



## Biomass Energy

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**B**iomass energy is energy derived from organic matter of recent biological origin. Common forms of biomass are agricultural crops, crop residues, and forest products. Actually, fossil fuels were created from organic matter that existed many millions of years ago; however, fossil fuels are not



considered biomass simply because the fossil fuels are not of *recent* biological origin. Generally, agricultural crops and

crop residues are renewed on an annual or biennial basis. Forest products and forest residues are considered biomass with a renewal on an every 30-40 year basis. Intermediate crops such as small-diameter wood species have a renewal rate of about three years. Methane captured from landfills and the anaerobic digestion of animal manures is also considered biomass energy.

Biomass energy or bioenergy is considered to be a sustainable form of energy because the natural resource materials renew themselves at a frequent rate so that the ability of future generations to utilize bioenergy is not compromised. Biomass is really concentrated solar energy or “green sunshine” derived from the solar-powered photosynthesis process during the growth and development phases of plant materials.

### Utilizing Biomass Energy

The four methods in which biomass energy is generally utilized are:

- Direct combustion
- Production of liquid fuels from crop seeds
- Cellulosic conversion of crop residues to produce liquid fuel
- Methane production from animal manures

The simplest method for utilizing agricultural crops, crop residues, and forest resources to produce energy is through direct combustion. Efficient, affordable systems are already in place for burning shelled corn and/or wood pellets in specially designed stoves, boilers, and furnaces for residential applications. The manufacturing of these combustion units has tripled in just the past several years, and it is anticipated that this trend will continue, especially if the prices for fossil fuels continue to increase.

Other direct combustion systems based on burning crop residues (such as corn stover, corn cobs, switchgrass, and straw) and forest-based resources (such as wood chips, sawdust, and bark) are more suitable for commercial and industrial applications. There are several pilot projects growing small-diameter wood species to be harvested every third year (without replanting) for direct combustion for heat and/or the generation of electricity.



A large portion of space heating demand in Northeast U S is met with fuel oil, natural gas, and propane. The vast, relatively low-cost forest resources and other biomass resources that are available become attractive economical options to fossil fuels and simultaneously improve our environmental conditions. Several enterprises have successfully implemented biomass heating systems at schools and other institutions throughout

Pennsylvania, and several more are being developed. The biomass boilers are not as efficient as natural gas or propane boilers but can achieve efficiencies similar to fuel oil burners. The relatively low cost of biomass and the environmental benefits more than offset any boiler efficiency losses compared to natural gas or propane.

The practice of utilizing renewable field crops such as corn and soybeans to produce ethanol and biodiesel, respectively, is quickly moving forward. There is continuing interest in using corn to produce ethanol to displace the use of MTBE as an oxygenate in gasoline because of the water-pollution potential of MTBE. Just a small amount of biodiesel blended with diesel fuel adds lubricity to the fuel. Improved lubricity is of particular importance because of the federal government's recent drastic reduction in the allowable levels of sulfur in on-road diesel fuel.

Cellulosic conversion of plant residues into ethanol and other fuel sources is

still largely on the laboratory scale. Within the next several years, there could be significant commercial production of ethanol and other fuels through cellulosic conversion of the crop residues.

The use of animal manures as an energy source has long been of interest. Anaerobic digestion systems to transform the animal manures to methane were developed many years ago; however, recent advances have made the process easier to manage and more economically feasible. The methane that is produced can be utilized for: 1) direct combustion for heating and steam requirements at the site, and 2) generation of electricity to be used on-site or sold into the grid system. The expenses associated with generating electricity from methane are indeed significant. Furthermore, the required equipment to tie into the electrical grid without sacrificing system integrity adds to the costs. Utilization of the methane resource on-site is always advantageous and encouraged.



## **Harvesting Crop Residues for Biomass**

Crop residues are often referred to as waste materials and are often left on fields. However, it is erroneous to think of crop residues as being wastes. Crop residues that remain in fields serve very useful purposes including:

- Reduce soil erosion
- Reduce soil compaction
- Increase organic matter
- Increase moisture holding capacity of the soil
- Reduce need for pesticides and fertilizer
- Provide food and sanctuary for wildlife

A common misperception is that crop residues are free. There are significant expenses associated with using crop residues; these expenses include harvesting, packaging, transportation, storage, further processing, and handling.

## **Characteristics of Biomass**

Biomass energy resources can be characterized generally as solid materials with:

- low bulk density
- high moisture content
- low heat energy content
- high oxygen content
- high ash content
- highly variable property values
- poor handling properties compared to the traditional fossil fuels.

Because of the low bulk density characteristic of most solid biomass, capacity limitations for transportation and storage are often dictated by volume rather than weight. These disadvantages are balanced by the fact that these resources are renewable, sustainable, often low cost, readily available, and less damaging to the environment when utilized.

Densification of biomass materials into pellets, briquettes, wafers, etc. is a necessary first step to overcome the logistics problems associated with transportation, handling, and storage.

A good rule-of-thumb is that most biomass materials have heat energy contents in the range of  $7,000 \pm 10\%$  BTU per pound, where BTU (abbreviation for British Thermal Unit) is a common unit for amount of heat. The metric equivalent of BTU is kJ (kiloJoule).

The conversion factor is 1 BTU = 1.0551 kJ. Notable exceptions to the 7,000 ± 10% BTU per pound rule-of-thumb for most biomass include soybeans, sunflower seeds, and sunflower hulls typically in the range of 8,800 BTU per pound. The heat energy content of most animal manures and sewage sludge is in the range of 3,000 to 4,000 BTU per pound.

The property values (heat energy, ash, sulfur, etc.) of biomass materials are highly variable even within the same crop and variety of crop. The variability in property values cannot always be fully explained other than to say “normal biological variability.” Some of the variability is associated with stage of maturity at harvest, weather conditions during the growing season and at harvest, soil fertility, crop management, drying method, and storage conditions.

### Determining Biomass Properties

There are many laboratories throughout the U.S. that are set up to measure the physical and chemical properties of biomass. A bomb calorimeter is used to measure the heat given off when a small sample is completely combusted. But more lab analyses are needed to determine the feasibility of using biomass as an energy source. The following analyses should be requested for each sample:

- Bomb calorimeter, BTU/lb
- Sulfur content
- Moisture content
- Ash content
- Bulk density

For additional expense, one can order the ultimate analysis which also includes carbon, hydrogen, oxygen, nitrogen, and chlorine contents in addition to the four properties above. Ultimate analysis results are used to calculate the molecular formula for a particular biomass material which is required for detailed combustion analyses.

Note that the heat energy content is expressed as BTU per pound of biomass material, including the moisture in the sample material provided to the lab. That is why it is important to know the moisture content of the sample. Unfortunately, BTU per pound of dry matter is often referred to as the heat energy content, but that applies only to bone-dry material. All biomass products used as energy sources contain some moisture, often within the range of 10 – 16% wet basis. Any calculations involving the heat energy content of biomass material must consider the moisture within the biomass.

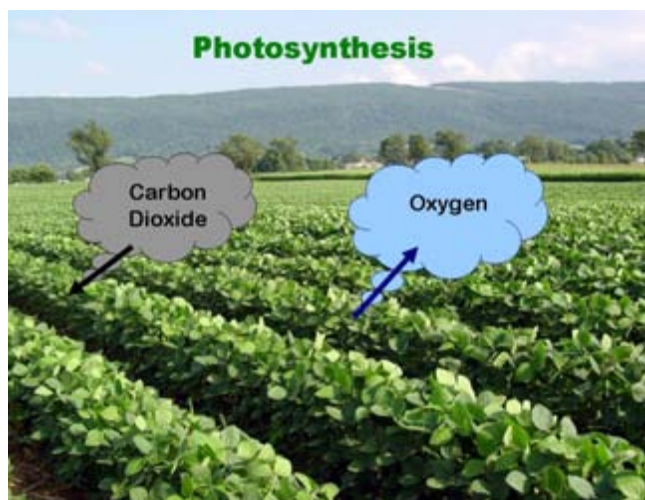
### Benefits of Biomass Energy

Utilizing biomass energy results in:

- Reducing dependency on imported petroleum
- Improving the environment and public health
- Increasing our domestic rural economy
- Increasing lubricity for engines with biodiesel
- Replacing MTBE as an oxygenate in gasoline with ethanol
- Promoting homeland security
- Increasing energy sustainability

NREL (National Renewable Energy Laboratories) reports that when biodiesel is substituted for petroleum diesel, there is a dramatic reduction of 78% in greenhouse gas emissions. The environmental benefits of biodiesel include large reductions in carbon dioxide, the sulfur oxides, particulates, and odor. However, there is a slight increase in the nitrogen oxides. There is also concern about increased water pollution associated with removing too much biomass from the land.

As soybeans (most common crop in U. S. for making biodiesel) are growing in the field, carbon dioxide is being sequestered out of the environment by the photosynthesis process into the soybean plants and oxygen is being released into the environment. During the growth and development phases, soybean plants are really scrubbing the environment.



While all biomass energy sources have more favorable carbon footprints than fossil fuels, they are not all equivalent in reducing carbon dioxide emissions. It is not sufficient to say that crops, crop residues or forest products absorb all of the carbon from the environment during their growth that they release when utilized. All of the processes associated with

crop establishment, fertilization, pest and disease management, harvest, drying, densification, storage, transportation and conversion of a biomass feedstock must be evaluated when assessing the overall carbon dioxide balance of a particular feedstock. All of these steps require energy inputs that release additional carbon dioxide. Careful accounting of carbon sources and sinks is critical to any assessment of the potential for biomass energy to reduce greenhouse gas emissions.

## **Impacts on Food Supply and Prices**

The agricultural industry in the U. S. and throughout the world is changing to meet the demand for biomass resources that can be processed into energy supplies. The production and processing of food and fiber for the ever-increasing global population remains the primary responsibility of agriculture. Increasingly, agricultural resources are being used to produce chemical feedstocks for processing, production of pharmaceuticals, and production of fuel.

There is evidence that utilizing corn for ethanol and soybeans for biodiesel has driven up the price of food in some parts of the world. It must be recognized that using these crops to produce motor fuels has the benefit of simultaneously improving environmental conditions by reducing carbon dioxide and sulfur oxides. However, many forms of biomass can be produced using native plant species on marginal quality land that have no impact on food supply.

Some may be concerned that diverting agricultural resources away from production of food will result in additional malnutrition problems throughout the world. It is recognized that malnutrition impacts 800 million people (about 15% of the global population). Malnutrition is clearly traced to problems associated with inadequate distribution and storage systems and, in some cases, the absence of political wills and desires to feed the people.

## **Summary**

Technological breakthroughs in the future will enable us to more feasibly process biomass and waste products from urban, suburban, and rural areas directly into energy. Biomass energy will never become the only energy resource that our society relies upon, but biomass energy will become a significant part of our energy solution.

Many states in the U.S. have already passed aggressive renewable energy portfolio standards or alternative energy portfolio standards. Utilizing various forms of biomass offers significant opportunities for the states to meet their portfolio standards.

The importance of increasing energy efficiency cannot be over-emphasized. We must recognize that the energy that is most affordable, friendliest to the environment, supportive of the domestic economy, and totally sustainable is the energy that *is not used*. Energy savings of 30 to 35% can easily be achieved through effective energy efficiency programs without sacrificing the comforts and conveniences that we have grown accustomed to over the years.

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