

Biomass Energy Sources for North Carolina

Introduction

The production of energy from biomass can be an important component of an effort to reduce greenhouse gas emissions, reduce pollution, and increase U.S. and North Carolina energy security. Biomass currently accounts for 79% of the independent renewable energy generation in North Carolina, and will continue to represent a large portion of the renewable energy portfolio for the foreseeable future. The production of renewable energy from biomass includes a wide variety of sources (basically all plant and animal products can be considered biomass) and conversion technologies. Three combinations of biomass sources and conversion technologies look especially promising for North Carolina:

- Anaerobic digestion of animal wastes
- Landfill gas from municipal solid waste
- Energy from wood waste and forest residues

These three technologies are profiled below. For each technology, a description is provided followed by an estimate of the resources available in North Carolina and a description of an existing installation in North Carolina.

Biogas from the Anaerobic Digestion of Animal Wastes

Technology Description: Anaerobic digestion is the microbiological degradation of organic wastes by a distinct group of microorganisms in an oxygen-free environment. This suite of microorganisms produce a gas (often referred to as biogas) consisting primarily of methane and carbon

dioxide from complex organic materials, such as carbohydrates, proteins and lipids. The recovered gas is 60-80 percent methane, with a heating value of approximately 600-800 Btu/ft³. Anaerobic digestion systems are commonly characterized by the technology used and the operating temperature of the digester. One of the simplest systems is the covered anaerobic digester, in which a synthetic cover is placed over a specially designed impoundment. The biogas is collected under the cover. Covered anaerobic digesters operate in the psychrophilic temperature range (<68 F). Digester temperature is not actively controlled and the gas production varies considerably with ambient temperature conditions. Other anaerobic digestion systems operate in the mesophilic (68-113 F) or thermophilic range (>113 F). In these higher temperature systems, digestion usually takes place in a tank. The primary advantage of higher temperature systems is that the required retention time of the feedstock is reduced, thereby increasing throughput and reducing capital cost per unit of feedstock. The highest value application for the biogas produced from anaerobic digestion is often to utilize it in an engine/generator set and generate electricity. The electricity can be used to offset electricity use on the farm or sold to the utility. Anaerobic digestion has significant benefits beyond electricity generation, including the reduction in pathogens in the effluent, the reduction in volume of the effluent, use of the effluent as fertilizer, and the opportunity to utilize waste heat from the engine/generator set.

Potential for North Carolina: North Carolina has significant animal waste resources, particularly swine waste. North Carolina's swine industry has, in the last 30 years, grown to become the second largest in the U.S. and is the state's largest single source of agricultural income. Environmental problems caused by swine operations have become a major problem in North Carolina in recent years. Anaerobic digestion would greatly reduce the pathogenicity and volume of effluent from hog operations and generate electricity in the process. It is estimated that 50 MW of electricity could be generated if all the hog waste on farms >2000 head were utilized in an anaerobic digestion process.

North Carolina Installation: Barham Farms is a 4000 sow farrow-to-wean hog facility located in Johnston County, NC. In 1996, Barham Farms partnered with the DOE/EPA/USDA AgStar program to install a covered in-ground anaerobic digester that supplies biogas to a gas engine/generator set. (see figure 1) This system has decreased reliance on outside purchased energy and, at the same time, reduced farm-based emissions. Barham Farms is currently producing and using on average 15 million Btu/day of biogas. This translates to an average electrical output of approximately 45kW. Waste heat from the engine is used to heat water, which in turn is used in the hog farrowing operation, and could be used to heat and humidify two 28,000 square foot greenhouses in which tomatoes are being grown. The tomatoes are fertilized with a portion of the effluent stream from the digester and there are plans to pipe some of the CO₂-laden exhaust gas from the engine into the greenhouse to enhance the growth rate of the tomatoes. A schematic of this highly integrated system is shown in Figure 2.



Figure 1. Engine/Generator Set Operating on Biogas from Swine Waste at Barham Farms
(courtesy Julian Barham, Dr. Alex Hobbs)

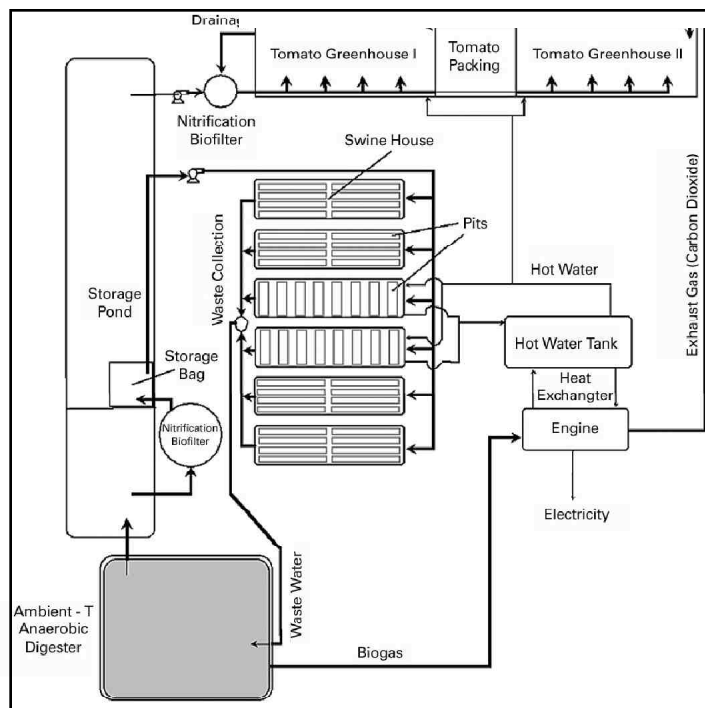


Figure 2. Integrated Swine Waste Management System with Energy and Nutrient Recovery
(courtesy Julian Barham, Dr. Jay Cheng)

Landfill Gas from Municipal Solid Waste Landfills

Technology Description: Landfill gas (LFG) is created when organic waste in a municipal solid waste landfill decomposes. This gas consists of about 50 percent methane (CH₄), the primary component of natural gas, and about 50 percent carbon dioxide (CO₂) and a small amount of non-methane organic compounds. Instead of allowing LFG to escape into the air, it can be captured, converted, and used as an energy source. Using LFG helps to reduce odors and other hazards associated with LFG emissions, and helps prevent methane from migrating into the atmosphere and contributing to local smog and global climate change.

Like other biomass sources, LFG is a renewable energy source that offsets the need for non-renewable resources such as coal and oil. Use of LFG, however, has an additional benefit in that the methane generated in landfills that would otherwise escape into the atmosphere is instead combusted to form carbon dioxide. Methane is a potent greenhouse gas, with 21 times more heat-trapping potential than carbon dioxide. Like any gaseous fuel, LFG can be burned to generate electricity, heat, or steam. A schematic of a landfill gas collection system is shown in Figure 3.

Potential for North Carolina: Excellent information on the landfills in North Carolina that could be utilized in

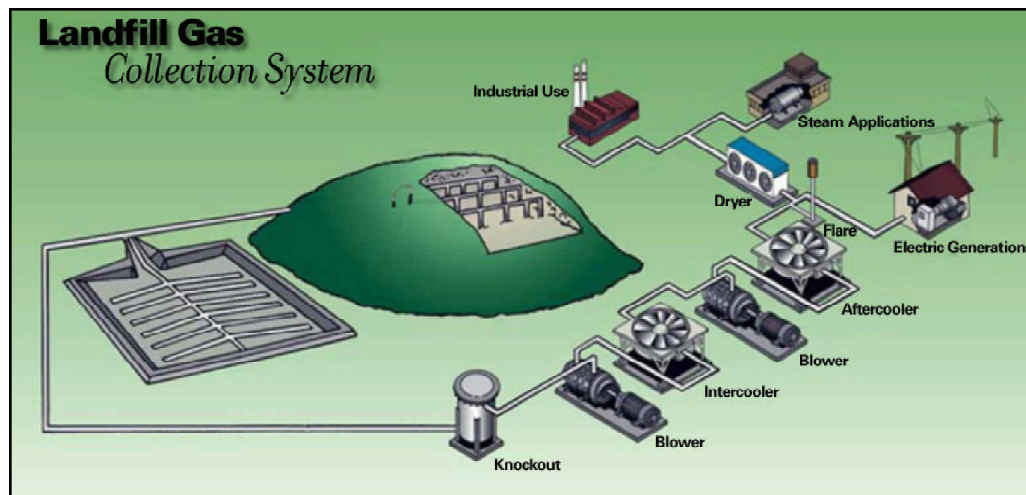


Figure 3. Landfill Gas from Municipal Solid Waste Landfills (courtesy DTE Biomass Energy, Inc.)

landfill gas projects can be found on the Landfill Methane Outreach Program (LMOP) website (<http://www.epa.gov/lmop/>). The LMOP, a U.S. EPA program, is a voluntary assistance and partnership program that promotes the use of landfill gas as a renewable energy source. By preventing emissions of methane—a powerful greenhouse gas—through the development of landfill gas energy projects, LMOP helps businesses, states, and communities protect the environment and build a sustainable future. LMOP lists 123 landfills in North Carolina in their Landfill and Gas Utilization Project Database. Of these, 12 have operational landfill gas projects. In the majority of these projects, the landfill gas is used directly in a boiler or other combustion apparatus for heating or raising steam. In four cases however, the gas is being used to generate electricity in either a reciprocating engine or gas turbine with a total capacity of 11.6 MW. LMOP estimates that more than 80 MW of LFG potential exists in North Carolina.

North Carolina Installation: The City of Winston-Salem contracted with DTE Biomass Energy, Inc. to construct and operate a landfill gas facility on the City's landfill in

Forsyth County, NC. (see figure 4) The facility began selling power to Duke Power in July 1996. This 4.3 MW facility produces enough electricity to serve over 2,900 homes in North Carolina. DTE Biomass Energy operates and maintains the facility and the landfill gas collection system. They also own the gas rights but pay the City a stipend based on the gas production from the landfill. The gas system includes nearly 100 vertical gas extraction wells that deliver about 2.8 million cubic feet of gas per day. The gas is used in a Solar T6500 combustion turbine.

Energy from Wood Waste and Forest Residues

Technology Description: A variety of technologies are employed to utilize wood waste and forest residues. These technologies include stoker boilers, fluidized bed boilers, and biomass gasification. Stoker boilers are a proven technology in which the fuel is typically pelletized and fed onto a travelling grate that passes through the combustion chamber. In a fluidized bed boiler, the wood fuel is fed into a bed of sand that acts much like a liquid because of the agitation caused by jets of air forced upward through the sand. The hot bed of moving sand quickly heats the incoming feed and in the presence of air the wood is combusted. In both of the aforementioned technologies, the hot combustion gases are used to generate steam that in turn drives a steam turbine for the purpose of generating electricity. In biomass gasification, the wood undergoes a partial oxidation process in the presence of air or steam. The products from this process are wood char and a combustible gas, the primary combustible components of the gas being hydrogen, carbon monoxide and methane. This gas can be direct-fired in a boiler but it usually makes better economic sense to utilize this combustible gas in a gas engine or gas

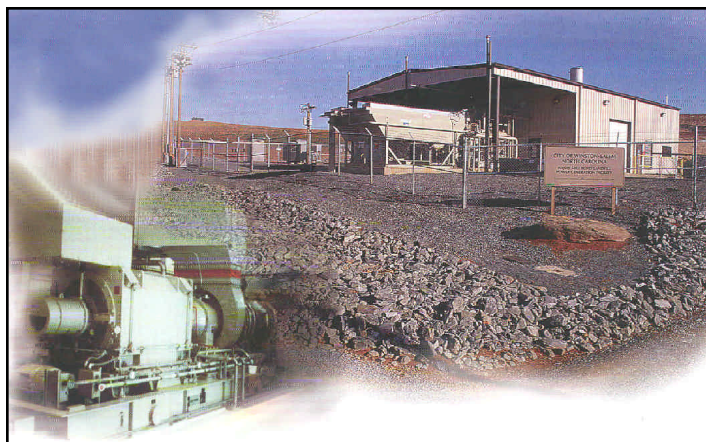


Figure 4. Landfill Gas Facility in Forsyth County (courtesy DTE Biomass Energy, Inc.)

turbine. The hot exhaust gases from the engine or turbine can be combined with hot flue gases from combustion of the char to generate steam and utilize the steam in a steam turbine as above. This system is called a combined cycle plant because both an internal combustion engine (or turbine) and steam turbine are used. The efficiency of the combined cycle is generally higher than the straight combustion approach used in the stoker or fluidized bed boilers.



Figure 5. Craven County Wood Energy Plant
(courtesy Wade Bennett)

Potential for North Carolina: Electricity generated from wood wastes represents the lion's share of electricity generation from renewable energy sources in North Carolina. Current capacity of wood waste power plants in North Carolina is 330 MW. Most of this capacity is associated with "captive" plants operated by the large paper mills in the state. A 1993 study done by the Research Triangle Institute for the NC Division of Forest Resources estimated the wood energy potential in North Carolina to be 1,017 MW (including captive generation).

North Carolina Installation: The Craven County Wood Energy plant (see Figure 5) is a 45 MW biomass power plant located near New Bern, North Carolina. This plant, commissioned in 1990, utilizes wood wastes consisting of bark from pulp mills, sawdust from sawmills, chips that are a by-product of logging operations, and clean waste wood recovered from landfills. The plant uses approximately 540,000 tons of wood waste per year. The energy generated by this plant is equivalent to the energy needs of 30,000 homes. Power produced by the plant is sold to CP&L.

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