Biomass Feedstocks Characteristics

INTRODUCTION. Bioenergy can be made from many different biomass feedstocks, or raw materials, ranging from trees and crops to yard and animal waste. Creating bioenergy begins with first acquiring the biomass, and then processing it for use in a bioenergy facility to produce heat and electricity (biopower) or liquid transportation fuels (biofuels). Biomass or processing residues (**by-products**) can be acquired after harvesting trees and agricultural crops, or from industrial[1] or urban[2] applications. Most biomass feedstocks are categorized as "**woody**" or "**non- woody**" and are transported as a processed densified material in the form of **chips, bales**, **pellets,** or **briquettes**.

Biofuels that are compatible with conventional fossil fuel transportation logistics are referred to as a **drop-in fuels** and do not require blending or separate fuel containers. The biomass feedstocks available to create energy or transportation fuels, will be discussed below.

Woody Biomass-Derived Feedstocks

LOGGING RESIDUES. Logging residues are the unused portions of trees cut during logging operations, that are often left on-site. Logging residues are obtained from standard forest harvests, thinning young tree stands, or from forest stands that have been damaged by pests, storms, disease, or fires. Thinning is a standard silvicultural practice that includes removing smaller trees to reduce tree stand density (or number of trees per acre) to alleviate competition between trees, and improve stand health. Logging residues and wood from thinnings typically have little or no value in locations where markets do not exist.

During a forest harvest, merchantable trees are brought to a logging deck or landing site in the field where the timber is sorted by product type[3] and transported to a nearby mill where the highest market value is obtained. Meanwhile, logging residues can be chipped on site and loaded into a tractor trailer or chip van for transport to a bioenergy facility or delivered as is to be processed at a bioenergy facility. Logging residues are typically processed in the field one of two ways- as clean chips or hog fuel. Clean chips do not include bark and are cut into short, thin wafers. Chips are used as a raw material for the production of paper, fiberboard, biomass fuel, and other products. Hog fuel refers to woody biomass and wood waste that has been ground in a tub grinder to produce a coarse mixture of bark and chips that

Biomass Delivery & Storage Methods

CHIPS *Small fragment of wood that may or may not contain bark.*

BALES *A bundle of compressed biomass that is bound.*

PELLETS *Compressed biomass that is cylindrical in shape with a maximum diameter of 25 mm.*

BRIQUETTES *Compressed biomass that may be cylindrical or any other shape with varying diameter sizes.*

[1]Residues can be acquired from industrial facilities such as: sawmills, pole manufacturing plants, veneer mills, plywood mills, pulp mills, furniture industries, and lumber and supply companies.
[2]Yard and municipal solid waste, and construction and demolition waste.
[3]Major products produced from trees include pulpwood, chip-n-saw, sawlogs, veneer logs, and pilings or poles.

vary in size. Hog fuel is primarily used in boilers that are able to handle the inconsistent mixture of differently sized pieces for energy production.

LUMBER MILL RESIDUES. Lumber mill residues include sawdust, shavings, and other waste from processing timber. This by-product is often used to fire the dry kilns or wood-fired boilers of the facility, thus producing some of the energy needed on site. Other times, residues are sold to other mills to make animal bedding, or pelletized and bagged for home heating in stoves. Throughout the Southeast, most mill residues are already utilized providing electricity to mill operations or sold to another mill to be converted to a higher-end product.

A pile of logging residues after a timber harvest on a southern yellow pine plantation in eastern North Carolina. Photo credit: NCSU Extension Forestry

OTHER WOOD WASTES –YARD WASTE, CONSTRUCTION & DEMOLITION WOOD WASTE. Some states or cities ban **yard waste**[4], or **land clearing debris**[5] from traditional landfills and require that the material be managed at separate facilities. Wood waste facilities primarily process the collected material into mulch, compost, or hog fuel. Hog fuel is primarily used for energy in wood-fired boilers while most yard waste residues are processed into mulch by public or private entities and sold or given to the public. Wood waste from these sources may be problematic for generating electricity since the material often has trash such as fencing, bottles, nails, etc. that requires additional processing before supplying a power plant. Construction and demolition facilities accept wood recovered from construction and demolition projects, which are then converted into hog fuel or mulch.

WHY PELLETIZE? *Pelletizing clean chips or pulpwood increases the energy content by volume and density and decreases the transportation cost of hauling excess moisture, leaves, and bark.*

An example of a wood waste pile. Photo credit: NCDENR, NC Recycling Business Assistance Center (RBAC).

SHORT-ROTATION WOODY CROPS. The practice of using **short-rotation woody crops** (SRWC) or fast-growing trees for bioenergy is under extensive research and development. Cellulosic feedstocks such as SRWC contain cellulose which is a carbohydrate and the principal component of the cell walls of trees and other higher-order plants, and are more difficult to break down than starchy grains such as corn. These cellulosic feedstocks are intended to be grown on marginal and other lands not commonly used for food production which helps to avoid the "food vs fuel" controversy[6]. Research towards this end includes improving tree genetics[7] and silvicultural practices, determining feedstock yield per acre on different soil productivity sites, and best ways to produce biofuels from the various SRWC.

SRWC species under research in the southeast United States include: hybrid poplars (*populous spp.*), sweetgum (*Liquidambar styraciflua*), American sycamore (*Platanus occidentalis*), loblolly pine (*Pinus taeda*), and eucalyptus (*benthamii, grandis, urophylla*). The hybrid poplars (sweetgum, American sycamore and loblolly pine) are able to be grown throughout most of the southeast. Eucalyptus species selected for biomass production in the southeast will be dependent on climate characteristics[8] with Eucalyptus *benthamii* more apt to thrive in temperate climates

[4]Leaves, tree limbs and other material collected from storm debris and landscape maintenance
[5]Trees and other vegetation from a graded landscape
[6]The international and national "Food vs. fuel" argument has encouraged advanced biofuels to be grown on marginal and other lands not suitable for food production.
[7]Biotechnology trees require regulatory oversight and approval prior to commercialization.
[8]Climate characteristics are based on the USDA Plant Hardiness Zone Map.

A research plot of hybrid poplars short rotation woody crops at the Williamsdale Biofuels Field Laboratory, Wallace, NC. Photo credit: NCSU Extension Forestry

and *grandis, urophylla* and their hybrids preferring more subtropical climates. SRWC are generally harvested in 1- to 6-year intervals, and coppiced woody crops can provide 3-6 harvests before replanting. Coppicing refers to cutting trees to the ground and then letting the shoots regrow from the main stump. SRWC can be harvested year round and is easier to transport, handle, and store than bioenergy grasses because of reduced storage and inventory costs and minimal loss or degradation of the product.

NC Renewable Energy and Energy Efficiency Portfolio Standard (RPS) *Small biogas projects such as Butler farms shown below are currently operating in NC. The RPS calls for "set asides" or a specified amount of electricity to come from swine manure or poultry litter in order to meet legislative requirements. The RPS requires investor-owned utilities to meet up to 12.5% of their energy needs through renewable resources.*

A covered swine waste lagoon biogas project at the Butler Bio Solar Farm, Harnett County, NC. Photo credit: Courtesy of Tom Butler.

Non-woody Biomass Feedstocks

ANIMAL WASTES: SWINE. According to the United States Department of Agriculture the U.S. hog industry is the third largest globally for consumed and produced pork. The industry today consists of large scale operations with the majority of these farms operating in the midwestern and in eastern North Carolina. Biogas, harnessed from swine or hog waste, can be used to power farm operations while reducing or eliminating fossil fuel use such as propane for heating. Harnessing waste from swine operations to produce biogas on-farm, not only provides energy but also alleviates environmental problems associated with waste disposal, such as degraded water quality.

ANIMAL WASTES: POULTRY. All poultry farms are required by the Environmental Protection Agency (EPA) to prevent waste discharges to surface waters and groundwater, also known as the National Pollutant Discharge Elimination System. Poultry farmers are also required to obtain a permit from their state authority, and most states require that animal waste management plans be in place. At this time, standalone power facilities utilizing poultry litter for energy do not exist in the southeastern United States, and the primary disposal method of animal waste includes land application. However, some biomass power facilities are capable of handling the high ash content from poultry litter, and are permitted to co-fire it with other feedstocks.

There is potential for an expanded bioenergy market for poultry litter if stricter clean water regulations were to be imposed. The traditional land application of dry poultry litter would be more difficult for farmers to practice, thus creating an incentive to use it for bioenergy. Social issues will need to be addressed as residents located near projects may take a "not in my back yard stance" (NIMBY) as they tend to have concerns that these bioenergy projects will impact their health from air emissions and will have a negative impact on their property values. Without stricter land application regulations pertaining to poultry litter disposal, or without more competitive prices paid by bioenergy companies for poultry litter, it is unlikely that there would be motivation to use it for bioenergy.

LANDFILL GAS (LFG). Landfills contain a variety of organic materials that are decomposed by bacteria under anaerobic conditions, producing methane. Landfills must meet state air quality laws and some are required to have a gas collection system installed to control the amount of emissions released. Generating electricity from these landfills is possible through the development of well fields and collection systems at the landfill. Collected methane can be used for on-site power generation or pipelined to another generating facility.

DEDICATED BIOENERGY CROPS. Long term national biofuels policy is encouraging a shift away from first-generation bioenergy crops like corn and soybeans that produce ethanol and biodiesel respectively, to second-generation or advanced biofuels such as switchgrass, grain sorghum, and SRWC to supply a wider variety of transportation fuels. The Environmental Protection Agency (EPA) is conducting life cycle analyses on the suitability of these bioenergy crops to determine whether they will be considered "advanced" under requirements outlined in the Federal policy known as the Renewable Fuel Standard (RFS2). Advanced biofuels will most likely be produced on marginal lands that are not able to support intensive agriculture.

AGRICULTURAL AND MANUFACTURING RESIDUES. Agricultural residues include the plant biomass that is left in the field after harvesting a crop. Some crops that produce a lot of residues include corn, wheat, barley, oats, and sorghum. Most farmers leave enough residue, or biomass, in the field to provide nutrients to the soil and prevent erosion, however, some of it can be safely harvested to produce bioenergy. Biomass that is left over after processing food crops such as wheat, rice, and sorghum is considered a waste product from the food industry and a promising feedstock for combustion, gasification, pyrolysis, or anaerobic digestion. Other feedstocks from manufacturing facilities include peanut hulls and cotton gin trash that are mostly used to produce steam for small industrial applications. These residues can also be made into pellets or briquettes for other heating applications. Other uses for manufacturing residues include using cotton gin trash as a potting soil amendment.

Various research plots of energy grasses at the Mountain Horticultural Crops Research and Extension Center, Mills River, NC. Photo credit: NCSU Extension Forestry.

CONCLUSION. There are many biomass feedstocks choices available to produce electricity, heat, and transportation fuels. They are usually categorized as woody or non-woody biomass and are derived from a variety of sources. Woody biomass feedstocks can be collected from logging residues, urban and industrial residues, forest thinnings and short-rotation woody crops. Non-woody biomass feedstocks can originate from animal wastes, landfill gas, bioenergy crops, and agricultural and manufacturing residues. Most biomass feedstocks are delivered as a processed densified material in the form of chips, briquettes, bales, or pellets. The public and private sectors are constantly working on increasing efficiencies throughout the supply chain as well as improving bioenergy crop species to allow for biomass feedstocks to be more cost competitive with other energy sources such as fossil fuels.

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USDA United States Department of Agriculture National Institute of Food and Agriculture