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Biofuels in the U.S. Transportation Sector¹

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Sustained high world oil prices and the passage of the EPACT2005 have encouraged the use of agriculture-based ethanol and biodiesel in the transportation sector; however, both the continued growth of the biofuels industry and the long-term market potential for biofuels depend on the resolution of critical issues that influence the supply of and demand for biofuels. For each of the major biofuels—corn-based ethanol, cellulosic ethanol, and biodiesel—resolution of technical, economic, and regulatory issues remains critical to further development of biofuels in the United States.

In the transportation sector, ethanol is the most widely used liquid biofuel in the world. In the United States, nearly all ethanol is blended into gasoline at up to 10 percent by volume to produce a fuel called E10 or "gasohol." In 2005, total U.S. ethanol production was 3.9 billion gallons, or 2.9 percent of the total gasoline pool. Preliminary data for 2006 indicate that ethanol use rose to 5.4 billion gallons. Biodiesel production was 91 million gallons, or 0.21 percent of the U.S. distillate fuel oil market, including diesel, in 2005 (Table 11). All cars and light trucks built for the U.S. market since the late 1970s can run on the ethanol blend E10. Automakers also produce a limited number of FFVs for the U.S. market that can run on any blend of gasoline and ethanol up to 85 percent ethanol by volume (E85). Because auto manufacturers have been able to use FFV sales to offset CAFE requirements, more than 5 million FFVs were produced for the U.S. market from 1992 through 2005. E10 fuel is widely available in many States. E85 has limited availability, at stations clustered mostly in the midwestern States.

Table 11. U.S. motor fuels consumption, 2000-2005 (million gallons per year)

	<i>Gasoline</i>	<i>Ethanol</i>	<i>Percent of gasoline pool</i>
2000	128,662	1,830	1.27
2001	129,312	1,770	1.37
2002	132,782	2,130	1.60
2003	134,089	2,800	2.09
2004	137,022	3,400	2.48
2005	136,949	3,904	2.85
	<i>Diesel</i>	<i>Biodiesel</i>	<i>Percent of diesel fuel pool</i>
2000	37,238	—	—
2001	38,155	9	0.02
2002	38,881	11	0.03
2003	40,856	18	0.04
2004	42,773	28	0.07
2005	43,180	91	0.21

In the AEO2007 reference case, ethanol use increases rapidly from current levels. Ethanol blended into gasoline is projected to account for 4.3 percent of the total gasoline pool by volume in 2007, 7.5 percent in 2012, and 7.6 percent in 2030. As a result, gasoline demand increases more rapidly in terms of fuel volume (but not in terms of energy content) than it would in the absence of ethanol blending. Overall, gasoline consumption is projected to increase by 32 percent on an energy basis, and by 34 percent on a volume basis, from 2007 to 2030.

Ethanol can be produced from any feedstock that contains plentiful natural sugars or starch that can be readily converted to sugar. Popular feedstocks include sugar cane (Brazil), sugar beets (Europe), and maize/corn (United States). Ethanol is produced by fermenting sugars. Corn grain is processed to remove the sugar in wet and dry mills (by crushing, soaking, and/or chemical treatment), the sugar is fermented, and the resulting mix is distilled and purified to obtain anhydrous ethanol. Major byproducts from the ethanol production process include dried distillers' grains and solubles (DDGS), which can be used as animal feed. On a smaller scale, corn gluten meal, gluten feed, corn oil, CO₂, and sweeteners are also byproducts of the ethanol production process used in the United States.

With additional processing, plants and other biomass residues (including urban wood waste, forestry residue, paper and pulp liquors, and agricultural residue) can be processed into fermentable sugars. Such potentially low-cost resources could be exploited to yield significant quantities of fuel-quality

feedstocks [145]. There are no significant differences in processing for the numerous biodiesel feedstocks, and they cannot easily be grouped into first- and second-generation categories. The major differences among biodiesel feedstocks are regional availability, co-product value, and the composition of fatty acids in the refined vegetable oil.

Resource Utilization and Land Availability

Currently, corn and soybean feedstocks for biofuels are grown almost exclusively on prime agricultural land in the Midwest. Increases in the supply of biofuel feedstocks could come from a combination of three strategies: increasing the amount of land used as cropland, boosting the yields of existing energy crops, and replacing or supplementing corn with cellulosic biomass and soybeans with oilseeds more appropriate for biodiesel production. All three strategies may be required to overcome the constraints of currently available feedstocks and sustain biofuel production levels that could displace at least 10 percent of gasoline consumption.

According to the most recent Agricultural Census (2002), the amount of cropland available in the lower 48 United States is 434 million acres [146], or 23 percent of the total land area [147]. The total amount of cropland—defined as the sum of land used for crops, idle land, and pasture—has been declining for the past 50 years and, increasingly, is becoming concentrated in the Midwest. The trend is expected to continue as population pressure leads to permanent conversion of some agricultural lands to other uses. It is unlikely that additional cropland will be added in the United States to accommodate increases in the demand for biofuels. Instead, the cultivation of biofuels will compete with other agricultural uses, such as pastureland and idle land, much of which is in the Conservation Reserve Program (CRP) [148].

The potential use of CRP acreage to grow corn and soybeans is constrained by productivity, environmental, and contractual limitations. Nevertheless, there may be significant opportunities in the future to use some CRP acres to grow such “low-impact” energy crops as native grasses (switchgrass) and short-rotation trees (willows or poplars) to generate cellulosic biomass. Pilot programs are underway in Minnesota, Iowa, New York, and Pennsylvania to determine whether CRP acres can be used to grow energy crops while preserving the environmental mandate of the CRP.

Land Use and Productivity

With a limited supply of cropland available for biofuel feedstocks, increasing yield (bushels per acre) on an annual basis could significantly boost available supplies of corn and soybeans without requiring additional land. With more than 81 million acres devoted to corn and nearly 72 million acres devoted to soybeans (2005 U.S. planted acres), even small increases in annual yield could boost supplies significantly [149].

There have been large annual increases in yields of both corn and soybeans over the past 30 years. Corn yields increased from 86.4 bushels per acre in 1975 to 151.2 bushels per acre in 2006, and soybean yields increased from 28.9 bushels per acre to 43 bushels per acre over the same period [150]. If corn yields continue to increase at the same rate (approximately 1.8 bushels per acre per year), production could increase by more than 3.1 billion bushels (29 percent) by 2030 without requiring any additional acreage. Similarly, soybean production could increase by nearly 1.0 billion bushels per year by 2030 with no additional acreage requirement if yields continue to grow at the rate of 0.5 bushels per acre per year [151]. Improvements in biofuel collection and refining and bioengineering of corn and soybeans also could contribute to improved biofuel yields. Research on methods to increase the starch content of corn and the oil content of soybeans is also ongoing.

Crop Competition

A key uncertainty is the availability of sufficient land resources for large-scale expansion of the cultivation of biofuel crops, given the intense competition with conventional agricultural products for arable land. Competition will favor those crops most profitable for farmers, accounting for such factors as growing region, farming practice, and soil type. Currently, corn and soybeans are competitive energy crops, because they provide high value to farmers at prices low enough to allow the biofuel industry to produce a product competitive with petroleum fuels.

Cellulosic biomass from switchgrass, hybrid willow and poplar trees, agricultural residues, and other sources has significant supply potential, possibly up to 4 times the potential of corn [152]. Switchgrass