Overview

Wood, grasses, agricultural crops and their residues, animal wastes, and other sources of biomass currently supply almost 2 percent of U.S. energy consumption (or about 1.5 Quads* /yr), primarily from the use of wood in the forest products industry and in home heating. Depending on a variety of factors, including the availability of cropland, improved crop yields, the development of efficient conversion processes, proper resource management, and the level of policy support, bioenergy could supply as few as 4 to 6 Quads/yr, or as many as 12 to 17 Quads/yr by 2000 (or up to 15 to **20** percent of current U.S. energy consumption). Of the "high development" 12- to 17-Quad range, up to 10 Quads/yr would come from wood, O to 5 Quads/yr from grasses and legume herbage (depending on cropland needs for food production), and 1 Quad/yr from crop residues. In addition, various smaller biomass energy sources could yield approximately 0.5 Quad/yr, including up to 0.3 Quad/yr of biogas from animal manure and about 0.2 Quad/yr of ethanol from grains (approximately 2 billion gal/yr of ethanol or 2 percent of current U.S. gasoline and imported oil consumption).

The bioenergy conversion processes that would be most efficient in displacing large quantities of oil are direct combustion and gasification for process heat and steam and home heat. Combustion technology for wood is commercially available, while suitable gasification units probably can be developed soon. Assuming that market and feedstock supply conditions are favorable, **development and deployment of these technologies could provide the difference of up to 10 Quads/yr between the high and low estimates for bioenergy use in 2000.** This 10 Quads/yr could displace the energy equivalent of 4.5 million barrels per day (bbl/d) of premium fuels (oil and natural gas). It is noteworthy, however, that in most cases, biomass would be competing with coal for these markets.

Liquid fuels are the most versatile form of energy from biomass. Ethanol can be produced from grains and sugar crops with commercial technology. Growing the grains or sugar crops and converting them to ethanol require roughly the same amount of energy as is contained in the ethanol. **A net displacement of premium fuels (oil and natural gas) can be achieved if ethanol distilleries are not fueled with oil or natural gas. This oil displacement can be even more favorable if the ethanol is used as an octane= boosting additive to gasoline rather than solely for its fuel value.**

For the major biomass sources—lignocellulosic materials such as wood, grass, and crop residues—methanol synthesis appears to be the least expensive and nearest term option for producing liquid fuels. Although no facilities to convert biomass to methanol currently exist, a wood-to-methanol plant is being planned, and grass-to-methanol technology probably can be demonstrated more rapidly than economic grass-to-ethanol processes. It is technically possible to displace the energy equivalent of up to 3 million bbl/d of oil in the transportation sector with methanol by 2000. Because of the greater difficulties associated with blending methanol in gasoline, however, **the en= tire liquid fuels system from refineries through distribution and various end**

*A Quad equals 1 quadrillion (10^{15}) Btu. It equals the energy of approximately 460,000 bbl/d of oil for 1 year, 50 million tons of coal, or the typical annual energy output of eighteen 1,000-MW powerplants.

uses should be examined to determine the most economic strategies for introducing methanol, especially in the transportation sector.

Both the quantity of biomass that can be obtained on a renewable basis, and the economic, environmental, and other consequences of obtaining it will depend critically on the behavior of growers and harvesters. For example, careless forest management could substantially reduce the amount of wood available for energy and result in severe environmental damage. In addition, production of ethanol from grains and sugar crops and other uses of cropland for energy (except crop residues) can compete with feed and food crop production and thus lead to more rapid inflation in food prices. At the same time, the needed expansion of acreage in intensive crop production, as well as any overuse of crop residues, will add to the already damaging rate of erosion on U.S. cropland.

Both the energy potential of biomass and the problems inherent in achieving that potential raise three main policy issues that Congress might choose to address.

First, vigorous policy support will be necessary if bioenergy use is to reach 12 to 17 Quads/yr by 2000. This support could take the form of economic incentives to accelerate the introduction of bioenergy and to promote the establishment of reliable supply infrastructures.

Second, because of the unresolved questions about the biomass resource base, the way the complex and interconnected markets will respond, and how constraints will change with time, **incentives for bioenergy development should include provisions for periodic review and adjustment.** In the case of grain ethanol, this reevaluation might occur when planned distillery capacity approaches 2 billion gal/yr—the level at which conservative economic calculations indicate that significant food price increases might begin. In the case of wood and other lignocellulosic materials, a formal review of the condition of the forests and soils might be instituted when 5 Quads/yr of these materials are being used for energy.

Third, bioenergy currently remains a low priority in the Departments of Energy and Agriculture— the Federal agencies able to directly influence the speed and direction of development. The aggressive promotion of bioenergy therefore will require a reorientation of Federal program goals, as well as extensive coordination among Federal agencies, and among National, State, and local governments.