Final Report

Biomass Energy Potential in South Carolina: A Conspectus of Relevant Information

Prepared for

South Carolina Energy Office
1201 Main Street, Suite 430
Columbia, SC 29201
www.energy.sc.gov

and

U.S. Department of Energy/Southern States Energy Board
Southeast Biomass State and Regional Partnership

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Prepared by:
South Carolina Energy Office
1201 Main Street, Suite 430
Columbia, SC 29201

Phone (803) 737-8030
Fax (803) 737-9846
www.energy.sc.gov

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Norcross, GA 30092

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This project is supported by the Southeastern Biomass State and Regional Partnership (SEBSRP) and administered by the Southern States Energy Board (SSEB) for the United States Department of Energy.

Note: References to SERBEP in this document refer to the U.S. Department of Energy (DOE)/Southern States Energy Board (SSEB) Southeastern Regional Biomass Energy Program, which preceded the DOE/SSEB Southeast Biomass State and Regional Partnership (SEBSRP).

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Foreword

The South Carolina Energy Office (SCEO) is a unit of the State Budget and Control Board. Established in law by the South Carolina Energy Conservation and Efficiency Act of 1992, the Energy Office has the mission of increasing energy efficiency and diversity, enhancing environmental quality and saving energy dollars for South Carolina.

Through its various programs and initiatives, the SCEO improves energy efficiency and deploys renewable energy projects. Its efficiency measures and programs are saving taxpayers over $70 million in the public sector alone. Workshops, financial aid programs, technical assistance activities and numerous publications and information activities assist and inform industrial, commercial, public sector and individual consumers in saving energy dollars and minimizing energy-related pollution.

Biomass Energy Potential in South Carolina: A Conspectus of Relevant Information is one of several activities in which the SCEO is partnering with the US Department of Energy, the Southern States Energy Board, and a host of others to identify and pursue opportunities to improve South Carolina's economy, environment and energy security through greater use of biomass energy.

Other biomass energy activities of the SCEO and its partners include formation and staffing of the South Carolina Biomass Council, implementation of a South Carolina Biomass Market Development Project, computation of macro-level metrics pertaining to potential economic and environmental benefits of biomass energy potential in the state, and studies on the feasibility of developing energy from poultry manure and litter, from waste water sewage facilities, and from used cooking oil and waste animal fats.

This conspectus is a general survey and digest of information relevant to biomass energy in South Carolina. Because it is Web-based and constantly updated as new information is gathered, it is a dynamic document. The most current version of the report is maintained on the SCEO website at www.energy.sc.gov. The online report provides links that allow the reader to access document summaries, and, in most cases, full-length documents referred to in the report.

Key SCEO staff responsible for preparation of this conspectus includes Erika Hartwig, John F. Clark, Michael Hughes, and Elizabeth Renedo.

We invite and encourage readers to correct errors, provide additional information and submit any other input that will assist in increasing the scope and accuracy of this document and its value toward the goal of increasing biomass energy production and use in South Carolina. Please send all comments to ehartwig@energy.sc.gov. Additional contact information is provided at www.energy.sc.gov.

Biomass Energy Potential in South Carolina: A Conspectus of Relevant Information

Introduction

The creation of energy from organic renewable materials in the form of gas, liquid or solid holds tremendous beneficial potential for South Carolina. Biomass energy can be created from a variety of processes including, but not limited to: direct combustion of biomass to produce process steam and/or electricity; collection of natural biomass decomposition products such as methane; and conversion of biomass materials to create transportation fuels such as ethanol and biodiesel.

The South Carolina Energy Office (SCEO) and other public and private organizations have encouraged production of biomass energy in the state for over 25 years. A significant number of studies and reports have been produced, both in South Carolina and in other states with similar biomass resources. Nevertheless, measurable progress in South Carolina in the use of biomass energy resources has been slight.

Greater use of biomass energy resources in South Carolina is important for several reasons:

1. Economic Development: South Carolina produces no fossil fuels and thus imports the vast majority of its primary energy resources from other states and nations. Greater use of fuels derived from within the state will result in greater income multipliers from energy expenditures and thus boost economic expansion within the state, especially for the rural sector greatly in need of economic stimulus.

2. Energy Security: The transportation sector relies almost entirely on petroleum, nearly 70 percent of which is imported from foreign sources. An overwhelming majority of foreign petroleum reserves are in the Middle East and other countries that are problematic for US energy dependence, such as Nigeria, Venezuela and Saudi Arabia. International supply, pipeline disruptions and price volatility put the country and the state at a high level of infrastructure vulnerability.

3. Environmental Enhancement: Almost two-thirds of all energy in the state is derived from fossil fuels (coal, oil and natural gas). Combustion of fossil fuels for energy releases harmful air emissions, in addition to creating problems associated with leaks and waste disposal. Fossil fuels contaminate air, water and land, create health problems, and have negative impacts on fish and wildlife. They cause crop and forest damage, and inflict enormous economic costs associated with environmental impacts. Nuclear power, providing almost a third of the state's primary energy needs, has safety problems associated with nuclear waste disposal. Biomass energy resources generally have far less adverse environmental impacts, and, in some cases, conversion of biomass into useful

energy mitigates other environmental problems, such as collecting and using harmful methane gases from landfills, animal manure, municipal sewage, and utilizing wood wastes, as well as construction and demolition debris, that would otherwise be buried in landfills.

Biomass Energy Potential in South Carolina: A Conspectus of Relevant Information summarizes studies conducted on various actual and potential feedstock resources in South Carolina and the Southeast, as well as relevant non-regional studies and other pertinent information. The report describes the existing information base, as well as information gaps, about the potential for three broad categories of biomass energy feedstocks: (1) resources for direct combustion of biomass to produce process steam and/or electricity; (2) resources for methane production; and (3) resources for production of ethanol or biodiesel transportation fuel. Ultimately, this report and other efforts will enhance biomass energy production and consumption in South Carolina.

The SCEO intends for *Biomass Energy Potential in South Carolina: A Conspectus of Relevant Information* to be a dynamic, on-going document. As additional existing and new information is identified and compiled, it will be incorporated into the report, which will serve as a primary information resource for future biomass energy production and use in South Carolina. The most current version of the report is maintained on the SCEO website at www.energy.sc.gov. The online report provides links that allow the reader to access document summaries, and, in most cases, full-length documents referred to in the report.

I. Potential for Direct Combustion of Solid Biomass

A. Woody Biomass

Bioenergy in the Southeast: Status, Opportunities and Challenges by The Southeast Bioenergy Roundtable was a work plan intended to further studies of the economic and environmental advantages of biomass energy.

Among the studies, Robert A. Harris et al. produced a definitive report, *Potential for Biomass Energy Development in South Carolina,* completed in 2004 for the South Carolina Forestry Commission. The study describes the amounts, locations, and types of forest biomass and agricultural crop residues available. Forest biomass includes: logging residues, pre-commercial thinning, commercial thinning, southern scrub oak, mill residues, urban wood waste, forestry biomass, and agricultural wastes and byproducts. Harris describes available biomass-to-energy technologies, costs for transportation, potential job creation, and economic benefits. Harris identified 22 million tons of forest biomass available annually for energy use, equivalent to powering ten 40 megawatt biomass power plants, potentially displacing 4.8 million tons of coal (1/3 of all coal used for power production in South Carolina).

Most dedicated biomass fueled power generators use direct-combustion boilers coupled with steam turbines (see Figure 1). These generators typically possess a biomass combustion chamber with equipment to evenly distribute biomass fuel over a grate which separates the ash from the burning biomass. The generated heat creates steam in an adjoining high-pressure water tube boiler which feeds process steam through a multi-stage steam turbine.

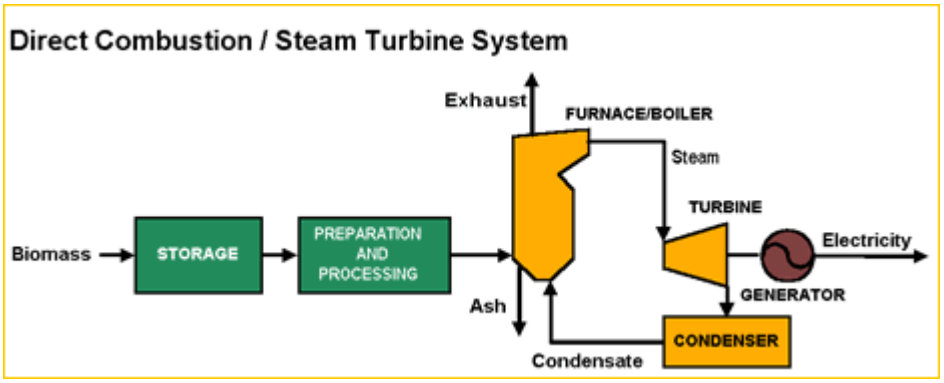

Figure 1: The most common biomass fueled power generator is a direct combustion/steam turbine system. Figure courtesy of the US Department of Energy, Energy Efficiency and Renewable Energy Program.

Another biomass generator is a simple cycle gas turbine. This generator uses a primary chamber devoid of air to gasify the biomass, which then passes into a secondary combustion chamber where the gas is used to produce heat (see Figure 2). These plants tend to be inefficient, small, and expensive compared to traditional power generation from coal and natural gas. However, a more efficient and less expensive form of biomass power is known as a combined-cycle biomass gasification system (see Figure 3).

Biomass is converted to a gas, in an atmosphere of steam or air, and produces a medium- to low-energy content gas. This biogas powers the combined-cycle power generation plant similar to the simple cycle. Unfortunately, these plants have not yet reached America, but with further study could be a reliable form of biomass power generation. The University of South Carolina (USC) plans to build a simple cycle gas turbine on their Columbia campus to go online in fall 2008. The plant will produce approximately one megawatt of electricity, equaling about 85 percent of campus energy needs. The USC plant will utilize 10-20 million tons of biomass over the course of its operating life and save almost $2 million annually. (For more information about this and other wood-burning processes, please see *Wood Energy Guide for Agricultural and Small Commercial Applications* by Larry Jahn, et al.)

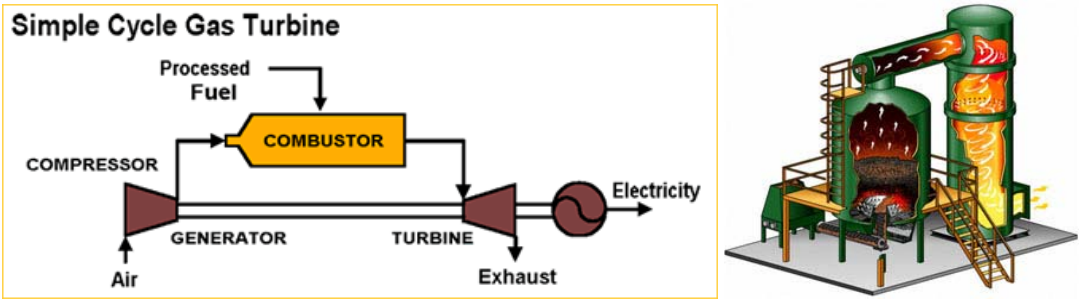

Figure 2: Simple cycle gas turbine electric generator, more expensive and less efficient form of biomass energy. Figure courtesy of the US Department of Energy, Energy Efficiency and Renewable Energy Program and the University of South Carolina.

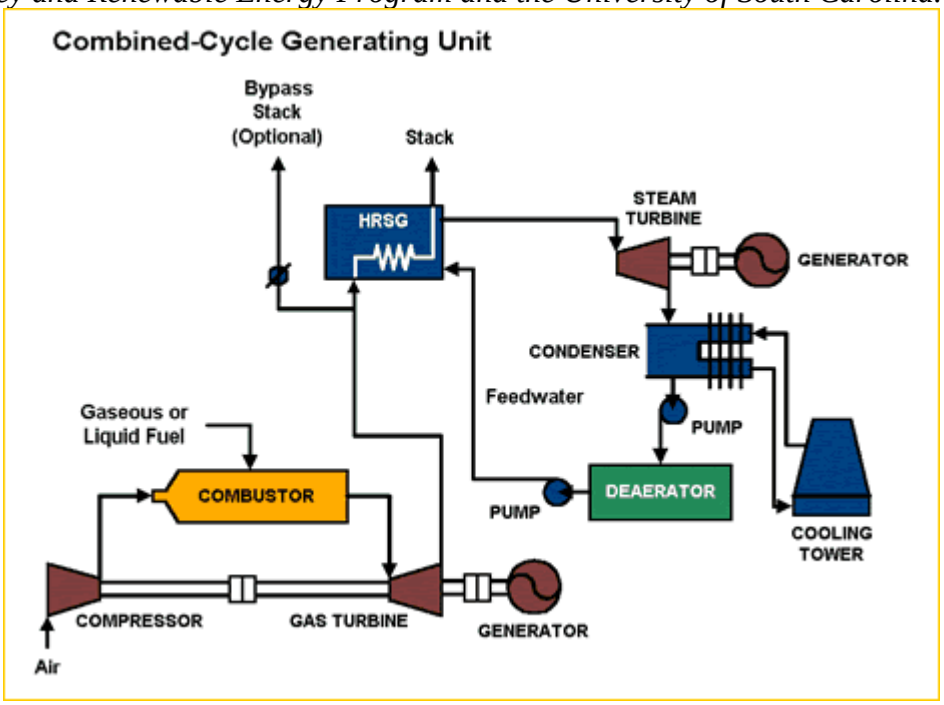

Figure 3: Combined-cycle generating unit, most efficient and less expensive form of biomass energy. Figure courtesy of the US Department of Energy, Energy Efficiency and Renewable Energy Program.

Using woody biomass for co-firing in coal-fired power plants has also been described as a source of power in the Harris report, but further study is needed. Co-firing involves mixing woody biomass with coal to reduce the amount of coal used in the process. Co-firing has been tested with a variety of boiler technologies. Though it decreases efficiency by a marginal amount, it increases air quality significantly. The main problems identified with co-firing are the logistics of storage, handling, and preparing the biomass fuel, as well as safely and efficiently adding the fuel to the combustion chamber. At the date of publication, no coal-fired power plants intend to use co-firing in South Carolina. However, new incentives exist for utilities and co-firing with woody biomass is a much more viable option. New research conducted by Agri-Tech Producers and North Carolina State University has introduced an economical method to treat wood through a torrefaction process, which allows the wood to be comparable in heating value and consistency to coal.

The *Primer on Wood Biomass for Energy* by Richard Bergman, et al., explains the environmental and economic advantages of using woody biomass. Environmental: 1) when compared to fossil fuels, wood is a renewable resource creating a sustainable and dependable supply with proper forest management; 2) wood burning releases fewer carbon emissions; 3) wood emissions contain minimal metal and sulfur; and 4) minimal byproduct (ash) is created. Economic: 1) A comparatively lower fuel cost; and 2) less life-cycle costs of a biomass combustion system versus a fossil fuel system. The *Primer* also discusses the three scales of wood fuel operations: 1) space heat; 2) electricity and cogeneration related to micro, small, medium, and large power generation facilities; and 3) thermal and electric power in the residential, commercial, municipality, industrial, and utility areas of use. The *Primer* recommends that decision-makers analyze the feasibility of biomass before undertaking a major economic analysis.

According to a report by Timothy Young, *Analyzing Market Constraints in Woody Biomass Energy Production*, there are five major constraints to using industrial wood energy by the non-forest products sector. These include: 1) lack of knowledge and poor perception; 2) high capital cost of conversion; 3) problems with wood fuel handling; 4) concerns about the availability of a long-term supply; and 5) lack of knowledge about the proper operation of a wood energy system. The study theorized these constraints prevent non-forest product industries and institutions from using wood energy, but in reality, barriers could be overcome with government assistance and information dissemination.

Already many operations have realized the benefits of wood fuel and the SCEO website, www.energy.sc.gov, lists a regularly-updated inventory of known users of wood waste for energy (see Appendix A). According to these inventories, 62 commercial and industrial operations in South Carolina use 4 million tons of woody biomass annually for energy purposes. According to a report titled *Analysis of Renewable Energy Potential in South Carolina* and published in 2007 by the Central Electric Power Cooperative, Inc. in conjunction with La Capra Associates, Inc., it is estimated that 360 MW of electricity is produced by direct-fired boilers and combined heat and power (CHP) projects. According to the report the state has enough logging residues and wood waste to support an additional 423 to 1,599 MW of electricity.

Despite concerns, operators do not need to construct new facilities to utilize wood waste. *Boiler Retrofit for Biomass Energy*, a report by Georgia Technical Research Institute, demonstrated that a simple retrofit of an existing boiler could reduce reliance on expensive fossil fuels by making use of sawdust from a local sawmill. Concerns about fuel reliability and temperature burdens were unfounded as the plant management was satisfied with the system and reported natural gas fuel bill reductions by 75 percent over the initial four-month period of operation.

Existing and upcoming biomass projects include:

- Santee Cooper announced plans in July 2008 to purchase electricity from 50 MW biomass energy operation. Details have not been publicized.
- Carolina Soya, a soybean crushing facility in Estill utilizes two waste wood/glycerin boilers that combined produce 70,000 lbs of steam an hour, and use 70,000 tons of waste wood a year. The waste wood comes from local sawmills and includes materials like bark, scrap wood, and glycerin, which is a by-product of biodiesel production. A biodiesel plant, Ecogy Biofuels LLC, has been constructed near the soy oil production facility and will provide the glycerin, which will reduce wood requirements significantly at Carolina Soya.

B. Agricultural Crops and Residues

Alternately, agricultural wastes and energy crops have been identified as a source of fuel for electrical generation in *Regional Assessment of Non-Forestry Related Biomass Resources, Summary Volume* by Jaycor, Inc. The study collected and developed county-level information on the availability of non-forestry biomass wastes and residues. The report helps potential biomass users locate resources and understand methods of collection, transportation and conversion cost data, which could also assist decision-makers with prudent economic decisions.

More studies need to be conducted to better understand the economic benefits of agricultural wastes and energy crops in South Carolina. The report, *Potential for Biomass Energy Development in South Carolina*, by Robert Harris et al., showed that no economic incentives currently exist to derive biomass from crop residues because federal law requires at least 30 percent of the soil surface be covered by plant residues to control erosion and maintain soil productivity. Additionally, due to the seasonality and low energy density of crop residues, it may not be as reliable and economical when compared to forest biomass.

Switchgrass and other tall canes have been called bioenergy crops because of their potential to be grown solely for energy use. Clemson University is currently studying a 1,000 acre plot of switchgrass in Florence for management and best practices. *Arundo donax* (Giant Reed) is being studied at the University of South Carolina for its potential as a bioenergy crop. According to the Central Electric Power Cooperative, Inc. report, the state could produce between 36 to 318 MW of electricity from agricultural crop residues and switchgrass.

C. Municipal Solid Waste

According to the *South Carolina Renewable Energy Combustion Facilities* inventory, only one example of combustion of municipal solid waste for energy exists. The Montenay Charleston facility in North Charleston burns 220,000 tons of solid waste per year, which is roughly 75 percent of the waste produced in Charleston County. The majority of the generated steam is used to produce 92,600 MWh/year, of which 70,000 MWh is sold to Progress Energy. Around 285,000 lbs of steam per year is sold to the US Navy, and the rest is used to generate electricity. The Montenay Charleston contract with Charleston County expires in 2009. A facility in Hampton, South Carolina was constructed in the 1980s to provide steam to a local manufacturing plant, but this facility converted to a medical waste incinerator and is now closed. The Wellman Energy Plant in Johnsonville at one time burned municipal solid waste, but now generates power from in-waste produced by the plant, according to *Case Studies of Biomass Energy Facilities in the Southeastern U.S.* by Meridian Corporation.

According to the *S.C. Solid Waste Management Annual Report*, in fiscal year 2007 South Carolina sent 6,558,129 tons of solid waste to permitted landfills. If this municipal waste were to be burned for waste-to-energy purposes similar to a plant in Hempstead, N.Y., it could generate 3,891,470 MWh of energy. However, the economic and environmental considerations of combusting municipal solid waste for energy purposes make this form of energy less desirable. According to the Environment Protection Agency, burning 6.5 million tons of municipal solid waste would produce approximately 5.6 million tons of carbon dioxide and other noxious chemicals and gases. Landfill-gas-to-energy projects (discussed in section II.E. of this report) and energy savings from recycling appear to be preferable energy derivatives from municipal solid waste.

However, if recovered properly, a portion of municipal solid waste could generate power in a more environmentally feasible way. According to the study, *Recycling Wood Waste for Use as Biomass Fuel*, by Charles Johnson of Alabama, due to the high costs of landfill space it was economically feasible to recover wood waste from citizens in a curbside pickup program and convert the wood waste into biomass fuel for an industrial boiler in Anniston. The program was a success and the city was able to recoup initial startup costs in two years while conserving non-renewable fuels that would have been used to generate the electricity. *A Sourcebook on Needs Assessment and Evaluation of Mobile, Multi-Community Wood Waste Processing for the Southeastern Regional Biomass Energy Program* by the TVA Environmental Research Center reached the same conclusion, but recommended a private contractor be employed to handle the wood waste because of existing and historical political barriers to inter-municipal cooperation. A report by C.T. Donovan Associates, Inc., called *A Sourcebook on Wood Waste Recovery and Recycling in the Southeast*, provides a starting point for generators, recyclers and end users to evaluate the planning, policy and regulatory approach needed to begin wood waste processing and combustion for fuel.

D. Waste Tires

Some believe waste tires are another form of biomass energy and due to their abundance could generate a reliable supply of power. *The SC Solid Waste Management Annual Report* estimated 83,000 tons of tires were recycled in fiscal year 2007, which included

the incineration of tires for energy. Two known factories in South Carolina use tire-derived fuel to generate onsite power. International Paper Company in Richland County uses 20,000 tons of tire-derived fuel each year to produce steam. The Blue Circle Cement Waste Tire Processing Facility in Harleyville also incinerates tires as a secondary fuel for the cement-making process. Burning tires releases similar air pollutants as fossil fuel-based power generators and therefore is not an environmentally preferred alternative. Despite the existence of waste tire incineration in South Carolina, no known studies have evaluated the environmental and economic feasibility of burning waste tires on a large scale.

The Savannah River Site announced plans in 2007 to replace a coal plant with waste wood boiler as the coal plant was too large for SRS's reduced steam requirements, resulting in venting of excess steam and reduced plant efficiency. Ameresco will replace this and two fuel back-up fuel oil boilers with two 120,000 pph biofuel BFB boilers w/ SNCR control, one 100,000 pph packaged fuel oil boiler for backup energy generation only, and one 18 MW condensing Turbine. The Site will use forest residue within the geographic region, tires and wood palettes from Three Rivers Landfill. The landfill will provide up to 200 tons of unprocessed tires and 84 tons of palettes per week.

E. Construction and Demolition Debris

The final type of solid biomass waste is construction and demolition debris. In fiscal year 2007, according to the *SC Solid Waste Management Annual Report*, approximately 2.3 million tons of construction and demolition debris were sent to South Carolina landfills. No known studies have evaluated the economic and environmental feasibility of burning construction and demolition debris in South Carolina and no known facilities in South Carolina use this waste for fuel.

II. Potential for Methane Production

In addition to burning biomass for power, energy can be produced from the biogases released during the decomposition process. Animal and human fecal waste, food service and processing byproducts, and pulp and paper residuals create biogas, but have been underutilized in South Carolina. Landfill-gas-to-energy facilities, however, have been extremely successful in South Carolina, but represent a small portion of total green power readily available.

A. Animal Waste

Methane can be produced from animal wastes in a process known as anaerobic digestion (see Figure 4). The process works best in an airtight container containing a mixture of bacteria normally present in animal wastes. The bacteria break down the waste, such as fat and protein, into simpler molecules. The final product is a biogas containing methane and carbon dioxide, which can be used for heating or electricity production in a modified internal combustion engine or an advanced gasification technique to fuel a gas turbine.

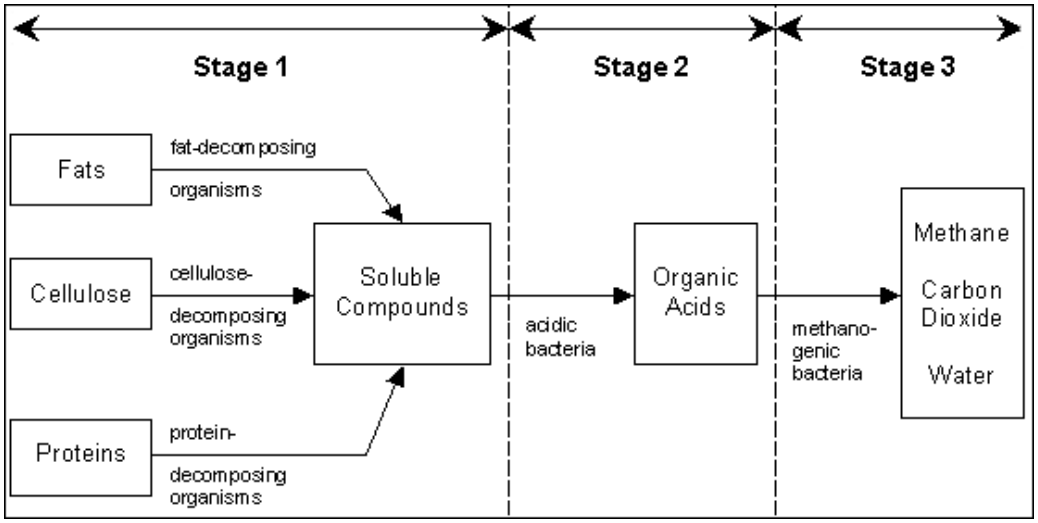

Figure 4: The process of anaerobic digestion in an airtight container with appropriate bacteria produce biogas, particularly methane. Figure courtesy of the Department of Energy, Energy Efficiency and Renewable Energy Program.

Animal manure was identified by the study, *Animal Manure and Related Biomass Feedstock Market Assessment and Preliminary Feasibility Study for a Paper Mill Biomass/CoGen Facility* produced by LINPAC, as the most available source of feedstock in the state, and though transfer costs might be high, changing regulation could make it more economical. The report lists, sector by sector, quantities of waste available. According to the report an estimated 32,000,000 tons of animal waste are available in the state each year, not including poultry manure. Anaerobic digestion was shown to be economically feasible and environmentally beneficial. LINPAC recommended using a gas combustion turbine/cogeneration system, and despite high capital costs, the system had a positive return on investment.

In a report commissioned in FY06 by the South Carolina Energy Office (SCEO), *Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production*, Dr. Joseph Flora identified between 400,000 to 700,000 dry tons of poultry litter produced each year. The majority comes from chicken broiler facilities, followed by turkey facilities. According to a cost analysis in the study, small-scale gasification appears to be the most economically viable means of utilizing poultry litter for biomass energy. Anaerobic digestion is also possible, but the energy would be more expensive and would require a longer start-up period and frequent maintenance, and the biogas would need to be used immediately since it cannot be stored.

According to the report by Central Electric Power Cooperative, Inc. 32 to 44 MW of electricity could be produced from swine and poultry wastes from technologies such as an anaerobic digester coupled with a combustion engine generator or co-fired with direct-fired applications.

The conversion of agricultural waste and crops to electricity is one of the fastest growing renewable energy industries in Europe. In Germany, 3,500 biogas plants already are producing 1,100 MW with a projected growth to 9,500 MW by 2020. Unfortunately, this technology has not been successful in the US because of substantially lower electricity prices, lack of subsidies and long term price guarantees, and high capital and operating costs for these facilities. If agricultural waste and crops are to be used successfully as a significant source of electricity in South Carolina, a different approach that produces large quantities of electricity at competitive prices is required. The SC Institute of Energy Studies is working with Santee Cooper to demonstrate a prototype bioenergy park module that:

- Produces utility scale power from a combination of swine waste and energy crops;
- Forms the basis for multi-module, multi-megawatt centralized facilities throughout SC and the US that can produce electricity at near market rates;
- Provides the potential for new jobs and attracts new renewable energy companies to SC;
- Provides additional revenue for SC farmers from existing waste streams and crops; and
- Improves the quality of South Carolina's air and water through the elimination of the odors and methane that are released from existing farm waste treatment facilities.

The prototype system is planned to be in operation by the end of 2009.

B. Animal Residuals, Food Service and Processing Byproducts

Though information gaps exist for methane potential from animal residuals, food service byproducts, and food processing byproducts in South Carolina, they are readily available for electricity generation through anaerobic digestion. According to the report, *Animal Manure and Related Biomass Feedstock Market Assessment and Preliminary Feasibility Study for a Paper Mill Biomass/CoGen Facility* produced by LINPAC, approximately 169,000 tons of animal residual and food waste are generated each year in South Carolina. A small portion of these food service and processing byproducts are used as animal feed and fertilizers, but a significant portion is sent to landfills. More study is

needed to understand the economic potential for these forms of green power in South Carolina.

C. Pulp and Paper Manufacturing Wastes

The pulp and paper industry produce large amounts of wood residues as a result of logging and processing operations. Plants are made of lignin, hemicellulose and cellulose fiber. Due to the chemical and physical properties of lignin, it breaks down easier than cellulose. Pulping separates the lignin and cellulose fibers to create paper. The leftover materials can be used to create energy for the paper mill. The report, *Animal Manure and Related Biomass Feedstock Market Assessment and Preliminary Feasibility Study for a Paper Mill Biomass/CoGen Facility* by LINPAC, estimates South Carolina produces approximately 250,000 tons of pulp and paper waste a year. Due to its homogenous nature, cellulose is an excellent source of feedstock for anaerobic digestion in a biomass cogeneration facility. However, care must be taken to modify current plant wastewater treatment procedures, as oftentimes biocides are used to prevent bacterial buildup in pipes which would alter the effectiveness of anaerobic digestion processes.

D. Human Waste

Sewage and human fecal waste have always been a contentious issue for city planners and finding an environmentally sound way to dispose of this waste has proven difficult. The anaerobic digestion of sewage sludge produces biogas similar to that produced by animal waste, with about 50-60 percent methane. Methane is compressed, purified and stored in a container known as a gasometer, and then transported to a gas engine to produce electricity (see Figure 5).

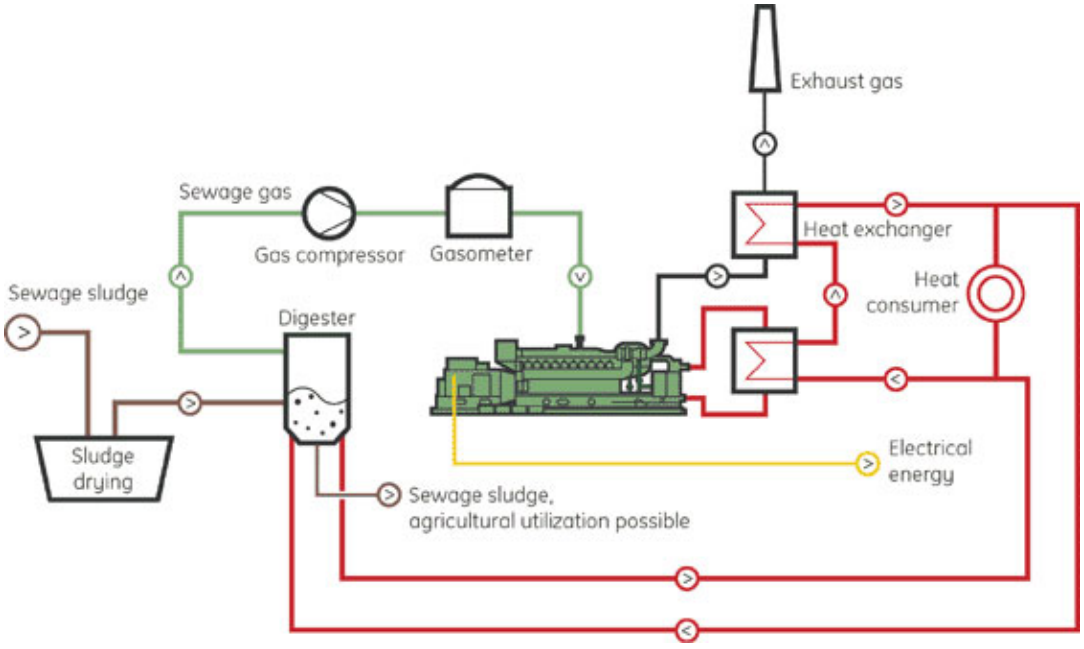

Figure 5: Sewage anaerobic digestion system, methane collection, and energy production process. Figure courtesy of GE Power.

A study conducted on behalf of the South Carolina Energy Office examined the feasibility of extracting methane from sewage in South Carolina. *Bioenergy from Municipal Sludge Study Report* by Hayes, Seay, Mattern & Mattern, Inc. determined the amount and locations of potentially recoverable useful energy from sewage treatment facilities in South Carolina, along with an analysis of economics and barriers of recovering and utilizing such energy. The study determined that approximately 100,000 dry tons of sludge is produced annually in South Carolina. This equates to approximately 1.5 trillion BTU's or 0.44 billion kWh of energy (or the equivalent of 44,000 homes).

E. Landfill Gas

Landfill gas accounts for almost all of the green power available to South Carolina households and businesses. Since 1999, the SCEO has partnered with the US Environmental Protection Agency's Landfill Outreach Program (LMOP) in an effort to reclaim and use landfill gas in the state. Concentrated efforts on the Landfill Gas to Energy Program (LFGTE) projects have resulted in significant energy and environmental benefits to the state. Landfill gas is produced in a similar manner to anaerobic digestion. The anaerobic conditions within a landfill produce methane and other gases naturally, and these gases migrate to tubes deep within the landfill. The tubes transport the gas to collection stations on the surface, where it goes through a cleaning process to remove harmful and corrosive chemicals prior to electricity generation (see Figure 6).

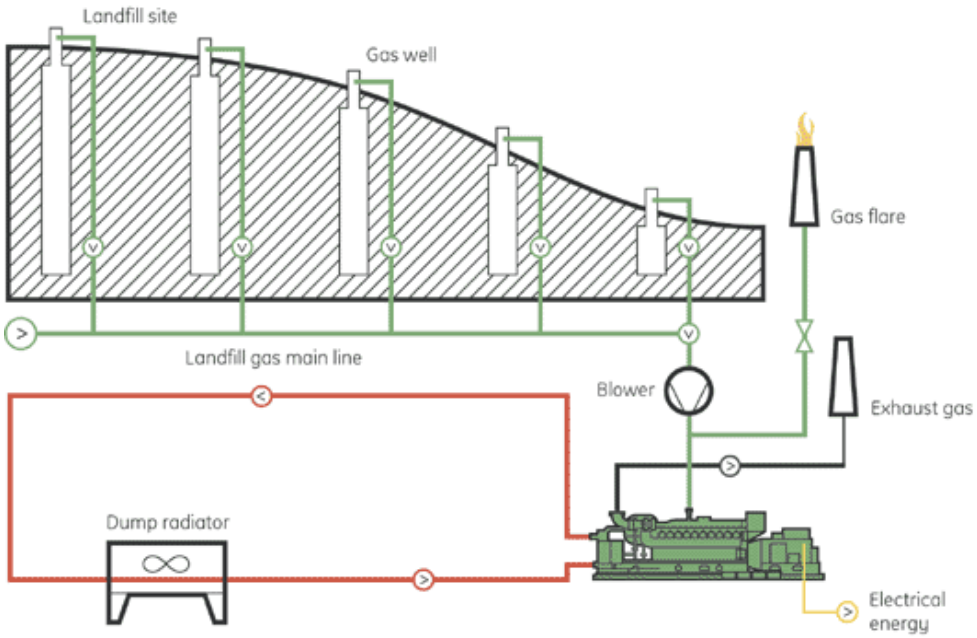

Figure 6: Landfill gas generation process. Figure courtesy of GE Power.

In July 2008 Santee Cooper reached a key milestone in energy produced with landfill methane gas—more than 250,000 megawatt-hours had been produced through this renewable energy process. Santee Cooper is the only utility in the state producing electricity through landfill gas-generating facilities. Landfill methane gas-generation is part of Santee Cooper Green, the utility's initiative to go green and help its customers go green, save energy and save money. Last fall, Santee Cooper announced an aggressive

goal to generate 40 percent of its energy – four times current levels – from non-greenhouse gas emitting resources, biomass fuels, energy efficiency and conservation by 2020.

As trash in landfills decomposes, it produces methane gas, which can be converted into energy through a process that also reduces greenhouse gas emissions. Plans are ongoing to bring additional facilities online with up to 45 MWs of generation projected in the future. The first Green Power generating facility was built in Horry County in 2001. Santee Cooper now operates three landfill gas-generating facilities throughout South Carolina-Horry, Lee and Richland counties and will soon start-up a fourth facility in Anderson county. A fifth location has been announced in Georgetown County.

- Horry County Landfill Generating Station near Conway – 3 MW
- Lee County Landfill (Allied Waste) - 5.4 MW. The project will expand to 10.0 MW in 2009 and 14.5 MW in 2012.
- Screaming Eagle Road Landfill (Waste Management) in Richland County - 5.5 MW. Another 1.6 MW engine will be added in 2009 and 2011 to produce a total of 8.7 MW on site.
- Anderson Regional Landfill in Richland County – anticipated capacity is 3.2 MW to be installed in late summer 2008.
- Georgetown County Landfill – anticipated capacity is 1.6 MW to be installed in 2009.

In addition to Santee Cooper, private companies are also utilizing landfill gas. BMW's South Carolina car assembly plant uses landfill gas (LFG) from Waste Management's Palmetto Landfill to fuel four gas turbine cogeneration units (4.8 megawatt capacity) and recovers 72 MMBtu/hr of hot water. The project cost approximately $12 million and was coordinated by BMW Manufacturing Co., LLC, Ameresco, Durr Systems, Inc., SCEO, and Waste Management, Inc. The turbines fulfill about 25 percent of the plant's electrical needs and nearly all of its thermal needs. For these outstanding environmental efforts, BMW was awarded LMOP's 2003 Project of the Year.

With excess landfill gas available and a continued desire to be environmentally responsible, BMW turned to the largest consumer of energy in the entire plant: the paint shop. Employing Durr Systems, the original designer of the paint shop, BMW converted equipment to burn LFG and still had enough excess LFG to burn in one of three boiler systems. This effort earned BMW Manufacturing recognition as LMOP's 2006 Energy Partner of the Year.

The project's highlights include:

- Nearly 70 percent of BMW's energy consumption comes from LFG.
- World's first automotive paint shop to integrate use of LFG in process equipment.
- A 9.5-mile pipeline crosses a river, two creeks, an interstate, and BMW's test track, delivering about 4,800 scfm of filtered and dehydrated landfill gas.
- Protection from rising and fluctuating natural gas prices over a 20-year contract, saving the company on average one million dollars a year.
- According to BMW, a reduction of carbon dioxide emissions equivalent to driving 105 million miles per year, or more than 4,000 times around the earth.

Additionally, MethaneCredit obtained the landfill gas rights for Greenwood County Landfill and will sell the gas to FujiFilm. MethaneCredit is currently developing the site and will install a 3.5 mile long pipe. The gas will be used to produce process steam that will generate up to 60% of the energy needs at FujiFilm's manufacturing plant in Greenwood. The project is expected to be complete in late 2008.

Finally, Three Rivers Solid Waste Authority in Aiken County will sell landfill gas to Kimberly-Clark. Siemens is developing the project that is expected to produce between 1 to 3MW-equivalent of gas.

III. Potential for Production of Ethanol and Biodiesel Fuel

South Carolina depends almost exclusively on petroleum-based fuels to power its vehicles. As noted in the introduction of this report, nearly 70 percent of those petroleum-based fuels are imported from foreign sources, leaving South Carolina vulnerable to a volatile petroleum market. However, South Carolina does have available biomass resources to produce alternative fuels and a growing infrastructure to distribute them.

The 1996 Southeastern Biomass State and Regional Partnership (SEBSRP) report *Regional Energy and Economic Self-Sufficiency Indicators in the Southeastern United States,* analyzed the amount and types of energy used throughout the Southeast. It concluded that the Southeast region consumes more petroleum than any other energy resource, and that between 1960 and 1996, the use of petroleum resources rose by 138 percent. Increasing the production and use of alternative fuels such as ethanol and biodiesel in South Carolina will offset dependence on imported petroleum and create economic opportunity in the state.

The SC Energy Office, in partnership with the Palmetto State Clean Fuels Coalition, has aggressively marketed ethanol and biodiesel in the state. Successes in promoting ethanol infrastructure through education, outreach and funding opportunities has allowed South Carolina to have the highest concentration of biofuel pumps with a total of 55 publicly-accessible E85 pumps and 52 publicly-accessible biodiesel pumps. An updated list of publicly-accessible pumps is available on the Palmetto State Clean Fuels Coalition website at www.palmettocleanfuels.org.

Between July 2007 and June 2008, the SC Department of Revenue reported that approximately 43 million gallons of ethanol and 1.5 million gallons of biodiesel were sold in South Carolina – the largest quantity by far since alternative fuel tracking began in 2000 and representing 1.5 percent of the motor fuels sold in the state during that period. Since 2000, approximately 67,000,000 gallons of ethanol, biodiesel, and compressed natural gas have been used in the place of conventional fossil fuels.

The PSCFC funded a total of nine of the aforementioned E85 stations with monies set aside by the South Carolina Department of Health and Environmental Control (DHEC) from an environmental fine against Willamette Industries. And another seven pumps with funds allocated through the 2007 US Department of Energy Southeast Ethanol and Biodiesel Infrastructure Corridor Grant.

In addition to publicly accessible refueling stations that both consumers and the government can use, a number of governmental entities have E85 and B20 infrastructure for restricted use by local, state and federal government entities. The first E85 station came about as a result of the partnership between DHEC, the South Carolina Energy Office and the PSCFC, as DHEC constructed the first ethanol refueling station in Columbia in 2001. This station, located at the DHEC refueling facility at 2600 Bull

Street, allows state and local government fleets to refuel at the site. DHEC currently averages sale of about 30,000 E85 gallons a year at this site.

As of January 1, 2008 all diesel pumps controlled by the state are now required to utilize at least 5% biodiesel blends in the tanks. Many tanks also contain B20 to meet federal regulations. The SC General Assembly approved a 15-year replacement cycle for school buses, which is expected to reequip South Carolina's aging fleet – considered to be among the oldest in the nation. Pollution, among other factors, was a large reason for replacing the older buses with newer vehicles with improved emission controls.

In a move to reduce air emissions, in fall 2008 all South Carolina school buses will use a blend of biodiesel and ultra low-sulfur diesel fuel, effectively reducing soot emissions by about 10 percent from standard diesel fuel. The contract for biodiesel was recently awarded to United Energy Distributors out of Aiken, one of the largest biofuels distributors in the state. According to Don Tudor of the SC Department of Education, the department expects to use over 2.4 million gallons of biodiesel after the first year – nearly double the amount used by the entire state in 2006. The department is currently testing equipment and buses with lower blends of biodiesel and will eventually increase the blend to twenty percent.

Between July 2005 and June 2008 the State of South Carolina used approximately 100,000 gallons of E85 (85 percent ethanol, 15 percent gasoline) and 200,000 gallons of B100 (100 percent biodiesel).

A. Corn

Corn is the major feedstock for ethanol manufactured in the United States. In 1990, the SEBSRP produced a report, *The Regional Assessment of Non-Forestry Related Biomass Resources*, which collected and developed county-leve1 data analyzing the availability of non-forestry biomass wastes and residues. The main objective of the study was to develop a comprehensive inventory of all available non-forestry biomass resources in the southeastern region. The data collected assist potential biomass users in identifying local biomass resources. The information, in conjunction with detailed collection, transportation and conversion cost data, helps potential users make prudent economic decisions on converting to biomass energy.

The project gathered data on many types of biomass resources at the county level, including those that can be used to produce transportation fuels such as corn. According to the report, South Carolina produces 4.5 percent of the Southeast's non-forestry biomass, including an average of 502,105 tons of corn per year. This low level of corn production makes South Carolina what is known as a "corn deficit state." Therefore, it may be more beneficial for South Carolina to focus on other energy crops that can be used to produce ethanol, such as switchgrass.

Case Studies of Biomass Energy Facilities in the Southeastern U.S., a 1986 report by the Meridian Corporation, identified a South Carolina ethanol project among its case studies. Beginning in 1985, the Wateree Correctional Institute had an ethanol facility capable of

producing 250,000 gallons of fuel per year. The $450,000 facility has since closed. The purpose of the Wateree Correctional Institute ethanol project according to the report was "to demonstrate to farmers and other agribusiness interests the value and viability of ethanol production." The facility processed 100,000 bushels of corn per year into ethanol fuel using standard fermentation and distillation processes. The distiller's grain, a protein-rich byproduct of the process, was used to feed the prison's farm animals, leaving no disposable waste. The operation was closed in 1987 for political reasons. While it was in operation during the mid-1980s, the facility's main difficulty was finding a market for its ethanol because gasoline was cheap and demand for ethanol was low. However, in today's marketplace, there is a greater demand for ethanol fuel.

The boards of Atlantic Ethanol, LLC, Mid-Atlantic Ethanol, LLC, Florida Ethanol, LLC and Palmetto Agri-Fuels, LLC, announced in September 2007 that their members recently approved a merger and consolidation of the four companies to form East Coast Ethanol, LLC. Prior to the merger, each of the four companies was separately developing a single 110 million gallon per year fuel ethanol production facility. East Coast Ethanol, LLC will now assume the financing, construction and operation of the four new ethanol production facilities being developed in the Southeast, including a plant in Chester County, South Carolina. It is expected that Fagen, Inc. will design and build all four of the planned ethanol production facilities.

B. Soybeans

Soybeans are often used as a feedstock for the production of biodiesel fuel. According to *Bioenergy in the Southeast: Status, Opportunities and Challenges*, given an average of 30- to 40-bushel-per-acre yields, 46-62 gallons of biodiesel fuel can be produced from one acre of soybeans. According to the South Carolina Department of Agriculture, 530,000 acres of soybeans were harvested in South Carolina in 2004, with a yield of 29 bushels per acre.

There are currently two biodiesel facilities in South Carolina that produce biodiesel from soy oil. These include:

- Carolina Biofuels, a division of the Taylors, South Carolina-based company Carolina Polymers, rolled out their first load of biodiesel fuel on March 14, 2006. Carolina Biofuels manufacturing facilities are currently in full operation, and though starting at 10 million gallons of biodiesel fuel expect to grow to over 40 million gallons annually. A large percentage of the fuel produced at Carolina Biofuels is sold to World Energy Alternatives, LLC which is leading global supplier of biodiesel located out of Massachusetts. Carolina Biofuels supports South Carolina industry by using locally-grown soybeans to make their fuel, and as production ramps up, they will create between 20 and 30 jobs in the Taylors area.
- Carolina Soya, LLC is a soybean processing plant in Estill. Carolina Soya processes soybeans, extracts the crude oil and hulls, and produces soybean meal as feed ingredients in poultry rations and other animal feeds marketed throughout the Carolinas, Georgia, and Florida. The company processes one out of every three bushels of soybeans grown in South Carolina and Georgia. Currently the

facility produces 15,000,000 gallons of crude soy oil, which is sold to Carolina Biodiesel, Verde Biofuels, LLC, and Farmers and Truckers Biodiesel. Carolina Soya will invest $13 million to add a soybean oil refinery and a waste wood boiler to its existing soybean processing plant. In late 2006, Carolina Soya had a groundbreaking and announced plans to partner with Ecogy Biofuels, LLC – a division of Knightsbridge. The company built a biodiesel plant across the street and utilizes Carolina Soya's soy oil in a pipeline under the road to produce biodiesel. Construction of the Ecogy Biofuels, LLC plant was completed in late 2007 and began selling fuel in January 2008. The plant will produce between 20-30 million gallons of fuel annually. Ecogy Biofuels has also researched alternative oils, including oils derived from algae.

Another report, *Biodiesel Fuels Demonstration During 1996 Olympics in Athens, Georgia*, evaluates biodiesel fuel. The project measured the fuel economy of two transit buses powered by B20 in the Athens, Georgia-area during the 1996 Olympics. Although feedstocks required to produce the biodiesel fuel used during the demonstration included both vegetable and animal fats, the results are applicable to all B20 fuel that meets American Society of Testing and Materials (ASTM) standards for biodiesel made from any feedstock, including soybeans, one of the most commonly used feedstocks.

The demonstration had the following objectives: 1) demonstrate biodiesel as an available clean fuel; 2) demonstrate low capital cost associated with conversion of vehicles and support facilities to biodiesel; 3) demonstrate long-term reliability and practicality of biodiesel fuel through daily use in public transit; 4) provide displays inside and outside of buses describing the project to riders; and 5) distribute news releases describing the project, attracting media attention. The biodiesel demonstration was a success, proving the alternative fuel has many benefits: it is biodegradable and emits few pollutants; its use reduces dependence on foreign oil; it provides additional markets for domestically-grown agricultural products such as soybeans, peanuts, and rendered animal tallow; it can easily be used in regular diesel engines without any modifications; and, it is completely safe. The study also found that the fuel mileage of the two buses operating on biodiesel received similar, and sometimes improved fuel mileage during the demonstration period, further supporting the efficacy of biodiesel as a mass transit fuel.

In 1995, SERBEP conducted a study to investigate the effect of fueling diesel engines with biodiesel made from soybeans in blends ranging from 0 to 100 percent biodiesel. The resulting report, *Fueling Engines with Soydiesel/Diesel Fuel Blends*, refers to biodiesel as "soydiesel." Specifically, the study sought to: 1) disseminate state-of-the-art information about soydiesel technology; 2) exhibit soydiesel-fueled vehicles at fairs, shows, and conventions across the state of Missouri; and 3) compare engine exhaust emissions of diesel engines that have been fueled with blends of soydiesel and diesel fuel.

According to the report, there were small differences in power when tractor engines were fueled with different blends of soydiesel fuel. These increased as the concentration of soydiesel increased, with the greatest reduction of power occurring when the engines were fueled with 100 percent soydiesel. The report also noted a number of emissions

improvements that resulted from the use of soydiesel. Smoke was reduced as the concentration of soydiesel increased, and carbon monoxide, nitrogen oxide and hydrocarbon emissions were also reduced linearly for all blends.

C. Waste Fat and Grease

Yellow grease (waste cooking grease), brown grease (waste trap grease) and rendered animal fat can be used as feedstocks for production of biodiesel fuel. The SCEO produced a report, *An Assessment of the Restaurant Grease Collection and Rendering Industry in South Carolina*, which identified over eight million gallons of yellow grease available in the state through a survey of waste grease collectors.

Furman University students are turning castoff dining hall grease into an environmentally friendly fuel that will supply about half the campus' diesel needs for its lawnmowers, backhoes and tractors. The students are making the fuel for about 60 cents a gallon and sell it at a mark-up to Furman's Services Department to raise money for their organization, Environmental Action Group (EAG). EAG can produce 55 gallons of fuel over two days with about three hours of student labor. Furman students will produce about 2,500 gallons a year. The main limitation is that they don't have more dining hall grease.

The Animal Co-Products Research and Education Center at Clemson University is currently studying the use of waste animal fats. The Center is working to identify new markets for the animal co-products industry and to resolve such issues as using animal fats and oils for the biodiesel industry. Currently, the high free fatty acid (FFA) content prevents many biodiesel plants from being able to utilize rendered animal fats and oils.

In May 2007, Southeast BioDiesel will begin commercially selling biodiesel made from poultry fats in North Charleston. Southeast BioDiesel is the only facility in the state equipped to accept poultry fats. The company's grand opening was October 27, 2006. Southeast Biodiesel capacity is around four million gallons a year and the company has plans to expand production once there is more demand in the Charleston area.

D. Cotton and Textile Residues

In 1991, the Tennessee Valley Authority (TVA) conducted a study at Mississippi State University to determine the usefulness of cottonseed processing wastes in the creation of sugars, which can be distilled into ethanol through a process called concentrated acid hydrolysis. Due to the elevated cost of disposing of cotton gin trash (CGT) and cottonseed waste treated with sulphuric acid, a common step in the ginning process, sale of this waste to an ethanol plant is likely to be appealing to cotton farmers.

According to the report, *Evaluation of Cotton Seed Processing Wastes as Feedstocks for the Tennessee Valley Authority (TVA) Concentrated Acid Hydrolysis Process*, CGT and cottonseed waste are good ethanol feedstocks. The study estimated that each 500-pound bale of cotton includes approximately 150 pounds of these wastes, which yield approximately 85-90 percent sugars in the concentrated acid hydrolysis process. The

estimated cost of a 50-ton-per-day concentrated acid hydrolysis plant is $15 million, with an estimated return on investment of 15 percent.

Because South Carolina is one of the 14 major cotton-producing states in the nation, harvesting 420,000 bales in 2005, CGT and cottonseed wastes are plentiful here. However, the South Carolina Department of Agriculture notes that CGT and cottonseed wastes produced in South Carolina are used in the manufacturing sector. Thus, although cotton waste is abundant in South Carolina, waste may not be readily available for use in ethanol production.

In 1999, SEBSRP published the report *Non-synthetic Cellulosic Textile Feedstock Resource Assessment*, describing the potential for converting CGT and non-synthetic textile mill residues to ethanol in the Southeastern United States. It summarizes available and emerging technology for the production of ethanol from lignocellulosic materials. In addition, the study characterizes the chemical properties of CGT and textile mill residue as being potentially useful feedstocks for the production of ethanol. The report also supplies a table listing the average annual cotton and CGT production in the Southeastern United States for 25-, 10-, and 5-year periods.

According to the study, estimated ethanol yields from CGT ranging from 44 to 55 gallons of ethanol per dry ton of CGT will not justify an ethanol facility. The total quantity of CGT produced is large at 500,000 dry tons annually in the Southeastern region alone. The overall quantity of textile mill residue generated in the Southeastern region is 170,000 dry tons per year. According to the study, the combined ethanol potential from CGT and textile mill residue is not sufficient to justify installation of an ethanol production facility dedicated to the use of CGT and non-synthetic textile wastes as feedstocks in any of the states studied. Transportation is a major factor.

The report concludes with the following recommendations from the findings of the study:

1. The data developed for this report should be merged with existing databases on the production, users and cost of lignocellulosic biomass for the United States as a whole, with the possible addition and update of other cotton-producing states;
2. Further disaggregating all potential lipocellulosic resource data to a county level would allow a location analysis to further identify counties that have a lignocellulosic resource base compatible with the installation of an ethanol plan;
3. Performing test runs in ethanol production pilot plants will determine actual ethanol potential from these lignocellulosic materials and improve understanding of the processing and fermentation characteristics on a step-by-step level;
4. Further lab testing should evaluate the survival and growth of fermentation organisms using textile residue as media;
5. The compatibility of textile mill waste with feeder mechanisms of current ethanol technology should be evaluated to determine any modifications that may be required to handling and processing equipment;
6. This report should be disseminated to cotton producing and processing organizations as a potential first step to developing alternative uses, such as ethanol, for their agricultural and manufacturing co-products.

E. Other Potential Crop Resources

Another SEBSRP publication, a book called *Wood Energy in the United States, Applications, Technologies, Incentives, and Policies*, briefly addresses the potential use of wood as a feedstock for the production of ethanol. However, because it focuses on solid wood energy, liquid fuel potential is not a major component of the book. It mentions that woody biomass can be used to create ethanol, but is a poor choice of feedstock due to its low sugar content. Another liquid fuel that can be made from woody biomass is pyrolysis oil, which can substitute for Number 2 or Number 6 petroleum-based fuel oils. Pyrolysis oil is made through a form of gasification in which the gases are immediately quenched and liquefied. The report mentions that several prototypes of this process exist in the United States and Canada, but does not include detailed information about them.

A 2003 report by Ralph Overend of the National Renewable Energy Laboratory entitled *Biomass Conversion Technologies*, addresses the use of several different feedstocks for the production of ethanol. One area of focus in the report is a comparison of corn and sugar cane as feedstocks. Corn is most commonly used as a feedstock in the United States, and sugar cane is most commonly used in Brazil. According to the report, a ton of sugar cane produces between 125 and 140 kilograms of raw sugar, and between 70 and 80 liters of ethanol. It states that a ton of corn with a starch content of 70-75 percent will produce between 440 (wet corn milling) and 460 (dry corn milling) liters of ethanol. It also addresses the costs associated with ethanol production from corn versus sugar cane feedstocks, concluding that large production facilities are favorable. Also, according to the report, it costs approximately 30 percent more to run a corn-based ethanol plant than one that produces ethanol from sugar cane due to the higher number of process steps required for corn-based production. However, the corn process also creates byproducts that can be sold for animal feed, offsetting some of the increased costs.

The *Biomass Conversion Technologies* report identifies lignocellulosics such as wood, straw and grasses as other potential ethanol feedstocks, but notes this as a major research and development area. These feedstocks contain approximately 40 to 50 percent cellulose and 25 to 30 percent hemicellulose. These substances produce amounts of ethanol that are comparable to corn, around 440 to 460 liters per ton. The report does not address the economic feasibility of using these feedstocks to produce ethanol, but it does assert that the development of technologies to simultaneously remove the sugars and distill ethanol from lignocellulosics will be a key to producing low-cost ethanol in the future.

Since South Carolina is not a major producer of either corn or sugar cane, lignocellulosic feedstocks may be better candidates for ethanol production in the state. According to *Potential for Biomass Energy Development in South Carolina*, there is significant lignocellulosic biomass created as a byproduct of agriculture in South Carolina each year, including 224,721 annual tons of wheat residue, 238,424 annual tons of soybean residue and 196,113 annual tons of cotton residue. The report includes evaluations of the amounts of biomass produced in each South Carolina county and the potential economic

impact of collecting the biomass and using it for the production of electricity. The report does not address the use of biomass for the production of liquid fuels.

In February 2007, California dot-com billionaire Vinod Khosla, owner of Range Fuels Inc., announced plans to break ground on the nation's first wood-to-ethanol factory in the Georgia town of Soperton, appropriately nicknamed the "Million Pines City," in spring 2008. Range Fuels Inc.'s estimated $225 million project will convert pine tree waste into ethanol that one day might help run the state's cars, trucks, and tractors. The company's system, called K2, uses a two step thermo-chemical conversion process: The first step converts biomass to synthetic gas and the second step converts the gas to ethanol.

Other feedstocks currently being researched in South Carolina include sweet potatoes, sweet sorghum, algae, and rapeseed.

IV. State Biomass Legislation and Organizations

A. 2008 Biomass Energy Legislation

Act No. 261 of 2008, also known as H.3649, the Energy Freedom and Rural Development Act, generated by the recommendations of the SC Biomass Council and the Strategic and Tactical Research on Energy Independence Commission, passed out of the SC General Assembly in June 2008 with improvements to 2007 legislation. Some of the highlights of the legislation include:

- Incentive payments beginning in 2009 for retailers of alternative fuel such as biodiesel and E85 ethanol ranging from $0.05 to $0.25 per gallon;
- Incentive payments beginning in 2008 for biomass energy users ranging from $0.01 per kwh or $0.30 per therm;
- Income tax credit of up to $2,000 for plug-in hybrid vehicles purchases;
- Income tax credits of up to $100,000 for research and development of renewable fuel feedstocks best suited for South Carolina such as cellulosic ethanol and algae-based biodiesel;
- Creates an additional $0.10 per gallon tax credit for non-soy and non-corn based biofuels to make South Carolina specific feedstocks more competitive;
- Income tax credit worth up to 25 percent of the cost of the equipment and installation for the construction of a building and equipment used in the intermediate steps of renewable fuel production such as milling, crushing, distillation, and handling of feedstocks; and an
- Income tax credit worth up to 25 percent for the purchase and installation of biomass energy equipment used to create power from a biomass resource including wood and wood waste, agricultural and animal waste, sewage, landfill gas, and other organic materials.

Other relevant acts in the 2008 session include:

- Act No. 203 which will require the State of South Carolina to give purchasing preference to hybrid, plug-in hybrid, biodiesel, hydrogen fuel cell and flex-fuel vehicles when the performance, quality and life cycle costs are comparable to other available motor vehicles.
- Act No. 338 allows S.C. gas suppliers to continue to blend fuel with ethanol instead of buying a pre-blended version from national oil companies.
- H.3395 requires the SC Office of Regulatory Staff and the SC Energy Office to write a report about state net metering policies by January 2009 and provide recommendations about how to improve net metering and interconnection policies.

B. South Carolina Climate, Energy & Commerce Advisory Committee

Governor Sanford issued Executive Order 2007-04 on February 16, 2007, establishing the South Carolina Climate, Energy & Commerce Advisory Committee (CECAC), due to the recognition of potential implications of global climate change on the economy, environment and quality of life in South Carolina.

The Committee is composed of members representing a broad range of stakeholders including: industry, environmental groups, government agencies, academic institutions, agriculture, forestry, coastal interests, real estate, tourism, banking, insurance and other sectors. The non-profit Center for Climate Strategies (www.climatestrategies.us) will provide facilitation and technical support. Additional citizens in South Carolina compose five other working groups that will do additional work outside of the committee framework.

Among the technical working groups (TWGs) are the Agriculture, Forestry, and Waste Technical Working Group and the Transportation and Land Use Planning Technical Working Group which represent the interests of biomass energy and alternative fuels. For more information, please visit www.scclimatechange.us. The CECEC expects to submit the final report to Governor Sanford in August 2008.

C. South Carolina Biomass Council

Another project of the SCEO is the formation of the South Carolina Biomass Council, which brings together stakeholders interested in achieving significant market penetration of biomass technologies and bio-based products. The Biomass Council used committees and working groups to develop and advocate a plan to increase use of biomass energy in South Carolina.

Each committee and working group analyzed feedstock availability, current energy production and use, economics of energy production from the feedstocks, and environmental costs and benefits, and then determined the barriers to production and use, which culminated into the group's final recommendations. Many of those recommendations have since been incorporated into the Energy Freedom and Rural Development Act, mentioned above.

Membership dues for the council range from $25 for regular members to $250 for corporate members. The council holds quarterly meetings at the Clemson Extension Sandhills Research and Education Center in Columbia. To learn more about the SC Biomass Council or to become a member, please visit www.scbiomass.org.

Conclusion

Landfill gas and combustion of waste wood by the forest products industry are the greatest biomass energy success stories thus far in South Carolina, and both products offer tremendous potential for future growth. Landfill gas opportunities have been well identified, and expansion of use of this resource is ongoing. With regard to woody biomass, the best untapped areas of potential are in use of this resource by non-forest products consumers who can switch from coal and natural gas.

Other clear opportunities are in the production of ethanol and biodiesel from corn and soybeans. Studies are now underway to determine the economic impact of biomass energy development in South Carolina and will be released in the near future.

Clearly, some additional analysis is needed to assess the environmental and economic viability of many forms of biomass energy production, and technology improvements are also needed before certain forms of biomass energy are feasible. However, many forms of biomass energy are already commercially available. The state only utilizes a small percent of its biomass energy capabilities and much more could be done right now. The major obstacles to overcome are not a lack of studies or need for the development of new technologies. The most significant present-day obstacle is a lack of understanding by policymakers, energy users and potential energy producers of the viability and magnitude of the opportunity for South Carolina if it makes a stellar effort to overcome institutional barriers and make full use of its indigenous biomass energy potential. Hopefully, this *Conspectus,* the work of the South Carolina Biomass Council and other stakeholder groups are giant steps toward optimizing the state's biomass energy future.

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Appendix A:

Combustion Renewable Energy Users in South Carolina*

*Additional and current information is available at www.energy.sc.gov.

Plant Name, City, County	Wood Feedstock
1. Black River Hardwood Co. Inc., Kingstree, SC Williamsburg Co	Sawdust Wood Waste
2. Bowater Inc., Catawba, SC York Co	Bark, Sawdust, Ground Pallets, Residential Wood Waste
3. Carolina Furniture Works Inc., Sumter, SC Sumter Co	Wood Waste
4. Cameron Lumber Co., Cameron, SC Calhoun Co	Wood Waste
5. Carr Storage	Wood Waste
6. Carter Manufacturing Co., Lake City, SC Florence Co	Wood Waste Bark, Shavings, Veneer Waste
7. Coastal Lumber, Walterboro, SC Colleton Co	Wood Waste, Green Sawdust and Dry Shavings
8. Cody Mfg. Co. Inc., Orangeburg, SC Orangeburg Co	Treated sawdust Wood chips
9. Cogen South L.L.C. at Mead Westvaco, Charleston, SC Charleston Co	Bark WTP Sladge
10. Collum Lumber Products, LLC Allendale, SC Allendale Co	Sawdust Shavings
11. Council Energy Co., Orangeburg, SC Orangeburg Co	Wood Waste
12. Council Lumber Co., Orangeburg, SC Orangeburg Co	Wood Waste
13. Elliott Sawmilling Co. Inc., Estill, SC Hampton Co	Sawdust
14. Georgia Pacific Corp., Prosperity Plywood Prosperity, SC Newberry Co	Bark Sanders dust Ply trim Woodchips
15. Georgia Pacific, Holly Hill, SC Orangeburg Co	Southern Pine – Wood waste- Bark and Sander Dust

Plant Name, City, County	Wood Feedstock
16. Georgia Pacific: Russellville Particleboard, St. Stephens, SC Berkeley Co	Wood Waste
17. Hutto Lumber, Leesville, SC Lexington Co	Wood Waste Sawdust
18. Ingram Lumber Co., Leesville, SC Lexington Co	Wood Waste Sawdust and Shavings
19. International Paper Eastover Mill, Eastover,SC Richland Co	Bark and Wood Waste
20. IP: Johnston Lumber Mill, Johnston, SC Saluda Co	Dried wood shavings
21. IP: Newberry, Newberry, SC Newberry Co	Wood Waste
22. IP: Sampit, Georgetown, SC Georgetown Co	Wood Waste Bark and Chips, in house.
23. Kearse Mfg. Company Inc., Olar, SC Bamberg Co	Hardwood Chips Bark, Sawdust
24. Kiser, VP Lumber, Bowman, SC Orangeburg Co	Wood waste, green saw dust, dry shavings
25. Koppers Inc., Florence, SC Florence Co	Pine, Mixed & Oak
26. Korn Industries Sumter Cabinet, Sumter, SC Sumter Co	Wood waste
27. Marsh Lumber Co., Pamplico, SC Florence Co	Wood waste
28. M.L. Corley & Sons Sawmill, Inc., Lexington, SC Lexington Co	Southern Yellow Pine Sawdust
29. Mead Westvaco South Carolina LLC, Charleston, SC Charleston Co	Bark Sawdust
30. Mead Westvaco Summerville Lumber Mill, Charleston, SC Charleston Co	Dry Wood Shavings
31. New South Camden Plant, Camden, SC Kershaw Co	Wood waste 60% bark and wet sawdust 40%
32. New South Conway Plant, Conway, SC Horry Co	Wood waste, Bark and sawdust

Plant Name, City, County	Wood Feedstock
33. Norbord, South Carolina, Inc. Kinards, SC Kershaw Co	Pine Bark
34. Pilliod Furniture, Nichols, SC Marion Co	Wood waste – (combination of particle board and MDF – material dense fiberboard)
35. Smurfit Stone Container, Florence, SC Florence Co	Bark Sawdust
36. Smurfit-Stone Container Corp. Latta, SC Dillon Co	Wood
37. Sonoco-Hartsville, Hartsville, SC Darlington Co	88.5% Bark and 11.5% sawdust (6.6 BTU/ton) and multiple waste products
38. GTP Greenville, Inc., Greenville, SC Greenville, Co	Poplar Wood Waste, #2 Fuel Oil
39. Talley-Corbett Box, Springfield, SC Orangeburg Co	Wood waste
40. Tucker, CM Lumber, Pageland, SC Chesterfield Co	Wood waste
41. Trigen Bio Powers, Greenwood, SC Greenwood Co	Chips Sawdust
42. United Wood Treating Co. Inc., Whitmire, SC Newberry Co	Pine Bark & Dust
43. Kinard Wood Preserving Ernhardt, SC Bamberg Co	Wood shavings from peeled posts & poles
44. Walterboro Veneer Co., Walterboro, SC Colleton Co	Wood waste
45. Warren & Griffin Co., Williams, SC Colleton Co	Wood waste
46. Weyerhaeuser: Chester Paper Mill, Fort Mill, SC York Co	Wood waste bark and sludge
47. Weyerhaeuser: Marlboro Paper Mill, Tatum, SC Marlboro Co	Wood waste bark and sludge
48. Withers Industries, Summerville, SC Dorchester Co	Wood waste and coal
49. Bowater Incorporated, Catawba, SC York Co	Wood products
50. MeadWesvaco, North Charleston, SC Charleston Co	Bark, waste treatment sludge

Plant Name, City, County	Wood Feedstock
51. Kauffman Truss Inc. Westminister, SC Oconee Co	Southern Yellow Pine
52. King Lumber Inc., Liberty, SC Pickens Co	Sawdust Mulch
53. John R. Frazier, Inc. Newberry, SC Newberry Co	Wood Products
54. Edisto Wood Preserving Co., Olar, SC Bamberg Co	Pine
55. Carolina Soya LLC Estill, SC Hampton Co	Wood Waste
56. Chester Wood Products, LLC Chester, SC Chester Co	Wood Waste
57. Chesterfield Lumber Company Darlington, SC Darlington Co	Wood waste
58. North American Container Rowesville, SC Orangeburg Co	Wood waste
59. Darlington Veneer Darlington, SC Darlington Co	Wood waste
60. Devro-Teepak Sandy Run, SC Richland Co	Bark
61. Standard Plywood Clinton, SC Laurens Co	Wood waste
62. Sumter Casket Co. Sumter, SC Sumter Co	Drywood waste Kilned burned wood waste

Plant Name, City, County	Waste Tires
1. International Paper Eastover Mill, Eastover, SC Richland Co	Tire Derived Fuel

Plant Name, City, County	Municipal Solid Waste (MSW)
1. Montenay Charleston Resource Recovery, North Charleston, SC Charleston Co.	Municipal solid waste (MSW)
2. Cryovac Sealed Air Corp. Simpsonville, SC Greenville Co	Solid waste

Plant Name, City, County	Landfill Gas
1. Ameresco/BMW, Spartanburg, SC Spartanburg Co	Landfill Gas Methane gas burned 4,000 standard cubic feet per minute

2. Horry County Landfill Gas Generation Facility, Conway, SC Horry Co	Landfill Gas Methane gas burned
3. Lee County Landfill Gas Generation Facility, Lee Co	Estimated. Commercial operation date in 1st qtr 2005
4. Richland County Landfill Gas Generation Facility, Richland Co	Landfill Gas Estimated. Commercial operation date in 1st qtr 2005
5. Anderson Regional Landfill Gas Generation Facility, Anderson Co	Landfill Gas Estimated. Commercial operation date in 1st qtr 2005

Appendix B: Summaries of All Reports Noted in this Conspectus

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Title: *Primer on Wood Biomass for Energy*
Author: Richard Bergman, Chemical Engineer, and John Zerbe, Wood Technologist
Date Published: May 2004
Type (article/study): Paper
Length: 10 pages

Content Summarization
The objective of this paper is to explain and describe the different concepts of wood energy with respect to a residential, commercial, and industrial scale in the United States. In doing so, the Forest Service can assist in meeting the demands of communities involved in the forest products industry.

Findings: This paper discusses the advantages of wood biomass. Environmental: 1) when compared to fossil fuels, wood is a renewable, sustainable, and dependable supply of energy with proper forest management in place; 2) releases fewer carbon emissions; 3) contains minimal metals and sulfur content; and 4) minimal ash. Economic: 1) lower fuel cost; and 2) fewer initial and life-cycle costs of a biomass combustion system compared to a fossil fuel system.

The paper also discusses four scales of operation of using wood fuel in space heat, electricity, and cogeneration in terms of micro, small, medium, and large. The paper then discusses thermal and electric power in the residential, commercial, municipality, industrial, and utility areas of use.

Wood system design is one of the most important factors in biomass combustion system performance. New and existing technologies such as gasification, co-firing, cogeneration, liquefaction, pellets and briquettes, and charcoal are all discussed in terms of use and price.

Conclusions/Recommendations: The paper recommends potential wood biomass users briefly assess the feasibility of wood energy for applications before undertaking major economic analysis.

Title: *Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production*
Author: Joseph R.V. Flora, Ph.D., and Cyrus Riahi-Nezhad
Date Published: September 2006
Type (article/study): Paper
Length: 22 pages

Content Summarization
An SCEO commissioned report, this study identifies poultry farms with significant amounts of waste, documents current disposition of waste transported for off-site processing or disposal, value of the organic waste available for anaerobic digestion, potential for on site and off site production and use of bio-energy, quantities of poultry manure available for bio-fuel feedstock, and the total organic waste available for potential anaerobic digestion processing.

Findings: The study identified between 400,000 and 700,000 tons of poultry litter available for energy use and found anaerobic digestion to be a less economically-viable bio-fuel option then gasification which was actually cost-competitive with current energy production types.

Conclusions /Recommendations: The study recommended pursuing an initiative similar to one recently formed in George between Earth Resources Inc and Green Power EMC using gasification technology to create green power. The author also suggested forming off site cooperative and regional energy generating facilities because of the difficulty of using at a smaller level. Next steps would be to identify a poultry integrator facility willing to perform a viability assessment.

Title: *A Sourcebook on Wood Waste Recovery and Recycling in the Southeast*
Author: C.T. Donovan Associates, Inc.
Date Published: June 1994
Type (article /study): Report (SERBEP)
Length: 255 pages

Content Summarization
A SERBEP produced sourcebook; it is the first regional sourcebook that focuses on wood waste processing for fuel and other purposes. It provides up-to-date information on the existing and future opportunities for separating wood from other waste and processing it for a variety of end uses.

Findings: This sourcebook provides information on technical, market development, public policy and regulatory issues affecting the processing and use of wood waste for energy and other purposes. The sourcebook looks at both clean, untreated wood waste such as residue, and treated wood waste such as plywood, pressure-treated wood, painted wood, and railroad ties.

Additional information provided on: types of wood commonly generated as waste and the physical and chemical characteristics that affect their use for fuel and other purposes; Wood waste separation and processing equipment and facilities commonly used to divert wood from land disposal; Federal and state energy, solid waste management, recycling, air emissions, and ash emissions policies and regulations affecting the processing and use of wood waste for fuel.

The sourcebook also provides state policy, regulatory, and permitting contacts for each state in the region.

Conclusions /Recommendations: The primary objective of the sourcebook is to provide generators, recyclers, and end users with some basic information to evaluate the planning, policy, and regulatory approach taken to wood waste processing and combustion for fuel in each of the SERBEP states.

The sourcebook states that it is not intended to be used as a step-by-step guide to obtaining federal, state, or local regulatory approval or permits needed to recycle, sell, or use processed wood waste. It is also not to be used as a guide for developing a wood waste processing facility. Its intended use is to serve as a starting point for those interested in pursuing future wood waste projects in more detail.

Title: *Boiler Retrofit for Biomass Energy*
Author: Georgia Tech Research Institute, Georgia Institute of Technology
Date Published: 1985
Type (article/study): Brief (SERBEP)
Length: 4 pages

Content Summarization
The brief reviews a conventional boiler retrofitted to burn sawdust from a lumber mill. The overview assesses equipment, operation, and economics of the retrofitted system.

Findings: Wood's low cost compared to fossil fuels creates potential for industry to improve productivity, be more competitive, and increase profits. The retrofitted boil used sawdust produced five miles from the system and indicated each load cost $8.00/delivered ton, and cost only $.94 per million Btus produced. The system was economically preferable comparable to natural gas, which at the time cost $5.25 per million Btus.

Conclusions/Recommendations: A conventional boiler, retrofitted to burn sawdust from a lumber mill, reduces reliance on expensive fossil fuels by making use of a waste product. Despite concerns about the system such as reliability, and the ability of the system to withstand high temperatures, the plant management was satisfied with the system and reported reductions in natural gas fuel bills by 75 percent over the initial four-month period of operation.

Title: *Biodiesel Fuels Demonstration during 1996 Olympics in Athens, Georgia/UGA*
Author: J.W. Goodrum, J. Sellers, Dept. of Biological and Agricultural Engineering, University of Georgia
Date Published: January 1996
Type (article/study): Report
Length: 4 pages (not including appendices)

Content Summarization
This report summarizes an alternative fuels biodiesel demonstration project conducted by the Athens Transit System with the University of Georgia. The project measured the fuel economy of transit authority buses powered by biodiesel. The project audience was Athens, Georgia city officials, bus management (owners, operators, drivers, etc), and Olympic attendees.

Findings: The fuel feedstock was animal or vegetable fat combined with alcohol. The report demonstrated: 1) biodiesel as an available clean air fuel for diesel vehicles; 2) low capital cost associated with conversion of vehicles and support facilities to biodiesel; 3) long-term reliability and practicality of biodiesel fuel by daily use in public transit; 4) provided displays inside and outside of buses describing the project to riders; and 5) distributed news releases describing the project.

Conclusions: The report claimed the demonstration proved biodiesel has many benefits. Biodiesel is biodegradable, has few pollution emissions, reduces dependence on foreign oil, creates additional markets for domestically grown agricultural products such as soybeans, peanuts, and rendered animal tallow, and is safe.

Recommendations: The report recommended certain improvements for future demonstration projects including: having better graphics on buses; increased effort to include environmental groups and public school visits in support of biodiesel; a longer demonstration testing period of exhaust emissions; toxicity or biodegradability testing; and combining the demonstration with a pilot plant for producing biodiesel.

Title: *Potential for Biomass Energy Development in South Carolina*
Author: Robert A. Harris, Tim Adams, Vernon Hiott, David Van Lear, Geoff Wang, Tom Tanner, and Jim Frederick
Date Published: September 23, 2004
Type (article/study): Study
Length: 51 pages (including 22 tables)

Content Summarization
This study quantifies the availability of forest and agricultural biomass energy in South Carolina. The study determines the economic viability of biomass; the cost and benefits; the direct and indirect benefits; the amount of subsidies required to promote biomass energy; and other considerations before South Carolina commits to develop a biomass energy program.

Findings: The resource used in the study is forest biomass and agronomic crop residues. Categories of forest residues are logging residues, and intermediate thinning--pre-commercial, intermediate thinning--commercial, southern scrub oak, mill residues, and urban wood waste. Categories of agronomic crop residue are cobs, stems, leaves, straw and other plant matter.

Conclusions: A key requirement for biomass energy is a reliable supply of reasonably priced biomass with sufficient and acceptable quantities to deliver to the site. The study recommends using biomass to make heat, in a simple cycle gas turbine, followed by producing process steam for industry, but neither type of energy has developed sufficiently.

The study states that in South Carolina there is a sufficient supply of biomass available on a sustained basis to support a biomass energy industry. Also, the harvesting can be done within acceptable environmental limits while managing and improving the state's forests. The easiest and most economical biomass available in South Carolina is logging residues and merchantable thinnings. The study says that it would take only 50 percent (i.e. four million tons annually) to power ten 40 MW biomass power plants. A goal of 400 MW of power production is a reasonable near-term goal for a sustainable biomass energy industry according to the study, and estimates 5700 jobs would be created in the state during the year that ten biomass power plants are built and 1060 jobs in subsequent years.

Recommendations: The study recommends creating a task force composed of utility, state government, the forest industry, and other stakeholder representatives. The economic feasibility of biomass energy must be further studied and a reasonable method of implementation and timetable developed. Finally, the study recommends creating a separate study to review if existing coal plants in the state may lend themselves to co-firing with biomass. When this information is available, policy-makers can determine if the benefits are worthwhile to the residents of South Carolina.

Title: *South Carolina Wood Energy Handbook*
Author: Robert A. Harris, Ph.D.
Date Published: Early 1980s (an estimate, not stated)
Type (article/study): Handbook
Length: 42 pages

Content Summarization

The handbook, designed by the Forestry Department at Clemson University for the Governor's Division of Energy, Agriculture and Natural Resources, assists industrial plant managers and engineers to evaluate the potential use of wood energy in the state. The handbook gives an overview of the nature of wood fuel and its application in the industrial setting.

Findings: The handbook states that South Carolina has no coal, oil, or natural gas reserves, but has an abundance of wood and an aggressive wood products industry to provide raw material at competitive prices. The handbook focuses on the resource (i.e. wood), wood fuel availability in South Carolina forests, and the handling and storage of wood fuel. The handbook evaluates different wood combustion systems along with pollution control, focuses on the procurement of wood fuel, and includes a brief

economic evaluation with estimated payback periods for wood-fired boiler systems. A section listing wood-burning installations, equipment suppliers by product or service, and forestry consultants by company name, city, and product in South Carolina is also supplied.

Conclusions: In the South Carolina piedmont, upland hardwood stands produce the equivalent of over 25 trillion Btu of energy per year, on a sustained basis. Wood fuel in South Carolina is abundant and its long-term supply is secure.

Recommendations: Harvesting increases of low-grade trees for fuel will increase the productivity of South Carolina's forests and create jobs (i.e. harvesting, transportation, and power plant operation). The handbook suggests South Carolina should look at wood as an alternative source of energy.

Title: *Bioenergy from Municipal Sludge Study Report*
Author: Hayes, Seay, Mattern & Mattern, Inc.
Date Published: December 2006
Type (article/study): Study
Length: 61 pages

Content Summarization

The study performed by Hayes, Seay, Mattern & Mattern, Inc. of Columbia, SC was commissioned by the South Carolina Energy Office to determine the amount and locations of potentially recoverable useful energy from sewage treatment facilities in South Carolina, along with an analysis of economics and barriers of recovering and utilizing such energy.

Findings: The study determined that approximately 100,000 dry tons of sludge is produced annually in South Carolina. This equates to approximately 1.5 trillion BTU's or 0.44 billion kWh of energy (or the equivalent of 44,000 homes).

Conclusions: The Grand Strand, the greater Charleston area, the Beaufort area, the Spartanburg area, and the greater Greenville. Spartanburg area appeared to be most promising locations for a regional facility due to the number of plants within close proximity.

Recommendations: South Carolina should further investigate and incentive local governments to utilize methane recovery of sewage treatment plants.

Title: *Auger Combustor for Chicken Litter*
Author: D. R. Jaasma, Virginia Tech.
Date Published: December 1987
Type (article/study): Report (SERBEP)
Length: 167 pages

Content Summarization

The main objective of this project conducted in 1987 was to develop a clean-burning combustion system using chicken litter as the only fuel during steady state operation.

Findings: The use of a small quantity of auxiliary fuel (cordwood) or fossil fuel was required for start-up. The project used an Eshland model E500 boiler combustion system. The system burned cordwood and chicken litter in an unmodified configuration with 100 percent efficiency according to the final report.

The system did experience an issue with burned ash building up, causing litter to become thermally insulated from the hot products of combustion which caused the system to fail. The report suggests modifications be developed to the system by the way it handles the ash to address the problem. Also, the boiler sustained extremely high combustion efficiency (only for several hours) because of the favorable control of equivalence ratio inherent in the configuration of the combustion system.

Conclusions/Recommendations: The report concludes: 1) the conveyor belt configuration showed little promise of meeting the project goals unless a more robust belt system is developed; 2) the raised grate configuration gave excellent combustion results, with extended periods over 99 percent combustion efficiency while retaining virtually all ash on top of the grates. Alternately, a more durable grate design would be required for commercial design and at the present state of the design; ash removal must be done manually. It is not clear how often ash would have to be removed under sustained operation; 3) the sloped floor/diverter block configuration showed promise that with modification for automatic stirring of the fuel, ash handling could be made adequate (and largely automatic) and sustained high combustion rate could be achieved. While conclusive combustion results were not obtained, there was strong indication that this configuration would run with sustained high combustion efficiency (over 99 percent) if properly-functioning secondary air control system ran during the remainder of the tests. Finally, the sloped floor configuration had the greatest potential to be durable and relatively maintenance-free of the four configurations tested. Overall, the sloped floor/diverter block configuration showed the greatest potential of being commercially viable; and 4) auger configuration handled ash automatically, with little interference with the gas flow. However, the current system discharged unburned combustible material to the cyclone and had problems with hardware durability as well. The auger configuration did the best job of automatically removing ash.

Title: *Wood Energy Guide for Agricultural and Small Commercial Applications*
Author: Larry G. Jahn, and R. Neal Elliott III, and the North Carolina Agricultural Extension Service
Date Published: March 1985
Type (article/study): Guide (SERBEP)
Length: 39 pages

Content Summarization
The purpose of this guide is to assist those interested in using wood energy for an agricultural or small commercial application. The guide's focus is on systems producing ten million Btus/hour or less. According to the guide, the information will help the reader decide if wood energy is practical and economical. The guide is broken down into: wood resource; heating systems and combustion equipment; storage; handling and feeding systems; the economics of using wood fuel; and lists equipment vendors.

Findings: North Carolina has five forms of wood fuel: roundwood; whole-tree chips; sawmill chips; mill residues; and densified wood. According to the guide, roundwood is the most popular because it's easy to purchase and store, and the equipment is simple to use. Roundwood is also the most efficient type of fuel in systems producing one million Btus/hour.

Conclusions/Recommendations: According to the guide the most common types of distribution systems are: hot-air; unpressurized hot water, and pressurized hot water and steam systems.

Wood energy systems are best at sites where there is a constant demand for steam, hot water, or hot air during most of the year. Hot air systems are more attractive than hot water systems because they are less expensive to buy and install. The payback period is longer in systems using commercial densified wood, short pulp, sawmill chips as well as whole-tree chips or roundwood produced on a farm.

Title: *Regional Assessment of Non-Forestry Related Biomass Resources, Summary Volume*
Author: JAYCOR
Date Published: March 1990
Type (article/study): Report (SERBEP)
Length: 206 pages

Content Summarization
The report collected and developed county-leve1 information assessing the availability of non-forestry related biomass wastes and residues for potential biomass users in 13 states of the Southeast Regional Biomass Energy Program (SERBEP). These states are: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The information, in conjunction with detailed collection, transportation and conversion cost data, provides users with important information to make prudent economic decisions.

Findings: The project detailed the following types of biomass resources at the county-level: 1) crop acres harvested, production, and total crop residues produced; 2) crop residues potentially available for energy use; 3) set-aside cropland; 4) aggregated crop data; 5) crop processing wastes; 6) collectible animal wastes; 7) municipal wastes; 8) landfills; and 9) solid, non-hazardous, industrial organic wastes.

Conclusions /Recommendations: The report concluded: available biomass waste and residues in the SERBEP region can annually provide approximately 900 trillion Btus; the five largest non-forestry biomass waste and residues total 815 trillion Btus (90.8 percent of the total available); the five largest producing states for each target area were selected; and the total available non-forestry biomass resources from each of the 25 targeted markets could produce the equivalent of 583.3 trillion Btus annually or 65 percent of total non-forestry biomass wastes and residues available annually in the SEBSRP region.

SERBEP Non-forestry Biomass Residues and Waste Target Areas Figure 1-4 from the study:

Municipal Solid Waste (Total $227x10^{12}$ Btu)	Corn Residues (Total $217x10^{12}$ Btu)	Set-Aside Lands (Total $167xl0^{12}$ Btu)	Winter Wheat (Total $109xl0^{12}$ Btu)	Rice Residues (Total $95x10^{12}$ Btu)
Florida	Missouri	Missouri	Arkansas	Arkansas
North Carolina	North Carolina	Arkansas	Missouri	Louisiana
Georgia	Kentucky	Georgia	Georgia	Mississippi
Virginia	Georgia	Mississippi	North Carolina	Missouri
Missouri	Tennessee	South Carolina	Tennessee	
		Louisiana		

Title: *Recycling Wood Waste for use as Biomass Fuel*
Author: Charles D. Johnson, Jr.
Date Published: March 1995
Type (article /study): Study (SEBSRP)
Length: 18 pages

Content Summarization

This study came about as a result of increased landfill costs in Anniston, Alabama. In order to reduce the cost of disposing municipal waste for citizens, the local governments were asked to develop alternative means of disposal and reutilization to conserve valuable landfill space. By converting reusable wood waste into biomass fuel for use in an industrial boiler, Anniston, Alabama intended to reduce waste disposal cost, take advantage of a valuable biomass resource and conserve non-renewable fuels such as oils and natural gas.

Findings: The study's five objectives were as followings: 1) identify waste streams which generate wood waste which can be converted to biomass fuel; 2) capture these waste streams and divert them away from the landfill to a recycling facility; 3) convert

these waste into usable biomass fuel; 4) market the fuel to local industries; and 5) provide documentation identifying sources and types of waste and demonstrate economic feasibility of reusing these waste streams.

Conclusions /Recommendations: The city implemented a curb side pickup service of residential wood waste to help achieve the first three objectives. The operational and development costs were reduced because they co-located the central processing facility with an existing sand and gravel operation.

The fourth objective of marketing the fuel to local industry and having them install a wood or co-fired boiler was postponed because to the cost effectiveness in doing so.

The fifth objective to prove the economic feasibility was achieved. As a result, the City of Anniston avoided over 180,000 in tipping fees over the two year time frame of the grant period. According to the study, the combination of this and the income generated in tipping fees and sales almost offset the cost of the program study.

The study's report also concludes that during the grant period, they remained in a transitional state which made statistical analysis inaccurate at the end of the study. Overall, the cost avoidance for the City of Anniston had proven the economic viability of a municipal wood waste program.

Title: *Regional Energy and Economic Self-Sufficiency Indicators in the Southeastern United States*
Author: Skip Laitner and Marshall Goldberg, Economic Research Associates
Date Published: May 1996
Type (article/study): Report (SERBEP)
Length: 85 pages

Content Summarization

This report is a continuation of previous SERBEP studies to better understand how energy expenditures affect the overall economic well-being of the states within the region. The study surveys energy production, energy consumption, and energy import data for the United States and the entire SERBEP region including each of the 13 states within its program region. The purpose of the study was to help policy makers and business leaders understand the context of energy use within the larger economic process according to the report.

Findings: The report lists the following major findings of the study:

1) In 1993, the Southeastern region as a whole had 26 percent of the nation's population but accounted for almost 29 percent of the nation's total energy fuel consumption.

2) From 1960 to 1993, total energy consumption in the SERBEP region grew by 145 percent. During the same time, electricity use in the region increased steadily and faster compared to total energy consumption.

3) Between 1970 and 1993, energy expenditures in the SERBEP region increased from $55 billion to $131 billion (both in constant 1987 dollars) and continue to rise more rapidly in the region than in the nation as a whole.
4) Nuclear resources provided no electricity for the SERBEP region in 1960. By 1993 nuclear power plants provided 23 percent of electricity consumption.
5) Coal was the second largest supplier of the region's energy needs, supplying 24.1 percent in 1993. Since 1960, coal consumption in the SERBEP region increased 192 percent, while it rose only 98 percent for the nation.
6) The SEBSRP region consumed more petroleum than any other energy resource. Since 1960, the use of petroleum resources rose by 138 percent in the region.
7) The SEBSRP region as a whole produced enough natural gas to meet all of its natural gas needs and export some to other areas. Nevertheless, in 1993 natural gas provided only 20 percent of the total energy needs for the region.
8) Renewable resources continue to play a small but ongoing role in meeting regional energy needs.

Conclusions/Recommendations: The report concludes that the energy patterns and trends in the Southeastern region of the United States are much like those of the rest of the nation. The consumption of fossil fuels has increased gradually to meet rising energy consumption and energy expenditures have risen significantly.

Title: *Evaluation of Cottonseed Processing Wastes as Feedstocks for the Tennessee Valley Authority (TVA) Concentrated Acid Hydrolysis Process*
Author: George R. Lightsey, Clifford E. George, and Allan G. Wehr, and the Department of Chemical Engineering, Mississippi State University
Date Published: December 1991
Type (article/study): Study (SERBEP)
Length: 27 pages

Content Summarization

This study was developed by The Delta and Pine Land Company's processing operations in the state of Mississippi for cottonseed. The company used sulfuric acid to remove cotton fibers in their process making the fibers hazardous waste. In order to meet pollution emission and landfill regulations in the state, the company had to use an expensive ammonia treatment. Since the seeds were treated with sulfuric acid, the fibers would hydrolyze to a sugar- the first step in ethanol production. The project determined the potential of using cottonseed waste fibers as a feedstock in a concentrated acid technology process.

Findings: The study findings included: 1) conducting analyses of feedstocks of hydrolyzed and non-hydrolyzed waste; 2) addressing economic development of ethanol blended gasoline; 3) reducing landfill and environmental related disposal costs; and 4) providing the basic technique and equipment for production of an environmentally safe alternative fuel.

Conclusions/Recommendations: The study concluded: 1) cotton linters and gin waste do not need to be reduced in size or cleaned; 2) wet cotton gin waste can be dewatered by pressing and drying to about eight percent moisture; 3) mixing of cotton linters, or gin wastes, and acid is relatively simple with the exception of heat removal; 4) hydrolysis reaction requires 3-4 hours at 210-212°F and results in approximately 90 percent xylose from hemicelluloses and 85 percent glucose from cellulose; 5) separation of the residual solids can be accomplished in a plate-and-frame filter; 6) designed data from the mini-plant is not optimized, but the types of equipment recommended and flows shown on the process flow sheet should be similar to those that would be obtained in a commercial plant; 7) mass and energy balances show a favorable output-to-input ratio; and 8) estimated cost of a 50-ton-per-day plant is $15,000,000 with an estimated return on investment of 15 percent.

Title: *Animal Manure and Related Biomass Feedstock market Assessment and Preliminary Feasibility Study for a Paper Mill Biomass/CoGen Facility*
Author: LINPAC Paper
Date Published: April 25, 2001
Type (article/study): Study (SERBEP)
Length: 90 pages (including 46 tables)

Content Summarization
Findings: This study assessed: the marketability of animal manure and related biomass feedstock suitable for a Biomass/CoGen facility tentatively planned for LINPAC; a raw material evaluation of rudimentary animal manure of neighboring SERBEP states for a Biomass/CoGen facility for LINPAC; a detail of waste management practices of animal manure and related feedstock; the feasibility of the proposed Biomass/CoGen facility; a regional market assessment of energy use; capital cost estimates, return on investment estimates and business plan to define the opportunity; and a review of literature on the BTA anaerobic digester and site review of the Canada Compost Inc. Newmarket facility that includes process flow diagrams for CoGen and BTA anaerobic facilities.

The study reviews permitting requirements for facilities, and investigates four different options for CoGen facility holistic designs: option 1 is retrofitting an existing boiler; option 2 is the steam turbine cogeneration system; option 3 is a gas reciprocating engine for cogeneration; and option 4 is a gas combustion turbine cogeneration system.

Conclusions: The study found enough available feedstock and technology for anaerobic digestion to be feasible and beneficial. The study details sector by sector waste estimates and analysis to determine quantities of waste available. It determined animal manure is the most available feedstock in South Carolina. Though transfer costs of animal manure may be a problem, changing regulations may help. South Carolina generates over 342,000 tons per year from all sectors.

Recommendations: The study recommended option 4, a gas combustion turbine cogeneration system. Even though project capital costs are higher, option 4 has a more positive return on investment. Fuel use would increase by 10 percent, but the system would produce all the electrical power needed by the LINPAC plant. The study analyzes in great detail the milestones typical of a project of this magnitude and gives an example of an Engineering Execution Plan specific to Biomass CoGen's project requirements.

Title: *A Life Cycle Assessment of Biomass Co-Firing in a Coal-Fired Power Plant*
Author: M.K. Mann, P.L. Spath
Date Published: March 2001
Type (article/study): White paper
Length: 10 pages

Content Summarization
The purpose of this report was to explore the effects of co-firing biomass in currently operating coal plants and examine the benefits and costs. The study examined the effects of no co-firing, a 5 percent biomass co-firing, and 15 percent biomass co-firing scenario.

Findings: The report focused on the environmental benefits of reduced air pollution, system energy balance, and resource consumption.

1) Air pollution reduction – in both the 5 percent and 15 percent co-firing scenarios, reductions in all types of air pollution including methane, carbon dioxide, and sulfur oxides were reported.

2) System energy balance – while power plant efficiency decreased with increased co-firing levels, the total system energy efficiency increased because less coal is burned and less energy consumed by the system overall. Additionally, less up-stream energy is required to produce and deliver biomass fuel as opposed to coal.

3) Resource consumption – biomass co-firing reduces the amount of non-renewable resources needed to produce electricity, reduces flue gas cleanup waste and boiler ash with less waste landfilled by as much as 86 percent. Also, there was a reduction in hazardous trace metals, net water usage, and global warming emissions.

Conclusions/Recommendations:
Co-firing will significantly mitigate the environmental impacts of coal-based electricity production by:
1) reducing air emissions;
2) avoiding emissions like methane from biomass decomposition by burning the feedstock;
3) generating a net energy balance improvement by reducing coal consumption; and
4) reducing non-renewable resources and solid waste production.

Though existing coal-fired power plants will incur capital costs to begin co-firing biomass, environmental benefits are significant and the costs would be justified by emissions restrictions and consumer demand for cleaner power.

Title: *Case Studies of Biomass Energy Facilities in the Southeastern U.S.*
Author: Meridian Corporation
Date Published: August 1986
Type (article/study): Study
Length: 196 pages

Content Summarization

The Meridian Corporation performed a case study of several biomass energy facilities throughout the southeastern United States to provide reliable, up-to-date technical and economic data on successful biomass energy facilities. The report believes a reason biomass energy is not more popular is due to a lack of understanding of biomass alternatives and unfounded negative perceptions of the technology, factors preventing the acceptance of biomass energy systems.

Findings: The main criteria for selection included the following: individual facilities must be operating in a commercial or industrial setting primarily for the purpose of energy production, not research; individual facilities must be successful in terms of technical and economic acceptance to the facility's operators; and the final collection of case studies must show wide diversity of facility types, biomass energy technologies and end-use applications.

Conclusions/Recommendations: A principal goal of the case study compilation was to demonstrate biomass energy systems are a "here and now" technical and economic reality throughout the region. A total of five facilities in South Carolina were part of the study including three wood and solid fuel fired facilities, one fuel supplier facility, and one municipal solid waste fired facility. Basic information, a narrative description, technical data (including fuels, system types, and energy use), and economic data (including fuel costs, system costs, and savings) were all provided on each facility in the case study.

Title: *Non-synthetic Cellulosic Textile Feedstock Resource Assessment*
Author: NEOS Corporation
Date Published: January 1999
Type (article/study): Study (SERBEP)
Length: 119 pages

Content Summarization

This study assessed the potential to convert cotton gin trash and non-synthetic textile mill residues into ethanol in the Southeastern region. By summarizing available and emerging technology for the production of ethanol from lignocellulosic materials, the study

characterized the chemical properties of cotton gin trash and textile mill residue most useful to the ethanol production.

Findings: The report supplies a table listing the average annual cotton and cotton gin trash (CGT) production in the Southeastern United States for 5-, 10-, and 25-year periods. South Carolina produced: 25-year: 195,360 cotton (bales), and 10,647 CGT (dry tons); 10-year: 254,300 cotton (bales), and 13,859 CGT (dry tons); and 5-year: 295,357 cotton (bales), and 16,097 CGT (dry tons).

Ethanol yields from CGT ranging from 44-55 gallons of ethanol per dry ton of CGT will not justify an ethanol facility, but the total quantity of CGT is large at 500,000 dry tons annually in the southeastern region alone. The overall quantity of textile mill residue generated, approximately 170,000 dry tons, is smaller than the quantity of CGT produced.

According to the study, the combined ethanol potential from CGT and textile mill residue for any given state is not sufficient to justify installation of an ethanol production facility. Transportation plays a factor.

Conclusions/Recommendations: Report recommendations included: 1) the data developed should be merged with existing databases on the production, user and cost of lignocellulosic biomass for the United States as a whole, with the possible addition and update of other cotton-producing states; 2) further disaggregating all potential lipocellulosic resource data to a county level would allow a location analysis to further identify counties that have a lignocellulosic resource base compatible with the installation of an ethanol plan; 3) performing test runs in ethanol production pilot plants will determine actual ethanol potential from these lignocellulosic materials and improve understanding of the processing and fermentation characteristics on a step-by-step level; 4) further lab testing should evaluate the survival and growth of fermentation organisms using textile residue as media; 5) the compatibility of textile mill waste with feeder mechanisms of current ethanol technology should be evaluated to determine any modifications may require handling and processing equipment; and 6) this report should be disseminated to cotton producing and processing organizations as a potential first step to developing alternative uses such as ethanol for their agricultural and manufacturing co-products.

Title: *Farm Scale Biodigester and Cogeneration Plant*
Author: Mark Moser, RCM Inc.
Date Published: November 22, 1989
Type (article/study): Study (SERBEP)
Length: 24 pages

Content Summarization
This study demonstrated the repair, completion and rendering operation of a biodigester cogeneration plant on a dairy farm located in Kingsport, Tennessee. The Cleek Dairy

Farm in conjunction with SERBEP funding, and an outside contractor, Resource Conservation Management (RCM), made corrections to the original design and construction of a biodigester/cogeneration plant that rendered the plant operational.

Findings: The project had the following eight specific tasks to meet its objective:

1. Modify the raw manure collection pit with a Flygt Chopper Pump, add a dilution water tank, and modify the hopper as required.
2. Repair the biodigester tank roof, inlet and outlet piping systems, remove the interior wall heating panel and replace with an RCM designed unit, pump out old manure, reroute inlet pipe, install new and larger outlet from the top of the biodigester to the lagoon.
3. Purchase and install a Winco Engine/Generator Cogeneration Module.
4. Replace original gas draw-off piping with a larger line to reduce pressure drop, eliminate obsolete gas mixing system, re-plumb gas pressure switches and scrubbers to reduce pressure loss, replace burner unit on boiler, design and install gas flare, and test gas handling system.
5. Finalize relationships with the local utility and test internal equipment and make adjustments as necessary.
6. Complete system monitoring equipment installation, startup demonstration plant, and move to continuous operation.
7. Produce an Operations and Maintenance Manual and train plant operation personnel. Produce as-built and single-line drawings of the plant.
8. Operate the biodigester for a period of 3 months during the 12 month proposal/grant period, and conduct final tour of completed project at the end of funding period.

Conclusions/Recommendations: All tasks were completed according to the project final report. The largest problem encountered was emptying the old manure out of the digester. That task took the longest and cost far more than what had been budgeted. Overall, the project was a success with the plant functioning normally at an output of 10-12 kWh per hour, 24 hours a day.

Title: *Biomass Conversion Technologies*
Author: Ralph P. Overand, National Renewable Energy Laboratory (NREL)
Date Published: April 2003
Type (article/study): Report
Length: 14 pages

Content Summarization

This report focuses on current biomass conversion technology used today. It discusses conversion systems, including heat, power, combined heat and power, and biofuels. It also discusses gaseous biofuels options.

Findings: The prevalent technology of conversion today consists of the combustion of biomass as fuel-wood, as field and forest residues, or as process residues, such as bagasse and black liquor. Combustion technologies now available are based on a closed-loop carbon cycle with low greenhouse impacts. The anaerobic-based technology is now commercialized. Charcoal and ethanol are at the top of the list for biofuels used in America, and in other countries such as Brazil extensively produce ethanol from sugarcane.

Conclusions: Many combustion processes used today are not efficient or environmentally responsible. Cook-stoves in developing countries add to greenhouse gases and cause respiratory diseases, thus challenging sustainable use in the future. The report looks at boilers such as pile burners, grate boilers, suspension fired boilers, fluidized beds, and circulating beds and states that pile burners are 50-60 percent efficient because of the grates.

Recommendations: Charcoal is the most significant biofuel and can be easily transported, but is polluting. Small scale combustion systems are expensive, due to pollution controls. Fluidized bed combustion is preferred because the use of a silica sand, alumina, or olivine beds keep heat uniformly distributed, resulting in better emissions.

Title: *SE Bio-Oil Application in Poultry Litter Co-Processing, Preservatives, and Turbine Testing*
Author: Robert Pirraglia
Date Published: July 1998
Type (article/study): Report (SERBEP)
Length: 9 pages

Content Summarization

This report summarized research by Ensyn Technologies, Inc. funded under Bioenergy Development Program (BDP) and the Department of Energy Southeastern Regional Biomass Energy Program (SERBEP). The study was divided into three categories: 1) the determination of operating procedures and bio-oil quality from co-processing of poultry litter with wood or Bermuda grass; 2) a feasibility study on the use of bio-oil as a wood preservative; and 3) a feasibility study on the operation of an industrial stationary gas turbine using Ensyn's bio-oil. The three categories are described in separate individual reports. This report focuses on the co-processing of poultry litter.

Findings: Combining poultry litter with Bermuda grass stems was not possible due to the lack of supply. Instead the study was modified and used mixed hardwood waste (MHW) as a feedstock. Once grinding was completed a feedstock analysis was conducted on percentages of poultry litter and the moisture content, ash content, and MF ash content. According to the report, ash contents varied from 15.1-21.2 percent, but the average was 18.1 percent.

Conclusions/Recommendations: The report concluded: poultry litter in concentrations greater than a 20 percent blend with hardwood did not yield high enough value by-products to warrant further investigation at that time. Liquid yields decreased with increasing moisture content and a single phase liquid was possible only when moisture was eliminated from the liquid. Gas quality decreased with increasing poultry litter with an increase in carbon dioxide. A relationship between carbon dioxide production and liquid yield water content, suggested a component in the poultry litter may have supported combustion in the reactor. Elevated inorganic components in the poultry litter contaminated the char and further limited its value as a carbon source or energy substitute.

Title: *Wood Energy in the United States, Applications, Technologies, Incentives, and Policies*
Author: Gregory A. Sanderson, Robert A. Harris, and Stephen A. Segrest
Date Published: January 1996
Type (article/study): Book (SERBEP)
Length: 124 pages

Content Summarization
The purpose of this book was to serve as a reference guide and educational tool for industry and government to attain relevant information about biomass energy development, promote biomass energy projects, and assist energy policies.

Findings: The book addresses the practical elements of project development in relation to biomass energy, including appropriate applications, potential economic barriers, available technologies, and government incentives and policies. The book is organized into three sections: 1) defining the role of wood energy; 2) application of incentives to wood energy; and 3) policy implications of wood and biomass energy. The book closes with an appendix containing a directory of wood energy system manufacturers in the United States.

Conclusions/Recommendations: Despite, many possible uses for the wood in the waste stream, the area with the greatest potential is wood energy. Though economic barriers to wood energy exist, such as funding initial capital costs and obtaining secured wood energy suppliers and users, many applications are appropriate for wood energy, and commercially proven technologies are available.

Title: *National Directory of Federal and State Biomass Tax Incentives and Subsidies*
Author: Gregory A. Sanderson P.C.
Date Published: 1994
Type (article/study): Directory (SERBEP)
Length: 301 pages

Content Summarization

This directory lists various tax incentives and subsidies available throughout the United States. It is the product of extensive research of various federal and state statues, tax forms, regulations, rulings, and industry publications.

Findings: Section 1 gives a summary of the project and how the directory evolved. Section 2 describes the Regional Biomass Energy Program and lists program management offices. Section 3 outlines federal tax incentives and subsidies, and offers commentary, planning techniques, example computations, discussions of rulings and regulations. Section 4 gives a listing of names, addresses, and the telephone numbers of state biomass contacts.

Conclusions/Recommendations: The directory is not intended to be an all-inclusive formal publication of tax laws for the alternative energy industry, nor is it to be used as legal advice. According to the directory, its use should be a starting point for researchers and project developers who are investigating the potential benefits available for biomass energy projects.

Title: *South Carolina Solid Waste Management Annual Report*
Author: SC Department of Health and Environmental Controls' Division of Mining and Solid Waste Management
Date Published: Fiscal Year 2005
Type (article/study): Annual Report
Length: 72 pages

Content Summarization
The purpose of the annual report is to compile the amount and composition of waste that is recycled, disposed of and incinerated; the progress of the state and county-level recycling and disposal goals; report on the revision to the state solid waste management plan; and give recommendations to the Governor and General Assembly about improving solid waste management.

Findings: The entire report is available online as of May 2006 at http://www.scdhec.net/recycle/forms/intro.pdf. Pertinent information related to the Biomass Inventory includes:

1) State and County Municipal Solid Waste Recycling and Disposal Costs are available on page 24 of the report. The MSW produced in 2005 totaled 3,446,675 tons which could be used in MSW incinerators to generate power.
2) Chart 6.6: Construction and Demolition Debris and Land-Clearing Debris in Landfills on page 61 was used to determine how much wood waste was generated that could be used for electricity production operations. 1,915,777 tons was generated by the state in 2005.
3) Chart 6.2: Disposal in Tons Chart, page 58, reports that 261 tons of processed waste tires were disposed of in SC landfills in 2005.

Conclusions/Recommendations:
Other information about waste, recycling, and incineration can be found in this report.

Title: *An Assessment of the Restaurant Grease Collection and Rendering Industry in South Carolina*
Author: SC Energy Office (Erika Hartwig and Travis Moore)
Date Published: August 2006
Type (article/study): Paper
Length: 31 pages

Content Summarization
The SCEO surveyed waste grease collectors in South Carolina and estimated between eight and twenty-seven million gallons of waste grease are produced in South Carolina each year. The report also discussed how the waste grease collection industry was regulated and identified current barriers to utilizing waste grease for biodiesel production.

Findings: The survey found that the majority of waste grease is currently being sold to feed mills in South Carolina while a small portion is being sold to SouthEast Biodiesel. At this time there are issues with waste grease in that it is an unpure feedstock and needs to go through extensive purification processes.

Conclusions /Recommendations: The report concluded that though there are large quantities of yellow grease available in the state and it needs to be better utilized.

Title: *Fueling Engines with Soydiesel/Diesel Fuel Blends*
Author: Leon G. Schumacher, Steven C. Borgelt, and William G. Hires, University of Missouri – Columbia
Date Published: May 1995
Type (article/study): Study (SERBEP)
Length: 82 pages

Content Summarization
The purpose of this study investigated the effect of fueling diesel engines with blends of soydiesel and petroleum diesel fuel ranging from 0-100 percent soydiesel. The study also supported earlier findings concerning the replacement of nitrile rubber fuel lines when fueling with soydiesel and soydiesel blends and establishing engine exhaust emissions trends when fueling with blends of soydiesel and petroleum diesel fuel.

Findings: The following are the more specific objectives of the study: 1) to disseminate state-of-the-art information about soydiesel technology; 2) exhibit soydiesel fueled vehicles at fairs, shows, and conventions across the state of Missouri; and 3) the comparison of engine exhaust emissions of diesel engines that have been fueled with blends of soydiesel and diesel fuel.

Conclusions: The study concluded: 1) little differences in power among the blends when the tractor engines were fueled with blends of soydiesel and petroleum diesel fuel; 2) the greatest reduction of power occurred when fueling engines with 100 percent soydiesel; 3) smoke reductions improved as the concentration of soydiesel increased; 4) carbon monoxide emissions were reduced linearly for all blends; 5) a positive linear relationship existed between the concentration of soydiesel in the fuel and the amount of oxides of nitrogen exhaust emissions; and 6) hydrocarbon emissions were reduced linearly for nearly all engines tested.

Recommendations: Additional engine exhaust emission testing is needed in an Environmental Protection Agency certified laboratory using ISO 8178 C1 to attain a more precise measure of the emissions reductions.

Title: *South Carolina's Strategic Energy Roadmap: Breaking the Dependence on Oil and Fueling the Future through Economic Development*
Author: Strategic and Tactical Research on Energy Independence Commission (STREIC)
Date Published: January 2007
Type (article/study): Report
Length: 22 pages

Content Summarization

The Strategic and Tactical Research on Energy Independence Commission (STREIC), a panel created by state energy legislation in 2006, released its final report to the South Carolina General Assembly. The commission developed recommendations to foster alternative fuel development in South Carolina to help the state become less dependent on imported oil.

Recommendations: The STREIC recommendations include: Revisions and clarifications to the aforementioned alternative fuel and alternative vehicle laws; Creation of an energy task force; Appropriations for Alternative Fuel Promotion including a biodiesel testing program, marketing program, and funding for state Clean Cities program; Job creation and R&D tax credits for alt. fuel industry; State motor pool requirement for biodiesel use; and the endorsement of hydrogen legislation and 25 X '25 biomass campaign.

Title: *Bioenergy in the Southeast: Status, Opportunities and Challenges*
Author: The Southeast Bioenergy Roundtable
Date Published: August 1996
Type (article/study): Report (SERBEP)
Length: 91 pages

Content Summarization

This report is a product of a meeting held in 1995 by the Southeast Bioenergy Roundtable. The group that convened was made up of representatives from various bioenergy groups- including privates industry, education, environmental groups, paper and lumber companies, farmers, utilities, government, trade associations, equipment manufacturers, and others.

Findings: The report, organized as a strategy document, also summarizes the potential for bioenergy in the Southeast. It lists issues and concerns of the Roundtable while presenting evidence in support of the strategies developed to address the identified challenges. It provides a common base of understanding including: the context for bioenergy development; the Southeast's biomass resources and its bioenergy potential; and the environmental and market development issues, challenges, and opportunities associated with the development of this publication.

Conclusions/Recommendations: The following topics were covered during the Roundtable, and discussed in the report: the context for bioenergy development to include energy, agriculture, forestry, and polices affecting bioenergy development in the southeast; the resource potential, conversion and use to include secondary, or residual, materials, forestry, agriculture, and production costs.

The report of the Roundtable presents strategies to two major categories of challenges that were identified as currently limiting bioenergy development. These strategies are:

- Minimize the adverse environmental impacts and maximize the environmental benefits of bioenergy production and conversion:
    - encourage use of residues in the short term;
    - develop the region's biomass crop potential over the longer term;
    - certain bioenergy resources should not be developed at this time;
    - encourage sustainable biomass production; and
    - monitor and reduce emissions from bioenergy conversion.

- Promote bioenergy market development:
    - increase biomass availability;
    - improve production and conversion technologies
    - increase demand; and
    - address institutional resistance to bioenergy embedded in the existing energy infrastructure.

Title: *A Sourcebook on Needs Assessment and Evaluation of Mobile, Multi-Community Wood Waste Processing for the Southeastern Regional Biomass Energy Program*
Author: TVA Environmental Research Center
Date Published: July 1996
Type (article/study): Study (SERBEP)
Length: 82 pages

Content Summarization

This study focused on wood waste that is generated and handled as part of the municipal solid waste (MSW) stream. The study is composed of two phases: phase I is information collected on needs assessment, concerning existing wood waste recycling activities and the feasibility of mobile, multi-community wood waste processing facilities; and phase II entails the development of an implementation manual that will serve as a how-to-guide for public agencies in the region to evaluate mobile wood waste processing options in their area and to plan and initiate programs.

Findings: The manual includes: assessment of feedstocks; potential markets for wood waste products; site selection; wood waste processing equipment; ownership and operation alternatives; program economics; implementation planning; site design and equipment specifications; and administrative and site management.

Specific to South Carolina: solid waste officials do not track inert landfill tipping fees, but the fees ranged from $10-$30 per ton; sanitary landfill tipping fees raged from $20-$30 per ton and averaged $27.79 per ton in April 1995; wood waste recycling facilities handling clean wood waste do not require a permit, but facilities need to register with the South Carolina Department of Health and Environmental Control (DHEC); DHEC maintains a partial list of wood waste recycling programs and a list of composting facilities; South Carolina has a landfill waste diversion goal of 25 percent and would determine on a case-by-case basis whether or not wood waste for fuel qualifies as diversion; and South Carolina has a landfill ban on yard waste, which includes brush and tree trimmings.

Conclusions/Recommendations: The study concluded: solid waste transportation and disposal fees throughout the SERBEP region are high enough to provide an economic incentive for wood waste recovery. In specific limited areas of the region, disposal fees and capacity are such that there is little economic incentive to recover wood waste; for communities that cannot recover large amounts of wood waste (e.g. over 30,000 tons per year), a mobile, multi-community or privately contracted mobile wood waste processing service may be the most viable option; existing and historical political barriers to inter-municipal cooperation in general; solid waste management can be very difficult to overcome; mobile, multi-community, publicly owned and/or operated facilities for wood waste recovery have limited viability in areas without an existing governmental entity, regional agencies, or lead community capable or implementing and managing the program; and in small-medium sized urban communities, contracting with a private mobile wood waste recovery service is the most viable in the near term, while a true multi-community program may be developed over time.

Title: *Analyzing Market Constraints in Woody Biomass Energy Production*
Author: Timothy M. Young and David M. Ostermeier
Date Published: September 1986
Type (article/study): Study (SERBEP)
Length: 188 pages

Content Summarization
This study identifies and analyzes constraints to industrial wood energy use by the non-forest products sector. The study theorizes market and institutional constraints exist which prevent non-forest products industries and institutions from using wood energy.

Findings: The three objectives of the study are as follows: 1) to identify the competitive segment of the industrial wood energy market for non-forest products industries; 2) to identify the actual and perceived barriers to industrial wood energy use; and 3) to identify and analyze alternative methods of removing, or at least partially modifying these constraints.

Conclusions/Recommendations: To address the first objective, two surveys, the National Wood Energy Survey, and the Southeastern Regional Energy Survey, asked biomass users to assess certain segments of wood energy and found successful facilities had: 1) use of a boiler for energy production; 2) boilers with turndown ratios of 3:1 or less; 3) a minimum to maximum response time of at least 20 minutes; 4) a process heat temperature not exceeding 800°F; 5) a boiler capacity greater than one million and less than 280 million British Thermal Units per hour; 6) operations of the energy system for at least 6,000 hours per year; 7) boilers that were at least 20 years old. The study concluded a company meeting all seven requirements was considered a "most likely" candidate for wood energy conversion.

Objective two identified five barriers to industrial wood energy including: 1) lack of knowledge and poor perception; 2) high capital cost of conversion; 3) problems with wood fuel handling; 4) concerns of availability of long-term supply; and 5) lack of knowledge about the proper operation of wood energy system.

Objective three identified alternative methods of removing or partially modifying the constraints by directly supporting efforts in the form of grants and low interest loans to potential candidates. Other methods were indirect, such as the creation of tax incentives and information dissemination. The study recommended five alternative policies including: 1) benign neglect; 2) status quo; 3) reform option; 4) market improvement; and 5) increased government involvement.

Title: *Analysis of Renewable Energy Potential in South Carolina*
Author: Central Electric Power Cooperative, Inc. and La Capra Associates, Inc.
Date Published: September 2007
Type (article/study): Study/PowerPoint
Length: 59 slides

Content Summarization
This analysis sought to quantify the renewable energy resource potential that could be used for electric generation within the state of South Carolina and to calculate the associated costs.

Findings: Landfill gas is the state's lowest cost renewable energy option for electric generation; the practical potential is about 70 MW, with levelized costs of <$90 per MWh.

Biomass (urban wood waste, logging residue, commercial thinnings, corn, and poultry litter) used in direct-fire generation can provide the next lowest cost renewable energy option for the state, contributing up to 490 MW in total, with costs ranging from $90 to $135 per MWh.

Small hydro (without impoundments) may provide about 100MWa of energy for the state, but costs may vary widely depending on site-specific issues and capacity factors. Permitting may also be an issue.

The report also assessed that offshore wind and solar PV were limited by costs and technical barriers.