Biomass Gasification at The Evergreen State College

Written by Students of the Winter 2011 Program
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Dani Madrone, Senior Student Editor

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Chapter 1: An Introduction to Biomass at the Evergreen State College

Dani Madrone

Carbon neutrality by 2020 is the goal of the Evergreen State College, which has led the school to investigate replacements for its fossil fuel consumption. One of the largest contributors to Evergreen's carbon footprint is the combustion of natural gas for a boiler system that provides heat and hot water for the campus. The main focus for a replacement thermal energy system has been biomass gasification, using the resource of slash from forest management. Biomass energy has been a major source of tension on campus and in the community, especially within the context of a budding industry. Several biomass facilities have been proposed for the region, prompting concerns about forest conservation, wise investment, clean air, climate impact, and public process.

Why Carbon Neutrality?

In June of 2007, Les Purce, the President of Evergreen, signed the American College and University Presidents' Climate Commitment (Evergreen, News). This action committed the college to write an institutional comprehensive plan, including a Climate Action Plan, the strategy and timeline for Evergreen to accomplish climate neutrality (ACUPCC). The Sustainability Council, composed of representatives from each division of the college, as well as faculty and student representatives, was formed to coordinate the success of the adopted goals (Evergreen, Sustainability).

Carbon is the central theme of the Climate Action Plan. The idea of carbon neutrality occurred after carbon dioxide was identified as a greenhouse gas and a major contributor to climate change. Both the loss of forestlands and the combustion of fossil fuels have contributed to an unbalanced level of carbon in the atmosphere (IPCC, 7). It is important that we become active, responsible, and willing to adapt to address issues of resources and energy. Evergreen's Climate Action Plan focuses on three major strategies for neutrality: conservation of energy, transition to renewable energy, and the purchase of carbon offsets for unavoidable carbon emissions (CAP, 9).

A potential action listed in the plan is biomass gasification for campus heat. During fall quarter of 2010, the Sustainability Council was charged with the task of researching the feasibility of biomass gasification for the fulfillment of the college's goals and values.

What is Biomass Gasification?

The term "biomass," in the context of energy, is defined as organic matter that can be converted into fuel, and therefore a potentially renewable energy resource (Biomass). There are many sources of biomass and various methods for processing it for bioenergy.

Most of us have heard of biofuels, in which energy crops are pressed for oil, such as soy and rapeseed, or fermented for ethanol, such as corn (Biofuel). Biogas generally refers to methane captured from agriculture and food wastes in an anaerobic digester, and can be used as a heating, electricity, or transportation fuel (Oregon.gov). Biomass energy, the option being reviewed by Evergreen, uses a fibrous material, such as wood, bamboo, or grain hulls, to be burned for the generation of heat, electricity, or both (UCS).

Biomass gasification is the technology that is being explored as a retrofit for the boiler heat system on campus, using a feedstock of unmarketable wood from local forestry operations. The standard practice for biomass energy is incineration, which involves the direct burning of wood chips. Gasification is a process of heating wood in a chamber starved of oxygen. The lack of oxygen forces the combustible components to be released as synthesis gas, or syngas, burned separate from the ash when exposed to oxygen (Kovács). Compared to incineration, gasification allows for more efficient combustion, and therefore cleaner emissions and less demand for resources (CGPL). Though the technology for gasification is decades old, the process has more recently been improved and made available for small industrial applications.

Both techniques for burning biomass are capable of producing thermal energy through a central boiler system, electricity using a steam-powered turbine, or combined heat and power, also known as cogeneration. Both release emissions to the air, requiring risk assessments for human health and air quality, and adequate pollution controls. Also, both generate an ash byproduct that must be either recycled or disposed. The proposed project for Evergreen is a Nexterra biomass gasification plant for producing thermal energy, designed for a retrofit in the future to include the necessary equipment for cogeneration.

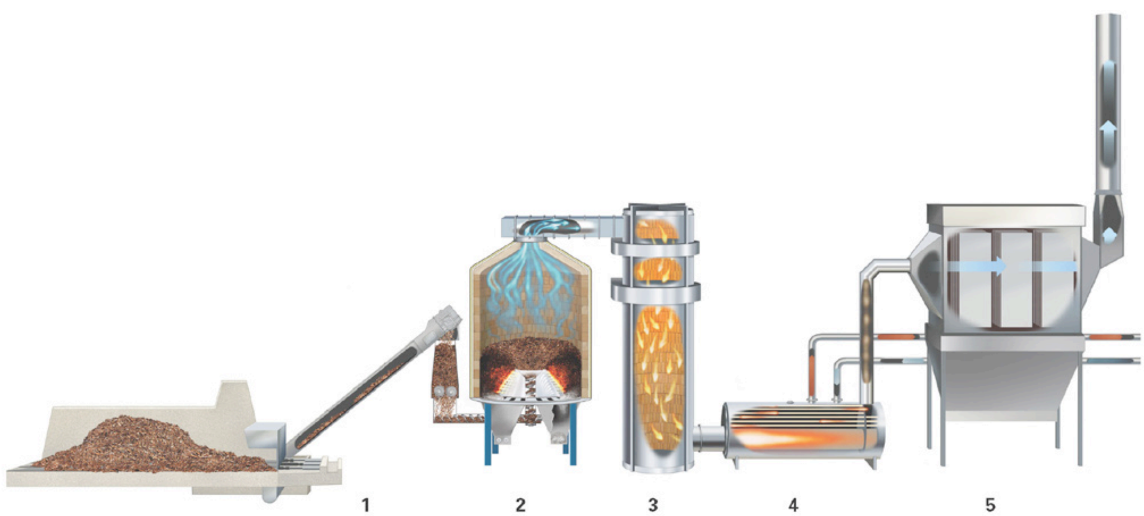

Figure 1: An overview of a Nexterra gasification system. 1. Fuel In-Feed 2. Gasifier 3. Oxidizer 4. Boiler 5. Electrostatic Precipitator (Nexterra)

At the time the Climate Action Plan was written, biomass was established as the most promising candidate for carbon neutral energy. The assumption was that carbon released from burning a plant-based fuel would be reabsorbed by the surrounding ecosystem (CAP, 60). That assumption has since been challenged, with a broader understanding of the carbon cycle, rates of combustion versus sequestration, and embodied energy, or the energy that was required to extract, transport, and process biomass.

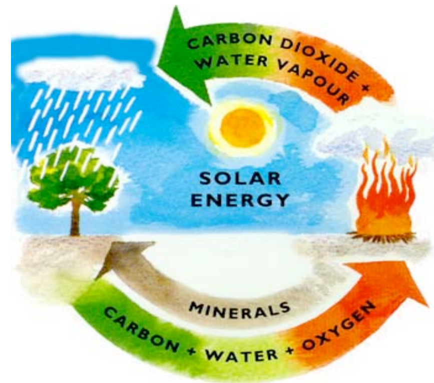

Figure 2: A simple diagram of the carbon cycle. More recent research demonstrated that carbon accounting is much more complex (Middlebury)

Sustainability Beyond the Carbon Cycle

As we explore the idea of a sustainable future, it is important to ask: What do we wish to sustain? Beyond the carbon cycle, we must consider all major impacts of our actions, and they are not always easy to identify. All energy is based on the utilization of resources, involving extraction, processing, and waste management. It is important to develop an energy system that can be managed and monitored to preserve resources and protect the health of local communities and ecosystems. Most of the energy that we consume today is based on resources that come from outside of our region, such as natural gas, coal, oil, metals, and minerals. The farther we reach to satisfy our energy demand, the less chance we have to control our impact. In many cases, energy resource policies are extractive and the economic benefit leaves the community while the environmental impacts remain.

Biomass provides a unique crossroad in the Pacific Northwest, with potential for the development a renewable energy system based on a local resource that supports the health of forest ecosystems, mitigates climate change through carbon management, and puts local people to work. However, forest ecosystems are not of our design; we can only do our best to understand the cycles of nature, make reasonable assumptions, and develop adaptable resource management systems. It is possible that, even with the best intentions, a poorly managed system can contribute to deforestation, compromise biodiversity, exacerbate climate change, and reduce the quality of life for local citizens.

Applied Research: Academic Involvement

This report was written in the winter of 2011 at Evergreen by a group of 24 undergraduate students in the program *Applied Research: Biomass, Energy, and Environmental Justice*. With diverse experiences and backgrounds, we explored the topics of climate impact, forest ecology, human health, economic analysis, political environment, alternatives to biomass gasification, and a survey of other facilities in western Washington.

Our work was informed by scientific research, literature review, guest lectures, personal interviews, and collaboration with members of the campus and local community. As students, we challenged ourselves to understand the complexities of managing natural systems and institutional projects. This research was carried out at the same time as the biomass project was being pursued at Evergreen, and it was a complicated task to analyze the constant flow of new information.

Since the discovery of fire, biomass has been a resource for energy. Only recently has it been explored at an industrial scale in the Pacific Northwest. As with any complex system, there will always be uncertainty. It is important to explore and monitor the development of all renewable energy. It is quite possible that the assumptions made in the following chapters may be proven wrong in the near or distant future. With this evolving issue, we acknowledge that the recommendations presented in this work may one day be considered invalid based on new information. Nevertheless, what we present here is our best assessment of this critical issue at the present time.

Recommendations for Biomass Gasification at Evergreen

As detailed in the remainder of this report, the seven research groups that comprised this academic program made the following recommendations:

- Based on the **survey of western Washington** (chapter 2) biomass energy projects, it is clear that biomass at Evergreen must be studied not only for the impacts for which the college will be directly responsible, but also with an understanding of the cumulative impacts on forest health and air quality that are likely to be caused by multiple bioenergy facilities in the bioregion.
- The research into the **impact on the climate** (chapter 3) was inconclusive, which reflects ongoing debates and uncertainty about carbon neutrality between and among governments, climate scientists, and sustainability advocates.
- The study on the **impact on forest ecosystems** (chapter 4) supports biomass gasification at Evergreen, provided that a sustainable system for harvesting fuel is managed exclusively within Forest Stewardship Council certified forestry practices.
- The **human health risk assessment** (chapter 5) determined that the health implications of biomass gasification, in terms of air quality, are insignificant.
- The group studying the **economic impact** (chapter 6) recommended a more detailed cash flow analysis by the college, taking into account variable scenarios, to determine the sensitivity of unpredictable economic factors over time.
- A more complete feasibility study of **alternatives to biomass gasification** (chapter 7) was recommended, paying more careful attention to the potential combination of Variable Refrigerant Flow, anaerobic digestion, and carbon offsets.
- The study of the **social and political environment** (chapter 8) of biomass at Evergreen recommended further work by the college, including an assessment of stakeholders, a reorganization of the current public involvement process to balance the distribution of power, and a determination of the appropriate level of public participation.

Through class discussions, students had the chance to learn from each other and gain enough understanding about this research as a whole to have informed conversations. By the end of the quarter, we developed a mutual respect for each other and the diverse opinions about the biomass gasification project at Evergreen. Though not every student agreed, we were all able to have a peaceful and friendly dialogue about our points of agreement and differences. At the end of our project, a final vote revealed that a handful of students were confident enough to express a firm "yes" to pursue biomass at this time or "no" to ever pursuing biomass. However, a strong majority voted "maybe," expressing the need for more conclusive research by the college so that it may make a better-informed decision than is possible at this time.

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Chapter 2: Survey of Biomass Projects In Western Washington

Carl Determeyer, Mike Kociolek, Walter Reichel

This is a survey of currently operational and proposed biomass projects in western Washington that studies their productivity, renewable energy practices, and impacts on forestry, climate, economy, and communities. The purpose of investigating these facilities is to compare and contrast Evergreen's proposed gasification plant to other biomass facilities around western Washington. There have been many objections and protests in regard to biomass facilities, especially in regards to pollution and carbon. How their successes and mistakes have affected the environment, human health, and how socioeconomic impacts shaped the state's opinion on woody biomass will be explained. Another concern is the availability of biomass fuel sources, where these sources are, and whether there will be enough biomass to distribute to each of these facilities based on the health and growth of Washington's forests.

The Evergreen biomass project cannot be viewed from a narrow perspective. To make an informed recommendation on the project will require an understanding of other facilities in the region and their accumulative impact. Evergreen, being one of the most influential institutions when it comes to forward thinking both socially and environmentally, makes an impact on other institutions trying to do the same. This survey addresses the collective impact.

Biomass In Western Washington

Biomass facilities have different types of boilers, processes of power generation, and reasons for existing. Because the amount of woody biomass available from Washington's forestlands, the state has been thoroughly involved in research and development of biomass projects on different scales. Washington Department of Natural Resources (DNR) is working to develop and permit for biomass "pilot projects" that are considered efficient, sustainable, and economically prosperous (DNR). Other large-scale facilities have previously used, or are currently using biomass-burning techniques in their facilities (NREL).

In western Washington specifically, there are 10 existing and 9 proposed biomass plants that range in combustion technology and energy output, from Evergreen's 4-megawatt scale to more than 60 megawatts in Mason County (Concerned Citizens of Thurston County). Many of these facilities use woody biomass and/or primary or secondary mill residues as fuel in their biomass projects (McKinstry Report). Evergreen's proposed biomass facility is unique in its gasification technology, though it lacks the ability for cogeneration, which means to produce electricity and heat.

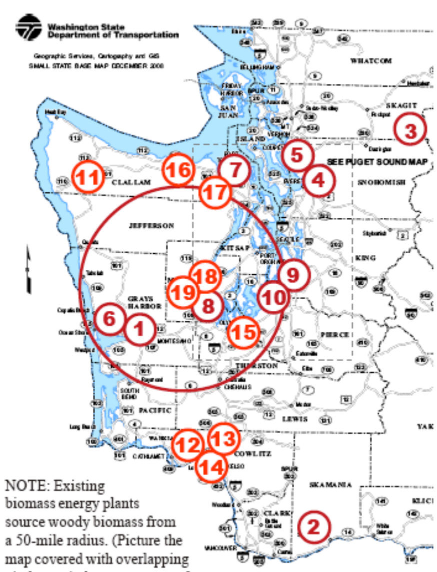
Brief History Of Biomass In Western Washington

There are 22,119,000 acres of forestland in the state; 7,858,000 acres belong to timber industries and private landowners (WCLA). Forest landscapes are seen as having high potential for biomass simply for the amount of local fuel harvest potential. Biomass cogeneration through wood burning has been a power generation technology used for many years in western Washington. Industrial power plants have made efforts to upgrade and improve current, out-of-date boilers and furnaces to more improved, productive facilities that create "green power" (Gibson, Gottlieb). Tacoma Steam Plant No. 2 was an industrial power plant opened in 1931 that burned coal for electricity. In the '80s the plant received a large grant from the Washington Department of Ecology to generate steam power from a combination mixture of wood waste, coal, and garbage. The plant is still in operation and upgrading its facilities (NREL). The Snohomish Kimberly-Clark plant has incinerated wood waste for more than 60 years. In 1993 they built a cogeneration facility with a twin-turbine generator and new boiler (NREL). It is still in operation in Everett, Washington producing 711,000 pounds of steam per hour and 38 MW of electricity (Biomass). Plants with biomass capabilities no longer burn refuse for fuel, but the technology of a biomass incineration facility has not changed much in decades.

"Woody Biomass" Energy Plants in Western Washington State

Information known as of January 2011.

(In addition to the projects shown, there are several biomass plants operating in Eastern Washington)



NOTE: Existing biomass energy plants source woody biomass from a 50-mile radius. (Picture the map covered with overlapping circles, as industry competes for resources and depletes our forests.)

EXISTING BIOMASS PLANTS

Map	Plant Location	Size	Owner
1	Aberdeen	12 MW	Sierra Pacific Industries
2	Camas paper mill	23 MW	Fort James Corp. Paper Mill
3	Darrington	7 MW	Hampton Affiliates
4	Everett/ Burlington	28 MW	Sierra Pacific Industries
5	Everett Papermill	43MW	Kimberly-Clark and Snohomish PUD
6	Hoquiam	18.5	Grays Harbor Papermill
7	Port Townsend Kraft	7.5 MW	Port Townsend Paper
8	Shelton Simpson	55 MW	Simpson
9	Tacoma Kraft	50 MW	Simpson
10	Tacoma Steam Plant No. 2	42MW	City of Tacoma

PROPOSED BIOMASS PLANTS

Map	Plant Location	Size	Owner
11	Forks	not known	Quilayeute School
12	Longview	67 MW	Longview Fibre
13	Longview	25MW	Northwest Renewables Inc
14	Longview	25MW	Rappaport Energy Consulting LLC
15	Olympia	4 MW	Evergreen State College
16	Port Angeles	20 MW	Nippon Paper Mill
17	Port Townsend - 2012	25 MW	PT Holdings
18	Shelton ADAGE	60 MW	ADAGE
19	Shelton Solomon	31 MW	Simpson

www.incineratorfreemasoncounty.org

Figure 3: Existing and proposed biomass facilities in Washington (Incinerator Free Mason County)

Economy vs. Human Health

One major concern within the biomass decision-making process that continues to come with many biomass facilities, especially among local communities, is how biomass affects the local economy and surrounding communities. Washington DNR and companies with biomass capabilities claim biomass is economically profitable, especially for local communities. Rural economies benefit from jobs in the fields of construction, maintenance, growing, harvesting and transportation (DNR). In terms of jobs, each facility will vary. Adage, a private entity proposing a plant in Mason County, boasts 400 new temporary jobs and about 100 permanent jobs during their building process (Mason PUD 3). Nippon Paper Inc., a DNR pilot project in Port Angeles, will retain 234 jobs with 10 new permanent jobs (Risiinfo.com). The Port Townsend mill will create 108 temporary jobs building its new facility (Peninsula Daily News).

Although these facilities provide jobs and economic benefits associated with timber industries, other factors have negative affects on local communities. If Adage does become operational it will require about 200 truckloads of biomass per day, all of the trucks commuting through the Shelton community. Fifteen hours of trucks going to and from the facility will create constant noise and air pollution, taking a toll on the region's health. The medical staff at Mason County General hospital signed a petition, attempting to halt production of biomass facilities in Mason County on the grounds that "current regulations and permitting systems may not be adequate enough to protect the community health." (Dr. Chris Penoyar). The American Lung Association has also expressed concern about biomass facilities that incinerate wood waste due to known and unknown health afflictions caused by emissions (American Lung Association of New England).

Western Washington Biomass Case Studies

The communities in which we live will be changing drastically with the coming of biomass facilities. Trucks, emissions, noise, roads, and neighborhoods will all be faced with changes. By studying the other facilities that exist, observing their scales, fuel consumption, and the quality of their emissions and generated power, their collective impacts will be better understood. It is difficult to compare other biomass projects to Evergreen because of the enormous differences of scale. In terms of size, fuel consumption, and power generation, Evergreen's project is significantly different from any other industrial biomass facility in western Washington at this point in time. Nevertheless, it is important to compare these facilities in order to differentiate biomass projects and see what effect they have on the environment and on human life. By understanding the impacts of the current facilities and studying what has proven to work and malfunction within the biomass community, progress can be made to improve or completely reevaluate the future of biomass technology in western Washington and the biomass community as a whole.

Case Study: Adage

A joint venture between Areva and Duke Energy, known as Adage, is working to build a power plant in the Shelton community within Mason County. Adage is the advanced biopower energy company that is breaking into the biopower scene with force. The investors and managers within the Adage company have very strong track records in the renewable energy industry and biopower market places, implementing a wide range of technology and execution skills. Biopower, as defined by the Adage Company, is a process of using biomass to generate electricity. Adage shows that at the local level they are having positive impacts, from creating "green collar" jobs, to millions of dollars being invested into the region. Met with mixed reactions from the public, words like "amazing," and "fear mongering," have been used to describe the plant.

By looking at the Adage facility it will be easier to compare the economic benefits to other human and environmental impacts. Adage is by far the most controversial biomass facility in western Washington. Its massive size and power generation capabilities combined with its extremely poor efficiency makes its legitimacy as a "green" plant extremely questionable. If Adage is able to make a feedstock contract with a fuel company they will continue plant construction. If not, the plant will not be built. If the plant is built, there is concern that Areva and Duke will exceed sustainable extraction of biomass from the forest, then abandon the operation and leave an economical and ecological debt with local communities. This facility is one of the most important to investigate because of the publicized controversy that surrounds it.

Plans for the $250 million plant have been in development for months (King 5 News). With a goal of opening by 2013, the building of this plant is estimated to create 400 jobs during the construction process, and nearly 100 workers will operate the plant once open in the 2013 year. With an estimation of powering 40,000 homes, this plant will be Adage's first 60-megawatt biomass plant. "Adage came to Washington nearly one year ago because of the great potential in the region for sustainable biomass. This alliance and the Mason County project are an extension of that vision and can become a new economic engine for the state," said Reed Wills, president of Adage. "The project will combine state-of-the-art biomass power technology with innovative forestry equipment that can make Washington a leader in the industry. We believe that building a vibrant biomass industry means new jobs, healthier forests, and a stronger energy portfolio for Washington."

The Adage plant has also sparked growing opposition in Mason County. Community groups are organizing in opposition to the project, including Incinerator Free Mason County and the Concerned Citizens of Mason County, and both expressed a large amount of concern for the statewide interest in biomass. There is also a concern that biomass energy will discourage tourism to the area. James John Bell, a member of the Union Tourism Association, is arguing that people are not going to want to stay at local hotels, or bed and breakfasts, when once-beautiful views are ruined with smoke stacks coming from incinerator plants in the distance.

Case Study: Simpson Lumber Company

The Simpson Lumber Company currently has two operational biomass plants in Tacoma and Shelton (Concerned Citizens). Simpson's Tacoma Kraft 50 Megawatt cogeneration plant is primarily involved in lumber harvesting and distribution, and the plant requires 250,000 bone dry tons (BDT) of biomass fuel annually (McKinstry Report). The facility will use woody biomass and black liquor, a waste product of paper pulp processing, as fuels in their new facilities. In addition, $20 million dollars will go toward local economy for temporary jobs involved with the project (Risiinfo.com). Their ultimate goal is to sell their excess energy and lower carbon emissions by 10%. This type of facility, like many others in the state of WA is a huge lumber industry, making enough energy to power their facilities and also sell their excess energy, enough to power 44,000 homes (The News Tribune).

Case Study: Nippon Paper Inc.

Nippon Paper biomass project in Port Angeles is considered to be one of the more moderate biomass facilities because of its size and efficiency. It is the largest of DNR's proposed cogeneration woody biomass pilot projects in Washington (DNR). The facility itself is not yet operational and cannot provide statistics of carbon emissions or effects on human health, but there is plenty of debate over whether or not it should exist. It will be considered carbon neutral according to the State and air pollution from the mill will be reduced with the introduction of the biomass facilities (Shelton Blog). This facility will produce up to 20 megawatts of electricity and require 160,000 tons of biomass per year (Peninsula Daily News). Their primary source of woody biomass will be purchased from timber companies who harvest slash piles, forests at risk for forest fires, and overcrowded timberlands (DNR). Nippon Paper will use its generated power from the system for making its products (Shelton Blog). Nippon will be cogenerating power at a 70% percent efficiency rate, compared to Adage's projected 20 to 30% percent efficiency (Shelton Blog, DNR). Nippon is an example of a more successful and clean burning biomass facilities in western WA relative to its size.

Case Studies: Gray's Harbor Paper and Sierra Pacific Industries

Two other established facilities, Gray's Harbor Paper and Sierra Pacific Industries in Aberdeen, are similar in terms of power generation. They are close in size, with regards to power production. Gray's Harbor produces 16 megawatts and Sierra Pacific generates 18 megawatts. These facilities require 80,000-90,000 BDT of fuel per year (McKinstry Report). By looking at these facilities in terms of scale we can compare them to Evergreen's biomass facility. These facilities require between 74,500 and 154,500 BDT of biomass fuels annually, using waste from mills and paper production.

Fuel and Forest Slash

The supply of biomass fuel for Evergreen's proposed facility will depend on the amount locally available, the price, and future competition for fuel. As is apparent from the

McKinstry report, there is enough woody biomass left over in local forest to supply fuel for Evergreen's project. In total per year, an estimated 76% or 448,827 bone dry tons (BDT) of unutilized forest residue is left unused on forest land located within a 90 minute haul time of Evergreen, which includes eight counties; Cowlitz, Grays Harbor, King, Kitsap, Lewis, Pierce, Mason and Thurston (McKinstry 82). According to Scott Morgan of the Sustainability Council, there is no regulation on where industries with biomass capabilities can harvest their forest slash. In terms of distance, there is a general understanding that biomass industries will collect fuel from between 30 and 50 miles away. This is for economic reasons, specifically because going beyond the 50 miles radius is not cost effective. Evergreen is proposing to obtain fuel from any Forest Stewardship Council (FSC) certified forest between a 30 and 50-mile radius of campus (McKinstry Report 98).

Although, sawmills create 1,499,520 BDT of primary mill residues per year they tend to market every BDT for its commercial value (McKinstry Report 96). Many currently operating biomass facilities are owned and operated by timber, paper or lumber companies who are burning waste wood products from their own operations. Gary Sitzman is a former 23-year employee of the Kimberly-Clark Worldwide, Inc. pulp and paper manufacturing plant in Everett, Washington. He reported in an interview that sawmills that have historically been a source of low-cost woody biomass have responded to new market opportunities for selling their wood waste byproducts at higher margins. At the same time, the McKinstry report's findings have shown that there will be plenty of resources available for all plants in the Washington region.

As for information regarding a reasonable forecasted price for woody biomass over the next ten years, the McKinstry report only accounted for one possible scenario. The report assessed the potential fuel competition that Evergreen would have to face in event of a shortage of fuel. The report included 19 plants scattered around the entire Northwest including Idaho, Oregon, and Montana, but did not specify many other future plants proposed in Washington. Their study seems incomplete in this regard because of unknown factors. With the state wanting to increase the amount of biomass facilities in the region, along with unknown impacts on forests from utilizing biomass as a fuel source over long periods of time, the report's data do not explain potential negative aspects of biomass collectively (McKinstry 90).

It has been forecasted the price for any form of woody biomass fuel will grow within the next few years. The McKinstry report advises a price range of 35 to 45 dollars per BDT (McKinstry 89). Gary Sitzman stated that acquiring a wood waste fuel source for Evergreen's biomass project could be challenging under current market conditions. "Biomass is available, it's just a matter of what price a new facility might be willing to pay to open up new sources of supply" (Sitzman interview). Sitzman also estimated the cost of biomass at current market prices to be 25 to 32 dollars a ton. It's important to note that George Burgman, a local independent logger with 20 years experience, reported that he cannot harvest green (freshly cut wood) biomass for any less then 25 dollars a ton on easy accessible flat land. It's important to recognize the logger is selling green biomass and the McKinstry Report is using BDT (McKinstry 90). Gathering biomass out of the woods in the most expensive part of acquiring fuel.

Every year, lumber companies burn many tons of slash to protect forests from fires (Shelton Blog). Evergreen intends to burn forest slash to heat its campus. Burgman believes a growing biomass demand from new facilities will improve forest health by providing financial incentives to plant, thin, and clean up slash piles that pose potential fire hazards. The challenge for Evergreen's project is to first secure an adequate suppler who offers a low price guarantee. Like Sitzman said, biomass is available; it's just a matter of what a new facility is willing to pay for it. After a supplier meets Evergreen's requirements—FSC certified wood and under 50% moisture content, even during the rainy season—the supplier or third party will need a processing and drying facility to prepare biomass for the gasifier (McKinstry 53). Evergreen may want to look into the cost of a drying facility, plus equipment to process the wood into pieces acceptable by the gasifier, before making a final decision. If Evergreen purchased a processing facility, an opportunity for student- and community-driven involvement is created for optional fuel sources for biomass such as yard waste and residential wood waste.

Conclusion and Recommendations

Biomass facilities are beginning to quickly multiply all over western Washington, bringing uncertain impacts on the environment, economy, forest ecology, the climate, and human health. Not enough efforts have been made to truly study and understand the cumulative impact of biomass energy. Based on our research on western Washington biomass facilities, there are too many unanswered questions in regard to human health effects and issues with fuel quality and quantity. It is clear that large-scale and inefficient biomass facilities, such as Adage, are not an appropriate use of the technology or resource. Smaller facilities such as Nippon, Sierra Pacific, and Gray's Harbor are more efficient, and therefore hold more promise. Nevertheless, considering the amount of fuel they all require over long periods of time, combined with the other existing and proposed facilities, there could be negative impacts on forest health and air quality that we are not yet aware of.

Biomass energy has its positive as well as negative aspects. The timber industry is here to stay, which means a constant amount of forest slash will be burned or left in the forest. Biomass energy will provide more jobs and a stimulated economy as well as an alternative to fossil fuels. These aspects are encouraging in the decision-making process but the many negatives counter these in many ways. Besides the many unknown factors in terms of human, forest, and climate health there are other negative factors. Although there is currently an abundance of unused wood, the impacts of removing slash from the forest will have an unknown effect on the overall forest. Also, forest slash and other wood wastes have been found to be useful as landfill cover, reusable construction materials, and ingredients for producing particle board, all of which have been found to be more efficient than burning them as fuel.

It is easy to view the biomass gasification project at the Evergreen State College through a narrow perspective and say that it is not comparable to these other facilities. However it is vital to recognize the collective impacts that Evergreen is associated with, especially when it comes to the health and wellbeing of people within and outside of the community, the environment, and the climate of our region. After taking all of the known and unknown factors of both biomass gasification and incineration into consideration, biomass energy should be researched much further before committing to implement the technology. Biomass could be a useful alternative fuel in the near future, but there is a need for more common understanding of the extent of the impacts.

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Chapter 3: Climate Impact

Mike Funston, Kristina Kirkman, Andrew Normann, Sam Richards, Neil Twilla

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Introduction

The Earth's climate is in a constant state of flux. These changes occur when the amount of energy stored by the climate system is varied. The most pronounced changes occur when the global energy balance between incoming energy from the sun and outgoing heat from the earth is interrupted. There are quite a few natural mechanisms that can upset this balance, for example fluctuations in the earth's orbit, variations in ocean circulation as well as changes in the composition of the Earth's atmosphere. In the last century the majority of the changes have occurred not as a consequence of natural processes but due to man-made emissions of greenhouse gases (GHG). By altering the global climate balance, theses mechanisms "force" the climate to change (Hansen, Sato, 14778). Consequently, the scientific community has come to call them "climate forcing" mechanisms. Humanity is currently conducting the biggest involuntarily climate forcing experiment in the history of the world.

Within the last quarter century various global societies have been developing strategies to combat the climate forcing mechanisms that we inadvertently started and continue to support, which is contributing to global warming. The concept of achieving zero net carbon impact has started working its way into the vocabulary of organizations whose broader strategic goals involve becoming sustainable entities. Institutions of every color and stripe as well as corporations from Fortune 500 companies down to “mom and pop” operations are diving into these murky waters. The over arching reason for the lack of clarity is the fact that the concept of what constitutes carbon neutrality is still unsettled. However as organizations go about “business as usual,” their operations continue to emit carbon into the atmosphere either by direct or indirect means. As a society we are only beginning to quantify and qualify the climate impacts each entity has on the natural carbon cycle.

Evergreen in particular will need a comprehensive understanding of the various ways in which the proposed biomass gasification project will affect the natural carbon cycle. That is the only way decision makers can legitimately support the proposal and go confidently forward with the project. In order to aid in the broader understanding this section will expand on topics related to climate impacts by addressing; 1) how our current understanding of the carbon cycle from a spatial and time lapse perspective effects how we view and talk about the claim of carbon neutrality, including an examination of tools currently available for aiding in that task, 2) the available methods and technologies are that may reduce climate impacts of the proposed project, 3) the benefits and liabilities biochar, a byproduct of gasification, has on the carbon cycle, 4) the other GHGs; what they are and how they affect our environment, including the emissions produced by both the proposed biomass gasification process as well as the natural gas boilers currently in operation.

These four topics will have a profound effect on how the project boundaries are drawn in relation to the claim of neutrality. Thus, it is important to explore and attempt to answer the questions that these topics raise in order that the concept of carbon neutrality may be fully embraced as a legitimate strategy in assuring that Evergreen's biomass gasification project has a minimal impact on the earth.

Understanding the Carbon Cycle

Carbon has been cycling among large reservoirs within the atmosphere, oceans, fresh water and terrestrial landmasses throughout geological history. This natural cycling of carbon dioxide (CO2) has historically taken millions of years to move large amounts from one system to another. However as anthropogenic, or manmade, emissions of carbon dioxide increase, these exchanges are occurring at an "accelerated rate by orders of magnitude", according to Bradley Sageman, professor and chair of Earth and Planetary Sciences at Northwestern and a co-author of two studies published in Nature Geoscience (January and February 2010). These journals report past geological climate events with the intention of better informing our current efforts at geoengineering the mitigation of climate change. The 19th century Industrial Revolution heralded a time of increased fossil fuel use that supported the growth of both industry and transportation, not to mention human population. However increased fossil fuel use, which continues unabated to this day, has created a climate forcing change which has amounted to a nearly 40% global rise in atmospheric carbon dioxide concentrations (Canadell et. al. 18866). This in turn has introduced an unnatural flow in to the carbon cycle with alarming consequences. In order to aid Evergreen in determining the factors that influence the relationship between the proposed Biomass Gasification Project and the carbon cycle this subsection will:

- Outline some of the difficulties related to understanding the carbon cycle from both a global and regional standpoint
- Explore the issue of how the passing of time effects carbon flows within the C cycle as well as complicates questions regarding biomass carbon neutrality.
- Parse out the language governing agencies use to make the case for neutrality
- Examine Life Cycle Assessment (LCA) and Net Energy Balance (NEB) as possible tools or methodologies for aiding in the determination of neutrality.

Global C Cycle

The global carbon cycle (C cycle) is significantly influenced by changes in the use and management of forests and agricultural lands. It has been well documented that we have the potential through land use practices to alter the magnitude of forest-carbon stocks and the direction of forest-carbon fluxes (Brown et. al. 1593, Carson 5, Mannion 168). Yet our predictions about specific physical-climate system and climate change are confounded by two main issues; first, for all the many scientific studies focusing on the C cycle it is still not adequately understood or quantified on either a global or even regional scale (Moore, Braswell 5, Milack 38). When specifically looking at the process of evaluating biomass modeling for the purposes of understanding their effects on the C cycle, it has been proven extremely challenging for the science community. Scientists attempting to replicate outcomes from their climate models have found that when they use the same input data sets their predictions can differ by as much as 100% from one another (Jenkins et al. 1174). Secondly, the study of biomass and carbon sequestration has led to controversy among scientists dealing with the utilization of terrestrial ecosystems in the mitigation of global warming (Singh et. al. 56).

Regional C Cycle

There is no such thing as a regional C cycle. There are no borders within the global cycle; every input and output in the system affects the whole. Equally important in the mix is the fact that an input cannot simultaneously be an output. Therefore the same concerns regarding the lack of scientific consensus and methodologies for assuring accuracy on the global cycle must be considered by policy makers on a regional level. However the reasons for drawing such borders are obvious. The axiom, *think globally act locally* is appropriate in that we must evaluate regional trends, assumptions and underlying processes in order to better understand their long-term effects on the global cycle (RECCAP 2007).

In the Northwest in particular, forestry operations have a major influence on the C cycle. Washington State has some of the most stringent forest practices in the country (DNR, Ecology, and WFPA). When considering private, county, and state forestland, DNR takes the position that these forests are a net carbon sink due in large part to their comprehensive forest practices and the increasing forest lands under their management. DNR has asserted that, "biomass combustion does not result in a net increase of greenhouse gases in the atmosphere because they are part of the natural baseline of atmospheric carbon and are not new in the atmosphere…" (DNR 2010). It is problematic to ascertain what "natural baseline atmospheric carbon" is. No scientific baselines for atmospheric carbon have been established. It can be theorized or it can be assumed but it may never be a knowable quantity. However one thing is certain, carbon cannot be in two places at once. Biomass combustion results in the release of embedded carbon from a place of biological terrestrial sequestration. It is arguably not atmospheric carbon until after it is burned. Therefore, the combustion of biomass will result in a net gain of carbon. This is where the question of time becomes critical to consider in the equation.

The Question of Time

The crux of the carbon neutrality claim surrounding the burning of biomass may depend on one critical consideration: time. Parsing out the role that time plays appears to be yet another place of complexity where science is focusing a critical eye. The Wilderness Society states that "because forests have evolved under a climate that has changed at *slow rates* over the past several thousand years, they cannot be expected to function in the same way…under elevated CO_2 levels and rapidly changing climatic conditions" (Wilderness Society 2008). The burning of biomass whether for the purposes of energy generation or slash disposal is part of that "rapidly changing climate" condition because when burned it releases more carbon in a shorter span of time than if left in the forest to decompose by nature's methods and timetables. The Evergreen Sustainability Council is currently working on a Biomass Gasification Feasibility Study. At the midway point in December of 2010 they published a list of their current understandings. Included in that list is the statement, "Although biogenic carbon remains preferable to fossil carbon, the global biosphere is stressed to the point that any additional carbon emissions (regardless of source) may threaten our climate stability" (TESC 2010). Their concern underscores the need to take extra precautions when looking at how the burning of biomass effects the C cycle.

In forests, the process of respiration returns carbon to the atmosphere making it available for utilization elsewhere in the cycle. A large portion of this CO2 is recycled through photosynthesis back into the forest. This creates a plausible scenario by which it can be reasoned that burning biomass is not adding to the "carbon debt" because this carbon originated within the forests. However due to the complexity of the system and the myriad of variables involved the claim of neutrality can only be theorized based on carbon accounting schemes. The process of burning biomass will accelerate the release of CO2. This will be problematic from the standpoint of claiming neutrality because no one knows when the balance will be achieved through photosynthesis (carbon sequestration). Mark Harmon, an Oregon State University forestry professor, recently stated that calling wood energy carbon neutral "is sort of true, but very misleading," Harmon said. "Forests eventually gain the carbon back, but it takes them a very long time to do it" (Oregonian 2010). This lag time makes the economic scaling of the biomass industry critical. The questions that Evergreen should give careful consideration to are; how biomass facilities are (or will be) releasing carbon into the atmosphere and at what rate? If we don't know the rate of re-absorption we are only guessing at neutrality, is that acceptable? Should our determinations of neutrality be based on scientific findings built on assumptions?

The Language of Neutrality

The utilization of biomass as a renewable energy source offers tremendous promise in helping our country wean itself off our over reliance on fossil fuels. Every stakeholder involved in the process understands the seriousness of the challenge to prove or disprove the viability of bioenergy. Thus it is no surprise that, when it comes to the neutrality question, federal agencies hedge their bets, relying heavily on creative wordsmiths in their public outreach when declaring agency positions in the absence of scientific consensus.

"[T]he emissions from combustion of biomass fuel source are not assumed to increase net atmospheric CO2 levels. The CO2 emitted from biomass based fuels combustion does not increase the atmospheric CO2 concentrations, assuming the biogenic carbon emitted is offset by the uptake of CO2 resulting from the growth of new biomass." 74 Fed. Reg. 25039

This statement from the Environmental Protection Agency (EPA) was made in May of

2009 and shows that they have no scientific study that definitively answers to the true nature of carbon neutrality and, therefore, must make assumptions. These assumptions are at the mercy of a complex climate system in the midst of a man-made climate forcing event which finds the scientific community scrambling to understand. The Northern Institute of Applied Climate Science (NIACS) within the Forest Service finds itself in a similar predicament when characterizing their position on neutrality:

> *"Bioenergy from wood sources is often described as "carbon neutral" because the carbon dioxide (CO2) emitted when wood-based products are used for bioenergy can be reabsorbed by new tree growth in a relatively short period of time"*

The NIACS does not state that bioenergy from wood sources is carbon neutral. They leave the determination to an unknown source that often describes it as carbon neutral. The quotations around the term carbon neutral further signify that the Forest Service has not committed to the term. Interestingly the United States Department of Energy (DOE) wisely stays out of the fray by taking no position on the neutrality of biomass utilization:

> *"Bioenergy is considered truly renewable because its source - biomass - is a replenishable resource. Vegetative matter will continue to grow as long as it is planted. Additionally, biomass energy recycles carbon dioxide during the plant photosynthesis process and uses it to make its own food. In comparison to fossil fuels such as natural gas and coal, which take millions of years to be produced, biomass is easy to grow, collect, utilize and replace quickly without depleting natural resources."*

The DOE's biomass program describes the process most often used to characterize the carbon neutral nature of biomass yet the actual term is conspicuous by its absence. The economic and political pressure being brought to bear on Federal and State agencies involved with the bioenergy industry and its development is incredible. With woody biomass in particular they understand that scientific consensus is at best not keeping pace with the need to move away from fossil fuel use and at worst may prove terminally inconclusive. This puts them in the unenviable position of having to carefully craft their agency's policy language in order to perch themselves on the fence. This strategy allows them wiggle room if it is later determined that the burning of biomass was never actually carbon neutral.

Tools for Measurement

In order to minimize the introduction of new flows into the natural carbon cycle, every component within Evergreen's biomass gasification project must be examined closely in order to determine where best to place the boundaries such that it obtains a carbon balance. Whether this is truly achievable is still a matter of conjecture. There are however many methodologies for quantifying the GHG implications of utilizing forest biomass for energy production. However the two most suited for this task are the Life Cycle Assessment (LCA) and Net Energy Balance (NEB).

LCA

Through the Life Cycle Assessment (LCA) process Evergreen could model the environmental impacts associated with producing heat for the college using biomass gasification. This “life cycle” examination can encompass boundaries as wide as cradle-to- grave or as specific as the harvest-to-grave process associated with gasification and combustion. This process will identify and measure all inputs starting at the “harvest” of the biomass expressed as logging residuals (or slash) and end with the production of heat which is considered the end of the process thus the “grave.” Outputs for every stage of the process will be calculated, allowing all energy and materials used and wastes released to the environment through the value chain to be counted. Through this process, decision makers will clearly be able to evaluate the end result of the project as far as its environmental impacts on the C cycle (USDA Forest Service 2007, SEI&ORCAA 2010).

NEB

Net Energy Balance (NEB) is a concept used in energy economics that refers to the difference between the energy expended to harvest an energy source and the amount of energy gained from that harvest. This figure is most often expressed in gigajoules (GJ/ha). Traditionally, biomass combustion, when compared with other biomass utilization schemes, has enjoyed a high net energy gain. The inputs that should be assessed are the energy used in producing the feedstock, which includes the running of forestry machinery and related equipment such as chain saws, plus the drying, chopping and transporting of feedstock. The outputs that should be assessed are the energy produced along with the disposal of waste byproducts from the gasification process.

Transportation Impacts and Methods of Mitigation

The methods Evergreen uses to ensure that the biomass gasification project is carbon neutral are critical. In light of that, this subsection will examine take a look at the impact of transportation and how to mitigate them. Transportation is examined because it constitutes one of the greatest factors that will generate carbon in this project. This report includes an analysis of carbon output from transportation as well as ways of reducing carbon emissions. Some of the ways to reduce the carbon generated from transportation include biomass densification and growing biomass via a local plot. Natural gas will also be scrutinized and have its transportation emissions compared to that of biomass.

Transportation is one important area where carbon can be found. One of the proposed boundaries for the fuel source is a 50-mile radius around the college. The facility will require a total of 59 to 57 thousand metric tons of dry biomass per year (McKinstry pg 50). This constitutes about 2 trucks per day throughout the year. These will likely be tractor-trailers according to Rich Davis, the college engineer. Considering the maximum of the radius proposed and that the trucks will be unloading biomass and removing ash on a daily basis 200 miles was used for the calculations. Using this information we get an estimate of about 163 tons of carbon dioxide emission per year (USDOE). This figure is a worst-case scenario. If we look at a best-case scenario 20 miles total, an area within the radius, we get approximately 16 tons per year (USDOE). As can been seen the greater the distance traveled to retrieve the biomass the greater the impact.

There are a few ways to reduce carbon generated from transportation, one of which is by increasing the density of the biomass itself. This is done be processing the wood chips, the raw form of biomass, into a higher energy density variant, meaning wood chips are converted into briquettes or pellets. By increasing the density of the wood chips that are used, we are able to increase transportation efficiency (Malatji pg 11). With the fuel more condensed we can carry more energy with the same amount of trips. In addition, by converting the wood chips, we increase the amount of heat energy generated by a single unit. Depending on the size and process, this can roughly quadruple the energy density yielded from a single unit, from “about 40 - 200 kg/m3 can be increased to densities as high as 600 – 800 kg/m3” (Shaw pg 11). By converting biomass into briquettes or pellets we also improve the handling of the biomass as well as storage.

While processing wood chips certainly has its advantages, it also has its disadvantages. One such disadvantage is that the process of condensing biomass requires energy. This can be counterbalanced by utilizing renewable energy from co-generation, which is proposed for the second phase of the gasification project. TESC could also utilize local renewable sources such as hydroelectric, geothermal, wind or solar. The denser wood material would be compatible provided it meets Nexterra requirements of wood chips being three inches or less.

An additional way to reduce transportation emissions is to have a localized fuel source within the 50-mile radius. Depending on the scale, this source could provide supplemental supply, or supply the colleges biomass needs completely. Generating one’s own biomass is not a lofty goal, as currently many other colleges, such as Colgate, already generate some of their biomass requirement via a 5-acre plot on the campus. This plot should generate about 3.7 to 5.1 metric tons of biomass per year (Doran, Sarrantonio, & Liebig 11). While this is a small percentage of Colgate’s needs, it hopes to either encourage local residence to create similar plots, or expand its existing experimental plot. When comparing the feasibility of this method of reducing carbon emissions, it is important to consider scale. Evergreen’s biomass gasifier requirements are much less. In addition, the college’s Nexterra gasifier is much more efficient burning 5.9 to 5.7 dry tons vs. 20 thousand dry tons which are the biomass requirements for Colgate’s biomass combustion facility (Colgate). This makes growing Evergreens own biomass much more feasible.

A problem with this approach is that space requirements are still substantial. The biomass demand will be about 5.9 to 5.7 thousand dry tons per. Using the figures from Colgate’s experiment, an estimate of the space required to meet half of TESC’s biomass demand, assuming the plot has a similar yield of 5.1 dry tons per 5 acres, approximately 560 acres would be needed. Also, the numbers are based on the assumption that willow is used as the biomass source if cedar residues were used it would likely change the equation requiring even more area to produce the same tonnage of biomass. In addition this would require energy for harvest and replanting. The current proposed approach would utilize forest slash and some mill waste and is therefore less energy intensive. Energy has already been expended in processing trees and therefore the only energy needed is for collection.

Natural gas is the current fuel of choice for the boiler at the college. While the current emissions expended on transportation are negligible, emissions from other factors are not. According to the 2007 college budget proposal, the current boiler emitted 5.3 metric tons of CO2 in 2007. These emissions are from burning natural gas but do not account for other externalities such as pipeline leaks that produce methane, a potent green house gas. Also unaccounted for are the processing and extraction cost which, as with pipeline leaks, are hard to quantify. It is also important to consider that actual physical transportation, transportation via truck, does not account for a great deal of the carbon impact, natural gas must be transported across great distances via pipeline. The energy used to compress the gas varies from a turbine compressor, which uses some of the natural for compression or an electric compressor that relies on energy from a nearby source. The compressors that actually use local energy are an area of concern. Compression stations are “usually placed at 40 to 100 mile intervals along the pipeline” however it is not know how many are electric vs. turbine are used (Natural Gas Pipeline Technology Overview 14).

In conclusion, it appears that there are ways to mitigate transportation emissions from the college's biomass project. Some of these methods are promising, while others have their problems. Among the practices that show promise is the densification of biomass. By compacting biomass we gain not only transportation efficiency, but also are able to get more out of each unit of energy. One method that did not appear feasible was growing the college’s own biomass. This solution, while attractive in terms of emissions reduction, turns out to have problems with scale and is less efficient then currently proposed ways of obtaining biomass. While natural gas has minimal impacts in terms of transportation due to the close proximity of a source other externalities such as leaks, extraction, and processing overshadow them are currently difficult to quantify.

Biochar: The Carbon Solution?

In the pursuit of carbon neutrality, every facet of the biomass energy system must be accounted for. One of the less obvious parts of the system is the leftover byproduct. Known as biocharcoal or “biochar,” the byproduct resembles something between charcoal and soot, depending on the specifics of the biomass process. Its primary function is use as a soil amendment. This has two important effects. First, biochar-enriched soil has been shown to improve soil fertility through “increased moisture retention, improved air permeability, elevated cation exchange capacity, increased buffering of soluble organic carbon, and synergistic interactions with soil microbial populations”(Hugh McLaughlin et al., 2009). More relevant to carbon neutrality, biochar soils have promising potential as a carbon sink. The idea is that the carbon in biochar is more stable and less degradable than the organic carbon in decomposing biomass.

Recent efforts to achieve carbon neutrality have created substantial interest in the sequestration properties of biochar. Although biochar is a relatively new term, its use in soil is not a new technique. The first evidence of biochar use comes from centuries ago in the Amazon Basin of South America. Native tribes enriched soil with wood ash to increase fertility. The soil is called Terra Preta, meaning "Black Earth". Terra Preta is one of the world's most fertile soils, containing unnaturally high levels of nutrients and excellent nutrient retention as well as increased amounts of carbon. Many projects have replicated the process to improve soil for villages in poor rural areas with great success. However most of these are low-tech, small-scale projects that are not concerned with carbon sequestration. Research into modern, industrial-scale biochar production is underway but the results are far from forming a complete picture. At this point, one thing is clear—feedstock and production techniques determine the capabilities of the biochar. Given the multitude of feedstock options and charring methods available, the deviations are significant.

Biochar Production at Evergreen

In order to assess Evergreen's biochar potential, it's important to understand exactly what the Nexterra gasifier leaves behind as byproduct. There are two relevant steps to the process. Initially the wood mass will go through a drying and heating process called pyrolysis. At this low-heat stage, the wood will start to chemically degrade and release energy-rich syngas consisting mainly of hydrogen and carbon. In systems dedicated to biochar output, there would be no further steps and the pyrolysized wood could be used as biochar. About 70% of the total energy available in the wood is converted to syngas during pyrolysis yet 50% of the initial carbon remains (Lehmann et al., 2006). In Evergreen's case, the next steps are the actual gasification, followed by char combustion. Gasification occurs at higher temperatures and starts to vaporize the remaining feedstock even further. At this point, some carbon is released but more importantly the volatile organic compounds are also released. Before char combustion, biochar with a highly stable carbon content is left. As the temperature continues to rise, char combustion occurs, leaving behind only ash. This ash byproduct is not the same as the carbon rich material left after pyrolysis. As such, Evergreen cannot expect to immediately offset carbon emissions from biomass gasification through sequestration because there is simply not enough carbon in the ash.

The byproduct ash can still be applied to soils with limited but beneficial effects. It generally does not contain harmful matter that may be present in the ash of other feedstock. It is acid soluble and can be applied to soil to increase pH. The system being installed at Evergreen will leave behind about five percent of feedstock mass used as biochar ash. Using around 5,600 bone-dry tons of woody biomass per year, Evergreen would have around 290 tons of ash available annually. The Gray's Harbor Paper mill has biomass boilers fueled by wood debris, similar to Evergreen's planned system. The ash product from Gray's Harbor Paper is trucked away to local farms so it can be used to increase the pH of acidic soil. It seems likely that Evergreen could establish a similar relationship with surrounding farmers for a practical and positive disposal of ash.

Making Gasification Sustainable

Clearly, Nexterra gasifiers do not provide the maximum potential for greenhouse gas mitigation available in biomass systems because of the final char combustion stage. If carbon sequestration is a main goal of the project, it may be wise to investigate methods of biomass gasification that do not fully combust the feedstock. As is turns out, gasification systems produce the most desirable biochars for soil supplementation. A report by Jim Amonette of the Pacific Northwest National Laboratory compares the stability of different biochars by applying high heat to excite volatile matter. By doing this the amount of "fixed" carbon can be determined. The results show that biochar from gasifiers have the highest amounts of fixed carbon and therefore the most stable carbon content. This is important because the "fixed" carbon is not easily biodegradable and cannot be effectively broken down by biological processes that would otherwise release carbon back into the ecosystem. Whereas non-stabilized carbon in soil can be expected to re-enter the atmosphere in less than a hundred years, stable biochar carbon could be left in the soil for hundreds or thousands of years.

Sustainable bioenergy production simply means removing the char combustion step from the process. As stated above, once 70% of available feedstock energy has been converted, only 50% of the feedstock carbon has been extracted. This is because the preliminary pyrolysis provides more energy by mass than char combustion (Sohi et al., 2009). Assuming a maximum efficiency of 90%, the extraction of the remaining 20% would release almost 50% of the feedstock carbon. In other words, sacrificing 20% efficiency results in halving the carbon emissions. There are a number of factors that make it difficult to quantify the amount of sequesterable carbon gained by removing char combustion. To quantify the net increase in sequestered carbon requires a number of calculations, some of which carry a significant margin of error. An accurate life cycle analysis comparison is probably not possible at this time. Even so, promising potential can be shown. If Evergreen increases fuel usage by 20%, from 5,600 BDT to 6,720 BDT, and does not combust its biochar, the school would have around 3,360 tons of carbon available in biochar per year. If half of that is stable carbon (McLaughlin et al., 2009), 1,680 tons of sequesterable carbon would be available each year. To put this figure into context, it would be important to know the GHG emissions of pyrolysis and gasification stages compared to the combustion stage. If emissions from the combustion stage are significant, their elimination would further reduce the carbon footprint.

Non-combusted Biochar as a Soil Additive

There are a number of variables that greatly affect the results of biochar-enriched soil. Ideally biochar provides immediate nutrient increases and improves long-term nutrient retention. It has been demonstrated that biochar can increase crop yields and increase the number of crop cycles possible without a fallow period. Immediate benefits can be contributed to increases in cation availability, phosphorus, nitrogen, potassium, and other essential nutrients (Glasser et al. 2002; Lehmann et al, 2003). Increases in pH have also been observed immediately after biochar application. Positive effects are seen most commonly with low amounts of biochar additive. As higher levels are approached the possibility of crop yield decreases become more realistic. This is generally attributed to nitrogen limitation that can occur with high carbon to nitrogen ratios (Lehmann, 2003). Some plant species, in particular legumes, can thrive in low-nitrogen soils and thus may be prime candidates for growth on biochar-enriched soil. All of these soil improvements will help to mitigate climate change by increasing the vigor of forest and crop growth thus increasing natural carbon sequestration.

Another effect probably more important to Evergreen is the reduction of greenhouse gas emissions from biochar-enriched soil. A nearly complete elimination of methane emission from soil was observed at biochar levels of twenty grams per kilogram of soil (Rondon et al, 2005). Nitrous oxide emissions were halved, possibly due to the nitrogen limitation mentioned earlier. Biochars are also effective at absorbing pollutants such as ammonia (Berlung et al, 2004).

Final Thoughts

Without char combustion, the energy created per unit of fuel would decrease, but the amount of sequesterable carbon per unit of fuel would greatly increase. This is the only way to approach carbon neutrality for the project. The process of creating biochar from an industrial bio-gasification energy system is a relatively new concept that has not seen much real-world implementation. Evergreen has the opportunity to establish itself as a pioneer of sustainable bio-energy systems. Indeed, further research into the topic should be a prerequisite for its installation. Based on the amount of unanswered questions about the proposed system, it would be wise for Evergreen to allot more time for research into both the proposed system and the viability of alternatives such as biochar production. The transition from natural gas is a great step towards sustainability but Evergreen must be careful to make the absolute best choice. Time is of the essence, but choosing the appropriate long-term replacement for natural gas should be done when a complete analysis of all the alternatives is possible.

Climate Impact and Other Greenhouse Gases

We are fortunate to live in a time when our society can not only identify our effects on the environment, but can also work towards minimizing, eliminating, or even reversing those effects by altering our emissions from our modes of transportation, our waste, and especially our energy sources. However, before any of that can happen, we first have to have a better understanding of all the greenhouse gases (GHG) and how they affect the world around us. It is essential for our society to recognize all greenhouse gases and for every person to have a basic understanding of how these gases affect our climate. This subsection will address:

- GHGs besides CO2; what they are and how they affect our environment.
- The emissions produced by both the proposed biomass gasification process as well as the natural gas boilers currently in operation.

- The GHGs produced by the burning process but also the retrieval and transport of the essential materials in both projects.

Methane (CH_4)

One of the more abundant greenhouse gases that are produced and used in our society is methane (CH_4). According to the EPA's Global Warming Potential (GWP), methane is approximately 21 times more powerful at warming the atmosphere by weight then CO_2 (EPA, Methane), and the amount of methane levels in the atmosphere have been rising over the past 100 years due to human influences (Reay, Dave: Human Influence). The main sources of human induced methane in the atmosphere are from the burning natural gas and petroleum products, agricultural activities, coal mining, wastewater treatment, and some industrial processes (EPA, Methane). Although methane has many good uses throughout the world, it is necessary for the production and use to be monitored.

Nitrous Oxide (N_2O)

Nitrous oxide (N_2O) is another greenhouse gas that has long-term effects on our atmosphere. Nitrous oxide has a 100-year lifetime, with a Global Warming Potential that is 296 times more powerful then CO_2 on a per molecule basis. What this means is that if 1kg of N_2O is released in the atmosphere it is equivalent to 296kg of CO_2 over a 100 years (Reay, Dave: Nitrous Oxide). However, according to the EPA, approximately 60% of the N_2O is produced by natural sources including biological processes in soil and water. The human sources of N_2O are agricultural soil management, combustion of fossil fuels, biomass burning and the production of nitric acid (EPA, Nitrous Oxide).

Fine Particulate Matter (PM 2.5)

Fine particulate matter (PM 2.5), also referred to as *nano-particulate matter*, are small particulates that mix with water in the air. These particles are only 2.5 microns in diameter and can stay aloft in the air for weeks, often traveling hundreds of miles. These particles are produced from a number of sources, including vehicles, industrial facilities, power plants, construction sites, tilled fields, unpaved roads, and wood burning (BAAQMD). The lasting environmental effects come about when PM 2.5 lands and begins to decompose. This causes the acidity in lakes and rivers to rise, the depletion of soil nutrients to occur, and changes the nutrient balance of coastal waters. This particulate matter also damages forests and farm products (BAAQMD). Fine particulate matter is still being studied to find out the extent of the long-term climate impacts.

In their combined form, greenhouse gases create what we know as climate change. They link to one another, creating an endless snowball effect that has major consequences to our climate and environmental health. It is for this reason that is important to consider the emissions of each GHG when considering a new green project, or when reviewing the environmental impacts of a facility already in use.

The Good the Bad and the Slash

The Good

Biomass gasification using woody debris, emits little to no sulfur dioxide or mercury from the stacks, a claim that cannot be made by the coal or natural gas industries. It also emits less N2O than coal and similar levels to natural gas powered plants according to the Department of Energy (UCS). A report produced by the Stockholm Environment Institute (SEI) for Olympic Region Clean Air Agency (ORCAA) states that, by using biomass gasification for heat production in place of fossil fuels, the result is a net decrease in GHG emissions (SEI 36). Currently production and use of nitrogen fertilizers cause N2O emissions, using biochar as a fertilizer in soil could cause a reduction in N2O emissions (SEI 57). Biomass provides a renewable form of energy and heat, which is the biggest reason it is beneficial to the climate. As long as the harvesting of biomass is closely moderated and regulated, it will have far more benefits to the environment then harmful effects (UCS).

The Bad

The major concern about biomass gasification of woody debris, besides the CO2 emissions, is the nano particles that are emitted from the smoke stack. A report by Dr. William Sammons, a pediatrician who has spoken out against the harmful long-term effects of biomass burning, states that the PM2.5 particles released would be approximately 492% more than those released by natural gas burning. The same report conflicts with what the DOE states, saying that the N2O levels produced by a biomass gasification plant would be close to 1000% more than what is produced when burning natural gas (Sammons 2). Many of the studies produced by multiple reputable agencies have conflicting results and limited data to state what exactly the short- or long-term impacts of biomass gasification would be on our climate.

The Slash

A question to consider when looking at using slash for biomass gasification is the impact these slash piles have on the environment if they were left in the forest to decompose at their own rate. Besides carbon, the main greenhouse gas released by the decomposition of slash is methane, as is released during anaerobic decomposition (Greenhouse Gases and Storing Carbon). However, here there are two points to be considered. First, this release is part of a natural cycle that the earth goes through, and it has its own ways of recycling the slowly released carbon. Second, an opposite point is that most of the woody debris in slash piles is due to the forestry industry and amounts to more than an unmanaged forest would produce.

Another concern to address with slash left by the forestry industry is that common practice is to set fire to these piles, in a controlled burn after they have been gathered, to prevent future forest fires from developing. According to the SEI, “Air pollutant emissions from burning biomass at industrial facilities, with emissions controls, result in

CO and PM 2.5 emissions that are much lower than emissions from uncontrolled burning on-site" (SEI 13). This means that as long as controls are implemented at a biomass gasification facility the PM 2.5 particles released from the plant are much lower than those currently being released by forestry practices.

The issues that surround biomass gasification are complex. Finding research specifically addressing biomass burning is a challenge. One thing is certain: fossil fuels, including natural gas, are a finite commodity that has reached its peak production, they will be harder to extract from the earth as time goes on. Our society must move quickly towards a future free of all geological fuels. These decisions need to be made carefully; otherwise unforeseen consequences will complicate our move toward more renewable forms of energy. The other GHGs detailed earlier are a serious concern; they are often more potent then CO_2 and can live much longer in our atmosphere. More importantly, their effects may not be limited to our area alone, but can travel the world over. Biomass technology is bringing the discussion of green energy into a new light.

Natural Gas: From Drilling to Burning

By many accounts natural gas can be considered the next major energy source to supplement oil and coal burning as a cleaner option. It is currently a major player in the energy and heating industry, and a highly debated topic among politicians and activists in Washington. Like most energy options, however, there are advantages and disadvantages when considering natural gas as clean energy.

The burning of natural gas is much cleaner than coal or oil since it produces less greenhouse gases (*NaturalGas.org*). Its abundance in North America makes it a popular choice because of the fact that the prices for natural gas are much more appealing than the prices for oil. The burning process leaves low amounts of residue and essentially no "sludge," meaning there is no need for scrubbers to remove pollutants. Sludge is largely made up of SO_2, or sulfur dioxide, and is left behind when coal and oil are burned (*NaturalGas.org*). Perhaps one of the biggest benefits of natural gas is that the EPA, Department of Energy, and the natural gas industry have joined together to create the ENERGY STAR program to help limit the impact natural gas drilling has on the environment. By working together to create more cost-effective and efficient ways to drill, store, and transport the gas, the STAR program helps to ensure that natural gas is a cleaner energy source (EPA, STAR Program).

Although natural gas is highly regulated and considered a clean burning gas, the process of getting the gas from the wells to the burner can be perilous, allowing billions of cubic feet of "fugitive" greenhouse gases, mainly composed of methane, to escape from loose valves or pipes during the process of extraction (Lustgarten, Abrahm). Robert Howarth, an environmental biology professor at Cornell University, stated that, "even small leakages of natural gas to the atmosphere have very large consequences" (Lustgarten, Abrahm). Once at the power plant the burning of the natural gas produces N_2O and CO_2, however at decreased levels compared to those found in coal and oil burning plants

(*NaturalGas.org*).

Perhaps the biggest disadvantage to natural gas burning is not actually the burning or the transportation processes, but the process by which the gas is extracted from the ground. A popular practice among natural gas companies is fracking. Fracking, or hydrofracking, is used to extract "shale gas" from the ground. Shale gas is natural gas that is trapped in pockets between layers of shale deep underground. It is also quickly becoming the most abundant natural gas source in the world. When extracting the natural gas from shale, a pipe drills into the ground and then pumps large quantities of a mixture of water, sand, and "fluid chemicals" into the rock causing pressure to build and eventually for the rock to fracture which releases the gas to be extracted (Sammons, PG 2). However, the natural gas companies discovered there are many iron- and sulfate-degrading bacteria that seep into the pipes and cause them to erode. To avoid this problem, they started to include biocides that kill the bacteria in their chemical mixtures (Matias, Johnathan). The major concern about the fracking process is that the chemicals being used can leak into the drinking water that is below the shale layer, having lasting effects on the environment, climate, and the health of the population.

Even considering the disadvantages to natural gas drilling and burning it is important to remember that it poses limited risks to the environment. It is one of the cleanest energy sources available. It offers at least a 25% improvement of GHG pollution over coal and oil (Source 8) and is an energy source that is in abundance.

Natural Gas vs. Biomass Gasification

There are several different sources of woody biomass. Forest slash is a byproduct of our current forestry practices, which gets collected into piles and either combusted on-site or left to decompose. Inevitably greenhouse gases are released during the process of decomposition. Another source of biomass comes from the "thinning" of forest trees, which is done to prevent forest fires or disease. Both forms of woody biomass have the potential to generate energy due to the embedded carbon. Forest fires can be a major contributor of excess carbon emissions. In 2006, greenhouse gas emissions from forest fires in Washington State exceeded the total amount of CO2 emitted from electricity production (Wood to Energy). Thinning forests to prevent forest fires is necessary and beneficial to the ecosystem and climate, so this waste will continue to be produced. Forest biomass has the potential of supplying industrial energy while reducing our greenhouse emissions. Its ability to reduce greenhouse gases is evaluated by the DNR accordingly:

"The evaluation of carbon neutrality of forest biomass is determined by the boundaries in space and time considered most relevant to that evaluation… The Department of Natural Resources supports the approach wherein a neutrality determination for a state's greenhouse gas emissions from forest biomass energy production is made so long the states forest carbon stocks are either stable or increasing. This is the case in Washington's forests. In addition, forest biomass energy production can have positive greenhouse gas results to the extent that it displaces energy production from fossil

fuels."(DNR Forest Biomass Initiative 2011)

DNR asserts that Washington State's forests are increasing annually and carbon neutrality can be achieved by the gasification of biomass (DNR). Assuming that biomass gasification can truly be determined carbon neutral, Evergreen's transition to a biomass gasification fuel system could reduce the amount of greenhouse gases emitted as well as replacing and eliminating fossil fuel emissions.

Greenhouse Gas Comparison

In our current natural gas system, Evergreen emits approximately 4,500 tons of carbon dioxide equivalents (tCO2e) annually in the combustion of 84,886 MMBtu of natural gas. Evergreen would need 5,600 bdt of biomass annually to replace the natural gas used in heating the campus. The gasification of 5,600 bdt of biomass emits 10,080 tCO2e. If this biomass where combusted on-site it would release 8,960 tCO2e into the atmosphere. In our natural gas system, this biomass would have been combusted on-site, or left to decompose, releasing 8,960 tCO2e. Accounting for the emissions that would have been used to displace natural gas that will be in the carbon cycle regardless, in addition to those from the natural gas system in place, amount to 13,460 tCO2e (SEI). This number is more than what will be released by the gasification system, reducing Evergreen's greenhouse gas emissions. This is taking into account emissions after harvest to its use. With the proposed gasification system Evergreen would benefit from a 3,290 tCO2e reduction of greenhouse gases each year, this is including the 90 tCO2e that could not be replaced (Figure 4).

Current Emissions	**Quantity**	**Metric Tons of CO2 Equivalent**
Natural Gas	86,000 MMBtu	4,500
Decomposition	5,600 bdt	8,960
	Total Annual Emissions	13,460
Proposed Gasification Emissions		
Natural Gas	1,700 MMBtu	90
Gasification of Biomass	5,600 bdt	10,080
	Annual Emissions	10,170

Figure 4: Annual GHG comparison of burning natural gas and the proposed biomass gasification plant at Evergreen (Evergreen)

Looking at the specific emissions calculated for gasification at Evergreen (Figure 5), there would be an increase in total particulate matter, associated with the transportation of the biomass and ash. With the use of an electrostatic precipitator these emissions are greatly reduced. Nitrogen oxide is an emission of concern, which has the potential to affect both human and ecosystem health. With the use of non-selective catalytic reduction controls this potential threat is minimized to 0.08 lb/MMBtu. Nitrogen oxide compounds are highly dependent on the type of fuel used; these projections are based on average wood typed in the Pacific Northwest. Local fuel samples have been sent to a third party for a chemical analysis, which will give the college more accurate projections.

Data on Evergreen's natural gas emissions are based on recorded data from 2009. The calculated emissions for the gasification plant are based on Nexterra's projections assuming that Evergreen's energy heating needs of 86,000 MMBTU/year, are met by the gasification of 5,600 bdt of biomass.

Emission Comparison Between Evergreen's Current situation and the Projected emissions from the Proposed Gasification Plant		
Specific Emission	**lb/MMBTu**	
	Natural Gas	**Gasification**
Total Particulate Matter (TPM)	0.002	0.004
Carbon Monoxide (CO)	0.084	0.01
Volatile Organic Compounds (VOC)	0.006	0.005
Nitrogen Oxides (NOx)	.1	*.08
Total Greenhouse gases (Carbon Dioxide equiv.)	117	261

(* with the use of Selective non-Catalytic Reduction Controls)

Figure 5: Emissions comparison between natural gas and biomass gasification at Evergreen (McKinstry)

Various Fates of Biomass and a Comparison of Emissions

Biomass from forest residues could be used in alternative ways, all of which share essentially the same problem—the release of greenhouse gases into the atmosphere. There are 6 different categories in which woody biomass could potentially be used: disposal, soil amendment, residential energy, industrial energy, industrial feedstock, and liquid fuel. In this subsection, each category of biomass fates are investigated and compared for their implications on air emissions associated with both global climate change (carbon dioxide, methane, and nitrous oxide) and local air pollution (fine particulates and carbon monoxide). This analysis includes GHG emissions in a life cycle approach from post-harvest to use of the biomass. By comparing the implications of these potential fates of our biomass residue, we can better decipher whether the biomass gasification project is the best way to reduce our greenhouse gas emissions, or if there is a better use of biomass resources. These data were gathered by the Stockholm Environment Institute (SEI) for the Olympic Region Clean Air Agency (ORCAA) and published in their report, *Greenhouse Gas and Air Pollutant Emissions for Woody Biomass Residues*. The greenhouse gases accounted for in this report are carbon dioxide (CO_2), methane (CH_4), nitrous-oxide (N_2O), and two criteria pollutants carbon-monoxide (CO) and fine particulate matter (PM 2.5).

1. Disposal
On-site decomposition emissions are based on decay rates on an average of wood types across the Pacific Northwest. The net emissions of CO_2 from 1 bdt of biomass are 1.58 tons. Large slash piles of woody biomass where size and moisture level is sufficient, methane can be generated from decomposition, but assuming that the debris is mostly scattered, no methane or nitrous oxide would be expected. On-site combustion emissions include the gathering of biomass into slash piles, and the combustion of the slash. The net greenhouse gas emissions for the combustion of slash piles are 1.75 of CO_2, 0.06 of N_2O, and 0.03 CH_4. The amount of CO being emitted is 74.15 lb/bdt and 8.02 lb/bdt of PM2.5. Regarding human health, the combustion of slash produces a significant amount of CO. Carbon monoxide (CO) is a product of the incomplete combustion of fossil fuel and biomass. CO emissions from combustion can be regulated through the use of emission control technologies with the exception of combustion in a fireplace or EPA-certified stove. All other fates result in a significant reduction in net CO emissions relative to the common practice of on-site combustion.

2. Soil Amendment
The biomass residue can be chipped and used as a mulch to increase soil fertility. This mulch would still emit 1.78 tCO_2/bdt, but would have a benefited use of enriching soil. Biochar (detailed more comprehensively in the biochar subsection) is a by-product of biomass gasification that has multiple benefits including soil enrichment and long term CO_2 sequestration. One application of biochar is as a soil amendment product, which due to its chemical makeup reduces the need for fertilizers.

3. Residential energy
The combustion of biomass can be used for residential heat both in fireplaces and EPA-certified stoves. This type of combustion has greater CH_4, CO and PM 2.5 emissions than the common practice of combustion on-site. These emissions are more likely to occur in denser populated areas, so they pose a greater threat to human health. It is reported that 60% of residential stoves do not meet the regulations set by the EPA, so these air quality implications are most likely greater. Biomass being used in a pellet stove is a slightly better option for

residential heating, but still produces more CO than on-site combustion, and about 75 lbs/bdt more than if the biomass was left to decompose. Using stoves for residential heating will introduce much more CO and PM2.5 into the air, than if the wood was to combusted or left to decompose, but residential stoves do have the ability to displace fossil fuels. In their displacement of fossil fuels, greenhouse gas reduction is possible, but on a small scale.

4. Industrial energy
Biomass is used as fuel in industrial boilers, integrated gasification systems, as well as cogeneration (combined heat and power) systems. With the use of emission controls, this type of biomass utilization releases only minute amounts of CO and PM 2.5. Relative to on-site combustion, CO can be reduced 93% or more, and PM 2.5 is reduced by 83%. When used as fuel in industrial boilers as a means of displacing fossil fuels, CO_2 emissions will be reduced but CO emissions will be much higher. An integrated gasification system, as already discussed in the paper has the ability to reduce greenhouse gases, and have a lesser effect on human health with limited particulate matter and CO being emitted.

5. Industrial feedstock
Using biomass for pulp production would decrease the amount of CO being emitted, but pulp production requires high quality wood. In this study it was assumed that only 10% of the biomass residue met the standards needed for pulp production, so this would not be a good alternative use of forest residue because it's simply inefficient.

6. Liquid fuel
The production of ethanol to displace gasoline provides the greatest benefit of CO reduction. However this technology requires a high quality of wood that is unrealistic to obtain in forest residue. It's a relatively new technology so emissions calculated for the integrated gasification system are used as proxy for this option.

Forest biomass has the potential to reduce greenhouse gases while eliminating the use of fossil fuels in the heating of Evergreen's campus. As greenhouse gas reduction is only attainable in the long run, the short term implications are unknown and need to be further addressed in order to make the right decision about implementing a gasification system at evergreen. One way we might assess the timing of greenhouse gas benefits is by knowing exactly what the biomass would have been destined for, if it weren't used as feedstock for gasification. Whether it was going to be combusted on-site, or left to decompose, both would have different implications on our carbon cycle. In analyzing other options for forest biomass, gasification is the best option for its limited effect on human health and its ability to displace fossil fuels.

Conclusion and Recommendations

Humanity's climate forcing experiment is real. The only argument within the scientific community appears to be how big a size slice of the global warming pie it occupies. It is both wise and prudent, based on the precautionary principle, to move forward cautiously yet quickly in our effort to curb our man-made emissions of GHGs. The fact that we are developing alternative power generating technologies based on the utilization of biological feed stocks is a testament to our desire to rid ourselves of our over-reliance on fossil fuels.

In Washington State, the quickly developing forest biomass sector if "thoughtfully deployed" (DNR) has the potential to significantly contribute to our renewable energy goals. However, there continues to be a "lack of integrated understanding of complex issues that need serious consideration if progress is to be achieved" on the state level (UW Report to Wash. Leg). These issues include technical, economic, environmental, social, and moral questions that require continued scholarly research. On the college level Evergreen is aware that, "Biomass is not automatically carbon neutral (and that) uptake and release rates are important "and that is why…the (Evergreen) Sustainability Council is currently trying to answer what the verifiable carbon balance of this project is" (TESC). Verifying where the college's institutional carbon responsibilities begin and end is no easy task. However, this is a burden they must welcome as a leader within the community. The community at large has the right to expect that the "best available science" was used to determine what effects the proposed biomass gasification project will have on the C cycle and climate in general. It is for these reasons that we recommend:

- The decision to install a biomass gasification system on campus should be postponed until more definitive data from scholarly research are available.
- A life cycle assessment (LCA) and Net Energy Balance (NEB) of the college's existing natural gas heating system should be commissioned, followed by the same set of studies for the biomass gasification project's anticipated footprint. This LCA must be specific to a biomass gasification system for the purposes of facility heating. For the NEB, ISO 13602-1 should be referenced as it provides methods to analyze, characterize and compare technical energy systems (TES) with all their inputs, outputs and risk factors. It also contains rules and guidelines about the methodology for such analyses (UW Report to Wash. Leg 2009).
- The Nexterra gasifier proposed for use at Evergreen does not provide the possibility of climate mitigation through biochar soil enrichment. Alternative gasifier systems that do not fully combust the feedstock are capable of producing biochar with substantial amounts of sequesterable carbon at the cost of overall energy efficiency. The benefits of biochar production should be compared to the impacts of increased fuel usage in order to ensure Evergreen is taking the most sustainable, climate-friendly approach to biomass gasification.
- Biomass feedstock densification should be considered if the proposed biomass gasification project is implemented. By using this technology Evergreen would be

able to increase transport efficiency while increasing unit energy density. This would assure that fewer carbon emissions would be associated with the transportation of the processed feedstock.

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Chapter 4: Forest Ecology Impact

Molly Fizer, Spencer Middleton, Julian Sammons

The project Evergreen is proposing is built around the idea that the potential energy contained within woody debris in our forests can be used to generate heat for our own needs on campus. Along with the other issues related to this project, the long and short-term impacts that this project has on forest health must be looked into extensively. This report attempts to help answer questions regarding these impacts and determine the questions that remain unanswered. This section will explain the different certifications available for sustainable forestry practices and how they apply to this project. Timber harvesting practices within regional forests and the impacts entailed will also be covered, as well as alternative uses for the biomass be considered for consumption on campus, and sources for biomass other than wood debris from timber harvesting. Research will also address what amount of biomass needs to remain in the forest to maintain sufficient nutrient levels. As proposed, in the context of the impact on local forests, the project at Evergreen appears to be sustainable. However, a system be needed to monitor the practice to ensure that impacts are kept to a minimum.

Evergreen has a reputation as an institution dedicated to social and environmental responsibility. Consequently, it has an obligation not only to minimize adverse ecological effects on the supply forest, but also to have beneficial effects on forests where possible. It is our conclusion that we can indeed accomplish this is by supporting responsible forest management practices.

Sustainable Forest Certification

Conveniently, organizations do exist with standardized criteria for the assessment of forest management. In response to increasing deforestation and irresponsible forest management, organizations have sprung up around the globe to assess and certify sustainable forestry. There are numerous forestry certification agencies in the United States, with the main competition in the Pacific Northwest between the Forest Stewardship Council (FSC) and the Sustainable Forestry Initiative (SFI).

The FSC is a non-profit organization that was developed by representatives from environmental, social, and forest management groups in order to strengthen requirements for forest management, whereas the American Forest and Paper Association founded the Sustainable Forestry Initiative (SFI). It began as the timber industry's response to the Forest Stewardship Council, as a way to market so-called sustainable forest products while adhering to lower standards (Heaton). SFI fails to include crucial environmental requirements in its standards, such as prohibiting genetically modified organisms and toxic chemicals, logging levels that exceed forest growth levels, and replacement of natural forests by tree plantations that lack biological diversity (National Wildlife Federation, 6).

FSC is internationally recognized as the best forest certification authority available today because its system of certification considers the comprehensive environmental and social implications of the forest practices. The system is based on ten principles, each of which is followed by a list of criteria. A principle is a statement of the system's overarching goals regarding forest management, and criteria are a means of judging whether or not a principle has been achieved. Adherence to criteria is measured by indicators, which are tailored to specific regions. Also, every certified forest is audited annually in order to maintain certification.

The sixth FSC principle is Environmental Impact wherein it is stated: "Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest." (FSC-US Forest Management Standard, 28) Drawing from peer-reviewed scientific analyses and local knowledge and experience, landowners use the best available information in order to assess the various aspects of their forest. Using this assessment, they develop a short- and long-term management plan with the intent that "Ecological functions and values shall be maintained, enhanced, or restored, including: a) Forest regeneration and succession. b) Genetic, species, and ecosystem diversity. c) Natural cycles that affect the productivity of the forest ecosystem." This holistic management plan includes such things as rare ecological communities, old growth, animal species and habitat diversity, riparian management zones, full range of tree sizes/declining trees, snags, and coarse debris, invasive species control, and fuels management (FSC, 35).

The FSC standards are stringent and thorough enough to realistically foster a productive, sustainable forest. Will biomass extraction alter this balance? Under the fifth FSC principle, entitled Benefits from the Forest, there exists a criterion stating, "The rate of harvest of forest products shall not exceed levels which can be permanently sustained." (FSC, 26) This demonstrates that if Evergreen does manage to contract with a forest that is FSC certified, the certification guarantees that the relatively small annual biomass extraction (5,600 bone dry tons [BDT] a year as needed by Evergreen) will not exceed sustainable levels.

Potential Suppliers and Current Uses for Biomass Fuel

Because the generation and use of biomass is very dependent on location, each candidate must be looked at individually when trying to consider the current or alternative uses of the biomass within. According to Sustainability Coordinator, Scott Morgan, Evergreen is currently considering three different suppliers:

1. Capitol Forest (DNR)
2. Fort Lewis (Federal land)
3. Private Landowners

Capitol Forest

Capitol Forest is approximately 91,000 acres of Department of Natural Resources (DNR) forestland located 11 miles away from the college campus. It currently contains considerable timber activity, which generates a significant amount of forest debris. This forest debris isn't utilized or extracted, and is rather left to decompose or to be burned in slash piles. According to Black Hills District Manager of Washington State DNR, "we have not sold biomass out of the Capitol Forest – although we have been working towards that end". Given that this is true, then currently there is no concern of Evergreen competing against other entities or other uses for this resource. However, the future may very well lead to more widespread uses of biomass, which could put Evergreen in the position of inhibiting other projects from getting the benefits Capitol State Forest has to offer. In such a scenario, the alternative to the previous would be requiring Evergreen to shift away from the ideal local resource, if competitors win over the source.

Fort Lewis

Fort Lewis, at 40,000 acres, is a less likely candidate for a fuel source due to the nature of the biomass production, as well as their lack of ability to form a substantial contract. However, according to Fort Lewis' Chief Forester Allan Derickson, Fort Lewis has provided fuel for local biomass facilities in the past, though they are no longer doing this. If it were to work out for Fort Lewis to form a partnership with Evergreen it would be very likely that this would be a competitive market, based on Fort Lewis' history with selling biomass. Long-term contracts are also unlikely. On top of that, Fort Lewis is currently doing a study looking at developing a biomass generator on the base in order to obtain a higher level of energy independence (Derickson). This would greatly increase the competitiveness of biomass from Fort Lewis, and Fort Lewis would always favor supplying itself above anywhere else if supply were to fall short of demand.

Private landowners

Private FSC landowners possess forests of various sizes and distances from the Evergreen campus. The ability of small, private landowners to meet Evergreen's demand for biomass is questionable, as the contracts would be complex to establish and manage, and availability from such small plots of land is conditional and essentially unreliable. Private landowners are in need of a market for their forest slash. There currently is no competitive market for biomass from these landowners, and therefore the resource currently serves no alternative or preferable purposes beyond nutrient retention (Hanson).

Extraction Process and Impacts

Capitol Forest is a large plot of DNR-managed land just southwest of Olympia, part of which is FSC-certified, and which is currently used for timber harvesting (dnr.wa.gov). It is being considered as a biomass source by the college for several reasons, including proximity, contracting, state agency ownership, sustainable practices, accessibility, state trust land. It is the ideal source for Evergreen's biomass project, and therefore will be assessed in this section as a model for forestlands that will supply Evergreen with biomass. Due to the overall size of Capitol Forest, the sizes of the managed stands being harvested at one time are considerably large, which has received negative responses from the public regarding aesthetic presence (Bradley). However, regardless of the general appearance of these harvested plots, what is most important is how the practices affect the forest ecosystems, habitats, and soil and water functionality/quality. The purpose of this section is to explore the practices and additional impacts that biomass generation and harvesting will have on the forest, which will overlap considerably with timber harvesting methods. It shall be assumed that as an FSC-certified forest, up to the point at which biomass is to be harvested, all practices and activities comply with the Forest Stewardship Council's guidelines ensuring minimized forest ecology impact, as outlined in the previous section of this chapter.

Before addressing any forest impacts in further detail it is important to distinguish Evergreen's proposed biomass project from others. Because Evergreen intends to purchase biomass derived from only FSC-certified working forests in the region (Morgan), and on a relatively small scale, the level of impact this project will have on the forests supplying the biomass will be considerably less than that of other proposed facilities in the region, such as the Adage plant proposed for Shelton, Washington. With that in mind, the focus of this section is strictly limited to the scope of Evergreen's proposed project, and is not to be inclusive of other biomass plants and their operations.

There are many variations in how timber is harvested from a forest, but all regional timber harvesting methods can fall under two general categories: conventional, and whole-tree harvesting (LD Jellison). Conventional harvesting, which has historically accounted for the majority of timber harvesting, is the method in which a tree is felled, then stripped of its limbs and the top, where the tree was felled (LD Jellison). The log is then moved to a landing near a road using one of many methods, where it is then likely to be cut to length and processed, removing the remaining limbs and stubs. This practice results in a wide dispersion of the majority of woody debris, which means that it is economically and practically challenging to collect and harvest the biomass material, though some does accumulate at the landing. Whole-tree harvesting, a method which is gaining popularity, is when a tree is felled, then transported to a central processing area in close proximity to road access, where it is then stripped of its limbs and top (LD Jellison). This results in a highly localized, and easily accessible accumulation of the unused woody debris. This accumulation of woody debris is known as a slash pile. Clearly, whole tree harvesting enables vastly greater efficiency in biomass harvesting, and is therefore the preferable process on sites where biomass is to be harvested for use. As stated above, whole-tree harvesting is gaining popularity, according to LD Jellison's Biomass Fuel Resource Study conducted in 2010. According to the report:

> *Changing timber harvesting practices...have encouraged whole-tree harvesting, which significantly increases the potential availability for forest residues from logging slash created by timber harvesting. Public and private commercial timberland owners and have begun to favor whole-tree harvesting as a more efficient means of harvesting timber as one of the ways to more efficiently*

> *manage timberland as the removal of slash promotes the growth of seedlings and reduces open burning of forest residues. In addition, government incentive programs such as the U.S. Department of Agriculture's Biomass Crop Assistance Program (BCAP), have sought to further increase the incentive for the removal of biomass from timberlands.*

Capitol Forest, however, largely does not use the whole tree harvesting method. Most of the timber harvesting in Capitol Forest is done using the conventional harvest method, using primarily tower logging or shovel logging to physically move logs closer to the road (Scott Sargent). Tower logging, also known as cable logging, is used on steeper slopes, generally greater than 35% slope (Scott Sargent). In this method the felled and limbed trees are pulled, or yarded in on a cabling system up to the landing, where the logs are collected. It is here at the landing where slash piles of remaining limbs and butt ends of trees are generated, though on a greatly smaller scale compared to whole-tree yarding. Shovel logging is used on relatively flat areas of timber harvesting. This method implements one or more tracked loaders that leave the road to pick up the felled and limbed trees. The loader grabs any trees or logs within reach and turns while stationary, placing the trees closer to the road. This method is good for minimizing soil impacts due to the fact that all the logs within reach of the loader can be moved in one trip, or pass, of the loader. Because there is no central landing in this method and logs are placed along the road spanning some distance, there is little concentrated slash piling from this practice. However, processors, which are advanced machines used for preparing logs, do generate some waste, such as short log chunks from log trimming (Scott Sargent).

After timber harvest is completed the slash piles remain on site. If they are to be harvested for biomass, generally trucks transport the woody debris to a biomass purchaser, such as Evergreen. But the physical transfer of biomass from a slash pile to a transport truck can be done several ways, though not all methods are entirely applicable to Capitol Forest. The simplest method, which should work at Capitol Forest, is done using an excavator that grabs large portions of slash and places them in an open-top truck. The large branches and tops will need to be broken down, or chipped, in order to be used in the gasifier. This means that the chips need to be processed in a chipping site before being used in Evergreen's gasifier. A different method that is still being developed is using a "buncher", or "bundler". This mobile machine is capable of grabbing large piles of slash and "bunching" them into tightly wound bundles. These machines can be set to create bundles of specific dimensions in order to allow for maximum transport efficiency for different trailer configurations (John Deere). What really makes this machine useful is its off-road capability; slash that is further from a road can be easily harvested by first using this machine to create bundles, followed by the use of a "forwarder", which also is an off-road capable machine that is responsible for harvesting the bundles and taking them to roadside for final transport (John Deere Catalog). Both machines are most useful during pre-commercial thinning, which is when biomass harvesting becomes economically challenging. Essentially, the use of this equipment expands the scope of what biomass can be harvested from a logging site, such as those in Capitol Forest, and ultimately may warrant updated calculations on how much woody biomass can be harvested from location such as Capitol Forest, depending on required nutrient retention. Another method that is relatively popular is on-site chipping, which requires implementation of a large, semi-mobile chipping machine. This displaces the need to an off-site chipping facility, and also allows for denser loading and transport of the biomass. The bundles generated by the "bundlers" can also be chipped before transport to maximize transporting efficiency.

It is important to keep in mind that throughout any of these processes of biomass harvesting on FSC-certified timberland, operations still must comply with all FSC guidelines. FSC guidelines do not distinguish between biomass and timber harvesting; "biomass and whole tree harvests are [collectively] addressed along with other types of removals." (FSC-US Forest Management Standard). Criterion 6.5 outlines erosion control, forest impacts from harvesting, road construction, and all other mechanical disturbances, and protection of water resources. Indicator 6.5c is particularly relevant to biomass harvest, and this fact is addressed by the FSC: "Attention to this Indicator is expected to increase with the amount and frequency of woody material removed from the site (e.g., biomass removals and whole tree harvests)." Within indicator 6.5c it is stated that, "Slash is concentrated only as much as necessary to achieve the goals of site preparation and the reduction of fuels to moderate or low levels of fire hazard." Essentially this implies that slash pile generation is limited to the sustainability practices during timber harvest that produce slash, as opposed to being generated with the intent of forming easily accessible large quantities of saleable biomass. Another requirement also under indicator 6.5c addresses regard to effects on soil from activity:

> *All soil disturbing activities, including road and trail construction, are conducted only during periods of weather when soil compaction, rutting, surface erosion, or sediment transport into streams and other bodies of water can be adequately controlled. Soils should be dry enough or frozen to minimize disturbance and compaction.*

While road and trail construction is not an operation of biomass harvest, this requirement will affect biomass harvest in that necessary heavy equipment and vehicles will have limited access to roads, due to the above ramifications of activity in certain weather conditions.

Family Forest (FF) FSC-certified working forests primarily use the whole-tree harvesting method. The trees are transported to a landing and a slash pile is generated after processing (Hanson). In certain cases, different amounts of this slash are redistributed back into the forest to mitigate nutrient depletion (Hanson). It is less likely that large industrial-grade equipment such as bundlers or whole-tree chippers will be implemented on smaller scale operations, so chipping will be managed accordingly.

Purchasing biomass from FF lands is ideal in terms of sustainability and environmental responsibility. These plots of forest, which are dispersed throughout the region, are at significantly higher risk of being developed than land managed for timber by the DNR (Morgan). It also supports and encourages the individuals managing these lands, and in the best case will provide incentive for more small landowners in the region to manage their land to FSC certification.

Soil Health and Biomass

Sustainable forestry is a critical part of protecting our resources for future use and enjoyment, and therefore it is crucial to determine the role of decaying matter in forest ecosystems. It is important to focus on how much of this woody, decaying debris should remain in the forest to allow the ecosystem to live productively and continue a healthy, thriving cycle. Taking woody debris from the forest has both positive and negative effects on overall forest life productivity. It is undeniable that the decay of wood is incredibly important to the ecology of the forest. From being a storage source of carbon, to providing homes for numerous other species, the dead trees and decaying debris play many roles that are often taken for granted (Franklin, Shugart, Harmon 550). Woody crops are also known to reduce nitrate pollution in water (Mann, Tolbert). Woody crops and decaying debris play a role in providing nutrient rich soil in forests and "upon disturbance such as clear cutting this balance is radically altered; forest floor nutrient and organic matter storages decrease" (Covington 41). It is clear that some decaying woody debris must remain in the forest.

There are positive effects of taking dead trees and decaying debris from the forest and these effects should also be considered. When taking this matter from the ecosystem, resources such as light and soil nutrients become available to other trees and organisms, and in turn allow these species to grow productively (Franklin, Shugart, Harmon 551). According to the European Environment Agency (EEA) "forest management and the removal of residues could contribute to reducing fire risk, especially in forests that are currently unmanaged" (EEA 9). One argument that is often brought up in favor of biomass gasification with woody debris as the energy source is that it is a much more sustainable way to get rid of slash. Instead of open burning such as traditional slash and burn methods, we can use the slash to produce energy in a specialized system. If it is there, why not use it for something that can help us become less dependent on fossil fuels? While it is easy to see what the positive effects of thinning forests are, we must be careful not to take more than is necessary.

How much debris can be taken from the forest? "The substantial rise in the use of biomass from agriculture, forestry and waste for producing energy might put additional pressure on farmland and forest biodiversity as well as on soil and water resources" (EEA 6). These added pressures may prove that biomass gasification could do more harm than good in terms of ecosystems and biodiversity. As stated in a letter by Dr. Mark E. Harmon from the department of forest ecosystems and society of Oregon State University, Timothy D. Searchinger, a research scholar and lecturer from Princeton University, and William Moomaw, a professor of international environmental policy at Tufts University, there is simply not enough decaying residue to provide enough feedstock for the proposed biomass plants in state of Washington:

> *The number and scale of biomass facilities proposed in Washington strongly suggests that new trees will have to be cut to provide fuel for these plants, because mill residues and logging residues are inadequate...As for forestry residues, a recent state-level biomass inventory estimates that there are about 3.5 million green tons of residues generated annually in Washington State. However, only about half of this, or 1.75 million tons, is really collectable due to the need to retain material onsite for soil fertility and the logistical constraints of collection* (Harmon 3).

In order to power all proposed facilities in Washington, two to three times more logging residue must become available, therefore more trees would have to be cut down.

It is clear that there is not enough woody debris to be used as feedstock to provide electricity and heat for the state of Washington and still have productive ecosystems. However, the EES concluded, “significant amounts of biomass can technically be available to support ambitious renewable energy targets, even if strict environmental constraints are applied” (6). While these resources may currently be available for Evergreen’s proposed plant, we must remember that there are other proposed plants statewide. Even if Evergreen gets the woody debris from sustainably harvested forests such as FSC certified land, how do we know that others will take these measures to ensure that their biomass gasification plants have minimal environmental impacts as well? One important question that must be addressed is how much of the woody debris can be taken away solely to power Evergreen’s proposed system? According to John Pumilio, the Sustainability Coordinator at Colgate University, one-fourth to one-third of the woody debris should be left on the forest floor after tree harvest.

Alternative Sources of Biomass

Many people have asked why Evergreen isn’t exploring the use of other waste as a feedstock instead of using wood from the forest. This is a valid question, but Evergreen and Nexterra have dismissed these sources for a variety of reasons. According to the Washington State University Energy Extension Bioenergy Department, animal manure and urban waste are available in less of a quantity in Washington than woody biomass, and tend to be less efficient at producing energy. Although woody debris is more readily available, animal waste is easier to gather and easier on the environment. Urban wood, or wood used in construction, can be taken from demolition sites. However, it must be sorted because treated and painted wood is extremely harmful when burned. Since wood is susceptible to both fungus and insect damage, treatments such as chromated copper arsenate (CCA) are usually added. While CCA is no longer allowed, much of the wood that would be re-used from demolition sites has been treated with it in the past (EPA). Yard waste could also be used in specialized systems but these leaves, tree trimmings, grasses, etc. tend have a high level of moisture, and therefore produce a small amount of energy. Yard waste is much better suited for composting.

While there are other options that have been considered, Nexterra has decided that woody debris makes the most sense as a fuel source for the proposed gasifier. Tyler Abrams, the senior account executive at Nexterra, has stated the main reasons why other feedstock sources such as sugarcane and switch grass would not be used. Availability is the first and foremost reason why Nexterra proposes using woody debris in Evergreen's system. Almost 90% of the fuel that Nexterra uses in gasifiers comes from slash piles and sawmills. Ease of fuel feeding is another reason woody debris would be used. Other debris such as ivy and kudzu are 'stringy' and therefore difficult to continuously feed through the system for an extended period of time (Abrams). Many other fuel sources are inherently leafy and therefore contain more nitrogen than woody fiber. Because of the high nitrogen levels, the combustion of these leafy materials raises NOx emissions (Abrams). While other fuel sources can and should be utilized elsewhere, woody debris is the best feedstock choice for Evergreen's proposed system due to availability, lower NOx emissions, energy efficiency, and ease of fuel feeding.

Recommendations and Conclusion

After completing our research and analysis, the recommendation by the authors of this chapter for the college's proposed biomass plant is positive and supportive, though conditional. We believe that *so long as* the project is committed to FSC certified forestry, from a forest impacts perspective, ultimately the biomass plant's operations will not have adverse impacts on the forest that would warrant cancellation or reconsideration of the project as a whole. We also believe it is crucial to make clear that this recommendation pertains strictly to Evergreen's proposed project, and our conclusion should not be extended to any other existing or proposed biomass facility. Also, it is important to emphasize that this recommendation only addresses forest-related issues, and does not take into consideration the many other issues related to Evergreen's proposed biomass project.

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Chapter 5: Human Health Assessment of Biomass Gasification

Katie Aiello, Chris Miller, Meridan Pickett, and Kyle Young

Some of the most important factors to take into account when considering the implementation of a biomass gasification system are the potential health risks. There are three phases in the biomass process and each phase has its own set of health concerns. The first phase, or the harvest stage, includes the harvesting and transporting of slash to a biomass facility. The second phase is the actual gasification process that takes place in the Central Utility Plant (CUP). The third and final phase is the disposal stage, which includes the disposal of ash and char and the processing of emissions. While all of these steps do have immediate occupational hazards, there are also risks with more long-term and far-reaching side effects. As a public institution, the Evergreen State College (TESC) has a responsibility not only to college employees and students but also to the greater community that the school participates in to research the health concerns of biomass gasification and compare these health effects to those related to the current natural gas heating system.

Phase One: Harvest

Immediate Health Concerns

The immediate health concerns regarding phase one are the occupational hazards surrounding the collection and transportation of slash. The Bureau of Labor Statistics reports that, in 2008, 4% of all forestry workers and 4.4 percent of those employed in support activities for agriculture and forestry suffered some kind of work related injury or illness (bls.gov). Additionally, the Centers for Disease Control and Prevention (CDC) states that in 2008 the fatality rate of logging workers was 108.1 deaths per 100,000 workers. The CDC goes on to say, "This rate is over 30 times higher than the overall fatality rate in the US in 2008 (3.5 deaths per 100,000)" (cdc.gov). Despite the risks associated with the forestry industry, they should not play a factor in TESC's decision. Because the college's need for slash will not create a significant increase in forestry practices, it will also not create a significant increase in forestry related injuries.

Long-Term Health Concerns

There are long-term health effects associated with phase one of biomass gasification. These effects would impact not only forestry workers, but also members of communities surrounding the harvest area and the transportation routes. The concerns are related to the actual forestry practices and transportation methods. The installation of a gasification plant on TESC campus will mean an increase in diesel truck traffic on campus. According to the Washington State Department of Transportation (WSDOT), heavy-duty highway vehicles account for 29% of diesel particulate matter in the entire state and 36% in Central Puget Sound alone. The Environmental Protection Agency (EPA) has found that diesel particulate matter is highly toxic. WSDOT states, “These fine particle are so small that several thousand of them could fit on the period at the end of this sentence. They are a health concern because they can be breathed deeply into the lungs and sometimes pass directly into the bloodstream - potentially affecting the lungs, heart, and other organs” (wsdot.wa.gov). It is important for TESC to consider the health effects that result from the transportation step of the process because members of the campus community will be directly affected by the daily fuel delivery to campus. The proposed plan calls for the construction of new road near the childcare center on campus for the specific use of transporting biomass fuel. And because TESC should consider the greater Puget Sound community, it should be noted that the biomass facility will cause an increase in logging and slash transportation within a 50 mile radius of the campus, which will, in turn, cause an increase in diesel particulate matter emissions in this area.

Transportation fuel combustion has been a predominant contributing factor to adverse human and environmental health risks for many decades. However there are minimal studies done regarding health impacts that extend past current criteria of regulated air pollutants. The amount of uncertainty regarding other toxic emissions is unknown which could contribute to more health impacts than already known. The EPA currently regulates 187 hazardous air pollutants (HAPs). Among this list are compounds such as benzene, aldehydes, butadiene, acrolein, and polycyclic aromatics, which are associated with transportation-fuel combustion. Exposure to hazardous air pollutants has been associated to chronic diseases such as cancer and morbidity due to acute chronic diseases such as asthma. Other pollutants, such as ultrafine particles, are heavily linked to transportation fuel use but are not well characterized in terms of emissions, exposures, and related health risks (EPA).

Phase Two: Gasification

Immediate Health Concerns

The immediate health problems of phase two are related to the operation of the biomass facility, and as with the immediate concerns of phase one, will only impact workers. A workshop on the *Health, Safety and Environment of Biomass Gasification* found that there are numerous technical problems that can arise in a biomass plant and can lead to a number of health problems of varying degrees. According to the workshop findings:

> *The following risk consequences have to be considered and analysed on the frequency of their occurrence: explosion, fire, danger from electricity, poisoning, danger to health, harms to persons (burn, scald, etc.), irritation (skin, mucous membrane), mechanic failure, noise pollution, ototoxic effects, immision, emergency stop gas engine, failure in combustion system, failure flare/emergency case gas utilisation, [and] failure/malfunction of the automation system. (p. 110)*

It will be extremely important that TESC take all the appropriate steps to properly train employees and maintain high standards of safety in the plant to avoid any injury to a college employee.

Long-Term Health Concerns

The lasting health effects of phase two are perhaps the most controversial of the entire gasification process because of the concerns about emissions from the biomass plant. Of all the potential health risks, those related to emissions will remain at the forefront of the argument because according to the college's Air Quality Policy, "TESC recognizes that: the air is shared by all members of the community and those who visit the campus; suitable air quality is important in fostering a healthful and creative learning and working environment, and; maintaining suitable air quality requires continual attentiveness to mitigate or to eliminate unfavorable conditions" (evergreen.edu). Therefore, it is essential that we examine what effects emissions will have on both employees and members of the campus and greater Olympia communities.

While there are many studies on the health effects in relation to wood burning stoves, the research on biomass facility emissions is minimal because lack of current regulation. So, in light of the lack of research, this report will use wood burning stoves as an example for its relation in fuel source. This research is only going to be used to represent type of emissions and related health risks. Concentrations and levels of emissions are not accurately represented for biomass through this. The use of wood burning stoves has been found to elevate levels of polycyclic aromatic hydrocarbons (PAHs), benzene, and 1.3-butadien (Gustafson et al. 2007, 2008). All of these emissions are known carcinogens. Implementing biomass will lead to an increase in exposure to each of these.

A study conducted by Environmental Health Perspectives gathered research on carcinogenic affinity in relation to fuel type used. Controlled populations from different continents were categorized by gender, age, smoker, non-smoker, and race. These people where studied for incidences of cancer in relation to type of fuel used for the majority of life. The research indicated that predominant coal users had an increased risk of lung cancer among men, and women. Predominant wood users also had an increased risk of lung cancer compared to the nonsolid-fuel users. This particular study indicates that people burning biomass would have a greater affinity to lung cancer than those burning natural gas (Environmental Health Perspectives).

A number of medical organizations have offered opinions on biomass facilities. The American Lung Association is a leading organization working to improve lung health and prevent lung disease. Stated in a letter from the American Lung Association, president Connor does not support combustion of biomass. "Legislation should promote clean renewable electricity, including wind, solar and geothermal. The Lung Association urges that the legislation not promote the combustion of biomass. Burning biomass could lead to a significant increase in emissions such as nitrogen oxides, particulate matter, and sulfur dioxides" (www.lungusa.org).

The five main emissions of concern as set by the EPA are estimated by the McKinstry report as follows:

Regulated Pollutant	**Potential To Emit tons/year**
Carbon monoxide (CO)	6.26
Nitrogen Oxides (NOx)	12.53
Sulfur Oxides (SOx)	2.41
Particulate Matter (PM10)	1.25
Volatile Organic Compounds (VOC)	1.25

PM-10, particulate matter smaller than 10 but greater than 2.5 micrometers, are a concern for the EPA as well as the TESC community because of their role as "inhalable coarse particles" (EPA). The materials of interest to the EPA are small enough to be inhaled and get caught in the respiratory system. Increased particulates contribute to many health issues including, decrease lung function, aggravate asthma, and even possible premature deaths.

SOx and NOx raise similar issues. These two pollutants are the main contributors of acids in our atmosphere. If moisture is present after their emission, they turn to aerosols that fall with rain, snow and fog (acid rain). In the absence of moisture they become nitric and sulfuric salts that settle with gravity. The main concern for the fate of these emissions around the community would be their effects on the forest. After the acids fall, they are often neutralized by valuable forest nutrients like magnesium and calcium cations (Hill, 156).

Carbon monoxide is arguably the most important of all the emissions. Whether the school chooses gasification or to stay with natural gas, CO will be a result of the process. The product of incomplete combustion, CO is very hazardous. When inhaled, it lowers bloods ability to carry oxygen to the body's tissues. The effects usually last for a month or two in the atmosphere before it is converted to CO2 and enters the traditional carbon cycle (Hill 120).

The emissions from biomass will vary to some degree. The contents of the wood chips burned will vary from source to source. Finding the cleanest wood to burn will not only help emissions but also help to maintain the facility and keep it running as efficiently as possible. There are also two proposed measures to treat the plant's emissions. An electrostatic precipitator would treat the particulate matter, and for NOx control a Selective Non-catalytic Reduction (SNCR) system would inject urea into the emissions in the stack, thereby reducing NOx to CO2 and nitrogen gas. It is assumed these treatments have been included in the emission estimates above. One promising piece of information comes from Middlebury College in Vermont. The college opened a similar gasification plant in 2009 and their website states they have achieved "99.7% efficiency of biomass plant's exhaust system in removing particulates" (Middlebury).

A major factor of this decision will come down to a comparison of current greenhouse gas (GHG) emissions from the natural gas system to the emissions from a biomass gasifier. GHG emissions alone will not account for all of the health concerns, but the health effects of the added emissions of concern will be nearly immeasurable. The comparison in sustainability appears to be most pertinent.

Phase Three: Disposal

The major health concerns for the solid waste from a biomass gasification plant are contaminates and particulates. Heavy metals such as lead will not be emitted, and will stay in the resulting residue. This could be a major concern is it comes in direct contact with people or a community. However, if the proposed application of ash as a soil amendment is considered, this concern may be lessened. Despite the possibility that these heavy metals could be absorbed by plants growing in the soil, the application of the ash itself could actually reduce the likelihood of that happening (Moilanen). In terms of air quality, due to the average particle size of standard wood ash, any resulting residue should pose no threat to raising airborne particulate levels, and especially not so if incorporated into soil.

Natural Gas Health Concerns

While TESC examines the ramifications of installing a new biomass gasification facility on human health, it is also important to compare the impact of the current facility. There is a need to know whether or not this change would be positive or negative, regardless of whether or not the actual numbers are “good.”

The current heating facility installed at TESC is a gas-burning boiler. In examining the changes made to the equipment, there would be little modification, the biggest difference being the addition a new piece of machinery to process the fuel (McKinstry). The biggest difference along the life cycle is the fuel source. Natural gas needs to be drilled for, extracted, refined, transported, and stored. The current supply arrangement is with Puget Sound Energy (PSE), which pipes the gas directly to the site.

The line of progression starts with the gas trapped deep underground. Wells are drilled into pockets of gas trapped in rock deposits. These deposits are then fractured and scrubbed for hydrocarbons by pumping liquid solutions down to increase the ambient pressure. This also causes the gas to displace, thereby equalizing the pressure. As soon as the gas is released, it is piped directly to be refined.

This gas is extracted by wells is sent to a fractionator, which separates the liquid gas into its component parts. Unrefined natural gas consists of mostly methane, but also can contain heavier hydrocarbons like ethane, propane, butane, and pentane. Other than hydrocarbons, one can find acid gases like carbon dioxide and hydrogen sulfide, other gases such as nitrogen, helium, radon and water vapor, as well as liquid water and mercury. To be usable, it is separated to be free of particulates, water, mercury, and only trace amounts of acid gases (Department of Energy). The final outcome is almost pure hydrocarbons, mostly consisting of methane.

After processing it is transported directly to a pipeline and sent to consumers or a storage facility, which is located for PSE underground at Jackson Prairie in Lewis County, ten miles south of Chehalis, Washington. The gas is stored in sand layers approximately 1000 to 3000 feet below the ground. A total of 45 wells inject and withdraw gas into total storage of 23 billion cubic feet located in an area of 3200 acres. Most of that area is privately owned for timber production and livestock grazing (PSE).

The piping to and from all sites is generally made of steel, and buried underground. There is a meter and compressor at the destination, allowing constant pressure and accurate readings of usage (PSE). After the gas has reached its end destination, it is burned cleanly, releasing mostly carbon dioxide, trace amounts of sulfur dioxide and nitrous oxides, and almost no particulates. The levels of carbon dioxide emitted from natural gas combustion are half that of coal for the same amount of power generated, and the other pollutants only fractions (EPA).

In terms of human health, if appropriate safety protocols are followed carefully, there is little to no risk. However, accidents can occur and it is important to evaluate where potential problems can arise. There are risks at all levels of the production process. Starting with drilling, there are obvious mechanical hazards. Additionally, the hydraulic fluid used in the fracturing process can affect surrounding communities. This fluid contains hazardous materials, and improper well lining can cause these to leak into drinking water reservoirs. Although there have been no scientific studies of this nature, it has been reported. According to the Natural Resource Defense Council (NRDC), there are many communities across the country that have had their groundwater contaminated or are in danger of being contaminated (Manuel).

The true nature of the issue will be concluded by an Environmental Protection Agency (EPA) study. Funding has been allocated for a life cycle assessment of the fracturing process, as well as its effects on groundwater and health (Manuel). This study should lead to increased regulation and subsequent reduction of health risks for this part of the natural gas consumption process.

While this phase of production may have the most long-term damaging effects, there is always a danger of leaks and subsequent explosions throughout the entire process. With thousands of miles of piping there is a large potential for leaks, but there are many safety measures in place to prevent this. There is also an education campaign to “call before you dig” to prevent construction from striking natural gas lines (PSE).

Lastly, the gaseous emissions from natural gas combustion are negligible, but if concentrated without proper ventilation, can cause serious health concerns up to and including death. Considering the layout of the natural gas plant at TESC, this is not an issue. Particulate matter levels from natural gas are also negligible (EPA). With proper ventilation, such as at TESC, natural gas combustion causes no health risk.

In conclusion, with proper equipment, safety measures and awareness, the use of natural gas as a fuel poses no known risk to human health. Without any one of these, natural gas production can cause harm on a localized level to surrounding communities. From this standpoint, it may be better to stay with the current facility, as there is a chance with the new fuel source for new, more complicated health issues to arise. However, there are serious health risks to consider at the point of extraction.

Conclusion and Recommendation

The Evergreen State College has a responsibility to its students, faculty and campus employees, as well as to the greater Olympia community, to examine all of the potential human health problems, both immediate and long-term, that could arise from installing a biomass gasification plant. In addition to exploring the health issues surrounding biomass, it is also necessary to compare them to the current natural gas heating system. The immediate heath problems from phase one are only related to those who would harvest and transport the slash. While there is a higher rate of injury and fatality in the logging industry, TESC's demand for slash would be not be high enough to warrant an significant increase in logging activity. The long-term health effects from phase one are related to the particulate matter emitted by the diesel trucks that would transport the slash to campus. The immediate problems of phase two would only have an effect on the workers in the CUP. With proper training, many of the dangers of operating the plant will be significantly reduced or eliminated. The long-term problems with phase two go as far as the added emissions. And while there more is being emitted, the effects it will have are almost immeasurable. Even with the added emissions, it appears that spending time at TESC would be no worse on a person's health than other more concentrated exposures, such as traffic jams or second hand smoke. In regards to phase three, while there are concerns over heavy metal content in the wood and resulting ash, no additional particulate matter would be produced. Although the emissions associated with natural gas are minimal, there are a number of health problems and work-related injuries that can occur in the processes leading up the actual use of it in the CUP.

Biomass gasification could be a very positive addition to The Evergreen State College in the future. The Thurston County Commissioners have placed a yearlong moratorium on all biomass facilities within the county and the college can use this time to its advantage. By waiting to make a final decision on biomass, the college can allow for further research to be done on all aspects of the project and more specifically, the human health impacts. This time can be used to conduct a survey of source specific emission levels, which will produce more accurate figures of emissions from the college's potential biomass facility. It will also be beneficial to research possible energy alternatives that are not only feasible in terms of cost and production method, but also have minimal or no health risks. Most importantly, the college can use this time to engage the community, both on and off campus, in a more open and transparent discussion and decision-making process in regards to biomass gasification at TESC.

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Chapter 6: Economics: Natural Gas Or Wood Chip Gasification

Tyler Howard, Gary Williams, Daniel Fitzgerald, Robert Weltman

Introduction

Biomass gasification is thought to be an excellent alternative source of energy to Evergreen's existing natural gas heating system. Combustion to generate energy has been commercially viable since the 1970s, and started using everything from tires, garbage, and coal as fuel. The State currently projects that woody biomass will be the fuel of the future in Washington; gleaning slash from the forest floor could be a renewable source for energy. However, exploring such new alternatives for energy, such as biomass gasification, it is important to also examine its effects on the environment, the financial aspect, and finally the overall benefits that the new source of energy would have for The Evergreen State College.

The Evergreen State College (TESC) is preparing to implement a biomass gasification plant. The maximum cost of the plant is $12,675,996 million. Evergreen has already been awarded a $3.7 million grant from the Washington State Department of Commerce as a part of the 2010 Jobs Act (McKinstry). Evergreen has also requested $4 million in appropriations from the 2011 State Budget, which has yet to be approved. It is expected that the rest of this project will be financed through energy savings bonds.

Will this plant bring jobs to the area, will it save the college money, and will it be a fiscally sound investment for the future? With the energy market always in flux, could the project be a financial burden to Evergreen if the market has a downturn? Relying on the undeveloped energy market for answers leaves uncertainties in the financial aspects of the project's future.

Who Pays for this Project?

There are two viewpoints for this question. One would be a viewpoint of shared financial responsibility between Evergreen and the state of Washington. Washington, through grants and appropriations, essentially "gives" Evergreen some portion of the final cost of the project. Evergreen uses this state "gift" to pay a certain amount of the total project cost upfront, and then finances the rest of the project through a third party lender. Through this lens, we can evaluate the project in terms of its impact on Evergreen and its operating budget, since we are treating Evergreen money and state money as coming from two different sources. When a Cash-Flow Financial Analysis (CFA) is conducted under this viewpoint of shared financial responsibility, we can find how fast the project will pay back Evergreen's capital investment, how much money Evergreen will pay the third-party lender, and determine if the project is in Evergreen's best interest to undertake.

Another way to look at the situation is to look at Evergreen, a state institution, as an extension of Washington. When taking this viewpoint of collective funding, one would view the grants, appropriations, and Evergreen's total budget as all coming from the same source (the state of Washington), which means that Washington would pay for a portion of the project upfront and then finance the rest of the project cost over a period of time. A CFA will help to uncover whether the total cost of upgrading the utility plant to use a biomass gasification system will pay for itself through the savings that will come from switching from natural gas to local woody biomass.

How might this project save Evergreen money?

Essentially, Evergreen is contending that there is a significant fuel cost saving involved with switching from natural gas to biomass. Natural gas prices have not only been volatile for the last several years, but are also predicted to rise drastically over time. According to the United States Energy Information Administration, the price of natural gas has been rising at a rate of roughly 6% over the last 6 years (US Energy).

Cash-Flow Financial

A Cash-Flow Financial Analysis (CFA) would help Evergreen to recognize under what scenarios the project might fail or succeed to pay for itself over the facility's useful lifetime. It is a comparison of the cash flow generated by a new upgrade when compared to the cash flow of the old system. In the case of Evergreen, the CFA will compare the net fuel cost savings (along with other savings) that Evergreen could attain by switching from heating with natural gas to heating with syngas generated from biomass, to the total project cost or the total financed amount for the project. When calculated over the lifetime of the project, the CFA can calculate various scenarios to determine if the project is likely to pay for itself over the project's useful lifetime.

Since we cannot know for certain what future market conditions will be like, we cannot make a responsible decision on the matter without first considering how a host of different market conditions could affect the viability of the project in the long term. By testing many different arrangements of future market conditions on this financial model for Evergreen's proposed facility upgrade, Evergreen can spot ahead of time certain market conditions that could cause problems for their proposal and make a more responsible choice based on current knowledge.

I. What items in the analysis are constants that will not change?

Excluding the cost of purchasing the natural gas fuel, the costs of operating and maintaining the current natural gas facility should not change from one scenario to another. Neither should the final project cost, nor the cost of operating and maintaining the proposed biomass gasification facility (once again excluding the cost of purchasing the woody biomass fuel and volatility of transportation costs).

In summary, the following is a list of the constants in this proposed CFA:

- Operation and maintenance costs of the current natural gas facility (minus fuel costs)
- Final project cost (not including grants or other financial assistance)
- Operation and maintenance costs of the proposed biomass gasification facility (minus fuel costs)

II. What are the variables in such an analysis, and how will they change?

There are seven variables that need to be manipulated in various permutations to determine the sensitivity of the entire cash-flow system:

In summary, the following is a list of variables to be included in the CFA, accompanied by a prediction of how they will likely change over the long term (where applicable):

- Rate at which the price of natural gas increases
  - Will likely remain constant or increase slightly.
- Rate at which the price of wood slash (biomass) increases
  - Will likely remain constant or increase slightly.
- Rate at which the price of diesel increases
  - Will likely remain constant or increase slightly.
- Interest rate at which Evergreen finances the project
- Rate of carbon tax if biomass facility is carbon neutral
  - If a carbon tax is implemented, then it is likely that the rate that is charged for every ton of CO_2 will also slowly increase over time.
- Rate of carbon tax if biomass facility is not carbon neutral
  - If a carbon tax is implemented, then it is likely that the rate that is charged for every ton of CO_2 will also slowly increase over time.
- The amount of funding for the project that is provided from sources outside of Evergreen and the third party lender

Conclusion and Recommendations

We can look at this overall analysis as a grouping of predictions of the financial viability of this biomass gasification project under different scenarios. It would be useful to look at the ratio of scenarios that end in the project being viable compared to the total number of scenarios looked at. If, for example, only half of these many and various scenarios end in the project being viable financially, then it would be prudent to take a closer look at the monetary aspect of the biomass project and find out why so few scenarios are in Evergreen's favor. If, however, the strong majority of scenarios end in the project being viable, then the project probably will end up being a good move for Evergreen from a financial standpoint.

We recommend that the TESC Sustainability Council and the Evergreen State College as a whole:

- Conduct a multiple, variable Cash-Flow Analysis for this project, as is outlined in this report, to better understand the sensitivity of this system to certain variables.
- Use the one-year moratorium enforced by the Thurston County Commissioners to have a group of students and faculty who specialize in economics study this aspect of the proposed biomass project.

This group is giving neither a definite “yes” nor “no” vote on this project, as we believe that more research is needed for the question of whether this project is economically harmful or not to Evergreen and the surrounding community.

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Chapter 7: Alternatives to Biomass: Considering a Different Path

by Andrew Nepstad, Brent Polmueller, Jeff Michael

The impulse of sustainability is woven into the administration of the Evergreen State College, and following that same vein, we must deliberate upon what course of action shall be the wisest given our circumstances. The majority of the effort in research for renewable energy options has been focused on biomass gasification, yet there remain some options that have yet to been examined with quite as much intensity. This paper will explore the feasibility of some options for a carbon neutral heating system for Evergreen. Variable Refrigerant Flow, an air source heat pump technology, appears to be the most promising option. Wet or dry anaerobic digestion could make use of waste generated on campus to produce methane for combustion. While these alternatives alone would not supply 100% of the college's heat, they could be used together, coupled with the practice of purchasing responsible carbon credits or offsets, to cover the carbon footprint of Evergreen's heating and hot water demand.

When making a foray into the plethora the many energy options available today, one could ask, is there such a thing as carbon neutral energy? No matter what energy source is explored there will always be adverse effects on the ecological, social, and political situations around the given idea. Extraction and transportation of materials, maintenance of the system, and disposal of waste materials will inevitably lead to some carbon output no matter how 'green' the energy option may be. Fossil fuels will be intrinsically linked to whatever application is chosen so there is no possibility of a completely carbon neutral energy system. It is important to analyze the trade-offs linked to our choices for renewable energy and make decisions based on the balance between the positive and negative impacts.

VRF: Using Efficient Electricity to Reduce Carbon

The main human impact on the destabilization of the climate is carbon dioxide, the byproduct from combustion-based energy sources. Biomass, although deemed carbon neutral by the state of Washington, releases more carbon from the point of combustion than our existing natural gas system. Some argue that the growing forest will reabsorb the carbon, but the different time frames of combustion and growth are of concern. Renewable energy that does not rely on combustion would alleviate this concern. In conjunction with purchasing renewable energy, Evergreen should explore a highly efficient form of electric heating and cooling called Variable Refrigerant Flow (VRF). This option could prove very effective in lessening the use of energy need to heat the campus, thus easing the transition towards carbon neutrality. Using VRF systems at Evergreen could completely eradicate the need for natural gas along with reducing electrical usage by an average 30% compared to the current HVAC systems (*Bettridge & Middleton*).

Variable Refrigerant Flow systems, which have been around for 25 years, use air source heat pump technology. Throughout the world many countries are utilizing these systems as their primary source for heating and cooling. VRF systems are very popular throughout Asia and Europe. Japan already utilizes VRF systems in more than a third of their largest commercial buildings and in over half their medium sized buildings. Over 90% of all new construction in Japan and 80% in Europe is utilizing VRF technology, which brings about the question as to why America has taken so long to jump on the bandwagon (Tolga). There are at least 10 college campuses and a dozen lower education public schools in Washington and Oregon already benefiting from VRF systems. Case studies available on these schools show between 25 and 50% annual energy savings (Mitsubishi).

VRF is a refrigerant system that uses an outdoor compressor unit and multiple indoor units. The outdoor condenser pressurizes refrigerant gas to raise its temperature. The heated gas is then sent through a condenser coil to radiate its heat to the outside air. This cools the gas to a liquid form and expands, losing pressure and becoming a cold gas. The gas is piped to the indoor units and is pushed through the evaporator coil. To finish the process, the refrigerant flows back outside and is condensed to exhaust its absorbed heat. VRF systems also utilize the ability to transfer hot or cool air between areas in a building. Advanced controlling technology along with inverters allow VRF systems to moderate exactly how much heating and cooling refrigerant is delivered to each zone (*Tolga*).

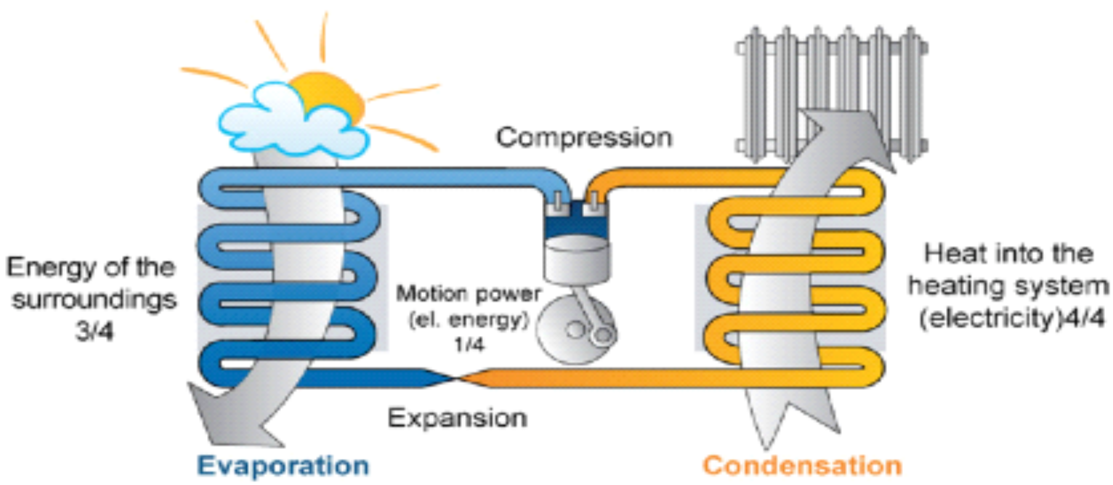

Figure 6: A diagram of VRF technology (Mitsubishi).

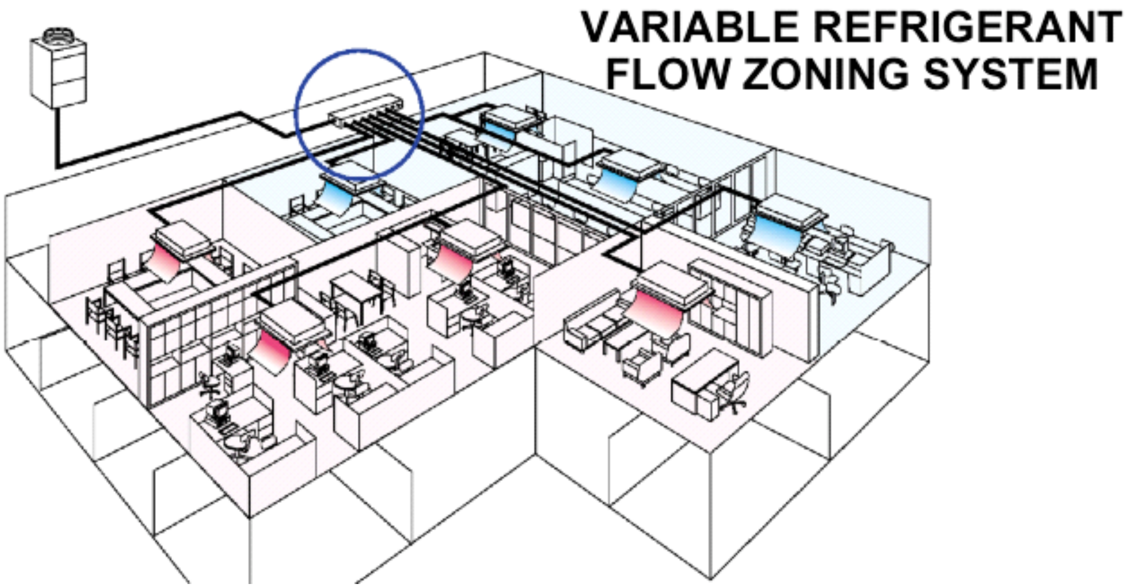

Figure 7: This VRF diagram depicts one external compressor supplying air to interior zones. The areas with more heat are transferring cool air from other areas, and vice versa (Mitsubishi).

With the ever-expanding technology in VRF systems, efficiency continues to improve. With the multi-split VRF systems available from Mitsubishi, energy consumption is reduced by up to 50% while in heating mode, and an average of 25% in cooling mode (Mitsubishi). The initial cost of a VRF system can fluctuate dramatically depending on installation options. Grant Middleton, the Northwest Engineer for Mitsubishi Electric, has proposed that a City Multi VRF system would be the most suitable for Evergreen.

A common concern regarding installation costs of VRF systems is the electrical load capacity of the existing buildings. Middleton assures that the system is so efficient that electrical service at Evergreen will not need to be increased to support it. Another myth behind VRF is that its technological complexity would require many new jobs at Evergreen. The reality of this issue is that no new positions would be required, and Mitsubishi provides local training that any adequate engineer would quickly grasp (Middleton). The total cost of installation and retrofitting for a City Multi VRF system throughout Evergreen will vary between $15 (Middleton) and $25per sq. ft (Bettridge).

Since being introduced to the United States in 2002, VRF is rapidly becoming an eco-friendly addition to our energy system. The energy savings of the technology are not disputable and are easily powered with the preexisting renewable power sources. Having a 300% heat efficiency ratio means that for every KW of energy, 3KW of heat are produced. The leading conventional HVAC system achieves about 85% efficiency and most HVAC systems achieve less than 70% (Middleton). It is not a matter of if VRF is going to be the dominant heating source in America, it is rather when.

Biogas through Anaerobic Digestion: Making our own fuel

A promising and efficient process called anaerobic digestion should be studied by Evergreen because it has the potential to use waste generated on campus. This process would address not only the goal of carbon neutrality, but also zero waste by 2020. This is a very important option to consider with the nationally growing bad sentiments regarding biomass energy in our region.

Anaerobic digestion is the process in which some sort of biomass is broken down by microorganisms in an oxygen-depleted environment. The process is done in a closed system that allows variables such as heat, pH, and moisture content to be precisely controlled. This process allows natural decomposition of organic waste to become accelerated, generating excess energy that can be used.

One way anaerobic digestion can be beneficial to Evergreen is using the food and vegetative waste from the various eateries, gardens, and the Organic Farmhouse with a process known as dry anaerobic digestion (DAD). DAD uses relatively dry organic solids. This option on a small scale is great because Evergreen could save some money on the shipping of compost waste while simultaneously creating an efficient biogas for use on campus.

The potential of DAD in the future is quite promising. Some researchers are finding that using DAD can make a “super” biogas enriched with the essential energy element, hydrogen.

> *"When hydrogen is mixed with methane and used for engine generators," explains Dr. Zhang, "the fuel will be cleaner and the emissions will be much less than using just methane. Another benefit is to use the hydrogen in fuel cells." Dr. Zhang is now on the verge of making her anaerobic digester technology commercially available* (Ryan Newhouse).

Along with food and organic waste a potentially great resource for anaerobic digestion would be solid human waste. This would be more feasible using wet anaerobic digestion (WAD). This is used currently in waste disposal and water reclamation systems locally and is used primarily for that application. This option would decrease the cost of transporting, treating, and storing the waste by an outside agency, thus decreasing carbon output. Along with a useful way to process waste the biogas production can get up to 60% weight by volume of digestible materials (Progress).

Anaerobic digestion is a good way to use waste products and reduce the need for outside resource, however, the feasibility of using it as a complete alternative to biomass gasification is unrealistic. Evergreen produces roughly 300 cubic yards of food waste per year (Lemay). This is much less than what the school would need. The biomass gasifier that is proposed will need roughly 5000 bone dry tons of biomass to produce 4 kWh of energy (McKinstry). With this amount of materials the heating needs of the school would not be met with this technology alone. One can estimate even with a substantial yield of biogas from the process, anaerobic digestion would at best be a good resource to be used in conjunction with other renewable energy options.

The technology of anaerobic digestion is able to process biological waste, but there are limitations to the process. Anaerobic digestion systems are best designed for waste processing or methane production. If the aim is methane production, the quality of the feedstock is not critical. In the aim of our college to reduce not only carbon emissions but also all greenhouse gases, the quality of the feedstock is critical because of the concentrated emissions that could be produced during the process.

Carbon Offsets and Credits: Let the buyer beware

Since the passage of the Kyoto Protocol there has been a surge in interest in the creation of a carbon-market. One group pays another group to not emit a certain amount of carbon, compensating for their own emissions. Through the purchase of a carbon 'offset', one is telling someone not to pollute a certain amount, and then the credit seller is expected to follow through on his or her word not to pollute. In Europe, the European Union Emissions Trading Scheme oversees about half of the carbon emissions made in the continent, allowing for some measure of stability within the market. In the United States, the venture remains more or less completely unregulated by the government, relying only on industry groups to self-monitor. These business oversight groups have a vested interest in looking the other way or have looser standards. Should Evergreen choose to pursue the route of purchasing carbon credits to mitigate (or repent for) our campus's institutional waste, it would be necessary to assure that all credits are purchased from groups that meet standards such as Climate, Community & Biodiversity or Clean Development Mechanism Gold.

Assessing the viability of carbon credits as a means to transition Evergreen into a carbon neutral institution means looking at the long-term availability of financial resources. To regularly purchase carbon credits at any price would require a reserved amount in the operating budget to offset current emission levels. It is obvious that carbon credits do not address the issue of peak oil, the fact that fossil fuels are finite and therefore should not be depended on for long-term sustainability. The real task of reducing the great mass of waste produced by Evergreen begins with reassessment of the day-to-day practices of consumption and waste by the students, staff, and faculty of the college, as well as infrastructural changes to problematic areas, such as areas of low energy efficiency.

Although the way forward may be murky, the great importance of our task remains clear. To address our collective responsibility for the destruction of our surroundings, we must examine the habits of the college from the ground up. Carbon credits do have a utility in a market system, placing financial burden on polluting groups, but they are by no means sufficient by themselves. Carbon credits are only one step in the bridge to sustainability.

Conclusion and Recommendations

In concluding our research, we have found that Variable Refrigerant Flow is a potential alternative in terms of engineering and cost effectiveness. The goals of Evergreen's Climate Action Plan are inherently met by using VRF systems, supplemented by carbon credits and innovative structural renovations. VRF eradicates the need for combustion-based fuels. However we shouldn't consider it to be the silver bullet to our heating and energy consumption problems. Increasing efficiency and conservation should be the first steps in addressing issues of energy consumption. Anaerobic digestion could be used on a smaller scale to heat the buildings for which VRF may not be well suited.

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Chapter 8: Political and Social Environment

Dani Madrone and Jelica Summerfield

> *"Energy issues in particular can [be] (and often are) killed in the final hour not because of technical or financial issues but because of social issues. It is extremely important to approach energy sources—such as forest biomass in the PNW—with extreme caution and patience. Engaging diverse stakeholders, building trust, and being transparent is also essential. The 'process' of exploring a biomass plant at Evergreen would seem to make for excellent student research!"*
>
> John Pumilio, former Director of Sustainability
> at The Evergreen State College

The recent emergence of industrial-scaled biomass energy in the United States has divided people across the nation. Divisive arguments are on the rise between and among environmentalists, governments, and neighbors. The complicated social dynamic has compromised the ability of communities to manage their resources in a civil and sustainable manner.

Both the city of Olympia and the Evergreen State College are known as hubs for activism, so it is no surprise that a biomass gasification project at Evergreen has come under a great deal of scrutiny. To address the sustainability of biomass gasification on campus, it is important to study not only the ecological and economic impacts, but also the social and political environment. This terrain can be observed by exploring the process of the project and the relationships of those involved.

Some argue that the scale of biomass at Evergreen is insignificant when viewed in a global context, especially in comparison to Adage, the largest and least efficient biomass facility proposed for the region. Others argue that the impacts of this project, for better or worse, are much more significant. Evergreen is not alone in turning to the forests in its quest for renewable energy. Biomass has been realized by many private and public entities as an untapped resource in the forested region of the Pacific Northwest. Can Evergreen model a responsible local resource system? If so, how many biomass energy systems could our region support? Will others look to Evergreen as a guide or a justification?

This chapter reviews the current process at Evergreen, beginning with the decision-making framework. The scope is then expanded to cover the State of Washington and its interests in ecosystems and energy, and also the impact on the local community that led to the Thurston County biomass moratorium. The chapter concludes with recommendations that could lead to a more engaged community with an open and well-planned process.

This report is based on interviews with stakeholders, along with research of campus and public policy, and local media to map the social terrain. This report is co-authored by students Jelica Summerfield and Dani Madrone. Dani holds a position at the Center for Community-Based Learning and Action (CCBLA) at Evergreen. Her position is a fellowship funded by Learn and Serve, and her list of responsibilities includes community engagement for the biomass project on campus, and managing elements of the Climate Action Plan. Much of the information listed below is based on her involvement in the process.

A Review of the Current Process

We will not move forward unless it is proven to be a good idea.
We will move forward unless it is proven to be a bad idea.
We are moving forward.

These three sentences guide a diverging vision for the consideration of biomass gasification at Evergreen. The first sentence has been guiding the process of evaluation by the Sustainability Council in its feasibility study. It suggests objectivity and doubt, a need for the precautionary principle. The second sentence has been guiding the process of planning, a responsibility of Facilities. Certainly, it does not make sense to commit to a deep exploration of the sustainability of this project if it is not technically or economically feasible. The third sentence has been guiding the process of funding, under the purview of Finance and Administration. In this economic environment, no one is reserving financial resources for a project that may or may not happen. A deeper look will provide an understanding of the decision-making framework at Evergreen.

The Strategic Plan, updated in 2007, describes the goals and directions of Evergreen as an institution, along with the principles that will guide development. It incorporates the value of a laboratory for sustainability and the goal of carbon neutrality by 2020. The final statement of the Strategic Plan are the next steps, "We will develop specific operational plans to pursue the strategic directions and achieve the stated goals. We will tie these plans to established metrics and milestones to ensure forward progress and long term success" (Strategic Plan, 15). The relevant operational plans that were developed as a result of the Strategic Plan are:

- The Climate Action Plan: A plan that strategizes carbon neutrality by 2020, to provide direction to the Sustainability Council. President Purce and the Board of Trustees approved this plan in September of 2009.
- The Campus Master Plan: A comprehensive plan that establishes priorities for development of Facilities. President Purce and the Board of Trustees approved this plan in 2008.
- The Ten-year Capital Plan: This plan is used by the State as it prepares the budget for higher education and the plan also guides the department of Finance and Administration. President Purce and the Board of Trustees approved this plan in the summer of 2010.

Biomass Feasibility Study: The Sustainability Council

The Sustainability Council is charged by the Vice Presidents to coordinate, facilitate, and support the success of the sustainability goals of Evergreen, including carbon neutrality by 2020 under the Climate Action Plan. The formal composition includes a chair, the Executive Director of Operational Planning and Budget, a student representative and designees from the four Vice Presidents at Evergreen. The designees include the Directors of Facilities, Residential and Dining Services, and Communications, as well as the Academic Budget Dean. The Council is currently lacking a faculty co-chair, and the process for filling that position is undefined. Advisory members are non-voting participants and include the Sustainability Coordinator and students, staff, or faculty who show a regular interest.

The largest hurdles to carbon neutrality are heat and energy. The Climate Action Plan (CAP) calls for on-site renewable energy, and the first action is to form a Renewable Energy Disappearing Task Force (DTF) in 2011-2012. The DTF is to investigate on-site energy generation, renewable energy credits, and the student clean energy fee, including community input and engagement. The recommendation from this group is due to the Sustainability Council by April 2012 (CAP, 55). According to faculty of the Agenda Committee, the committee responsible for assigning governance duties, the formation of such a task force would take place in Summer 2011 for the 2011-12 academic year.

In Summer 2010, the Council was charged by the Vice Presidents to conduct a feasibility study of biomass. Biomass gasification is a strategy of the CAP slated for the 2013-15 biennium. At the time of publication, biomass was considered unquestionably carbon neutral, as stated in the CAP, "because the amount of carbon released during harvest, transportation and gasification of the fuel crop is sequestered by the crop itself, creating a discrete carbon cycle" (CAP, 59-60), an assumption which has since been challenged.

Concerns listed in the plan include fuel sourcing and forest management practices, carbon cycle analysis, costs compared to natural gas, and an economic analysis of the fuel supply market and regional impacts. The first action listed is to secure funding. Other steps, including planning and fuel source development, mention the incorporation of educational programs at Evergreen (CAP 59).

On July 16, 2010, the Sustainability Council organized a biomass gasification planning meeting. According to Steve Trotter, the chair of the Council, the purpose of the meeting was to define the scope of the feasibility study. A group of participants that included representation from a broad base of stakeholders and a diverse range of perspectives on biomass attended this meeting. The concerns that were identified included questions of climate impact, forest ecology, human health, economics, alternatives to biomass, and the impact on the local community (Evergreen, "Biomass"). The Council has the responsibility of collecting and analyzing information on these topics of study and to make a recommendation to the Vice Presidents.

With the charge to conduct this study on biomass, there has been a clear deviation from the Climate Action Plan. Especially given that the carbon neutrality of biomass energy has been challenged, it is important to establish a deliberative process to study the impacts on the climate and explore the alternatives. Additionally, the Council has been charged with an in-depth evaluation of topics that go beyond its area of expertise. As mandated in the CAP, a Renewable Energy DTF for this task should be appointed in the summer of 2011 with a plan on how their recommendation would affect the final decision. The DTF should contain faculty, staff, and students who are knowledgeable in climate science, renewable energy technologies, human health, forest ecology, and resource management.

Capital Construction: Facilities

The construction of any facility on campus is a long-term investment in the infrastructure of the school. Planning and construction for capital projects are the responsibility of the Director of Facilities, a formal member of the Sustainability Council. The priorities of campus development are established in the Campus Master Plan (CMP), which is described as a living document that will be frequently revised and updated. The Campus Master Plan incorporates the goal of carbon neutrality and outlines some strategies for energy conservation. There is no plan for biomass energy, though there is a recommendation for an Alternative Energy Education Center to be built into the Central Utility Plant (CMP, 67). The possibility of running the current system on biofuels is also mentioned, with a recommendation to study the viability of geothermal heat pump systems (CMP, 92).

The most impressive component of the CMP is the detailed description of the process. Along with community dialogue and stakeholder involvement, the process is described as "intensive, inclusive, collaborative, and based on the philosophy of 'placemaking' and 'building community'." The planning was divided into three tasks:

- Goals, Objectives, and Needs Assessment
- Alternatives and Evaluation
- Recommendations and Implementation

Campus and community gatherings were organized over the period of a year in the writing of this plan (CMP, 25). Revisions and updates of this plan should follow these values and actions to maintain the integrity of the planning process.

Though a biomass gasification system has yet to be included in the Campus Master Plan, the planning process for biomass gasification has been initiated. The standard procedure for construction projects on campus is to first contract a predesign, and then follow the design, bid, build (DBB) process. Because this project is an energy project that could save money through energy savings, it was pursued through the Energy Savings Performance Contracting (ESPC) process. ESPC is a process that involves a contract that provides a predesign and guarantees specified financial savings for energy costs. Leveraging those savings with grants, utility rebates, and capital dollars from the State allows financing within existing operating budgets (GA, 4). This process was initiated by an interagency agreement between Evergreen, the General Administration, and an Energy Services Company (ESCO).

Funding for the predesign was solicited from the students, the college, and the state. The Clean Energy Committee (CEC), a student-led group that allocates a student fee for renewable energy, received a proposal from the Chair of the Sustainability Council and the Director of Facilities in October of 2009, one month after the adoption of the Climate Action Plan. The CEC awarded $125,000 with stipulations of student involvement and transparency (CEC). Matching grants came from Evergreen through a grant from Puget Sound Energy and the State, totaling $375,000.

A more thorough investigation of renewable energy for campus should be conducted through the process that was used in the creation of the Campus Master Plan. This work could be done in tandem with a Renewable Energy DTF to provide an update to present to the Board of Directors for approval for the 2013-15 biennium.

Funding: Finance and Administration

The process for funding biomass gasification began after President Purce and the Board of Trustees approved a 10-year Capital Plan in July 2010. The plan includes the construction of a biomass gasification facility with an estimate to start the design process in July 2011 and the construction date beginning May 2012 (Capital Plan, 193). The Vice President of Finance and Administration is leading the funding process through Facilities, the Office of Government Relations, and the Executive Director of Operational Planning and Budget, who is also the chair of the Sustainability Council.

The first action taken to fund a biomass gasification plant on campus was an application from Facilities in July of 2010 to the Department of Commerce, which funds projects designed to increase jobs through energy-saving projects at educational institutions. The original proposal for $5 million was not funded. The application was resubmitted in September and Evergreen received a $3.7 million grant, which would cover nearly 30% of the total project cost of $12.6 million. To maintain this grant, the college has to be under contract to build the biomass facility by June 30, 2011which would initiate the design process (Dodge "Two").

Also submitted in September 2010 was a request to the legislature for $4 million dollars to fund biomass gasification. This item was not included in the Governor's state budget, however, at this time (early March, 2011), there is still an opportunity for funding if the legislative branch prioritizes the project. The Office of Government Relations is lobbying for biomass to be included in the capital budget. One of its documents states, "A key component of the feasibility study is to determine the availability of the necessary wood waste stream. Currently, the thought is that this stream may be made up of urban wood waste from the neighboring cities/counties, construction wood waste, and forestry wood waste from harvesting operations on both family farms and major corporate forest areas" (Evergreen, "Capital Projects"). This statement is in conflict with the study of the

Sustainability Council, which is only considering forest slash from forests certified by the Forest Stewardship Council.

If Evergreen can secure capital funds, the remaining costs can likely be funded through bonds repayable through energy savings. According to Paul Smith, the Director of Facilities, the bonds would come in the form of loans from the State, to be paid back in either 10, 12, or 15 years with money saved by switching from natural gas to biomass (Smith).

Again, there is clear deviation from the Climate Action Plan. With the adoption of the 10-year Capital Plan, the President and Board made a formal decision to build a biomass gasification system at Evergreen in the 2011-13 biennium. This is inconsistent with the 2013-15 timeline of the CAP. The lack of unified vision between the processes is also noticed in the description of the fuel source. While the work of the Sustainability Council has been focused on responsible sources of forest slash, the information being used to solicit funds for construction includes corporate forestry.

Summary of the Process: The Decision Making Framework

The Board of Trustees and President Les Purce hold the most power in the decision of whether or not Evergreen will move forward with biomass gasification. Three formal recommendations will be issued to inform the decision, based on sustainability, technical and economic feasibility, and available funding. Within this decision-making framework, there is an unbalanced distribution of power, leaving almost no influence from the students or faculty of Evergreen. The majority of the Sustainability Council is made up of designees of the Vice Presidents. The chair of the Council is also the Executive Director of Operational Planning and Budget. The Director of Facilities serves on the Council, is managing the planning of the project, and is involved with soliciting funds. The Vice President of Finance and Administration is among those who will be writing a final recommendation for the President.

The decision-making process at Evergreen can be either superseded or supported by higher authorities whose control extends beyond campus. Since Evergreen is a state institution, relying on Washington for the funding of this project, it is important to consider the views of biomass on a state level, and how the public reaction can influence representatives. There are also local governments who intend to have a say in the final decision, such as the Thurston County Commissioners.

Biomass in Washington State: Legislation and Environmental Regulation

Legislation

In the 2011 legislative session (the 62nd Washington State Legislature), biomass has surfaced as a contentious and popular item. At a glance, there are no fewer than seven bills dealing directly with the production or regulation of biomass as an alternative energy source. For example, House Bill 1422 would, "authorize the Department of

Natural Resources to develop and implement a forest biomass to aviation fuel demonstration project" (Authorizing). The bill's content outlines the ways in which biomass fuel production must meet set standards, not unlike those proposed by the Sustainability Council in regards to Evergreen's own proposal. The biomass initiative must be both economically and ecologically feasible, generate income, create jobs, and comply with current efficiency goals. Other bills focus on permitting regulations and definitions: HJM 4002 would "exclude biomass combustion emissions in calculating greenhouse gas emissions and remove all rules relating to biomass combustion" (Concerning).

House Bill 1081, introduced to the Legislature in January 2011, provides an example of public concerns directly influencing alternative energy politics. In its original text, the bill would have allowed for various small-scale alternative energy projects to be sited in a timely manner, where permitting standards have not yet been established. Wind, solar, geothermal, landfill gas, tidal and biomass were specifically referenced as the types of facilities allowed by the bill (Regarding). After uproar from community members, the bill was amended to specifically exclude biomass as one of the renewable energy options in this bill.

Due to the volume and apparent emotional weight of legislation regarding biomass, critics such as the Concerned Citizens of Thurston County (CCTC), have requested that Evergreen and other biomass advocates wait before making their final decisions (Concerned Citizens). Just as the Sustainability Council must weigh various sides to the issue, the State government is doing the same. Biomass regulation is new to politics, and stakeholders like CCTC would like to see the current legislative frenzy settle down before making drastic changes or decisions like creating Evergreen's proposed facility (Concerned Citizens).

State Environmental Policy Act

An issue brought to bear at several community and campus meetings is the lack of a formal State Environmental Policy Act (SEPA) process at this time. SEPA "provides the framework for agencies to consider the environmental consequences of a proposal before taking action. It also gives agencies the ability to condition or deny a proposal due to identified likely significant adverse impacts" (WSDOE) .In other words, a SEPA review would consider all environmental impacts, address probable risks, encourage public involvement and offer mitigation strategies. A SEPA review is required by any proposed government action that is likely to have a significant negative environmental impact.

These "actions" are divided into two categories: project actions and non-project actions. A project action includes decisions for funding or implementation of a specific project, including those for public buildings and facilities. Non-project actions are decisions regarding policies, programs, ordinances, zoning and capital budgets (WSDOE). Interestingly, Evergreen's biomass proposal can fall into either category: it concerns both public facilities and funding from the State's capital budget. Even before the consideration of biomass, the Climate Action Plan (CAP) should be/have been reviewed by the SEPA; it defines ways in which Evergreen hopes to mitigate its carbon footprint. This is a comprehensive plan that falls under the category of non-project concerns.

After the designated governmental agency reviews the proposal and public comment periods have been satisfied, one of three outcomes will occur: a Determination of Nonsignificance (DNS), a mitigated DNS, or a request for an Environmental Impact Statement (EIS). A DNS reports that the proposal is not likely to produce adverse effects on the environment; a mitigated DNS "contains mitigation or conditions that reduce likely significant adverse environmental impact(s) to a nonsignificant level;" and an EIS, created when significant adverse effects are likely, addresses alternatives and mitigation measures to reduce the impact (WSDOE).

As stated above, the SEPA process takes place during the initial phases of a project's development in order to identify and mitigate potential environmental problems. However Evergreen has not begun this official process, required for acceptance of state funding. Various community members have voiced their concerns about the lack of SEPA approval, but an action plan for its completion has yet to be formulated.

Thurston County Biomass Moratorium

On December 21, 2010, the Thurston County Commission (TCC) took action into its own hands and adopted a moratorium on permitting for all biomass facilities in the county. In addition to citizen concerns regarding primarily environmental and health issues, the large number of biomass facilities currently being proposed for the Western Washington region and concurrent lack of regulation in Thurston County Code were components leading to the decision. Adage's proposed biomass facility in Shelton was another component leading to the moratorium: its 50-mile fuel-sourcing radius includes parts of both Mason and Thurston counties. The citizen uprising surrounding Adage, which led to questioning Evergreen's motives and feasibility for its own proposed facility, became the ultimate catalyst for the moratorium.

To comply with regulations, the commissioners were required to hold a public hearing for the moratorium within 60 days of its adoption. This hearing, which demonstrated general support to keep the moratorium in place, was held on February 7, 2011. According to an article written by John Dodge in *The Olympian* on February 8, 2011,

> The commissioners said they need time to investigate concerns about air pollution and to determine if enough wood debris is available in the region's forests to support multiple projects without damaging forest health. They also want to study whether biomass projects would mesh with county land-use and zoning regulations. Several people who testified said Thurston County is the only local government in the nation to take a stand like this on biomass projects (Dodge, "Thurston").

Among the one hundred citizens present at the hearing, Dodge reports that an overwhelming majority was there in support of the moratorium. In addition to citizen turnout, the Thurston Mason County Medical Society (TMCMS), representing some 400 physicians, the American Lung Association and the League of Women Voters of Thurston County supported the decision (Dodge, "Thurston").

Although a majority of those in attendance were supporting the moratorium, a few key stakeholders from Evergreen testified and offered suggestions for alternative measures. In a letter to the Commissioners, Evergreen Interim Academic Vice President and Provost Ken Tabbutt outlined several reasons why the TCC should work with the college to allow for the proposed facility. Evergreen's relatively small size, commitment to helping the public, probable carbon benefit, and FSC-certification were among the topics considered by Tabbutt for the proposal's validation. In addition, he adds the following suggestion for working collaboratively with the Commission: "*If Evergreen finds that biomass gasification meets its own standards, the college could be a partner in the implementation of the moratorium, perhaps as a demonstration focusing on research to help determine and document best practices that would benefit everyone*" (Tabbutt 2). This excerpt suggests a research and educational partnership between Evergreen, community members and Thurston decision-makers regarding the future use of biomass as a viable alternative energy option for our immediate region.

College Engineer Rich Davis, writing as a Thurston County citizen, came out in support of exempting Evergreen from the moratorium. He touched on a few of the same points as Tabbutt, but also questioned the Commission's jurisdiction. The moratorium, he said, is "an inappropriate use of county authority," adding that ORCAA already has the vested authority to deal with such air-quality issues. "The moratorium essentially maintains the college's freedom to burn oil, coal, and natural gas, but not wood. In other words, the college may burn fossilized biomass, but not fresh biomass under the moratorium as drafted" (Davis 1).

For the next year, a Thurston County technical advisory group will meet to discuss concerns and to study biomass technology to better inform the TCC on how to regulate such facilities. This group will likely be comprised of individuals from the Concerned Citizens of Thurston County, the TMCMS, Evergreen, and other interested parties. Once a decision has been reached, the moratorium will be lifted. This may happen before or after one year has passed (Thurston County Biomass).

The Social Impact

The social impact is rooted in the process, which has been the chasm of the biomass feasibility study of the Sustainability Council. The initial question was identified in the first planning meeting, which took place on campus on July 16, 2010. What is the community engagement for the process, and how is their input used in the decision-making process? The notes from this meeting state, "the social dynamic is critical and just as important as the technical and biological" (Evergreen, "Biomass"). The Council's fall, online update, which was posted at the end of 2010, indicated a question mark for recommended actions on the social impacts, though it was noted that there was a need for analysis of community impact (Evergreen, "Council"). However, the process for studying the social impact still remains undefined, as of March, 2011. Had the Council established the public process shortly after the need was identified, Evergreen may have saved itself from a damaged public image, wasted human resources, and a lot of grief.

A necessary action in the deliberation of the renewable energy options for Evergreen is to define a public process that will build social capital. Social capital is defined as the bonding relationships between community members that result from their participation, trust, and reciprocity (Butterfoss). The level of community participation needed for the process to result in an increase of social capital will depend on these relationships. If there is a high level of trust that is maintained throughout the process, then there will be faith in the ability of Evergreen to make a responsible decision. If the level of trust is low and deteriorates throughout the process, then there is an urgent need to examine the process and act to improve the relationships of the stakeholders.

Loosely defined, a stakeholder is anyone who has an interest in a project, someone who stands to gain or lose from the outcome. Because biomass gasification is intended to address issues of climate change, it is correct to include all people, species, and future generations as stakeholders in the project. However, given the limited capacity of the college to provide the resources for endless engagement, it is necessary to define a boundary that includes those directly affected by this particular project and can provide representation for various stakeholder groups. Figure 8 presents a map of the directly affected stakeholders for this project, the darker boxes representing the power centers. It will be important to analyze the claims of these stakeholders and determine which claims are legitimate and urgent. It is also necessary to understand the distribution of power amongst the stakeholders, to ensure that those who have legitimate claims, but little power, will still be considered in the final decision.

Communication is the media through which social change can occur, for better or worse. Since this issue is already in a stalemate state of conflict, it is important to establish reasonable dialogue amongst the stakeholders. According to Zahid Movlazadeh, the program coordinator for the Global Partnership for the Prevention of Armed Conflict, building dialogue is part of the process for addressing conflict. “Many of these network or partnership building processes are essentially aimed at bridging the gaps between the conflicting societies and building confidence and trust. This in turn will create a safe space for the sides to start manifesting their values and underlying motivations, thus making a shift from expressing their positions to discussing their interests – a key factor in addressing any conflict in a sustainable manner” (Movlazadeh).

According to the International Association for Public Participation (IAP2), the level of public impact should determine the level of participation, as shown in Figure 9. An analysis of the stakeholders and their claims can provide a determination of the public impact. Given the importance of renewable energy issues and a need for building consensus, the collaborative framework would be a good approach.

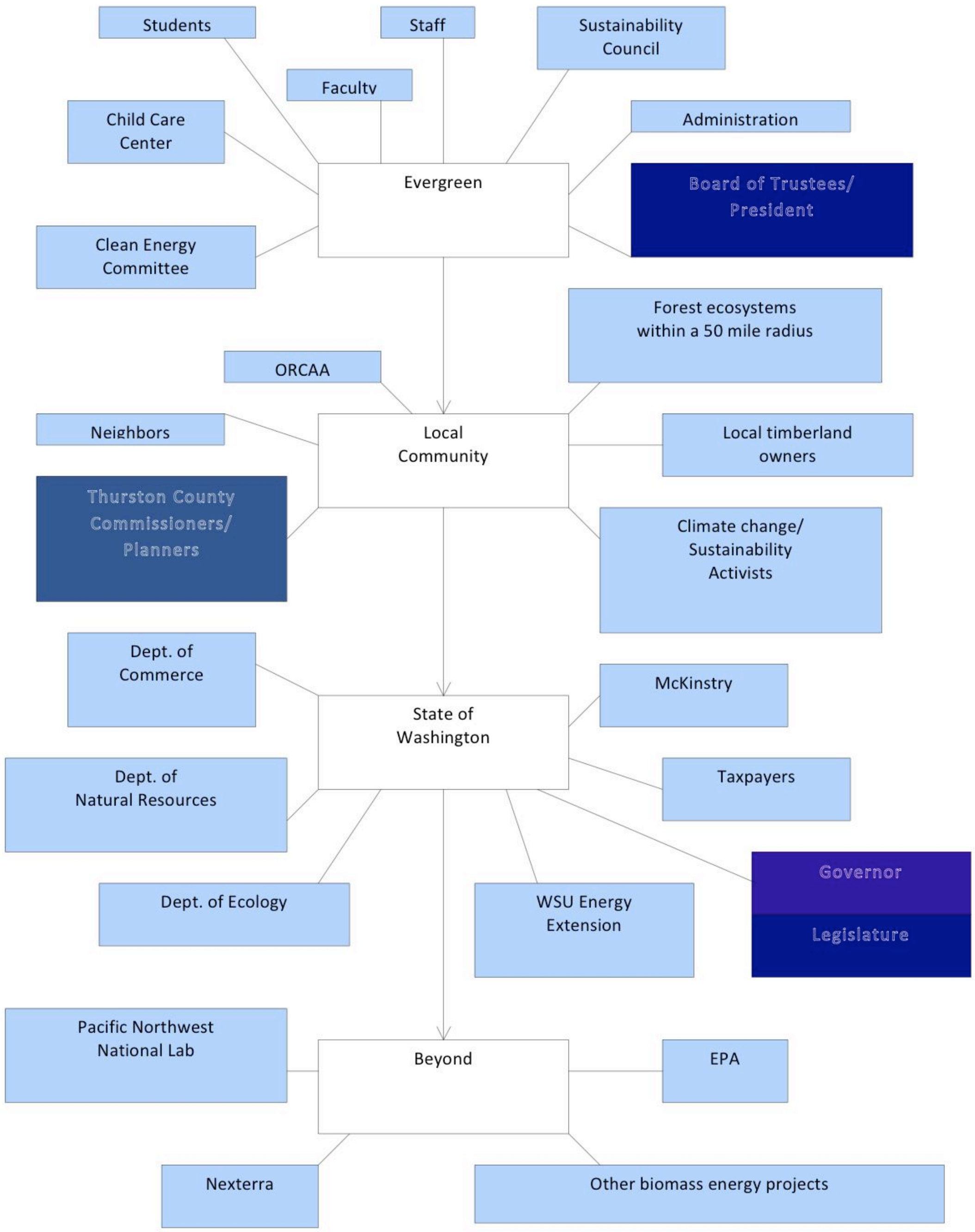

Figure 8: Map of stakeholders in the Evergreen biomass gasification project. The darkly shaded boxes mark the centers of power.

IAP2 Spectrum of Public Participation

International Association for Public Participation

Increasing Level of Public Impact →

	Inform	Consult	Involve	Collaborate	Empower
Public participation goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
Promise to the public	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
Example techniques	▪ Fact sheets ▪ Web sites ▪ Open houses	▪ Public comment ▪ Focus groups ▪ Surveys ▪ Public meetings	▪ Workshops ▪ Deliberative polling	▪ Citizen advisory committees ▪ Consensus-building ▪ Participatory decision-making	▪ Citizen juries ▪ Ballots ▪ Delegated decision

Figure 9: Spectrum of public participation (IAP2)

Conclusion and Recommendations

We support the precautionary principle approach to decisions that impact the environment and the local community. Evergreen has already decided to pursue biomass gasification and it is apparent that the college should take a step back from this decision. Reasonable dialogue on carbon neutrality will be more productive if the objective is renewable energy solutions, rather than justification of a project that has already been selected. To improve the decision-making framework and increase social capital through this renewable energy exploration, we recommend that:

- A Renewable Energy DTF be established, as described in the Climate Action Plan
- The major planning documents at Evergreen be updated to reflect new information
- An analysis of stakeholders be performed to determine the legitimacy and urgency of claims as well as the balance of power
- A process for public participation be determined based on the current level of social capital and the needs of the campus and local community
- Evergreen honor the Thurston County moratorium to encourage stakeholders to participate in the process

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