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ABSTRACT

This teaching unit develops the possibility of using biomass as an alternative source of energy. The concept of biomass is explained and the processes associated with its conversion to energy are stated. Suggestions for development of biomass technology in different geographic areas are indicated. Lessons for 6 days are presented for use with eighth or ninth grade science students. Each day's lessons include: (1) student objectives; (2) list of materials needed; (3) methods; and (4) activity descriptions. To accommodate the need for seedlings in the unit's experiments, it is recommended that this class be taught in the spring and after coursework on seed germination. Student activity and information sheets are also included. (ML)

ED258816

ENERGY WORKSHOP

Dr. Arie Halachmi, Director

BIOMASS: AN ALTERNATIVE SOURCE OF ENERGY FOR EIGHTH OR NINTH GRADE SCIENCE

By

Lillie Heyward

Marye Murff

Teaching Unit

Energy Workshop

Tennessee State University

November 1982

SE 045 812

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U.S. Dept. of ENERGY

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INTRODUCTION

The subject of biomass as an alternate source of energy is very new. All of our information was found in current Science magazines and government publications from which we have paraphrased a great deal.

However, my partner and I after hearing about biomass in an Energy Workshop at TSU, thought it was a fascinating subject--it did something to our imagination! It was easy and pleasant to imagine how the future might be with less air, water, and land pollution by burning less fossil fuels. And to add to that, the hauling of trash and garbage to a thermo-chemical plant instead of a landfill, to produce energy.

It all sounds like an answer to a lot of our environmental problems. So we felt obligated to pursue further in hopes that biomass, an alternate source of energy, will become an important part of studies about energy resource.

BIOMASS: AN ALTERNATIVE SOURCE OF ENERGY

In the year two thousand and fifty, fossil fuels will be very scarce. Other or alternate energy sources will be important.

Perhaps by then scientists will have perfected the use of an alternate source of energy called biomass.

Biomass is a form of solar energy. It is stored in a wide variety of plant and animal organic matter. The process in the creation of biomass is photosynthesis. Photosynthesis uses sunlight to convert carbon dioxide and water into higher energy products such as carbohydrates and oxygen. Forest materials and residues, grains, crops, animal manures and aquatic plants are the main resources.

Basically, there are two kinds of processes by which biomass can be converted to energy: thermo-chemical conversion and biological conversion. The first uses heat to produce a chemical reaction, like the burning of wood. Other thermo-chemical techniques include gasification, which releases bio-energy by heating waste in a limited amount of oxygen, and pyrolysis, which breaks down biomass with heat, but without oxygen and at a lower temperature than is required for gasification.

Biological conversion is a chemical reaction caused by treating biomass with enzymes, fungi or microorganisms. Two processes which produce either liquid or solid fuels include anaerobic digestion, the controlled decay of organic material in the absence of oxygen, and fermentation, by which carbo-

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hydrates are fermented and distilled to produce ethyl alcohol (ethanol). Ethanol mixed with gasoline produces gasohol.

Biomass is a great source of energy because in some form or another, everybody has some. The production of energy from biomass does not pollute the air, water, or land. The residue can easily be disposed of as a fertilizer, animal food, or "filler" for road beds. Or if it has to be carried to a landfill, it will occupy a very small space and will be sterile causing no contamination.

So let me tell you how biomass could possibly be used in the year two thousand and fifty.

In large cities trucks labeled "Biomass" will be picking up municipal waste--trash and garbage from residences and industry, to carry to a thermo-chemical conversion plant. The burning of this trash will produce oil, charcoal, synthetic gas and steam. The steam is used to produce electricity or to heat nearby buildings.

Smaller towns and/or counties where the population is not so dense, have grouped together to dispose of their waste by taking it to a centrally located thermo-chemical plant.

In some of the more rural areas we may find energy farms. Farmers growing grains, sugar beets, sugar cane, soybeans or a crop of sycamore or eucalyptus trees to be processed to make ethanol.

Or the farmer may be energy self-sufficient by using animal manure in a process called anaerobic digestion to produce methane gas.

On the vast stretches of arid lands in Arizona, New Mexico, and Nevada, the desert is blooming with gopher plants (Euphorbia lathyris). The federal government is growing one hundred million acres of gopher plants. The same plant the California gardener used to call obnoxious. In the middle of this area is a refinery producing crude oil.

Around Walt Disney World, near Orlando, Florida, water hyacinths may be growing in the sewage reservoir. The hyacinths not only purify the water but can be harvested and mixed with bacteria to produce methane.

Also on the West Coast giant kelp could be grown in oceanic farms several miles off shore. After the kelp is harvested it is processed in much the same way as the water hyacinths.

In Canada there may be acres and acres of salt water tanks where microbes work in tandem to make oil out of atmospheric carbon dioxide. One square mile of tanks full of salt water and bacteria could produce twelve million barrels of oil a year.

By far the most ambitious biomass programs were planned by Brazil, Red China, and Sweden.

Brazil may have several large distilleries to produce alcohol from cassava, wood, and sugar cane grown on energy farms or plantations.

Red China has a program of providing small scale units on individual farms for producing methane. The methane produced is used at the farmstead.

Sweden may be producing more than sixty percent of its energy from biomass. Forty-five percent of this is from energy farms of willow trees. Only six to seven percent of the total land of Sweden is devoted to the willow plantations.

Back home in the United States the most important biomass fuel is alcohol--ethanol and methanol. The use of alcohol as a motor fuel dates back to the 1880's when some of the first cars ran entirely on alcohol.

And that is what they use in the cars at Indianapolis 500!

The primary goal of the Department of Energy (D.O.E.) and Biomass Energy Systems (B.E.S.) has been to supplement fossil fuel resources through the growth, harvest, and use of plant and animal residues. The national program for biomass research and development, directed by BES has further advanced the application of technologies. The large resource potential of agricultural and forest residues and other organic waste should encourage the commercialization of biomass technologies to continue.

Biomass is readily available in many waste materials and the supply could be greatly increased by proper management and the use of such techniques as energy farms.

However, there is an argument against "plant for energy" farming in that the land might be needed for [illegible] of the Unit[illegible]

It does not seem necessary for energy farms to be located in the middle of America's bread basket. There are arid and/or unproductive lands that c[illegible] planted for biomass, and not compete with food farming.

Little is known about the long-term effects of large scale single crop farming as it might be done in energy farming. One-crop farming might encourage epidemics of disease or insects.

For the present, bioconversion of agricultural crops remain an interesting and exciting alternate for fossil fuels. Biomass is not only a clean and safe fuel source, but also a renewable and literally inexhaustible one.

As educators we can help students as future citizens be aware of the advantages and disadvantages of biomass as a source of energy. Who knows--one of them might be the one to research, legislate, farm, or perhaps even use biomass as an alternate source of energy in the year two thousand and fifty!

BIBLIOGRAPHY

1. "Benefits of Wood Biomass Make Cultivation Essential" by Paul Heilman. Forest Scientist, Washington University, Puyallup, WA. Weeds, Trees and Turf. February, 1981.

The Division of Forestry sent me some material upon request. There is in-depth discussion of various ways of using trees as a source of energy.

2. Biomass Energy. DOE/CS0202. November, 1980. U.S. Dept. of Energy Technical Information Center, Box 62, Oak Ridge, TN 37830.

This is the pamphlet suggested to be used by students as a study sheet. It is brief, but covers biomass from history to future outlook.

3. "Energy Farmers: Growing Tomorrow's Fuel" by Peter Ognihene. Science Digest. August, 1981, pages 98-100.

This is a very exciting story about all of the possible sources of oil from plants. Melvin Calvin is America's foremost advocate of energy farms.

4. Energy From Biological Processes. Office of Technology Assessment, Washington, DC 20510.

This summary presents the findings of an assessment of the energy potential of biomass. It was requested by the Senate Committee on Commerce, Science and Transportation.

5. Facts About Gasohol. Solar Energy Research Institute, 1617 Cole Boulevard, Golden CO 80401.

This is questions and answers about gasohol produced from biomass. There are questions about production, cost, regulations, automobile use, and extent of use today.

6. Supplementary Energy Sources. American Petroleum Institute, 2101 L. Street, Northwest, Washington, DC 20037.

A very readable source concerning the efforts of companies to find new energy sources. This would cut the importing of so much oil.

7. "Synthetic Fuels and Renewable Energy". Two Energy Futures: A National Choice for the Eighties. American Petroleum Institute, 2101 L. Street, Northwest, Washington, DC 20037.

8. Biomass I. January, 1981, by Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37830, under Contract No. DE-AC05-760R00033.

This is a packet containing several hands-on activities related to biomass studies. The activites are simple, directions are clear, and materials are inexpensive.

9. Film Solar Energy: The Great Adventure, 16mm, color, 27 min., 1979, No. 534, by United States Dept. of Energy, DOE Film Library, P.O. Box 62, Oak Ridge, TN 37830.

A lively and unique look at American "grassroots" ingenuity. In the next century we will be turning to renewable sources of energy. Eddie Albert narrates (615) 576-1285/1286/1287.

The best time to teach this lesson would be in the spring after you have taught about seed germination. You will be able to use available seedlings in experiments on day 5.

If you do not plan to teach this after a lesson in seed germination, you will need to plant seeds 3 to 4 weeks before this lesson to have available seedlings for day 5.

Day 1--Objectives: Students will: (1) realize the need for alternative energy resources.
(2) learn about the major primary energy sources.
(3) become familiar with the history of energy.

Materials: vocabulary word list, world map with Tennessee outlined with magic marker, map pins, five lengths of different color yarns, energy time-line worksheet, specify 5 types of energy.

Methods:
1. Teacher asks questions to see if students know where our energy sources are located.
2. Use world map to show geographical location of sources.
3. Place yarn from primary energy sources to your home town. Examples: uranium--Australia, natural gas--Texas, oil--Saudi Arabia, coal--Kentucky.
4. Discuss energy timeline worksheet.
5. Establish the need for conserving and finding new sources of energy.
6. Suggest biomass as an alternative to our energy supply.

Activity: After teacher's discussion of energy time-line, have students complete the worksheets.

Finish the Energy Timeline

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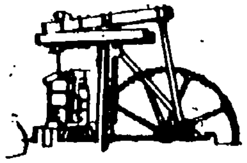
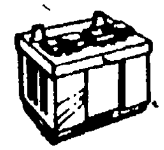
1780 1785 1790 1795



1776
In England James Watt puts two engines to work in factories & starts an energy revolution. The energy is steam

1783
Two men fly in a balloon at Paris, France
The energy used is hot air

Most people burn wood for heating and cooking and travel by horse or on foot.



1800
In Italy, Volta invents the battery and gives his name to the volt. The energy produced is electricity

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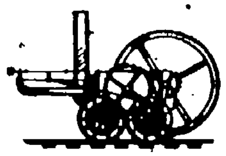
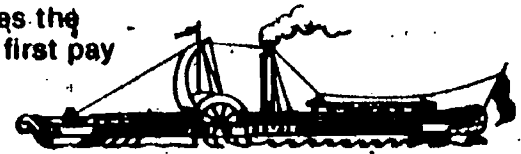
1800 1805 1810 1815 1820 1825



1804
An Englishman, Richard Trevithick, puts James Watt's engine on wheels and rails. He is the father of the railroad locomotive.

1807
Robert Fulton doesn't build the very first steamboat, but he makes the one people first pay to ride on.



Wood continues to supply most household energy needs. But coal begins to do more in factories and railroad engines.

1821
First attempt to develop and market natural gas near Fredonia, N.Y.

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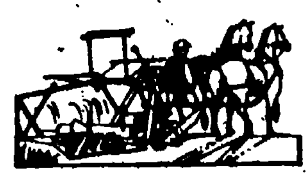
1830 1835 1840 1845

1829 An American named Joseph Henry and an Englishman named Michael Faraday each invents a generator. Who is first? Henry
The energy produced? electricity

1837 Americans put new inventions to work. First comes McCormick's reaper, then the steam shovel by Otis, and the telegraph by Morse



Railroads expand rapidly, hauling freight and passengers brave enough to stand the jolts and to risk hot cinders that often fly from the engine into their cars. England is first and America second in railroad locomotive production.

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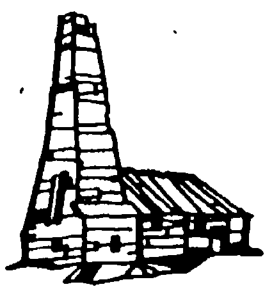
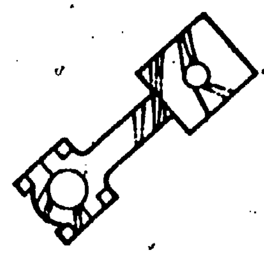
1850 1855 1860 1865 1870 1875

1859
Edwin Drake strikes oil in Pennsylvania beginning the petroleum industry.



1860
Lenoir of France invents the internal combustion engine.



An explosion inside a cylinder paves the way for the later invention of the automobile. An oil strike hastens the discovery of the fuel that will run it.

cut

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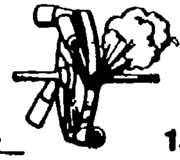
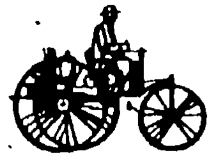
1880 1885 1890 1895

Coal and wood still furnish most of the energy in homes. Coal-fired "iron horses" (railroads) — and real horses — continue to take most people places. Although the electric bulb has been invented most people still use kerosene or gaslights to read by.

1884 In England, Charles Parsons perfects the steam *turbine* and advances the development of electrical energy.





1886 Karl *Benz* builds the 1st successful automobile.

1892 The oil-burning engine is invented by *Rudolf Diesel*. Eventually, this engine will replace steam-powered ones.

1895 The power of Niagara Fall is harnessed to make *electricity*

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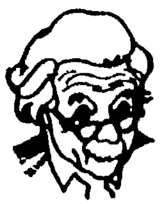
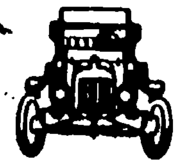
1900 1905 1910 1915 1920 1925

1903 The engine in the Wright brothers' plane is powered by *gasoline*



1905 Albert Einstein develops a theory for measuring energy and prepares the way for the *atomic* age.



1910 Ford makes the first Model *T* car.

By the end of this period, many new homes have coal furnaces in the basement. And more and more cars appear in garages.

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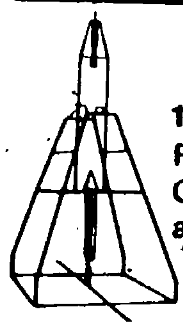
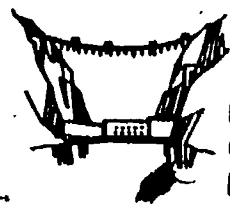
1930 1935 1940 1945

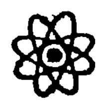


1926 Robert Goddard tests a *rocket*



1936 Hoover Dam on the Colorado River is built to generate *hydroelectric* power.

1940 *Nylon*, a fiber made from oil, coal, and water makes its first public appearance.



1942 In Chicago, Enrico Fermi sets off the first *nuclear* chain reaction.

Many homes convert from coal to natural gas for heating. Most families own at least one car and some have two.

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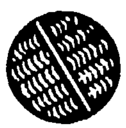
1950 1955 1960 1965 1970 1980

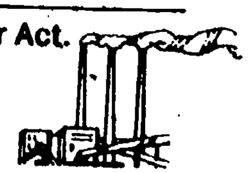
1952 Bell scientists raise hope for our energy future with the *solar* battery.



1957 The U.S. gets its first big *nuclear* electric power plant at Shippingport, Pa.

Demands for energy grow. America gets more people, more homes, more factories and businesses, more cars, more trucks, more buses, more planes. Demand grows faster than supply.

1970 Congress passes the *Clean* Air Act.



1973 OPEC nations *embargo* oil and produce an energy crisis.

1980 Americans continue to look for ways to *conserve* the energy we have and find new *energy* sources.

cut

KEEP GOING

1. Get a large map of the world.
2. Locate your town with a map pin or flag.
3. Outline Tennessee with a magic marker.
4. Learn the sources of various fuels such as crude oil from Saudi Arabia, coal from Pennsylvania, natural gas from Texas, uranium from Australia, etc. Make a color code such as black for coal, red for oil, blue for natural gas, green for wood, etc. Connect the source of the fuel to your town with a length of colored yarn to demonstrate the distance the source must travel for your use.

KEEP THINKING

Are the countries from which we get our fuel supplies our allies? Are they dependent on us in any way? How much of our fuel supplies come from these sources?

See if you can devise methods to release the energy. Which gives the most heat? Guess which is most efficient.

UNDERLINED WORDS are in your glossary.

AVAILABLE

For other activities in chemical energy, use Coupon #8.

MATERIALS

Pencils, slips of paper, sack or small box.

METHOD

1. Let each student pick an energy subject, such as conservation, solar power, wind, etc., and write it on a slip of paper.
2. Put all papers into the sack or box and shake.
3. Call on students to take a slip from the "grab bag" and talk for one minute on the subject.

Be sure to have a timekeeper.

At the end, judge the best speaker from among those who talked the full minute.

An award might be in order.

AVAILABLE

For other energy awareness games and simulations, use Coupons

Biomass Vocabulary Wordlist

1. Alcohol--a colorless, volatile, flammable liquid; formula C_2H_5OH.
2. Biological conversion--a chemical reaction caused by treating biomass with enzymes, fungi, or microorganisms.
3. Biomass--any material derived from living organisms, including everything from manure to trees to algae.
4. Deforestation--to clear a forest of trees.
5. Ecosystem--a system formed by the interaction of a community of organisms with their environment.
6. Energy--the capacity to do work; available power.
7. Erosion--the process in which the surface of the earth is worn away by the action of water, glaciers, wind, waves, etc.
8. Ethane--a colorless, ordorless, flammable gas.
9. Feed stock--raw material supplied to a machine or processing plant (as pulpwood to paper mill).
10. Gasohol--liquid fuel made up of 90% gasoline and 10% alcohol.
11. Manure--animal waste that can be used as a fertilizer for soil.
12. Methane--a light hydrocarbon; an inflammable natural gas; forms explosive mixtures with air.
13. Microbes--organisms that cannot be seen without the use of magnifying lenses.
14. Organic--materials obtained from living things.
15. Organism--any living thing.
16. Photosynthesis--the process by which green plants convert radiant energy (sunlight) into chemical energy.
17. Renewable--capable of making again; restore state of being. Replenished.
18. Solar energy--source of energy from the sun.

Day 2--Objective: Students will learn what biomass is. They will be able to see and touch samples of biomass.

Materials: Samples of biomass--wood chips, sugar cane, soybean seeds, grass, sunflower seeds, etc. Film.

Methods:

1. Give students 10 minutes to extend the energy time line to the year 2025 (encourage creativity).
2. Ask questions about biomass.
   (a) Have you ever used biomass?
   (b) What is biomass?
   (c) Is biomass a renewable resource?
   (d) What are some examples of biomass?
3. Show film, "Solar Energy: The Great Adventure".
4. Discuss film.
5. Present samples of biomass.

Activity: Have students identify the samples of biomass and tell how they may be used to produce energy.

Day 3--Objective: Students will obtain detailed information on the history of biomass. They will see how biomass is produced, used, and can be used in the future.

Materials: Worksheet on biomass. Biomass Energy.

Methods:

1. Review vocabulary words used in previous lessons.
2. Have students name biomass resources.
3. Distribute article and worksheet on biomass energy.
4. Give students time to read silently and answer on worksheet the first ten questions.
5. Discuss the first ten questions on worksheet.
6. Assign the last ten questions for homework. Have students put article and worksheets away.
7. Prepare class for outdoor activity.
   (a) Identify area where you and your students can collect local weeds. (Clear with principal first.)
   (b) Discuss the need for safety with tools.
   (c) Divide class into groups.
   (d) Discuss procedure for collecting specimen.
   (e) Discuss measuring techniques.

Note: Ask agriculture teacher to provide class tools.

BIOMASS ENERGY

Biomass is a form of solar energy stored in a wide variety of plant and animal organic matter. The key process in the creation of biomass, photosynthesis, uses sunlight to convert carbon dioxide and water into higher energy products such as carbohydrates and oxygen. Forest materials and residues, grains, crops, animal manures, and aquatic plants are the principal resources of biomass. These raw materials can be transformed into liquid or gaseous fuels and petrochemical substitutes, as well as heat, electricity, and steam. Biomass products have numerous industrial applications and residential uses. The primary objective of the Department of Energy (DOE) Biomass Energy Systems (BES) Division is to supplement fossil fuel resources through the growth, harvest, and use of plant and animal residues.

Biomass has important energy supply potential because of its extensive and well-located resources in the United States, the potential of conversion technologies, and the availability of a strong commercial market. Biomass is already providing approximately two percent of our energy needs, primarily by the direct combustion of wood. The forest products, and pulp and paper industries are major biomass consumers. They are working toward 100 percent energy selfsufficiency in the near future by using manufacturing and forest residues for production processes.

Annual biomass production goals for the year 2000 are about 7 quads of energy. One quad, or quadrillion Btu's, is equivalent to approximately 494,000 barrels of oil per day for one year, or enough energy to heat 500,000 homes for 20 years.

History

Biomass is the oldest source of energy known. For thousands of years, people have burned wood for both heat and protection. Until the mid 19th century, wood accounted for about 90 percent of the energy supply in the United States. In 1940, 20 percent of U.S. homes still used wood for space heating.

Although fossil fuels replaced wood as the prime energy source in the 20th century, interest in biomass never completely faded. During the 1930s, several American studies investigated the

Conservation and Solar Energy
Department of Energy
Washington, D.C. 20585

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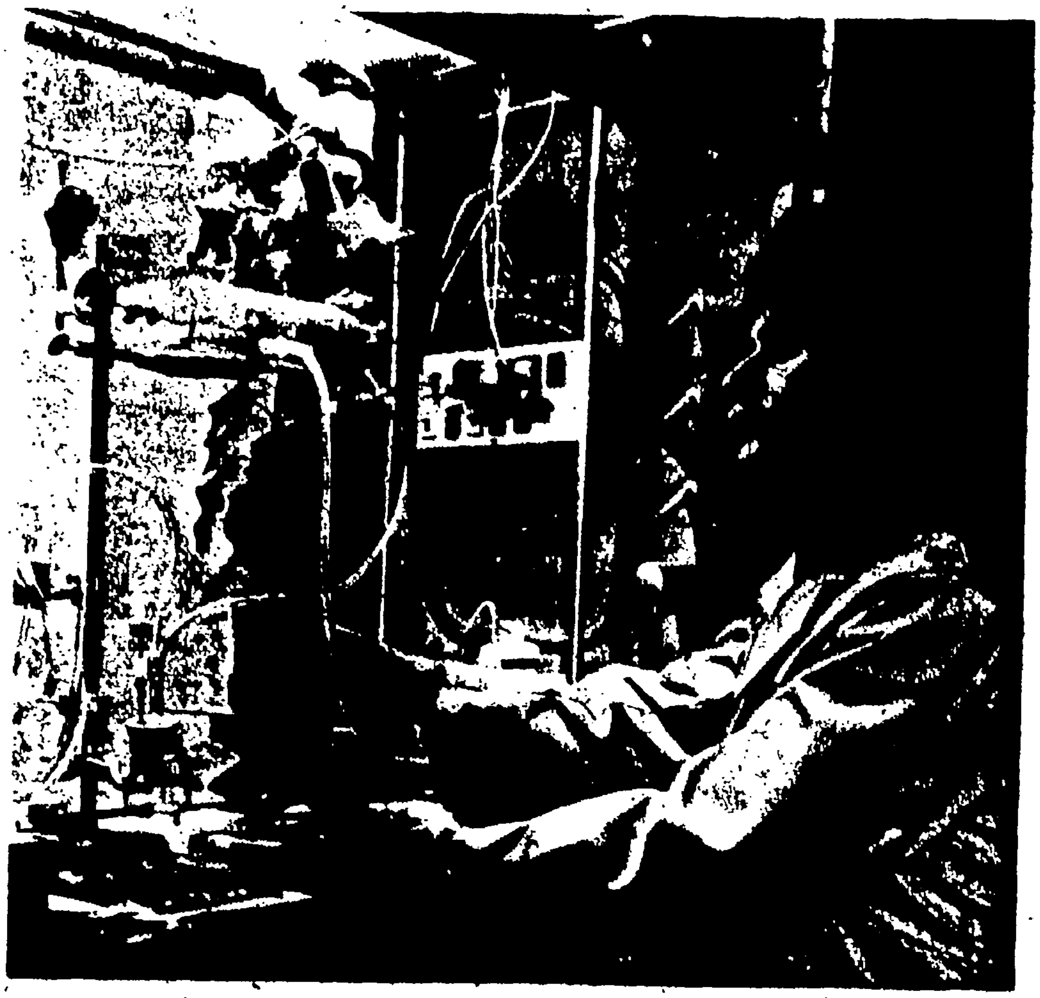
feasibility of converting grain to ethyl alcohol as a gasoline substitute. During World War II, many nations worked to develop the fuel potential of trees; Sweden, for example, cultivated large forest areas specifically for energy consumption and research. Today, private industry and government in the United States have renewed interest in biomass by researching conversion methods and encouraging the application of available technologies.



Photosynthesis research with hybrid poplars in Rhinelander, WI

Resources

Because biomass is 50 to 90 percent water, the most cost-effective way to utilize the organic matter is at or near its source. If converted into liquids or gases, however, it can be transported easily and economically. Because biomass is available in wooded areas, on farm land, and in water, conversion sites are located throughout the country.

Wood, of course, is a major biomass resource. It serves as a fuel in the form of logs or residues. Residues consist of excess forest growth, insect-infested and diseased trees, and mill remains. To improve wood fuel production, researchers are developing new tree varieties such as hybrid poplars which grow rapidly and are totally consumable. Silvichemicals such as turpentine and resin, and carbon-based compounds made from lignin and cellulose are other energy-related wood derivatives. These materials serve as feedstocks for the production of a variety of chemicals such as alcohol, aldehydes, ketones, ethylene, acids, and ammonia which can be used as petrochemical substitutes.

Non-woody plants such as herbs and grasses have a potential as cost-effective energy feedstocks. These plants have a high yield capacity and can grow in arid or marginal land with minimal management.

Crops are another popular biomass resource. Sugar beets, sugar cane, sweet sorghum, and grains such as corn and wheat are processed for their carbohydrate content to make ethanol (ethyl alcohol). Cellulosic materials found in herbaceous crops such as corn and rye are converted by liquefaction to fuel oil. Alcohol development is receiving special emphasis under the new DOE Office of Alcohol Fuels.

Animal manure is an excellent source of methane gas which can be manufactured by a process called anaerobic digestion. This fuel supplies farmers with the energy necessary to grow crops and raise livestock. It can be viewed as completing a biomass energy cycle whose goal is energy self-sufficiency on farms.

Kelp and algae are aquatic sources of biomass. Through a process called biophotolysis, blue-green algae produces hydrogen as a waste product. Kelp produces hydrogen gas through photoelectrolysis, a photochemical process which uses a catalyst to separate hydrogen and oxygen.

Conversion Techniques

Thermochemical

The direct combustion of wood is the most common biomass conversion method. The number of wood-burning stoves in homes has increased dramatically in the past few years, indicating a resurgence in the popularity of wood as a residential heating fuel. It is estimated, for example, that 40 percent of the homes in Maine use wood stoves. Wood can also supplement oil, natural gas, or solar energy heating systems. Nationwide, approximately five million American homes already have a working wood stove, and the practical potential exists for another 13 to 18 million homes.

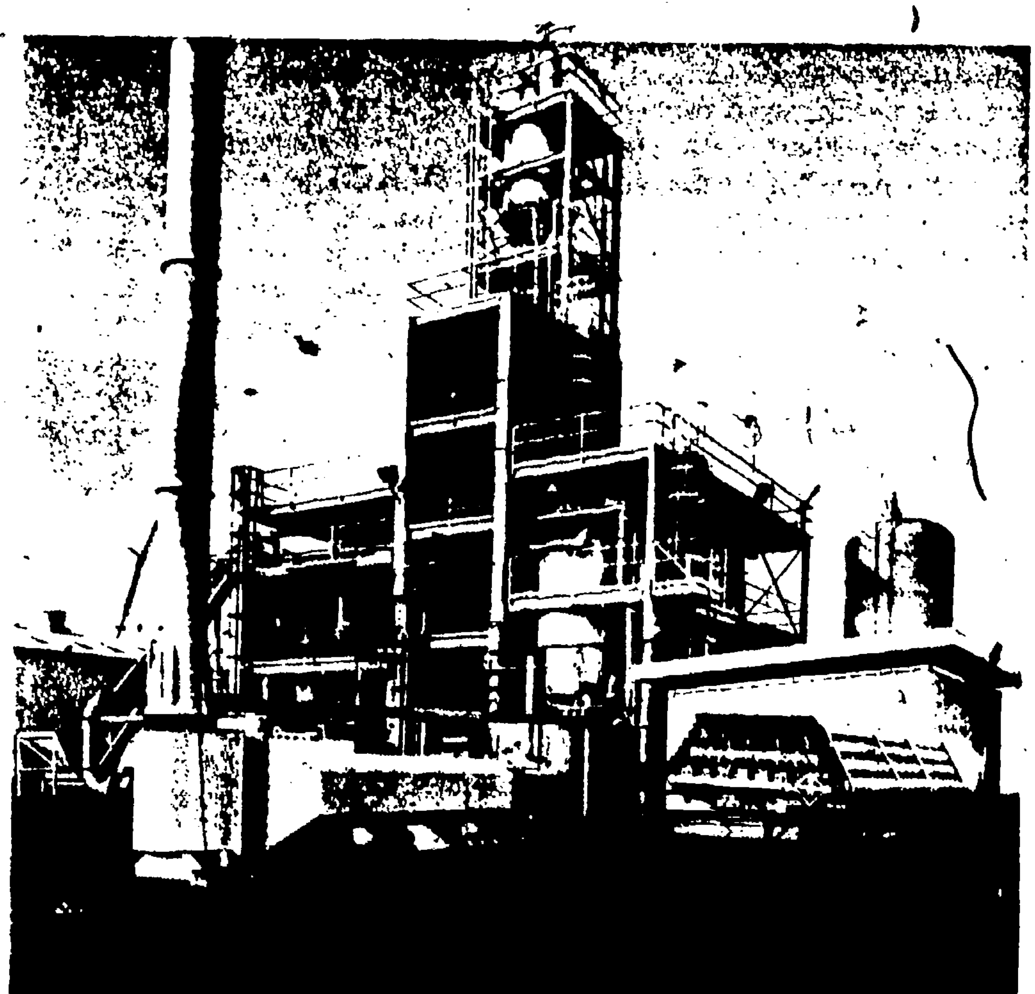
Direct combustion of biomass residues has industrial applications for the production of process heat or electricity. Currently, direct burning is economically competitive with fossil fuels for some industries, especially those having easy access to biomass resources. A sugar company in Hawaii meets 75 percent of its mill and irrigation pump electricity needs from the burning of bagasse, sugar cane residue.

Utility plants in Vermont and Oregon also produce electricity from direct combustion. Two 10 MW units in Burlington, Vermont are 100 percent wood burning. They serve 40,000 people and sell an additional 15 percent of their output to surrounding utilities. In Eugene, Oregon, a 33.8 MW utility plant has been producing steam and electric power since the 1930s by burning mill wastes supplied by local sawmills. In addition to proving very economical, this plant reduces air pollution and helps solve wood residue waste disposal problems.

Other direct combustion efforts include brick and textile industries in the South which burn sawdust and wood, respectively, to provide process heat. DOE is working with industry to evaluate wood conversion processes and to retrofit large conventionally-fueled process heat boilers for direct firing of green wood.

Gasification and liquefaction are two technologies which convert biomass into gas or liquid fuels. Gasification is the reaction of biomass with steam and oxygen at high temperature and pressure. The products include synthetic natural gas (methane), low and medium Btu gas, and hydrogen. DOE sponsors five process development units which perform catalytic and non-catalytic gasification processes. The units are located in Texas, Ohio, New York, Washington, and Missouri.

A large scale, experimental liquefaction facility in Albany, Oregon, uses wood chips to produce oil. Biomass reacts with carbon monoxide in the presence of an alkaline catalyst under moderate temperature and high pressure. The resulting oil product has a consistency similar to heavy heating oil and a heating value (15,000 Btu/lb.) similar to bunker



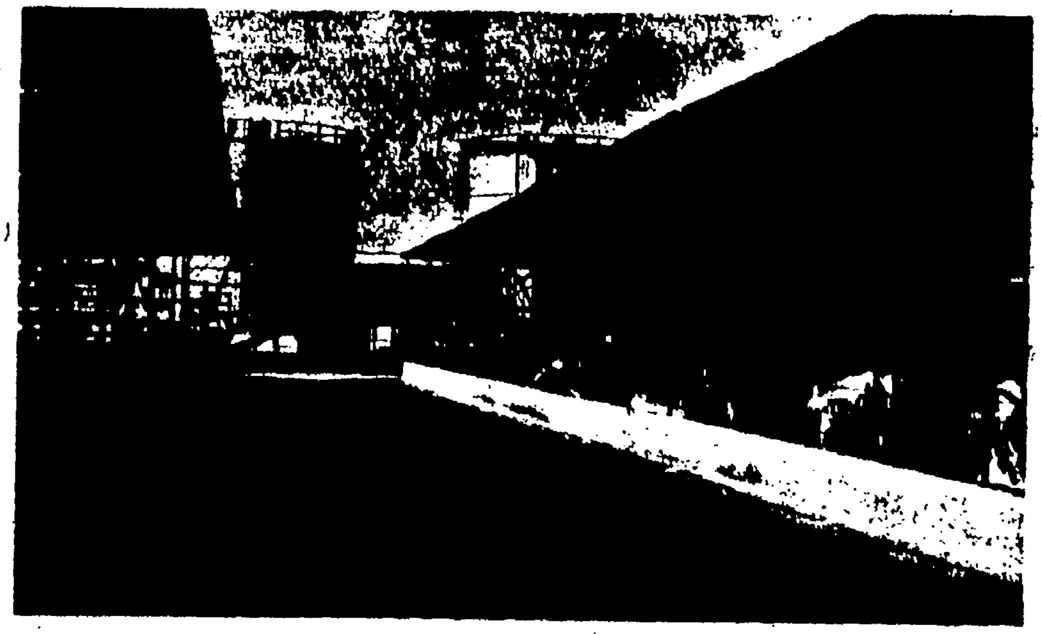
The experimental biomass liquefaction facility in Albany, OR fuel oil. The Albany facility has proven that liquefaction is an energy efficient process which produces non-polluting water, flue gases, and ash.

Pyrolysis is a thermochemical conversion process which functions without oxygen and at a lower temperature than gasification. Residue materials are gasified, ignited, and completely burned in a thermal reactor to produce gases. The biomass resources used in pyrolysis include manure, agricultural and wood wastes, and municipal solid wastes. Oil, charcoal, and synthetic gas as well as steam are the products.

Biochemical

Anaerobic digestion is the controlled decomposition of organic matter. In the absence of oxygen, bacteria decays the material, producing methane. The feasibility of using animal manure in this process is being tested at a full-scale facility in Bartow, Florida. Located in the state's largest slaughtering and packing plant, this facility can handle 25 tons of manure daily. By processing the wastes from 10,000 cattle, the operation can produce enough methane to meet nearly all of the packing plant's energy needs, the equivalent of 35 barrels of oil per day. A by-product of this process, protein-rich digester solids, will be concentrated to serve as a dietary supplement for 6,000 cattle. Anaerobic digestion also plays a large role in the production of energy from aquatic plants.

In addition to liquid and gaseous fuels, biochemical and thermochemical conversion systems produce petrochemical substitutes such as aldehydes, ketones, ethylene, acids, and ammonia. These chemical compounds are used in a wide variety of manufacturing processes.



The anaerobic digestion facility in Bartow, FL

Markets

Certain biomass conversion technologies, most notably direct combustion, anaerobic digestion, and gasification, are sufficiently advanced for near-term energy development. Direct combustion of wood is providing energy to the residential, industrial, and utility sectors. Anaerobic digestion of manure and agricultural wastes on farms is the first step in the attempt to make farmers energy self-sufficient. Low BTU gasifiers using wood as a feedstock are already in use by industry.

The national program for biomass research and development, directed by BES, will further advance the applications of these technologies. The large resource potential of agricultural and forest residues and other organic wastes should encourage the commercialization of biomass technologies.

Future Outlook

The BES Program is rapidly reaching its goal of providing a reliable alternative energy source. Although most near-term accomplishments have come in the areas of liquefaction, gasification and direct combustion, early advances are expected in anaerobic digestion, biophotolysis, and photoelectrolysis.

Energy farms are being used in herbaceous and silviculture research to grow terrestrial and aquatic plants throughout the country. Research management is performed at the 1000 acre silviculture test plantation established in Aiken, South Carolina, to investigate the forestry concept of short rotation. Consistent accomplishments in the development of all biomass technologies are expected to meet biomass goals for the year 2000.

Read the article Biomass Energy and answer the following questions correctly.

1. Define Biomass and Photosynthesis.

2. For thousands of years wood was the main source of energy. Name the energy source that replaced wood in the 20th century. ____________.

3. Which country cultivated large forest areas specifically for energy consumption and research? ____________.

4. Why is it most effective to use biomass near its source?

5. What is being done to improve wood fuel production?

6. Make a list of crops that can be used to make ethanol?

7. Can animal manure be used to produce energy? Explain.

8. Name two aquatic sources of biomass.

9. Name some chemicals produced from feedstock?

10. What is the objective of the research in biomass done by the Department of Energy?

11. What is the most common biomass method?

12. Give an example of direct combustion used in industry.

13. Approximately how many homes in America use wood stoves?

14. Name two states that produce electricity from direct combustion. ____________ and ____________.

15. Write the definition for gasification.

16. Write the definition for liquefication.

17. Write the definition for pryolysis.

18. Write the definition for anaerobic digestion.

19. How does the slaughtering and packing plant in Bartow, Florida, use cattle manure in anaerobic digestion?

20. Name three biomass conversion technologies that are near term energy development?

21. Name the department of government represented by the letters DOE.

Day 4--Objective: Students will draw a conclusion about biomass source of energy produced from weed.

Materials: meter sticks (one for each group), area of weed, hoes, shovels, bags, balance scale, activity sheet (bibliography 8), 5 lb. (metal) coffee can, thermometer, 500 Ml. beaker, asbestos wire.

Methods:

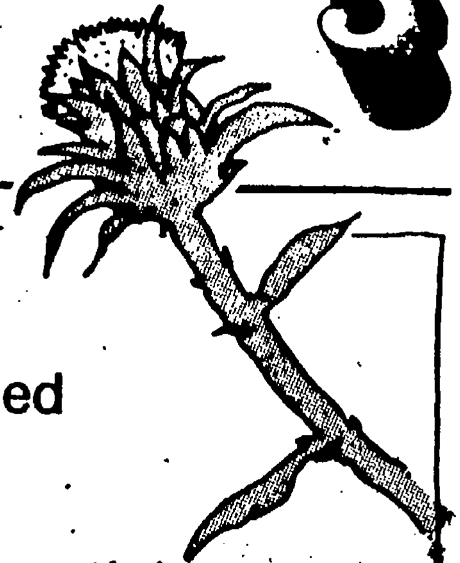
1. Review preparations for outdoor activity discussed in previous lesson.
2. Measure one square meter.
3. Collect weeds from one square meter of lush growth of local weed.
4. Wash off the soil, dry with paper towel, and weigh.
5. Dry the plants until they are crisp (about one week), then weigh again.
6. Burn dried biomass in can. Show the increase of temperature in water at least 5° C.

*Note--If sunlight is not available, dry the plants by placing them in a warm oven or under a lamp.

Activity: Calculate the weight change from the green to dried plants. Calculate the weight of one acre of weed. Discuss remaining questions on "Biomass Energy" activity sheet.

HOW MUCH BIOMASS IS PRODUCED BY 1 SQUARE METER OF A LOCAL WEED?

5



MATERIALS:

An area with a lush growth of a local weed (kudzu, Johnson grass, honeysuckle, thistle, hyacinth, etc.)
Hoes; shovels; bags; balance scale; meter stick

Collect weeds (tops and roots) from one square meter of lush growth of a local weed.

	biomass of wild plant crop	
	fresh weight	dry weight
plant used		

Wash off the soil, dry them with a paper towel, and weigh.

Dry the plants until they are crisp, then weigh again.

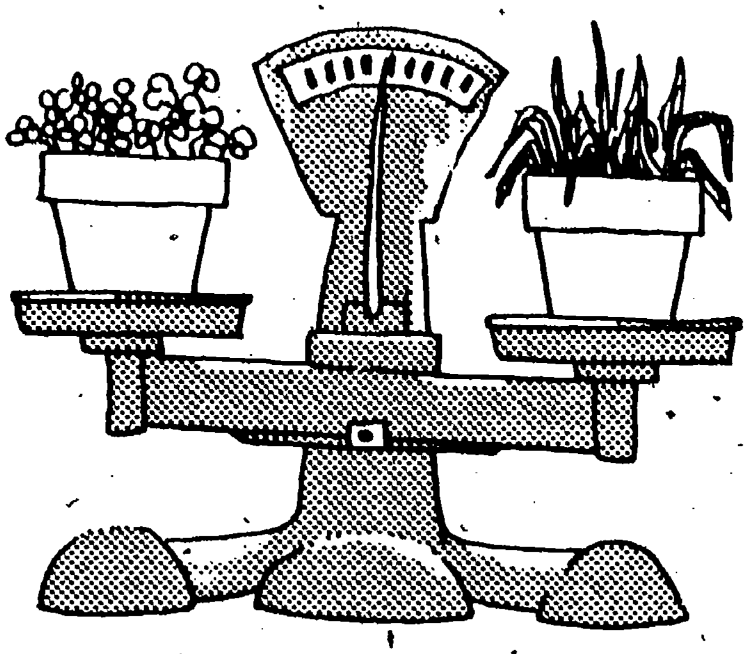
Summary questions:

Would the amount of weeds in your area be useful in solving the energy crisis?

What normally is done with the weeds in your area? What are new uses of weeds grown in your area?

OTHER IDEAS TO EXPLORE:

Try this experiment using one square meter of cultivated growth like clover, barley, or grass.



How do the weed and cultivated growth compare?

How much biomass could be produced in an acre of weeds? In an acre of cultivated crops?

Try cultivating the weed. Does it grow better with additional fertilizer and water?

Try growing the weed with a hydroponic solution. (See Activity 4.)

What is the difference between a weed and a cultivated crop?

Which plants, wild or cultivated, do you think might survive best under unfavorable conditions like lack of rain, poor soil, or disease?

Biomass I - 5

Question
How much biomass is produced by 1 square meter of a weed?

Process Skills
Measuring and making inferences.

Time
About one hour, depending on distance to weed patch. Twenty minutes for final discussion. Five-day activity.

Materials & Procedure Clues
Identify an area where you and your students can gather a local weed.

You may wish to send a small group of students to gather weeds for the entire class.

An acre contains 4085 square meters.

Objective
Students will draw conclusions about biomass as a source of energy produced from weeds.

Concept
Weeds produce biomass and are a source of energy.

Background
There is ongoing experimentation with using weeds as a source of fuel. Methane gas is produced when anaerobic bacteria digest biomass material. It is estimated that one acre of kudzu, when converted to methane gas, would heat and cool a four-person home for one year.

Cutting and collecting the weeds makes the biomass-derived methane gas very expensive compared to natural gas. Using weeds which need to be cleared, such as waterweeds which clog waterways, might be more economical for methane production, especially as the cost of natural gas continues to rise.

Note: If sunlight is not available, dry the plants by placing them in a warm oven or under a lamp.

Precautions
Watch out for poison ivy!

Strategies
Before: Discuss measuring techniques.

After: Discuss summary question.
Calculate the weight of one acre of the weed.

Results
Generally, the weight loss ranges from 40 to 60 percent less than the original weight.

Day 5--Objectives: (1) Discuss the effects of light in producing biomass.
(2) Discuss the effect of plant nutrients in producing biomass.

Materials: Seedlings (radish and beans), metric ruler, balance scale, paper towels, tongue depressors.

Method: Refer to strategies in Biomass I-I.

Have students discuss and compare the methods and nutrients used in the growth of their radishes.

Homework assignment--have students write a paper on "How Biomass Will Be Used in the Year 2000 to Supplement Our Energy Needs".

*Note: Dry the bean seedlings in sun until crisp over weekend. Weigh again on Monday. Discuss summary questions.

Day 6--Objective: Biomass is an indirect source of solar energy.

Material: Dried seedlings, balance scale.

Method:

1. Weigh dried seedlings.
2. Discuss which plants produced most biomass.
3. Award students with the largest radishes blue ribbons.
4. Teacher discusses the pros and cons of biomass as an alternative energy.
5. Teacher collects and reads aloud some students' homework assignment, "How Biomass Will Be Used in the Year 2000 to Supplement Our Energy Needs".
6. Teacher discuss the progress that has been made in biomass research.
7. Summarize the future of biomass energy.

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