IPRO 349: Solid Fuel from Biomass for Cogeneration

Project Plan
September 19, 2008

1. Objectives

The following are our objectives for the Fall 2008 semester:

- Re-evaluate and update the calculations done by the previous IPRO group for theoretical energy content at each stage of the process.
- Develop a flow scheme for a small scale cogeneration plant using solid biomass fuel from corn stover.
- Research current equipment capacities and methods of heat transfer which could be used to implement a small scale cogeneration power plant.
- Construct as economic analysis.
- Deliver a final report that describes the overall energy yields, feasibility and economic analyses and possibly some recommendations for a large scale project.

2. Background

Renewable energy is one of the most important and widely researched topics today. It is classically defined as any form of energy that comes from replenish-able sources and, for all practical purposes, cannot be depleted. This may include solar, wind, or geothermal power, as well as biomass or biofuels. When considering biomass, or any living or recently dead biological material, the chemical energy of the molecules is generally collected through the process of combustion.

The area of liquid fuels from biomass has gained much notoriety and support in recent years. This is due to the lower emissions and clean-burning nature of these fuels when compared to more traditional approaches, as well as the obvious renewable nature of the starting material. While vegetable oils or animal fats can be used as a replacement for diesel fuels, corn, switchgrass, or other grains are more widely used to produce ethanol for use in common combustion engines. Today's E85 fuel is sold to customers with a chemical makeup of 85% ethanol and 15% gasoline. However, one of the main downfalls of processing ethanol from biomass uses the actual ear of corn, which takes away from a very large source of food worldwide.

The use of solid biomass in forms such as briquettes or charcoal as a direct supplier of energy, however, is an area still left relatively unexplored in this growing field. In theory, and as preliminary research suggests, harvesting energy directly from solid biomass may be considerably more efficient than gathering it from its processed liquid counterpart. In fact, some studies suggest that the energy acquired from burning ethanol is up to 67% lower than is contained in the plant cellulose from which it is derived.[1]

There are, however, several other factors besides energy projections to consider when looking at the economic viability and marketability of such an approach. One of the main advantages of liquid over solid fuels, for example, is the ease of transportation and storage at a much lower cost. Additionally, the feasibility of developing a whole new process of biomass collection and processing must be balanced with economic and

logistical constraints. This includes not only careful analysis of energy and cost balances, but also in-depth examination of all equipment, manpower and environmental limitations.

IPRO 349 was established to examine these (and many more) considerations in the viability of sold fuel from biomass. Specifically, we have narrowed the scope of our research to biomass derived from corn stover (leaves and stalk left in the ground after harvesting) within the state of Illinois. Illinois was chosen because it is currently the largest producer of corn in the nation.[2] Corn stover has been shown to have an energy content of 5,290 Btu/lb. wet, and 7,560 Btu/lb. dry.[2] With such an approach, it may be possible to utilize what would otherwise be considered "waste" to produce useable, renewable energy, since the stover makes up 50% of the yield of a crop.[3] For the purposes of this project, cogeneration, or the simultaneous generation of both electricity and useful heat, will be examined with a focus on a smaller scale, which may be a few farms, houses, or businesses, so that large scale projections may be made for the future.

3. Methodology and Team Organization

Our project has been divided in to two focus areas with 70% being focused on the research into engineering a solution for a small scale project and then roughly 30% will focus on the institution and integration into further larger scale projects. Our initial task is to go through the research of the previous IRPO team and double check their research and calculations before we move on to our projects goals. The entire team is working on the research for each of these areas. Some team members have been assigned roles for processing and uploading information online. Each member has been assigned specific research areas and is expected to explore all avenues to provide the best available analysis for this project. The information will be brought back and presented to the group during weekly meetings. Weekly meetings will also be used as a time to discuss where our plans currently are and whether we should move in a different direction with the available information we have. Information is also going to be continuously uploaded online to iGroups where a team member will check research data and facts to make sure no two individuals have conflicting results in between meetings times. The research has been divided into the following groups: collecting/harvesting, bunching, transportation, storage, legality/emissions, processing, cogeneration process, transport of heat and economics.

The final goal of our project is to gather enough information to put together a plan for the implementation of a small scale cogeneration system. The information needed to bring this together is roughly divided into two categories: the actual physical processes of machine operations and energy flow as well as the economics of such a system and the impact on the community using it.

Once a substantial amount of research has been done, the team will decide if it is enough to move on to the next step of the project. The amount of research outside of class should extend to about three times the amount of class time which is about 8 hours per week depending on the topic. Various methods of research accepted are journal articles,

contact with companies involved in related fields of biomass or cogeneration and possibly professors for some engineering aspects of the research. If other topics come up during the research process, the team members will be assigned further duties to aid in the collection of the relevant data and research. Current team member roles are listed below.

Research Team: Gather essential data through use of the internet, articles, books and direct correspondence with companies to determine the feasibility and details of collecting and processing corn stover in Illinois for cogeneration.

- Sub-Team Leaders: Oluwafunso Ajigbo, Sangkyoung Lee and Ademola Adekola – While also researching their respective topics, the sub-team leaders will ensure that the research team is keeping scales consistent, and they will also take on the responsibilities of the leader if he is unable to make it to a meeting, etc.
    - Sung Kim – Collection and Harvesting
    - MinSoo Kang – Bunching
    - Oluwafunso Ajigbo – Transportation
    - Ken Ogata – Transportation
    - Sangkyoung Lee – Storage and Legality/Emissions
    - Grace Chee - Processing
    - Tyler Rhodes – Cogeneration process
    - Lee Yeseul – Cogeneration process and Economics
    - Kelsey Camp – Transport of heat
    - Branden Schombert – Legality/Emissions
    - Ademola Adekola – Economics

Deliverables Team: Help produce the standard documents required by the IPRO office and help with other administrative items such as minutes, code of ethics, etc. All members of the team are expected to help with the final deliverables including final report, final presentation, poster, etc.

- Team Leader: Branden Schombert – The team leader will oversee the actions of both the deliverables and the research teams while also conducting some research.
    - Oluwafunso Ajigbo – Minutes
    - MinSoo Kaen – Minutes
    - Sangkyoung Lee – Code of Ethics
    - Ken Ogata – Code of Ethics
    - Branden Schombert – Project Plan
    - Kelsey Camp – Project Plan
    - Ademole Adekola – Project Plan
    - Grace Chee – Project Plan

4. Expected Results

By the end of the semester, all team members are expected to

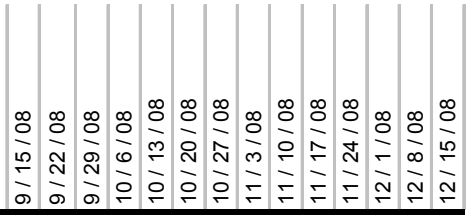
- Understand the process of harvesting and collecting corn stover efficiently from farm lands without damaging the soil.
- Formulate a more efficient way to bunch the stover for easy transportation and longer storage periods.
- Calculate the cost of transportation of the stover from site to processing areas.
- Make calculations and comparisons on the most effective way of processing the stover in to solid biomass.
- Understand the use of energy from corn stover processing for cogeneration of heat and power.
- Make calculations on the economic advantages of corn stover as an alternative energy source.
- Understand the legal issues associated with the use of corn stover as an alternate energy source.
- Make future recommendations for the use of corn stover for a large scale process.

5. Project Budget Plan

Expense	**Description**	**Amount**
IPRO Day Materials	Presentation board and handouts	$50.00
Transportation	Visits to farms and/or cogeneration power plants	$150.00
Team Dinner	Informal team-building activity	$120.00
	Total:	**$320.00**

6. Schedule

WBS	Tasks	Name	Start	End	Duration (Days)
1	Research/Re-evaluation		9/17/08	10/03/08	16
1.1	Collection	Sung	9/17/08	10/03/08	16
1.2	Bunching	MinSoo	9/17/08	10/03/08	16
1.3	Transportation	Funso/Ken	9/17/08	10/03/08	16
1.4	Storage	Sangkyoung	9/17/08	10/03/08	16
1.5	Processing	Grace	9/17/08	10/03/08	16
1.6	Cogeneration	Tyler/Yeseul/Kelsey	9/17/08	10/03/08	16
1.7	Legality/Emissions	Branden/Sangkyoung	9/17/08	10/03/08	16
1.8	Economics	Ademola - Yeseul	9/17/08	10/03/08	16
2	Compile Data/Create Model		10/06/08	11/08/08	33
2.1	Collection	Sung	10/06/08	11/08/08	33
2.2	Bunching	MinSoo	10/06/08	11/08/08	33
2.3	Transportation	Funso/Ken	10/06/08	11/08/08	33
2.4	Storage	Sangkyoung	10/06/08	11/08/08	33
2.5	Processing	Grace	10/06/08	11/08/08	33
2.6	Cogeneration	Tyler/Yeseul/Kelsey	10/06/08	11/08/08	33
2.7	Legality/Emissions	Branden/Sangkyoung	10/06/08	11/08/08	33
2.8	Economics	Ademola - Yeseul	10/06/08	11/08/08	33
3	Administration/Deliverables	Branden	9/19/08	12/05/08	77
3.1	Project Plan	Branden/Kelsey/Ademola	9/17/08	9/19/08	17
3.2	Code of Ethics	Sangkyoung/Ken	9/17/08	10/03/08	17
3.3	Midterm Presentation		10/01/08	10/06/08	5
3.4	Midterm Report		10/01/08	10/06/08	5
3.5	Final Report		10/25/08	12/04/08	40
3.6	Final Presentation		11/17/08	12/03/08	16
3.7	Poster/Brochure		11/17/08	11/26/08	9
3.8	IPRO Deliverables CD		12/03/08	12/04/08	1
3.9	IPRO DAY		12/05/08	12/05/08	1



7. Our Team

Name	Major/Year	Sub-Team	Skills and Roles
Ademola Adekola	CHEM / 4th	Project Plan Development Economics Research	Organization skills Sub-team Leader
Oluwafunso Ajigbo	CHE / 4th	Minutes and Deliverables Transportation Research	Organization skills Sub-team Leader Excel Research
Kelsey Camp	CHE / 4th	Project Plan Development Heat Transport Research	Research Experience Public Speaking Process Design
Grace Chee	BME / 3rd	Business Communications Processing Research	Research Experience Organization skills Public Speaking Graphic Design
MinSoo Kang	EE / 4th	Minutes and Deliverables Bunching Research	Power Plant knowledge Research
Sung Kim	MMAE / 3rd	Business Communications Collection Research	Problem Solving Design
Sangkyoung Lee	ME / 4th	Charter and Ethics Storage and Legality/Emissions Research	Research Sub-Team Leader Math Skills
Ken Ogata	CHE / 3rd	Charter and Ethics Transportation Research	Organization skills Research
Tyler Rhodes	BioChem / 4th	Research/Calculations Cogeneration Process Research	Critical Thinking Design Analysis Research
Branden Schombert	BME / 3rd	Project Plan Development Legality/Emissions Research	Team Leader Goal Orientation Motivational skills
Lee Yeseul	CHEM / 4th	Research/Calculations Cogeneration Process and Economics Research	Research Math skills

8. Sources

[1]
http://www.ethanol-gec.org/information/briefing/20a.pdf
[2]
http://www.epa.gov/chp/documents/biomass_chp_catalog_part3.pdf
[3]
http://www.agr.state.nc.us/drought/documents/1217andNCDACSCornStoverGuidance082707.pdf