A Feedstock Processing Center for South Carolina

June 2010
EXECUTIVE SUMMARY

The outlook for the bioproducts industry is optimistic. Our country’s rich biomass resources are projected to provide a large increase in bio-based power generation, transportation fuels and materials from biorefineries. The bioproducts industry is not mature, however and there are a number of technical, logistical and educational challenges that must be met as this new technology is implemented. Many of the technologies necessary to use biomass on a large scale for power generation or liquid fuels have significant technical barriers to overcome before they can make a significant impact on our fossil fuel usage. Current systems are inadequate to support the volume of biomass that needs to be grown, processed and transported. An educated workforce will be needed to integrate these emerging technologies into the existing infrastructure.

A Biomass Feedstock Processing Center is proposed as a research and education institute to support the growing biomass industry in South Carolina. This center will address technical challenges in growing the biomass economy, provide training for the needed workforce, educate the public on biomass issues and support the expansion of biomass-related businesses. South Carolina is a biomass-rich state and is well positioned to become a leader in the emerging biomass economy. In order to do so, a coordinated effort must be made to address the technical, logistical and educational challenges associated with an increasing focus on use of our biomass resources.

Prepared for: The South Carolina Biomass Council

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**Biomass Use is Projected to Expand**

Use of renewable fuels such as biomass has increased in recent years\(^7\) (Figure 1) and is projected to grow as the cost of fossil fuels increase, emission standards become more stringent and use of renewable fuels becomes mandated by states and federal government. At the same time, the worldwide use of energy is increasing. The US Department of Energy estimates the global demand for energy will increase by at least 50% by the year 2030\(^6\). It is likely that a large portion of the renewable energy demand will be met by biomass. Biomass is the largest domestic source of renewable energy\(^{12}\) and the Biomass R&D Technical Advisory Committee envisions a 30 percent replacement of the current U.S. petroleum consumption with biofuels by 2030\(^{12}\). Recently, the “Twenty in Ten” objective by President Bush set the goal of offsetting 20 percent of gasoline consumption by 2017 with use of alternative and renewable fuels\(^3\).

In South Carolina, woody biomass has been used to produce heat, steam and electricity for well over a century\(^2\). While biomass is not currently a large part of the energy production in South Carolina\(^7\) (Figure 2), interest in using biomass has been increasing with the emergence of industries and technologies that make use of this resource. There are a large number of biomass industry stakeholders in South Carolina (APPENDIX G) with varied applications including pulp and paper manufacture, solid wood products, power generation and chemical production. Applications for South Carolina biomass products are going beyond our local region as an export industry of biomass to Europe has begun. As new regulations dictating the use of biomass become law and new technologies continue to emerge that use biomass as a feedstock, an increased demand on this resource can be expected.

There are several technologies that use biomass in generation of electricity, liquid fuel production and other bio-based products\(^5\). The projection is that growth in each of these applications will increase dramatically over the next twenty years\(^{12}\). The most readily applicable technology is direct combustion of feedstocks as solid fuels. Feedstocks such as woody biomass, agricultural wastes, energy grasses, municipal solid waste and construction debris can be chipped or ground for power generation through combustion. Alternatively, solid feedstocks can be processed into pellets or briquettes and then burned to generate electricity. Some wastes can be readily converted into a gaseous form, called syngas, using a process called...
gasification, or harvested from decomposing matter in landfills\textsuperscript{19}. Target feedstocks for gasification include animal and human wastes, although the technology for gasification of wood and other biomass feedstocks is becoming more common. Liquid fuels can be generated from biomass feedstocks as well. Oil crops such as soybean, sunflower and algae can be processed to produce biodiesel fuel. Technology for creating ethanol from biomass is a hot topic for research and development in recent years. This liquid fuel can be made from starch- and sugar-based biomass, such as corn and sugar cane, through a fermentation process. Technology for making ethanol from woody or herbaceous crops is currently being refined and, if successful, will open up a very large market for making liquid fuels from biomass. Another process for making liquid fuels from biomass is called pyrolysis, which creates a bio-oil by heating biomass in an oxygen-starved environment. Bio-oil can then be refined to produce a number of different products including liquid fuels. Other relatively short-term applications for biomass include production of ethanol from sweet sorghum as well as from lignocellulosic crops and processing oilseed crops into biodiesel\textsuperscript{14}. Biodiesel can also be made from recycling used cooking oils.

**Feedstock Resource Vision Goals\textsuperscript{12}**

**Biopower...in the industrial sector** will increase at an annual rate of 2\% (and)...biomass consumption in electric utilities will double every 10 years through 2030.

**Transportation fuels from biomass** will increase significantly from 0.5\% of U.S. transportation fuel consumption in 2001 to...20\% in 2030.

**Production of chemicals and materials from biobased products** will increase from ...5\% of the current...U.S. chemical commodities in 2001 to...25\% in 2030.

**South Carolina is in a good position to address this growing demand.**

South Carolina and the Southeastern USA are well positioned to supply the growing biomass demand\textsuperscript{11}. The region grows a lot of wood and is also developing an array of other biomass crops to meet energy needs\textsuperscript{11, 17}. Many of these crops, such as wood and grasses, are known as lignocellulosic feedstock and are not derived from food crops. They can be grown on marginal land. See Table 1 for a list of biomass feedstocks for South Carolina.

South Carolina’s indigenous energy resources, particularly biomass, can form the basis for a strong, sustainable biofuels industry and clean electrical energy\textsuperscript{13}. One study estimates that there is up to 1,779 MW of biomass potential for electricity generation from wood, agricultural crop residues, poultry litter and swine waste\textsuperscript{15}. Other studies suggest that a large portion of the biomass need will be supplied by wood, bark, secondary processing residues, urban wood

**In addition to the many benefits common to renewable energy, biomass is particularly attractive because it is the only current renewable source of liquid transportation fuel\textsuperscript{12}.**
residues, dedicated energy crops, agricultural waste, use of Conservation Reserve Program land, unused residual from logging and recycling of waste oils and grease.  

**Table 1. Plant-Based Biomass Feedstocks for South Carolina**

<table>
<thead>
<tr>
<th>Woody Lignocellulosic</th>
<th>Sugar &amp; Starch Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loblolly Pine</td>
<td>Corn Grain</td>
</tr>
<tr>
<td>Other Southern Yellow Pines</td>
<td>Winter Wheat</td>
</tr>
<tr>
<td>Oaks</td>
<td>Barley</td>
</tr>
<tr>
<td>Sweetgum</td>
<td>Sweet Potato</td>
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<tr>
<td>Hybrid Poplar</td>
<td>Grain Sorghum</td>
</tr>
<tr>
<td>Cottonwood</td>
<td>Sweet Sorghum</td>
</tr>
<tr>
<td>Sycamore</td>
<td>Sugar Beet</td>
</tr>
<tr>
<td>Other Hardwoods</td>
<td>Duckweed</td>
</tr>
<tr>
<td>Forest Residues</td>
<td>Waste Fruit Crops</td>
</tr>
<tr>
<td>Wood Waste</td>
<td>Waste Vegetable Crops</td>
</tr>
<tr>
<td>Power Line Trimmings</td>
<td></td>
</tr>
<tr>
<td>Construction &amp; Demolition Debris</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Grass Lignocellulosic</th>
<th>Other Lignocellulosic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchgrass</td>
<td>Peanut Hulls</td>
</tr>
<tr>
<td>Miscanthus</td>
<td>Pecan Hulls</td>
</tr>
<tr>
<td>Arundo</td>
<td>Corn Cobs</td>
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<tr>
<td></td>
<td>Corn Stover</td>
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<td></td>
<td>Other Agricultural Waste</td>
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</tbody>
</table>

**Barriers to biomass.**

While biomass energy applications are gaining popularity and strides are being made in conversion of various feedstocks into fuels there are significant challenges that limit the growth of the biomass industry such as the high cost of implementation and technical issues in processing and handling. Improvements need to be made in feedstock processing and handling, infrastructure and end-use markets. The need to improve feedstock processing, handling, to reduce costs and increase efficiencies has been recognized by US Department of Energy and has even been called the “Achilles’ heel” in some biomass end uses. Furthermore, feedstock logistic issues will be regionally specific because of the different feedstocks available, land ownership patterns and economies of scale. Therefore, local and regional efforts in addressing biomass processing and handling issues will be of the utmost importance when developing an effective biomass use plan.

One immediate application for biomass energy is to mix biomass with coal for power generation, a process called cofiring. While the principle of cofiring is straightforward, most coal-fired power plants currently in operation were not designed for use with biomass. Europe is most active in coal-biomass cofiring. Their experience stresses the importance in biomass processing to avoid downstream problems such as boiler slagging and fouling. Another
challenge with cofiring is that biomass does not crush or flow in the same manner as coal. This creates a need for specialized systems to handle biomass. There is a need to establish standard biomass specifications, taking into account the type of feedstock and targeted end use. Cofiring, direct combustion, gasification, pyrolysis and fermentation each have unique challenges which vary with feedstock used and energy conversion process used. New technologies are needed to support efficient, economic and sustainable biomass handling from farm to power plant. These include creative approaches to moving feedstocks from field to plant, such as sending slurry through dedicated pipelines, single pass harvesters for agricultural residue collection during commodity crop harvest and in-forest grinders to enable forest residue densification at time of collection. All of these proposed solutions will require dedicated research and development for proper implementation.

Local issues with biomass.
A study was conducted from February to May 2010 to determine specific needs in the South Carolina biomass community, focusing specifically on biomass feedstock logistics. A literature review was carried out and interviews conducted with biomass stakeholders, including biomass growers, processors, transporters and end users. The study included large and small companies, educators, researchers and policy makers.

The study indicates a great interest in developing a robust biomass economy in the region and identified a number of specific technical challenges facing the South Carolina biomass community. APPENDIX C contains a partial listing of concerns uncovered during the four month study. In general, there is interest in developing new markets for biomass and concern about the sufficiency of available biomass resources to supply current needs and increased future demand. One universal issue is concern about biomass quality regardless of end use. The need for biomass feedstock quality controls, methods for measuring quality, development of standards and methods for assuring those standards was identified as needing attention.

Another widespread issue revealed by the survey is lack of a renewable energy standard (RPS) in South Carolina is a barrier to developing a robust local biomass industry. Several interviewees cited the lack of an RPS as a hindrance because, while the need for increased biomass use was desirable, the lack of guidelines made it difficult to address technological problems associated with its use.

A solution: The Biomass Feedstock Processing Center
A Biomass Feedstock Processing Center (FPC) is proposed as a research and education institute to support the biomass industry of South Carolina and the Southeastern USA. The FPC will address technical, educational and business development roles that support increased use of biomass in South Carolina and across the region.
The FPC seeks to be instrumental in positioning South Carolina to be a leader in the biomass economy. Objectives for reaching this goal include creation of a centralized biomass brain trust among the various state agencies and biomass stakeholders in South Carolina, establishment of a facility, or network of facilities, to provide technical support to research programs, assistance for biomass-related business in opening new markets and overcoming technical challenges, functioning as a biomass-related education center and providing support to biomass producers.

The vision of the FPC is to stimulate the biomass industry in the southeast by providing technical and business support to the biomass community this will create local biomass jobs and provide training for a future workforce. Specifically the FPC will focus on technical issues which are under-represented in other research and development programs as well as issues specific to the needs of the South Carolina biomass community.

Technical Role of the FPC

The FPC will provide resources to address technical problems with biomass processing and handling. The FPC will maintain a core group of equipment that can be used for a wide range of biomass feedstock processing and handling technical projects. These core groups of equipment will be geared specifically toward particular feedstocks and end uses.

The need for biomass feedstock quality controls, methods for measuring quality, development of standards and methods for assuring those standards was identified as needing attention.

Different “modules” of capabilities for the FPC can be implemented based on the feedstock or volume requirements. In addition to the biomass processing work, biomass quality testing would be integrated into procedures to allow tracking of biomass chemical and physical properties throughout the processes.

Technical support in wood processing might also determine efficient techniques to provide material for ethanol production from southern pine trees. In this case, a core group of equipment would be assembled to allow a two-stage size reduction of the pine trees with the necessary screening equipment to control variation in particle size and a dryer to remove moisture. In the case of preparing wood for fermentation to ethanol, a final size of 1-2 mm is required along with no more than 15 percent moisture. These are very challenging goals to achieve as this is a very energy intensive process.

Energy grass processing is very similar to wood processing in that it is primarily a lignocellulosic crop, but there are significant differences in the density, moisture and fiber qualities of the starting material. Thus, for energy grass processing the core group of equipment may have the same basic functionality as for wood processing but with significant modification in the internal design of the equipment to account for the different starting material.
Sweet sorghum is an energy crop that yields several different products including, sugar, starch and lignocellulose. Thus, the processing strategy for sweet sorghum would require additional equipment to wood and energy grass processing. Notably, a roller press or extrusion mill is required in one of the early steps to remove the sugar-containing juice from the lignocellulosic parts of the plant. The sugar juice is then concentrated in some way to prepare for fermentation to ethanol while the remainder of the plant is processed in a manner similar to the other lignocellulosic plants.

These three examples show that biomass feedstocks require different types of processing optimization. Each feedstock will require its own specialized research and development stream to take into account differences in harvesting methods, chemical profile and physical characteristics. Furthermore, it is likely that mixtures of biomass feedstocks will be desirable to create specific blends that meet end users. The processing of biomass is further complicated because, besides wood, most feedstocks are only available seasonally while bioenergy providers will require a year-round supply of feedstock. This presents a challenge because different of feedstock requirements for long term storage, both before and after processing and handling.

APPENDIX D contains several sample work plans showing how the FPC can address specific biomass stakeholder needs. APPENDIX E shows examples of selected core equipment for the feedstock processing center.

Educational Role of the FPC
One of the proposed functions of the FPL is to serve as an educational outlet for South Carolina colleges and universities, as well as to address education of the general public in biomass related issues.

The FPC will serve as a satellite campus for research universities and technical colleges. South Carolina technical colleges will be able to collaborate with the FPC to develop training programs for biomass processing and in equipment operation and repair. Research universities throughout the southeast will develop collaborative research relationships in which the FPC serves as a link between laboratory scale research projects and larger pilot scale projects to demonstrate economic feasibility.
As feedstock processing techniques are developed and optimized for the southeast region, landowners, growers and cooperatives will have access to these methods. Educational programs will be developed to keep biomass producers aware of the these developments as well as learning about specifications required for specific end uses and how to efficiently achieve them with a particular feedstock.

Public educational roles will be a part of the FPC mission. School groups and others interested in learning about biomass basics will have access to educational programs on how biomass is used to make energy and other products. Hands-on demonstrations, such as making fuel pellets will be available as well.

**Business Development Role of the FPC**

As the biomass business continues to expand in the region the FPC will assist businesses in getting established. The FPC will provide businesses with information on the biomass resources available and provide technology assistance in accordance with the research and development program. There is a desire for such services within the South Carolina community for businesses, research universities, technical colleges and economic development organizations. The biomass industry in SC is expanding. Coordinated statewide goals for promoting biomass and providing assistance to business in this area are needed.

**Other Biomass Research Centers in the Southeast**

There are other research and development centers in the southern USA that are available for technical and business assistance. Most notably are the Herty Advanced Material Development Center (Savannah, GA), UT Biofuels Initiative (Knoxville, TN) and the Biofuels Center of North Carolina (Oxford, NC). See APPENDIX F for a listing and description of southeastern biomass research centers.

While these entities can serve as regional centers of excellence in biomass research and development, their main focus is the biomass community in their home state. It can be argued that there is a need for a biomass research center to serve the specific needs of South Carolina and also to address specific outreach issues and research niches that have not been addressed by research centers in neighboring states.

**Organization and Management**

A model is proposed wherein the FPC will operate as either a state-owned facility or a non-profit company. It is envisioned that the FPC will operate with a Board of Directors and an Industrial Advisory Board. The Board of Directors will have representatives from the SC legislator, research universities, technical colleges and business leaders. The Industrial Advisory Board will consist of stakeholders in the biomass economy in South Carolina. If the FPC adopts
a cooperative model for operation, it is likely that the majority of the Industrial Advisory Board will comprise representatives from member companies.

Staffing of the FPC will depend on the scope of work and will vary as the FPC progresses through growth stages. It is envisioned that the FPC will start with a small, well-defined mission with set capabilities to address feedstock processing in support of combustion end uses. As funding for projects expands, the FPC will expand its capabilities to address additional needs.

Initial funding will be raised to build the facility and for limited staffing. This initial staffing requirement to allow for organization and building a client base and will consist of a director and possibly a facilities manager. Ongoing staffing requirements will depend on the scope of work contracted and will likely consist of an additional two to six technicians. Depending on the location of the FPC, some staff sharing may take place. For example, if the FPC is located at one of the Clemson research and education campuses, there may be an opportunity to use existing staff for FPC projects. As part of the FPC mission is education, student labor will be utilized as the educational programs are developed.

**Marketing and Sales Strategy**
Marketing FPC services will include direct contact with biomass stakeholders, promotion through presentations at biomass related meetings, Informational articles in news media, and contact with economic development groups and an Internet presence.

**Funding**
Federal, state and private funds are being sought to assist in the establishment and initial operation of the FPC. Ongoing funding to support operations will come from a combination of fee-for-service, membership dues, grants and state support.

**Location**
Currently, there is no set location for the FPC. The FPC can be established as either a single stand-alone facility or as a distributed network of sites throughout the state. There is an interest by the Clemson Public Service Administration to host the FPC at one of the research and education campuses with the leading candidates being the Clemson Pee Dee REC and the Clemson Restoration Institute. In the networked site model, one particular site would take responsibility as the lead site and coordinate with other sites throughout the state. This networked site model would take advantage of existing facilities and also increase the level of access to FPC expertise across the region.
Feedstock Processing Center – Proposed Site Plan

A proposed building plan has been developed for the FPC that outlines the initial concept of the facility and allows for expansion. Details of the proposed facility are given in APPENDIX B. The proposed FPC consists of a simple metal building, as well as outdoor facilities. The indoor facilities consist of a 300 sq ft classroom, 200 sq ft laboratory and 150 sq ft office space. This indoor space can be easily expanded as needed. The outdoor space consists of 20,000 sq ft of concrete pad, half of which is covered with a roof with 25 ft clearance to allow operation of equipment. The design of the roof is such that it can be partially or fully enclosed if needed. The pre-construction plan accounts for the necessary utilities to operate feedstock processing equipment. The design accounts for truck traffic to enable delivery and shipping of biomass feedstock before and after processing. The estimated cost of the facility in Figure 1 is $1.7 M excluding land cost and necessary permits.


Feedstock Processing Center – Proposed Facilities

- 5 acre site
- Pre-engineered metal building
- 10K ft² covered processing area
- 10K ft² loading and storage area
- 700 ft² Conference / Class room
- 180 ft² Office space
- 200 ft² Lab space
- Access for large trucks
- Expandable to accommodate future increased capabilities
Construction of the FPC is proposed in two phases. Phase 1 included the features in dark outline on the diagram while Phase 2 includes the features in the broken line. Cost to construct the Phase 1 of the FPC is estimated at $1.7M.

The following is included in the "Phase 1" cost of $1.7M:

- Construction Permits and applicable insurance
- Construction Management for the project
- Engineering
- Grading of (5) acres
- Underground utilities to the building - sanitary sewer, potable water and fire water (natural gas to be provided by the local utility which is the standard method)
- Paved parking lot with adjacent gravel parking as shown
- (6) Exterior pole mounted lights
- Signage for parking and entrance - $2,500 allowance
- Sidewalks as shown
- Landscape allowance of $10,000
- Gravel perimeter road
- Office area complete with lab, canteen, classroom, restrooms
  - Includes painting, floor coverings, etc
- Office area constructed as metal building with windows and canopies as depicted on rendering
- Allowance for telephone, data, security in office area
- Fire alarm and sprinkler system in office area
- Heating, ventilation and air conditioning for office area
- Plumbing fixtures and piping as required
- Lab cabinets
- Lighting, grounding, power distribution for office area
- Covered "process" area -10,000 sf 8" concrete slab with metal columns, roof and siding down from top 8'
- Lighting and grounding for covered process area
- Electrical room located in covered area with electrical gear provided
- Air compressor and packaged boiler
- Piping for natural gas, potable water, compressed air, steam and condensate
- Power distribution for process equipment

Items not included:
- Cost of land
- Furniture, furnishings or cubicles
- Primary electrical transformer (this should be provided by the local utility company)
- Process equipment not listed above
- Any environmental permits required from the State
APPENDIX C – TESTIMONIALS

• A small business developing seasonal starch crops for ethanol conversion identifies effective early processing and storage of the crop is critical to avoid losses in storage due to self-metabolizing of the crop prior to conversion to liquid fuels.

• An electrical utility company is concerned about the rheological properties of biomass, particularly the particle size and moisture content, while designing equipment that will allow introduction of biomass into coal-fired boilers.

• There is a general concern about the quality of biomass derived from forest residuals as this resource tends to contain a large quantity of sand and dirt. This contaminant can result in slagging and fouling in boilers which leads to expensive maintenance.

• A small business developing advanced technology for biomass preparation and densification identified primary size reduction as a barrier to increasing the efficiency of their product.

• A biotechnology company developing new varieties of biomass feedstock would like to know how the chemical and physical properties of new varieties would affect the performance of the material in biomass processing equipment and the efficiency in a variety of end uses.

• A national research laboratory requires an efficient method for early processing of a variety of biomass sources that will allow economical development of advanced biofuels from South Carolina feedstocks.

• A state agency indentified improved early processing of biomass to reduce moisture and increase BTU value is a critical need to make biomass energy affordable.

• Several companies that develop and sell biomass processing equipment desire to modify equipment to provide a more uniform product, especially from residual materials that are likely to be large component of biomass energy.

• Feedstock harvesters said that their customers are concerned about uniformity of biomass feedstock as large pieces can cause a shutdown of feedstock handling equipment and small particles (fines) can be a health and spontaneous combustion hazard.

• A logger would like to have equipment that produces a more consistent product which would allow access to new markets.

• A biodiesel manufacturer identified recycling of waste oils and grease as an important potential source of renewable fuels that is not currently available because efficient methods for refining this resource have not been developed.
• A distributor of biodiesel identified improved efficiency in processing and distribution the product are needed to reduce cost to the consumers.

• A small company that manufactures that densifies biomass waste for export identified a need to improve quality of the densified product to reduce fine content and reduce breakage of the product in handling and shipping.

• Researchers identified that for advanced technologies to produce liquid fuels, very small particle sizes and low moisture contents are required (ethanol 1-2 mm size with <15% moisture; pyrolysis 2-3 mm size with < 10 % moisture) and current technology to produce this target is very expensive because of processing costs.

• Energy crop farmers desire to start a cooperative to manufacture pellets but lack to detailed know-how to efficiently process feedstocks to size and moisture targets.

• A research producing advanced biofuels identified that different feedstock have very different characteristics during processing and that optimizing methods for particular feedstocks would increase the efficiency of fuel production.

• Farmers identified harvest and delivery costs as the highest components of production and that improvements in processing and handling would increase profit margins
END USE: Co-fire biomass with coal. Wood biomass blown into boiler through an inspection port with custom equipment.

END USER: SCANA

FPC SERVICES: Determine best biomass specification for efficient combustion of biomass and problem-free materials flow in the overall system. Biomass specification will be based on the top size of wood chips/grindate, size variability, and moisture content. Monitor the chemical and physical properties of wood to allow correlative analysis with boiler performance. Develop a scalable process to produce a target specification within acceptable limits. Standards can be applied to determining price to be paid for delivered material based on set size and moisture ranges.

OUTLINE OF PROPOSED PROCESS:

EQUIPMENT TO BE USED IN PROCESS DEVELOPMENT:
- Wood Chipper
- Horizontal Grinder
- Disk Screen
- Drier
- Hammermill
- Vibratory Screen
- Custom flow testing
- Outsources Proximate and Ultimate Analysis

RESULT:
- Product specifications for acceptable performance of biomass introduced into boiler through inspection port.
- Set of testing standards that can be applied to delivered biomass to determine acceptability according to desired product specification.
- Definition of a scalable process for producing desired biomass specification from clean wood chips.
APPENDIX D – SAMPLE WORK PLANS

END USE: Yellow grease recovery from commercial restaurants for biodiesel production.

END USER: ECOGY BIOFUELS

FPC Services: Determine an effective method for removal of solid and particulate material from yellow grease to allow further processing of these materials into biodiesel. Method will take into consideration that further processing steps such as water removal, odor removal, and additional refinement steps. The feedstock is available in several storage forms depending on the collection method on site, several of these storage forms will be used as a starting point.

OUTLINE OF BASIC PROCESS:

EQUIPMENT:
- Heater
- Filtration Systems
- Chemical Testing Services
- Particulate Analysis

RESULT:
- Method for effective filtration of yellow grease from common commercial collection systems.
- Means for evaluating the filtration method used on the overall efficiency of biodiesel production.
- Quantitative data to allow recommendation of effective yellow grease collection and storage systems.
APPENDIX D – SAMPLE WORK PLANS

END USE: Feedstock processing quality assessment of varietal southern yellow pine.

END USER: ArborGen

FPC Services: Determine processing and end use characteristics between different pine varietal feedstock and effect of wood only, wood plus bark and whole tree chipping.

OUTLINE OF BASIC PROCESS:

EQUIPMENT TO BE USED IN PROCESS DEVELOPMENT:
- Wood Chipper
- Horizontal Grinder
- Disk Screen
- Drier
- Hammermill
- Pellet Mill
- Storage bins
- Vibratory Screen
- Outsources Proximate / Ultimate Analysis
- Muffle Furnace
- Pellet Durability Tester

RESULT:
- Data on how various feedstocks perform in downstream processes where chemical and physical properties of input feedstock can be used to predict: power required by process, rate of throughput, and effect of storage time.
- A correlative method to predict end use product quality based on non-destructive spectrometry.
- Quantitative data that can be used to determine the value and performance of specific varietal feedstocks in end uses including combustion, pelletization, production of advanced biofuels.
END USE: Co-fire coal with wood biomass mixed on coal conveyor

END USER: Santee Cooper

FPC Services: Determine best biomass specification for efficient combustion and materials handling in pre-pulverization mixing of biomass with coal. Develop a scalable process to produce a target specification within acceptable limits.

OUTLINE OF BASIC PROCESS:

RESULT:
- Product specifications for acceptable performance of biomass mixed with coal on conveyor prior to pulverization.
- Set of testing standards that can be applied to delivered biomass to determine acceptability according to desired product specification.
- Definition of a scalable process for producing desired biomass specification from clean wood chips.

EQUIPMENT TO BE USED IN PROCESS DEVELOPMENT:
- Wood Chipper
- Horizontal Grinder
- Disk Screen
- Dryer
- Hammermill
- Vibratory Screen
- Custom pulverizer performance test
- Outsources Proximate / Ultimate Analysis
END USE: Improved equipment design for biomass size reduction.

END USER: Vermeer

FPC Services Determine improved methods for removal of soil contaminants from logging debris by comparing several screening methods and combinations of methods. Monitor degree of wear in secondary size reduction and quantify the degree of soil removal. Monitor the uniformity and range of product size and shape. Work with Vermeer to test different knife and screen configurations in the primary size reduction equipment. Work with Vermeer to explore new designs for Wildcat Trommel Screens to improve soil removal.

OUTLINE OF BASIC PROCESS:

![Diagram of process]

EQUIPMENT TO BE USED IN PROCESS DEVELOPMENT:
- Wood Chipper
- Horizontal Grinder
- Disk Screen
- Trommel Screen
- Vibratory Screen
- Hammermill
- Testing Screen
- Outsourced Proximate / Ultimate Analysis

RESULT:
- Improved method for removing soil contaminants from logging debris and residual feedstock.
- Data on effect rate of wear in size reduction equipment correlated with screening method.
- Data and process information to enable design of advanced equipment for more effective processing of logging debris and residual materials.
APPENDIX D – SAMPLE WORK PLANS

END USE: Torrefied biomass for pellets and cofiring with coal.

END USER: Agri-Tech Producers LLC

FPC Services Determine the effect of various size reduction protocols on the efficiency of the torrefaction process and quality of the end products or final end use. Determine if different sizes and uniformity of the torrefaction input biomass can increase or decrease the efficiency of heat use, residence time, and quality of torrefied material.

OUTLINE OF BASIC PROCESS:

EQUIPMENT TO BE USED IN PROCESS DEVELOPMENT:

- Wood Chipper/Grinder
- Disk Screen
- Sizing Screen
- Torre-Tech
- Pellet Mill
- Pellet Durability Tester
- Outsourced Cofiring

RESULT:

- Determine optimum size reduction method and particle size for specific end uses after torrefaction.
- Provide quantitative data on torrefaction performance linked to material pre-treatment.
- Definition of a scalable process for sizing pre-treatment of material to be torrefied.
APPENDIX D – SAMPLE WORK PLANS

• END USE: Biomass briquettes with reduced fine content in shipping.

END USER: Carolina-Pacific

FPC Services Determine modifications to the briquetting process that will result in a product with reduced fines content. Test a variety of mechanical changes (size reduction method, moisture content, etc) to the briquetting process and binders that can be introduced without negatively affecting the target specification for combustion. Test various final briquette sizes to determine effect of the durability of final product during handling and shipping.

OUTLINE OF BASIC PROCESS:

EQUIPMENT TO BE USED IN PROCESS DEVELOPMENT:
- Wood Chipper/Grinder
- Hammermill
- Feedstock Mixer
- Nielsen briquetter with “puck maker”
- Briquette Durability Tester
- Storage Bins
- Calorimeter
- Muffle Furnace

RESULT:
- Quantitative test for briquette quality to determine: fines content, BTU value, storage limitations, and other desired properties.
- Determination of the optimum briquette size to reduce fines content during handling and shipping.
- Testing of briquette binder compounds and their effect on briquette quality.
APPENDIX E – SELECTED CORE FEEDSTOCK PROCESSING EQUIPMENT

- Trommel Screen
- Pellet Durability Tester
- Roll Press
- Extruder
- Torrefier
## APPENDIX F – RELATED RESEARCH CENTERS IN THE SOUTHEAST

<table>
<thead>
<tr>
<th>Research Center</th>
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<th>Focus Areas</th>
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<tr>
<td>Herty Advanced Material Development Center</td>
<td>Savannah, GA</td>
<td>Natural and synthetic fiber research. Biomass feedstock processing and pulping performance, feedstock chemical and combustion analysis.</td>
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<tr>
<td>UT Biofuels Initiative</td>
<td>Knoxville, TN</td>
<td>Production, harvesting, and conversion of lignocellulosic energy crops for ethanol production. Emphasis on switchgrass.</td>
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<tr>
<td>Biofuels Center of North Carolina</td>
<td>Oxford, NC</td>
<td>Develop a statewide biofuels industry to reduce the state’s dependence on imported liquid fuels. Center makes facilities available such as laboratory, greenhouse, and field areas.</td>
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<tr>
<td>Louisiana Institute for Biofuels and Bioprocessing</td>
<td>Throughout LA</td>
<td>A “virtual center” that will provide the roadmap needed to support new biofuels and bioprocessing endeavors in the state and prioritize pathways for integration of those industries into the mainstream</td>
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<td>Combustion systems performance and design</td>
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<td>USDA Testing Lab</td>
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<td>Wood testing services</td>
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## APPENDIX G – PARTIAL LIST OF BIOMASS STAKEHOLDERS IN SOUTH CAROLINA

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