Chapter 4:Alternative Fuels from Biomass

North Carolina's biomass resources from the agricultural and waste management sectors are a leading potential source of energy in the state. An estimated 15.8 billion kWh of electricity could be generated using renewable biomass fuels in North Carolina. This is enough electricity to fully supply the annual needs of 1,579,000 average homes, or 39 percent of the residential electricity use in North Carolina. These biomass resource supply figures are based on estimates for five general categories of biomass: urban residues, mill residues, forest residues, agricultural residues, and energy crops.

- **Mill residues –** Sawdust, bark, and wood scraps from paper, lumber, and furniture manufacturing operations are typically very clean and can be used as fuel by a wide range of biomass energy systems. North Carolina produces approximately 5,028,000 dry tons of mill residues per year.

- **Forest residues –** Underutilized logging residues, imperfect commercial trees, dead wood, and other non-commercial trees that need to be thinned from crowded, unhealthy, fire-prone forests. Because of their sparseness and remote location, these residues are usually more expensive to recover than urban and mill residues. North Carolina produces an estimated 2,005,000 dry tons of forestry residues per year.

- **Urban residues –** Consists mainly of chips and grindings of clean, non-hazardous wood from construction activities, woody yard and right-of-way trimmings, and discarded wood products such as waste pallets and crates. Using clean and segregated biomass materials for electricity generation recovers their energy value while avoiding landfill disposal. The estimated supply of urban residue available for energy purposes in North Carolina is 1,060,000 dry tons per year.

- **Municipal solid waste** – The average North Carolinian disposes of 1.25 tons of solid waste per year via local sanitation services. Much of the waste ends up in landfills that generate substantial quantities of methane as organic materials in the waste decompose. Local governments and other organizations can develop energy resources by using the energy content of the solid waste directly or by capturing the methane emitted in landfills.

- **Methane Reclamation-**The benefits of reduced odors and better air quality make methane reclamation particularly applicable to wastewater/sewage treatment plants. TVA has been using a variation of methane reclamation technology similar to that used in agricultural applications at several plants in Tennessee. Power produced by this program is then used to support Tennessee's Green Power Program.

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- **Energy crops –** Crops developed and grown specifically for fuel. These crops are carefully selected to be fast growing, drought and pest resistant, and readily harvested alternative crops. Energy crops include fast-growing trees, shrubs, and grasses such as hybrid poplars, hybrid willows, and switchgrass, respectively. In addition to environmental benefits, energy crops can provide income benefits for farmers and rural landowner. Potential production levels for North Carolina are estimated at 1,632,000 dry tons per year.

- **Agricultural residues –** The biomass materials remaining after harvesting agricultural crops. These residues include wheat straw, corn stover (leaves, stalks, and cobs), orchard trimmings and rice straw/husks. Due to the high costs for recovering most agricultural residues, they are not yet widely used for energy purposes; however, they can offer a sizeable biomass resource if supply infrastructures are developed to economically recover and deliver them to energy facilities. An estimated 1,131,000 dry tons of agricultural residues are available per year from corn stover and wheat straw in North Carolina.

Wood and Forest Residues

Wood energy continues to lead the United States in biomass energy production and accounts for 80% of the biomass market. Wood waste comes from logging operations, industrial processes, construction activities, yard waste, and disposal of wood products such as pallets. In North Carolina, wood and wood wastes produced 1.5 million megawatt-hours of electricity in 1999 representing almost 1/3 of total net renewable production (15). The industrial sector is the largest user of wood waste in the form of mill residue. In fact, wood and wood wastes provide over 11% of North Carolina's industrial energy needs. Common industrial uses of wood and forestry residues include on-site electricity generation and process heat.

Municipal Solid Waste (MSW)

Local governments can capture the energy content of MSW directly through combustion in boilers to generate electricity. In some cases, pulverized MSW has been mixed with coal in coal-fired power plants. The mix is usually 10% MSW and 90% coal. The city of Wilmington, utilizes a MSW co-firing system to produce over 7.5 MW of electricity. However, in North Carolina, most MSW is transported to landfills. Burning MSW is perhaps the least favorable method of extracting energy content from this particular resource, as the environmental consequences of particulate and gas emissions offset energy gains. While research efforts concerning smokestack scrubbers are producing cleaner emissions from power plants, adding to North Carolina's current emissions inventory by burning MSW defeats the sustainability of this particular alternative fuel resource.

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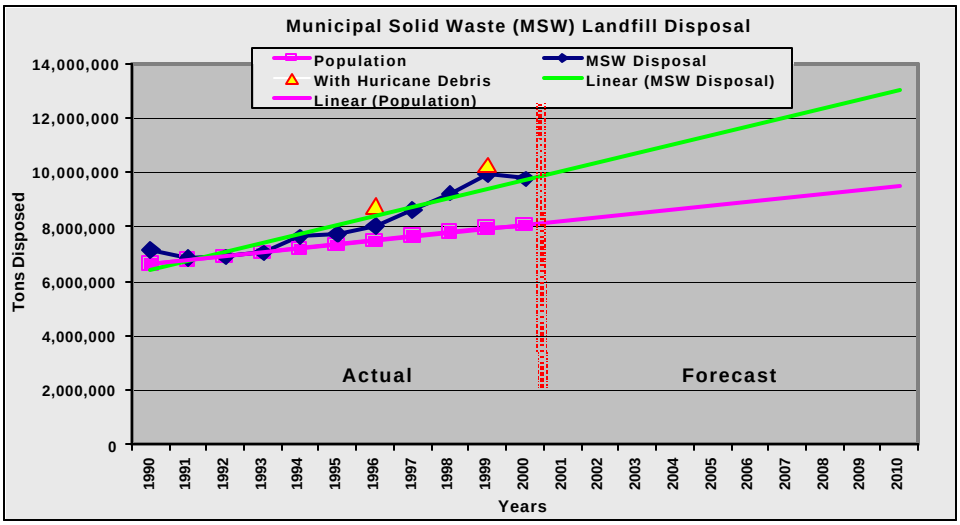
Figure 4-1:
Landfill Levels in North Carolina: 1990-2010



As is evident in the previous graph, landfill levels in North Carolina have been steadily increasing, with an almost 40% increase in 2000 levels (10 million tons) from 1990 levels (6 million tons). This trend is expected to continue, with forecasted levels in 2010 reaching over 13 million tons (a 67% continued increase from 2000 levels).

The gas escaping from landfills is about half methane and half carbon dioxide, with small amounts of other organic compounds. The methane emanating from landfills is a major greenhouse gas problem, contributing 18 percent of all global warming emissions. Methane is about 25 times more powerful than carbon dioxide (the primary greenhouse gas) in trapping heat in the earth's atmosphere. Landfills are the largest human-generated source of methane in the country, contributing about 37 percent of all methane emissions. Methane also contributes to the formation of smog and poses an explosion hazard if uncontrolled.

Recovering methane gas at solid waste landfills provides significant environmental and economic benefits by eliminating methane emissions while capturing the emissions' energy value. It can be transformed into a cost-effective fuel source for generating electricity and heat, firing boilers or even powering vehicles. In addition, capturing landfill gas (LFG) reduces odors and improves questionable air quality in the vicinity of the landfill.

North Carolina is a member of the LMOP (Landfill Methane Outreach Program) State Ally Program, which encourages cooperation between EPA and state energy and environmental agencies to promote the development of LFG resources. As a state ally, the North Carolina Department of Environment and Natural Resources works to develop consensus among landfill operators, utility companies, independent power producers, project developers, utility regulators, and state regulators to promote new energy

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and environmental opportunities.

According to the North Carolina Division of Waste Management, fifteen LFG projects are currently operating in North Carolina and several more are under consideration. With the closure of unlined landfills located in almost every county, North Carolina has a number of landfills with the potential to support economically viable LFG utilization projects. LFG projects generate revenue from the sale of the gas and also create jobs associated with the design, construction, and operation of energy recovery systems. LFG projects involve engineers, construction firms, equipment vendors, and utilities or end-users of the power produced. Much of this cost is spent locally on construction and operational personnel, thereby directly influencing local economies.

Benefits of Landfill Gas Energy

In Raleigh, a boiler fueled by landfill gas generates steam at an average rate of 24,000 lbs./hr. to meet the needs of a pharmaceutical plant.

The North Carolina Division of Waste Management estimates that the state produces 10 million tons of municipal solid waste each year. If 50% of the MSW was placed in landfills from which gas recovery systems could occur, annual benefits would include:

- 1,500 cubic feet per minute of landfill gas
- 35 million kWh of electricity (0.03% of North Carolina's total electrical consumption in 1999)

The North Carolina Landfill Methane Outreach Program (LMOP) estimates the benefits of methane reclamation from 1 million tons of MSW as follows:

- 1 million tons of MSW produces about 300 cubic feet per minute (cfm) of landfill gas that could generate 7 million kilowatt (kWh) per year.
- 7 million kWh would power 700 average-sized homes for a year.
- This level of methane reclamation yields the same reduction in greenhouse gases as removing 6,100 cars from the road for a year or planting 8,300 acres of trees.

North Carolina LFG Projects

- Raleigh, North Carolina
  - A boiler fueled by landfill gas generates steam at an average rate of 24,000 pounds (11,000 kilograms) per hour to meet the needs of a pharmaceutical plant.
  - The energy conversion system uses gas collected from the city-owned Wilder's Grove Landfill.
  - The private developers, Natural Power, Inc. and Raleigh Landfill Gas Corporation, invested $1.6 million in the project.
  - The developers' annual gross revenue from steam sales ranges

from $450,000 to $500,000, of which the city of Raleigh receives annual royalties of $65,000 to $75,000.

- ◊ The project won the 1993 North Carolina Governor's Energy Achievement Award.

- ♦ Project EnergyXchange
  - ◊ The Blue Ridge Resource Conservation and Development Council, which represents seven North Carolina counties, worked with an 80-member task force to identify end users for the LFG at the Yancy/Mitchell Landfill.
  - ◊ The landfill has just over 360,000 tons of waste-in-place.
  - ◊ The LFG heats and powers on-site greenhouses as well as glass blowing studios, a pottery kiln, and the visitor's center.
  - ◊ The three facilities provide a unique economic development opportunity for the community.
  - ◊ Funding sources include the Blue Ridge Resource Conservation & Development Council, the Department of Environmental and Natural Resources, Handmade in America, the North Carolina Technological Development Authority, the U.S. EPA, the U.S. Forest Service, the State Energy Office, Mayland Community College and Yancy/Mitchell counties.

Ethanol from Energy Crops

Ethanol Overview

While ethanol has been in use as a fuel since Henry Ford's Model T, the fuel crisis of the late 70's resulted in the increased development of ethanol refineries and government subsidy programs. Today, ethanol is primarily used for fuel oxygenation and octane enhancement. Recently, ethanol has received attention as a replacement for MTBE, a fuel oxygenator discovered to be a significant groundwater pollutant. Petroleum companies are largely opposed to the continued Federal oxygenation requirement and would prefer to formulate fuels to an emissions standard rather than having an additive requirement. Dropping the fuel oxygenation requirement would reduce certainly reduce the potential market for ethanol. The primary advantages of increased use of ethanol are:

1. Supplanting a finite energy resource, petroleum, with a renewable source of energy
2. Reducing national energy imports of petroleum.
3. Reducing emissions of carbon dioxide – a greenhouse gas – as well as certain particulates
4. Increasing agricultural sector employment and income.
5. Augmenting the in-state chemical industry through ethanol refineries and gasoline blending facilities.
6. Increasing overall state income via in-state energy production.

However, the following criticisms have been leveled at development of a ethanol as fuel derived from state agricultural sources:

1. Ethanol is at present more expensive than standard blended gasoline.
2. In order for ethanol to compete in the market place, it would have to be subsidized
3. Ethanol combustion increases emissions of certain air pollutants.
4. Production of agricultural crops for energy detracts from potential food production.
5. North Carolina has insufficient agricultural land to provide the necessary feedstock for producing the amount of ethanol required.

Midwestern states such as Minnesota, Iowa, Nebraska and Indiana have led the ethanol production charge, largely because of their proximity to the bulk of the nation's corn supply. At this time, starch-derived ethanol is the most economical to produce. The most likely feedstock to produce the ethanol required is corn or a similar starch-rich crop. While cellulosic-based ethanol does have potential for meeting volume requirements, the technology is still not yet economically proven.

Required Land Feasibility Issues

North Carolina used about 4.2 billion gallons of motor gasoline in 2000. Implementing a 10% blend requirement would necessitate approximately 420 million gallons of ethanol. Table 1-1 illustrates the amount of land needed for North Carolina to produce this volume of ethanol:

Table 4-1: Acreage & Feedstock Requirements for In-State Ethanol

North Carolina 2001 Motor Gasoline Consumption: 4.2 billion gallons

10% Ethanol Blend Requirement: 420 million gallons

Feedstock Requirement: 168 million bushels of corn

Current Corn Production: 80 million bushels from 710,000 acres

Acreage Requirement: 1,344,000 acres

Available Cropland: 1.8 million acres-improved/unimproved

Acreage/Production Sources: USDA 2001

Assumptions: 125 bu/acre for corn production, 2.5 gal/bu for ethanol production

As seen in the above table, North Carolina could potentially produce the entire amount of ethanol needed to support a 10% ethanol fuel blend. While North Carolina corn growers currently do not produce enough corn for

animal feedstock, the acreage to support an ethanol-dedicated feedstock is available. Research is currently being conducted on the feasibility of using a non-edible, white sweet potato for a feedstock, which could potentially reduce the amount of corn acreage required. However, a final answer on whether or not the new sweet potato could viably support an ethanol industry remains uncertain.

Ethanol Production Economics

Certainly the most obvious criteria for any renewable resource is that the fuel be cost-competitive with existing fuel sources. Some allowances should be made regarding ethanol costs, considering that the industry is significantly less developed, financed and subsidized than the petroleum industry. A primary concern of the proposed State Energy Policy is to develop a position of leadership for North Carolina in the area of energy management. The State should strongly consider the potential economic and environmental paybacks of lending support to the developing ethanol industry.

Ethanol powerhouse states such as Minnesota, Nebraska and Iowa have enjoyed success with alternative fuel programs primarily through the use of tax incentives, fuel blend requirements, and producer subsidies. North Carolina could certainly see the same level of success and world recognition as Midwestern states, however, policymakers would need to provide the same degree of support to ethanol producers as the industry has enjoyed in other states. It is important for the alternative fuels industry to be seen as a means to an end, not necessarily the final answer to North Carolina's energy issues. By assisting in the development of an ethanol industry, policymakers can be assured of putting together the pieces which will eventually create a profitable renewable energy industry for North Carolina. The following tables illustrate the costs of producing ethanol from corn, various fuel energy balances and the cost of developing a starch-based ethanol refinery.

Table 4-2: Production Costs of Starch-Based Ethanol

Expenses	Annual Costs	Per Gallon Costs
Shelled Corn	$17,000,000	$0.68
Misc Raw Materials	$1,600,000	$0.06
Denaturant	$600,000	$0.03
Utilities	$4,000,000	$0.16
Labor/Supplies/Overhead	$3,100,000	$0.13
Depreciation of Capital	$2,800,000	$0.11
Dry Distiller's Grain Credit	($7,100,000)	($0.29)
Total Production Cost	**$22,000,000**	**$0.88**

Source: www.afdc.doe.gov

Figures are based upon a 25 million gallon/year refinery-1999$

Table 4-3:Fuel Energy Balances

Fuel	Energy Yield	Net Energy Loss/Gain
Gasoline	0.74	26% net energy loss
Diesel	0.83	17% net energy loss
Ethanol	1.34	34% net energy gain
Biodiesel	3.2	220% net energy gain

Source: www.MDA.state.mn.us/ethanol energy balances

As the ethanol industry in North Carolina is still very much in the proposal stage, it is difficult to assess the exact economic impacts the industry would have upon the state. However, the economic impact the ethanol industry has made nationally is significant:

- increases net farm income more than $4.5 billion
- boosts total employment by 192,000 jobs
- improves the balance of trade by over $2 billion
- adds over $450 million to state tax receipts
- results in net federal budget savings of over $3.5 billion.
- Industrial corn use, which includes ethanol and sweetener production, is now the second largest consumer of corn in America. Each $1 of up-stream and on-farm economic activity generates $3.20 in downstream economic stimulus attributable to ethanol processing, compared to just $0.31 when corn is exported.
- The demand for corn created by the ethanol industry increases crop values -- accounting for approximately $0.14 of the value of every bushel of corn sold, or $ 1.4 billion.
- Domestic ethanol production reduces demand for imported oil and imported MTBE which drains our economy - oil and MTBE imports now represent almost 80% of the U.S. trade deficit.
- Ethanol reduces the demand for gasoline and MTBE imports by 98,000 barrels per day. A 98,000 barrel/day replacement of imported MTBE would represent a $1.1 billion reduction to our national annual trade deficit.

The economic impact of the proposed ethanol refineries in North Carolina could be very substantial. DFI Corp of Raleigh, estimates the three production facilities planned will utilize 22 million bushels of corn per plant, all from North Carolina farms. These operations will create upwards of 1,200 new jobs and contribute over 1 billion dollars to North Carolina's economy.

- For every 23.8 gallons of ethanol produced, 1 barrel of imported oil is displaced. A 10% blend requirement would equate to an import reduction of 22,268,907 barrels of crude oil into North Carolina.

Ethanol Environmental Benefits

A 10-percent ethanol blend reduces carbon monoxide better than any other reformulated gasoline blend -- more than 25%. Ethanol is low in reactivity and high in oxygen content, making it an effective tool in reducing ozone pollution. Ethanol is a safe replacement for toxic octane enhancers in gasoline such as benzene, toluene and xylene. Environmental benefits of various ethanol blends are:

- Use of E10 (10% ethanol and 90% gasoline by volume) achieves:

Table 4-4:

Capital Costs of a Starch-Based Ethanol Refinery

Component	Cost
Feedstock Handling	$2,600,000
Saccharification	$2,300,000
Fermentation	$4,600,000
Distillation	$5,300,000
Solid/Syrup Separation Drying	$10,500,000
Storage/Load Out	$1,500,000
Wastewater Treatment	$1,000,000
Air Compressor	$100,000
Total Capital Investment	**$27,900,000**

Figures are based on a 25 million gallons/year refinery-$1999

Source: www.afdc.doe.gov

6% reduction in total national petroleum use

1% reduction in total national GHG emissions

3% reduction in total national fossil energy use

- Use of E85 (85% ethanol and 15% gasoline by volume) achieves:

73–75% reduction in total national petroleum use

14–19% reduction in total national GHG emissions

34–35% reduction in total national fossil energy use

Ethanol adds oxygen to gasoline – helping it burn more completely, thus significantly reducing tailpipe emissions. Gasoline is a complex mixture of dozens of chemicals – many of them toxic such as benzene. When oxygenates such as ethanol are added to gasoline, the potency of these toxic additives is diluted. Ethanol contains 35% oxygen which results in more complete fuel combustion and reduced tailpipe emissions. Ethanol is a clean-burning renewable fuel that helps reduce emissions of carbon monoxide (CO) and smog-forming volatile organic compounds (VC).

While ethanol increases the volatility (tendency to evaporate) of fuel in warm weather, the total emissions from gasoline evaporation are regulated in areas where air quality is a concern during the summer. Therefore, refiners are responsible by law for managing the components in gasoline so as not to exceed those limits – and they do so by reducing levels of volatility of gasoline. These environmental benefits are the primary reason that the American Lung Association (ALA) was involved in the development of the fuels provisions of the Senate energy bill. The ALA of Metropolitan Chicago credits ethanol-blended reformulated gasoline with reducing smog-forming emissions by 25% since 1990.

Studies have shown that ethanol:

- Reduces tailpipe carbon monoxide emissions by as much as 30%
- Reduces exhaust VOC (volatile organic compounds) emissions by 12%
- Reduces toxic emissions by 30%
- Reduces particulate matter (PM) emissions by more than 25% (Particulate matter has been found to penetrate deeply into human lungs.)

A 1999 study of the impact of ethanol on air quality by the California Environmental Policy Committee concluded that ethanol in gasoline resulted in slightly higher levels of acetaldehyde and peroxyacetyl nitrate (PAN). However, the study concluded that these slight increases were more than offset by reductions in formaldehyde, a toxic substance considerably more harmful than acetaldehyde. The study noted that "other components of gasoline, such as aromatic compounds and olefins, are primarily responsible for the formation of formaldehyde, acetaldehyde and PAN due to both their greater abundance in gasoline and their shorter atmospheric lifetimes."

Ethanol is non-toxic, water soluble and is the most harmless and biodegradable component of gasoline. In fact, ethanol occurs naturally during the fermentation of organic matter. When gasoline is spilled on land or in water, ethanol is the first component to quickly, safely and naturally degrade. More important, the presence of ethanol in gasoline means the reduced presence of other more toxic components such as benzene – so gasoline spills result in a reduced threat to the environment.

Recommended Subsidies and Incentives

Provide a $0.20 per gallon production incentive to in-state ethanol producers-Minnesota is at the forefront of ethanol production and utilization. The success of the ethanol industry in Minnesota can be attributed directly to this incentive. While this does present an additional cost to the state, the costs of remediating groundwater and air pollution, complete dependence on imported oil and the human health issues associated with polluted air and water are far more substantial and far-reaching. Suggested sources for this incentive could entail increased driver's license fees or vehicle registration fees. If this incentive could be implemented, it would certainly need to have a sunset period, say 8-10 years from inception. This would allow developing industries to gain market share and recoup facility and infrastructure investments in a short period of time. The sunset period would encourage ethanol refineries to fund their own research and develop more cost-effective ways to produce ethanol.

Provide a $0.10 per bushel production incentive to feedstock producers- Leading agricultural states such as Minnesota and Nebraska have implemented this type of incentive. The payment to the farmer provides additional farm income and encourages efficient, production-focused farming practices.

Provide a tax exemption schedule for ethanol refineries and infrastructure investments-A tax exemption schedule for ethanol refinery equipment investments and necessary infrastructure requirements would encourage the development of new facilities and facilitate new refineries coming on-line. This exemption should be limited to equipment and infrastructure purchases, such as refinery processing equipment, rolling stock, piping, tanks, etc. The facilities would not be exempt from property taxes, which would provide an additional tax base for the counties in which they were sited.

All of the previously presented incentives could provide an excellent marketing campaign for alternative fuels. Promoting the use and development of pro-ethanol incentives should be a primary concern of the State Energy Office. By "selling" the value and importance of a clean, renewable fuel source, consumer opposition to increased vehicle fees will be minimized. As the program gains momentum and market share, North Carolina will begin to actually realize the economic and environmental benefits offered by ethanol.

Alternative fuels are not the all-inclusive answer to North Carolina's energy supply and pollution issues. However, promoting the development of this industry will contribute to reduced pollution levels, additional markets for agricultural products, increased employment levels and higher tax bases. Additionally, North Carolina's utility providers can expect support from an alternate fuel industry through on-site, cleanly generated power produced by ethanol refineries. Finally, the development of an alternative fuels industry will establish a position of economic and political leadership for North Carolina in the southeast region.

Ethanol from Agricultural and Other Wastes

Substantial reductions in the cost of producing ethanol may be possible by replacing corn with less expensive, cellulose-based feed stocks, such as agricultural wastes, grasses, forestry residues (logging waste, mill waste, imperfect trees, etc.) and other low-value biomass such as municipal waste. Although cellulosic materials are less expensive than corn, they are more costly to convert to ethanol because of the extensive processing that is required.

Poultry litter as received averages 4000-5000 Btu/lb as does pig manure solids at 70% DM. The unit converts biomass into highly combustible gases and then very efficiently combusts the gases at extremely high temperatures (2150^{o}F) resulting in heat energy, pathogen free nutrient rich ash and clean and odorless atmospheric emissions similar to clean burning natural gas.

- The U.S. Department of Energy has a goal of reducing the cost of producing ethanol by as much as $0.60 by 2015.

Ethanol derived from biomass can reduce greenhouse gas emissions in North Carolina. ***Argonne National Laboratory estimates that a 2-percent reduction in greenhouse gas emissions per vehicle mile traveled is achieved when corn-based ethanol is used in gasohol (E10, approximately 10% ethanol), and that a 24- to 26-percent reduction is achieved when it is used in E85 (85% ethanol/15% gasoline).*** Cellulosic ethanol can produce an 8- to 10-percent reduction in greenhouse gas emissions when used in E10 and a 68- to 91-percent reduction when used in E85.

Corn-based ethanol has a net energy balance of 20,000 to 25,000 Btu per gallon, whereas cellulosic ethanol has a net energy balance of more than 60,000 Btu per gallon. The net energy balance is the amount of energy that a particular feedstock can deliver balanced against the energy required to extract or produce the fuel from the feedstock.

Methane from Agricultural Wastes

The benefits of harvesting methane from swine and dairy waste are numerous and most importantly, create a renewable able cycle of production. Research sponsored by the North Carolina State Energy Office has determined that swine and dairy farmers can effectively and economically recover an estimated 1.5 trillion Btu of biogas annually.

While less than 1% of annual natural gas and propane consumption of 229 trillion Btu, methane reclamation does provides the following benefits:

- Farm owners around the state would provide about $8 million worth of methane per year.
- The recovery of methane through digester technology alone equates to a cumulative emission reduction of 86,610 tons of greenhouse gases by 2010.
- The recovered methane could generate about 130 million kWh annually (0.11% of North Carolina's consumption) which would create an additional emission reduction of 113,000 tons of greenhouse gases.

Another emerging waste recovery technology that could benefit North Carolina farmers and consumers alike is agricultural waste combustion. This technology is currently being researched by Smithfield Farms and would use animal waste to fire electricity generation stations. The business venture is called BEST Solutions; BEST is an acronym for Biomass Energy Sustainable Technology. This project is estimated to cost $4 million dollars and is partially funded by money ($800,000) from the Smithfield Foods/ Attorney General agreement and will be officially evaluated by NCSU scientists. This technology is expected to be in operation within the next two years. Animal waste will be collected from several farms and transported in dump trailers to a centralized biomass energy plant. At the plant, the pig manure solids, along with the required volume of turkey and poultry litter, will be used as biomass feedstock for an innovative gasification/combustion unit manufactured by the Renewable Energy Corporation.

Poultry litter as received averages 4,000-5,000 Btu/lb as does pig manure solids at 70% dry measure The unit converts biomass into highly combustible gases and then very efficiently combusts the gases at extremely high temperatures (2,150^{o} F) resulting in heat energy, pathogen-free, nutrient-rich ash and clean and odorless atmospheric emissions similar to clean burning natural gas.

The BEST project may prove to be a viable integrated solution to animal waste issues because:

- It is a realistic, environmentally sound solution based on known, proven patented technologies that have been put together in a unique process.
- The energy and nutrient content of pig and poultry manure is economically and practically harvested, combusted and recycled as opposed to land applied or treated as waste and destroyed. This plan takes advantage of the density of animal operations, impending regulations on poultry producers and the high volume of nutrient rich, combustible biomass feedstock available by integrating manure from the poultry industry. Additionally, other organic streams, such as Coastal Bermuda hay, the primary crop of lagoon irrigation and litter applications fields, can serve as another excellent source of biomass feedstock should a higher market value not be found. This option

The cheapest coal costs between $1.50 to $2.00 per MMBtu. Natural gas costs $3.00 to $4.00 per MMBtu. Consequently, biomass appears to be cost competitive with standard fuels.

further reduces nutrient loading of the land.

- The phosphorus-loading problem is solved that both the pig and poultry industries may soon face due to impending regulations that may reduce manure application rates because plant phosphorus uptake is lower than nitrogen uptake.
- It achieves affordable, simple, practical and low labor primary treatment of pig manure. Farms will remain land based and utilize existing manure management infrastructure to manage residual nutrients in the supernatant. However, with the transport of solids off farm and greatly reduced organic loading of the lagoon, this system will achieve compliance with the AG's agreement performance standards for environmentally superior technology.
- It achieves environmentally beneficial recycling of the key fertilizer elements in a closed loop from the farms back to the grain growers.

Biomass Energy Costs

Following is a breakdown of the various biomass resources available to North Carolina and their respective costs:

- For self-use in the forest products industry, biomass is essentially free.
- Purchasing forestry-produced biomass will cost between $0.50 and $3 per million Btu (MMBtu), with economically successful projects paying less than $1.50/MMBtu. The cheapest coal costs between $1.50 to $2.00 per MMBtu. Natural gas costs $3.00 to $4.00 per MMBtu. Consequently, biomass appears to be cost competitive with standard fuels.
- Burnable municipal solid waste (MSW) is usually disposed of for a fee. Thus, it has a negative fuel price. However, plant operators must process MSW to eliminate toxics. They also need to install emissions control equipment.
- Dedicated feedstocks, such as woody and herbaceous crops, cost almost 3 times more than residues ($2.50 per Gigajoule [GJ] compared to $0.95/GJ).
- Biodiesel based on soybeans can cost approximately $2 per gallon, which is higher than petroleum-based diesel though wild oil price fluctuations have sharply reduced the price gap during periods within 2000 and 2001.
- Ethanol costs in the range of $1.10 to $1.30 per gallon,

which compares very favorably to petroleum-based gasoline.

Overall, biomass plants have higher capital costs and O&M costs than fossil fuel plants. Also, their power output efficiencies are typically poor (an average of 20% nationwide), so fuel costs are higher than those for more efficient fossil fuel plants. Experts predict more efficient technologies such as gasifiers to have electrical output efficiencies of 25% to 35%.

CHP (Combined Heat & Power) represents an improvement in the energy efficiency of power plants. Instead of releasing steam and heat that are byproducts of power generation, CHP systems capture this energy. Thus, CHP's cost is primarily capital costs for installing equipment for energy capture (REPP-CREST).

- An estimate for the Powering the South effort, which estimates clean energy potential in the South, finds that CHP projects will yield power that costs 3.3 cents per kWh in 2010.
- The cost of power from conventional biomass combustion can range from 6 cents to 12 cents per kilowatt-hour. Co-firing biomass with coal is much cheaper, since the power plant is already built and costs are limited to the biomass fuel and its preparation at the plant site. Costs can hover from almost nothing to 4 cents per kilowatt-hour for a project where biomass is 10% to 15% of the total fuel input of the power plant.
- The cost of power from of landfill gas can range from 3.5 – 7.9 cents per kilowatt-hour, depending on the size of landfill, financing available, distance from the grid or local application, and other factors.

If bioenergy is to play a larger role in North Carolina's energy mix, energy generators will require a steady supply of biomass. Essentially, a new industry must be formed to harvest, transport and prepare biomass into a usable form.

Biomass Energy Concerns & Barriers

If bioenergy is to play a larger role in North Carolina's energy mix, energy generators will require a steady supply of biomass. Essentially, a new industry must be formed to harvest, transport and prepare biomass into a useable form. If biomass power plant operators must supply steady power year-round, there must be enough biomass available throughout the year to fulfill their obligations.

However, suppliers of biomass do not sell just to the energy market. For example, wood chips can go into mulch or animal bedding. Other wood waste can be recycled into new products. Consequently, bioenergy operators must compete with other industries for biomass. This means that they must pay enough money consistently to secure the supplies they need.

Additionally, professionals in the energy sector are usually not familiar with

biomass, biomass energy conversion technologies, and biomass markets. As a result, project initiators often rely on local professionals with limited knowledge. Such professionals often "reinvent the wheel" when designing projects, thereby driving up costs or creating a less than optimal project. And farmers have no experience with growing, processing, storing, and transporting crops suitable for combustion. With biomass competing against fossil fuels for different applications, inconveniences based on inexperience are enough to discourage early adoption.

Finally, there are still a number of challenges to mass commercialization of bioenergy. For example, co-firing can be difficult if the coal power plant has selective catalytic reduction (SCR) to comply with new, more stringent limits of nitrogen oxide emissions. The alkali content of biomass fuels may contaminate SCR technologies. Up to 70% of coal-fired power plants potentially capable of biomass co-firing are likely candidates of SCR retrofits.

Biomass Policy Recommendations

The State Energy Office shall work with the Department of Agriculture to conduct a thorough assessment study of the potential for alternative fuels in the state. The study should determine the overall impact on the state of a commitment to an alternative fuels industry and develop and evaluate associated policy options.

Renewable fuels and biomass technologies are expanding industries in other agriculture-intensive states, such as Iowa, Ohio, Illinois and Wisconsin. Agriculture and forestry industries in North Carolina could become a rich resource of fuels for electricity generation and motor vehicle fuels. The success seen in the midwestern states is the direct result of state and federally sponsored research and incentive programs. North Carolina possesses significant biomass resources and policymakers would be wise to capitalize upon the state's domestic resources. Supporting and enabling renewable and biomass technologies will directly benefit North Carolina's economy with improved employment opportunities, new businesses for local tax bases and increased energy reliability.

Wood Waste

North Carolina should conduct a thorough assessment of current wood waste resources and estimate the amount of potential energy resources available in the state. The study should also conduct an examination of the economic and environmental aspects of waste-to-energy conversion and whether increased utilization of wood waste resources would result in any detrimental effect on the state's forests.

Alternative Fuels Production

For an alternative fuels industry to grow in North Carolina, three requirements must exist simultaneously:

- Practical availability of alternative fuels, such as ethanol, propane, CNG and electricity.
- A distribution network and fueling facilities
- A supply of vehicles that can use the fuel

The chapter on transportation discusses policies for providing distribution, fueling facilities, and more alternatively fueled vehicles. This section concerns biomass-derived fuels, primarily ethanol for use in vehicles and for electric power generation. To supply more ethanol, the state could initially continue to import fuel from other states. However, one of the primary reasons that alternative fuels have gained support in the state is the potential economic development opportunity for the agriculture industry. Thus, the state needs to devise mechanisms to increase production in the state.

The State Energy Office shall assist the Department of Agriculture to conduct a thorough assessment study of the potential for alternative fuels in the state. The assessment should consider the availability of farmland for energy-related crops, as well as agricultural and animal wastes. It should evaluate the economics of fuel production from the field through conversion facilities to fueling facilities. ***The study should determine the overall impact on the state of a commitment to an alternative fuels industry and develop and evaluate associated policy options.***

North Carolina should implement a specific tax credit for ethanol refineries and distributors in the state, as well as for farmers who supply ethanol plants. Farmers in the state would gain significant benefits from state funding targeting the production of energy crops and waste recycling.

A 35% tax credit for renewable energy manufacturing facilities already exists in North Carolina, however, the tax credit is not performance-based. This tax credit addresses renewable energy facility construction and equipment. By implementing a performance-based incentive system for ethanol feedstock crops, North Carolina could develop a reliable, domestic energy source that provides income and employment for the citizens of the state. Both producer and farmer tax credits should be performance-based and significant enough to attract the attention of investors. For example, the state of Wisconsin has enacted legislation that provides a $0.20 per gallon incentive for ethanol produced in state. To qualify, a company must produce at least 10 million gallons of ethanol annually. The first 15 million gallons produced each year are eligible for this incentive. Developing an incentive program that encourages production will create higher supply levels with consequently improved market share and recognition.

A tax relief incentive for prospective ethanol plant investments (no sales taxes or property taxes for a finite, developmental period for new ethanol plants) would encourage ethanol infrastructure investments and improve employment levels. Additionally, North Carolina should consider exempting ethanol from all or part of the state's gas tax. Tax incentives on property and product will encourage higher production levels and infrastructure investments, consequently lowering the price of

alternate fuels.

Landfill Gas

North Carolina should consider supporting LFG projects through direct grants and loans, as well as technical assistance. Landfill gas reclamation projects hold significant potential for contributing to cleaner air and

establishing renewable fuel sources. By investing in landfill methane recovery projects, the state will ensure a more reliable, domestic energy portfolio.

Because many of the organizations pursuing development of LFG projects are either governmental or non-profit entities, a tax credit may not serve as a suitable incentive. Instead, the State Energy Office and Department of Environment and Natural Resources shall develop a grant and loan program to support such projects.

Agricultural Wastes

The State Energy Office shall support research in conjunction with the state's electric utilities to investigate the potential of alternative fuels ranging from switchgrass to municipal solid waste in coal-fired power plants. There are several successful national projects in utility co-firing. It would provide a substantial market for alternative fuels. However, the fuel would have to have minimal negative impact on existing utility operations and economics. Use of the technology would help meet Renewable Portfolio Standards, as well as provide a potential source of electricity for the NC GreenPower program.

The State Energy Office shall conduct research in conjunction with the state's animal production industry and agricultural research institutes on developing fuels from animal wastes. As discussed earlier, animal wastes, have become a severe environmental problem as well as a potential economic problem for farmers. The state should develop and implement a larger scale pilot project converting animal waste to methane or other fuels. The research effort should also assess the economic and environmental consequences of widespread implementation of animal waste-to-fuel technology.

The State Energy Office and Department of Environment and Natural Resources shall develop incentives for farmers to convert animal and crop wastes into energy. Currently, North Carolina now offers a 35% tax credit for renewable energy installations. A state tax credit program would have the most success, although loan programs developed and implemented in conjunction with North Carolina's financial institutions that work most closely with farmers and industries may satisfy the more vital need for up-front capital.

Environmental Monitoring

North Carolina's Department of Environment and Natural Resources shall carefully monitor air pollutant and other emissions from alternative energy facilities and assess the impact of vehicular emissions from vehicles powered by alternative fuels**.** ***As a key objective of the State Energy Plan is to improve the state's environment, the state must make a concerted effort to confirm that clean energy sources have minimal environmental impact.***

Conclusion

Currently, North Carolina is entirely dependant on imported energy resources. Establishing a reliable, domestic energy portfolio should be of the utmost concern to policymakers and residents alike. It is crucial for the success of developing alternate fuels that the State Energy Office continue to support existing renewable fuel incentives and work to promote new alternate fuel developments. By investing in renewable energy, North Carolina will be able to reinforce existing energy suppliers as well as maximize indigenous resources.

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