Part II.

Conversion Technologies and End Use

Chapter 6

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Most bioenergy currently comes from direct combustion of solid biomass for space heating, process steam, and a small amount of electric generation. As chemically stored solar energy, biomass can be converted to a number of gaseous and liquid fuels, which can be used for a variety of energy purposes not suited to direct combustion.

Thermochemical conversion, or chemical processes induced by heat, is currently the most suitable process for the major biomass feedstocks–wood and plant herbage. Aside from direct combustion, these processes include gasification and liquid fuels production. Various types of gasifiers are being developed which **could be used for process** heat and retrofits of oil- and natural-gas-fired boilers. Suitable gasifiers may be commercially available in less than 5 years with adequate development support. Methanol synthesis is the near-term option for liquid fuels production. Wood-to-methanol plants can be constructed immediately, while herbage-to-methanol processes need to be demonstrated. Various other processes are being developed, and thermochemical conversion of biomass offers considerable promise for improved processes and new applications for fuel and chemical syntheses.

Fermentation is the biological process used to convert grains and sugar crops to ethanol – currently the only liquid fuel from biomass used in the United States. The byproduct of distillery grains can be used as an animal feed, thereby reducing the competition between food and fuel uses for the grain. Some farmers are producing ethanol onfarm, but with current technology the processes are not economic unless they are heavily subsidized or the onfarm production leads to increased grain prices—thereby enabling the farmer to earn more on the crops he/she sells for feed. However, process development could decrease the costs. Several processes for producing ethanol from wood and herbage are being developed, but the costs are highly uncertain.

Anaerobic digestion is a biological process, which produces a gas containing methane (the principal component of natural gas) and carbon dioxide. Suitable feedstocks include many wet forms of biomass, such as animal manure and some aquatic plants. For the near to mid term, digesters for onfarm production of gas from animal manure appear to hold the greatest promise. Not only can this technology serve as a waste disposal process, but it also could make most confined animal operations energy self-sufficient. There is a need to demonstrate a variety of digesters using different feedstocks to gain operating experience. Because the major cost is the initial investment, policies designed to lower capital charges will increase market penetration of the technology.

The alcohols most easily produced from biomass—ethanol and methanol —are not totally compatible with the existing liquid fuels system and automobile fleet. These alcohols can be used in gasoline blends or as standalone fuels, but methanol blends will have more problems than ethanol blends unless suitable additives are included with the methanol. All of the problems regarding the alcohols' incompatibility with the existing system have multiple solutions, but it is unclear which strategies will prove to be the most cost effective.

The energy balance for ethanol from grains and sugar crops has been the subject of considerable controversy, because the farming and processing energy consumption together are approximately the same as the energy contained in the ethanol. A net displacement of premium fuels—oil and natural gas—can be assured with ethanol, however, if: 1) distilleries do not use premium fuel for their boilers and 2) the ethanol is used as an octane-boosting additive to gasoline. Failure to fulfill either of these criteria could lead to ethanol production and use increasing the U.S. consumption of premium fuels, although there would be a small net displacement of premium fuels in most cases. Failure to comply with both criteria would almost certainly be counterproductive in terms of premium fuels displacement.

Methanol and ethanol can be produced from wood and plant herbage, although ethanol production is considerably more expensive with current technology. In each case, however, the biomass might be burned or gasified as a substitute for oil or natural gas. Liquid fuels production is considerably less efficient than combustion or gasification if the liquid is used as a standalone fuel. Using the liquid as an octane-boosting additive to gasoline, however, makes the options more comparable in terms of premium fuels displacement per ton of biomass. Future developments in refinery technology could change this conclusion.

Biomass already supplies substantial quantities of chemicals, and an expanded use of biomass chemicals is a widely discussed subject. Numerous plants produce potentially useful chemicals for industrial synthesis and as a source of natural rubber, mutant cells can produce highly specialized chemicals, and chemical synthesis from wood and plant herbage is developing or could be developed in a number of potentially very interesting directions. Because of the higher value of chemicals, as compared to fuel, the economic limitations on chemical production from biomass are considerably less severe than for energy production.

These topics and related aspects of conversion technologies and end use for bioenergy are presented in the following chapters.