Biofuel Utilization

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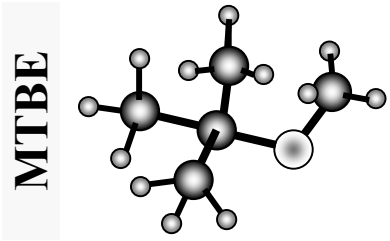
Middle School/Unit of Study

Technology Description

During the course of the last decade biofuels in the form of blended gasoline (Gasohol), and biodiesel have begun to find a place in our energy economy. While better emissions and air quality was the driving force for their use, biomass derived biofuels will be required to offset the loss of dwindling petroleum reserves in the near future.

Since the middle of the 19th century, our nation has primarily invested in coal and petroleum to the extent that we now consume 25% of these nonrenewable resources while only having 2% of the world population. Our ability to adapt to diminishing fossil fuel resources is critical to our survival as a nation.



Oil and coal are major contributors to the pollution problems faced by many of our nation's cities. Smog, acid rain, and airborne particulates can all be traced to some degree to emissions from our cars, trucks, power plants, and factories. Add to that the potential threat of global warming from accumulations of heat trapping carbon dioxide released from 200 million years of captivity and its obvious we need new alternatives for fueling our transportation system.

Biofuels have the potential to offer an attractive alternative since they originate from sources that utilize *existing* carbon dioxide to create the new fuel source. This results in a zero sum gain since the carbon dioxide returns to the atmosphere when the fuel is burned.

The challenge for biomass technology is to find a biomass raw material that has a high energy content which can be transformed to a usable fuel for as low an energy input cost as possible. Hydrogen, Methanol, and Ethanol can all be produced using biomass technologies. Growth rate, processing time, agricultural costs, etc. all have to be considered when selecting a candidate material for use as a biomass fuel. Previous societies failed to heed these factors and were faced with the loss of biomass resources.

Excess removal of wood products (deforestation) for use as fuel for heating and cooking has resulted in soil erosion and loss of habitat. Proper harvesting and regrowth practices are essential if the potential of biomass as a renewable energy source is going to be realized.

The easiest way to understand the processes involved in biomass becoming a biofuel is to imagine the

warmth and glow of a log burning. Today's research focuses on how to release that energy more efficiently and with fewer emissions. Biofuels offer great versatility. They can extend the utility of conventional fuels, such as blends of gasoline and diesel fuel. Gasification of wood chips from forest thinning projects can supply both heat and electricity. Biofuels can take the form of a biogas that is created from the same kind of bacteria that allows cows to digest grass.

Dave Mussell

Two common sources of biogas!

The above cartoon illustrates that humans also generate biogas. Sometimes what we eat results in some unpleasant biogas experiences.

Good sources of general information on biofuels utilization include:

http://www.veggievan.org/

http://www.eere.energy.gov/RE/bioenergy.html

http://www.need.org/needpdf/BIOMASSSecondary.pdf

Questions to Consider:

1. Why are biofuels potentially a more environmentally friendly source of energy when compared to fossil fuels?
2. In the late 1980's chemicals called oxygenates were added to gasoline to create blended fuel which burned cleaner and helped reduce air pollution in large urban areas. In the last ten years controversy has arisen over use of one oxygenate in particular – MTBE. How has solving one environmental problem created another?
3. Suppose you and your friends were stranded on an island thousands of miles away from the nearest cell phone tower. You have limited biomass resources. Investigate what happened to the people of Rapa Nui and explain how you would do things differently.
4. An average coal or nuclear power plant in the United States produces 1000 MW (Megawatts) of electrical power. By the year 2030, the United States will require 900,000 MW of power. It is estimated that biofuels will be capable of providing 100,000 MW of power. What percentage of power will be provided by biofuels?

Check out these sites:
http://www.netaxs.com/~trance/rapanui.html
http://www.energyquest.ca.gov/
http://www.mtbepollution.com/About_MTBE/default.htm

Project Ideas

1 Can nuts be used as a fuel source?

Learning Objective: Is the oil content in commercial nut varieties sufficient to develop an agricultural industry based on harvesting nuts as a fuel source?

Controls and Variables: Variety of nut, heat loss to environment, distance of nut to object to heat.

Materials and Equipment: Soft drink can, large paper clips, balance (0.01g accuracy), 100 ml graduate cylinder, mixed nuts, and water. If possible use temperature probe and data logger/calculator setup such as Texas Instruments, TI-83+ and CBL for data collection. Otherwise thermometer and stopwatch will be adequate.

Safety and Environmental Requirements: …….

Suggestions: Bend paper clip to act as a support to hold nut you will burn. Measure rate of temperature rise of water per gram of burning nut material. Soda can is inexpensive vessel to hold water being heated.

Other Ideas: Compare published energy content for nut variety to experimental results. Comparison of fuel efficiency of nut varieties to other fuel sources such as paraffin and kerosene.

2 Can biodiesel reduce pollution?

Learning Objective: Compare the emissions of diesel fuel to pure biodiesel and 20% biodiesel blend to validate pollution reduction.

Controls and Variables: Type and concentration of biodiesel, emission capture system, combustion chamber

Materials and Equipment: Plastic bag (1 gallon), small alcohol burner, glass funnel, plastic tubing, beaker, two-hole stopper, glass tubing, triangular file, good imagination, Calculator/Data logger combination, CO_2 sensor (www.vernier.com)

Safety and Environmental Requirements: …

Suggestions: Need to develop method for measuring combustion product quantitatively. Carbon Dioxide can be measured with sensor (Rate of production?) or color change of indicator as carbonic acid forms in water.

Other Ideas: Develop a way of measuring particulate emissions using filter paper.

3 Can a model Stirling engine be powered by biodiesel?

Learning Objective: Develop a small working model of a car (similar to a mouse-trap) car powered by a Stirling engine and biodiesel as a fuel source. Compare the performance of your car using different biomass fuel alternatives.

Controls and Variables: …

Materials and Equipment: …

Safety and Environmental Requirements: As with all experiments with open flames and solvents, work in an appropriate area (fume hood or outdoors) and never leave a flame unattended.

Suggestions: …

More Project Ideas

Compare energy and soot formation of methyl esters of animals with methanol.

Compare the benefits of various alternative fuels (emissions, cost. Performance)

What is the effect of size on the burning rate of wood?

Can a gasoline engine be modified to run on methane? How efficiently?

Do coal-wood or coal-RDF (refuse-derived fuels) pellets burn cleaner than coal alone?

For the Teacher

The ideas and concepts discussed in this unit, **Biofuel Utilization**, not only lend themselves to excellent science fair projects but also can be adapted to mathematics, and social studies lessons when used to introduce students to environmental issues concerning limited resources. The Rapa Nui investigation suggested in question 3 at the end of the "Technology Description" section will dramatically illustrate what can happen to a society that is careless in handling its natural resources.

It is important for you as the teacher to emphasize to your students that use of biomass for energy production is much more than burning wood. Critics of biomass like to view it as just another word for incineration and this is very misleading. Having your students research waste water treatment or visiting a waste water treatment plant in your area will demonstrate how biomass is used to not only treat wastewater in the secondary treatment process, but also produce enough natural gas to heat and operate the sewage treatment plant!

Another area of biomass energy research that has stirred a great deal of interest is the production of biodiesel fuels, which can be produced from waste cooking oils. An EPA study of combustion products of pure biodiesel (B100) and a 20% blend of biodiesel (B20) with regular diesel fuel reduced

visible smoke and odor and toxic emissions as shown in following table. The elevated combustion temperature because of the cleaner burning does result in a slight increase in NO_x emissions. Biodiesel also reduces the amount of sulfur emissions.

Emission	B100*	B20*
Carbon Monoxide	-47%*	-12%*
Hydrocarbons	-67%*	-20%*
Particulates	-48%*	-12%*
Nitrogen oxides	+10%*	+2%*
Air Toxics	-60%-90%	-12%-20%

**Environmental Protection Agency Draft Technical Report EPA420-P-02-001 (2002)"A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions*

B100 and B20 refer to the biodiesel content of the fuel, 100% biodiesel and 20% biodiesel respectively.

The National Renewable Energy Laboratory (NREL) is actively involved in basic research and development with various industrial partners to find cost-effective technology for producing liquid transportation fuels from biomass materials. In addition, gas production using anaerobic processes and pyrolysis technologies are being investigated.

Gasifier technology produces an extremely clean combustible gas using a wide variety of woody fuels that otherwise would not have commercial value. Both electricity and heat are produced for small communities in remote areas lacking access to on-grid electricity. More information about this new biomass technology can be found at www.gocpc.com.

Recent breakthroughs in low cost catalysts for hydrogen production from biomass may result in helping the world make the transition from a fossil fuel to hydrogen based economy. For more info see: www.news.wisc.edu/view.html?get=8740

Relevant Curriculum Standards

CONTENT STANDARD A:
As a result of activities in grades 5-8, all students should develop

* Abilities necessary to do scientific inquiry
  - Understandings about scientific inquiry

CONTENT STANDARD E:
As a result of activities in grades 5-8, all students should develop

* Abilities of technological design
* Understandings about science and technology

CONTENT STANDARD F:
As a result of activities in grades 5-8, all students should develop understanding of

* Personal health
* Populations, resources, and environments
* Natural hazards

* Risks and benefits
    - Science and technology in society

CONTENT STANDARD G:
As a result of activities in grades 5-8, all students should develop understanding of

* Science as a human endeavor
* Nature of science
    - History of science

Unifying Concepts and Processes

STANDARD: As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:

* Systems, order, and organization
* Evidence, models, and explanation
* Constancy, change, and measurement
* Evolution and equilibrium
* Form and function

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