slowly or if it is not reaching optimal temperatures shortly after its integration into the pile. However, if the compost is managed in a way that follows an appropriate composting recipe, the carbon to nitrogen ratio will be optimal for composting, which will result in rapid increases in temperature, and therefore faster composting (Hayashigawa, J., personal communication, 22 May 2014). Since well-maintained compost will quickly heat to its optimal temperature of about 160 degrees Fahrenheit, the high temperature of the compost will increase the rate of decomposition as well as deter pests, as the compost will be too warm. Eventually the compost will lose heat and the rate of decomposition will slow, but by this time the original food wastes will be unrecognizable and pests will no longer see it as food (Hayashigawa, J., personal communication, 22 May 2014).

Despite the debate regarding the inclusion of meat and dairy in on-site compost, TES has found success collecting all food wastes indiscriminately. Since its implementation in the 2011 school year, TES has not experienced any problems with pests or foul odors, a success that they credit to carefully following the compost recipe that properly balances out the carbon to nitrogen ratio to optimize composting conditions (Hayashigawa, J., personal communication, 22 May 2014). Although the TES system freely accepts meat and dairy products, there are times when dairy products are specifically restricted due to concerns over the composts moisture content. When the compost appears too dry, the compost can be supplemented with discarded milk products from the cafeteria rather than using water. Similarly, when the compost is too wet, the school can limit the amount of liquids being collected. In addition to altering the collection process, more/less carbon materials could be added to the compost to discount for the amount of liquid inputs but this would require a change in the compost recipe that could eventually disrupt the carbon to nitrogen ratio. Since unwanted liquids can be discarded down a drain rather than being taken to a landfill, limiting the amount of liquids collected does not pose a substantial risk to the environment and it would be ideal to use these liquids to supplement the compost in times of need rather than alter the compost recipe (Hayashigawa, J., personal communication, 22 May 2014).

As previously mentioned, the plastic cutlery being used in the cafeteria should not be collected since they will only break down in a commercial composting facility (Profita, 2013). Even though these types of plastics have the ability to biodegrade under composting conditions, the utensils being used at TA are ultimately being deposited in a landfill where this sort of decomposition cannot take place. The benefits of using compostable utensils can only be seen when the materials are taken to a commercial composting facility that can sustain the high temperature required to break down such items.

Monitoring

Throughout the decomposition process, the compost in the active bin will need to be continually monitored to ensure that the correct inputs are being used. To efficiently monitor the compost temperature and moisture should be checked daily. Temperature is an especially important metric for compost since the chemical process of aerobic decomposition releases heat as a byproduct, meaning that rapidly increasing initial temperatures and sustained high temperatures are indicative of active and effective compost. When the internal temperatures of the active bin begin to fall after plateauing at a relatively high temperature it could mean that the compost is not being sufficiently aerated, suggesting that food is not being collected fast enough to maintain a bin system, or that the bins are too large. In the event that temperatures are falling before the bins are ready to be turned in the succession, the compost should either be manually aerated or turned early, regardless of the amount of compost in the active bin. Consistently monitoring compost temperatures will allow the students and staff to follow the progress of the compost by graphing the rise, plateau and fall of internal temperatures; this will not only be informative for fine-tuning the composting practice, but will also have educational value that can be applied in the classroom.

The other metric that should be assessed is the moisture of the compost to ensure that the compost is decomposing at an optimal rate. This could be done through observation or with a meter designed to determine moisture content, but of the purpose of compost, observation will be both inexpensive and sufficient. Ideally, the moisture content of the compost in each bin should be about 40- 60% by weight (Monitoring Compost Moisture, 1996). The approximate moisture content can be measured without the use of a moisture reading device by squeezing the compost; ideal compost will have the consistency of a wrung sponge. If, when squeezed, water comes out of the compost, it is too wet. If the compost crumbles, it is too dry. Ideal compost should be able to be squeezed without releasing water or crumbling (Measuring Moisture in Your Compost Pile, 2014). Excessive drying can limit the microbial activity within the compost and eventually, dry compost will stop decomposing all together. If compost is too dry, it can be remedied with supplemental water. However, unlike excessive drying, having too much moisture in the compost will inhibit aerobic decomposition, as oxygen availability will decrease as the moisture content rises. Compost that undergoes anaerobic decomposition will produce a foul odor since methane will be produced as a byproduct (Monitoring Compost Moisture, 1996). To maintain proper moisture content, the consistency of the compost should be monitored regularly.

Aeration

Aeration is a vital aspect of maintaining compost since the method of decomposition employed by compost is aerobic decomposition (rather than anaerobic decomposition) which requires oxygen. The current system at TES has found that the processes of turning the compost thought the sequence of bins approximately once a month has provided sufficient aeration for aerobic decomposition (Buxton, C., personal communication, 6 May 2014). Due to the fact that aerobic decomposition is being maintained in the current TES system, TA should increase the amount of aeration to decrease the time that the compost requires to reach the maturation stage. For TA, an ideal method of aeration would be to use an aerator, which is a device with extending arms that will allow for easy manual aeration of the compost without disrupting the 5-bin system. Manual aeration would not be used in place of turning the compost from one bin to the next, but would be used during the month, between the times when the compost is turned. Using an aerator would require relatively little effort compared to manual turning using a pitchfork since the design of the aerator is specifically made for compost. When using an aerator, the aerator is placed directly into the compost and removed, and the arms that extend as the instrument is retracted from the bin accomplish aeration (Compost Aerator, 2014). The movement and displacement that occurs inside the bin will allow for additional oxygen to reach the decomposing materials, thus increasing the rate of degradation.

C:N Ratio and adding materials to the compost

Another highly important aspect of maintaining efficient compost is maintaining the ratio of carbon and nitrogen inputs, more simply referred to as the C:N. An optimal C:N would be approximately 25- 30 parts carbon to 1 part nitrogen (The Carbon:Nitrogen Ratio, 2014). Because the amount of carbon in carbon-rich “brown materials” is much greater than the amount of nitrogen provided by the food wastes (or “green material”), the ratio of carbon and nitrogen-rich materials should not be added 30:1 per unit. Since calculating the individual C:N of each product being added to the compost can become extremely complicated given that the type of food wastes varies on a daily basis, the compost system will operate under the assumption that food wastes in general have a C:N of 17:1 (The Carbon:Nitrogen Ratio, 2014). To balance out the input of food wastes, it is imperative that a specific composting recipe be followed. The recipes used at TA were provided by the HighFields Center for Composting, and they clearly outline what, and how much, of each carbon-rich material should be added per unit of food waste to maintain an optimal C:N. (For more information refer to Appendix 1 and Appendix 2)

The Curing Process and Uses

Once the compost has been turned though each of the 5-bins it would have been composting for months, meaning that when compost reaches the end of the succession of bins, the compost has reached the maturation phase of the process. The compost in bin 5 (or the bin furthest from the active bin), will be placed directly on the ground after being removed from the bin during the turning process. The act of placing the compost directly on the ground during the final stages of composting is referred to as the curing phase, which should last at least a month after the process appears complete, but can persists for years (Appendix 3). While on the ground, the naturally occurring microorganisms and worms from the surrounding environment will infiltrate the compost and continue to degrade any remaining organic materials while aerating the pile and neutralizing the compost pH. At TES, the compost is covered during the curing process with a semi-permeable cloth that allows air to get in while protecting the compost from rain. Another countermeasure that should be taken in the event of rain is that the curing process should occur on level ground to prevent run off (Hayashigawa, J., personal communication, 22 May 2014). Once the compost has fully matured in the pile, the compost is ready for use.

The finished product created by the composting program can be used to benefit TA in a number of ways. Composting, and using the resulting end product, preserves nutrients that would have otherwise been lost to a landfill, and thus the end product can be used to reintroduce these nutrients to the environment. The compost can be used for the maintenance of TA's landscaping as well as being used in the new on-campus garden to close part of the TA food loop. Additionally, any remaining compost that is not being used on the TA campus could then be donated to the local community garden, or sold as part of a fundraiser to benefit TA (Buxton, C., personal interview, 6 May 2014). While composting is time consuming, and the processes is lengthy, operating a continuous program will provide TA will continuous supply of compost that can be used as needed.

Student Involvement

Begin at the Middle School Level (especially for a pilot program)

The most viable grade level to implement a compost system is the middle school students. Since the middle school students have recently attended TES where they would have participated in the maintenance of a successful composting program, these students will already be familiar with the tasks and responsibilities that the new program will require (Hayashigawa, J., personal communication, 22 May 2014; Huling, C., personal communication, 22 April, 2014). Allowing these students to become heavily involved in this new program will create a solid core of students who are interested in composting and knowledgeable about the process as they move on to the high school where they will serve as leaders for the students arriving from other schools.

Beginning this program at the middle school level will provide the greatest chance for the longevity of a new program because the middle school creates a smaller target for implementation. In working closely with the middle school students during the initial stages, the hope is that these students will become involved in the process and consider composting a priority moving forward, and hopefully this momentum will be carried with them as they enter high school.

Once the program has been officially established on the TA campus, TA can adjust the process in ways that would accommodate the interests of other students that were not originally involved in the process, such as the high school student body. It is possible that interested students could be involved and volunteer though various extra-curricular groups, such as the Environmental Club. Alternatively, TA could expand the program to incorporate the high school students on an involuntary basis by assigning high school students to composting responsibilities. Since high school students will be more capable of carrying out complex tasks, potential duties would include assisting the middle school students with adding materials to the active bin, calculating the amount of carbon materials that will need to be added to offset the amount of nitrogen/ food wastes being added, and assisting with turning the bins when necessary.

Student Roles

Students' primary role will be sorting food wastes from recyclables and landfill wastes. While this process may initially result in incorrect sorting, eventually sorting between compostable, recyclable, and landfill wastes will become habitual for students and employees. Participation in food waste collection is vital to ensure that a sufficient amount of food scraps are being integrated into the system, and to prevent unnecessary wastes from being deposited into a landfill. As a new program composting will encounter initial resistance and various obstacles, but the hope is that eventually TA will embrace the changes in social norms as behavior adapts to the new system.

Students will be assigned weekly duties. The assigned students will be responsible, under adult supervision, for transporting food waste from the cafeteria to composting site, and adding the wastes and appropriate carbon materials to the active bin. While at the composting site, students will also be responsible for recording the temperature and moisture content of the existing compost, and notifying the faculty advisor if changes need to be made. Lastly, intermediate aeration of the compost can be done on a weekly schedule whereby the assigned students will be instructed to use the aerator to facilitate faster composting.

The main obstacle of maintaining a long-term program is time, and arranging when certain tasks need to be carried out. For waste transportation and addition to the composting bin, the assigned students should be allotted a 10-15 time period during the school day to carry out this task, ideally, this would be either at the end of the last lunch period, during a study hall, or at the very end of the school day. Since this part of the process would need to occur under adult supervision, the availability of the faculty advisors will also be a constraint. Additionally, while turning the bins will only need to be done monthly, or as needed, this process will require a lot of time and effort. This process will involve removing the front wall of bin 5, moving the bin 5 contents into a wheelbarrow, and transporting the compost to the curing site, all before this process can repeat when moving the contents of bin 4 to bin 5, and so on. This process is timely and may take several days to complete given that students and staff are only available for short periods of time throughout the day.

Materials Needed

- ❏ Compost bins
    - ❏ Constructed out of wood (need hinges, screws, etc)
    - ❏ Insulation
- ❏ Roof over composting site
- ❏ Aerator (Compost Aerator, 2014)
- ❏ Collection bins
    - ❏ 5 gallon buckets (at least 3 to start)
- ❏ Wagon
- ❏ Shovels
- ❏ Wheelbarrow
- ❏ Composting cloth (ComposTex Covers, 2014)
- ❏ HighFields Composting Consultation (Contact James McSweeney)
- ❏ Paper bags for each classroom
- ❏ Visual display in the cafeteria

3.6 Supporting Institutional Changes with a Culture of Sustainability

Revisiting a Systems Approach

Thus far in our report, we have primarily focused on major institutional changes we believe TA should make to improve its food system: alternative food purchasing practices and a better waste management program. As discussed earlier, in order to be effective, “school food reform requires changes throughout the system, given the interdependencies involved in the process that brings food from farm to fork” (Sonnino & Morgan, 2010, p. 69). Our proposed initiatives address both inputs into the system, food, and outputs from the system, food waste. However, these top-down measures alone, though addressing two different processes, will not necessarily lead to a healed food system. Why? In order for institutional changes to be effective or successful, they must receive support from key actors in the system – which in the case of TA, are the students and staff members.

In the previous section we discussed how the compost operation would require involvement from the 7th and 8th graders and key faculty members. Given that, it may seem like the students and staff’s future actions will support these new institutional changes. But, support cannot simply be acquired through mandatory participation in certain programs. The future of TA's food system will also require support from a less tangible perspective, a cultural perspective. Why is culture important? The culture of an organization, especially at a school, "guides the decisions of its members by establishing and reinforcing expectations about what is valued and how things should be done" (Bertels & Papania 2010, p. 10). Therefore, the behaviors, attitudes and values of the students and staff at TA must reflect an understanding of and deep appreciation for food issues and sustainability at large in order to effectively support the proposed institutional changes in the long run.

Assessment of TA's Culture Towards Food and Sustainability

Purpose

To avoid making any assumptions, we set out to discover what TA students and faculty currently knew about food systems and environmental issues: how engaged they were with such topics, what they valued, and how they were behaving in order to postulate how we believed these actors would interact with our proposed plans. The assessment of these 4 relevant cultural components at TA, **1) Knowledge 2) Level of Engagement 3) Behaviors and 4) Values,** was carried out to help us determine what was working well, what needed to be strengthened or transformed, and if anything was completely missing from the current system.

Methodology

To understand the current culture at TA, we spoke with a variety of key actors: students of all grades, important faculty members, and external actors with previous involvement at TA. With the students, we conducted series of informal interviews during lunch to gauge the level of students' preexisting environmental knowledge, especially as applied to food and waste, to gain a better understanding of how engaged they were with these topics inside and outside of the classroom, and to determine what they valued. In addition, we also conducted an in-depth interview with a junior girl who demonstrated a vested interest in our project and was able to illuminate certain aspects of campus, especially with regards to the behavior of her peers. To gain a better understanding of the faculty's orientation toward these topics, we spoke with Casey Huling and Len Whitaker. We also examined written resources, specifically the TA Course Guide and the TA website, to supplement our in-person interviews. It should be noted that the categorization of these cultural components is somewhat arbitrary -- there are certainly other important aspects of a school's culture; however, we felt that these 4 components were most relevant to our project. Further, we realize that these cultural components to not exist in isolation of each other – i.e, environmental education in the classroom often affects knowledge and includes active engagement. Additionally, we recognize that these interviews are subjective in nature and thus any conclusions derived from them may not truly represent the exact state of affairs. That said, we choose to do interviews instead of written, systematic surveys because we felt these topics would be better communicated orally and we wanted to be able to ask follow up questions.

Results

Knowledge

Unfortunately, our first conversations with the 7th and 8th graders did not provide us was a clear understanding of what they knew because they were not incredibly talkative. Given that we are an older, outside party with no personal connection to these students, this was obviously understandable. Fortunately, almost all of the 7th & 8th grade students at TA attended Thetford Elementary School (TES) beforehand. Therefore, we had an extensive conversation with Cat Buxton, the education coordinator at the nearby Cedar Circle Farm, and Joette Hayashigawa, the school nurse at TES, both of whom have played a major role in the composting operation and school garden at TES. Through these interviews, we were able gain a better understanding of what the 7th and 8th graders likely knew about food issues. To summarize, TES currently has 13 raised gardens, 7 of which feed the cafeteria and 6 of which correspond to a specific curricular component for each grade. In Kindergarten, students tend to a rainbow, “senses” flowerbed that is used to help them understand how each of the 5 senses work. Next, in 1st grade, the focus is on soil studies and history; students plant a “Three Sisters Garden,” a corn, beans, and squash garden that provides long-term soil fertility and originates from Native American farming societies. Students in the 2nd grade plant flowers that attract pollinators and then in the classroom they learn about the relationship between them. The 3rd graders are in charge of planting and tending to the blueberries, raspberries, and apple trees. Starting in 4th grade, students begin focusing on compost; the 4th and 5th graders are in charge of collecting the compost in the school, bringing it to the bins, monitoring them and aerating them. These actions are then connected to the curriculum because students are in charge of charting the temperature of each pile using an iPad application. In the past students have also taken their compost samples to Dartmouth to look at the samples under a microscope (Buxton, C., personal communication, 6 May 2014). Based on that, we feel we can confidently assume that most of the 7th and 8th graders’ knowledge is likely about basic gardening practices, soil processes, the historical roots of sustainable agriculture and compost. Moreover, it doesn’t seem unreasonable to assume that their understanding of these topics is likely higher than the average middle school student that has not been forced to participate in these programs. This is good news for TA because when students move from TES to TA, they are equipped with a relatively substantial knowledge base, given their age, on some of these topics.

With the high school students we are able to make more direct conclusions about their existing environmental knowledge because they were more inclined to answer our questions. In general, we found that students had strong opinions about food sourcing and heavily favored more local options in their cafeteria. They could not understand why the school was not capitalizing on the abundant corn, dairy and meat production occurring nearby and instead importing food from “god knows where” (Male TA student, personal communication, 22 May 2014). These fervent opinions, however, seemed to reflect a general discontent with the quality of the food rather than informed opinions about the benefits and drawbacks of local and regional sourcing. When pressed about food issues and other environmental topics like pollution and global warming, it was clear that the students knew relatively little about the science behind these topics. As stated earlier, it is certainly good news that students at TA want more local, real food because this means that they will likely purchase more of it if and when the school supplies it. However, these students currently lack an understanding of how and why their food purchases affect the environment.

Next, we sought to understand what the faculty’s current level of knowledge about these issues. Our understanding of faculty knowledge was explicitly limited to what Casey Huling and Len Whitaker, two teachers engaged with these topics, shared with us. Both of them spoke about their colleagues’ general lack of awareness and interest in food systems and sustainable practices. Unless a faculty member directly teaches a course that engages with this kind of material, they believe that most do not have a lot of scientific knowledge on agricultural practices and waste management (Huling, C. and Whitaker, L., personal communication, 21 May 2014). We found this rather unsurprising given that most teachers are far removed from their undergraduate and high school educations and thus they likely haven’t been forced to learn about these topics for a while. Moreover, the current mandatory “in-service” staff development programs do not address sustainability at TA and therefore faculty are not made aware of their role in the system (Huling, C. and Whitaker, L., personal communication, 21 May 2014).

In addition to speaking with students to determine the level of environmental knowledge, we reviewed the current curricular offerings at TA that incorporate sustainability concepts, especially relating to agriculture. We did this because these academic opportunities inevitably affect students’ understanding of these issues to some degree. For 7th graders, in their required “Introduction to Laboratory Science”, exposure to environmental issues involves investigations of ecological and meteorological topics in local environment (Thetford Academy Course Guide 2014). It should be noted that instruction on these topics is limited in scope because it is a subsection of the larger biological section of the course. In 8th grade, the first section of the *The Flow of Matter and Energy Through the Biosphere*, teaches students about the ecological structure and composition of the nearby forest and pond ecosystem (Thetford Academy Course Guide 2014). To be clear, students are learning about important and relevant environmental topics like the complex dynamics of the biotic and abiotic world, including food webs, nutrient cycles and species interactions, but currently, these concepts do not appear to be applied to agriculture. In 9th grade, there is no real interaction with environmental topics in *Conceptual Physical Science*. In 10th grade, students are reintroduced to environmental concepts in the mandatory course: *Essentials of Biology: An Introduction to the Science of Life*. One of the many topics in this class does involve ecology, and students are able to engage with it in a variety of labs and hands-on field explorations (Thetford Academy Course Guide 2014). After completing their sophomore year science requirement, students are free to choose from 13 other science courses, many of which involve no engagement with environmental issues. Of the courses that do pertain to these topics, *Environmental Science: The Connecticut Watershed: Its History, Geology, Biology and Chemistry, and Horticulture* are noteworthy. The former teaches 11-12th grade students about fresh water aquatics, soil biology, air quality, biotic and abiotic factors in these ecosystems and the impact of human activity and development on watershed ecosystems (Thetford Academy Course Guide 2014). Again, though these topics are relevant, they don't currently have direct links to agricultural practices or other food-related topics. In *Horticulture*, however, 10-12th grade students are taught about organic gardening, greenhouse management, fertilizer usage, biological controls of pests, gardening, etc., from a hands-on perspective (Thetford Academy Course Guide 2014). This course definitely adds to student's knowledge about topics we find relevant. Additionally, in *Forestry and Wildlife Studies*, students have the opportunity to learn about nutrient cycling and decomposition as well as concepts like disturbance, wildlife habitat management, ecosystem diversity, etc. (Thetford Academy Course Guide 2014). Outside of science courses, a number of other courses touch on topics that could contribute to a students' knowledge base on food issues. The middle school aged students are exposed to important topics in *Global Studies and Geography*, a required Social Science course, that involves learning about how people affect their environment and what it means to be a responsible global citizen – topics that could potentially integrate material related to food production, purchase and consumption (Thetford Academy Course Guide 2014). Additionally, in *Human Geography*, 11-12th grade students learn about the geographies of natural resources, which could involve discussion on global food production. Lastly, the course that most directly applies to food issues is Casey Huling's *Why What You Eat Matters: An Introduction to Local, Regional, and Global Food Systems*. This course teaches students about the complex systems that bring food from farm to table; in other words, its focus is on exactly what we believe is most crucial to understanding the links between food production, distribution and consumption. The goal of this course is "to prepare students to become active and informed participants in their own local, regional and global food systems" (Thetford Academy Course Guide 2014). Though there are a substantial number of course that touch on important topics, it should be noted that because students have a lot of liberty in course selection after 10th grade, they may not engage with these topics in the classroom thereafter.

In summary, most of TA's curriculum on environmental studies is limited to scientific topics and not interdisciplinary in nature. Moreover, students' and faculties' knowledge of issues relating to sustainability is not very substantial.

Active Engagement

To understand TA's current level of active engagement food system and sustainability, we examined relevant extracurricular organizations and school projects relating to these topics.

The most obvious place to start our research was looking for the existence or absence of an Environmental Club. We found that in theory such a club does exist, however, in practice the same cannot be said. Currently, there are very few students interested in participating in an Environmental Club and as Mr. Whitaker put it, it has "kind of fallen apart" (Huling, C. and Whitaker, L., personal communication, 21 May 2014). This year the club has been absent of a consistent, dedicated body of members and held meetings very infrequently. Interestingly enough, this was not always the case at TA. Many teachers, including Mr. Huling, believe the waxing and waning student interest toward the Environmental Club is unfortunate but inevitable. Mr. Huling mentioned that while he has been at TA he has sometimes seen a group of students get interested in a certain environmental issue or other topic but then in four years when they graduate a new body of students fails to carry the momentum (Huling, C., personal communication, 22 April 2014). Therefore, in terms of extracurricular participation, we have concluded that student engagement with sustainability is almost entirely nonexistent.

Of course student and faculty engagement with the food system or sustainability at TA does not only have to manifest itself through the efforts of clubs. We looked also into other efforts that were started inside of the classroom. The most prominent and relevant examples of student led ventures are the Service Learning projects that junior and seniors in Mr. Whitaker's Environmental Studies class have taken part in. At TA, the purpose of Service Learning projects is to "connect the aims and content of the course work directly with meanfulty projects at school and in the community" (Thetford Academy Course Guide 2014). Past projects have focused on roof gardens, solar panels, recycling, composting, etc. In these projects, students team up to tackle an environmental issue facing TA (Glidwell, J., personal communication, 30 April 2014). In addition to conducting research, students are required to develop a unique proposal related to their topic to improve a certain aspect of sustainability at TA. There is opportunity for students to see their plans realized, but for the most part these projects are just an experiential learning exercise. Student engagement in the solar panel, roof garden, and composting projects was short-lived in that after they completed the course their efforts ceased. The students involved in the recycling project, including Jordan Glidwell, are still actively pursuing it outside of the classroom. In the first week of June 2014, they hope to conduct an experiment that seeks to quantify current recycling rates at TA by collecting and counting Izze cans in both trash bins and recycling containers (Glidwell, J., personal communication, 30 April 2014). Though the future of the recycling project at TA is uncertain, it is promising that even though they have completed the course, they still remain engaged with it.

Obviously the students are only part of the equation – in order for TA to truly engage with its food system the faculty must also play an active role. From an operational standpoint, campus organizations must have a dedicated faculty advisor to exist and run effectively, especially at the high school and middle school level. Beyond that though, faculty engagement must also come from a cultural perspective. Unfortunately, staff members, even teachers with a demonstrated interest, are largely uninvolved in campus involvements besides athletic teams. According to Mr. Huling and Mr. Whitaker, the primary reason for this is the absence of financial compensation for club advisors (Huling, C. and Whitaker, L., personal communication, 21 May 2014). With busy lives and families of their own, it is understandable that if teachers are to dedicate their time to something after hours, the absence or presence of a stipend is a deciding factor. In addition to the lack of faculty engagement on an operational level, Mr. Huling described faculty culture relating to these topics as “very disengaged” (Huling, C. and Whitaker, L., personal communication, 21 May 2014). From these interviews, our unfortunate conclusion is that the level of student and faculty engagement with food issues and sustainability is quite low.

Values

Though it is difficult to determine what individuals’ values are and how they aggregate on campus, we believe that understanding how students choose to spend their time is telling of the sorts of things they value. Interestingly enough, with regards to clubs in general, a low level of student involvement in the Environmental Club was not an anomaly; across campus most of the clubs had low participation rates. After school, students are largely, and almost exclusively, involved in athletics. The reasoning behind this, though not decisively, seems to be largely a logistical matter. Athletic practices are held directly after school and thus it is relatively impossible for students, who are frequently on sports teams throughout the year, to also be members of clubs. Moreover, faculty members frequently have meetings after school, making it difficult for them as well to act as advisors (Huling, C. and Whitaker, L., personal communication, 21 May 2014). To be fair, there are a number of clubs that continually attract some students, most notably acapella, Debate Team, and QSA (Queer Students Association) (Glidwell, J., personal communication, 30 April 2014). However, these alternative extracurricular involvements play a much less substantial role in students’ lives compared to sports teams. Even if student or faculty interest emerges, it is difficult for clubs to establish a presence in student life at TA. Beyond logistical barriers, it seems as though students and staff members prioritize their participation with teams over clubs because they value athletics more than other commitments. As described by a current student, “Team sport help bring people together. You get really close with your team” (Thetford Academy Course Guide 2014). This theory is further legitimized even in subtle ways. For instance, in the summary of TA’s core values in the Course Guide, one of the values, “Cooperation,” likens teachers to coaches, and students to team members. The mention of athletics in TA’s Course Guide, though seemingly insignificant, reinforces our claims.

Regarding the earlier discussions, we wanted understand the less apparent manifestation of values at TA, aside from athletics. According to the Course Guide, the core values at TA are excellence, commitment, cooperation, caring, and diversity. The manifestation of “excellence” and “commitment” includes the Personal Learning Plan for Growth initiative, as well as the high graduation rates TA has and the high rates of college enrollment (91%) (Thetford Academy Course Guide 2014). Beyond academics, community spirit is also mentioned throughout the Course Guide. Events like Founders’ Day, Mountain Day, Operation Day’s Work, and the Mr. Thetford Academy Pageant, are “binding forces for the school community”. Despite these truly wonderful traditions that undoubtedly foster a sense of community, currently, on a day-to-day basis, it seems like the student body “doesn’t really engage with itself” (Huling, C. and Whitaker, L., personal communication, 21 May 2014). Both Mr. Huling and Mr. Whitaker mentioned that the degree of day-to-day engagement of the student body certainly varies class to class, and certain grades prove to be more dynamic and cohesive than others. Of course, given that our assessment of TA’s values is based on conversations with a select number of teachers and students over a short period of time, we recognize that this claim may not reflect a nuanced understand of student life at TA.

Behaviors

Lastly, we wanted to assess student and staff behaviors as they relate to food systems and sustainability in general. Unfortunately, but somewhat unsurprisingly given the above assessment of knowledge, engagement, and values, our assessment of student and staff behaviors unveiled the rampant incidence of individual’s unsustainable actions at TA. With regards to recycling, and despite the presence of a zero-sort system, students frequently toss out their Izze cans instead of properly recycling them during lunch and during the school day in the classroom. Moreover, students are especially not inclined to recycle their yogurt containers because they are required to clean them out prior to disposal (Glidwell, J., personal communication, 30 April 2014). In addition to poor recycling habits, plastic water bottle use is widespread. Despite there being a number of fill stations around campus, most students choose to buy plastic water bottles instead of bringing their own reusable water bottles from home. Lastly, vegetarianism, one of the most environmentally sustainable practices one can take part in, is not very prevalent on campus (Cornwell, D., personal communication, 31 March 2014).

With regards to the TA staff, our findings were very similar. Teachers were just as guilty of plastic water bottle use and poor recycling practices as the students. Most alarmingly, Mr. Whitaker discussed how the colleague that co-taught the Environmental Studies course with him frequently bought and used plastic water bottles (Huling, C. and Whitaker, L., personal communication, 21 May 2014). This is obviously just one teacher but we find it noteworthy because conventional wisdom would suggest that a teacher that teaches about these concepts would be more likely to engage in pro-sustainability behavior, but that here that is not the case. Though recycling, water bottle usage, and vegetarianism are only a few ways sustainable behavior is manifested, we chose to highlight these 3 behaviors because they are most related to our project and in a school setting they occur with high frequency.

Analysis

Our assessment of TA's current culture of sustainability revealed a number of key insights. Most obviously, students and staff do not currently actively engage with topics of sustainability very often. This lack of involvement is not only a result of logistical barriers that prevent club participation, but also a testament to how students and staff place little value on sustainability. There are not an overwhelming number of opportunities to actively engage in these topics in a curricular or extra-curricular setting, but we don't believe merely increasing this will necessarily garner the needed support. We will focus on ways to improve these aspects of TA in Section 4, but not to a large degree. The reasoning for this is these changes would represent more institutional, structural changes. Therefore, we think analyzing and addressing student and staff behavior will be more beneficial.

First, despite there being a number of courses that highlight issues we think are important for students to be aware of, most students seem to know relatively little about food systems. More importantly, there seems to be a pronounced void in procedural knowledge when it comes to students' understanding how their daily decisions impact the environment. It is difficult to determine if unsustainable student behavior is a result of absolutely no existing knowledge on the topics or an inability to translate classroom learning into action or a general indifference toward these topics. We are inclined to believe that it is likely a combination. Even for the students who have the opportunity to learn about different aspects of sustainability inside of the classroom, much of their awareness of environmental problems has not manifested into any sort of behavior change. This would suggest that currently, students are unable to translate their learning in the classroom into everyday action. For instance, Jordan Glidwell, though having taken Mr. Whitaker's Environmental Science class and being involved with a recycling project, continued to purchase plastic water bottles. Though she acted sustainably by recycling, she chose not to abandon plastic water bottles usage in favor of a purchasing and using a reusable one. Additionally, it seems safe to assume that students in courses that touch on these topics either more generally or more briefly than Mr. Whitaker's would have an even more difficult time applying their coursework to specific behaviors. To be fair, we believe the ability to apply complex learning from the classroom to your daily life is not an easy conceptual jump for anyone, let alone middle school and high school students. In fact, research has proven that in most cases, "increases in knowledge and awareness do not lead to pro-environmental behavior" (Kollmuss & Agyeman, 2002, p. 241). There are countless empirical examples of this but there is one worth mentioning: a study of high school students revealed that two months after having taken a six-day workshop "focused on creating awareness of environmental issues," students were "no more likely to have engaged in pro-environmental actions" (Mckenzie-Mohr, 2011, p. 4).

If knowledge doesn't seem to greatly affect behavior, then why are TA students and staff acting unsustainably? It is unfair to attribute student laziness to the high usage of plastic water bottles, low levels of vegetarianism and certain failed recycling and composting projects at TA. The truth is Thetford students are not lazy; they are passionate, bright, driven individuals and are surrounded by teachers who motivate them in the classroom. This "laziness" is a manifestation an overall indifference to sustainability related issues. Caring about the environment, how we fit into a larger food and energy system, and understanding the impact of our actions on the environment is not something that is regularly on students' or staff members' minds. To put it simply, the culture fostered at TA does not value the environment. At least not yet.

Thus it seems safe to conclude that TA's current culture will be unable to support our proposed institutional changes to food sourcing, compost and the greater food system. So, how do we fix this, how do we foster a culture at TA that values sustainability? It's not an easy question to address because culture is intangible, and when something is difficult to define, it makes it that much harder to address and improve (Barlag, 2014). Moreover, sustainability must certainly be addressed from "multiple vantage points, from physical infrastructure to specific behavior of community members" (Beery, 2013, p. 2). Why? School food reforms must be synchronized so that "they have a mutually reinforcing, synergistic effect (Sonnino & Morgan, 2010, p. 70). Culture building, especially with regards to sustainability, is a slow, highly unique and conditional process. Given all of the above, we have chosen to primarily focus on behavioral change as a way for TA to foster a culture around food systems and sustainability. Sustainable behavior, which we will define using Bonnes and Bonaiuto's definition, is the set of individual and collective deliberate and effective actions resulting in the conservation of the socio-physical environment for present and future generations (Bonnes and Bonaiuto 2002). In order to provide recommendations that were aimed at increasing pro-sustainability behavior, we first needed to understand how behavior was influenced in general.

Influencing Behavior

There is an overwhelming body of sociological and psychological research that has identified a laundry list of factors that influence behavior both indirectly and directly. For our purposes, we have chosen to highlight the factors that influence pro-sustainability behavior that could specifically relate to feasible recommendations. We have chosen to break up our discussion, somewhat arbitrarily but for purposes of clarity, into two sections: external factors and internal factors.

External Factors

Institutional Factors. Most intuitively, "pro-environmental behaviors can only take place if the necessary infrastructure is provided," i.e., recycling bins, compost facilities, etc. (Kollmus Agyeman, 2002, p. 248). Additionally, the existence of prompts, or signage, that remind people to act a certain way can promote sustainable behavior (Levy & Maranas, 2012).

Social Factors. An important social factor that influences behavior is norms. Social norms influence people's behavior somewhat indirectly: when someone perceives something as a 'normal' of acting, that individual is more likely to engage in that behavior (Fishbein & Ajzen, 2010). Relating to sustainability, if the "dominant culture propagates a lifestyle that is unsustainable than pro-environmental behavior is less likely to occur" (Kollmus & Agyeman, 2002, p. 242). On a related note, behavior is often shaped by incentives, which are the "internal factors that can reinforce and support ecological behavior" (Kollmus & Agyeman, 2002, p. 246). Incentives may sometimes be social, as with wanting to do something because it is socially desirable, but they may also be financially related. Lastly, verbal and written commitment to a certain action, not only gives some indication about a someone's willingness to engage in pro-sustainability behavior, but public commitments have been found to actually enhance the likelihood that the individual who has made the commitment will engage in the behavior (Hines & Hungerford, 1986; McKenzie-Mohr 2011).

Internal Factors

Knowledge of Issues. Environmental knowledge, as discussed earlier, seems to only directly affect pro-environmental behavior very minimally (Kollmuss & Aygeman 2002). That said, the logic behind the knowledge-behavior relationship is that when individuals feel more competent or knowledgeable, they are more likely to make environmentally responsible choices (Levy & Marans 2012).

Procedural Knowledge. In addition to knowledge of a problem, procedural knowledge, meaning knowing how to address that problem, is also important for affecting behavior change (368). Procedural knowledge is very similar to environmental awareness

– which is “knowing the impact of human behavior on the environment” (Kollmus & Agyeman, 2002, p. 253).

Motivation. Motivation for a certain behavior is very convoluted; it can be conscious or unconscious and can be based on our personal values or focused on a specific situation (Kollmus & Agyeman 2002).

Values. On a very related note, values are “responsible for shaping much of our intrinsic motivation” (Kollmus & Agyeman, 2002, p. 251). individual values are influenced by our family’s values, experience, education, culture at large, etc. (Chawla, 1999).

Application

Clearly, behavior is influenced by a multitude of factors, so we believe fostering a culture of sustainability at TA will require a variety of approaches (Levy & Maran, 2012). We will begin with a number of recommendations that focus on ways to improve the classroom experience. That said, we firmly believe that merely adopting a classroom, information-based strategy focused on increasing student and staff theoretical knowledge of the environment will have little likelihood of substantially changing behavior (McKenzie-Mohr, 2011). Information is obviously important, but it must not simply be presented in a conceptual sense and it must be supported by other initiatives in order to be effective. Therefore, we have also provided a number of suggestions for TA to improve their culture and change behavior outside of the classroom. Our earlier recommendations have provided certain institutional and structural changes that provide the opportunity for students’ and staff to act sustainably. However, TA also needs to take a bottom-up approach in order to truly adapt a systems approach.

Recommended Strategies

Inside the Classroom

Curricular Integration. To truly establish “sustainability” as a value and driving force at TA, students must be exposed to concepts in a myriad of ways. The complexity of the food system can be capitalized on because the linkages between “the food we eat, the ways that culture shapes our food choices and behaviors, the relationship between food and our health, and the interconnections between our food systems and the environment” address many different academic disciplines, not just environmental science (Sly & Comnes, 2014, p. 3). Specifically, knowledge of regional food systems would allow students to understand the importance of the cafeteria’s new purchasing decisions and thus lead to the success of this initiative. Curricular integration is already happening in biology classes and Mr. Huling’s food systems class, however relevant topics can also be addressed in history, economics, English, art, health and culinary arts classes. We have attached an in-depth report by the Center for Ecoliteracy and National Geographic that provides suggestions for curricular integration in middle school and high school because we think this will provide invaluable insight into how this can be achieved while adhering to educational standards. For each grade level the report provides examples as to how all topics relating to the food system: food, culture, health, and the environment, can be incorporated into curriculum. In addition to the information in that report, we believe there are three other ways curricular integration can be achieved specifically at TA.

Art Classes. According to the students, at TA, art is one of the more popular classes (Glidwell, J., personal communication, 10 April 2014). Therefore, to capitalize on student interest we think it would be wise to involve Mrs. Newbauer's art students in a public art project relating to food or sustainability that could be displayed on campus for years to come. This could involve some sort of sculpture making out of recycled Izze cans or be a picnic table-painting project that utilizes a specific sustainability slogan or image. Constant visual reminder would undoubtedly promote the norm around sustainability. Moreover, there are countless examples of interactive art displays that students could design in art class and then actively engage with outside of the classroom. Artist Candy Chang is a noteworthy artist who has developed an array of interactive projects on a myriad of topics. Her work is worth examining because the framework she has designed can be transferred to other topics. (http://candychang.com/).

Culinary Arts Classes. It would be productive to create a unit or an entire class focused on cooking seasonal or sustainably sourced food. Additionally, students could learn how to cook a wide variety of vegetarian dishes and coursework could emphasize why such a diet is ecologically friendly. Perhaps these culinary arts students could even serve one of their creations to an entire lunch period and present the rationale behind their dishes.

Challenge Class. The Challenge Course at TA seems like an ideal opportunity for students to learn about and actively engage in these topics in a manner that is not currently available to them at TA. Perhaps this could be an extension of one of the Service Learning projects or the course could focus on how to build on the efforts of this report. Students could do research on the food system, compost, education, psychology of behavior, etc., and look into efforts at other schools to incorporate sustainability.

Compost Curriculum. The new compost program obviously offers an incredible opportunity for students to understand and apply learning about the food system. As discussed in the previous section, the 7th and 8th graders would likely be the best grades to involve in the maintenance of this operation. Therefore, a curricular component that ensures they know why composting is important habit and how the process works is critical to emphasizing the procedural knowledge aspect. The older grades could be involved in upper level biological and chemical research into the exact soil processes. Alternatively, the compost program could be incorporated into Statistics or Calculus classes; the focus could be on changes temperature rates, rates of decomposition, yield of the compost pile, etc. (Buxton, C., personal communication, 6 May 2014). Educational Coordinator at Cedar Circle, Cat Buxton, would also be able to provide more specific recommendations for age-appropriate curriculum and experiential learning opportunities as she was an integral in designing TES's educational components.

Emphasis on Procedural Knowledge

In addition to just providing students with more information or more ways to interact and understand concepts of sustainability, there should be a strong emphasis on ways in which these topics can be applied to students' daily lives. In each class touches on related concepts, it should be reiterated how this information can be translated into behavior. It is difficult to make specific recommendations on this because we are not aware of the exact coursework for each class at TA.

Faculty "In-Service"

The staff could seemingly benefit from a workshop on the food system or the importance of sustainability so that they too are knowledgeable on the issues and understand how their behaviors impact the environment. Efforts at other schools have included a tutorial that informs members about the rationale and methods for recycling, conserving electricity, etc. (Levy & Marans, 2012). These In-Service sessions could also serve as a way for teachers to discuss how issues of environmental sustainability can be better integrated into their courses. Additionally, in these sessions it should be stressed that faculty behaviors influence student behavior and therefore by acting sustainably themselves they will provide positive reinforcement for such behavior.

Outside of the Classroom

Social Media Based Marketing Campaign

It is no secret that students are frequent users of social media tools like Instagram, Facebook and Twitter. Therefore, we suggest making a @SustainableThetford account across these platforms that is run and utilized by the students. In addition to a central account that can post pictures or messages, the entire student body could engage in such a campaign by utilizing specific hashtags or tagging @SustainableThetford. Here at Dartmouth, these applications have been used to promote specific behaviors, i.e, drinking tap water or using a reusable mug for coffee and tea. Such campaigns have used specific hashtags like #BYOMug (Bring Your Own Mug), #MugsofDartmouth, and #I'dTapThat (In reference to tap water). (See Figure 3.6.1 & 3.6.2).

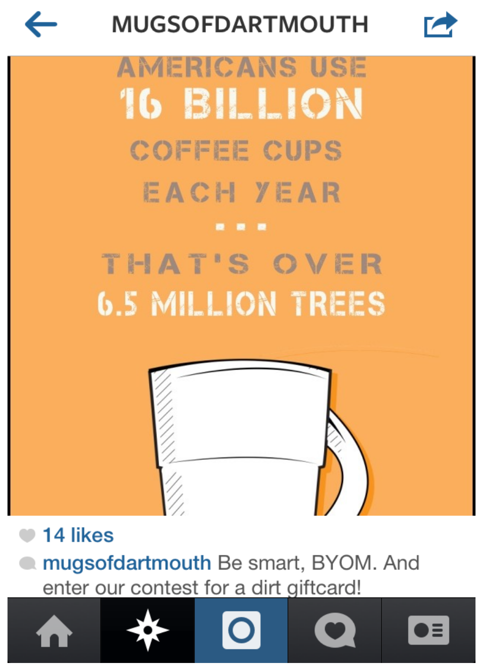


Fig 3.6.1 **Fig 3.6.2**

Other possible examples could include, #MeatlessMonday, to promote a vegetarian diet on Mondays, #EngrossedinCompost, to highlight student involvement in the compost program, #WhatsYourFoodPrint, to facilitate reflection on the way food production influences the 'carbon footprint', etc. See Figure 3.6.3 for an idea of what possible marketing materials could look like. (http://thewellnessscientist.com/meatless-monday-recipe-sweet-corn-salsa-with-mango-and-ginger/).

Fig 3.6.3

These are just examples; we recommend that TA students come up with their own, unique hashtags so that they are specifically tailored toward student life at TA. These grassroots campaigns have been widely successful because they are a cool way to promote a behavior in a manner that is relatable and popular. This sort of initiative could also involve a competition aspect, thus giving students the social incentive to partake in it. For instance, there could be some sort of Instagram photo competition in which a panel of students and staff pick their favorite photo each week and the winner receives some sort of prize or recognition. Social media campaigns have the tendency to become contagious; all they need is a key actors to get them off the ground. By utilizing a behavior that students already do frequently and consider 'normal', i.e, using social media platforms, it will be much easier for them to relate to and want to partake in sustainability at TA. We recommend utilizing student leaders on campus, be them team captains or club leaders, in each grade, to participate in this program in order to establish a norm more effectively, thus spreading behavior to spread more quickly.

Thetford On Purpose

Another initiative here at Dartmouth that we think could work at TA is a 21 day challenge-based program designed to encourage students to change an individual behavior or habit. A description pulled from the Dartmouth On Purpose website explains the program and its rationale: "It takes three weeks of continued effort to make a lasting change. What do you want to work on? Brainstorm and set your own goal, find a buddy to share your progress with, and spend 21 days consistently focusing on that effort" (http://sites.dartmouth.edu/purpose/event/21-day-challenge). Similarly, at TA, students could begin by setting a specific goal, i.e., pledging to not use plastic water bottles for one month, going vegetarian for one month, or volunteering at Cedar Circle for at least 10 hours, etc. There could be an opening registration ceremony of sorts, perhaps during morning meeting, during lunch or a school-wide event after school, where students are able to make a verbal and/or written pledge. These pledges could be hung up with student pictures around the school to remind students what goals they set, provide students with other ideas, and create a social 'pressure' of sorts to maintain their pledges. Individuals could set goals or entire student groups, like teams, or full grades, could adopt the same goal, thus making it a competition. Prizes could be awarded to the group with the most participation, most unique goals, highest success rate, etc. We suggest that a student group or class designs marketing materials and/or creates a branding for this initiative to raise awareness and to make the campaign recognizable.

Regional Foods Night

Lastly, if TA chooses to adopt Black River Produce as its main distributor over Reinhart, we recommend holding an event with the local meat and dairy farmers, community members, students, staff, and parents, would be a great way to highlight these new changes and promote the valuation TA's commitment to regional sourcing. This could involve a discussion between the participants about farming, sustainability, etc. Additionally, it could include games, cooking competitions, giveaways, an auction, etc. to keep people engaged and interested.

Chapter Four: Outdoor Leadership Practice and Education

Andres Ramirez and Melina Turk

4.0 Executive Summary

This report provides an evaluation of the feasibility of implementing various outdoor leadership programs at Thetford Academy. Outdoor leadership consists of a variety of outdoor activities (such as outdoor survival, wilderness first aid, cross country skiing, snowshoeing, hiking, outdoor ropes course, etc.) with a focus on personal and group safety, environmental stewardship, and quality of experience for all participants. Thetford Academy, with its 284 acres of land, has a unique opportunity to utilize its natural resources while also providing important learning experiences for young people. Our methods of analysis included research of preexisting outdoor leadership programs and the administration of a student survey. Our methods of analysis resulted in the proposal of six different outdoor leadership program structures. From our findings, we recommend three courses of action for Thetford Academy: 1) to incorporate outdoor leadership into its Physical Education curriculum as either a stand-alone course or a unit in a preexisting course, 2) to create and implement an extracurricular outdoor leadership program that takes place on a weekday, and 3) to create and maintain a relationship with Dartmouth's Tucker Foundation in hopes of implementing a mentorship program with Dartmouth students in the future.

4.1 Introduction

What is outdoor leadership and why is it important?

Outdoor leadership consists of a variety of outdoor activities (such as outdoor survival, wilderness first aid, cross country skiing, snowshoeing, hiking, outdoor ropes course, etc.) with a focus on personal and group safety, environmental stewardship, and quality of experience for all participants. *Outdoor Leadership: Theory and Practice*, a book written by Bruce Martin (2006), defines outdoor leadership to be, "the practice of leading individuals and groups into natural settings via a variety of modes of transportation: walking, biking, canoeing, caving, kayaking, and mountaineering, to name a few" (p. 6). Martin (2006) also describes three primary goals of outdoor leadership and the responsibilities of outdoor leaders to be as follows: 1) "to ensure the safety of individuals engaging in outdoor education and recreation experiences," 2) "to ensure the protection and preservation of the natural environments into which people venture for outdoor education and recreation experiences," and 3) "to enhance the quality of outdoor experiences for individuals with whom they are working" (p. 6).

In a study conducted by Paisley et al. (2008), it was demonstrated that students engaging in outdoor leadership activities showed significant gains in six main areas: communication skills, leadership skills, small-group behavior, judgment in the outdoors, outdoor skills, and environmental awareness (p. 202). Paisley et al. (2008) defined the six learning objectives as follows:

> Communication skills are defined as communicating effectively in a small-group setting and include discussion leading, feedback provision, and expressing ideas. Leadership involves taking initiative, responsibility, and decision-making roles. Small-group behavior is defined as being a positive and productive group member. Judgment in the outdoors is the ability to recognize potential hazards and make good decisions in the backcountry. Outdoor skills are competencies for backcountry travel and living. Environmental awareness is defined as a combination of perceived knowledge of environmental stewardship practices and regulations and an appreciation for the environment. (p. 202)

These six learning objectives are important developmental skills for young people, making outdoor leadership an incredibly valuable experience. If an outdoor leadership program is implemented at Thetford Academy (TA), students will have the opportunity to learn important leadership, communication, and outdoor skills, as well as gain critical environmental knowledge and appreciation that cannot be taught in a classroom.

4.2 Outdoor Leadership at TA

What is the vision for outdoor leadership at TA?

Thetford Academy has expressed a strong interest in implementing an outdoor leadership program at the institution. As a private school located on 284 acres of land in the Upper Valley (Thetford Academy Homepage, n.d.), Thetford Academy has a unique opportunity to utilize its natural resources for student involvement and educational purposes; however, it is not currently doing this to the extent that it could be. By implementing an outdoor leadership program at TA, the school will make use of its natural land, as well as provide important student involvement opportunities to those who are interested, particularly targeting those whose interests are not necessarily satisfied in other curricular and extracurricular activities.

Additionally, Thetford Academy's large acreage and woody, natural location could provide a future opportunity for the Academy to become a prominent school in the field of outdoor leadership. Our goal is to provide TA with the framework for a number of different outdoor leadership programs in order to help the Academy utilize its natural resources and provide outdoor education opportunities to students.

Since TA is still in the early stages of developing any such program, we have provided faculty with a variety of program scenarios so they will be better suited to implement a program in the future and will not be forced to adhere to the rigid guidelines of one single program structure. By providing a number of options, the Academy will also have the opportunity to implement more than one type of program (e.g., both extracurricular and curricular) as they move toward their goal of establishing outdoor leadership at the school.

4.3 Case Studies

We interviewed a number of key individuals outside of Thetford Academy that have been heavily involved in various outdoor leadership programs in order to help us better understand how these different outdoor leadership programs are organized and operated. We focused on two programs: Dartmouth's Outdoor Leadership Experience and The Westminster Schools' Discovery Program. We gained a significant amount of insight through our research that helped us to later design six program structures that will serve as possible frameworks for Thetford Academy to implement in the future.

Dartmouth's Outdoor Leadership Experience

Dartmouth's Outdoor Leadership Experience (OLE) is a mentorship program that allows Dartmouth students to mentor middle school students from the Indian River School in Canaan, New Hampshire by engaging in outdoor activities together. OLE cites three main goals for the program: 1) to "provide a safe environment… for the middle school students to feel free to be themselves," 2) to "teach skills centered around the outdoors" that kids will feel confident using later in life, and 3) to create an environment that is "fun for everyone" (Outdoor Leadership Experience, 2011).

Interviewee: Michael Berger

Michael Berger is a Dartmouth student in the class of 2014 and is a student coordinator for Dartmouth's OLE. Michael was able to share helpful information about OLE with us, such as: the schedule of OLE, the types of outdoor activities involved in the program, the extent of both outdoor education and mentorship training that is provided to Dartmouth student leaders, and general information regarding equipment and budgets. Michael also provided us with the "OLE Leader Manual," included in the Google drive for additional information.

Typically, OLE allows for Dartmouth students to spend three hours at a time with their respective middle school mentees, typically meeting on Wednesdays, Thursdays, and Fridays from 3 p.m. to 6 p.m. They engage in activities such as ice skating, snowshoeing, and skiing in the winter, and hiking and scavenger hunts in the spring. Dartmouth student leaders are scheduled to meet for one hour a week, generally on Sundays, for day planning and leadership development, in which they brainstorm and practice scenarios that address issues that might arise between student leaders and middle school students. In terms of equipment, OLE owns some of their own equipment, but rents most of it from the Dartmouth Outing Club (DOC). OLE also spends some of its budget on snacks, which they have stocked at all times in case kids get hungry.

Interviewee: Tracy Dustin-Eichler

Tracy Dustin-Eichler is the Program Officer for Local Community Service at Tucker and is heavily involved with the OLE program at Dartmouth. Tracy was able to inform us of the challenges she had while coordinating with the Indian River School, the level of outdoor education expertise that is required by OLE to run this type of program, and more specific information about the costs that are involved with the program (specifically equipment and transportation).

Dartmouth has a well-established relationship with the Indian River School that was first established over 11 years ago. When creating mentor-mentee pairings, OLE coordinators are mindful of how they match students together, making sure to take boundary issues into account in order to establish healthy mentoring relationships. Tracy emphasized the importance of these boundary issues and advised never to create a mentor-mentee relationship in which students are close in age. Generally speaking, the larger the age gap between mentor and mentee, the better the relationship. OLE, composed of approximately 25 to 30 Dartmouth student leaders and approximately 30 to 40 middle school students, uses group mentoring instead of individual mentoring, as it is more community based and protects against the possibility of flakey leaders. Dartmouth student leaders are required to take an orientation course and go through the appropriate training for the outdoor leadership program, which they receive through the DOC. Sometimes, however, guest experts are brought in when a higher level of expertise is required (e.g., when using rock climbing facilities). OLE spends a large portion of its budget on transportation, estimating up to $15,000/year. Other costs include: snacks, equipment rentals, and the occasional hiring of experts. These costs average nearly $2500/year.

The Westminster Schools' Discovery Program

The Westminster Schools' Discovery Program, introduced in 1980, is a well-established experiential education program in Atlanta, Georgia in which students engage in seven two-hour meetings followed by a four-day expedition of their choice. The Discovery curriculum, accredited by the Association for Experiential Education, focuses on four main objectives: responsibility, compassion, self awareness, and environmental awareness. (The "Association for Experiential Education Accreditation Self-Assessment" is included in the Google drive for additional information). The program is required by all ninth graders at Westminster and is optional to all students in subsequent grades. Students are provided with a portion of their physical education (P.E.) credit upon completion of the program. (Upper School - Discovery, n.d.)

Interviewee: Sarah Alexander

Sarah Alexander is a Dartmouth student in the class of 2014 and is heavily involved in many sustainability initiatives and outdoor programs on campus. Sarah attended high school at Westminster and was a participant and student leader for the Discovery Program. Sarah was able to provide us with information regarding the infrastructure of the program, including: the number of students that were involved, the age/grade of students that were involved, the length of the program, the number of staff that are involved with program, and the types of outdoor activities that students and leaders engage in.

The Discovery Program begins with two weeks of team building activities (such as building a bridge, completing a ropes course, and working in a garden) and ends with a three-night (four-day) camping trip in which students learn how to pack a backpack, tie a knot, and set up a tent, amongst other things. There are three hired staff/supervisors that act as outdoor educators while the rest of the leaders are students who completed the program in the ninth grade and went on to be trained as a student leaders.

Interviewee: Emily Horne

Emily Horne is a faculty director for the Discovery Program at The Westminster Schools. Emily is a key representative for the Discovery Program and was able to tell us about the history of the program, the administrative work and costs involved with the program, and the training of faculty and student leaders. She also provided us with two informative documents that could be helpful in creating an outdoor leadership program, including: "Discovery Program: Risk Management Policies and Procedures," and "Discovery Program Ninth Grade Parent Packet," both included in the Google drive for additional information.

The Discovery Program was established 34 years ago as an outdoor leadership program with an "outward bound" philosophy. The program hires three full-time faculty and serves up to 210 first-year students each year. Ninth graders are all required to participate in the program and each receives half a P.E credit upon completion. Students can choose between eleven different options of outdoor courses, offered at various times throughout the year, including: canoeing and watersheds; art in nature; gardening and sustainability; rock climbing; caving and geology; poetry and writing; Wilderness First Aid certification; kayaking, beach camping, service, sustainability; food systems; photography; and urban adventure (Upper School - Discovery, n.d.).

After students have completed the course, they have the opportunity to apply to become outdoor leaders and peer mentors for future ninth graders. These students work with the faculty to become stronger leaders and mentors through various training sessions. Usually the program works with groups no larger than twelve students with two adults in each group (consisting of both part-time faculty and full-time faculty). Full-time staff that are hired for Discovery have extensive background in outdoor education and many have worked at outdoor education centers prior to employment at The Westminster Schools. Most staff members also have background in low ropes and high ropes facilitation. Westminster provides its own outdoor training annually, but Wilderness First Responder certification is obtained elsewhere. Wilderness First Responder certification is necessary for staff and is available at various locations throughout the country, including at Stonehearth Open Learning Opportunities (SOLO), a school of wilderness medicine, in New Hampshire (Stonehearth Open Learning Opportunities, 2014).

Discussion

Dartmouth's OLE and The Westminster Schools' Discovery Program are both well-established outdoor leadership programs that provided a vision for the future of outdoor leadership at Thetford Academy. We used the information from these two programs, which we collected through the above interviews, to inspire various possible frameworks for outdoor leadership at TA.

Dartmouth's OLE has helped advise possible structures for mentorship programs at TA. These programs should include many similar characteristics to those of OLE, the most important being weekly student leader meetings. TA student leaders should meet amongst themselves once a week in order to discuss issues between mentors and mentees and to work through specific problems that may arise in mentorship relationships. Michael Berger expressed this as one of the most important aspects of OLE as a mentorship program, and, thus, TA should consider echoing this aspect into its own program. TA should also account for boundary issues when pairing mentors with mentees, specifically accounting for age gaps. It is important to be mindful not to pair students of similar ages together, as this does not always promote successful mentoring relationships.

TA can also use much of the budget information obtained from OLE to advise decisions when creating its own budget for various outdoor leadership programs. TA will have to consider the large cost of transportation, especially if instituting a mentorship program with a partnering school. TA may also attempt to utilize its own campus for many of the outdoor activities in order to save transportation costs involved with off-campus activities. In terms of equipment, TA can use information from “OLE Leader Manual” to obtain equipment rental information and costs.

Westminster’s Discovery Program has also helped to create possible frameworks for outdoor leadership programs at TA. Though Westminster is much larger than TA, its success in outdoor leadership can provide a vision for which TA can aspire to achieve on a smaller scale. For instance, TA might consider implementing a mandatory program similar to Discovery, but shorter in length and less extravagant in location (taking place mainly on TA campus). The program can contain similar learning objectives and teach similar skills, such as how to pack a backpack, set up a tent, or tie a knot, but may differ in the types of activities and number of staff members that are involved.

The full time staff that work for Discovery, however, are an integral part of the program and one of the reasons that the program is so well established and well endowed. Hired outdoor staff members are knowledgeable in outdoor activities as well as certified in outdoor education and safety measures (e.g., ropes course certification and Wilderness First Responder certification). In the future, TA could benefit from hiring one or more outdoor educators to ensure that the program runs efficiently. Additionally, this will also allow TA to save annual costs incurred when hiring experts for certain activities (such as for high ropes courses or rock climbing). TA may also consider providing students with some type of P.E. credit upon completion of a mandatory outdoor leadership program, as the program provides students with the opportunity to learn about physical health and to engage in various physical activities – fitting the requirements of the P.E. curriculum.

Based on our findings from the above case studies, as well as the information we obtained through our meetings with TA staff, we were able to propose six outdoor leadership program structures for TA to implement (described below).

4.4 Program Structures

Program 1: Extracurricular Afterschool/Weekend Program for TA Students

Thetford Academy students will meet together outside of school hours to engage in outdoor activities as a cohesive group. Students will participate in a mixture of team-building activities, outdoor skills, and outdoor sports. Students will be taught and supervised by TA staff members, who will be paid a small financial stipend for their work outside school hours. This option is very flexible as to the day/time, duration, and frequency of the program, as well as the specific outdoor activities involved, in order to best accommodate students and staff members as well as the financial budget of the school.

Program 2: Extracurricular Afterschool/Weekend Mentor Program with TES Students

Thetford Academy students will become mentors for Thetford Elementary School (TES) students while engaging in outdoor activities. This program will take place outside of school hours and times must be coordinated with Thetford Elementary School's schedule. This program will also require additional weekly meetings for TA students to engage in leadership training and to discuss any issues that may arise in mentor-mentee relationships. Leadership training will be taught by TA staff members, and all students will be supervised by TA and/or TES staff while engaging in outdoor activities, whom will receive a small stipend for their work.

In terms of transportation between TA and TES, Thetford may consider non-vehicular forms of transportation in order to avoid incurring large transportation costs (e.g., supervised walks between TA and TES as it is a short distance).

Program 3: Curricular Course Offered in the P.E. Department as Alternative P.E. Credit

Thetford Academy students will have the option to sign up for an outdoor education course to obtain full P.E. credit. The outdoor leadership class must incorporate the learning objectives and themes that are required in a regular P.E. course in order to allow students to take outdoor leadership as an alternative to the standard P.E. course. The new course will meet during school hours, as often as a regular P.E. course, and will be taught by TA staff members, whom will be paid appropriately. The course will involve learning various skills (such as teamwork and leadership) in outdoor settings, as well as gain important knowledge about environmental and personal health issues.

Program 4: Short Unit Incorporated into Existing P.E. Curriculum

All Thetford Academy students will be required to complete a short outdoor leadership learning experience that will be incorporated into the existing mandatory P.E. curriculum. This short unit can last up to a couple weeks and will include various leadership activities, outdoor survival skills, team-building activities, outdoor sports, and more – depending on the resources that are most accessible to TA and the learning outcomes that the unit must meet. This unit will be taught by existing TA staff members in the P.E. department.

Program 5: Mandatory Three-Day Outdoor Leadership Event for Ninth Graders

Thetford Academy has already implemented some notable outdoor and team-building activity days, including a mandatory daytime hiking event called Mountain Day, in which students hike a mountain in the surrounding area, and a daylong ropes course event at Hulbert Outdoor Center that is mandatory for ninth graders. In addition to these existing programs, TA could also implement a mandatory outdoor leadership experience for ninth graders that can take place during the summer months, possibly in the weeks directly before the new school year commences. If Thetford Academy decides to implement the J-term, this could also be an ideal time period to implement the program.

This program will be a three-day outdoor leadership experience that includes a number of outdoor leadership activities and concludes with an overnight camping experience, which can take place on TA campus. TA should hire existing staff members with some prior experience in outdoor leadership to supervise and teach outdoor activities for a small stipend. These staff members will have to be trained to have basic knowledge in outdoor education as well as receive Wilderness First Responder certification from SOLO in New Hampshire. In the future, TA may consider hiring some full-time staff for the program, but this is dependent on feasibility and resources.

This program can also be optional to tenth, eleventh, and twelfth graders who can apply to be student leaders in the subsequent years after they have completed the program. Student leaders will have to complete student leader training as well as some additional training in outdoor education.

Program 6: Extracurricular Afterschool/Weekend Mentorship Program with Dartmouth College

This program will act as an extension of Dartmouth's existing OLE program, in which Dartmouth students mentor middle school students while engaging in outdoor activities. This mentorship program will exist as an optional extracurricular program for TA students in grades seven to nine, where TA students will be paired with Dartmouth student leaders. TA mentees and Dartmouth mentors will participate in various outdoor activities together, including: leadership and team-building activities, outdoor survival skills, outdoor sports, and more. TA students will be given the opportunity to spend time with and learn from a Dartmouth student while also gaining important skills and awareness (e.g., communication and leadership skills, as well as environmental and self awareness).

Note: This program, if chosen, will not be implemented within the next year as Tucker Foundation is undergoing some important changes and will not have the capacity to accommodate TA at this time. However, it is a relationship that Tucker is interested in making a few years down the road.

4.5 TA Student Preference Survey

Our case studies helped inform the suite of options for possible ways to structure outdoor leadership at TA. Based on these options and the general knowledge gained from our case studies, we designed a self-administered questionnaire to survey TA student preferences.

Methods

We surveyed the students at Thetford Academy to better understand the level of interest that different students held at the school. Our survey instrument was a eleven-question written questionnaire handed out by TA homeroom teachers to every member of the student body. Our survey instrument and data collection methods were modeled after Barlow (2010). Our questionnaire is included in Appendix 3.

Students were provided with a definition of outdoor leadership as well as a description of TA's goal of implementing such a program. The survey began with demographic questions that included gender and grade, then asked whether the student was interested in participating in outdoor leadership. The next set of questions were designed to determine students' interest levels in particular program structures as well as students' availability to participate in an extracurricular outdoor leadership program. We concluded our survey by providing space for further comments and contact information for students wishing to be involved in the process of implementing the program.

We calculated summary statistics to assess student preferences for various outdoor leadership options. We assessed potential differences in student responses based on gender, grade level, and self-reported interest in outdoor leadership. To determine whether gender or grade affected the ranking of preferences, we conducted two sets of t-tests. One set compared female to male responses across all survey questions, and the other sets compared members of each individual grade level (e.g., ninth graders) to all other respondents.

We also separated students by self-reported interest level regarding outdoor leadership. In analyzing these data sets, we focused on whether an individual responded to being interested in outdoor leadership by answering "yes" in the survey, without accounting for gender or grade level. To determine whether interest level affected the ranking of preferences, we conducted a similar set of t-tests. This set compared students who answered "yes" to all other respondents. All analyses were performed in Excel (2008).

Results

We received responses from approximately 74% of the student body (out of approximately 300 students), totaling 222 student responses that encompass grades seven through twelve. We found that there was no significant difference in preference between female and male respondents ($\alpha = 0.05$) (**Table 4.5.1**). There was also no significant difference in preference between each particular grade and other respondents. Our p-values looking across gender and class differences ranged from 0.37 to 0.99, indicating that no statistical significance was found.

On the other hand, we found that there was a significant difference in preference between respondents who answered "yes" on the survey (to being interested in outdoor leadership) and other respondents. Of the students surveyed, 78 students reported an interest in outdoor leadership, representing 35% of respondents. Our p-values were all well under 0.05, signifying a statistical significance, as seen in Table 3.1.

In the survey, we asked if students were involved in extracurricular sports that would conflict with their ability to participate in an extracurricular outdoor leadership program. We found that students that reported they were interested in outdoor leadership were more likely to be participating in extracurricular sports than those that reported they were uninterested or unsure if they were interested. On average, approximately 40% of students who reported an interest in outdoor leadership were involved with sports in each Fall, Winter, and Spring, compared to only 35% of the overall respondents. Students who reported an interest in outdoor leadership were also less likely to respond that they were not involved in sports, with only 20% of interested students reporting no involvement in sports, compared to 35% for overall respondents.

In the survey, we also asked students how likely they would be to sign up for an outdoor leadership program in each of four different categories: a P.E. class that provided credit, a weekday extracurricular activity, a weekend extracurricular activity, and a mentorship program in which students would mentor an elementary school student. We found that students who reported they were interested in outdoor leadership were more inclined to be somewhat likely or very likely to participate in each of the four programs than were the overall respondents. The most popular program structure for both groups was the P.E. course, with overall respondents and respondents reporting interest in outdoor leadership averaging response rates of 3.77 and 4.45, respectively.

Additionally, students were asked to indicate their availability for each day of the week as well as for each time period provided throughout the day. The most popular day for the overall respondents was Wednesday, while Thursday was most popular for respondents who reported an interest in outdoor leadership. We also found that the most popular time period for all relevant respondent groups was between 3 p.m. and 4 p.m. on weekdays (Monday to Friday).

Students rated their interest level for various outdoor leadership activities, including: survival skills, hiking, kayaking/canoeing, snowshoeing, mountain biking, and ropes course. Students who reported an interest in outdoor leadership were more likely to be somewhat interested or very interested in each activity. Both relevant respondent groups rated kayaking/canoeing as the activity that they were most interested in.

Figure 4.5.1. *Total number of students that reported they were interested in outdoor leadership, unsure of their interest level, or uninterested in outdoor leadership. (Note: not all students answered this question in the questionnaire).*

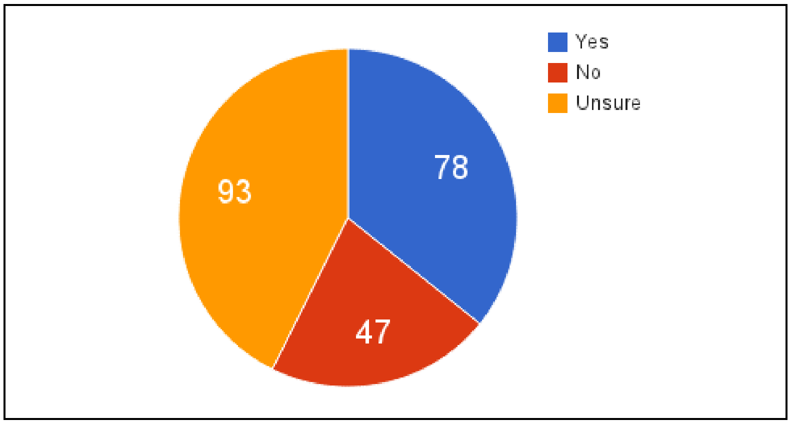


Table 4.5.1. *Mean preference values and P-values for those who reported an interest in outdoor leadership and those who reported that they were uninterested or unsure of their interest level.*

Question	N	T Test Gender	P Value	Mean Preference: Yes	Mean Preference: No/Unsure
Survival Skills	78	0.9999984923	0.0000018957844	4.19	3.43
Hiking	78	0.9999996733	0.0000004063626	3.97	3.07
Kayak/Canoe	78	1	0.0000000003507	4.47	3.47
Snowshoeing	78	0.9999995154	0.0000006113634	3.32	2.4
Mountain Biking	78	0.9999998967	0.0000001415436	3.71	2.72
Ropes Course	78	1	0.0000000046042	4.41	3.33
P.E. Class	78	1	0	4.45	3.4
Weekday E.C.	78	1	0	3.53	2.23
Weekend E.C.	78	1	0.0000000021731	2.99	1.85
Mentorship	75	0.9999998988	0.0000000896294	3.69	2.68

Figure 4.5.2. *Number of overall students that reported involvement in extracurricular sports, by season.*

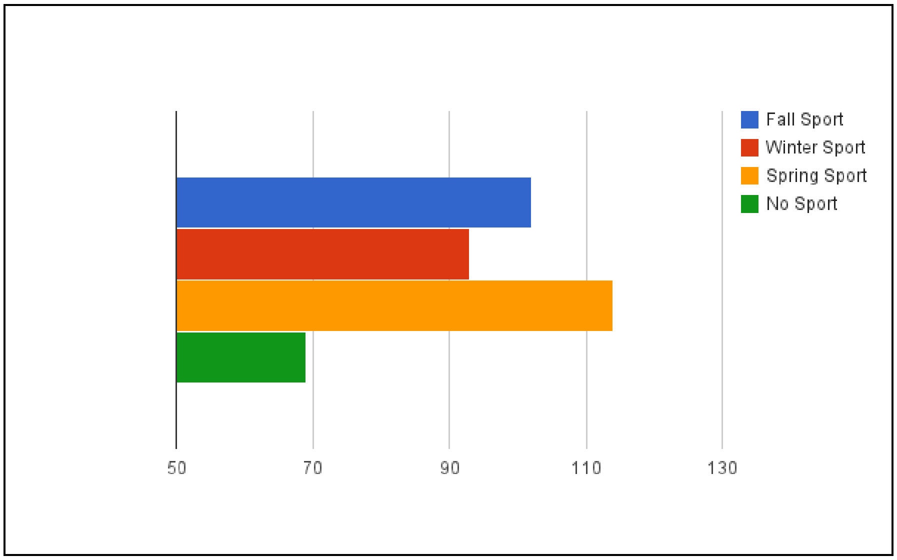


Figure 4.5.3. *Number of interested students that reported involvement in extracurricular sports, by season.*

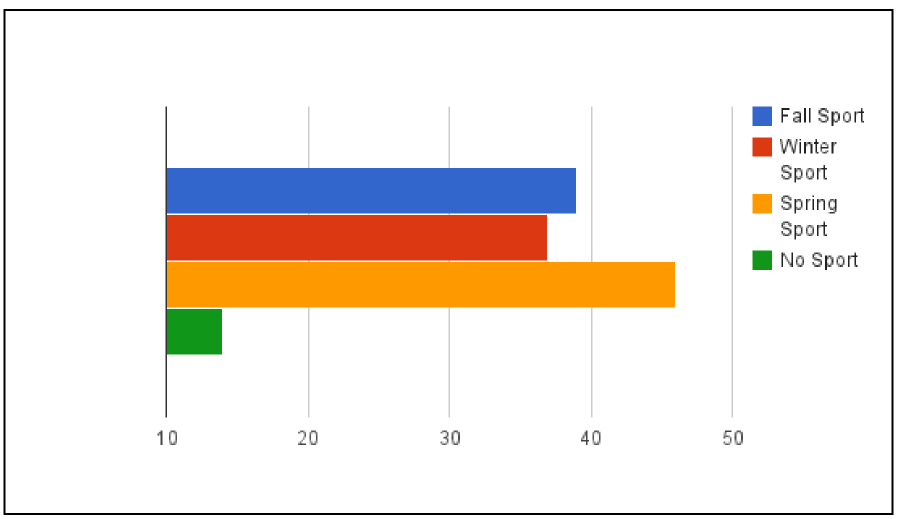


Figure 4.5.4. *Overall students' reported likelihood to participate in each outdoor leadership program, ranging from not at all likely (1) to very likely (5).*

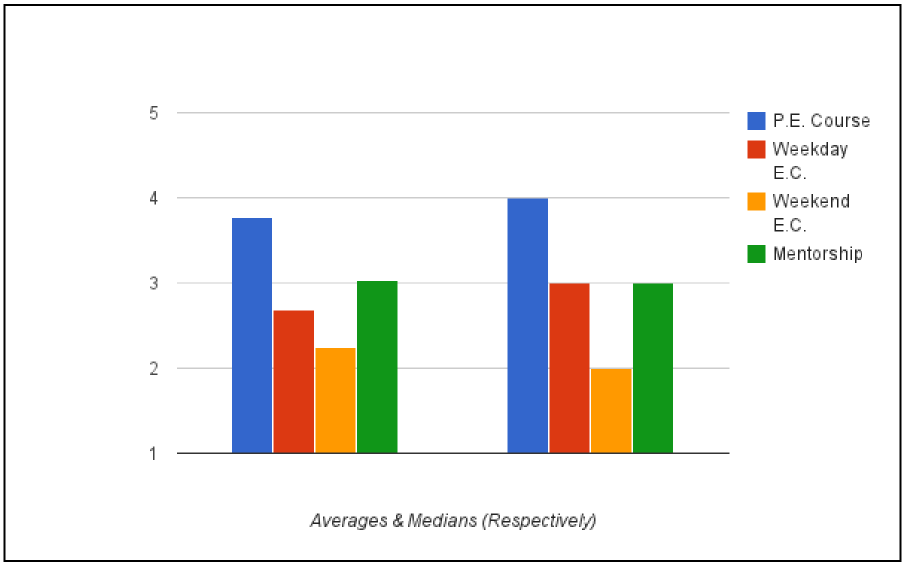


Figure 4.5.5. *Interested students' reported likelihood to participate in each outdoor leadership program, ranging from not at all likely (1) to very likely (5).*

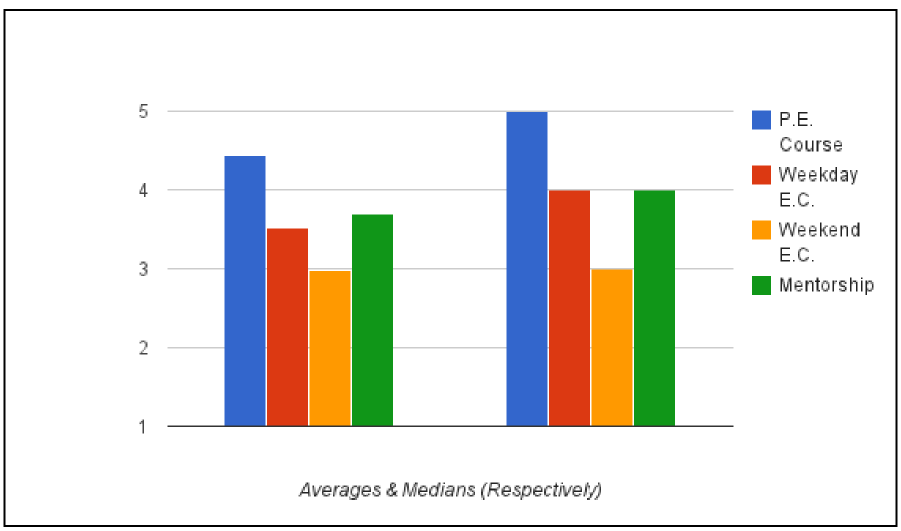


Figure 4.5.6. *Number of overall students who reported availability to participate in an outdoor leadership program for each day of the week.*

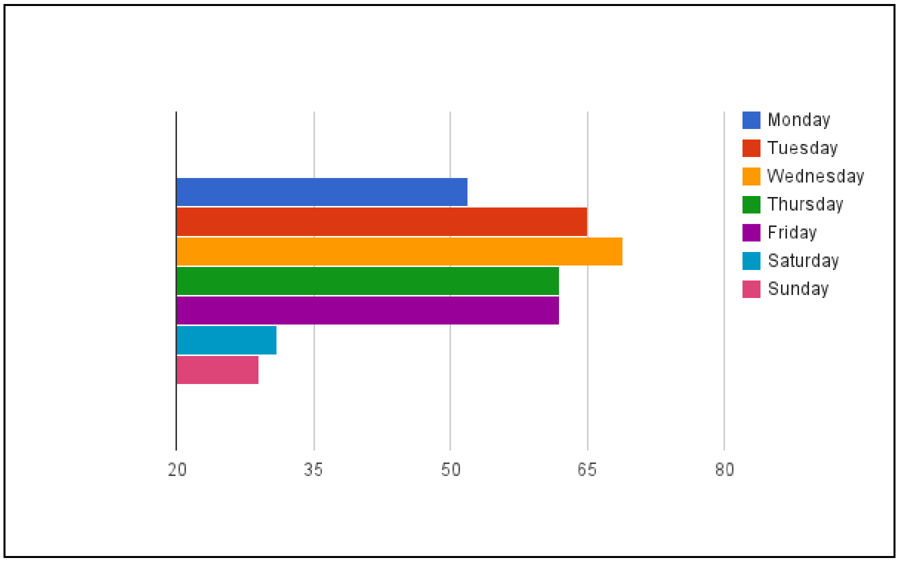


Figure 4.5.7 *Number of interested students who reported availability to participate in an outdoor leadership program for each day of the week.*

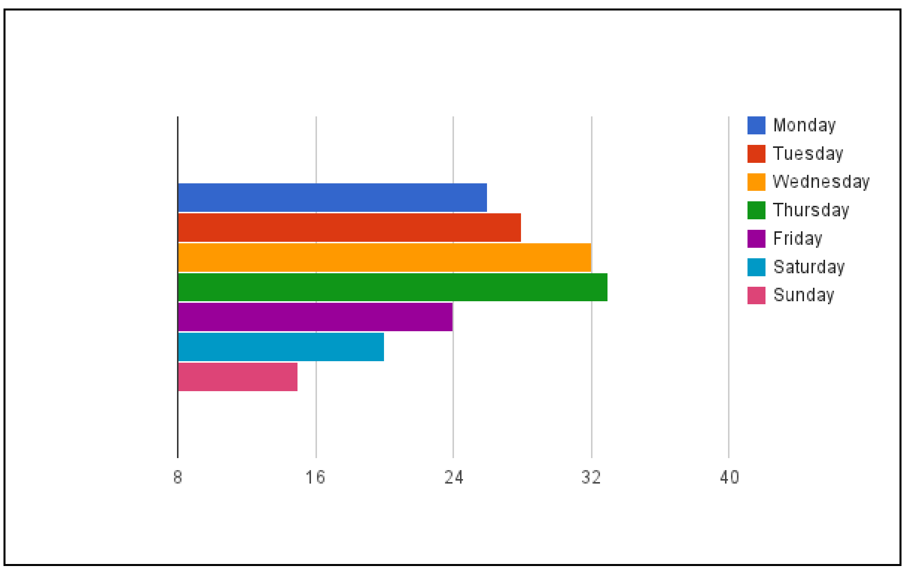


Figure 4.5.8. *Overall students' reported interest level in each outdoor activity, ranging from not at all interested (1) to very interested (5).*

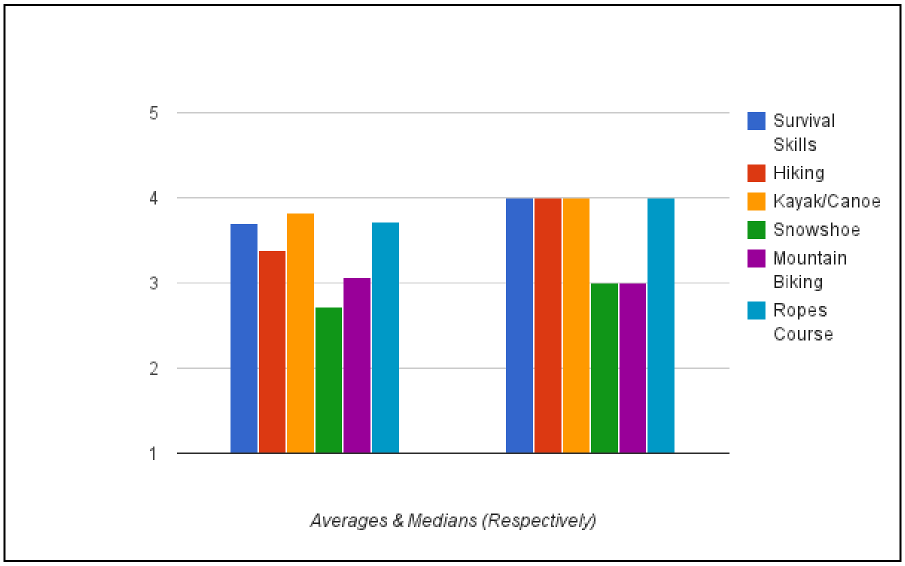
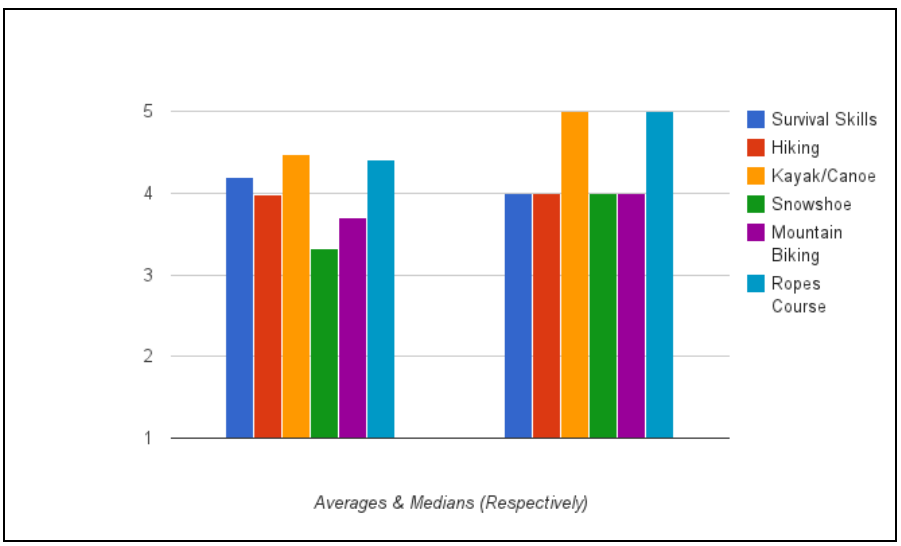


Figure 4.5.9. *Interested students' reported interest level in each outdoor activity, ranging from not at all interested (1) to very interested (5).*



Discussion

The results of the questionnaire illustrate that there is a substantial sector of the student population that is interested in participating in an outdoor leadership program at TA, totalling 78 students. Since many outdoor leadership programs run in groups of twelve or smaller, it seems likely that if TA were to implement a program, there would be sufficient student involvement to make this program successful.

Since many of the programs listed above are extracurricular and, thus, catered to students who are interested enough to sign up for the program, we felt it important to separate the responses for those who indicated an interest in outdoor leadership from the overall respondents. We found it would be helpful for TA staff to know the preferences and availability of those students who are interested in participating in an outdoor leadership program as there was a significant difference in the responses put forth from this group compared to that of the overall respondents.

Most importantly, we found that interested students were more likely to be participating in sports that could conflict with their ability to participate in additional extracurriculars. This is important because it could provide insight as to whether an extracurricular outdoor leadership program would have the necessary student participation to be successful at TA.

Another notable result was the strong preference for a curricular program in the P.E. department amongst both groups. While interested students were more likely to give a higher rating to all program structures, they also rated the option of a P.E. course much more favorably than other programs. This is important to consider as it could provide important insight as to whether certain program structures would be successful at TA. The results show that a P.E. class could be the most favorable option.

Lastly, students also provided day and time availability information, and these results were split in a similar manner. Interested students were most available on Thursdays and Wednesdays (in order of most preferable), and both student groups agreed that 3 p.m. to 4 p.m. would be the most ideal time to participate in an outdoor leadership program. This information is important as it could provide guidance to TA staff members when, if ever, implementing an extracurricular program.

However, we would like to note that when we created the questionnaire, we neglected to include an important time period within the options (between 2:15 p.m. and 3:15 p.m.) that we feel may have been a popular time amongst students as it is directly after the school day ends. TA should consider surveying students about this time slot before implementing any extracurricular program.

4.6 Recommendations

According to our findings from the case studies, the student questionnaire, and the many meetings with TA staff members, we propose three primary courses of action to establish outdoor leadership at Thetford Academy, listed with our most important recommendations first:

1) We propose that TA implement an outdoor leadership into the P.E. curriculum, which can be done either by creating a new, stand-alone course (Program 3) or adding a unit into a preexisting course (Program 4). From our findings, we concluded that students interested in outdoor leadership would be more likely to engage in a program during school hours, as many of these students have conflicts with other extracurriculars as well as issues with transportation. Additionally, we found that these programs have important learning objectives that would benefit everybody, not only those who are interested. Not to mention, those who have never participated in any outdoor leadership activities may not realize they are interested, but discover that they are. Therefore, by incorporating outdoor leadership into the curriculum, we are reaching those interested in the program (without the constraints of time and transportation), as well as providing those less eager to participate with an opportunity to learn important communication and leadership skills as well gain environmental awareness.

2) We propose that TA establish an extracurricular outdoor leadership program that meets on a weekday (Program 1). This program would serve mainly those who reported an interest in outdoor leadership and also had adequate availability in terms of sports involvement, day, and time. This program could take a number of forms and is flexible as to day, time, duration, and frequency of meetings, in order to accommodate students and staff. From our results, we found that Wednesday or Thursday from 3 p.m. to 4 p.m. might be the best time to run the program (excluding the possibility of running the program directly after the school day ends). However, the implementation of this program also relies on the involvement of TA staff to supervise and teach outdoor activities and skills. Therefore, staff schedules will also play a major role in deciding the day and time that the program will meet.

3) We propose that Thetford work to initiate and maintain a relationship with Dartmouth's Tucker Foundation in hopes of implementing a mentorship program with Dartmouth students in the future. Dartmouth has already established its OLE program and has expressed some interest in partnering with TA to expand this program. Although this cannot happen immediately, as Tucker is undergoing some important changes in the next year, we believe it is worthwhile for TA to continue to pursue this option very seriously. Since Dartmouth has already established the program, TA will avoid many of the difficult logistical issues that come with starting a program from scratch. Not to mention, TA students will have the unique opportunity of learning from Dartmouth students while also engaging in fun outdoor activities.

Chapter Five: Instituting a Maple Sugaring Operation

Frohman Anderson, Natalie Flowers, Varun Ravishanker, and Nelson Santry

5.0 Executive Summary

This report investigates the feasibility of starting a maple sugaring operation at Thetford Academy, VT and provides strategy recommendations to optimize the sugaring process, minimize costs and environmental impacts, and incorporate educational opportunities for Thetford Students.

Information about best sugaring practices was accrued through a combination of site visits of already established operations, fieldwork at proposed Thetford Academy site locations, and statistical methods based on research. Site visits provided experiential insight into the process, and also yielded qualitative data in the form of recommendations from experienced sugarers. Fieldwork consisted of plotting the GPS coordinates of each tappable tree in the proposed site location. A literature review of the sugaring process revealed methodologies for estimating sap yield and syrup yields as well as several numerical constraints to be aware of during the implementation process.

Results of this investigation indicate that implementing a small, commercial-scale maple syrup operation should certainly be feasible at Thetford Academy. Based on plotting, there are roughly 200 tappable trees in the stand, more than enough for the desired scale of the operation. Initial investigation indicates enough ecological resilience in the stand to deal with the relatively low environmental impact of this project. Financial analysis demonstrates that while there are some fairly large initial infrastructure investments (shack construction, evaporator, etc.), the only consistent annual cost will be fuelwood. In order to mitigate some of the initial costs, a simple heuristic clustering model was used to generate a lining system that both meets the constraints observed in the literature and to attempt to minimize the amount of lining necessary to purchase for the operation.

Given that a sugaring operation does seem to be feasible at Thetford Academy, this report includes several recommendations for how to best proceed with the development process. The management and operations strategies provide a comprehensive list of general practices to follow to properly perform the process, improve performance, and reduce risk. Computations performed with tree GPS coordinates generate potential sets of trees to connect to the same lateral lines and indicates whether trees are suitable for the gravity line system or whether they would need to be bucketed if tapped. The financial analysis provides a list of recommended equipment and rough estimates of the pricing of these items. The report also contains several recommendations about how to incorporate sustainable practices into both the development and management of a sugaring operation.

5.1 Introduction

A maple sugaring operation at Thetford Academy offers an exciting opportunity for community engagement and curriculum enrichment. Maple sugaring occurs during the spring months when patterns of freeze and thaw build pressure within the trees and allow for sap to flow. Sap is collected through buckets and lines and stored in a sap storage tank at the sugar house. From the storage tank, sap is boiled in an evaporator pan. The water evaporates until a sweet sugary substance with golden bubbles is left in the pan. Finally the substance is reheated or "finished" to the perfect density and then filtered to take out any remaining particulate matter (Croft, 2014). Maple sugaring exposes students to a quintessential part of New England history and provides for hands-on, experiential learning with real-life applications. Maple sugaring also allows for students to build a community through positive connections with the environment. Overall, the operation requires leadership and dedication from students, faculty and community members. Furthermore, strict stand management and operation practices will ensure overall health of the stand. The sugaring operation takes advantage of the beautiful natural surroundings while engaging students with environmentally friendly practices. In conclusion, we recognize that starting the sugaring operation will be an evolutionary process and our recommendations serve as a baseline guide for future work.

5.2 Maple Stand and Sugaring Environmental Assessment

Purpose

This assessment is to be used to evaluate the maple stand and syrup operations for .

Affected Environment

The construction of the sugarhouse and sugaring operations will affect an eight-acre stand of trees across the road from . The stand contains sugar maples and black and red pine trees. The sugar maples vary in age and are growing on well-drained soil.

Specific Environmental Considerations of The Stand

Identifying and properly managing the environmental and geological features during the construction process and sugaring operations are integral in maintaining biodiversity and overall health of the maple stand.

One such feature is the vernal pool, which contains a unique microenvironment. Vernal pools are shallow water collections found in forest ecosystems, and they host indicator species, which may include Wood Frogs, Mole Salamanders and Fairy Shrimp (EPA, 2013). In addition to benefiting biodiversity directly in the pool, this environment provides food for animals of the surrounding upland including insects, frogs, salamanders and tadpoles.

Due to demand for clean water, vernal pools' existence is delicate, and they can be made uninhabitable by pollutants such as road salt, pesticides, oils and sediments. To ensure the vernal pool is not disturbed, we recommend no sap lines stretch across it or along its banks to reduce foot traffic. Particulate pollution from the sugarhouse should be small, and the vernal pool is likely frozen during the time of the year when sap boiling occurs. As a result, it will be unlikely that particulates settle in the water, but maintaining vigilance and awareness of the vernal pool will be integral to its survival.

Other environmental features to consider are the invasive species present in the maple stand. Non-native species may negatively impact the biodiversity of a forest environment and its resulting resilience. Present on the TA maple stand are Honey-Suckle and Hay Scented Fern. There is no information as to whether these species will directly affect the sugar maples or their sap production. However, monitoring the prevalence of these species on an annual basis could prove useful in identifying trends or potential threats to the maple stand's biodiversity.

How to Sugar Sustainably

After considering the unique environmental features of TA's maple stand listed above, incorporating various approaches and tools described below will ensure the overall sustainability of the sugaring operation. These steps will ensure a minimal effect on the surrounding environment, and enable biodiversity to thrive.

In the proposed sugaring operation, the largest energy input and pollution contribution is the combustion of fuel to heat the sap evaporator. Processing maple sap into syrup can be a highly energy intensive operation, but it can be done sustainably with properly sourced fuel.

The options for fuel include natural gas, propane, and liquid fuels. Although these fuels are effective, they are non-renewable. In order to combat this potential environmental cost, we propose wood to fuel the evaporator. Although not always thought of as a renewable resource, timber harvesting can be done in a sustainable manner when a forest management plan is properly executed. To do this, we recommend TA create a plan in its forestry class to sustainably harvest the red pine that is prevalent across its property. Ensuring that the maple stand does not trend toward a monoculture is critical, as a monoculture has the potential to negatively affect maple trees through lowered resilience to changing environmental conditions (Sam Kelman, The Mountain School, March 2014). If TA cannot internally source enough wood to fuel the evaporator, they can harvest the black ash. Because ash is highly valued in current timber markets, the revenues generated could be used to purchase wood fuel from local, responsible harvesters to continue the sustainability of TA's maple syrup production. It is important to note that potential environmental costs from burning red pine include noise and particulate pollution. However, timber remains the most renewable source of energy for sugaring (Sam Kelman, The Mountain School, March 2014).

There are sugaring operation procedures that are essential to maintaining the sustainability of maple syrup production in addition to sourcing sustainable timber for fuel. After meeting with several veteran sugarers, it was made clear that making plans and sticking to them are integral to operational success and overall sustainability. We believe it is essential to produce both a stand management plan and a waste management plan. These will be developed with input from, the TA forestry group and other advisors.

In addition to creating operational management plans, efficiency gains are made possible by identifying areas of improvement in the sugaring system to reduce waste and cost. It is a common practice in the sugaring industry to annually reflect on operations. A great way to keep track of, and more effectively examine, each year of sugaring is to keep a log of successes and failures throughout the season. Efficiencies and progress will only be achieved when the sugaring system and operations are carefully critiqued. As well as logging procedural successes and failures, there are certain environmental data that we recommend be recorded and studied. Such metrics include soil pH, species prevalence and yearly sap flows. Recording and monitoring such factors will allow insights into, or be indicators of, environmental changes in climate, temperature, precipitation, invasive species and related areas (Sam Kelman, The Mountain School, March 2014).

Construction Considerations

To maintain the goal of sustainability throughout the sugaring process, we recommend using best practices in the sugarhouse construction. Such efforts include minimizing waste, sourcing local materials as much as possible, and maintain a small overall building site.

Soil erosion should be of concern when heavy machinery is used in the erection of the sugarhouse structure. Well-maintained access roads into the stand will lead to minimal erosion and a negligible overall environmental impact.

5.3 Management and Operation Strategies

Trees

The Northeast sugar maple (*Acer saccharum*) is the traditional tree species used for maple sugaring (Davenport, 1998). The ideal sugar maple tree has a well-developed crown and grows within a stand of healthy, mixed age sugar maple. Large crowns are required so that leaves are exposed to as much sunlight as possible. Maple trees do best in slightly acidic soils with a pH of 5.5 to 6.8 and levels of organic matter over 3.5 percent. Sugar maples may suffer from high sodium levels, which may be a result of road salt runoff. (Luzadis and Gosset, 1996).

Tree Maintenance

We recommend periodic removal of seedlings and young maples in order to prevent overcrowding and allowing older trees to develop fuller crowns. Consistent pruning is also necessary for handling natural hazards such as hanging, dead limbs and branches, which are a common problem in the maple tree stand.

Sugar maple trees are also prone to manganese deficiency. This generally occurs in soils with high pH. Trees with manganese deficiency exhibit yellowing between veins of leaves. Furthermore, droughts and severe winters may cause leaf spot diseases or limb dieback. Drought also leads to leaf scorch or leaf browning during the summer. Trees may suffer from fungi or nematodes causing great damage to the trunk and limbs. Other possible dangers for maple trees include insects, mites, leaf-feeding caterpillars (most notably the gypsy caterpillar, tent caterpillar, and cankerworm) and aphids. Deer and squirrels also often eat or drink the sweet sap, opening entryways for canker fungi (Luzadis and Gosset, 1996).

Common Sugar Maple Diseases

- ❏ Anthracnose (*Gloeosporium apocryptum*)-look for purple, brown or black dead area in leaves, may be circular
- ❏ Tar spot (*Rhytisma acerinum*)-foliage disease, look for large, black, thickened spotting
- ❏ Fungal diseases (*Nectaria* and *Eutypella*)-trees exhibit cankers on trunks of

branches
- ❏ Vascular diseases may also occur from fungi entering the stems (Luzadis and Gosset, 1996)

Basic Maintenance Strategies for Sugar Maples
- ❏ Mulch young trees- aids in water conservation and soil maintenance
- ❏ Pruning during winter months
- ❏ Anthracnose and leaf spot treatment application during mid spring
- ❏ Leaf monitoring during summer months
- ❏ Check soil moisture in early summer
- ❏ Monitor soil pH during the fall (Luzadis and Gosset, 1996)

Safety

Workers should be de-briefed on all safety procedures within the sugarhouse. In particular, workers should be warned of incredibly hot surfaces including pans, steam hoods, draw-off valves and evaporator arch. We recommend that only one or two students help with the boiling process at a time — other students would ideally observe from a viewing area surrounding the sugar house.

Workers engaging with the firing process should wear long sleeved clothing, closed-toed shoes and fire protection gloves. A dry chemical fire extinguisher should be accessible at all times.

Design Recommendations

Design should aim to prevent entry of birds, rodents, insects and other organisms that could lead to contamination in the final product. Interior surfaces in particular should be impermeable so as to prevent any possible microbial growth. Additionally, we would recommend that all equipment be lead-free stainless steel or similar, and that surfaces are sterilized and cleaned periodically (UMass 2009).

Water

We recommend the use of potable water sources, which are important for cleaning equipment and washing hands. Furthermore, any water within the sugaring house needs to be tested periodically to ensure that it is contaminant-free. In particular, sugarhouse water should be tested at least once a year for the presence of *E. coli* or other bacteria (UMass, 2009).

Pre-season

During the pre-sugaring season, all equipment should be washed with potable water in order to remove dust particles and any other possible contaminants. Recommendations for washing include filling the evaporator with clean water and boiling for an hour prior to use. Furthermore, all sap filters should be washed and dried before use.

Tapping

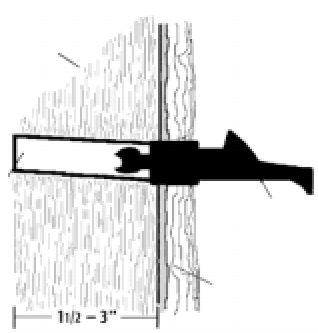
In general, avoid tapping trees less than 10-12 inches in diameter. During our mapping, we took care to only mark trees with correct tapping dimensions. In addition, experts recommend using no more than four taps on trees greater than 24 inches in diameter. Tapping should also be avoided on trees suffering from disease, ice damage or draught (Davenport, 1998.)

Table 1. Guideline for Number of Taps Per Trees (Davenport, 1998)

Diameter	**Circumference (inches)**	**Number of Taps**
10-17 inches	31-53 inches	1
18-24	57-75	2
25+	79	3

Tap holes should be no closer than five inches to either side or six inches above or below old holes.

We recommend drilling primarily white wood with create clean, neat holes (see figure below). Tap holes will depend on the size of the spouts. Smaller spout sizes are recommended for reducing tree damage. Usually, spouts require a 7/16 or 5/15 diameter bit size. Tap holes should be no deeper than 1.5 to 2 inches. Tap holes should also be at least two to three feet above the ground (Davenport, 1998). Bits should be periodically sanitized throughout the tapping process. We recommend washing the bits in a detergent solution and using household bleach followed by clean water (Davenport, 1998.)



Correct spout drilling (UMass 2009)

Timing

Tapping should be done early spring when trees are partially or completely thawed or very close to anticipated sap flow time.

Buckets

Buckets should be cleaned after every sugaring season with detergent and water. The Massachusetts Sugaring Manual recommends that buckets be carefully triple-rinsed to remove any residue. Containers previously used for any type of hazardous material should never be used.

Tubing

Tubing systems also require proper cleaning at the end of each sugaring season. We recommend washing with water and bleach promptly following the sugaring season. Tubing systems have the potential to grow microbial “biofilm,” which can drastically impact sap quality and ultimately damage syrup quality.

Evaporator Cleaning

Evaporators should be cleaned with fermented sap or acid cleaners. In addition, accumulated carbon should be frequently disposed of from evaporator surfaces. Throughout the sugaring process, workers should take care to avoid sugar sand accumulation.

Filtering

We advise filtering with paper and cloth gravity filtration. Following filtration, all filters must be washed and sanitized.

Finishing syrup

Finishing syrup, or heating syrup to the correct temperature, prevents fermentation or over crystallization (UMass 2009). Syrup should be finished to a density between 66 and 68 degrees.

Syrup storage

All containers should be packed and cooled to room temperature. Each container should be labeled according to sugaring date. All containers should be stored in a cool, dark space.

Bulk containers must be packed and sealed tightly (UMass, 2009).

Sugarhouse cleaning

The sugarhouse should be cleaned at the end of each sugaring day. All paper filters should be washed and air-dried, and all holding tanks should be rinsed and emptied to avoid microbial growth. We recommend that waste be disposed of frequently in pest-controlled containers. A mixture of one part unscented household bleach to 20 parts clean water may be used with a cloth to clean the insides of any sap collection equipment (Davenport, 1998). We also recommend the use of a daily sugarhouse cleaning record (Luzadis and Gosset, 1996).

Pest management

Ants, birds, raccoons and rodents are particularly concerning for sugaring houses. Ants, in particular, can cause syrup contamination. Ant invasion may be avoided with frequent cleaning and proper techniques. In addition, doors and windows should be kept in good operating condition with door sweeps and tight seals. Finally, frequently emptying all trash containers will help with rodent problems (UMass, 2009).

5.3.1 Sugaring Calendar

A basic sugaring calendar can be used as a guideline throughout the year. In addition to this calendar, it is important that the school creates and follows a stand management plan in order to ensure overall tree health. Below, we provide the framework for a year-round sugaring calendar. This framework was obtained from the lesson planning section of tapmytrees.com

Fall/Winter:

- ❏ Identify maple trees, explore topography of land
- ❏ Thin trees as necessary

January/February:

- ❏ Track temperature data
- ❏ Prune trees

Late February/Early March:

- ❏ Gather equipment
- ❏ Clean supplies
- ❏ May tap trees and collect/store sap at this time
- ❏ Record temperature data
- ❏ Begin boiling process

Late March/April:

- ❏ Pull taps
- ❏ Present information gathered
- ❏ Clean equipment
- ❏ Check for leaf spots

Early Summer:

- ❏ Check soil moisture and pH (“Tap My Trees”, 2011)

Specifics on Vermont maple sugaring seasons: According to the US Department of Agriculture, the 2013 Vermont maple-sugaring season began January 8 and closed May 1. The average season length in 2013 was 41 days (USDA 2013).

5.4 Sugarhouse Design

In this section, we provide a number of design recommendations for the sugarhouse. Although we foresee TA's timber framing class developing more specific plans, we hope to share some constructive tips to aid in the design process.

Important factors to consider in sugarhouse design include drainage, accessibility, air movement and space. First and foremost, it is important for the sugarhouse to be located on well-drained soil. Designers should also consider the use of utilities at the sugarhouse site, and how water and electricity might be brought to the sugarhouse. Based on conversations with Len and an internal review, we determined that the sugarhouse would likely not use electricity and boil during the daylight hours. Finally, sugarhouses require sufficient air movement in order to allow steam to leave the building. We believe that our proposed sugarhouse site location in the clearing will create sufficient air passage. Below, we list some specific recommendations for various components of the sugarhouse. Design recommendations were adapted from the "Maple Sugaring Manual" produced by the University of Vermont.

Wood storage

We recommend building a shelter or storage facility with sufficient storage area for at least one season of fuel wood. This storage area should be located at the end of the sugarhouse. For example, the Mountain School's sugaring operation featured a wood storage area with a rail cart system for the wood transport from the storage area to the boiling area. This enabled extremely efficient wood movement during the boiling process.

Air movement

It is important for the sugarhouse to be located in an area with good airflow to create sufficient steam movement. Excessive moisture has the potential to create mold and designers should aim to find a location where the house will be located within a relatively open area with little air settling. Ultimately, it is important that the sugarhouse stay as dry as possible.

Location

We recommend allowing at least 40 feet per vehicle around the sugarhouse for parking and turning a vehicle around. The firebox should face downhill or toward the wind.

We have located a suitable site for the sugarhouse at the bottom of the drainage on a flat clearing, and indicated this location on our map. This site is also located just off the access road, allowing for easy access and transportation of materials (Wells). The yellow circles are the maple trees and the red square is our proposed sugar shack location:

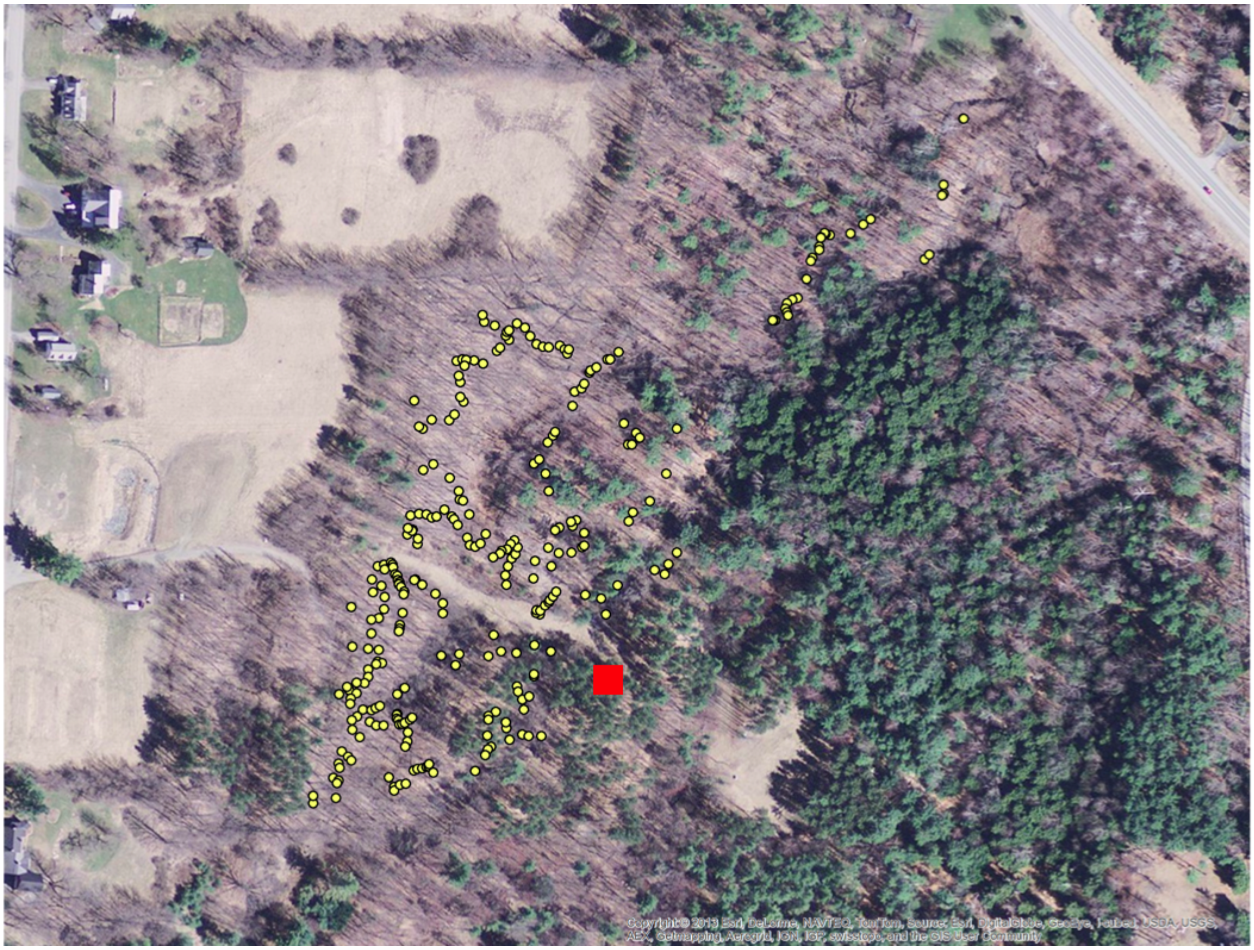


Fig 5.4.1

Foundations

We recommend a stone foundation or concrete slab. If stone is used, most sites require a three to four foot deep foundation (Wells).

Size

Size of the sugarhouse should be determined by the size of the evaporator. Most experts recommend a minimum of four feet of work room around the evaporator. It is also important to leave enough room in front of the firebox in order to load wood. The manual lists possible sizes based on number of taps, outlined in the table below.

Number of Taps	Minimum size house recommended (Wells)
150 or less	14’ x 16’
Up to 1,500	16’ x 20’

Over 1,500	18’ x 24’

Recommendations for Main Components of Sugarhouse

- ❏ Evaporator/evaporator room – located near center of building, beneath ventilation
- ❏ Wood storage – often located at the end of the sugarhouse, near fire chamber
- ❏ Sap storage tank – north or east side of house; large enough for one day of sap; should be easy to clean
- ❏ Syrup processing area – space for filtering syrup, stove for boiling syrup
- ❏ Drain – a drain should be put in place for water drainage from the sugarhouse. We recommend constructing a screen over the drain to collect any particulate matter (Wells)

Important Factors to Consider

- ❏ Shorter walls (7-8’) – allow for steam to leave the building (Wells)
- ❏ Roof ventilators – required, can be built on hinges and pulled open as needed
    - ❏ Rule of thumb- ventilators should be half length of building, long as the pan
- ❏ Fire stack – allow for a good draft
- ❏ Windows – important for lighting, as we don’t anticipate the use of electricity within the building

Design of the sugarhouse may also depend on constraints not discussed above, such as the timber availability and budget. We hope that these design recommendations serve as a starting place for administrators, community members and students.

5.5 Curriculum Ideas

We see curriculum incorporation as an exciting opportunity for TA. The sugaring operation provides opportunities for experiential learning and exposes students to a quintessential part of New England history. Furthermore, the operation has the potential for community engagement by inviting local experts to visit TA for special events. We foresee opportunities in many different subject areas, including science, math and history. Below, we provide a few possible lesson plans that could be adapted for different classes and grade levels.

Possibly the most accessible curriculum lessons involve teaching students the basics of the sugaring process. This introduces basic sugaring vocabulary and the steps of the maple sugaring process, including:

- ❏ Sap
- ❏ Sugarbush
- ❏ Syrup
- ❏ Tapping

Other concepts from the sugaring process may be applied in many different subject areas, including math, physics and environmental science.

Sugaring Process Lesson

- ❏ Define boiling and freezing point of sap
- ❏ Learn about concept of ratios (approximately 40:1 ratio for making syrup)
- ❏ Effects of global warming on sugaring process
- ❏ Ways to reduce carbon footprint throughout sugaring process
- ❏ Explore fuel sources and different technology options (“Tap My Trees,” 2011)

The lessons listed below are adapted from “Sugar From Trees,” a guidebook on interdisciplinary maple sugaring in the <u>Minnesota Conservation Volunteer</u> magazine.

Activity 1: Science/Physics Lesson

Sap Flow

Help students understand the process that makes sap flow

Basic points covered in lesson:

- ❏ Rise in temperature above 32 degrees F causes a positive pressure
- ❏ Internal pressure, when greater than atmospheric pressure, causes the sap to flow out (think of how a blood flows out of a cut)
- ❏ Sap moves towards the point of lowest pressure from all directions
- ❏ When temperature is near freezing, pressure may become negative
- ❏ Four cell types exist within trees, acting as pipes transporting sap
- ❏ In maples, the surrounding dead wood fibers are filled with gas, when freezing

occurs frost forms on the inside of these cells

- ❏ Trees yield sap when frost thaws and internal pressure increases
- ❏ Sap flow occurs as long as internal pressure is greater than atmospheric pressure
- ❏ Sap flow periods can vary from a few hours to days on end
- ❏ Good sap flow occurs when temperatures cycle above and below freezing
- ❏ Stored starch from previous growing seasons also drastically affects sap flow
    - ❏ Starch converts to sucrose and then dissolves in sap as spring starts
    - ❏ Amounts of sucrose depends on tree genetics, leaf size, site, and amount of sun received

Activity 2: Science Lesson

Teach students about the seasons of maple sugaring with these basics:
Create worksheet with spaces for each season

Spring

- ❏ Boiling season

Summer

- ❏ Chlorophyll absorbs energy from sun
- ❏ Roots absorb water and minerals from soil
- ❏ Photosynthesis occurs-simple sugar produced
- ❏ Sugarers often package and sell syrup during this time
- ❏ Sugarers may also chose to thin out trees in the sugarbush

Autumn

- ❏ Leaves slow down chlorophyll production
- ❏ Leaves begin to drop, good time to clean up sugarbush and cut firewood for evaporator

Winter

- ❏ Trees dormant, starch stored in trees waiting to be converted to sugar
- ❏ Equipment ordered and prepared for upcoming sugaring season (“Tap My Trees,” 2011)

Activity 3: Culinary Arts or Science Classes
Sugar on Snow

This is a fun activity for early sugaring season — this springtime activity has been carried out in sugarhouses for over 200 years. “Sugar on Snow” candies are know as “leather aprons” or “leather britches” because of the chewy consistency

Process:

- ❏ Heat syrup between 22 to 28 degrees
- ❏ As soon as the syrup reaches this temperature, pour immediately over packed snow
- ❏ The supersaturated solution does not have a chance to crystallize and it forms a thin glassy taffy substance
- ❏ Eat with a fork or serve with sour pickles, saltines or doughnuts

Activity 4: Math Lesson

- ❏ Calculate average yield from maple trees
- ❏ According the USDA, Vermont had on average 3,800 taps in 2013, with approximately 0.347 gallons per tap and a total of 1,320 gallons of syrup produced across the state (USDA, 2013).
- ❏ Average price per gallon in Vermont is $35.50 (compare this to $63.50 in Connecticut)
- ❏ Vermont contains approximately 40 percent of all maple production in the United States with just over 1.3 million gallons of maple syrup produced annually (USDA, 2013)
- ❏ Explore ratios
- ❏ Graph temperature change versus sap yields

Activity 5: Science Lesson

- ❏ Learn about the basics of evaporation as it applies to the sugaring process
- ❏ Explain boiling point versus freezing point
- ❏ Measuring the density of liquid
- ❏ Explore entire process from sap flow to sugaring
- ❏ Identify tree species

Activity 6: History Lesson

- ❏ Explore the history of maple syrup production
- ❏ Native Americans first started sugaring and taught their techniques to settlers
- ❏ 1680-European settlers and fur traders harvested maple syrup
    - ❏ Sugar became an important commodity for early settlers
- ❏ 1858-First evaporator was patented
- ❏ 1900-First evaporator created with a series of flues decreasing overall boiling time and increasing heated surface are of the pan
- ❏ 1970s-Vacuum pumps first introduced, reverse osmosis machines first developed, preheaters developed to recycle heat lost in steam

Activity 7: Climate Change

- ❏ Discuss the influence of climate change on sap flow
- ❏ Utlilize http://www.climate.gov/teaching/resources/maple-syrup-sap-flow for interactive maps on sap flow with different emission scenarios

5.6 Tubing System Layout Recommendations

Determining a proper layout for the tubing system is crucial for optimizing sugar production at the site. Typically, an experienced tuber or forester does an assessment of the site, ensuring that several key conditions are met. For example, at any given point along a mainline, the grade (slope) of the tubing should be at least 2% to facilitate sap flow and the grade for lateral lines should be 5%. Other factors include the maximum number of trees per lateral line (20-30), and maximum line lengths for main (1000') and lateral (100') lines. It is difficult to envision even the most experienced forester having the ability to perfectly encapsulate geography the site and all the factors involved in producing an optimal layout from qualitative and solely rudimentary quantitative metrics. For this reason, some preprocessing is done on the stand in order to provide anyone doing actual layout in the future with information that may both ease the initial layout process and minimize layout costs.

In order to perform this preprocessing of the site, some information about the trees and their locations is necessary. The latitude, longitude and altitude of each tappable maple tree as well as the theoretical shack location were collected using GPS devices. It is generally considered bad practice to have trees in the tubing system within 30 feet altitude of the sugar shack. Therefore, all trees less than 30 feet higher than the shack are removed from the tubing system calculations. Given the three values for each tree, the trees are clustered using a k-means clustering algorithm. This algorithm works by generating some number k of centroids, each of which have a latitude and a longitude value. Then, each tree is assigned to the cluster which produces the minimum distance between the tree and the centroid of each cluster. Then, once all trees have been clustered, the centroid is recomputed to be the average latitude and longitude of all trees in the cluster. This process can be performed iteratively until clusters don't change from step to step, at which point the clustering is complete and the clusters should be representative of potential tree groups that can be tapped with the same lateral line. Lateral lines are then drawn between trees in each cluster based on the great-circle distance between the two. The cumulative distance of all lines computed by the program is then a rough estimate of the amount of lateral line needed for the project. Given the GPS data and the constraints listed above, the estimate of lateral line is 2788 feet. Since this fails to incorporate drop lines and other smaller uses of lateral line, this number is slightly depressed, but the data seems to indicate that 3000 feet of lateral line is a safe amount.

The full results are represented by the map below:

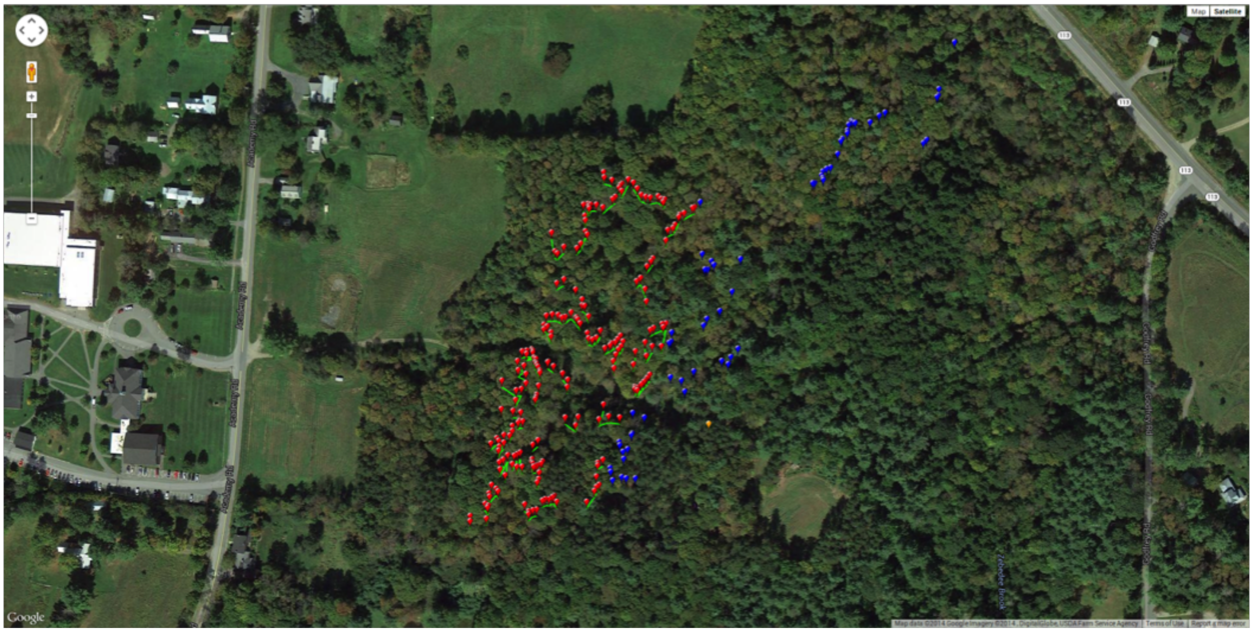


Fig 5.5.1

The yellow dot represents the shack. Red dots in the image represent trees eligible for the tubing system; while blue dots are do not meet the height difference requirement. It is recommended that a fraction of these trees be tapped using a bucket system in order to solve this issue.

A zoomed-in picture provides a better view of the lateral line paths:

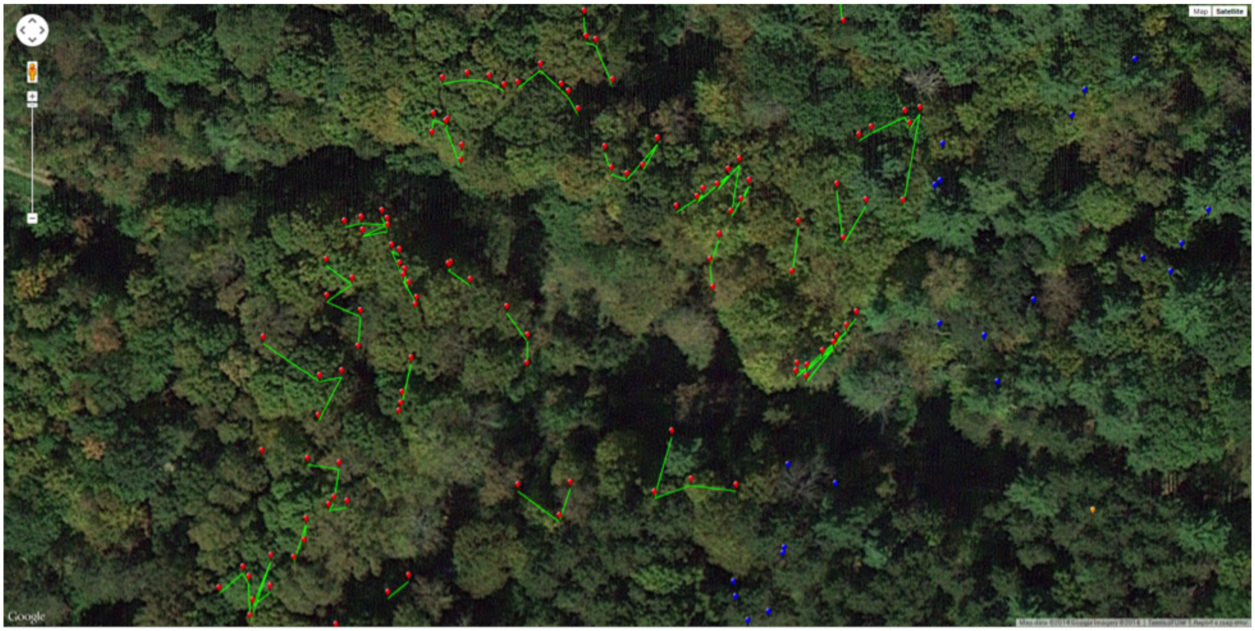


Fig 5.5.2

5.7 Financial Analysis

In order to set up a successful maple-sugaring farm from scratch, there will be fixed capital costs paid once as well as recurring annual costs to maintain the operation. For the initial capital costs, see Table 2. After surveying the stand, we determined that 200 taps would need to be purchased. Additionally, to store the sap before processing, a 300-gallon tank would need to be placed next to the sugarhouse. The evaporator that will provide the best value, and maintain efficient production of the sap will be a 2' x 6' evaporator. This evaporator can process roughly one gallon of raw sap per minute. So, with a maximum sap recovery of 200 gallons in one day, the lead operator will finish production in just over three hours.

We also considered reverse osmosis as another possible syrup processing tool. Reverse osmosis or RO increases the sugar concentration of the sap before it enters the evaporator to around 16% from 2%. This allows the sugarer to cut back on fuel needed because the sap is closer to the 66-67% sugar concentration of the finished product (Smallidge, 2011 <http://maple.dnr.cornell.edu/produc/evap.htm>) . This equipment is expensive and as a result we omitted it from our startup costs. The appliance is also difficult to master, and only really needed when economies of scale are considered during production. If TA later feels the need to add a reverse osmosis apparatus to the operation, there is room for expansion, but for the initial startup, it is not necessary.

Annual costs of operation will hinge on the fuel needs for the season. We estimate that the TA maple tree stand can produce about 1,830 gallons of sap per year. Given our recommended evaporator capacity, we anticipate processing 20 gallons of finished maple syrup per cord of wood. Therefore, TA will need a little over two cords of wood annually to handle the production of maple syrup. Depending on Len's assessment of how much wood can be sustainably sourced from TA's land, wood may need to be purchased from an outside timber supplier. Given Len's expertise here, he will assess and handle the wood fuel needs of the sugarhouse and purchase wood as necessary. It is also worth noting that annual expenses will vary depending on the condition of taps, lines, buckets, storage tanks and the sugarhouse structure. Best practices, such as proper management to limit wear and tear, will lengthen the life of the equipment; we also recognize, however, that equipment may break, and these costs will present themselves as the operation moves forward. Below we list estimates on equipment costs based on figures obtained from mapletrader.com.

Table 2. Equipment Requirements and Associated Costs. MapleTrader Classifieds (http://mapletrader.com/traderclassifieds/).

Equipment	Cost ($)
200 Taps	$100.00
300 Gal Storage Tank	$1,500.00
2' x 6' Evaporator	$6,000.00
5 Gal Filter	$350.00
1500' Main Line	$510.00
3000' Lateral Line	$300.00
30 Buckets	$300.00
30 Bucket Covers	$120.00
Total Cost	**$9,180.00**

5.8 Conclusions

Through insightful discussions with knowledgeable sugarers at various sites, accurate surveying of the maple stands, and research on maple sugaring operations, we conclude that the costs of starting a sugaring facility are far outweighed by benefits fostering community connections and curriculum enrichment. Initial capital costs under $10,000 and the annual fuel costs for wood are relatively minimal, considering the large forest resources TA currently manages. The two cords of wood needed annually can be harvested locally from TA, in conjunction with Len Whitaker’s forestry class, or sourced sustainably from a reputable local timber dealer. Furthermore, the building and operating of a maple house will have limited environmental impact if constructed at our recommended location, and road infrastructure is already in place. Once set up, TA should anticipate community involvement. Maple sugaring is a prominent part of the Vermont economy, and a trade many take tremendous pride in. As a result, introducing TA to this passionate community will likely provide immediate benefits to both students and faculty. Furthermore, TA will be able to market the addition of a sugaring operation to prospective students, and offer a point-of-parity from other comparable institutions. Prospective students and parents will be able to see that education goes beyond the classroom, and into hands-on experiential learning. The main focus of TA, the student will benefit tremendously from the addition of a sugarhouse. After witnessing interactions and engagement between students and faculty at The Mountain School, we cannot help but admire the level of respect, diligence and excitement students expressed when participating in sugaring, where their successful work produces a tasty, sugary final product.

5.9 Resources
Below is a list of helpful websites and resources for different aspects of the sugaring operation.
Ecological Impact Statement of Sugaring operation in Southern Vermont
http://maplesyrupecology.blogspot.com
Town of Thetford Resource Draft-
http://www.thetfordvermont.us/wp/wp-content/uploads/2011/05/Natural-Resources-draft-1.7.14.pdf
Forest Service Guide to Maintaining Tree Health
http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/scanned/OCR/gtr-ne-129_files/ne_gtr129a.pdf
NH School Garden Grant Resources
http://www.nhfarmtoschool.org/school-garden-grant-resources
Best management practices for Massachusetts maple sugaring operation
http://ag.umass.edu/sites/ag.umass.edu/files/pdf-doc-ppt/maple_bmp_final.pdf
Maple Setup and Guidelines
http://extension.unh.edu/resources/files/Resource002015_Rep2980.pdf
Vacuum Recommendations
http://extension.psu.edu/natural-resources/forests/maple-syrup/collecting/tubing-system-installation/vacuum).
Influence of Climate Change on Sap Flow
http://www.climate.gov/teaching/resources/maple-syrup-sap-flow.

Community Resources

Name	**Email**	**Phone**	**Notes**
Sam Kelman	sam.kelman@mountainschool.org		Runs the sugaring facility at The Mountain School (~700 taps)
David Pilla	david@proctor.net		Runs the Proctor Academy sugaring operation (~350 taps)
Scott Stokoe	Scott.Stokoe@dartmouth.edu	603-643-5196	Manages the Dartmouth Organic Farm
Mary Parkman	zoning@thetfordvermont.us	802-785-2922	Zoning Administrator

D. Downey	d.downey@thetfordvermont.us		Recently moved but has several names of community members with sugaring knowledge
Mike Pomeroy	m.pomeroy@thetfordvermont.us	802-785-2539.	Currently has a sugaring facility

Chapter Six: Summary of Recommendations

Maple Sugaring

The recommendations of the sugar group strongly hinge on the tangible benefits TA students can touch and internalize, through participation in sugaring. Due to minimal startup costs, and low long-term operating costs, the addition of a Sugar farm will provide extremely good value to TA. Faculty and students alike will benefit from: the increased interaction with passionate local sugarers and community members; the ability to attract a broader scope of students for their class composition; and the added dimension to an already dynamic educational experience. Prospective students and parents will surely delight knowing the lessons taught across nearly all disciplines, will be able to be applied outside the classroom with hands on experiential learning.

However, the focus is to provide a comprehensive framework enabling TA to make this addition to their educational opportunities with sustainability in mind. Continuing to evolve and grow with the installation will be critical, as efficiencies can be overlooked in the plan, but easily observed once the boots are on the ground. Most critically will be to log yearly data on the operation, and the surrounding forest. Being keen to environmental change as this project gets off the ground will enable the sugaring operation to adapt and maintain its purpose.

Energy Efficiency and Production

Improving energy efficiencies at TA will be a continued effort, and will build on the already impressive strides the school has taken. Picking 'low hanging fruit', such as exercising best practices whenever renovations are done such as installing double paned windows, and replacing lights with up-to-date LED bulbs will contribute to lowering energy needs.

However, infrastructural changes will allow TA to produce energy more efficiently and cost effectively, while simultaneously protecting their financials from more stable energy prices. TA's boilers are scheduled for replacement soon, and pellet systems offer an attractive financial return. The ROI from a pellet system is 6.5 years. And yearly savings estimates are roughly $20,000 per boiler the pellet system replaces.

In addition to these attractive financial gains, students stand to gain tremendously from incorporating energy considerations into the curriculum. By developing *energy literacy*, students will further understand the energy world around them, and their role within it. Ultimately, students' exposure to learning about and experiencing TA's energy initiatives will provide a holistic, comprehensive foundation for future participation in the global pressing issues surrounding energy.

Food Systems and Sustainability

Reforming TA's food system will require a number of concurrent initiatives that intervene in multiple processes within the system and involve key stakeholders. With regards to food sourcing, specifically of meat and dairy products, TA should aim to limit its purchasing from Reinhart Foodservice, a nationwide distributor, and replace it with Black River Produce, a regional distributor based in Vermont. In establishing Black River Produce as its primary distributor, TA will not only provide students with more sustainably produced and higher quality food, but it will help stimulate the local economy and therefore nurture ties with the greater Vermont community. Additionally, purchasing fresh, regional meat, though potentially more expensive upfront, will likely result in more meals purchased, thus enabling TA to close its budget deficit.

A systems-solution must address food outputs, as well as inputs, to be considered sustainable. The food-loop can be healed with the addition of a compost program. A successful composting operation at TA will require student and staff involvement in the collection, transfer, monitoring, aeration and curing process. Functionally, a 5-bin system will be user friendly, provide ample storage for compost at each stage, and effectively deter pests.

Lastly, if TA is to truly take a whole-school, systems approach, these institutional changes mustn't occur without considering the key participants. Currently, the culture at TA, specifically the behavior, attitudes and values of the students and staff, is ill prepared to support these new initiatives. Therefore, TA must make efforts to promote a cultural shift, aimed at promoting pro-environmental behaviors and establishing sustainability as a norm and core value. Sustainable behavior may be fostered inside of the classroom, with increased curricular integration and faculty development, as well as outside of the classroom, with grassroots social media campaigns, student-led challenges, and a regional foods night event.

Outdoor Leadership

An outdoor leadership program at TA will provide benefits to students in a way that conventional classroom learning is not capable of doing. Through participation in outdoor activities, students may see significant gains in their communication skills, leadership skills, small-group interactions, judgment in the outdoors, technical outdoor skills, and environmental awareness. TA currently has the physical capital, 284 acres of woody, natural land, and the human capital, eager and interested students, necessary for an outdoor leadership program.

There are six main ways that TA could establish outdoor leadership program, each with its own set of costs and benefits, but all of which are based in the same goals and principles. Given the feedback from the students, 3 of these programs will likely achieve the greatest success. The first of these options involves incorporating an outdoor education course into current PE curriculum. The other two dominant program options are extracurricular. One of the programs would occur during the weekday with support from TA staff. Alternatively, TA could also explore a partnership with Dartmouth's Tucker

Foundation, and establish an outdoor leadership program similar in nature to Dartmouth's current OLE program with Indian River Middle School. In the end, TA may choose to institute one or multiple outdoor leadership programs depending on available resources and feasibility.

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