BIOMASS

It's almost everything that grows or has grown, and it can be turned into energy in a variety of ways

BY ROBERTA NAVICKIS

Perhaps the most pedestrian and pragmatic plan for using solar energy is to tap energy supplies stored in biomass. What is biomass? It's almost everything under the sun — everything from sewage to sweet sorghum. The word is a catchall, covering the many living, or derived from the living, materials or substances that potentially could be used as energy sources. Lumped together in this category are wood and wood wastes, agriculture products and wastes, algae, animal wastes, municipal sewage, and so on.

Biomass energy is appealing for many reasons. Like other types of solar energy, it is infinitely renewable, and unlike direct collection of solar energy, there is no storage problem. The energy is stored in trees or algae or municipal wastes. Proposed technologies are not far-fetched in most cases. Agriculture and forestry operations are already a workable part of the economy and a desirable use of land. Furthermore, biomass addresses not only the problem of energy production, but also that of waste disposal, a major environmental source of pollution. Biomass, in itself, being low in sulfur, is less polluting than many fossil fuels.

But biomass utilization is not without problems. The chief ones are still the same reasons why wood was abandoned for coal in the 1800s. Biomass raw material is often quite low in energy content. Coal, oil and natural gas have much higher ones. Biomass usually contains a lot of water and is mostly composed of carbohydrate. Carbohydrates don't contain as much energy per molecule as the hydrocarbons found in the fossil fuels. Biomass can be converted into fuels that are of high energy content, but that takes energy and money.

Furthermore, biomass is generally considered to have a problem of scale: Not enough material is available in one location for efficient collection and economic generation of power.

These two problems add up to a high price tag for biomass energy. But with rising costs of petroleum, the depletion of natural gas and development of better ways to process and convert biomass to more energy-rich fuels, the price tag may not look so outrageous in a few years.

In fact, biomass is being used for energy now. Last year, one and one-half percent of the United States' energy came from biomass. That's approximately one-half of the energy derived from nuclear power. Wood wastes burned for fuel by the pulp, paper and forest industries account for most of this use.

But at least 20 U.S. cities have built or are considering plans for "resource recovery" plants that can generate fuel from organic garbage. Calorific Recovery Anaerobic Process, Inc. — CRAP, for short — of Guymon, Okla., provides Chicagoans with methane (natural gas) made from feedlot wastes of cattle. More exotic forms of biomass energy — plantations of petroleum-producing plants and huge kelp farms in the ocean — are projected for the future.

Biomass can be used on either a small or a large scale. Small-scale energy-from-wastes projects are coming into increasing use throughout the world. Methane-producing "digestors" are popular, especially in Third World nations. The digestors, usually installed near homes, consume animal wastes and produce methane for cooking providing, almost, the proverbial free lunch.

Much planning is afoot for large-scale farms of trees, which would be used for fuel. A 1,000-acre pilot-scale plantation on the Savannah River in Aiken, S.C., under the direction of Robert E. Inman of the Mitre Corp. in McLean, Va., is being funded by the Department of Energy (DOE).

All in all, DOE is proposing a 30 percent increase in total long-range allocations for biomass next year to $26.9 million. DOE is also funding a broader program at The Solar Energy Research Institute in Golden, Colo., (see p. 255) on ways to produce biomass and convert it to fuel efficiently. Thomas B. Reed, the project's director, is reported in the March 6 ENERGY RESEARCH REPORTS to estimate that as much as 30 quads (quadrillion Btu; the United States used about 75 quads in 1977) could be produced from biomass annually around the year 2000. Others are more conservative about the potential contribution of biomass. Almost everyone agrees that energy from biomass will never meet all of our energy needs.

Charles D. Scott, associate director of the chemical technology division of Oak Ridge National Laboratories in Oak Ridge, Tenn., told SCIENCE NEWS he predicts that in the next 20 years forest products will be the major source of biomass energy. C. C. Burwell, a research engineer at ORNL, writes in the March 10 SCIENCE that the total biomass growth in the 500 million acres of commercial forests — forests producing 20 cubic feet or more of stemwood per acre per year — is somewhat in excess of 9 quads each year. He reports that the National Research Council estimates that the yields could be doubled if the forests were better managed. Most forests are not now actively managed for production, except for the 13 percent that are industrially owned.

In the January CHEMTECH, R. Thomas Ledig and Daniel Linzer of Princeton University calculate that in Connecticut as little as 84 square miles could support a 150 megawatt power plant, providing 4.3 percent of the state's energy needs.

Forest management taken to the extreme is short rotation forestry. Projects such as the one in Savannah River apply intensive agriculture techniques to growing trees. Trees are planted close together and propagated from cuttings. More productive types of trees are selected for. The Ontario Ministry of Natural Resources has selected fast-growing hybrid poplars whose trunks in 5 years measure 8 inches in diameter, compared with normal diameters of 2 inches.

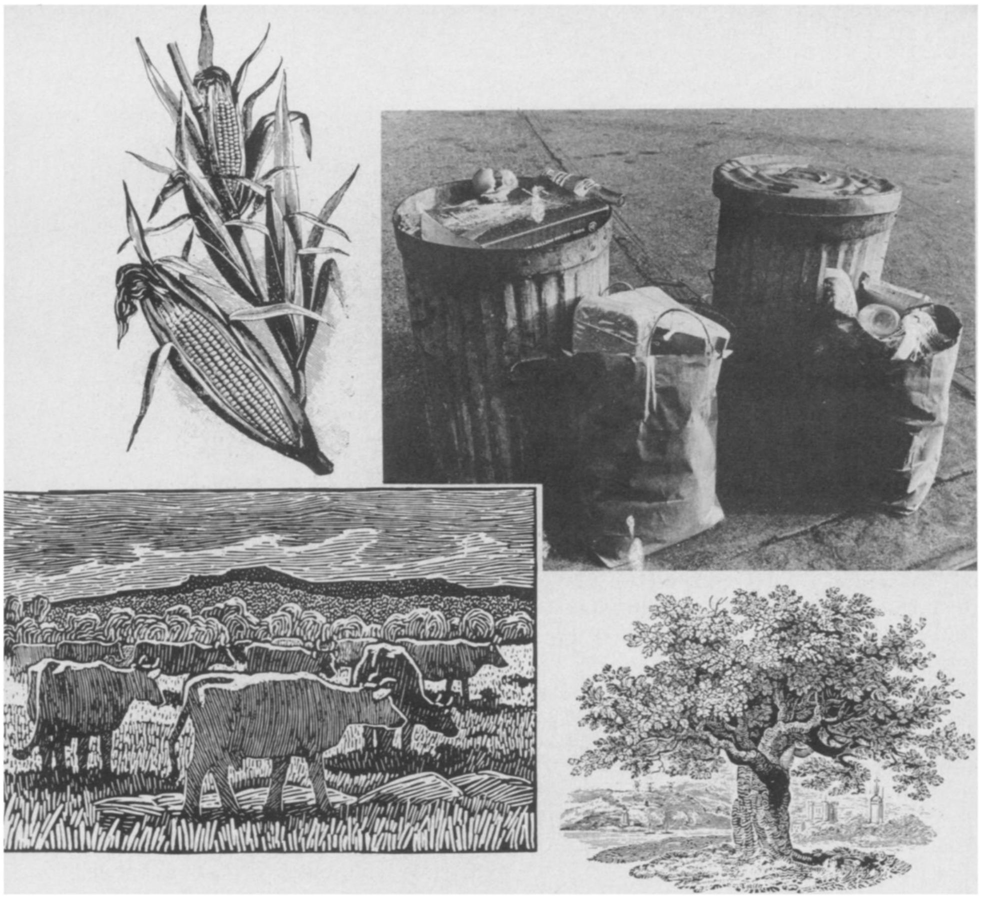
Such intensive forest management requires big doses of water, phosphorous and nitrogen. And the threat of attack by pests, especially insects and rodents, always looms.

But, all in all, growing trees is relatively cheap. The processing is what is expensive. Collecting and hauling trees is labor- and time-consuming. The Agriculture Department's Paul Koch in Pineville, La., however, has developed a mobile chipper that chomps trees to wood chips. But wood chips still have a low energy content relative to the fossil fuels. It takes many more wood chips than coal chunks to fire a furnace.

According to Peter Schauffler, the coordinator of the Bio-Energy Council in Washington, a machine made by Guaranty Fuels, Inc., of Independence, Kan., and Woodex Co. of Eugene, Ore., can eliminate this problem and make wood economically competitive with coal in some areas. The machine compresses wood so much that wood's heat content per pound becomes comparable to coal's. The pellets can be burned in the place of coal or burned with it.

But most homes, schools and businesses are not at present equipped to burn wood, other types of biomass or coal directly. So efforts are being made to find ways to convert biomass into more conventional fuels. Scott said the techniques developed to gasify coal can be modified to gasify wood. In fact, gasification of biomass should be easier than coal gasification because biomass contains more volatiles.

Agriculture crops are also sources of fuels. A classic example is sugar cane. The



cut cane is crushed with water. The washing water goes to an evaporator for extraction of sugar and the cellulose residue (bagasse) goes to the boilers where it is burned, providing steam to run the machinery of the mills. Excess steam can be used to generate electricity; the sugar cane can be fermented to alcohol and used as a fuel.

In January 1978, Brazil, the largest sugar cane grower in the world, was meeting about 10 percent of the fuel requirements of the state of Rio de Janeiro with alcohol from sugar cane, and hopes by 1982 to have 20 percent of liquid fuels be alcohol. Brazil's success is partially attributable to cheap labor and land, and a semi-tropical to tropical climate. Sugar cane can't be grown in most of the United States, and land is by no one's estimate cheap or available. In fact, one of the most frequent objections raised against the biomass-for-fuel programs is that they use land that would otherwise be used for raising food and could cause a food shortage. Advocates counter that some biomass could be grown in marginal land that is today nonproductive. But water and nutrients are often limiting factors on marginal land.

Other problems with agricultural wastes are that they are even less energy dense than trees, and are only available at harvest time, not year round, like an oil well. (Trees have an advantage in that they can be stored "on the stump" and harvested at any time.)

Edward S. Lipinsky of Battelle Laboratories in Columbus, Ohio, told SCIENCE NEWS that the answer to some of these problems lies in adaptive systems, ones that integrate the fuels-for-biomass with the production of food and materials. The economics of growing fuel are much improved if one combines fuel crops with some other useful crop: Sugar cane yields bagasse and sugar, corn yields stalks and corn kernels. The two-purpose crop concept is particularly attractive in areas less favorable to fuel farms than those with abundant sunshine. By-products such as fertilizer can also be derived from biomass.

Lipinsky says that sweet sorghum, a grain that can be fermented to alcohols with yields comparable to those of Louisiana sugar cane, can be grown on the same land as corn and soybeans. When it is unprofitable to raise the standard crops, sweet sorghum can be grown. He writes in the Feb. 10 SCIENCE, "Knowing when and where to switch from emphasis on food and materials is just as important as knowing how to produce fuels."

Biological methods to convert crops to synfuels (methane, methanol, ethanol, etc.) are advancing rapidly. George Tsao of Purdue University has produced a breakthrough in converting cellulose into glucose and other fermentable sugars which in turn can be converted into alcohol and other chemicals. He has found an organic acid that facilitates the attack of fungal cellulases on lignocellulose, formerly a very undigestible component of plants. This finding makes wastes such as corn stover (cobs, stalks, etc.) much more valuable.

Methanol can now be produced for 45 to 50 cents a gallon from biomass, according to Schauffler, making it competitive with today's gasoline prices. Methanol can be the sole fuel for car engines, provided they are modified slightly. Today's engines can run on "gasohol," a mixture of ethanol and gasoline. Ethanol costs $1.20 a gallon to produce from biomass and so isn't economical at this time, he said, but could be if petroleum prices keep rising. (Methanol isn't used because it doesn't mix well with gasoline.)

Some plants store energy in hydrocarbons rather than carbohydrates and could be used to produce gasoline directly. Melvin Calvin of the Laboratory of Chemical Dynamics at the University of California at Berkeley proposes petroleum plantations of such plants on semi-arid currently unproductive land. He has raised a small crop of gopher plants (*Euphorbia lathyris*) in southern California and estimates that such hydrocarbons can be grown today for $20 a barrel. Others think his estimate may be overly optimistic, because water scarcity may reduce yields on such large-scale "gasoline farms."

Water is no problem for algae and other water-based biomass. In fact, processing of algae has not been attractive because it has not been possible to concentrate algae to more than 4 percent by weight. A group at the New Mexico Solar Energy Institute under the direction of G. L. Mauldin has developed a technique (a slurry of algae put on a moving endless belt of very fine mesh nylon screen) to concentrate algae to 20 to 28 percent.

Water hyacinths, fast-growing floating aquatic plants that feed on raw sewage, and at the same time clean the water around them, are also being investigated as sources of biomass.

The most grandiose aquatic scheme for the harvesting of energy is to establish large sea kelp farms. Kelps, which grow two to three feet a day under good conditions, could be converted to methane and other products. The kelp plants will be attached by their holdfasts to a grid of nylon lines suspended 60 feet below the surface so that the fronds of the mature plants will float in the photosynthetic layer just below the surface. Next March, the American Gas Association and General Electric Co.'s Environmental Systems Division at Philadelphia will carry out a $3 million project on a quarter acre of seabed five miles offshore from Laguna Beach.

Solid waste conversion of organic garbage is receiving the most attention now. Methane is being obtained by sinking wells into already existing land fills, or by sorting out garbage fresh from collecting trucks. But this source of methane will always be relatively minor. Biomass's potential lies in such deliberate energy farms — be they of kelp, trees or petroleum plants.

The bioenergy field is rapidly developing after years on a back burner. The scope is vast; artificial biomass systems, such as synthetic leaves, may also be in the future. But that's another story. □