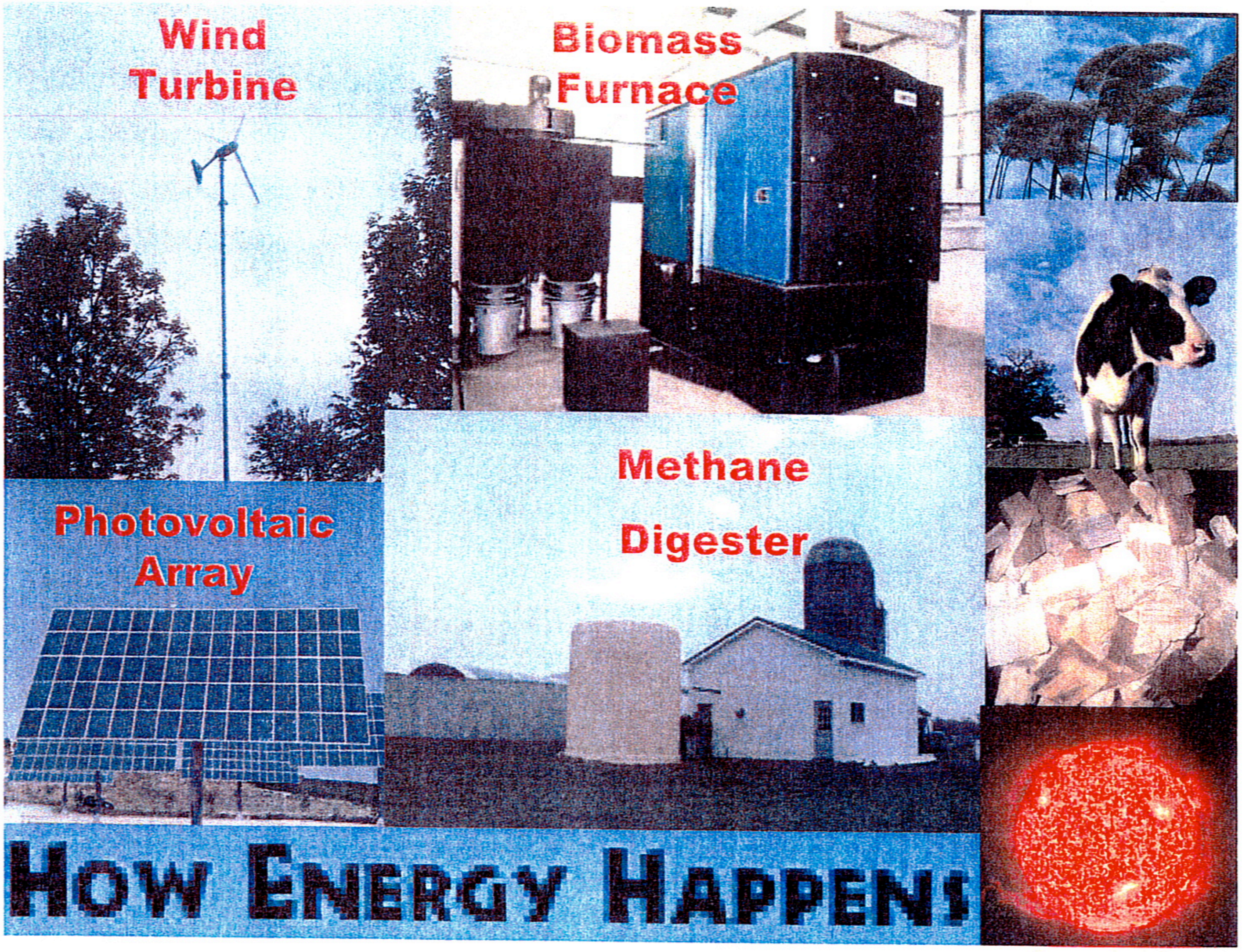
Alternative Energy Report



June 11, 2007

Team Farside

Jennifer Lawson
Christine Napolitano

Wind Power

Shawna Arthers
Colin Babcock
Kaitlyn Cusson
Cara Strona
Hannah Sturtevant
Clayton Childers
Kyle Darwin
Melissa Webb
Benjamin Parsons

Solar Power

Arlene Atkins
Tabatha Danyow
Greta Krahn
Starr Whitney
Victoria Anguish
Sara Mitchell
Kristen Nolan
Dominick Simpson

Methane Power

Joseph LaPerle
Andrew Lucia
Nicole Brown
Morgan Correia
Maxwell Flynn
Natasha Moulton
Jason Sampson
Peter Smith

Biomass Power

Kyle Adams
Willard Magoon
Brian Richer
Monique Simpson
Jazmin Spear
Molly Struhammer
Michaela Bicknell
Dustin Bradford
Lillian Haigis

ACKNOWLEDGMENTS

The students and teachers of Team Farside would like to take this opportunity to express their appreciation for the invaluable assistance and support we received from the following contributors:

John Tedcsco of Green Mountain Power
Andy Shapiro of Energy Balance Program
Chris Burns of Burlington Electric
Mike Irish and Chris Giard of Burlington High School
Chris Tall of NRG Systems
Norm Etkind of Vermont Superintendents Association
Christa Schute of Earth Tubines, Inc.
Tom Tailer and Regg Wedge of Mt. Abraham Union High School
Wayne Howe of Addison Central School
Marie Audet at Blue Spruce Farm
Central Vermont Power Services
The custodial staff at VUHS
Paul MacGowen of Video Expeditions
Searsburg Wind Farm
Mike O'Malley, former VUHS Building Manager

An extraordinary thanks goes out to Adela Langrock, who spent six days working with groups of students developing the format for their writing as well as individually conferencing with most of the students on the team. We truly could not have done it without Adela's help.

A special acknowledgement goes to Eveline Killian of Vermont Energy Education. She offered many hours and days working with our students, specifically with the financial representatives of each alternative energy source. She also specifically worked with Sam Langrock and Oakes Trombly on their Independent Study regarding the lighting in the gymnasiums.

Special thanks also go out to Robin Roy, Wendy Cusson, and Carol Spencer who all offered time during their busy school days to meet with students regarding editing, research, or computer formatting advice.

Last but not least, all the students on Team Farside should be acknowledged for their perseverance and diligence during this expedition. They have proven to everyone that as "crew not passengers" a small group of students can complete tasks beyond their belief and make a difference in the our environment..

Table of Contents

Introduction

During this past year, Team Farside has become more aware of issues all around the world, not only in our community. As such, after careful research, we find it shocking and unconscionable how much carbon dioxide our VUHS two Hurst steam boilers release into the air. We determined that the school's current carbon footprint is a shockingly large amount! A carbon footprint is a measure of carbon a place or person will release in a certain amount of time. According to our calculations, Vergennes Union High School's carbon footprint is 2,515,737 pounds of CO_2 every year. Think about that for a minute. That number is around 1,260 tons of CO_2 released into the air every year… that is as much as eight blue whales.

For the past four months, Team Farside has spent hours researching the effects of carbon dioxide in the atmosphere on the environment. Not only have we been researching, but we also we have taken our own actions to reduce the amount of CO_2 in our classroom. To that end we added hanging plants in our classroom, developed a composting system, and removed our electric pencil sharpeners and replaced them with manual ones. We have also put *footprints* on every computer around the school reminding the teachers and staff to turn off their computers at night. In our classroom, whenever there's enough sunlight, we turn off the overhead lights and we have developed a "No Paper Towel Pledge." Because of this pledge, we now use cloth hand towels instead of using paper towels. However, this is only happening in two classrooms in the school. As such, we need to take action to effect change throughout the entire school. We would like to recommend an alternative energy source selected from wind, solar, methane, or wood chip furnace power for use in our school.

Team Farside has also reviewed the energy bills from the past twelve months to learn more about the costs we put into heating our school to find out how much energy and heat we use. VUHS uses 824,400 kWh per year…an immense amount. We found that number by averaging the amounts from the past three years. This cost is surprisingly high for the size of this school. We found that cost by multiplying the average kWh by $0.107, which is the average cost per kWh. Therefore, we spend $88,210 a year on electricity. We also have found out that we use an average of 53,876 gallons of oil per year. We have found that number by averaging the amounts from the past three years. To buy that oil, we paid $106,674.48. We found that number by multiplying the gallons per year by $1.98 per gallon. Unfortunately, the cost per gallon has been increasing and will continue to do so, as the need for oil gets larger and there is less of it. This rise in prices will cause the school payments to rise even higher over time. That is probably the most deplorable number that we have found yet!

As you might expect, we have put a lot of our personal and school time into preparing our presentation for you tonight. We have spent not only class time, but lunches, snacks and after-school hours in the classrooms hunting for facts and anything that will help support us in our goal which is for you to approve our proposal. Even though many people on our team have a fear of speaking in front of people, we have managed to interview many different professionals about this topic.

In the beginning of this expedition, we talked to Mike O'Malley, who was the head maintenance director for VUHS, about our goal. He supported us and helped us as much as he could. We measured the dimensions of every room and hallway in the school, did painstaking math, and eventually found out the volume of the entire school. This proved to be a long and tedious task. Then our teachers decided that it would be a good idea for us to do an energy audit of Vergennes Union High School. We did this by going into every room and hallway of the school, finding everything that used electricity and energy in that location. After all the information was recorded, we calculated the total kilowatts per year the school used. We combined all the totals and found out the yearly kilowatt usage for the whole school. As you can probably see by now, we have done a lot of work to get here today.

Furthermore, in our efforts to change the school heating system, Team Farside divided into research teams to better understand the alternative energy sources. The groups visited different sites that used that form of energy. At those sites, each group interviewed a specialist about the energy source that they had. We have determined which source we believe will best fit our school financially and environmentally, and tonight we would like to encourage the board to consider ways to move toward its use in our schools and to have such a supplemental energy source installed in Vergennes Union High School.

We thank you for your time and we hope you will seriously consider what we will propose to you.

Science behind the Technology

Methane Digester Steps

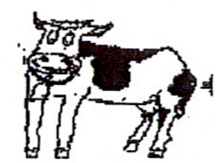
By: Andrew Lucia and Joey LaPerle

My team, Farside, has been studying alternative energy sources after reading and viewing "An Inconvenient Truth". We realize we have to start the process of using alternative energy sources to help the planet with the rising CO2 levels. My group studied Cow power. We were able to go to a farm in Bridport where they have a methane digester. When the manure is placed in the methane digester it begins a process which separates the gasses from the solids. The gasses go into the generator which runs the generator to produce electricity. The methane is a renewable resource which produces clean power.

The diagram below it represents the process in which the methane digester produces energy. Each individual step highlights the process through which this conversion occurs through methane.

Cow

The first step of this process the cows produce the manure which then that same manure that the cows produced is put into a digester.

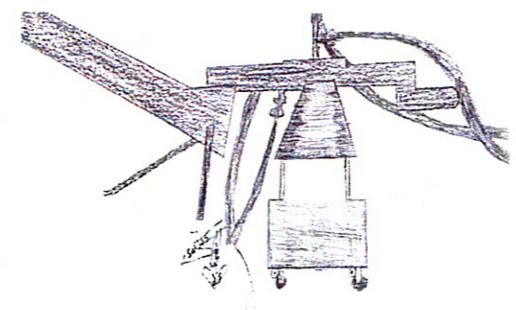


Methane Digester

In the digester the methane gases from the cow manure rise to the top of the digester and some of it goes into storage tanks and the rest of it goes into the generator to run the generator to produce the energy.

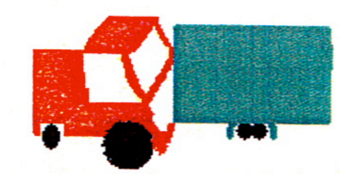
Separator

The separator separates the manure into 2 different by-products, one of which is 95% odorless liquid and the other is 95% odorless dry solid waste which is then used for cow bedding.



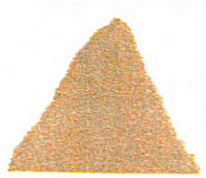
Generator

The methane fuel runs the generator which then spins an electric generator to produces the energy.



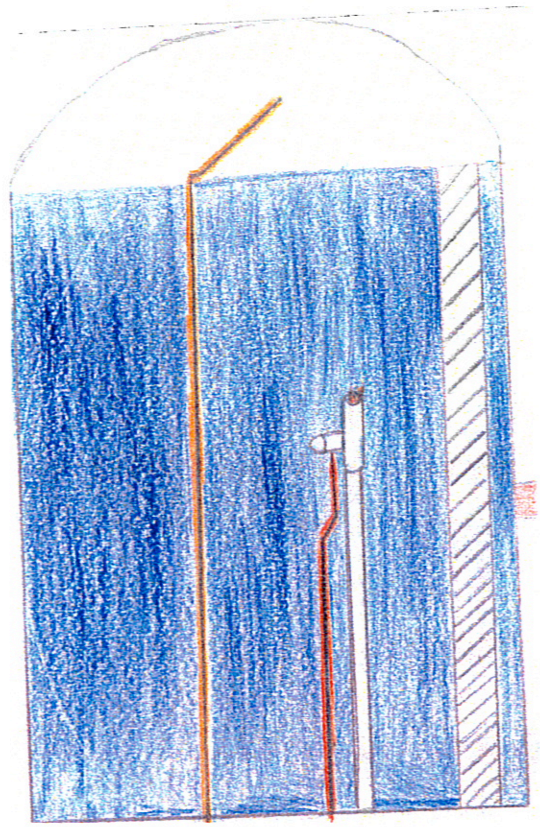
Solids

The solid is dry solid waste which is then used for cow bedding after being processed.



Liquids

The liquid is 95% odorless processed manure which is used to spread on the fields as fertilizer.



Glossary

Word	Definition
Methane Digester	A big silo that keeps the cow waste at 101 degrees Fahrenheit to turn into cow bedding or the liquid to go on the field as fertilizer
Solids	The process solids that turns into dry solid waste which is used for cow bedding.
Liquids	Cow manure that didn't turn into a solid and used as fertilizer.
Alternative Energy	A reusable energy source
Generator	A machine that converts one form of energy into another, esp. mechanical energy into electrical energy, as a dynamo, or electrical energy into sound, as an acoustic generator.
Separator	The separator separates the liquid and the dry solid waste from the manure.

Case Study

To help us determine whether a methane digester would be good for VUHS, we decided to visit a location similar to ours, which is using this alternative energy solution. We visited Blue Spruce Farm in Bridport, and met with Marie Audet, part owner of the farm. During the visit, we discussed why the Audet's examined alternative energy solutions for their farm. We also examined how a methane digester was installed and how the power is dispersed. We learned many interesting things about the workings of a methane digester that we brought back to further examine whether this system would make sense at VUHS.

The Audet's examined alternative energy solutions because they were operating at a deficit. For many years they collected information to see whether they had enough manure from their cows to run the methane digester. They determined that they had the space to install a digester and that they could sell the energy produced to their power company. In addition, by running a methane digester the Audet's determined they could also use the materials produced by the process. They spread the separated liquid on the field as fertilizer. They now use the solid waste as bedding for their cows and for potting soil. The Audet's have 1,000 milking cows, which is enough for them to run the methane digester. After analysis of this information they realized the methane digester was a perfect fit for them.

During our discussion about installation we learned that methane digesters are extremely expensive. We also learned that they had to make some changes to their farm. For example, they needed to construct a building to house the generator and separator for the methane digester and to store the solid waste. They also had to make changes to the barn to collect the manure. These changes made it more efficient to move the manure to the digester. Even with these changes, the Audets' decided that they could afford to install a manure digester because of the amount of energy it would produce.

We learned many interesting facts about the amount of "cow power" the Audets' digester produced. For example, thirty gallons of manure can light two 100-watt lights for twenty-four hours. The total electricity produced at the Audet`s farm last year was 1.2 million kWh.

Site Specifics

One part of our investigation is determining where our school could place the methane digester. In this section of the report you will look at the specific location and additional construction that would be necessary. This information is important to examine before deciding the place a methane digester on the VUHS campus.

Regarding the proposed location of the methane digester, the ideal location would be by the tree line near Route 7, above the JV soccer field. This location has the most open area. This location is the easiest to reach. This is necessary because the location would need an access road to deliver the manure.

However, the school would need to build a sizeable structure. This building would need to house the underground digester, generator, and the by-product for processing the manure. These by-products include liquid and solid waste. Our investigation determined that a digester at VUHS would require thirty trucks a day delivering the manure.

In conclusion, we hope you can use this information to consider an alternative energy source, like a methane digester. Using the methane we would use the CO_2 naturally released source by the manure. The school could also sell the by-product produced by the process.

Advantages and Disadvantages

We are studying methane as an alternative energy source. For this source I am looking at the disadvantages for a methane digester. The disadvantages are one, that it takes a lot of management. Two, it costs about two million dollars and will take about seven years to overcome the purchase. Three, if it is exposed to air it can cause an explosive mixture and four it takes three weeks to fully digest.

The advantages are that it eliminates the odors, 500 cows produce 1.2 to 3.5 million kWh a year, you can use the digested manure for sawdust, and it is renewable. There are some farms around that we could get some manure to put in the digester either by the outdoor classroom or by the tree line by Route 7. The role of a digester is when you put the manure in the digester it will kill all the weed seeds, bacteria, and will eliminate the odors. It also separates the liquids and solids from each other. If you decide to purchase the methane digester then taxes will go up but once you start making energy you will make a big profit.

	Advantage	Disadvantage
School	1. After going through the digester the manure is odorless.	1. The digester takes a lot of management.
Financial	1. The state may pay for some of the digester costs.	1. Costs about two million dollars and takes about 7 years to overcome it.
Community	1. It could provide energy for the people that live near the school.	1. It takes 3 weeks to fully digest the manure. 2. If it is exposed to air it can cause an explosive mixture.
Supporting the System	1. There is a farm right down the road on Route 7.	1. There is only one farm that is close to us and we need more then one farm to support us in getting manure to the digester. 2. Farmers have to take time out of their day just bring us manure. They would have to bring the manure on school property and they might get manure everywhere.

In conclusion, if we get a methane digester than we would have to pay about two million dollars and the taxes would go up but when the digester starts to make energy then we would make a big profit but it would be a while. A methane digester also takes a lot of management so that means that someone would have to watch it carefully and make sure that it's running right and it's not exposed to air; then it can become very dangerous because it would make an explosive mixture.

Cost Benefit Analysis

In order to determine whether our site is a good location for a methane digester we visited Blue Spruce Farm, which currently uses a methane digester, we researched how they work, we contacted other local farms, and we spoke with the local electric companies. We have investigated the school having a methane digester as well as the possibility of the school supporting farms that produce cow power.

Our total cost would be broken up into several different payments. These would include the digester, the generator that converts the methane into energy, the motor that operates the generator, and the building to store all of the fresh manure as well as store all the solid and liquid waste. Although we would be able to sell the solid and liquid waste for money it would not pay off the amount to transport the manure. If we got the right grant then there could possibly be a payback, but in our case we would probably have to get several grants.

According to Marie Audet, if we get the digester on our campus we would have to get thirty truckloads of manure per day. The loads cost at least $115 a load so that would cost $3,450 per day. She also told me that their system cost $1.5 million, but this does not include the motor. The digester with everything except for the manure would cost approximately $1.8 million dollars.

Another important thing Marie explained was that Green Mountain Power has plans that support cow power. Green Mountain Power revealed that there is one plan they have that charges you $0.03 cents extra per kWh (kilowatt hour) or we can wait and get pure cow power supplied by an independent farm in Vermont that will be working with them soon. Cow power is a somewhat complicated system. First, farm owners use the digester to produce electricity from the methane in the cow's manure. Then they sell that electricity to an electric company who can then sell the electricity to people for three or four cents per kWh more than what they have previously. More and more people are being educated about this type of alternative energy source and are considering it. There are already three places with methane digesters and one is coming soon.

Currently at VUHS we are paying $88,210 a year for our electricity. If we were to get the plan and pay $0.03 cents extra from GMP we will be paying $117,942. That is $29,732 more than we would have to pay if we support cow power. With our current income put away for electricity itself, $96,500, we would not be able to afford this. Although we would not save money we would be supporting an alternative energy source and it would be a good example for other schools and businesses to see that they might be able to do something like this too. It also lessens the amount of methane that goes into the atmosphere and it helps support our local farms. Seventy percent of cow's waste is methane and sixty-five percent of that methane is let out into the environment each time they eliminate waste.

In conclusion, financially this school would not be a great spot for a methane digester due to the cost to build the digester and the cost of the transportation of the manure. Although, we may not be able to get the digester on campus, our school could sign on to support cow power.

Science behind the Technology

Solar Energy Steps

By Tabatha & Kristin

In this section we will teach you how photovoltaic cells convert solar rays into usable electricity. Also you will learn the process of how the energy goes from the panel to the electric wire. We will explain the difference between a tracker panel and a stationary panel.

The diagram below represents the process in which the sun produces energy. Each individual step highlights the process through which this conversion occurs through solar energy. The illustration in the center of the page demonstrates the process from beginning to end.

1. The sun produces radiant energy.

2. This solar energy is then transmitted to the earth in portions of energy called photons.

3. These photons interact with the earth's atmosphere and it's surface.

4. When the earth receives the solar radiation it collects it in the atmosphere, oceans and plant life.

5. The solar photovoltaic cells (located on the rooftops) convert solar radiation into electricity. Individual cells are called modules, groups are called arrays.

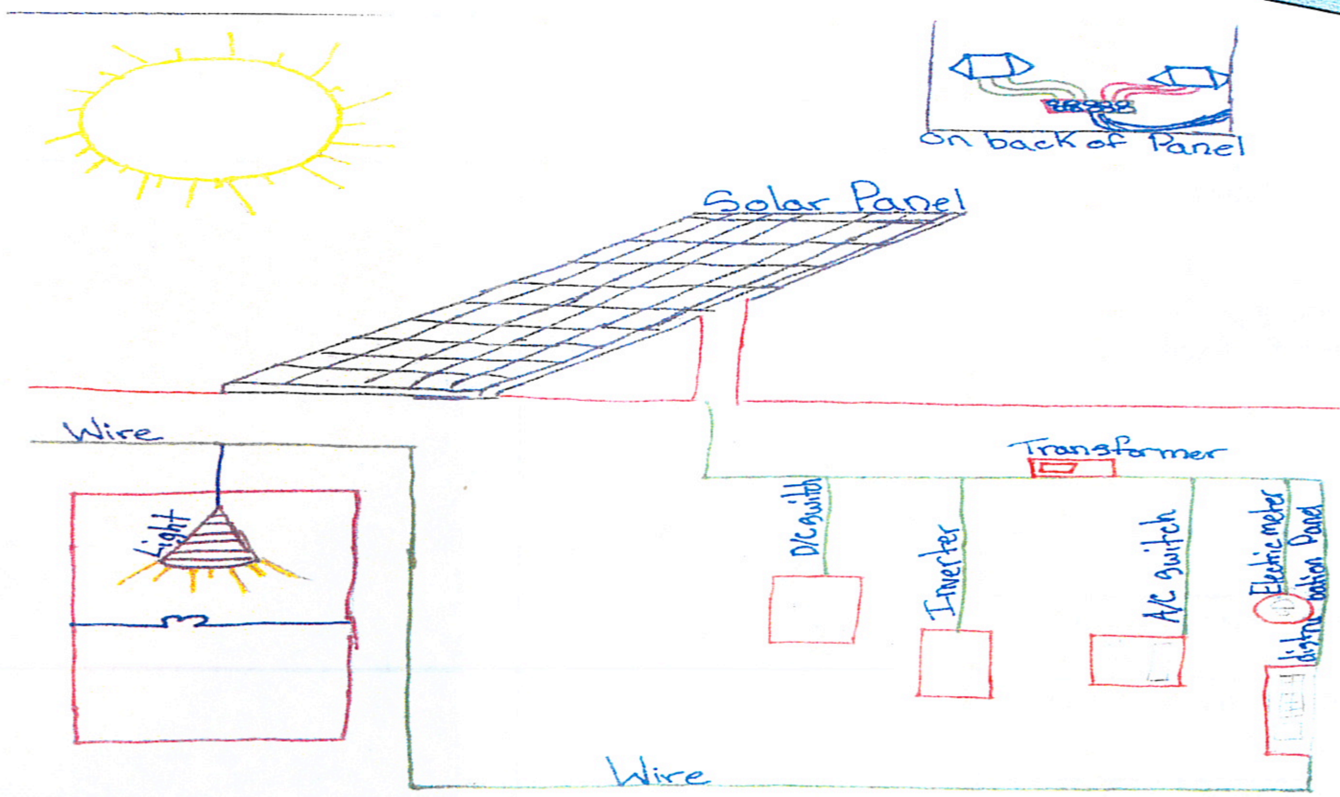
6. Photo voltaic arrays act like a battery while the sun is shining. This produces a stream of direct current (DC) electricity, sending it into the school building.

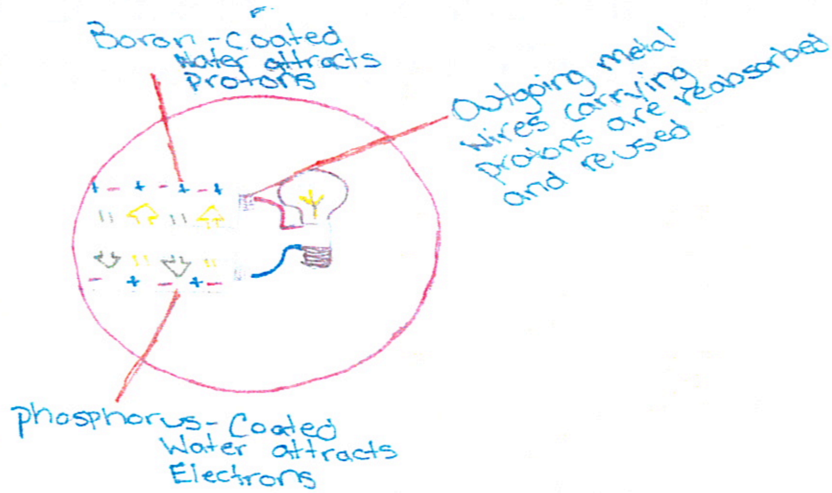
7. The inverter takes the DC electricity and changes it into alternating current (AC) electricity.

8. Then the transformer ensures that the voltage of the electricity coming from the inverter is compatible with the schools electricity.

9. The electric meter keeps track of the amount of electrical energy being produced by the solar photo voltaic system. The electrical energy is measured in kilowatt hours.

10. After the energy is sent to the schools (or buildings) a distribution panel takes the energy and combines it with the other electricity to route it into classrooms to power lights, ect.





Facts

- Stationary Panels stay in one spot all day.
- Tracker Panels track the sun through-out.
- On very sunny days the panels can produce about 4 kw of electricity.
- This energy can be used by any appliance except for high powered machines. This energy can heat swimming pools, water for domestic use, and space heating boilers for fixed orientation.

Glossary

Word	Definition
A/C	Alternating current- electricity switch-ing direction
D/C	Direct current- electricity flowing in one constant direction
Inverter	Takes in the D/C electricity and changes it into A/C electricity
Transformer	Takes the A/C electricity and mixes it with the school's original electricity
Photovoltaic	Light energy
Photon	A quantum of electromagnetic radiation

Case Study

To learn more about photovoltaic arrays and solar energy one group of students from Team Farside went to Burlington High School, where we talked to Chris Burns from the Burlington Electric Department. During the visit we learned about the cost of an array and how it is maintained, the energy it creates, and how it is often used as an educational tool for the whole community.

Installing a photovoltaic array requires structural attachment of the panel to the roof. Doing this keeps the array aligned while it is being installed. Each panel holds 20 of a total of 40 Siemens (a unit of measure equal to one ampere per volt). Then a reflective roof coating is applied to the roof to mirror the sunlight back onto the panel. Finally the conduit is run to connect the array to the inverter so that the energy can be converted into the A/C energy that is used in our school.

Burlington High School saves as much money and energy as was expected. They produce about 1 kWh of electricity each year. The energy it produces saves them only about 120 dollars annually on their electricity bill. However it is also very strongly being used as an educational tool for the school community.

Solar energy could be used at our school as an educational tool and to help our school reduce its' carbon footprint. This is because it would be using a renewable resource that does not pollute or require any additional cars to be on the road to deliver its fuel source.

Site Specifics

A group of students studied the roof at Vergennes Union High School. This allowed us to determine a good location for the array, but also to see the areas the photovoltaic array would allow the public to see the panels. It also helped to determine where a good location for the array would be in order to capture the most sunlight exposure through the day and year.

According to our investigation, the most efficient placement for the array would be on the roof above the high school girl's locker room. This is a south facing roof, which maximizes the amount of exposure of the array to an average of six to ten hours of sunlight that it could receive each day. Also it has easy access for maintenance especially during the winter months so that it may be cleared of snow. The array that was recommended for us by Andy Shapiro, an energy consultant for Energy Balance, Inc. of Burlington, is twenty feet long and at least a 5 kW system. The proposed area allows for maximum exposure for the array to the sun. The array could be mounted four feet from the wall of the high school gym and would stretch to the other side of the roof.

VUHS' location allows for sunlight through the day with minimal shade if placed on the proposed area of the roof. This place could be seen from Route 7 or the athletic fields, making it more than a source of power but also an educational tool for our whole community.

With few obstacles around the possible location of the array, this location would be fairly well provided with sunlight year-round. During the summer months, when it will create the most power, the energy produced by the panel could be used in the school or it could be sold back to our power company. There are few times when a photovoltaic array would produce little energy, because even on cloudy days there is usable sunlight, though it is not as direct.

There are a few additional resources required to produce solar energy. These include a lift and small crane plus labor for installation of the array. There is little maintenance once array is installed. These few costs include any training needed for maintenance, which can be done by the school's existing maintenance staff. Also, occasionally the array may need to be repaired by a professional.

An array on our school would be powered sufficiently; with little maintenance other than after large snow falls. The location above the high school girl's locker room would have sunlight on it most of the day, year-round. During the summer the energy the array produces can be sold back into the grid.

Advantages and Disadvantages

We have researched some of the advantages and disadvantages for using solar power. Below we have compiled our data. One major advantage is that solar panels will help lower our current carbon footprint. A financial advantage is that you get payback; however it takes over twenty years to get the money back. Also, a disadvantage is that solar panels cost over eight dollars a watt. An advantage for the community is that other people will see the solar panels and they might think it would be a good alternative source for them as well. A disadvantage is that it is very hard to find a location for solar panels. The school would need a backup energy source to fully provide VUHS energy needs.

	Advantages	Disadvantages
School	1. Students can learn how the sun creates energy. 2. Students can learn about renewable energy sources. 3. Teaching possibilities.	1. It could get damaged. 2. Requires maintenance.
Financial	1. Potential to lower electric costs. 2. Potential grants available for installation.	1. It takes a long time to earn the investment back 2. Cost of the system is very high.
Community	1. It can help others learn about alternative energy sources. 2. Others might want to use solar energy at their homes. 3. Increases awareness about solar panels.	1. There are not really any disadvantages for the community.
Supporting the system	1. Tapping natural source with no additional support needed. 2. Maintenance minimal.	1. Vermont does not get a lot of sun all year long.

In conclusion, solar energy might be the alternative energy source of the future. Arrays are expensive, but they can save more energy than one might think. They can be a model for people to copy so the fate of the world is not global warming; instead it is a peaceful place for people and animals to live. This means that it will not hurt nature's habitats and it will not pollute the atmosphere.

Cost Benefit Analysis

Currently at Vergennes Union High School we use 828,000 kWh of electricity per year, costing us $90,000. If we were to purchase and install one 5 kW stationary solar array for our school we would potentially save about $50 per month or $600 per year.

The total installation cost of this system is about $37,000 (not including the incentives available that I will explain shortly). Maintenance involves securing the bolts monthly and sweeping off the heavy snowfalls.

However, there is an incentive specifically directed towards customers of 5 kW solar arrays: a direct credit of $8,750. This incentive is especially available for purchasers of any 5 kW systems; it doesn't matter if you are buying multiple amounts of arrays because the maximum amount of money is set at $8,750.

Solar panels are not very efficient for schools because they don't produce nearly enough energy to make a great impact on how much we use. The main reason schools get solar panels is for educational studies. After paying for and installing the panels, the payback would be approximately 48-62 years.

Costs:

Installation	$37,000
Total Cost	$37,000
Annual Savings	$600
Incentives	$8,750
Cost with Incentives	$28,250
Payback with Incentives	48 years

The cost of solar panels will likely decrease and the cost of electricity is always increasing, therefore waiting would overall make the solar panel system we are looking at a little less expensive.

Science behind the Technology

Wind, it's everywhere. We are here to harness its powers. Wind can make a change. Wind turbines work by capturing the wind's kinetic energy. The wind blows on the blades (or rotors) of the turbine causing them to spin. The spinning of the rotors turn the wind's kinetic energy into rotational energy. This energy travels through the main shaft to the generator, becoming mechanical energy. Inside the generator is a magnet surrounded by a coil of wire. The magnet's rotation causes the electrons to move around inside the wire making D/C electricity. The new electricity goes to an A/C converter and is changed from D/C to A/C energy, and then goes through in-ground wires to get to the power lines and is carried off to where it is needed.

In the diagram below, you will see the process in which the wind turbines produce energy. Each individual step highlights the process through which this conversion occurs through wind. The center of the page illustrates the process from beginning to the end.

1. The wind blows on the rotors or the blades

2. The wind's kinetic energy is changed to rotational energy via the spinning rotors

3. The energy travels through the turbine to the gearbox which in turn spins the low-speed shaft. It is spun at about 40rpm

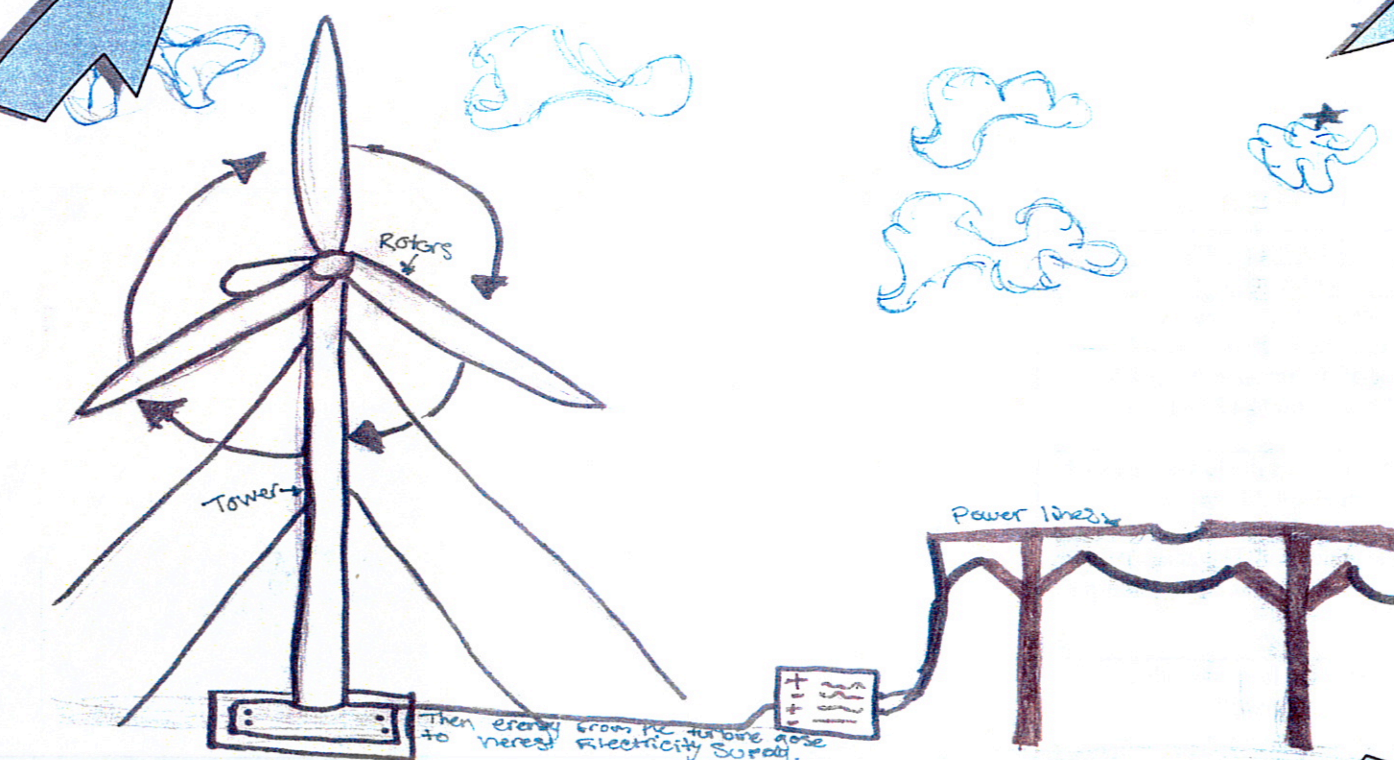
4. The low-speed shaft spins the high-speed shaft at about 1300rpm

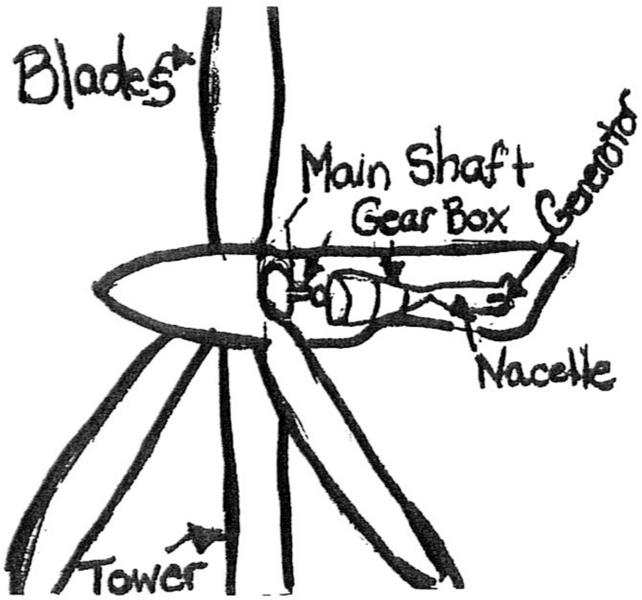
5. The high-speed shaft spins the generator. Inside the generator is a magnet surrounded by wire.

6. The magnet causes electrons to move around in the wire and turning it into D/C electricity.

7. The D/C electricity goes to an A/C converter.

8. The newly converted electricity goes to some in-ground wires to be sent to where it is needed.





Glossary

Word	Definition
A/C	Alternating current
D/C	Direct current
Gearbox	The gearbox consists of multiple gears connecting the low-speed to the high-speed shaft increasing the rpm from about 30-60 to 1200-1800.
Low-speed shaft	The gearbox spins the low-speed shaft at about 30-60rpm
High-speed shaft	Spins the generator. The gearbox/low-speed shaft spins it at about 1300rpm
Tower	The tower is the large pole that holds the nacelle
Nacelle	The egg shaped air streamed container on top of the tower that holds all the working parts.
Rotors	The blades
Wind vane	A little metal rod on the nacelle that spins with the wind showing its direction.
Kinetic energy	Moving energy
Rotational energy	Energy that is caused by rotation

Case Study

Before deciding whether a wind turbine would be a valuable energy system at VUHS, it is important to examine how the system is working at a site similar to ours. We went to Addison Central School in April to study their wind turbine. We interviewed Principal Wayne Howe and discussed the issues of costs we need to be aware of before installing a wind turbine at VUHS. Finally we discussed how satisfactory the new system is operating.

One of the important issues we must address is placement. Mr. Howe made us aware of restrictions regarding placement. One important restriction is the proximity to surrounding play areas. This is a safety issue. If the tower were to fall the restriction is that it would not land in a play area. For example, it could not land in the playground or soccer field. In order to address this restriction at Addison Central the wind turbine was placed in the leach field.

Another important issue that we must address is proximity of the turbine to the property line. This was a community issue that required attention. The landowner beside Addison Central School was worried that their cows would be frightened by the wind turbine. A member of the school board went the farmer's house and reassured him that his cows would not be frightened. This incident highlights the importance of listening, and responding to community concerns as we evaluate whether a wind turbine would work at our school.

One topic discussed during the interview was the financial component of having a wind turbine on the school site. The wind turbine at Addison Central School cost $38,000. Part of this cost was grant funded. Mr. Howe explained that the remaining cost of the wind turbine was paid off in six months. Mr. Howe also reported that the school saves approximately $2,500 per year. Mr. Howe reported that there are no monthly maintenance costs, and that as the electricity costs increase the wind turbine saves the school, and taxpayers, money.

Addison Central School is also very pleased with the low maintenance of the wind turbine. To date, the only task to maintain the wind turbine has been tightening the guy wires. In addition, they decided to change the blades to make the wind turbine even more energy efficient.

Addison Central School is very satisfied with the wind turbine. Not only are they saving money, but also increasing community awareness about reducing the school's carbon footprint. Mr. Howe reported times when people stopped at the school to look at the wind turbine, and take pictures. Community responses, such as this, support the school's effort to reduce their carbon footprint.

Site Specifics

The purpose of this report is to analyze the potential for placing an alternative energy source on the school grounds of Vergennes Union High School located in Vergennes, Vermont. This report investigates geographical requirements of installing a wind turbine, giving the school free and renewable energy.

If the school were to get a wind turbine we would place it on the highest, windiest point possible on school property. Christa Schute, a consultant from Earth Turbines, came to the school to test different locations for the windiest spot (she was testing our site for an experimental turbine). She determined that the best location was the top field next to the dip that goes down to the JV soccer field near the tree line and Route 7. We determined the elevation of the top field where we would place the wind turbine to be 188 feet above sea level. We did thi s by visiting the web-site www.topozone.com, finding the Vergennes topographical map, locating Vergennes Union High School, and triangulating on the top field in back of the school.

Since the wind turbine is taller than 45 feet, we would require a height exception permit from the City of Vergennes Zoning Board. We would also need a land use waiver from Pomerleau Real Estate. Pomerleau Real Estate is the current owner of the property that abuts the high school's top field. According to city official with whom I spoke, Pomerleau has not requested any zoning permits to start a building project on that site. This means it would be likely for the school to get a land use waiver from Pomerleau in order to place a wind generator. However, the school could apply to the state for an override of Pomerleau's decision.

The type of resources we would need for this project includes:

- Trucks to transport the parts from NRG or Earth Turbines to the school,
- A crane to actually put up the turbine, and
- A team to make sure that everything is set up correctly.

Placement is critical in the installation of a turbine. That's why it is important for us to have experts come to the school to ensure proper installation. It must be placed where people will stay at least 50 feet away with the exception of maintenance workers and janitorial staff. It must be installed at a height at which birds would not fly into it. Height could be a problem because of the two obstructions caused by Buck Mountain and Woodman Hill (the hill by the Christian school). Buck Mountain and Woodman Hill both block wind currents from getting to our location

Advantages and Disadvantages

Before you decide if we should install a wind turbine, you should first consider the advantages and disadvantages of wind power. One major advantage is that wind power is clean, efficient and also free. However it may not be the best option for our school because studies show that where we are located will not produce enough wind energy. The location at VUHS is a problem because we don't have a bluff. In addition we have Buck Mountain behind us and a hill blocking the wind from the turbine. Also the wind speed is only 7 mph where we are located and the required wind speed is 10mph to generate a 120-foot turbine. The turbine at VUHS would only produce 100-200 kWh a month. At VUHS payoff would be slow. This is different from ACS because Addison wind turbine produces more wind energy. Each turbine is built to last about 20 years. Depending on the location of the turbine, some birds could get killed by the turbine. It took about three years of paper work, phone calls, and public meeting until the turbine can be put up for Addison Central School.

	Advantages	Disadvantages
School	1. Students and community can learn how a turbine works and how it is built.	1. A wind turbine would not work well for our school. Where we are located does not produce enough wind.
Financial	1. The cost of a turbine is $23,780 including instillation.	1. The turbine would not generate enough electricity to pay for it self. 2. The turbine only last 20 years and it would take longer to pay off than the life of the turbine.
Community	1. The community might pay less for the school electricity bill.	1. Some people do not like the way they look. 2. They can make some noise. 3. They would not save any money because the turbine will not be able to pay itself off so in stead they would be losing money for paying for the turbine. 4. Their taxes will increase to cover the cost of the turbine if we don't have a grant.
Supporting the system	1. There is support from the government for small wind turbine.	

In conclusion the wind turbine does not appear to be the best option for VUHS. Having a turbine can educate students, but it does not produce enough energy and will not save much money. It cost $23,780 including installation and we will not be able to pay it off in 20 years. It is likely to produce only 100-200 kWh for a month. Our location only produces 7mph winds and the requirement is 10mph for a 120 foot turbine.

Cost Benefit Analysis

Saving money and helping the environment in one swift movement is an amazing opportunity. For VUHS wind could be that chance. Our group researched the feasibility of installing a wind turbine here at our school. We studied costs including installation, maintenance, and material prices. We then compared this to the savings including pay-offs and grants.

In order to research the feasibility of this project, we looked at the school's current energy system. We found we currently purchase all our electricity from Green Mountain Power and receive all our power through the grid. This means we pay the company's rate of approximately 11 cents per kilowatt-hour. Using 824,400 kilowatts, we spend $88,000 annually.

We researched the costs involved in having a wind turbine at our site; installation, maintenance, and materials. The optimum output turbine for our site would be a 120 ft. 10 kW turbine. The total cost turn-key (installation parts and inspection) would be, according to Christa Schute of EarthTurbines, about $24,000. There is little maintenance involved in the upkeep of a small wind turbine however a turbine has an approximate life of 20 years. Installation is a major project. It would take 2 full days with a group of four professionals. An additional cost could be collecting data at the site to estimate its wind productivity. That costs between $500 and $1500.

Another part of our research was the savings and payback of a wind turbine. To do this we compared the current system to a system with a wind turbine. We determined the site's wind speed to see how much electricity a wind turbine would produce here. The estimate cost would be $24,000 without grants, rebates or incentives. With our wind production the turbine would produce only about 100-200 kWh per month. In the turbine's lifespan of about twenty years the turbine would pay back only approximately $4000.

The last part we researched was the potential funding available in the form of grants and incentives. If we spent $24,000 we discovered that there are several possible funding opportunities. Another available saving is available through the Vermont Solar and Small Wind Incentive Program and provides $20,000 or 50% of the total installed cost, with an additional incentive of $4.50/watt for qualified systems. The state will provide $10,000 in rebates. EarthTurbines would also provide us with a 20% discount because it would be an educational tool. We estimate the final cost with all feasible grants and rebates to be about $10,000.

In conclusion, despite advantages, a wind turbine would not be the best choice for this location. Although the total price is low overall with the grants and rebates, the site is the problem. Another option for our school is a hybrid wind and solar system. Through using the wind during the winter when there is more wind, and then using a photovoltaic array during the sunny summer, we have a better potential of creating a larger amount of electricity. This option would have better potential to pay for itself in a shorter amount of time. Whatever happens for the school it would be a better and cleaner place, because we would be reducing our dependency on fossil fuel and therefore reducing the pollution caused as a result of this fuel.

Case Study

As part of our examination of whether to install a woodchip furnace at VUHS, we visited MAUHS, which currently operates a woodchip furnace. During our visit we talked to Tom Tailer, a physics teacher, and Regg Wedge, the building manager. We discussed how MAUHS decided to install a woodchip furnace. We also discussed the cost and savings the school receives from this system.

He said that they save a lot of money by using this source. They needed to build a 500 square foot area to store the furnace and woodchips. The school installed the furnace in spring 2006 and the final construction was finished by November. It began running in December and continued until May 2007 when they shut it down for the summer. It took almost 18 months from the initial idea to the functional plant.

The idea came from two freshmen that were looking for a way for the school to be environmentally friendly. After months researching, they prepared to present their idea to the school board. When they introduced the idea many people thought it was a good idea but others were concerned that they would be cutting down too many trees to supply the woodchips. However, after the furnace was running and they could see all the money it saved, more and more people were satisfied with the furnace. Nevertheless a small group was still concerned about cutting down trees.

The furnace is fairly low maintenance. The woodchips furnace runs during the winter months and provides the school with 99.5% of their heat. There's a conveyor belt that move the chips from the bucket to the furnace unless the chip is too large, in which case it is rejected. Someone has to sweep up the chips the machine rejects. The machine creates ash leftovers, which MAUHS spreads in the woods. They also have a backup boiler just in case the furnace breaks down.

So in conclusion MAUHS finds the woodchip furnace to be an efficient source of heat.

Site Specifics

We surveyed the school property to determine where we could put a woodchip furnace. We would need a location accessible to trucks and it must be approximately 500 square feet in order to accommodate a building for woodchip storage and the furnace. In determining which spot would be best we would need to know how much piping underground we would have to get in order to connect the woodchip furnace to the boiler room. We would also need a location to store the ash created by the furnace. After our research of other sites and our school property, we have determined a specific location next to the small garage.

We have decided that the location next to the small garage would be the best spot with the help of Andy Shapiro, energy consultant at Energy Balance, Inc. This is because it is away from the school, but close to the parking lot allowing accessibility for trucks. It is also the closest location to the existing boiler room.

The location next to the garage would need the least amount of underground piping to reach the new building and to connect the woodchip furnace to the existing boiler room. This would save heat that could be lost by excessive piping. We would not be able to put the woodchip furnace into the existing boiler room because the new furnace would be too big. Even with the new building we could use the existing heat distribution system to spread the heat from the furnace to the whole school. This would allow us to not have to buy and install more pipes. We would have to hire an experienced contractor to build the building and install the furnace.

In order to run the woodchip furnace we would need to contact the Lathros Mill about buying woodchips from them. Trucks from the mill would then bring the woodchips to our school on an as need basis. The wood we would use would cost less to buy than the oil we currently use for the boilers.

Advantages and Disadvantages

We have interviewed eight schools on the phone from all across Vermont; we have spent hours on the internet gathering advantages and disadvantages; and we went to Mount Abraham Union High School in order to interview two people, and see a real wood chip furnace. We have found both benefits and problems for this particular alternative energy source, but from what we have found, there seems to be more pros than cons. The below table summarizes our findings and we categorized them into 4 main groups: school, community, financial, and supporting the system.

	Advantage	Disadvantage
School	1. The wood chip furnace heats the school more efficiently. 2. Wood is a renewable resource. 3. The furnace can be used as an educational tool	1. The furnace and the wood chips needs a storage building on campus 2. There is an increase in truck traffic on campus to deliver the wood chips
Financial	1. The wood chip furnace saves money on heating bills almost immediately. 2. The furnace is less expensive compared to other energy sources. 3. Wood chips are approximately ½ the cost of #2 fuel oil. 4. The money that purchases wood chips stays in the local economy	1. Boiler feeding equipment is very expensive 2. Wood chips create approximately 800 kW h/cubic meters, which is not as efficient as it could be, but it is still more efficient than oil. 3. Chips are fairly inefficient because they are made up of 50% moisture content
Community	1. The wood chips burn cleaner than oil 2. Wood chips are carbon neutral 3. Less fossil fuels being burned	1. Releases some emissions 2. There is energy used in transporting the chips, but less than in transporting oil 3. Smoke stacks are visible
Supporting the system	1. Wood chips are easily accessible 2. The wood chips easy to burn	1. Sometimes the chips are not very high quality because they are too large 2. Big chips clog the system

Cost Benefit Analysis

This is the financial part of the project. The following reviews the financial costs associated with the installation of a wood chip furnace and storage building, looking at possible grants or amounts that the government pays, and potential saving with the proposed system.

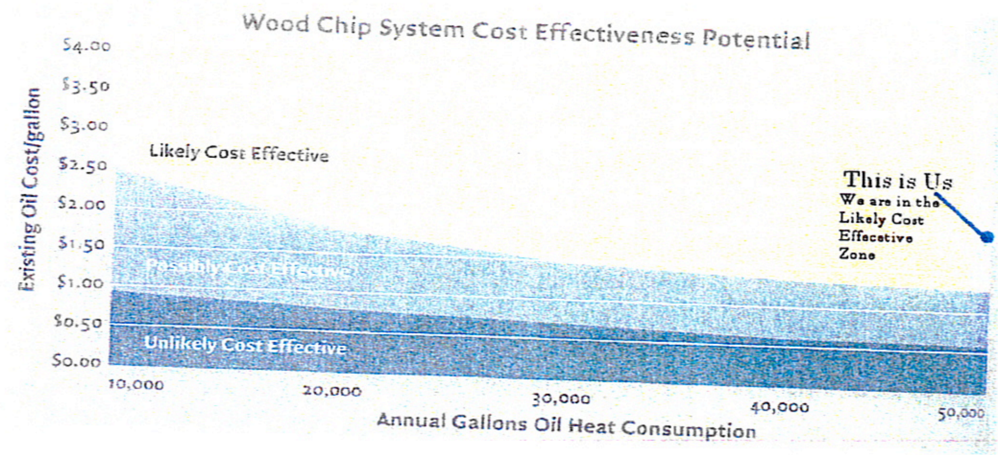
Currently, VUHS uses an oil-burning furnace. We burned 55,781 gallons of oil in 2004, 50,525 gallons in 2005, and 40,506 gallons in 2006. That is an average of 53,876 gallons per year burned.

Current annual oil usage	Current annual oil cost [$1.98/gal.]	Average wood chip replacement in VT schools	Oil saved per year	Total cost of oil for the year
53,876 [gallons]	$106,674.48	82%	44,178 gal.	$87,472.44

Current wood cost [per ton]	Annual tons of wood chips for a year	Annual wood chip cost	Total savings per year on heating fuel
$33	618.49 tons	$20,410.17	$67,062.27

As you can see from the table above, we would be saving approximately $67,000 per year on heating fuel. The average wood chip replacement in Vermont schools is eighty-two percent. This means that during the course of the year, the wood chip furnace will produce all of the heat for the school eighty-two percent of the time.

Thirty-one public schools and two private schools in Vermont used wood furnaces in the 2005-2006 heating season. These schools have saved a cumulative amount of about $677,000. These schools, because of the switch to woodchips for fuel, saved about $42,000 per year on average. (These schools, though, are about half the size of our school.) They paid an average of $41 per ton for wood chips. We will be paying $33 if we use the mill in Bristol. They made an 80% decrease in the total amount of fossil fuels used for heating by schools, which is about 570,000 gallons of oil. With the data from the schools, this number will soon reach 1,000,000 gallons of oil equivalents offset.



This is a graph that shows the likely cost effective for buildings. It is from Wood-Chip Heating Systems: A Guide For Institutional and Commercial Biomass Installations, by Timothy M. Maker.

We will say now that to do this project, it will require a lot of money. We are talking about a maximum of $2,239,197.34. They are currently debating if they should stop the hold on government funding to help schools buy biomass furnaces. They were paying for 75% of the cost. It was 90% of the cost when they first started the school funding. The life span of the furnace is about 30 years. It will take 22 years for the furnace to make a surplus. Surprisingly, in the last 8 years of its life, it will make a surplus of $2.8 million. That means it will be able to pay for another furnace and still have a surplus.

If the government paid for 50% of the project, we would only have to pay $1.1 million. It would take 14 years for us to pay off the debt. If they paid 75%, they would pay $1.65 million, and we would pay $550,000. It would take 9 years for us to pay off the debt. Finally, if the government paid for 90% of the project, they would pay $1.98 million, and we would pay $220,000. It would take us 4 years to pay off the debt.

In conclusion, we think that it is feasible that getting a biomass furnace would be the best idea. We know that raising the money will be hard, but we think the community will support our cause. It would also help if the government withdrew their hold on this funding. There is a waiting list to get financial support so if we get on it now it will not be long until we get support.

Conclusion and Recommendations

As a result of our study and discussions, we have found what we believe to be the top two alternative energy sources that will fit this school. We have reached this conclusion by voting on our first and second choice and we have also gotten teacher input about the finest source. In this case, as soon as we tallied up the results, it was very clear that the wood chip furnace was preferred among the team members and teachers. An alternative to the wood chip furnace would be the solar/wind hybrid. For the hybrid, the students that voted for it said that it would be a good choice because the wind turbine would produce energy in the winter/fall and the solar panel would produce energy in the summer/spring. Some people also believed that there could possibly be good payback and the hybrid source also uses renewable natural resources.

However, even though the hybrid would probably be a beneficial source, a wood chip furnace would be the best possible one for VUHS. Approximately eighty three percent of the class voted for a wood chip furnace for their first or second choice. There were a lot of reasons for that opinion, but there seemed to be one overall reason related to financial feasibility due to its potential payback of $2.8 million in the last eight years of its life. Out of those twenty-nine out of 35 students who voted for the furnace, twenty-four people said that it had a shorter payback time compared to the other alternative energy sources and it would become financially profitable in the long run. Also, students mentioned that they had a good feeling about the wood chip furnace because a wood chip furnace uses renewable resources and it reduces our dependency on oil. In addition, people thought that by using the ashes left behind we could be keeping the carbon cycle running by turning the waste into fertilizer. Last, this energy source is easy to repair in case of breakdown and it requires low maintenance.

In conclusion, after careful study and dedication we realize that the wood chip furnace would be the absolute best alternative energy source for Vergennes Union High School. As such, we strongly recommend that the school board take action and install a wood chip furnace in our efforts to reduce our carbon footprint and significantly decrease the financial costs for the school and community.

Bibliography

Wind

Woelfle, Gretchen. *The Wind at Work* Chicago Review Press Chicago, Illinios,1997
Cruden, Gabriel. *Energy Alternatives* Lucent Books Farmington Hills, Michigan, 2005
Peterson, Christine. *Wind Power* Scholastic Books New York City, New York, 2004
Howe, Wayne. personal interview 17 May 2007
Killian, Eveline. personal interview 5 June 2007
Langrock, Adela. personal interview 27 May 2007
Schute, Christa. personal interview 1 June 2007
Tall, Chris. E-Mail interview 6 June 2007
"Grants" www.dsireusa.com 25 May 2007
"Incentives" www.rerc-vt.org 25 May 2007
"Vermont Small Wind Program" www.anwsu.org 1 May 2007
"Wind Energy" www.howto.altenergystore.com 28 May 2007
"Wind Turbine Diagram" www.eere.energy.gov 25 May 2007
"Energy Research" www.ec.europa.eu/resaerch 1 June 2007
Vermont Billing Green Mountain Power Green Mountain Power Energy Bill

Solar

Burns, Chris. Personal interview. 15 May 2007
Shapiro, Andy. personal interview 30 May 2007
Donnelly, John. www.TimesArgus.com 25 My 2007
Killian, Eveline. personal interview 5 June 2007
Langrock, Adela. personal interview 27 May 2007
www.YellowBook.com
Springfield Solar. www.Timesargus.com 15 May 2007

Methane

Audet, Marie. Group interview. 17 May 2007.
Killian, Eveline. personal interview 5 June 2007
Langrock, Adela. personal interview 27 May 2007
"Science News Online" www.sciencenews.org 31 March 2007
www.burnmanure.com/management/index.html
www.mndaly.com/atricles/206/10/26/69572
www.epa.gov/methane/sources.html
VPS Cow-Power. *Why Farms Generate* 2006
VPS Cow-Power. *Cow Power* 25 March 2002

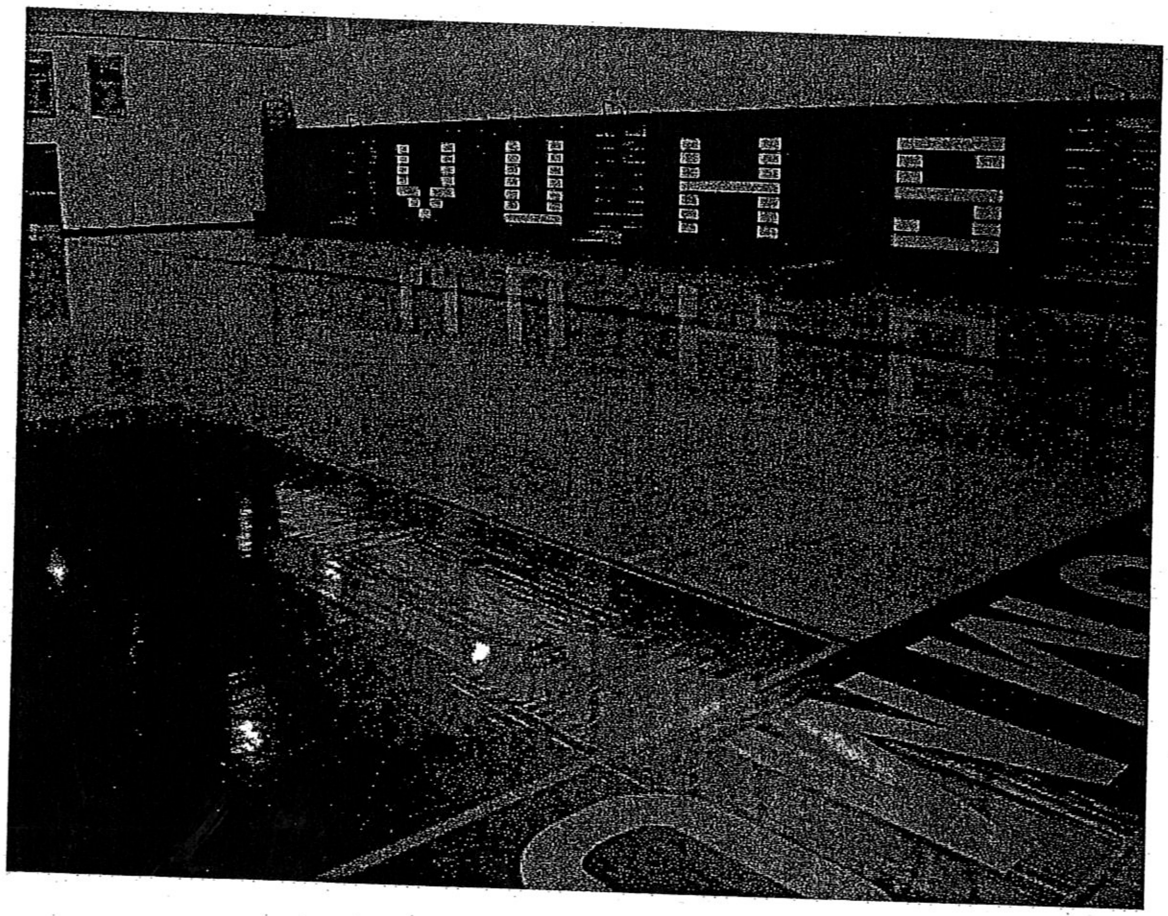
Biomass Furnace

Tailer, Tom. E-Mail interview. May 2007
Tailer, Tom. Personal interview. 18 May 2007.
Norm Etkind. Energy Assessment 20 February 2007.
Maker, Timothy M. *Wood-chip Heating Systems* United States Department of Energy, Washington D.C. 1994
"Wood Chips" www.biomasscenter.org
"Vermont Heat" www.sredmond.com/vthr-index.htm 2006
Killian, Eveline. personal interview 5 June 2007
Langrock, Adela. personal interview 27 May 2007
Brown River Middle School. Phone Interview, May-June 2007
Brattleboro High School. Phone Interview, May-June 2007
Blue Mountain Union School. Phone Interview, May-June 2007
Berlin Elementary School. Phone Interview, May-June 2007
East Montpelier Elementary School. Phone Interview, May-June 2007
Champlain Union High School. Phone Interview, May-June 2007
Camels Hump Middle School. Phone Interview, May-June 2007
Burlington High School. Phone Interview, May-June 2007

ENERGY SAVINGS

A PROPOSAL FOR VERG ENNES UNION HIGH SCHOOL AND MIDDLE SCHOOL

JUNE 11, 2007



SUBMITTED BY SAM LANGROCK

Bibliography

Burgess Mechanical. Cost Benefit Analysis, Phone Interview, 4th May 2007.
Killian, Eveline. Efficiency Vermont, Personal Interview, at VUHS, April 3rd 2007.
Leblanc, Guy. Peck Electric, Phone Interview, June 7th 2007.
O'Malley, Mike. Former Building Manager, at VUHS, Personal Interview, 5th April 2007.

Sam Langrock

On February 5th, 2007 Norm Etkind, Energy Management Program Director of the Vermont Superintendents Association, came to Vergennes Union High School to perform an energy audit. The energy audit examined the energy use at our school. His report highlighted the lighting in the 2 gyms as consuming a significant amount of the school's energy. He stated that to reduce energy use in the school the gym lighting could be converted to T-5 or Super T-8 lighting systems and add occupancy sensors. Oakes Trombly undertook an independent study project to try to come up with a way to reduce the amount of electricity used in the gyms. We have examined a variety of energy efficient light fixtures, figured out how many hours per day the lights should be on in order to figure out if adding occupancy sensors would be a good energy efficient. We also investigated if use of day lighting controls on the windows would further increase our energy efficiency.

Over the last couple of months our team has been learning about the effects of global warming on the environment. We are now very motivated to make this school as energy efficient as possible, and since the two gyms have been using a high percentage of the energy in the school we think it would be a good idea to address this. Our recommendation, after all the work collecting and evaluating information from a variety of sources, is to change the lights in both gyms to T-5's and add occupancy sensors on two of every four lights in a fixture. The current lights in the gym are metal halide lights that take 15 minutes to warm to their full luminosity, and because they take so long to warm up people don't like having to turn them off. During this time they are still using electricity, costing the school even when they're not at full brightness. The addition of occupancy sensors to half of the lights in each fixture (two out of four) would allow half the lights to be turned off when full lighting of the gym is not required. We have asked Peter Maneen the athletic director, and he gave us the okay that more than half the lights aren't needed except for during games. This simple step would cut down on the school's energy use.

To investigate the lighting in the gym, we discussed lighting systems and energy efficiency with a variety of experts including Chris Tall of NRG, Mike O' Malley, the former head custodian here at VUHS, and Eveline Killian, from Efficiency Vermont. Through these interviews we gained a lot of useful information and knowledge. We also measured the gym, contacted contractors for site visits, and calculated the daily use of the gym lights. Through these interviews, Oakes and I gained an extensive knowledge about how we could address energy consumption in the gyms.

Tables 1 and 2 below present the energy consumption and finances for the two gyms and what these would be like if we installed the T-5's and added occupancy sensors. Tables 3 and 4 present demand savings for the same options. Energy is measured over time, demand is connected load and is instantaneous. CVPS bills us based on energy and demand. Energy costs us $.097 a kWh, demand costs us $11.21 per kW.

Table 1: Current Energy/Proposed Energy Usage and Cost for the High School Gym

	Regular 400w metal halides	T-5's without occupancy sensors	Occupancy sensors
# of bulb per fixture	1	4	4(2 would be on 2 would be off)
# of fixtures	36	36	36
# of bulbs	36	144	144
Watts per bulb	400w	60w	60w
Total watts per gym	14,400w	8,640w	8,640
Hours used per year	4,760hrs	4,760hrs	208hrs
Hours at half lighting	0	0	4532hrs
Total kilowatts	14.4 kW	8.64kW	8.64kW
Total kilowatthour per year	68,544kWh	41,126.4	21375.36
Energy cost per year	6,648.77	3,989.26	2,073.41

Estimated energy savings would be:
T-5's: $2,659.51
T-5's with occupancy sensors: $4,575.36

Table 2: Current Energy/Proposed Energy Usage and Cost for the Middle School Gym

	Regular 400w metal halides	T-5's without occupancy sensors	Occupancy sensors
# of bulb per fixture	1	4	4(2 would be on 2 would be off)
# of fixtures	20	20	20
# of bulbs	20	80	80
Watts per bulb	400w	60w	60w
Total watts per gym	8000w	4800	4800
Hours used per year	4,102.25	4,102.25	4,102.25
Hours at half lighting	0	0	4,102.25
Total kilowatts	8kW	4.8kW	4.8kW
Total kilowatthour per year	32,818	19,690.8	9,845.4
Energy cost per year	$3,183.35	$1,910.01	$955

Estimated energy saving would be:
T-5's: $1,273.34
T-5's w/ occupancy sensors: $2,228.35

Table 3: Demand Savings in High School Gym

	Regular 400w metal halides	T-5's without occupancy sensors	Occupancy sensors
Total kilowatts	14.4kW	8.64kW	4.32kW
Demand cost	$1,614.24	$968.54	$484.27
Demand Savings	$0	$645.70	$1,129.97

Table 4: Demand Savings in Middle School Gym

	Regular 400w metal halides	T-5's without occupancy sensors	Occupancy sensors
Total kilowatts	8kW	4.8kW	2.4kW
Demand cost	$896.80	$538.08	$269.04
Demand Savings	$0	$358.40	$627.76

Not only would the school be cutting down on their electricity costs, it would be doing a great good for the community and environment. Through this process of reducing energy consumption in the gym more people may become aware of some easy ways to reduce their own carbon footprint instead of having to add costly and possibly risky alternative energy saving solutions. As detailed in the tables above the cost savings are advantageous.

At the beginning of the report I mentioned that our team was learning about global warming and some the effects it's having on the earth. Any way to cut down on carbon emissions would be beneficial to the environment and help reduce the effects we have been seeing over the past years. Adding more efficient lights in the two gyms at VUHS would be a positive step and also increase the awareness about the energy efficiency in this school. Also future educational projects can be done to examine the efficiency of the new lighting systems to see how much the school is saving on energy costs.

Total Project Costs Including Occupancy Sensors:

	H.S. Gym	M.S. Gym
Fixture cost	$7,380	$4,100
Efficiency Vermont Incentive	$1,800	$1,000
Labor costs	$2,250	$1,750
Final cost	$7,830	$4,850
Annual Savings	$5,705.33	$2,856.11
Simple payback	1.37 years	1.70 years

This table shows what we will be getting for the next year after we switch to my proposed plan. As I have said before switching to this plan would create a lot of benefits, and let us spend money elsewhere where we need it instead of over paying for electricity in the gym. Making this school a more energy efficient school and giving us more money for more important things.