Energy Producing Systems: Biomass Power

Introduction

Biomass can be defined as any plant or animal matter. The burning of wood is a form of **biomass power** and was one of the first energy forms that humans learned to manipulate. Examples of substances that can be used for biomass power are wood, crop wastes, seaweed, animal wastes, energy crops and the various components of municipal solid waste. Biomass sources can often simply be burned directly for energy production. The resulting **thermal energy** can be used to run machinery, drive **turbines** to produce **electrical power**, or provide heat to buildings.

In some cases the organic material is first allowed to ferment and partially decompose prior to use. This process releases smaller secondary organic materials such as ethanol, methanol or methane gas. These fermentation products can then be used as a fuel source for a variety of energy systems. Methane gas can be converted to electricity using fuel cells or turbine systems, or **combusted** directly. Both ethanol and methanol are promising substitutes for traditional transportation fuels such as gasoline or diesel.

Types of Biomass Energy Production

Forestry and Agricultural Biomass

Crop waste is a valuable source of biomass fuel.

The majority of **biomass energy** sources are composed of plant material (crops, crop waste and wood) or derived from plant material (paper, cardboard and wood products). These systems are **renewable energy resources** and are "refueled" by recurring plant growth. **Fossil fuels** such as **coal**, **oil**, and **natural gas** were formed thousands of years ago from ancient plant and animal matter that was deposited and trapped geologically. Technically, fossil fuels are a form of biomass energy as well. However, fossil fuels represent a limited and **nonrenewable energy resource**. Modern biomass energy systems are based on recent plant growth cycles and are completely renewable systems. Such systems can be expected to provide energy well into the future.

More than 2.8 million American homes are heated primarily with wood. Currently, the majority of biomass energy generated in the United States results from burning wood and agricultural waste products. Both forests and crops provide long term sources of energy when soundly managed for re-growth. Most wood and crop waste by-products can provide on-site power to the industries that produce them. Many agricultural crop residues such as corn stalks, cornhusks, corncobs, wheat stalks, rice stalks, fruit pits and soybean stalks can also be fermented to produce liquid fuels such as ethanol and methanol. This strategy offers the dual advantage of reducing energy needs while minimizing disposal costs associated with these by-products.

Plants can also be grown specifically for production of energy. Such "energy crops" are usually fast growing species that can be ready for harvest in a short time. Species such as switch grass, bamboo, fescue grass, poplar trees, willow trees, eastern cottonwood and sycamore trees are examples of common energy crops. Missouri has great potential for producing such energy crops. These crops require significantly less fertilizer than food crops, and are disease and pest resistant.

Issues with Energy Crops

Energy crops typically grow fast and large with minimal care and maintenance.

A fundamental problem associated with growing plants specifically for energy is the trade-off between food versus fuel. Increased agricultural intensities supporting energy crop production also lead to elevated fertilizer and pesticide use, soil erosion and water quality impacts. An acre of land is required to produce 40-50 gallons of bio-diesel. Many countries do not posses the agricultural resources of the United States and cannot afford to sacrifice food production to create **biofuels**.

Municipal Solid Waste

Paper products compose more than 20 percent of the waste sent to Missouri municipal sanitary landfills. Paper and cardboard are manufactured by processing wood pulp and represent a viable source of biomass energy. Some electrical utility companies have begun to “co-fire” these solid wastes with coal. These paper products provide a supplementary energy source and can significantly reduce air emissions as compared to utilities burning coal alone.

However, most solid waste generated in Missouri still ends up being placed in a municipal sanitary landfill. It’s estimated that the average Missourian produces 5.6 pounds of solid waste every day. Much of this material that gets buried in Missouri landfills is composed of organic matter such as food waste, yard waste, waste paper and cardboard. While current landfills are not designed to promote the biological degradation of these products, some level of microbial fermentation of the wastes does occur. These fermentation reactions produce predominantly carbon dioxide and methane gases. The methane gas is flammable and can become a safety issue if not properly controlled. Most landfills routinely capture these gases on-site and simply burn or “flame-off” the methane.

Waste fiber material can be recycled rather than placed into a landfill.

Landfill gases are now being viewed as a potential power source. Methane gas can provide on-site power by combusting the gas to generate electrical power. Emerging technologies such as gas fired micro turbines, stirling-heat engines or fuel cells now promise to make generating on-site power from landfill gas economically favorable. Fuel cell systems have been developed that can use methane gas directly and produce electrical power with no significant air emissions.

Landfill gas can also be sent off-site as a substitute for natural gas. Schools and other large buildings located near landfills can be directly connected to the land fill gas recovery system. This approach has been successfully demonstrated at Pattonville High School in North St. Louis County, Missouri. Pattonville High has been heating its buildings with the gas produced by a nearby land fill since 1997. The school estimates that they save around $30,000 a year by using land fill gas rather than natural gas for their heating needs. The U.S. Environmental Protection Agency (EPA) estimates that more than 400 landfills across the United States could be used in this manner to generate power from the land fill gas. The state of Missouri has at least eight additional sites that could be developed to produce energy from landfill gas.

Animal Waste Power

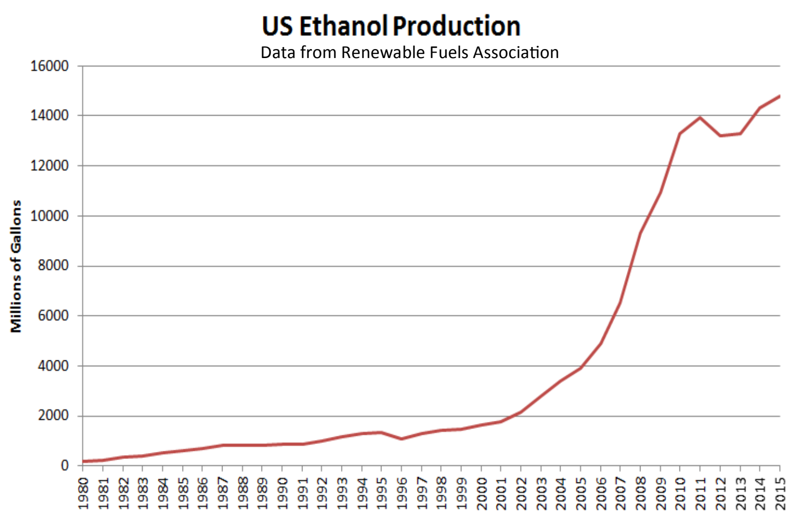
The concentration of swine, poultry and beef operations that could be used to generate biomass energy is indicated on the following map. These are mostly confined animal feeding operations (CAFO's), which would often lend themselves to biomass power systems. As indicated on the map, Missouri has very good potential in this area. Developing these systems would not only provide local power but would also help to reduce the environmental impact associated with these highly concentrated waste streams.

Humans have used animal waste products as a fuel source for thousands of years. In many parts of rural India dried cow manure is still used as a primary fuel source for cooking and space heating needs. Such animal wastes are composed of complex organic material and as much as 60 percent of fecal matter can be composed of microbial cells mass. When produced in sufficient volume such animal wastes often pose serious environmental problems such as in confined animal feeding operations (CAFO's). Such facilities routinely raise thousands of animals in confined pens, using automated feeding systems. Vast quantities of animal waste are produced from these facilities. CAFO's have come under increasing regulation as the environmental impacts of these operations unfold.

However, the waste streams produced by CAFO facilities are rich in organic matter and represent a viable source of biomass power. The waste can be sent to a digester tank where natural microbial degradation processes are optimized. The decomposing waste produces large quantities of carbon dioxide and methane. The methane can be captured and combusted to provide local heat to the operations animal pens for example. Large facilities can even use the methane produced to operate micro-turbine systems and generate electrical power. A successful operation of this type installed at a dairy farm in Wisconsin provides enough electricity to power 250 nearby homes.

Biofuels for Transportation

Twenty-eight percent of the total energy consumed in the United States is used for transportation needs. Current systems rely almost solely on fossil fuels such as gasoline or diesel and about half of the petroleum consumed by the United States is imported. Missouri alone consumes over 330,000 barrels of petroleum a day, ranking 17th in the U.S. and spending $17 billion a year. Further, transportation fuels account for more than 1/3 of our nation's carbon dioxide emissions and contribute to climate variability. Other pollutants found in vehicle emissions such as nitrogen oxides and reactive hydrocarbons can contribute to localized air pollution (ozone). This is a real problem for large metropolitan areas and significant health risks have been attributed to these pollutants. St. Louis and Kansas City have both suffered from significant air pollution problems related to vehicle emissions.



Viable substitutes for fossil fuels have been developed and are derived from plant sources (biomass), these liquid fuels are known as biofuels. Biodiesel is manufactured from vegetable and soybean oils and gasoline can be mixed with ethanol fermented from corn. Biomass derived fuels such as ethanol-gasoline blends and biodiesel burn significantly cleaner than fossil fuels and can help reduce the pollution associated with using fossil fuels. Utilization of biofuels has increased during the last 15 years. Ethanol production has increased by 739 percent since 2000 (see chart) and more than 90 percent of U.S. gasoline is blended with ethanol. Biodiesel is produced in much smaller total quantities, but has still increased by over 1000 percent from nine million gallons in 2001 to 967 million gallons in 2012.

The Future of Biomass

Currently less than six percent of America's energy comes from biomass derived sources. This represents an untapped energy source when one considers the extensive agricultural resources that exist in the United States. Rapidly improving technologies such as micro-turbines, fuel cells and other small power production systems can be expected to help set the stage for smaller biopower producers. Missouri has great potential in the area of biomass power. Currently the state generates about 80 percent of its electricity using imported coal. Missouri was the fifth-highest ranked coal receiver in 2014, getting 42.49 million short tons of coal and spending around $1.6 billion on coal importation in 2013. Replacing even a portion of these expenditures with "home-grown" energy sources would have a positive impact on Missouri's economy as well as help to reduce the environmental impacts associated with fossil fuels. Missouri has a high potential for biofuel production—the fourth highest potential in the U.S., actually. Biomass power is a rapidly developing field and will almost certainly play a role in Missouri's future energy needs.

Glossary of Terms

Biofuels: Liquid fuels such as biodiesel and ethanol derived from plant sources

Biomass: Any plant or animal matter; can be used as fuel especially as crop waste, wood, grasses, paper waste, and other plant material

Biomass energy: Energy produced by combusting biomass materials such as wood

Biomass power: Power produced from the combustion of biomass

Coal: A solid fossil fuel mined from the Earth's surface and underground which is often used to produce electricity through combustion. There are several different qualities of coal including anthracite, bituminous, and lignite

Combustion: A high-temperature chemical reaction resulting from the combination of a fuel with oxygen which releases carbon dioxide and water mixed with other substances (smoke) as well as thermal and light energy

Electrical power: Electrical energy used to conduct work; the measure of the rate of electrical energy used by a circuit. This is usually measured using a unit called a Watt (W)

Fossil fuels: Highly combustible substances generally found underground that were formed as the result of high levels of heat and pressure on decaying organic matter from millions of years ago. Fossil fuels include liquid oil, solid coal, and gaseous natural gas and are often burned to generate energy and power

Landfill gases: The gases produced from the decomposition of waste in landfills (esp. methane). Can often be utilized for energy production

Natural gas: A fossil fuel gas which can be recovered from underground and combusted as a fuel source. Increasingly used to generate electricity

Nonrenewable energy source: Primary energy source that cannot be replenished at an equal or greater rate to its consumption; unsustainable energy source

Oil: Also known as petroleum; a viscous and combustible fossil fuel liquid found underground which can be refined into different products including fuels which are often burned for transportation or other energy needs

Renewable energy source: Primary energy source that can be replenished at an equal or greater rate to its consumption; sustainable energy source

Thermal energy: Kinetic energy associated with the movement of molecules; commonly produced from combustion. Heat is the transfer of thermal energy from bodies of higher kinetic energy to lower kinetic energy

Turbine: A device which harnesses the kinetic energy of an incoming force (often steam, water, or air) to spin rotors and create mechanical power. In electrical power generation the spinning motion of turbine rotors is used to turn generators which use rotating magnets inside copper wire to create an electrical current

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