BIOMASS AS A FUEL

A Lesson Plan
developed for
Teachers of Agriculture

This lesson plan is designed to assist teachers in guiding the learning process in students as they learn more about biomass as an alternative fuel. As with any lesson materials that are not prepared by the teacher who uses them, this lesson plan serves only as a guide. Teachers must adapt, supplement, and/or alter this suggested plan according to the local needs, interests, and expected outcomes of the students who are in that classroom. Only in this way will the instruction given meet the needs of the students, school, community, and state in which the students live and the teacher works.

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Lesson Title: Implications for Biomass as a Fuel Alternative in the Agriscience Industry

Terminal Objective: To determine the feasibility and opportunity of using biomass to carry out functions in the agriscience industry and society

Enabling Objectives: Given a lesson on biomass, students will be able to:

1. define energy;
2. define biomass;
3. describe the three main types of biomass fuels;
4. explain the relationship of photosynthesis to the biomass process;
5. explain the relationship of the carbon cycle to the biomass process;
6. list examples of plants and products that can be converted into energy(fuel); and
7. assess the value of biomass to the agriscience industry and society as an alternative fuel source.

The teacher is encouraged to add his/her own enabling objectives that would take into account local situations or the need to add additional content information not provided within this lesson outline.

References, Equipment, Instructional Aids, and Related Web Sites

NOTE: ***Teachers should use professional judgment in the selection and use of web sites. Web sites change over time and thus, the relevancy and accuracy of information contained on these sites will change as new information and research findings in the area of biomass develop.***

http://www.eia.doe.gov/kids/energyfacts/sources/whatsenergy.html - An overview of energy

http://www.eia.doe.gov/kids/energyfacts/sources/renewable/biomass.html - An introductory site to biomass fundamentals

http://www.eia.doe.gov/kids/energyfacts/uses/consumption.html - Data on the users and uses of energy

http://www.nrel.gov/docs/fy00osti/28024.pdf - Examples of biomass for rural development

www.infinitepower.org/factsheets.htm - The U.S. Department of Energy Biomass Biopower Program

http://www.nrel.gov/docs/fy03osti/33257.pdf - A small modular biomass power system that can be used to provide electrical power to villages without electricity in the world

http://www.eere.energy.gov/biomass - Web site on biomass programs, biofacts, global warming, and related information

http://www.eia.doe.gov/emeu/aer/pdf/pages/sec2.pdf - Facts and figures on energy consumption by sector

http://www.eere.energy.gov/states/alternatives/ - Biomass information by states

http://www.eere.energy.gov/biomass/biomass_benefits.html - Benefits of using biomass as an energy source

Equipment Needed
Living plants
Sawdust
Wood Chips
Celery

Lesson Plan Color Code
GREEN – Suggestions to the teacher of teaching approaches, teaching techniques, instructional aids, or other ideas that the teacher might find helpful in teaching this lesson. Space is also adequate for teacher notes.
BLUE – Web sites that provide information, knowledge, or background that relate to the Enabling Objectives for the lesson. In some cases, the teacher can use the web sites to prepare for the lesson, in other cases; the students can go to the web sites for basic information or further reading.
RED – Questions a teacher can pose to the students or they can be used to guide the teaching process. Question numbers relate back to the number of the Enabling Objectives found at the beginning of the lesson.

Introduction: The following ideas are possible suggestions for introducing this lesson topic.

1. Have the students stand up. Did it take energy to do that? Where did that energy come from? Where do their bodies get their energy?
2. If the heat or air conditioner is on in the classroom, where did that energy come from?
3. Where did the energy come from to operate your vehicle to get to school this morning?
4. Light a wooden match. Why does the match keep burning?
5. If you have a hydroponic unit, how can the plants grow without any soil? Where do they get their nutrients?

TEACHING OUTLINE

1a. What is energy?
www.eia.doe.gov/kids/energyfacts/sources/whatsenergy.html

Energy is the **ability to do work.** Used to **operate** cars, truck, and tractors, **heat** buildings, **run** computers, lights, and televisions -- only a few examples.

Teacher assigns students to go home and make a list of the energy used in their homes. Report back to class

1b. What did people do years ago when this energy was not available?
Light bulbs followed candles
Cars followed horses-followed-walking

Air conditioners followed-fans

1c. Who are the major users of energy?
http://www.eia.doe.gov/kids/energyfacts/uses/consumption.html
http://www.eia.doe.gov/emeu/aer/pdf/pages/sec2.pdf

Industrial sector uses **37 percent** of the energy consumed Energy is provided by:

- 38 percent natural gas
- 32 percent other
- 7 percent electricity
- 6 percent coal

Data is shared with students not for rote learning, but to gain a perspective on who uses the energy and a concept on how much each sector in society uses of the total.

Transportation uses **27 percent** of the energy consumed. Energy is provided by:

- 61 percent gasoline
- 19 percent diesel
- 13 percent jet fuel
- 7 percent other

Which is used by

- 34 percent by cars
- 25 percent by light trucks
- 18 percent by other trucks
- 9 percent by airplanes
- 4 percent by water craft
- 10 percent by other

Residential uses **20 percent** of the energy consumed. Energy is provided by:

- 52 percent by natural gas
- 35 percent by electricity
- 10 percent by fuel oil
- 4 percent by propane
- 9 percent by others

Which is used for

- 51 percent for space heating
- 22 percent for lights and appliances
- 19 percent for water heating
- 4 percent for refrigeration
- 4 percent for air conditioning

Commercial uses **16 percent** of the energy consumed, which is used for:

- 32 percent for space heating
- 23 percent for lighting
- 15 percent for water heating
- 7 percent for cooling
- 23 percent other

And is provided by

- 54 percent electricity
- 35 percent natural gas
- 11 percent other

1d. What are the two kinds of energy?

Potential – energy which is stored
Examples are food that we eat contain chemical energy, fuels (coal and wood) that we burn

Kinetic – energy that is working (of motion)
Examples are a bowling ball rolling down an alley, fly wheel on an engine or machine

1e. How is energy categorized?

Renewable – an energy source that can be used over and over again

Nonrenewable – an energy source that once used cannot be used again, at least within a short period of time and it may take years to replenish

1f. What are examples of each type of energy?

Examples in community **Renewable energy resources** include solar, wind, geothermal, hydropower (water), and biomass

Examples in community **Nonrewable energy resources** include the fossil fuels; oil, natural gas, and coal, and uranium

Examples in Community **Oil, natural gas, and coal** were formed by great pressure applied on **dead plants and animals** over a long period of time

2a. What is biomass?

http://www.nrel.gov/learning/re_biomass.html

Biomass is organic material which has stored sunlight in the form of chemical energy

2b. Why is biomass considered a source of fuel?
Since chemical energy is **stored** in biomass, it becomes a source of fuel when burned

3a. What are the three types of biomass fuels?
1. Wood
2. Waste
3. Alcohol fuels

3b. What would be included under the wood type biomass fuels?
1. **Wood** – hardwood and softwood
2. **Saw dust** **Wood byproducts** – sawdust, black liquor
3. **Wood chips** **Wood waste** – wood chips, hogged fuel, manufacturing scrap wood

3c. What would be included under waste as a type of biomass fuels?
- **Solid waste** – residential, commercial, and industrial refuse and methane gas from landfills
- **Manufacturing process waste** - animal and plant residues and other manufacturing wastes

3d. What would be included under alcohol fuels?
Ethanol – derived from corn, lignocellulosic biomass and other grains

4a. What is photosynthesis?
Samples of living plants
Photosynthesis is the process by which plants **make foods** by capturing the **sun's energy** and **converting** it into **chemical energy** in the form of **sugar**

4b. Why is photosynthesis important?
Place equation on chalkboard Using carbon dioxide, sunlight, water, and aided by chlorophyll serving as a catalyst, two products are produced: oxygen and sugar. This process is called photosynthesis.

carbon dioxide water
Light + $6CO_2$ + $6H_2O$ = $C_6H_{12}O_6$ + $6O_2$
Sugar oxygen
(glucose)

Oxygen is **given off** by plants and is used by animals, including man
Sugar is stored by the plant and later used for plant growth or **stored as chemical energy**, which later may be **eaten** by animals, thereby **releasing** the chemical energy.

Eat celery and then dry some, then burn it
If the plant is **not eaten**, the chemical energy is **still in** the plant, and thus, the raw plant can be converted into energy, or if it dies, the residue left can be converted into energy. Thus, it is called **biomass**.

5a. What is the carbon cycle?
It is a **cycle** that carbon goes through in plant growth, processing, chemical transformation, returning to be used again and again in the cycle.

5b. What is an example which results in biomass fuel?
Teacher can denote cycle by drawing a circle on the chalkboard
Corn is **grown**
It is **processed,** ground into fine particles
Through chemical processes, it is **separated into sugars**
Sugars are **distilled** to make **ethanol**
Ethanol is **mixed** with other fuels or can be burned by gasoline engines alone
When it is burned, it **gives off carbon dioxide**
Carbon dioxide is needed and **absorbed** by corn, and produces the next crop
Thus the cycle is **complete** and **starts over again**

6a. What are examples of products that can be converted into biomass fuel?
http://www.eere.energy.gov/biomass

- **Corn** processed into ethanol
- **Corn stover** made into biofuel
- **Sugarcane** – juice is removed for sugar, leaving the cane, when burned releases heat
- **Sawdust** can be burned, releasing heat
- **Dried chicken manure** can be burned, releasing heat
- **Residential garbage** can be burned, releasing heat
- **Landfills** can produce methane gas
- **Pig manure** can be converted into methane gas

Teacher assign students to look up these alternative crops and report to class
Alternative crops can be grown, e.g. switchgrass, small woody plants, poplar trees
Soybean and canola made into biodiesel
Any stalks, leaves, and branches can be made into biofuel
Willow and poplar trees converted into biofuel

6b. What are some conversion factors for agricultural crops being made into biofuels?
Soybeans – one bushel (60 pounds) yields about 11 pounds of soybean oil, making 1.5 US gallons of biodiesel
Corn – one bushel (56 pounds) yields about 2.5 US gallons of ethanol

Corn stover – one ton (2000 pounds) will yield about 80-90 US gallons of ethanol

Students research switchgrass
Switchgrass – one ton (2000 pounds) will yield about 75-100 US gallons of ethanol

7a. What is the value or importance of biomass as a source of fuel (energy)?
http://www.nrel.gov/docs/fy00osti/27939.pdf
http://www.eere.energy.gov/biomass/biomass_benefits.html
Reduce use of nonrewable fuels, such as oil, gas, coal, and uranium, especially for electricity
Biomass fuel is part of a cycle, can be used over and over. They are renewable.
Reduce the need for landfills or space for landfills
Uses a source of energy that is now for the most part wasted
Source of energy in rural areas of the world
http://www.nrel.gov/docs/fy03osti/33257.pdf
http://www.nrel.gov/docs/fy00osti/28024.pdf
Ethanol industry currently **employs 200,000**
About **$2 billion a year is saved** on oil imports
Ethanol as a fuel additive **boosts** octane
Biofuels, when blended with conventional fuels, **reduce** air pollutant emissions such as sulfur, carbon monoxide, and hydrocarbons
Biofuels are **less toxic** in spills or leaks since they rapidly biodegrade
http://www.eere.energy.gov/biomass

Burning one gallon of biofuel versus one gallon of gasoline or diesel fuel **saves 20** pounds of carbon dioxide emissions into the atmosphere
Growing perennial energy crops in place of surplus annual crops can **reduce soil erosion and compaction**
There is some indication that perennial crops will help **increase levels** of soil carbon
Biomass fuels account for about **8 percent** of the energy produced and about **6 percent** of the energy consumed in the U. Use of biomass fuels **reduces** use of fossil fuels, which should help **reduce global warming**
http://www.eere.energy.gov/biomass

7b. Where is the nearest biofuel plant to us?
Teacher assigns students to find the nearest biofuel plant

7c. What are examples of products that can be made from biomass?
Products produced from biomass is called **bioproducts. 12.4 billion pounds** of bioproducts are produced each year Examples of products produced are:

- plastics
- solvents

- paints
- adhesives
- drugs
- lubricants
- inks
- resins
- ethanol
- cellulose
- citric acid
- all proteins

Summary
Teachers are encouraged to summarize at the end of each day's lesson. The emphasis should be on the content covered for each enabling objective.

Plans for Application
1. If the school is located near a biomass fuel conversion plant, the teacher should consider taking the class on a field trip to the plant.
2. Invite a biomass expert to class to explain the process and how the local farmers might now or in the future consider growing crops for biofuel production.
3. Suggest students go to web sites that report and summarize biomass projects, e.g. willow trees, corn stover, etc. Prepare a report for class.
4. A possible topic for public speaking assignments, the future of biomass for biofuels.
5. Assign students with production enterprises to convert (using the conversion information) what they produce into biofuel production output.

Evaluation
Using the enabling objectives for the lesson, develop quizzes and tests that will measure the content learned.

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