

Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy

The Renewable Fuel Standard (RFS), which mandates that 35 billion gallons of ethanol-equivalent biofuels and 1 billion gallons of biomass-based diesel be consumed in the United States by 2022, is not likely to be met. Even if RFS is to be achieved, it may not be effective in addressing global greenhouse-gas emissions because the extent of emissions reductions depends to a great degree on how the biofuels are produced and what land-use or land-cover changes occur in the process.

The United States is the world's biggest consumer of crude oil. High U.S. consumption has contributed to two major problems: low U.S. energy security and high greenhouse-gas emissions. About 52 to 60 percent of oil consumed in the United States from 2005-2009 was imported, and transportation fuels contribute about 30 percent of all carbon dioxide (CO₂) emissions in the United States.

Biofuels offer an alternative to petroleum-based fuels.

Interest in biofuels stems from their potential to improve U.S. energy security because they are produced from renewable domestic sources and from their potential to provide life-cycle greenhouse-gas benefits compared to fossil fuels (see Table 1).

The U.S. Congress enacted the Energy Independence and Security Act (EISA) in 2007 (110. P.L. 140) “to move the United States toward greater energy independence and security,” and “to increase the production of clean renewable fuels.” The Renewable Fuel Standard subtitle within EISA mandates that different types of biofuels be consumed each year (Figure 1). This report, produced at the request of the U.S. Congress, provides an independent assessment of the economic and environmental effects associated with achieving the RFS.



Source: National Renewable Energy Laboratory

RFS Cellulosic Fuel Mandate Unlikely to be Met by 2022

The United States is already producing 14 billion gallons of corn-grain ethanol (an amount close to the consumption mandate for conventional biofuels in 2022) and has infrastructure for producing 2.7 billion gallons of biomass-based diesel (an installed capacity that exceeds the consumption mandate for biomass-based diesel in 2022, see Table 1).

However, the consumption mandate for cellulosic biofuels will not likely be met.

Although the United States can likely produce adequate cellulosic feedstock to be converted into biofuels to meet the 16 billion-gallon-consumption mandate in 2022, there are currently no commercially viable biorefineries to convert such plant matter into fuel. A previous National Academies report, *Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs, and Environmental Impacts*, estimated that if robust commercial-scale technology was available by 2015, aggressive deployment of this technology—where capacity build rate would double the build rate for corn-grain ethanol seen in recent years—would be needed to meet the 2022 goal. However, policy uncertainty and high production costs may deter investors from supporting aggressive

The Renewable Fuel Standard Consumption Mandate

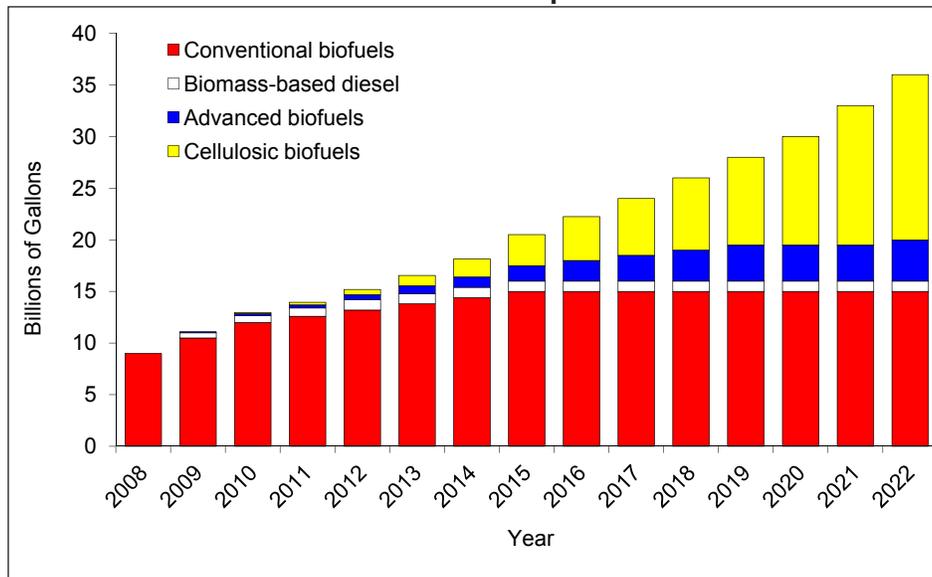


Figure 1. This chart shows the amounts of renewable fuel consumption mandated by the Renewable Fuel Standard for each year between 2008 and 2022. The total amount is made up of four different types of biofuel: cellulosic, advanced, biomass-based diesel, and conventional biofuels (see Table 1). All volumes, except for volumes of biomass-based diesel, are shown in billions of gallons of ethanol-equivalent.

deployment in the timeframe necessary to meet the mandate.

Economic Effects

The report’s authoring committee used the Biofuel Breakeven Model to evaluate the costs and feasibility of a local or regional market for cellulosic biofuel made using a variety of different feedstocks. The model estimates the minimum price that biomass producers would be willing to accept for a dry ton of biomass delivered to the biorefinery, and the maximum price that biorefineries would be willing to pay to at least break even. These calculations showed that the prices that suppliers are willing to accept to break even exceed the prices that biofuel processors are willing to pay.

Because the price of crude oil is highly volatile and it influences willingness to accept and willingness to pay, the committee conducted the analysis under three different oil prices: \$52, \$111, and \$191 per barrel (the

low, reference, and high projections of oil prices for 2022 from the 2010 Department of Energy’s Annual Energy Outlook). The analysis projects that willingness to accept exceeds willingness to pay for all feedstocks analyzed assuming an oil price of \$111 per barrel—meaning that no cellulosic feedstock market is feasible without policy incentives such as government subsidies to cover the price gap (see Table 2). Of the three scenarios analyzed, the gap between willingness to accept and willingness to pay would only be closed under the oil price of \$191 per barrel.

Alternatively, a carbon price of between \$118 and \$138 per tonne of carbon dioxide equivalent could close the gap between willingness to accept and willingness to pay at an oil price of \$111 per barrel for some feedstocks. A government subsidy of \$1.01 per gallon of cellulosic biofuel blended with fossil fuel was established in 2008, but this payment is not sufficient to close the price gap at \$111 per barrel of oil.

Table 1

Fuel	What is it?	How much less life-cycle greenhouse gas emissions must the biofuel emit compared to petroleum-based fuels to qualify for RFS?
Conventional biofuel	Any biofuels ¹	At least 20% reduction
Cellulosic biofuel	Fuel derived from the structural tissues (cellulose, hemicellulose, and lignin) of crop residues and plants such as switchgrass	At least 60% reduction
Biomass-based diesel	Diesel produced from the oil of soybean and other vegetables and also from animal fat	At least 50% reduction
Advanced biofuel	Includes cellulosic biofuels, biomass-based diesels, or other biofuels made from a sugar or starch other than those derived from corn	At least 50% reduction

¹ The conventional biofuel mandate can be fulfilled with corn-grain ethanol.

Table 2

Feedstock	Willingness to Accept	Willingness to Pay	Price Gap (Per Dry Ton)	Price Gap (per Gallon of Ethanol)
Corn Stover (stalks, leaves, and cobs)	\$92	\$25	\$67	\$0.96
Corn Stover in a 4-year Corn-Alfalfa Rotation	\$92	\$26	\$66	\$0.94
Alfalfa	\$118	\$26	\$92	\$1.31
Switchgrass in the Midwest	\$133	\$26	\$106	\$1.51
Switchgrass in Appalachia	\$100	\$26	\$74	\$1.06
<i>Miscanthus</i> in the Midwest	\$115	\$26	\$89	\$1.27
<i>Miscanthus</i> in Appalachia	\$105	\$27	\$79	\$1.13
Wheat Straw	\$75	\$27	\$49	\$0.70
Short-Rotation Woody Crops	\$89	\$24	\$65	\$0.93
Forest Residues	\$78	\$24	\$54	\$0.77

Finding: Only in an economic environment characterized by high oil prices, technological breakthroughs, and a high implicit or actual carbon price would biofuels be cost-competitive with petroleum-based fuels.

Effects on Land Prices

Unless there are major increases in agricultural yields or improvements in the efficiency of converting biomass to fuel, an additional 30 to 60 million acres of cropland would be required to produce enough biomass to meet the Renewable Fuel Standard by 2022. Therefore, increasing biofuel production to meet the RFS consumption mandate is expected to create competition among different land uses and increase cropland prices.

Effects on Food and Feed Prices

Diverting a portion of food crops, such as corn and soybean, to biofuel production was one of the many factors that contributed to increasing prices for agricultural commodities, food, and livestock feed starting in 2007. Other factors affecting food and feed prices include growing global population, crop failures in other countries, high oil prices, decline in the value of the U.S. dollar, and speculative activity in the marketplace.

Environmental Effects

Although biofuels hold potential for providing net environmental benefits compared to using petroleum-based fuels, specific environmental outcomes from increasing biofuel production to meet the RFS consumption mandate cannot be guaranteed. Some of the key factors that influence environmental effects from producing feedstocks for biofuels are site specific and

depend on the type of feedstocks produced, the management practices used to produce them, prior land use, and any land-use changes that their production might incur. In addition to greenhouse-gas emissions, production and use of biofuels affect air quality, water quality, water use, and biodiversity (see Box 1).

Many processes affect the overall greenhouse-gas emissions from the production and use of biofuels; some processes result in sequestration of greenhouse gases while others result in greenhouse-gas emissions. For example, carbon dioxide is stored in plants as they grow, but emissions are generated by fossil fuel combustion during the process of manufacturing and transporting the biofuel. Conversely, replacing an annual crop with a perennial biofuel crop could increase the amount of carbon dioxide sequestered at the site.

Indirect changes in land use can also occur and affect greenhouse-gas emissions. If the increased production of biofuel crops causes decreases in the production of commodity crops, the price of commodities could increase. Farmers could respond to market signals and expand production of the displaced commodity crop by converting noncropland to cropland. If the expanded production involves removing perennial vegetation on a piece of land and replacing it with an annual commodity crop, then the land-use change would incur a one-time greenhouse-gas emission from biomass and soil that could be large enough to offset greenhouse-gas emissions benefits gained by displacing petroleum-based fuels with biofuels over subsequent years. Furthermore, such land conversion may disrupt any future potential for storing carbon in biomass and soil. Although RFS imposes restrictions to discourage U.S. farmers from land-clearing or land-cover change,

the policy cannot prevent market-mediated effects nor control land-use or land-cover changes in other countries.

Finding: RFS may be an ineffective policy for reducing global greenhouse-gas emissions because the effect of biofuels on greenhouse-gas emissions depends on how the biofuels are produced and what land-use or land-cover changes occur in the process.

Barriers and Opportunities

Although RFS guarantees a market for the cellulosic biofuels produced, even at costs considerably higher than fossil fuels, uncertainties in enforcement and implementation of RFS mandate levels affect investors' confidence and discourage investment. Of the three crude oil prices tested in this study, the only one for which biofuels were economically viable without subsidies was \$191. The price at which cellulosic biofuel would break even with crude oil is between \$111 and \$191. As of 2011, biofuel production is contingent on subsidies, RFS, and similar policies.

Finding: Key barriers to achieving RFS are the high cost of producing cellulosic biofuels compared to petroleum-based fuels and uncertainties in future biofuel markets.

Box 1. Potential Environmental Effects

The environmental effects of increasing biofuel production largely depend on feedstock type, site-specific factors (such as soil and climate), management practices used in feedstock production, land condition prior to feedstock production, and conversion yield. Potential environmental effects include:

Air quality: The production and use of ethanol from biomass is projected to result in the higher release of air pollutants such as particulate matter, ozone, and sulfur oxide than petroleum-based fuels.

Water quality: Feedstock types that require less agrichemical input and have high nutrient uptake efficiency could provide water quality benefits while others might result in high discharge of sediment and nutrients.

Water use: Published estimates of consumptive water use for producing corn-grain ethanol are higher than those for producing petroleum-based fuels, but the effects of water use depend on regional availability.

Biodiversity: Low-input and high-diversity grass stands are likely to have higher animal diversity than their high-input and low-diversity counterpart.

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<http://dels.nas.edu/banr>

Committee on Economic and Environmental Impacts of Increasing Biofuels Production: Lester B. Lave, *Chair* (until May 9, 2011) (IOM), Carnegie Mellon University; Ingrid (Indy) C. Burke, *Cochair* (from May 9, 2011), University of Wyoming, Laramie; Wallace E. Tyner, *Cochair* (from May 9, 2011), Purdue University; Virginia H. Dale, Oak Ridge National Laboratory; Kathleen E. Halvorsen, Michigan Technological University; Jason D. Hill, University of Minnesota, St. Paul; Stephen R. Kaffka, University of California, Davis; Kirk C. Klasing, University of California, Davis; Stephen J. McGovern, PetroTech Consultants; John A. Miranowski, Iowa State University; Aristides (Ari) Patrinos, Synthetic Genomics, Inc.; Jerald L. Schnoor (NAE) University of Iowa; David B. Schweikhardt, Michigan State University; Theresa L. Selfa, State University of New York – College of Environmental Science and Forestry, Syracuse; Brent L. Sohngen, Ohio State University; J. Andres Soria, University of Alaska, Fairbanks; Kara N. Laney, *Study Codirector* and Evonne P.Y. Tang, *Study Codirector*, National Research Council.

The National Research Council appointed the above committee of experts who volunteered their time to address the specific task. Their report is peer-reviewed and the final product signed off by the committee members and the National Research Council. This report brief is based on the committee's report.



For more information, contact the Board on Agriculture and Natural Resources at (202) 334-3062 or visit <http://dels.nas.edu/banr>. Copies of *Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy* are available from the National Academies Press; (800) 624-6242; www.nap.edu.

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