PEP
POWER EFFICIENCY PROJECT

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How BioEnergy is Collected and Distributed

What is Biomass?

Bioenergy, derived from biological sources, is one of the largest **renewable energy resources** used today. It plays a crucial role in developing countries where wood is used for simple cooking and space-heating applications. **Biomass** describes any solid, liquid, or gaseous organic material produced from living or dead organisms and includes agricultural waste, wood waste, special crops grown specifically for bioenergy usage, organic municipal solid waste, and animal manure (**Figure 1**). Energy from the sun is stored in plant matter through the process of photosynthesis. This energy can be harnessed from biomass through **combustion** or chemical processes to provide renewable heat, electricity and transportation fuels.

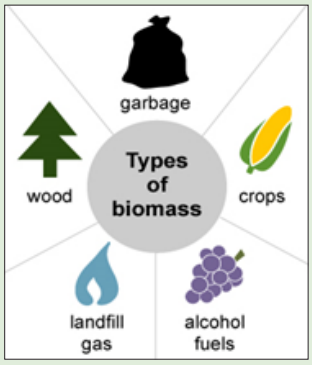

Figure 1:
Types of biomass.
Source: www.eia.govenergyexplained/?page=biomass_home

Using Biomass to Produce Biofuels

Biofuels are renewable **transportation fuels** manufactured from a variety of biomass resources: corn, sorghum, barley, sugarcane, sugar beets, yard clippings, and tree bark to name a few. Studies by the International Energy Agency show that biofuels can be expected to provide up to 27 percent of world transportation fuels by 2050.[1] Ethanol and biodiesel are the main biofuels manufactured today.

Ethanol is an alcohol made from starch-based or sugar-based feedstocks, using either **wet milling** or **dry milling** processes. Most of the ethanol produced in the U.S. is made from corn because of its availability and low price. The final product is clear, colorless, nontoxic, and biodegradable. The production process creates several byproducts which can be sold as feed product for livestock or made into corn starch and corn syrup. Today, almost all gasoline sold in the U.S. is 10 percent ethanol by volume (E10). E85, which contains up to 85 percent ethanol, is an alternative fuel used by **flex-fuel vehicles**.[2] Ethanol can be considered nearly **carbon neutral** since its original components absorb carbon through photosynthesis and offset the carbon dioxide produced as ethanol is made.[3]

Biodiesel is another clean-burning, renewable fuel replacement for conventional fuels. Biodiesel is comparable to petroleum-based diesel. Biodiesel is made from vegetable oils, used cooking oils, and animal fats.[4] The production of biodiesel is called **transesterification**, which consists of mixing the oils and fats with an alcohol (such as methanol) to form **long-chain mono alkyl esters**. Biodiesel can be used in its pure form or mixed with petroleum diesel to help reduce pollutants generated by burning fuel in a vehicle. Biodiesel can be used in diesel engines without any upgrades or retrofits to the vehicle.[4]

Using Biomass to Generate Electricity

In addition to transportation fuels, biomass can be used to produce electrical and thermal energy. **Bioenergy** electricity or **biopower**, is generated by burning biomass directly or converting to a gaseous state to drive a turbine generator. In 2012, production of biopower was estimated to be 370 terawatt hours (TWh), which accounted for 1.5 percent of world electricity generation.[1] Biomass or biomass residue (forest

slash, urban wood waste, lumber waste, agricultural wastes, municipal waste, or animal manure) can be burned directly in combustion or used along with coal in a **biomass**, co-fire, coal power plant. **Biomass co-firing** in coal-fired boilers is a way to implement biomass into traditional fossil-fuel energy-generation technologies (**Figure 2**).

Figure 2:
Coal and biomass mixture fed into a coal-fired boiler.
Source: www.nrel.gov/docs/fy04osti/33811.pdf

Using Biogas to Generate Electricity

Biomass gasification is the term used to describe the process of converting a solid biomass fuel into a combustible gas. The biomass gasification process converts biomass to hydrogen and other byproducts without combustion. Biomass is fed into a **digester tank** where it is combined with oxygen and steam at high pressure. This process breaks the biomass into molecules, and allows for the safe removal of pollutants and impurities. Gasification produces a **biogas** that can be cleanly burned, which can be used to generate electricity and liquid fuels.[5]

Another way to produce biogas from biomass is anaerobic digestion. **Anaerobic digestion** is like biomass gasification except it must occur in an oxygen-free environment. Microorganisms are used to convert the biomass into a gaseous product and a byproduct called **digestate**. The biogas generated "is about 55-70 percent methane (the primary component of natural gas) and therefore can make an excellent energy source."[6] Additionally, the digestate can be used as fertilizer. Anaerobic digestion is being used to treat municipal solid waste, and farm and industrial wastes. This technique of biomass utilization is advantageous over direct combustion as it lowers carbon dioxide emissions, eliminates odors, and reduces production of toxic products.[7]

Bioenergy in Kansas

Kansas has 15 biofuel facilities with a combined capacity of more than 525 million gallons produced per year.[8] Abengoa Bioenergy, a frontrunner in biofuel production, has constructed a hybrid biomass power plant in Hugoton, Kansas, which produces cellulosic ethanol along with electricity. The plant was constructed in Hugoton for its significant supply of biomass resources and state and local support for the project. Abengoa Bioenergy plans to generate 16 million gallons per year of cellulosic ethanol and 29,000 tons of lignin byproduct, while generating 70 MW of renewable electricity.[9]

Curriculum & Activity Links

Primary

- Biomass Factsheet, Grades K-2, http://www.need.org/files/curriculum/infobook/BiomassP.pdf
- Biomass Factsheet, Grades 3-5, http://www.need.org/files/curriculum/infobook/BiomassE.pdf
- Bioenergy K-12, Grades 4-12, http://agsci.oregonstate.edu/bioenergy-k-12/bioenergy-lessons
- Coloring and Activity Book, https://energy.gov/sites/prod/files/2015/04/f22/beto_coloring_activity_book.pdf
- Great Lakes Bioenergy Classroom Materials, Grades K-12, https://www.glbrc.org/education/classroom-materials

Intermediate

- Biomass Factsheet, Grades 6-8, http://www.need.org/files/curriculum/infobook/BiomassI.pdf
- Bioenergy K-12, Grades 4-12, http://agsci.oregonstate.edu/bioenergy-k-12/bioenergy-lessons
- Alternative Fuels Used in Transportation (5 Activities), Grades 5-8, https://energy.gov/sites/prod/files/2014/07/f17/transportation_alternativefuels.pdf
- Transportation Fuels: the Future is Today (6 Activities), Grades 4-8, https://energy.gov/sites/prod/files/2014/06/f16/transportation_fuelsfuture.pdf
- Great Lakes Bioenergy Classroom Materials, Grades K-12, https://www.glbrc.org/education/classroom-materials

Secondary

- Biomass Factsheet, Grades 9-12, http://www.need.org/files/curriculum/infobook/BiomassS.pdf
- Bioenergy K-12, Grades 4-12, http://agsci.oregonstate.edu/bioenergy-k-12/bioenergy-lessons
- Cell Wall Cheamistry of Biofuel, Grades 9-12, https://energy.gov/eere/education/downloads/cell-wall-chemistry-biofuel
- Transportation Fuels: the Future is Today (6 Activities), Grades 9-12, https://energy.gov/sites/prod/files/2014/06/f16/transportation_fuelsfuture.pdf
- Creating Biodiesel and Mitigating Waste, Grades 9-12, https://energy.gov/sites/prod/files/2014/06/f16/acts_brown_biofuel_309.pdf
- Great Lakes Bioenergy Classroom Materials, Grades K-12, https://www.glbrc.org/education/classroom-materials

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3. "Ethanol Vehicle Emissions." Alternative Fuels Data Center. US Department of Energy, n.d. Web. 10 Oct. 2016. http://www.afdc.energy.gov/vehicles/flexible_fuel_emissions.html
4. "Biodiesel." Biofuels: Ethanol and Biodiesel. US Energy Information Administration, n.d. Web. 04 Jan. 2017. http://www.eia.gov/energyexplained/index.cfm?page=biofuel_biodiesel_home
5. "Hydrogen Production: Biomass Gasification." Office of Energy Efficiency and Renewable Energy. US Department of Energy, n.d. Web. 10 Oct. 2016. http://energy.gov/eere/fuelcells/hydrogen-production-biomass-gasification
6. "Biogas Digesters." Clean Energy Resource Teams Manual (n.d.): n. pag. Clean Energy Resource Team. Web. 10 Oct. 2016. http://www.cleanenergyresourceteams.org/files/CERTsManualCh7.pdf
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8. "Alternative Energy." Kansas Department of Commerce. Web. 11 Oct. 2016. http://www.kansascommerce.com/index.aspx?NID=468
9. "Abengoa Bioenergy Hybrid of Kansas, LLC (ABHK)." Kansas Corporation Commission. Web. 11 Oct. 2016. http://www.kcc.state.ks.us/energy/kwrec_09/presentations/B1_Robb.pdf