Agriculture-Based Biofuels: Overview and Emerging Issues

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Summary

Since the late 1970s, U.S. policymakers at both the federal and state levels have enacted a variety of incentives, regulations, and programs to encourage the production and use of agriculture-based biofuels. Initially, federal biofuels policies were developed to help kick-start the biofuels industry during its early development, when neither production capacity nor a market for the finished product was widely available. Federal policy has played a key role in helping to close the price gap between biofuels and cheaper petroleum fuels. Now, as the industry has evolved, other policy goals (e.g., national energy security, climate change concerns, support for rural economies) are cited by proponents as justification for continuing policy support.

The U.S. biofuels sector has responded to these government incentives by expanding output every year since 1980 (with the exception of 1996), with important implications for the domestic and international food and fuel sectors. The production of ethanol (the primary biofuel produced in the United States) has risen from about 175 million gallons in 1980 to nearly 14 billion gallons in 2011. U.S. biodiesel production, albeit much smaller, has also shown strong growth, rising from 0.5 million gallons in 1999 to a projected 800 million gallons in 2011.

Despite this rapid growth, total agriculture-based biofuels production accounted for only about 8% of U.S. transportation fuel consumption (gasoline and diesel combined) on a volume basis and 6% on a gasoline-equivalent basis in 2011. Federal biofuels policies have had costs, including unintended market and environmental consequences and large federal outlays (estimated at over $6 billion in 2011). Despite the direct and indirect costs of federal biofuels policy and the relatively small role of biofuels as an energy source, the U.S. biofuels sector continues to push for federal involvement. But critics of federal policy intervention in the biofuels sector have also emerged.

Current issues and policy developments related to the U.S. biofuels sector that are of interest to Congress include the following:

- Many federal biofuels policies (e.g., tax credits and import tariffs) require routine congressional monitoring and occasional reconsideration in the form of reauthorization or new appropriations funding.
- The 10% ethanol-to-gasoline blend ratio—known as the "blend wall"—poses a barrier to expansion of ethanol use. The Environmental Protection Agency (EPA), has issued waivers to allow ethanol blending of up to 15% (per gallon of gasoline) for use in model year 2001 and newer light-duty motor vehicles. However, the limitation to newer vehicles, coupled with infrastructure issues, is likely to limit rapid expansion of blending rates.
- The slow development of cellulosic biofuels has raised concerns about the industry's ability to meet large federal usage mandates, which in turn has raised the potential for future EPA waivers of mandated biofuel volumes and has contributed to a cycle of slow investment in and development of the sector.

Several trade issues (including European Union anti-dumping and countervailing duty proceedings against imports of U.S. ethanol precipitated by surging U.S. ethanol exports) emerged in 2011 that, if realized, could slow further development of the U.S. biofuels sector.

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Introduction

Increasing dependence on foreign sources of crude oil, concerns over global climate change, and the desire to promote domestic rural economies have raised interest in renewable biofuels as an alternative to petroleum in the U.S. transportation sector. However, energy from renewable sources has historically been more expensive to produce and use than fossil-fuel-based energy.[1] U.S. policymakers have attempted to overcome this economic impediment by enacting an increasing number of policies since the late 1970s, at both the state and federal levels, to directly support U.S. biofuels production and use. Policy measures have included blending and production tax credits to lower the cost of biofuels to end users, an import tariff to protect domestic ethanol from cheaper foreign-produced ethanol, research grants to stimulate the development of new technologies, loans and loan guarantees to facilitate the development of biofuels production and distribution infrastructure, and, perhaps most importantly, minimum usage requirements to guarantee a market for biofuels irrespective of their cost.[2]

This report reviews the evolution of the U.S. biofuels sector and the role that federal policy has played in shaping its development.[3] In addition, it highlights emerging issues that are critical to the biofuels sector and of relevance to Congress.

Federal Biofuels Policies Have Encouraged Rapid Growth ...

Federal biofuels programs have proven critical to the economic success of the U.S. biofuels industry, primarily ethanol and biodiesel, whose output has grown rapidly in recent years. Yet, despite the rapid growth, U.S. biofuels consumption remains a small share (5.9% on an energy-equivalent basis in 2011) of national transportation fuel use (**Figure 1**).

Furthermore, the sector remains heavily dependent on federal policies that, concomitant with the growth in U.S. biofuels production, have required rapidly increasing federal budget outlays. In 2011, the estimated annual cost of direct federal support for biofuels production and use was estimated at over $6 billion. In addition, the rapid expansion of U.S. corn ethanol production to meet the dramatic rise in corn use for ethanol (the U.S. Department of Agriculture estimates that 40% of both 2010 and 2011 U.S. corn production was used for ethanol production) has provoked questions about its long-run sustainability and the possibility of unintended consequences in other markets as well as for the environment.[4]

It is widely believed that the ultimate success of the U.S. biofuels sector will depend on its ability to shift away from traditional row crops such as corn or soybeans for processing feedstock, and toward other, cheaper forms of biomass that do not compete with traditional food crops. Recent federal biofuels policies have attempted to assist this shift by focusing on the development of a

[1] Excluding the costs of externalities (e.g., air pollution, environmental degradation, illness and disease, or indirect land use changes and market-price effects) linked to emissions associated with burning either fossil fuels or biofuels.

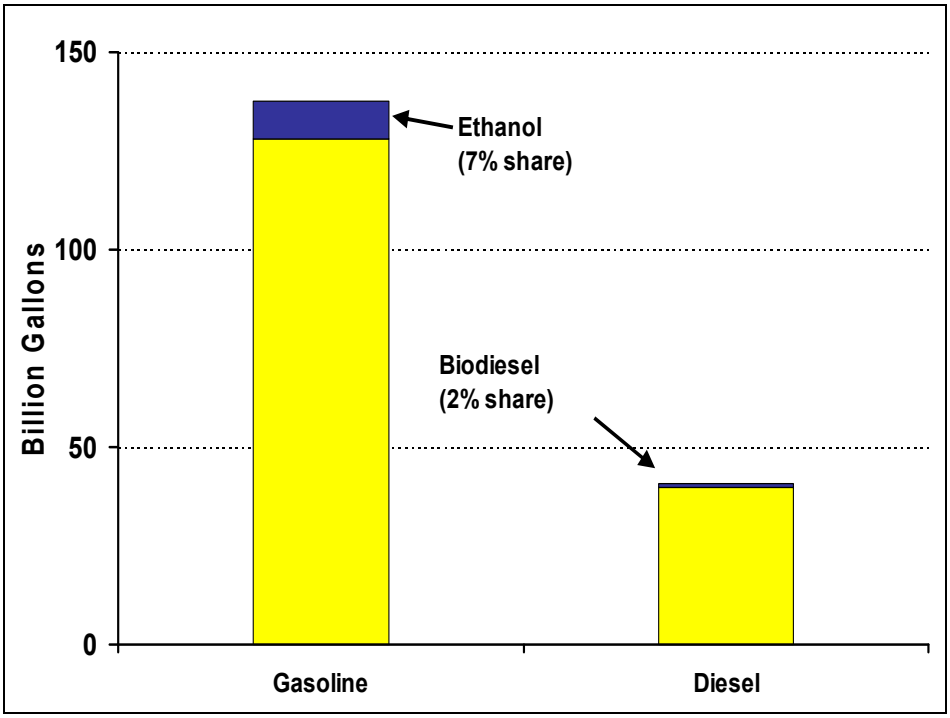
[2] For more details and a complete listing of federal biofuels programs and incentives, see CRS Report R40110, *Biofuels Incentives: A Summary of Federal Programs*.

[3] For background information on agriculture-based U.S. biofuels, see the list of related CRS Reports available at the CRS website "Issues in Focus: Agriculture: Agriculture-Based Biofuels."

[4] See CRS Report R40155, *Renewable Fuel Standard (RFS): Overview and Issues*.

cellulosic biofuels industry.[5] However, the speed of cellulosic biofuels development remains a major uncertainty, since new technologies must first emerge and be implemented on a commercial scale.[6] The uncertainty surrounding the development of such new technologies and their commercial adaptation has been a major impediment to the flow of much needed private-sector investment funds into the cellulosic biofuels sector.

Figure 1. Biofuels Were a Small Share of U.S. Motor Transportation Fuel Use in 2011



Sources: Ethanol use: Renewable Fuels Association; Biodiesel and total motor vehicle fuel use: Energy Information Agency (EIA), Department of Energy (DOE).

Note: All data are in gasoline-equivalent gallons (GEG).

... And Conflicting Viewpoints

The trade-offs between benefits to farm and rural economies, as opposed to large federal budget costs and the potential for unintended consequences, have led to emergence of both proponents and critics of the government subsidies and mandates that underwrite biofuels production.

Proponents of government support for agriculture-based biofuels production have cited national energy security, reductions in greenhouse gas emissions, and raising domestic demand for U.S.-produced farm products as viable justifications. In many cases, biofuels are more environmentally friendly (in terms of emissions of toxins, volatile organic compounds, and greenhouse gases) than

[5] Cellulosic biofuels are derived from the sugar contained in plant cellulose. For more information, see CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*.

[6] See CRS Report R41460, *Cellulosic Ethanol: Feedstocks, Conversion Technologies, Economics, and Policy Options*, and CRS Report R41106, *Meeting the Renewable Fuel Standard (RFS) Mandate for Cellulosic Biofuels: Questions and Answers*.

petroleum products. In addition, proponents argue that rural, agriculture-based energy production can enhance rural incomes and expand employment opportunities, while encouraging greater value-added for U.S. agricultural commodities.[7]

In contrast, critics argue that, in the absence of subsidies, current biofuels production strategies can only be economically competitive with existing fossil fuels at much higher petroleum prices, or if significant improvements in existing technologies are made or new technologies are developed.[8] Until such technological breakthroughs are achieved, critics contend that the subsidies distort energy market incentives and divert research funds from the development of other renewable energy sources, such as solar or geothermal, that offer potentially cleaner, more bountiful alternatives. Still others question the rationale behind policies that promote biofuels for energy security. These critics question whether the United States could ever produce sufficient feedstock of starches, sugars, or vegetable oils to permit biofuels production to meaningfully offset petroleum imports.[9] Finally, some argue that the focus on development of alternative energy sources undermines efforts for greater conservation to reduce energy waste.

Biofuels Defined

Any fuel produced from biological materials—whether burned for heat or processed into alcohol—qualifies as a "biofuel." However, the term is most often used to refer to liquid transportation fuels produced from some type of biomass. Biomass is organic matter that can be converted into energy. Common examples of biomass include food crops, crops for energy (e.g., switchgrass or prairie perennials), crop residues, wood waste and byproducts, and animal manure. The term biomass has been a part of legislation enacted by Congress for various programs over the past 30 years; however, its explicit definition has evolved with shifting policy objectives.[10] Over the last few years, the concept of biomass has grown to include such diverse sources as algae, construction debris, municipal solid waste, yard waste, and food waste. The exact definition of biomass is critical, since it determines which feedstocks qualify for the different biofuels programs. For example, a current point of contention regarding the definition is the inclusion of biomass from federal lands. Some argue that removal of biomass from these lands may lead to ecological harm. Another example involves algae-based biofuels, which presently do not qualify for inclusion under cellulosic biofuels usage mandates, but do qualify for the "advanced other" biofuels mandate.[11] This differentiation may slow or inhibit investments in algae-based biofuels.

[7] Examples of ethanol policy proponents include the Renewable Fuels Association (RFA), the National Corn Growers Association (NCGA), and Growth Energy. Biodiesel proponents include the American Soybean Association and the National Biodiesel Board.

[8] Advocates of this position include free-market proponents such as the Cato Institute, federal budget watchdog groups such as Citizens Against Government Waste, Taxpayers for Common Sense, and farm subsidy watchdog groups such as the Environmental Working Group.

[9] For example, see James and Stephen Eaves, "Is Ethanol the 'Energy Security' Solution?" editorial, Washingtonpost.com, October 3, 2007; or R. Wisner and P. Baumel, "Ethanol, Exports, and Livestock: Will There be Enough Corn to Supply Future Needs?," *Feedstuffs*, no. 30, vol. 76, July 26, 2004.

[10] See CRS Report R40529, *Biomass: Comparison of Definitions in Legislation Through the 111th Congress*.

[11] See CRS Report R42122, *Algae's Potential as a Transportation Biofuel*.

Types of biofuels include ethanol, biodiesel, methanol, and butanol; however, the two principal biofuels are ethanol and biodiesel. Ethanol, or ethyl alcohol, is an alcohol made by fermenting and distilling simple sugars.[12] As a result, ethanol can be produced from any biological feedstock that contains appreciable amounts of sugar or materials that can be converted into sugar such as starch or cellulose. Sugar beets and sugar cane are examples of feedstock that contain sugar. Corn contains starch that can relatively easily be converted into sugar. Trees, grasses, and most agricultural and municipal wastes are made up of a significant percentage of cellulose, which can also be converted to sugar, although with more difficulty than is required to convert starch.

Ethanol from Corn Starch Dominates U.S. Biofuels Production

Since its development in the late 1970s, U.S. biofuels output has relied almost exclusively on ethanol produced from corn starch. Small amounts of ethanol have been produced using sorghum, wheat, barley, and brewery waste. This contrasts with Brazil, the world's second-largest ethanol producer behind the United States, where sugar cane is the principal feedstock. In 2010, the United States and Brazil accounted for 88% of the world's ethanol production.[13] Approximately 13.2 billion gallons of ethanol were produced in the United States in 2010, over 95% from corn starch. Other domestic feedstocks used for ethanol production include grain sorghum and sweet sorghum.

Because of concerns over the significant expansion in corn production for use as an ethanol feedstock, interest has grown in spurring the development of motor fuels produced from cellulosic biomass materials. Since these biomass sources do not compete with traditional food and feed crops for prime cropland, it is thought that their use would result in substantially fewer unintended market effects. However, the technology needed for the conversion of cellulose into its constituent sugars before conversion to biofuels, while successful in laboratory settings, remains expensive and has yet to be replicated on a commercial scale. Many uncertainties remain concerning both the viability and the speed of commercial development of cellulosic biofuels.[14]

After ethanol, biodiesel is the next most significant biofuel in the United States. Biodiesel is an alternative diesel fuel that can be produced from any type of organic-based oil, including vegetable oils, animal fats, and waste restaurant grease and oils. In the United States and Brazil, biodiesel was traditionally made from soybean oil. In the European Union, rapeseed oil is the primary feedstock. However, persistently high vegetable oil prices have pushed biodiesel producers to refocus on much cheaper animal fats (especially poultry fat) and tropical palm oil.

Other biofuels with the potential to play a role in the U.S. market include diesel fuel substitutes and other alcohols (e.g., methanol and butanol) produced from biomass. In addition to expanding domestic production of biofuels, there is some interest in expanding imports of sugar-based ethanol—usually produced from sugar cane in Brazil. U.S. sugar-ethanol imports peaked at 660 million gallons in 2006 (including 434 million from Brazil). Recent market factors—U.S. ethanol production approaching the "blend wall", high international sugar prices, lower-than-

[12] See CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*.

[13] According to data from the Renewable Fuel Association, U.S. ethanol production in 2010 was 13.231 billion gallons, Brazil's was 6.922 billion gallons, and the world total was 22.947 billion gallons.

[14] See CRS Report RL34738, *Cellulosic Biofuels: Analysis of Policy Issues for Congress*.

expected sugarcane output in Brazil, and a weak U.S. dollar—have resulted in the United States becoming a net exporter of ethanol during 2010 and 2011.[15]

Biofuels Value Determinants

The value of a biofuel is determined by its end use. Biodiesel's primary use is as a substitute for petroleum-based diesel fuel. Ethanol is primarily used as a substitute for gasoline; however, it has some additional properties (i.e., oxygenate and octane enhancer) that provide value as a gasoline additive. Both ethanol and biodiesel may derive value as an additive to meet federal usage mandates depending on market conditions. A federal usage mandate (referred to as a Renewable Fuel Standard or RFS) was first introduced in 2006 by the Energy Policy Act of 2005 (P.L. 109-58), which required that a gradually increasing minimum volume of biofuel must be blended into the national transportation fuel supply each year.[16]

With respect to ethanol, there is no difference to the end user between corn-starch ethanol and cellulosic ethanol, although their production processes differ substantially in terms of feedstock, technology, and cost. As a result, they both share the same value determinants. In the presence of government policy, demand for ethanol derives from four potential uses:[17]

- as an additive to gasoline to enhance its octane level;
- as an oxygenate to help improve engine combustion and cleaner burning of fuel;
- as an additive to gasoline to meet federally mandated minimum usage requirements under the RFS; or
- as a substitute for gasoline, either blended with gasoline as a fuel extender at low blend levels (e.g., 10% ethanol to 90% gasoline, known as E10), or in pure (E100) or near pure (E85) form in flexible fuel vehicles.

Ethanol's use as an additive for octane or oxygenate purposes occurs primarily at low blend levels of 2% or 3%, and is small relative to the growth in total usage of recent years. When ethanol is being added to enhance engine performance rather than as a fuel extender, it is a complement to gasoline and may potentially capture a price premium over standard gasoline.

Federal policy that mandates the use of a minimum volume of biofuel creates a further source of demand that behaves very much as though ethanol were a fuel additive like an oxygenate or octane enhancer. Demand for biofuels to fulfill a mandate is not based on price, but rather on government fiat. As long as the consumption of biofuels is less than the mandated volume, its use is obligatory. However, when the supply of biofuels exceeds the mandated usage volume, its use is no longer obligatory and it must compete directly in the marketplace with its petroleum-based counterpart. As a result, once they have met their RFS blending mandates, gasoline blenders, seeking to maximize their profits, are very sensitive to ethanol and gasoline price relationships.

Since 2006, when the RFS was first introduced, both ethanol production capacity and supply (production and imports combined) have easily exceeded the federally mandated usage levels

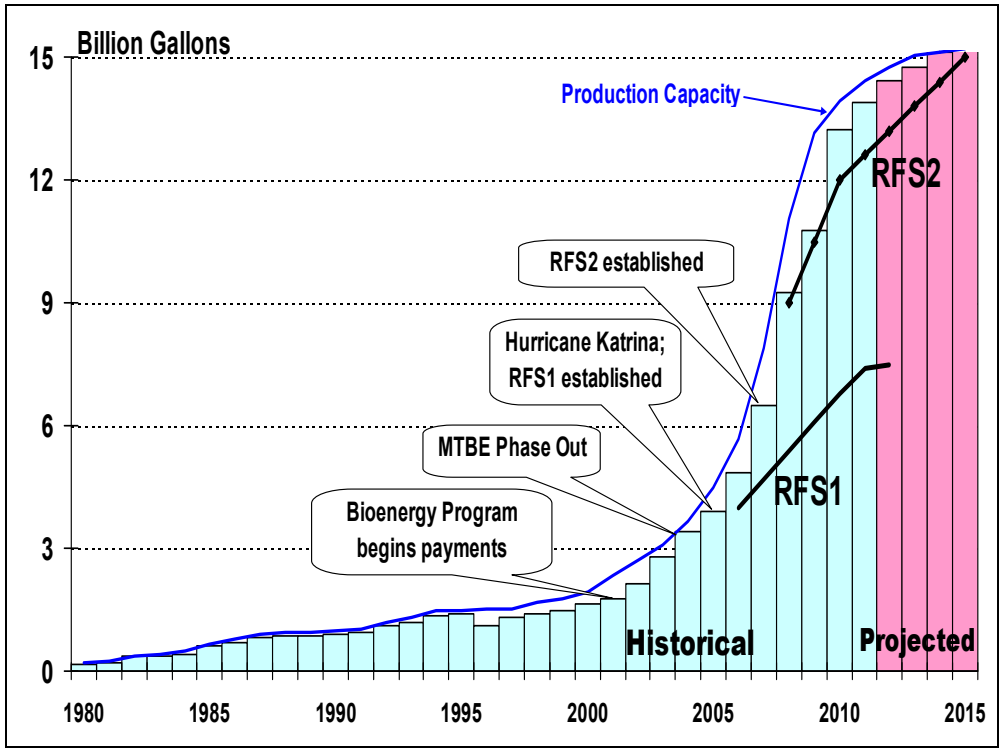
[15] Based on official statistics from the International Trade Commission, Dept. of Commerce.

[16] This is described in greater detail later in this report, in the section titled "Evolution of the U.S. Ethanol Sector."

[17] See CRS Report RL33290, *Fuel Ethanol: Background and Public Policy Issues*.

(**Figure 2**). As a result, ethanol's principal value has been as a transportation fuel (rather than as an additive), where it competes directly with gasoline. Furthermore, since ethanol contains only about 68% of the energy content of gasoline, value-conscious consumers can be expected to willingly pay only about 68% of the price of gasoline for ethanol.

Figure 2. Annual U.S. Ethanol Production, Historical and Projected, 1980 to 2015



Source: 1980-2010, Renewable Fuels Association. Projections for 2011-2015 are from CRS.

Note: RFS2 shown in the chart includes projections for both corn-starch and cellulosic ethanol production.

Evolution of the U.S. Ethanol Sector

Federal Policy Kick-Starts Ethanol Production

Several events contributed to the historical startup and growth of U.S. ethanol production in the late 1970s. First, the global energy crises of the early and late 1970s provided the rationale for a federal policy initiative aimed at promoting energy independence from foreign crude oil sources. In response, the U.S. Congress established a partial exemption for ethanol from the motor fuels excise tax (legislated as part of the Energy Tax Act of 1978). All ethanol blended in the United States—whether imported or produced domestically—was eligible for a $0.40 per gallon tax credit. In 1980, an import duty for fuel ethanol was established by the Omnibus Reconciliation Act of 1980 (P.L. 96-499) to offset the domestic tax credit being applied to foreign-sourced ethanol.

As U.S. ethanol production began to emerge in the 1980s, ethanol became recognized as a gasoline oxygenate. The Deficit Reduction Act of 1984 raised the ethanol tax credit to $0.60 per

gallon.[18] Based on its oxygenate characteristic, provisions of the Clean Air Act Amendments of 1990 (CAAA90) favored ethanol blending with reformulated gasoline (RFG).[19] One of the requirements of RFG specified by CAAA90 was a 2% oxygen requirement, which was met by blending "oxygenates," including methyl tertiary butyl ether (MTBE) and ethanol into the gasoline.[20] Ethanol was the preferred oxygenate in the Midwest where it was produced, while MTBE was used in almost all RFG outside of the Midwest.

In addition to CAAA90 oxygenate requirements, a small ethanol producer tax credit was established in 1990 (Omnibus Budget Reconciliation Act of 1990; P.L. 101-508) as a $0.10 per gallon supplement to the existing ethanol tax credit, but limited to the first 15 million gallons of ethanol produced by ethanol producers with production capacity below 30 million gallons per year.[21] Aided by these events, the U.S. ethanol industry slowly grew during its first two decades—rising from an estimated 175 million gallons in 1980 to 1.8 billion gallons in 2001. By 2001, ethanol production was using about 7% of the U.S. corn crop.

Government Role Has Grown Since 2000

The first decade of the 2000s experienced a substantial increase in federal involvement in the U.S. biofuels sector. In FY2001, the Bioenergy Program[22] began making payments from the U.S. Department of Agriculture's (USDA's) Commodity Credit Corporation (CCC)[23] to eligible biofuel producers—ethanol and biodiesel—based on any year-to-year increases in the quantity of biofuels produced. The Bioenergy Program was instituted by USDA because the program's principal goal was to encourage greater purchases of eligible farm commodities used in the production of biofuels (e.g., corn for ethanol or soybean oil for biodiesel).

The executive order creating the Bioenergy Program was followed by a series of legislation containing various provisions that further aided the U.S. biofuels industry. The first of these, the Biomass Research and Development Act of 2000 (Biomass Act; Title III, P.L. 106-224), contained several provisions to expand research and development in the area of biomass-based renewable fuel production.

The 2002 farm bill (P.L. 107-171) included several biofuels programs spread across three separate titles—Title II: Conservation, Title VI: Rural Development, and Title IX: Energy (the first-ever energy title in a farm bill). Each title contained programs that encouraged the research,

[18] "Ethanol Policy: Past, Present, and Future," by James A. Duffield, Irene M. Xiarchos, and Steve A. Halbrook, *South Dakota Law Review*, Fall 2008.

[19] USDA, Office of Energy Policy and New Uses, *The Energy Balance of Corn Ethanol: An Update*, AER-813, by Hosein Shapouri, James A. Duffield, and Michael Wang, July 2002.

[20] "Status and Impact of State MTBE Ban," Energy Information Administration (EIA), U.S. Dept. of Energy (DOE), revised March 27, 3003; available at http://www.eia.doe.gov/oiaf/servicerpt/mtbeban/.

[21] The 30 million gallon threshold was extended to 60 million gallons by the Energy Policy Act of 2005 (P.L. 109-58).

[22] The Bioenergy Program was initiated on August 12, 1999, by President Clinton's Executive Order 13134. On October 31, 2000, then-Secretary of Agriculture Glickman announced that, pursuant to the executive order, $300 million of Commodity Credit Corporation (CCC) funds ($150 million in both FY2001 and FY2002) would be made available to encourage expanded production of biofuels.

[23] The CCC is a U.S. government-owned and -operated corporation, created in 1933, with broad powers to support farm income and prices and to assist in the export of U.S. agricultural products. Toward this end, the CCC finances USDA's domestic price and income support programs and its export programs using its permanent authority to borrow up to $30 billion at any one time from the U.S. Treasury.

production, and use of renewable fuels such as ethanol, biodiesel, anaerobic digesters, and wind energy systems. In addition, Section 9010 of Title IX codified and extended the Bioenergy Program and its funding by providing that $150 million would be available annually through the CCC for FY2003-FY2006.[24]

The Healthy Forests Restoration Act of 2003 (P.L. 108-148) amended the Biomass Act of 2000 by expanding the use of grants, contracts, and assistance for biomass to include a broader range of forest management activities. It also expanded funding availability of programs established by the Biomass Act and the 2002 farm bill, and it established a program to accelerate adoption of biomass-related technologies through community-based marketing and demonstration activities, and to establish small-scale businesses to use biomass materials.

The American Jobs Creation Act of 2004 (P.L. 108-357) contained a provision (Section 301) that replaced the existing tax exemptions for alcohol fuels (i.e., ethanol) with an excise tax credit of $0.51 per gallon. This act also extended the small ethanol producer tax credit.

In addition to a growing list of federal and state policies, the U.S. biofuels industry received an additional boost in the early 2000s with the emergence of water contamination problems associated with MTBE in several locations scattered throughout the country. MTBE was thought to be a possible carcinogen and, as a result, posed serious health and liability issues. In 1999, California (which, at the time, consumed nearly 32% of MTBE in the United States) petitioned the U.S. Environmental Protection Agency (EPA) for a waiver of the CAAA90 oxygenate requirement.[25] However, California's waiver request was denied by the EPA in mid-2001 since the EPA determined that there was sufficient ethanol production available to replace MTBE.

By 2003, legislation that would phase out or restrict the use of MTBE in gasoline had been passed in 16 states, including California and New York (with a combined 40% national MTBE market share).[26] Between October 1, 2003, and January 1, 2004, over 43% of MTBE consumption in the United States was banned. According to the EIA, the state MTBE ban would require an additional demand for ethanol of 2.73 billion gallons in 2004.

With the legislative boosts and the MTBE phase-out, investments in the biofuels sector began to show results. The number of plants producing ethanol grew from 50 on January 1, 1999, to 81 by January 1, 2005. Concomitantly, U.S. ethanol production began to accelerate, rising to 3.9 billion gallons by 2005 and using over 14% of the nation's corn crop (**Figure 2**, **Figure 3**, and **Table 1**).

The Ethanol Industry's Perfect Storm in 2005

On the heels of the large MTBE phase-out that occurred in 2004 and the surge in ethanol demand, two major events coincided in 2005 to produce extremely favorable economic conditions in the U.S. ethanol sector that persisted through most of 2006. These events included the following.

- The Energy Policy Act of 2005 (EPACT; P.L. 109-58) was signed into law on August 8, 2005. EPACT contained several provisions related to agriculture-based

[24] The Bioenergy Program was phased out at the end of FY2006.

[25] "Status and Impact of State MTBE Ban," Energy Information Administration (EIA), U.S. Dept. of Energy (DOE), revised March 27, 3003; available at http://www.eia.doe.gov/oiaf/servicerpt/mtbeban/.

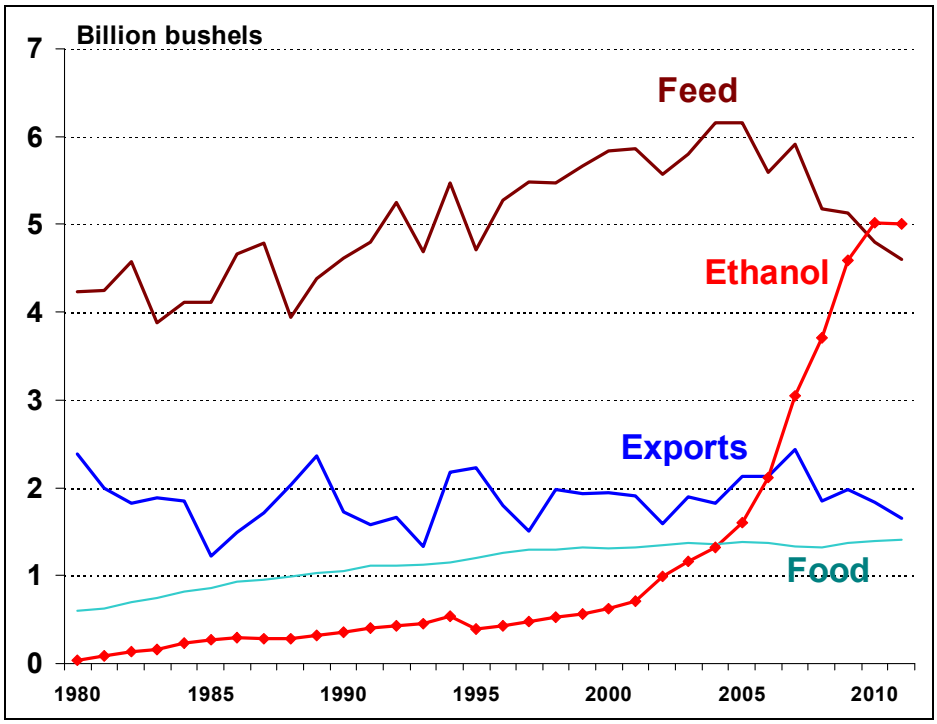
[26] Ibid.

renewable energy production, including biofuels research and funding, expansions of existing biofuels tax credits and creation of new credits, and the creation of the first-ever national minimum-usage mandate, the Renewable Fuels Standard (RFS1; Section 1501), which required that 4 billion gallons (bgals) of ethanol be used domestically in 2006, increasing to 7.5 bgals by 2012.

- In August and September, Hurricanes Katrina and Rita struck the Gulf Coast region, causing severe damage to Gulf Coast petroleum importing and refining infrastructure, putting them off-line for several months, and driving petroleum product prices sharply higher. Meanwhile, corn prices remained relatively low at about $2 per bushel, creating a period of extreme profitability for the sector.

The combination of high ethanol prices and low corn prices that persisted in 2006 created a period of "unique" profitability for the U.S. ethanol industry. At that time, a 40 million gallon nameplate ethanol plant costing approximately $60 million could recover its entire capital investment in less than a year of normal operations.[27] In addition, the establishment of the first RFS—by guaranteeing a market for new ethanol production—removed much of the investment risk from the sector.

Figure 3. Annual U.S. Corn Use by Major Activity, 1980 to 2011



Source: USDA, Production, Supply, and Distribution (PSD) database, January 12, 2012.

Notes: Feed includes a residual category to balance USDA supply and demand estimates.

[27] Based on CRS simulations of an ethanol dry mill spreadsheet model developed by D. Tiffany and V. Eidman in *Factors Associated with Success of Fuel Ethanol Producers*, Staff Paper P03-7, Dept of Applied Economics, University of Minnesota, August 2003. Note, nameplate capacity represents the capacity that the design engineers will warrant. In most cases, an efficiently run plant will operate in excess of its nameplate capacity.

Table 1. U.S. Corn-Use Share of Annual Production by Major Activity, 1980 to 2011

Crop Year	Ethanol	Food	Exports	Feed
1980	1%	9%	36%	58%
1985	3%	10%	14%	63%
1990	4%	13%	22%	59%
1995	5%	14%	26%	55%
2000	6%	13%	20%	60%
2005	14%	12%	19%	55%
2010	38%	11%	14%	37%
2011	40%	11%	13%	36%

Source: Calculations are by CRS from USDA, PSD database, January 12, 2012.

Note: Values may sum to greater than 100% because some usage may derive from carryover stocks.

As a result of this "perfect storm" of policy and market events, investment money flowed into the construction of new ethanol plants, and U.S. ethanol production capacity (either in existence or under construction) more than doubled in just two years, rising from an estimated 4.4 bgals produced in 81 plants in January 2005 to 11.1 bgals produced in 110 plants by January 2007. The ethanol expansion was almost entirely in dry-mill corn processing plants. As a result, corn's role as the primary feedstock used in ethanol production in the United States continued to grow. In 2006, corn use for ethanol nearly matched U.S. corn exports at about 2.1 billion bushels. In 2007, U.S. corn exports hit a record 2.4 billion bushels; however, corn-for-ethanol use jumped to over 3 billion bushels. For the first time in U.S. history, the bushels of corn used for ethanol production would be greater than the bushels of corn exported (**Figure 3**).

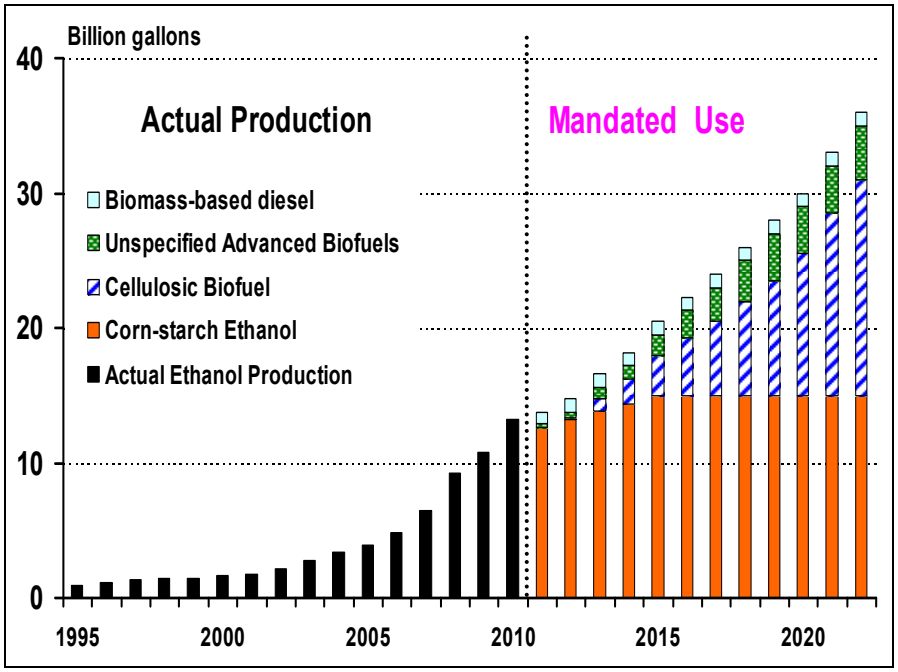
EISA Greatly Expands Mandate, Shifts Focus to Cellulosic Biofuels

In light of the rapid expansion of the U.S. biofuels industry, the RFS1 mandate was quickly outgrown in 2006 (**Figure 2**). On December 19, 2007, Congress dramatically raised the "bar" by passing the Energy Independence and Security Act of 2007 (EISA, P.L. 110-140).[28] EISA superseded and greatly expanded EPACT's biofuels mandate relative to historical production (**Figure 4**).

The expanded RFS (referred to as RFS2) required the use of 9 bgals of biofuels in 2008 and expanded the mandate to 36 bgals annually in 2022. The new mandate had some provisos, foremost of which was that only 15 bgals of RFS-qualifying biofuels could be ethanol from corn starch. In addition, all increases in the RFS mandate from 2016 onwards must be met by advanced biofuels (i.e., non-corn-starch biofuels) and no less than 16 bgals must be derived from cellulosic feedstock in 2022. In addition, the new mandate established by EISA carved out specific volume requirements for biomass-based diesel fuels.

[28] See CRS Report R40155, *Renewable Fuel Standard (RFS): Overview and Issues*.

Figure 4. Renewable Fuels Standard (RFS2) vs. U.S. Ethanol Production Since 1995



Sources: Actual ethanol production data for 1995-2010 is from Renewable Fuels Association; data for RFS2 mandates is from EISA (P.L. 110-140). Data includes revisions to RFS2 cellulosic mandates for 2011 and 2012.

Meanwhile, prices for many agricultural commodities—including nearly all major U.S. program crops—started a steady upward trend in late 2006. Then, in early 2007, the upward trend for commodity prices turned into a steep rise. By mid-2008 market prices for several agricultural commodities had reached record or near-record levels (**Figure 5**).[29] In particular, both corn and crude oil hit record high prices in both spot and futures markets, thus symbolizing the growing linkage between U.S. field crops and energy markets.[30] The upward rise in the price of corn in 2007 and early 2008 sucked the profits out of the U.S. biofuels sector and put the brakes on new investment. It also fueled a "food-versus-fuel" debate about the potential for continued expansion in corn use for ethanol to have unintended consequences in other agricultural and environmental markets. While most economists and market analysts agreed that the dramatic price rise of 2008 was due to factors other than biofuels policy, they also are nearly universally agreed that the strong, steady growth in ethanol demand for corn has had an important price effect, not just on the price of corn, but in other agricultural markets including food, feed, fuel, and land.

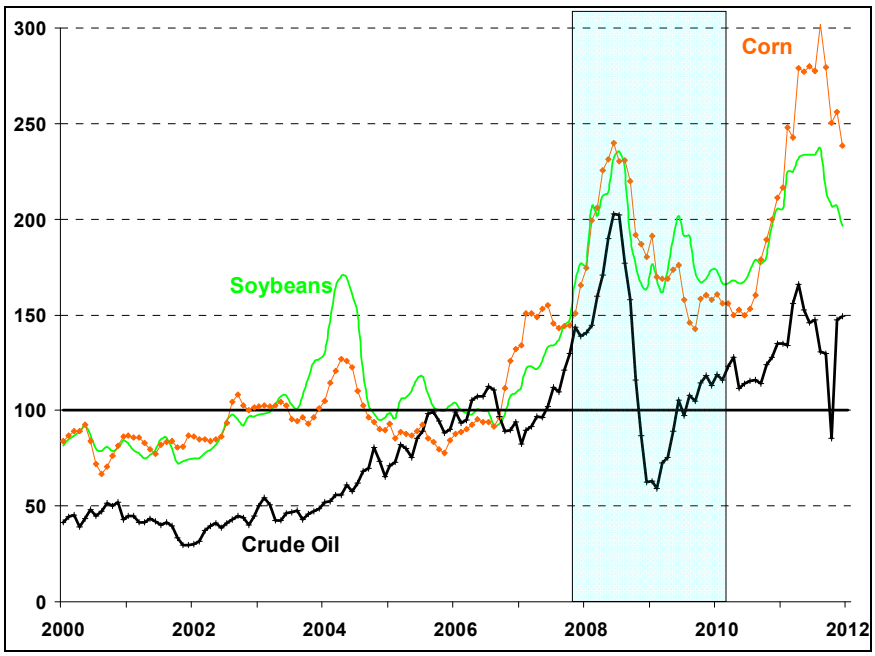
By mid-2008, the commodity price rise had completely reversed itself and turned into a near free-fall, coinciding with the financial crisis that broke in late 2008. The extreme price volatility created many difficulties throughout the marketing chain for agricultural buyers and sellers. The experience of $7.00-per-bushel corn, albeit temporary, shattered the idea that biofuels were a panacea for solving the nation's energy security problem and left concerns about the potential for unintended consequences from future biofuels expansion.

[29] For more information about markets during this period, see CRS Report RL34474, *High Agricultural Commodity Prices: What Are the Issues?* See also, "What Is Driving Food Prices," by Philip C. Abbott, Christopher Hurt, and Wallace E. Tyner, Farm Foundation, July 2008; hereinafter referred to as Abbott et al., 2008.

[30] On June 23, 2008, the nearby futures contract for No. 2, yellow corn hit a record $7.65 per bushel on the Chicago Board of Trade. On July 7, 2008, the nearby futures contract for Crude Oil hit $147.27 per barrel at the New York Mercantile Exchange, while the nearby Brent Crude Oil contract hit $147.50 at the ICE Futures Europe exchange.

Figure 5. Monthly Farm Prices for Corn, Soybeans, and Crude Oil, 2000 to 2011

(Index: 2006 = 100)



Sources: Corn and soybean prices are monthly average farm prices, National Agricultural Statistics Service (NASS), USDA; crude oil is the spot price, f.o.b., for West Texas Intermediate, Cushing, OK, EIA, DOE.

Notes: To facilitate comparison of relative price movements, the monthly prices have been converted to an index where the 12-month average for calendar 2006 has been set to 100.

2008 Farm Bill Reinforces Focus on Cellulosic Biofuels

The 2008 farm bill (Food, Conservation, and Energy Act of 2008; P.L. 110-246) extended and expanded many existing biofuels programs.[31] In particular, Title XV ("Trade and Tax Provisions") extended the biofuels tax incentives and the tariff on ethanol imports, although the tax credit for corn-starch ethanol was reduced to $0.45 per gallon. But in the wake of the commodity market price run-up of early 2008, the new farm bill also re-emphasized EISA's policy shift towards research and development of advanced and cellulosic bioenergy in an effort to avoid many of the unintended consequences of relying too heavily on major field crops as the principal biomass feedstock. In addition, it established a new tax credit of $1.01 per gallon for cellulosic biofuel.

Like the 2002 farm bill, it contained a distinct energy title (Title IX) that covers a wide range of energy and agricultural topics with extensive attention to biofuels, including corn starch-based ethanol, cellulosic ethanol, and biodiesel. Energy grants and loans are provided through initiatives such as the Bioenergy Program for Advanced Biofuels to promote the development of cellulosic biorefinery capacity. The Repowering Assistance Program supports increasing efficiencies in existing refineries. Programs such as the Rural Energy for America Program (REAP) assist rural communities and businesses in becoming more energy-efficient and self-sufficient, with an emphasis on small operations. Cellulosic feedstocks—for example, switchgrass and woody biomass—are given high priority both in research and funding. The Biomass Crop Assistance

[31] See CRS Report R41985, *Renewable Energy Programs and the Farm Bill: Status and Issues*.

Program (BCAP), the Biorefinery Assistance Program, and the Forest Biomass for Energy Program provide support to develop alternative feedstock resources and the infrastructure to support the production, harvest, storage, and processing of cellulosic biomass feedstocks.

Title VII, the research title of the 2008 farm bill, contains numerous renewable-energy-related provisions that promote research, development, and demonstration of biomass-based renewable energy and biofuels. One of the major policy issues debated prior to the passage of the 2008 farm bill was the impact of the rapid, ethanol-driven expansion of U.S. corn production. This issue was made salient by the dramatic surge in commodity prices experienced in 2007 and early 2008. In partial consideration, the enacted bill requires reports on the economic impacts of ethanol production, reflecting concerns that the increasing share of corn production being used for ethanol contributed to high commodity prices and food price inflation.

Questions Emerge Concerning Rapid Biofuels Expansion

By 2009, more than half of all U.S. gasoline contained some ethanol (mostly blended at the 10% level or lower). U.S. ethanol consumption in 2011 is estimated at 13.8 billion gallons (bgals), which was blended into roughly 138 bgals of gasoline—this represents about 10% of annual gasoline demand on a volume basis, and 7% on an energy basis. With national gasoline consumption stagnant (following the financial crisis of 2008 and ensuing economic recession), ethanol production may have reached the 10% ethanol-to-gasoline blend wall (described later in this report).[32]

Meanwhile, robust economic growth in major global markets in 2010 and early 2011 (including China, India, Brazil, and other parts of Asia and the Middle East) reinvigorated international consumer demand and, when coupled a weak U.S. dollar and events that occurred in international feed grain markets—drought in Russia, Kazakhstan, and the Ukraine in 2010, plus strong Chinese demand for corn and feedstuffs—contributed to record U.S. agricultural export values in 2010 and 2011.[33] U.S. ethanol production in 2010 consumed 40% of the U.S. corn crop, surpassed corn-for-feed use for the first time in history (**Figure 3**), and contributed to near historic low ending stock projections (relative to expected demand) for U.S. corn and soybean for 2010 and 2011.[34] These market conditions helped to spur another surge in agricultural commodity prices starting in mid-2010 (**Figure 5**), thus spreading the effects of rapidly expanding ethanol production and corn demand across several other sectors of the U.S. economy as well.

In the long term, the expanded RFS2 is likely to play a dominant role in the development of the U.S. biofuels sector, but with considerable uncertainty regarding spillover effects in other markets and on other important policy goals.[35] Emerging resource constraints have provoked questions about corn-based ethanol's long-run sustainability and the possibility of unintended consequences in other markets as well as on the environment.

[32] See CRS Report R40445, *Intermediate-Level Blends of Ethanol in Gasoline, and the Ethanol "Blend Wall."*

[33] USDA, ERS, *Outlook for U.S. Agricultural Trade*, AES-72, November 30, 2011.

[34] For more information on this and other market factors, see CRS Report R41956, *U.S. Livestock and Poultry Feed Use and Availability: Background and Emerging Issues* .

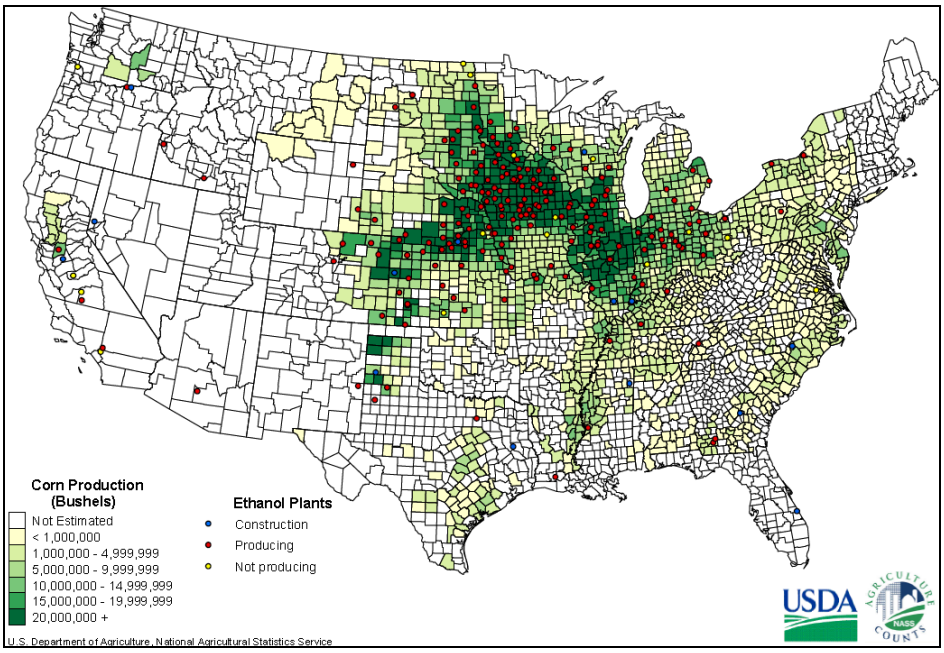
[35] See CRS Report R40155, *Renewable Fuel Standard (RFS): Overview and Issues*.

By late 2011, policy makers and the U.S. biofuels industry were confronted by questions regarding the ability to meet the expanding mandate for biofuels from non-corn sources such as cellulosic biomass materials, whose production capacity has been slow to develop,[36] or biomass-based diesel, which remains expensive to produce owing to the relatively high prices of its feedstocks. In addition, despite plentiful production, domestic consumption of corn ethanol appeared to be increasingly stymied by the "blend wall" (described later in this report). Finally, considerable uncertainty remains regarding the development of the infrastructure capacity (e.g., trucks, pipelines, pumps, etc.) needed to deliver the expanding biofuels mandate to consumers.

Ethanol Production Capacity Centered on Corn Belt

As of January 10, 2012, U.S. ethanol production was underway or planned in 209 plants located in 28 states based primarily around the central and western Corn Belt, where corn supplies are most plentiful (**Figure 6** and **Table 2**). Existing U.S. ethanol plant capacity was estimated at 14.797 billion gallons per year (BGPY), with another 0.025 BGPY of capacity under construction (either as new plants or expansion of existing plants). Thus, total annual U.S. ethanol production capacity in existence or under construction was about 14.8 BGPY, well in excess of the 13.2 bgals RFS2 mandate for corn-starch ethanol in 2012 (**Figure 2**).

Figure 6. U.S. Ethanol Production Capacity Is Centered on the Corn Belt



Source: USDA; U.S. corn production for 2010 compared with ethanol plant locations as of March 3, 2011; available at http://www.nass.usda.gov/Charts_and_Maps/Ethanol_Plants/U._S._Ethanol_Plants/index.asp.

Iowa is by far the leading ethanol-producing state, with a 27% share of total U.S. output. The top six Corn Belt states of Iowa, Nebraska, Illinois, Minnesota, Indiana, and South Dakota account for nearly 73% of national production (**Table 2**). On a national level, actual operating capacity of

[36] See CRS Report R41106, *Meeting the Renewable Fuel Standard (RFS) Mandate for Cellulosic Biofuels: Questions and Answers*.

14.2 BGPY represents about 96% of nameplate capacity. However, several states including Nebraska, Minnesota, Indiana, Kansas, Ohio, and the "other" category of states are operating substantially below their nameplate capacity, suggesting that industry profitability varies by geographic circumstance, primarily due to variations in feedstock cost and availability, with current circumstances favoring producers located near ample corn supplies.

Table 2. U.S. Ethanol Output and Production Capacity by State

Rank	State	# of Plants	Operating Production			Current Nameplate Capacity (MGPY)	Under Contr. or Expansion (MGPY)
			MGPY	% of output	Cum % output		
1	Iowa	39	3,864	27.2%	27.2%	3,864	—
2	Nebraska	26	1,701	12.0%	39.2%	1,803	—
3	Illinois	13	1,352	9.5%	48.7%	1,395	—
4	Minnesota	22	1,207	8.5%	57.2%	1,225	—
5	Indiana	14	1,141	8.0%	65.2%	1,162	—
6	S. Dakota	15	1,032	7.3%	72.5%	1,032	—
7	Wisconsin	9	504	3.5%	76.0%	504	—
8	Ohio	7	478	3.4%	79.4%	538	—
9	N. Dakota	6	460	3.2%	82.6%	470	—
10	Kansas	13	437	3.1%	85.7%	496	25
11	Texas	4	355	2.5%	88.2%	355	—
12	Michigan	5	268	1.9%	90.1%	268	—
13	Missouri	5	251	1.8%	91.9%	251	—
14	Tennessee	2	225	1.6%	93.5%	225	—
15	Colorado	4	125	0.9%	94.3%	125	—
	Others	25	804	5.7%	100%	1,084	—
U.S. Total		**209**	**14,203**	**100%**		**14,797**	**25**

Source: Renewable Fuels Association as of January 10, 2012; state-level aggregations are by CRS.

Note: Output and production capacity data are in million gallons per year (MPGY).

Evolution of the U.S. Biodiesel Sector

Biodiesel can be produced from any animal fat or vegetable oil (such as soybean oil or recycled cooking oil). Historically, most U.S. biodiesel was made from soybean oil. However, with the rise in soybean prices since 2007 (**Figure 5**), biodiesel producers have aggressively shifted to cheaper vegetable oils and animal fats (especially poultry fat) such that by 2011 less than half of U.S. biodiesel production was estimated to be based on soybean oil.

According to the National Biodiesel Board (NBB), biodiesel is nontoxic, biodegradable, and essentially free of sulfur and aromatics. In addition, it works in any diesel engine with few or no modifications and offers similar fuel economy, horsepower, and torque, but with superior

lubricity and important emission improvements over petroleum diesel.[37] Biodiesel is used almost uniquely as a substitute for petroleum diesel. Biodiesel delivers slightly less energy than petroleum diesel (about 92%). As a result, fuel blenders and consumers are very sensitive to price differences between biodiesel and petroleum-based diesel. The price relationship between vegetable oils and petroleum diesel is the key determinant of profitability in the biodiesel industry. About 7.5 pounds of vegetable oil are used in each gallon of biodiesel. Because soybean oil has traditionally been the primary feedstock for biodiesel, U.S. soybean producers and the American Soybean Association (ASA) are strong advocates for greater government support for biodiesel production.

U.S. Biodiesel Industry Starts Late, Grows Slowly

The U.S. biodiesel industry did not emerge until the late 1990s. Despite strong growth in the 2000s, U.S. biodiesel consumption remains small relative to national diesel consumption levels. In 2011 (**Figure 1**), U.S. biodiesel consumption represented about 2% (in diesel-equivalent units) of national diesel transportation fuel use of about 40.7 billion gallons.[38] Because biodiesel and diesel fuel are so similar, biodiesel can also be used for the same non-transportation activities. In 2011, 54.7 billion gallons of diesel fuel were used for heating and power generation by residential, commercial, and industry, and by railroad and vessel traffic, bringing total U.S. diesel fuel use to nearly 102 billion gallons (including 6.5 billion gallons of residual fuel oil).

U.S. biodiesel production grew slowly from under 1 million gallons in 1999 to an estimated 678 million gallons in 2008 (**Figure 7**), before falling back substantially in 2009 and 2010. Bioenergy Program payments provided an initial impetus for plant investments from 2001 through 2006. The American Jobs Creation Act of 2004 (P.L. 108-357) created the first ever federal biodiesel tax incentive—a federal excise tax and income tax credit of $1.00 for every gallon of agri-biodiesel (i.e., virgin vegetable oil and animal fat) that was used in blending with petroleum diesel; and a $0.50 credit for every gallon of non-agri-biodiesel (i.e., recycled oils such as yellow grease). The distinction between biodiesel from virgin and recycled oils was eventually removed (P.L. 110-343; October 3, 2008), and all biodiesel qualified for the credit of $1.00 per gallon until its expiration on December 31, 2011.

In 2005 the U.S. biodiesel industry received a major economic boost from the same series of market and policy developments described earlier in the ethanol section of this report.[39] The Energy Policy Act of 2005 extended the biodiesel tax credit and established a Small Agri-Biodiesel Producer Credit of $0.10 per gallon on the first 15 million gallons of biodiesel produced from plants with production capacity below 60 million gallons per year.

Biomass-based diesel was not part of the initial biofuels RFS1 mandate under the Energy Policy Act of 2005, but was included as a distinct category in the RFS2 created under EISA of 2007. The RFS2 biomass-based diesel mandate for 2009 was 500 million gallons. However, since EPA did not have rules in place to operate that portion of the RFS in 2009, the mandate took effect for the first time in 2010 under a special one-time arrangement whereby the biomass-based diesel RFS

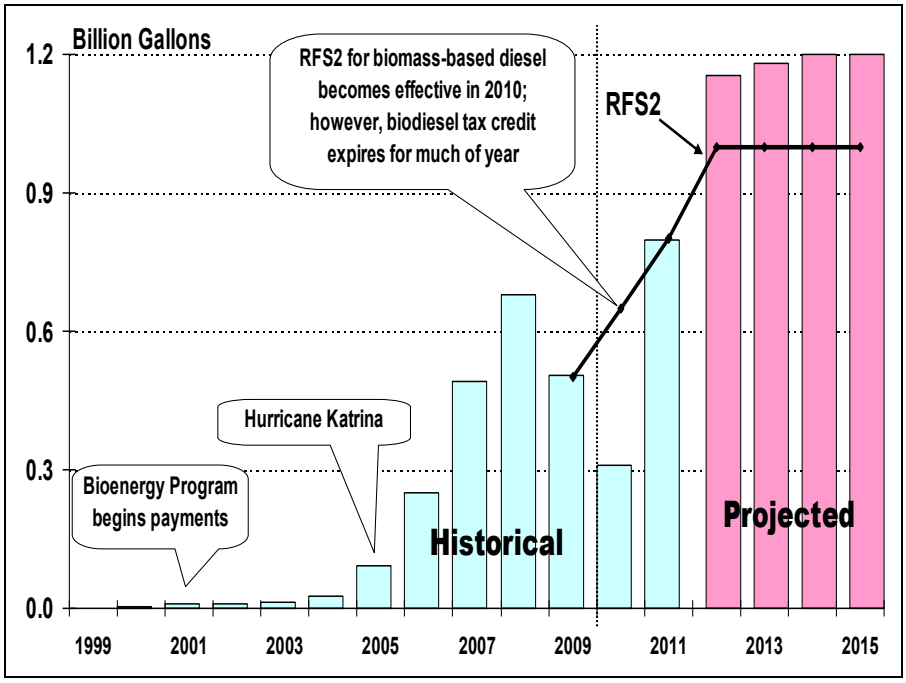
[37] For more information, visit the NBB at http://www.biodiesel.org.

[38] EIA, DOE; biodiesel production estimates from "Annual Energy Outlook 2011," Transportation Sector Energy Use by Mode and Type, Reference Case.

[39] See section "The Ethanol Industry's Perfect Storm in 2005."

for 2009 was combined with the 2010 mandate (of 650 million gallons) into a single RFS of 1,150 million gallons for 2010. In 2011, the mandate returns to its original trajectory of 800 million gallons, rising to 1 billion gallons in 2012. While most or all of this mandate is expected to be met using biodiesel, other fuels, including renewable diesel,[40] algae-based diesel, or cellulosic diesel, would also qualify.

Figure 7. Annual U.S. Biodiesel Production, 1999 to 2015



Source: Data for 1999-2010, Energy Information Agency (EIA), Dept. of Energy (DOE). Projections for 2011-2015 are from CRS.

Notes: Although the RFS2 mandate for biodiesel was to begin in 2009, implementation rules were not available until February 2010. As a result, the RFS2 mandate for 2009 of 500 million gallons was combined with the 2010 mandate of 650 million gallons for a one-time mandate of 1.15 billion gallons in 2010.

Starting in mid-2007, the U.S. biodiesel industry suffered from unfavorable market conditions as prices for vegetable oil rose relative to diesel fuel. Most biodiesel plants continued to operate into 2008 in hopes of either higher diesel prices or lower vegetable oil prices, and the industry produced record output of an estimated 678 million gallons.[41] However, the financial crisis of late 2008 and the ensuing economic recession weakened demand for transportation fuel, and petroleum prices (including diesel fuel) fell sharply in the second half of 2008. In March 2009, the European Union (EU) imposed anti-dumping and countervailing duty tariffs on imports of U.S. biodiesel (described later) that effectively shut down U.S. biodiesel exports to the EU.[42]

[40] While similar to "biodiesel," "renewable diesel" is produced through different processes and results in a fuel with somewhat different chemical characteristics. There is a separate tax credit of $1.00 per gallon for renewable diesel.

[41] DOE, EIA, *Monthly Biodiesel Production Report*, March 2009.

[42] "EU Imposes Five-Year AD, CVD Duties on U.S. Biodiesel," *Inside U.S. Trade*, July 7, 2009.

As a result, the biodiesel industry experienced several bankruptcies and some loss of capacity during 2009. U.S. biodiesel production in 2009 fell to 506 million gallons,[43] down over 25% from 2008. The unfavorable economic conditions for biodiesel production extended into 2010 and were made worse by the expiration of the biodiesel tax credit at the end of 2009. The tax credit was eventually renewed on December 17, 2010 (P.L. 111-312), and made available retroactively to all 2010 biodiesel production; however, the extended delay and poor market conditions contributed to substantially reduced U.S. biodiesel production of 311 million gallons in 2010. During 2010, the U.S. biodiesel industry saw 52 out of 170 operating plants stop operations while many others scaled back on production.[44] The renewal of the tax credit and the expanded RFS2 biodiesel usage mandate of 800 million gallons in 2011 revived the industry and spurred a projected record production of 800 million gallons in 2011.

Two factors are expected to support biodiesel production at or above 1 billion gallons starting in 2012 and going forward: first, the RFS2 biodiesel mandate grows to 1 billion gallons in 2012 and 1.28 billion in 2013; second, the RFS2 for advanced biofuels (for which biodiesel is a qualifying fuel) grows even faster, with 2 billion gallons in 2012 rising to 21 billion gallons by 2022. Although cellulosic biofuel was originally envisioned to fill most of the advanced biofuel mandate, slow progress in commercial production to date suggests that biodiesel may be used to meet at least a portion of the advanced biofuel mandate in the future.

Biodiesel Production Capacity Spreads Nationwide

As mentioned earlier, the primary feedstock for biodiesel includes both vegetable oils and animal fats, both of which are produced over a greater geographic area than corn. As a result, biodiesel plants are more widely dispersed across the United States than are ethanol plants (**Table 3**). According to the National Biodiesel Board (NBB), as of January 17, 2012, there were 148 companies in the United States with the potential to produce biodiesel commercially that were either in operation or idled, with total annual production capacity (within the oleochemical industry) of 1.426 billion gallons per year. Because many of these plants also can produce other products such as cosmetics, estimated total capacity (and capacity for expansion) is far greater than actual biodiesel production.

The unfavorable economic conditions of 2009 and 2010, coupled with the delay in extending the biodiesel tax credit in 2010, contributed to a substantial shake-up in the biodiesel industry. Many plants situated in the heart of corn and soybean country dropped out of business, while new plants sprang up in locations near alternate vegetable or animal oil sources. As a result, the U.S. biodiesel industry is more diversified and less centralized than the ethanol industry. Unlike ethanol, where the top six producing states account for 73% of national capacity, the top six biodiesel-producing states achieve only a 51% share, thus demonstrating the more widespread nature of U.S. biodiesel production capacity.

[43] Energy Information Administration (EIA), DOE.

[44] "Tax Credits, Mandates Bring Back Biodiesel Plants," *Energy & Environmental New*, September 19, 2011.

Table 3. U.S. Biodiesel Production Capacity Partial Estimate as of January 12, 2012

Rank	State	# of Plants	Production Capacity (MGY)	% of output	Cum % output
1	Missouri	8	195.5	13.7%	13.7%
2	Washington	5	130.0	9.1%	22.8%
3	Texas	13	122.8	8.6%	31.4%
4	Iowa	11	112.0	7.9%	39.3%
5	Indiana	4	85.8	6.0%	45.3%
6	N. Dakota	1	85.0	6.0%	51.3%
7	Ohio	3	65.0	4.6%	55.8%
8	South Carolina	3	65.0	4.6%	60.4%
9	Pennsylvania	7	61.6	4.3%	64.7%
10	Kentucky	4	60.8	4.3%	69.0%
11	California	11	57.8	4.0%	73.0%
12	Arkansas	2	50.0	3.5%	76.5%
13	Alabama	3	45.0	3.2%	79.7%
14	Georgia	7	37.1	2.6%	82.3%
15	Oklahoma	2	35.0	2.5%	84.7%
	Others	64	217.9	15.3%	100%
U.S. Total		**148**	**1,426.1**	**100%**	

Source: National Biodiesel Board (NBB), http://www.biodiesel.org/buyingbiodiesel/plants/showall.aspx. State-level aggregations are by CRS.

Notes: This list is limited to members of the NBB. As a result, the total biodiesel production capacity of 1.4 bgals is a lower bound on actual national production capacity.

U.S. Retail Delivery Infrastructure and Vehicle Fleet

A key determinant of the demand for biofuels as a transportation fuel is the U.S. vehicle fleet and the infrastructure that delivers fuel to consumers at the retail level. According to the Department of Energy (DOE), over three-fourths of U.S. transportation fuel is consumed as gasoline or gasoline blends (**Figure 1**). The U.S. Department of Transportation (DOT) estimated that there were 254.2 million registered passenger vehicles (including trucks and buses) in the United States in 2009.

Because of its physical properties, pure ethanol cannot be used in the same infrastructure (e.g., pipelines, storage tanks, service pumps) used to deliver retail gasoline. In the past, conventional thinking was that standard motor vehicles were not intended for ethanol blend ratios above 10%, as ethanol tends to make the engine run at a higher temperature than standard reformulated gasoline. In addition, the presence of ethanol can be corrosive on rubber and plastic parts in the car engine.

As a result, prior to October 2010, the amount of ethanol that could be blended in gasoline for use in standard vehicle motors without modification was limited to 10% by volume, by guidance

developed by the EPA under the Clean Air Act, as well as by vehicle and engine warranties, and certification procedures for fuel-dispensing equipment. In addition, most vehicle warranties did not cover any motor damage resulting from use of ethanol blends above 10%. In the past, only flex-fuel vehicles (FFVs) have been capable of using higher ethanol blends.

Regional infrastructure issues suggest that the actual limiting value is something less than the 13.8 bgals implied by the 10% blending limitation. This "blending-limited" volume is often referred to as the "blend wall."[45]

However, recent EPA rulings have expanded the eligible vehicle pool for ethanol blends greater than 10%. In October 2010, EPA ruled that 15% ethanol blends could be used in 2007 model year or newer passenger vehicles (including cars, SUVs, and light pickup trucks). Then, on January 21, 2011, EPA further expanded the eligible passenger vehicle pool to include model years 2001 through 2006. Despite this expansion, the fact that a portion of currently active passenger vehicles are not eligible for E15 both limits ethanol retail delivery opportunities and raises the cost of delivery. In contrast, biodiesel is very similar in nature to petroleum diesel and does not have the same infrastructure limitations.

Flex-Fuel vs. Standard Ethanol-Gasoline Blend Vehicles

Ethanol has traditionally been blended into gasoline at the 10% level (E10) or lower, where it can be used in vehicles with standard motors. It has also been sold in purer forms such as E85 (85% ethanol and 15% gasoline) targeted for flex-fuel vehicles (FFVs) with motors specially designed for higher ethanol content. However, E85 presently represents less than 1% of U.S. ethanol consumption.[46] Its wider distribution and use is limited by the number of filling station pumps capable of dispensing E85, the number of FFVs in the United States, and the willingness of consumers to use the fuel.

In 2011, ethanol blending as a share of the national gasoline supply reached 10% on a volume basis.[47] In many urban retail fuel stations, pure gasoline is no longer available. Instead, gasoline fuel pumps are labeled as containing "up to a 10% blend of ethanol." In these situations, ethanol is treated as indistinguishable from gasoline by consumers.

In 2012, as much as 14.2 bgals of ethanol are mandated under the RFS for use in the nation's gasoline supply (including 13.2 bgals of corn-starch ethanol, 8.5 million gallons of cellulosic ethanol, and potentially another 1.0 bgals of "other" advanced biofuel). The combined level of mandated biofuels represents a 10.4% volumetric share of the projected 138.4 bgals of U.S. gasoline consumption for 2012.

[45] See CRS Report R40445, *Intermediate-Level Blends of Ethanol in Gasoline, and the Ethanol "Blend Wall."*

[46] The most recent EIA, DOE, data on E85 consumption is from 2008, when 62.5 million gallons of E85 were consumed out of about 137.6 billion gallons of blended gasoline.

[47] Calculated by CRS as 13.8 bgals of ethanol out of approximately 137.7 bgals of gasoline and ethanol consumed.

Ruling on the Ethanol-to-Gasoline Blending Limit: 10% vs. 15%[48]

For ethanol consumption to exceed the so-called blend wall and meet the RFS mandates, increased consumption at higher blending ratios is needed. For example, raising the blending limit from 10% to a higher ratio such as 15% or 20% would immediately expand the "blend wall" to somewhere in the range of 20 billion to 27 billion gallons. The U.S. ethanol industry is a strong proponent of raising the blending ratio. On March 6, 2009, Growth Energy (on behalf of 52 U.S. ethanol producers) applied to the EPA for a waiver from the then-current Clean Air Act E10 limit and an increase in the maximum allowable concentration to 15% (E15).

As mentioned earlier, on October 13, 2010, EPA issued a partial waiver for gasoline that contains up to a 15% ethanol blend (E15) for use in model year 2007 or newer light-duty motor vehicles (i.e., passenger cars, light-duty trucks, and sport utility vehicles).[49] However, EPA also announced that no waiver would be granted for E15 use in model year 2000 and older light-duty motor vehicles, as well as in any motorcycles, heavy duty vehicles, or non-road engines. This later restriction opens up the possibility of "mis-fueling"—that is, using higher ethanol blends in vehicles not appropriate for the EPA 15% blend waiver.

On January 21, 2011, following the results of additional DOE testing, EPA expanded the waiver on E15 to allow its use in model year 2001-2006 vehicles. According to the Renewable Fuel Association (RFA), the approval of E15 use in model year 2001 and newer passenger vehicles expands eligibility to 62% of vehicles on U.S. roads.[50] In addition to the EPA waiver announcement, fuel producers will need to register the new fuel blends and submit health effects testing to EPA. Further, numerous other changes have to occur before gas stations will begin selling E15, including many approvals by states and significant infrastructure changes (pumps, storage tanks, etc.). As a result, the vehicle limitation to newer models, coupled with potential infrastructure issues, is likely to limit rapid expansion of blending rates. Moreover, a group of engineering and equipment manufacturers has challenged the partial waiver in court, arguing that EPA failed to estimate the likelihood of mis-fueling (using E15 in equipment denied a waiver) and the economic and environmental consequences of that mis-fueling.[51]

Two additional options to resolving this bottleneck exist but appear to be long-run alternatives. First, increased use of ethanol in flex-fuel vehicles (FFVs) at ethanol-to-gasoline blend ratios as high as 85% (referred to as E85) is a possibility. However, increased E85 use involves substantial infrastructure development, particularly in the number of designated storage tanks and E-85 retail pumps, as well as a rapid expansion of the FFV fleet to absorb larger volumes of ethanol.

A second alternative is to expand use of processing technologies at the biofuel plant to produce biofuels in a "drop-in" form (e.g., butanol) that can be used by existing petroleum-based distribution and storage infrastructure and the current fleet of U.S. vehicles. However, more infrastructure-friendly biofuels generally require more processing than ethanol and are therefore more expensive to produce.

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[48] For more information, see EPA Fuel Additive Notices, at http://www.epa.gov/otaq/additive.htm.

[49] EPA, Fuels and Fuel Additives, "EPA Announces E15 Partial Waiver Decision and Fuel Pump Labeling Proposal," EPA420-F-10-054, October 13, 2010; at http://www.epa.gov/otaq/regs/fuels/additive/e15/420f10054.htm.

[50] "E15 Decision Opens Blend to 2 Out of 3 Vehicles; More Work Yet to be Done," RFA news release, Jan. 21, 2011.

[51] Outdoor Power Equipment Institute (OPEI), "Fact Sheet: E-15 Partial Waiver Legal Challenge," December 17, 2010. The case is *Alliance of Automobile Manufacturers et.al v. Environmental Protection Agency.*

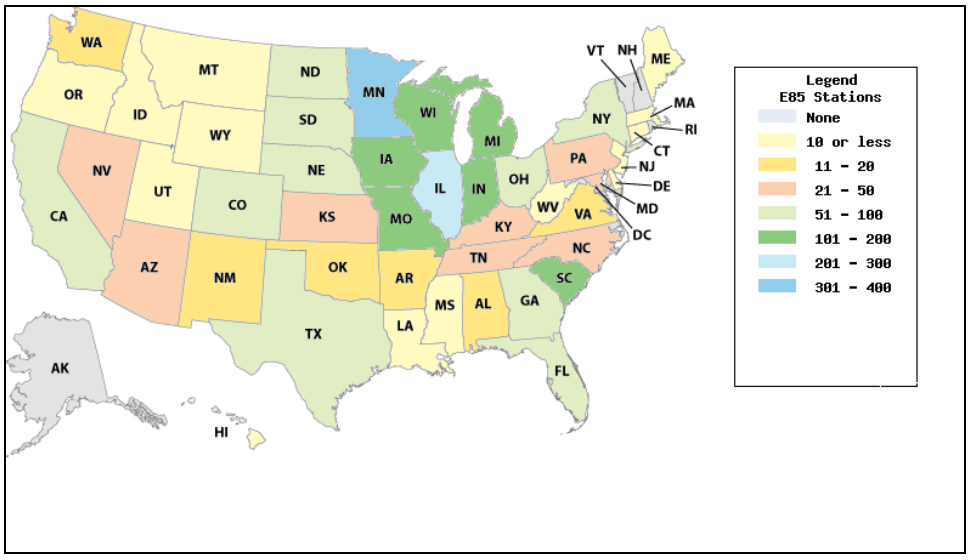
FFV Fleet and E85 Pump Availability as Limiting Factors

At blend ratios above 10%, ethanol must compete directly with gasoline as a transportation fuel. For ethanol to operate primarily as a gasoline substitute, at least two things must happen. First, ethanol must be priced competitively with gasoline on an energy-content or miles-per-gallon basis. Second, both the U.S. fleet of FFVs and the number and availability of high-blend-ratio retail pumps must expand.

FFVs can be designed to operate with a varying share of ethanol; however, the most common is the flex-fuel E85 vehicle.[52] For consumers with FFVs that have access to E85 pumps, the price relationship between ethanol and gasoline is important. Varying blend ratios of ethanol with gasoline make the miles-per-gallon calculation more difficult, but the principal holds that, whenever the consumer has a choice between different fuels, he or she is likely to prefer the fuel choice that returns the most miles-per-gallon at the lowest cost.

The market for E85 is limited by both the number of E85 vehicles and the number of E85 fueling stations. According to the Renewable Fuels Association (RFA), there were more than 8 million FFVs on the roads in 2011, representing about 3% of U.S. passenger vehicles. However, not all FFV owners have access to (or choose to use) E85 retail pumps. As of early 2012, about 2,860 retail stations in the United States offered E85 (1.8% out of 160,000 stations).[53] Most E85 fueling stations are concentrated in the upper midwestern states near the current ethanol production heartland (**Figure 8**).

Figure 8. E85 Refueling Locations by State



Source: U.S. DOE, Alternative Fuels and Advanced Vehicles Data Center, November 2010, available at http://www.afdc.energy.gov/afdc/ethanol/ethanol_locations.html..

[52] In Brazil, the nation's entire fleet of passenger vehicles is made up of FFVs. All gasoline sold in Brazil contains at least 20% ethanol, while 100% ethanol is also available at every retail service station. Thus, Brazilian consumers make fuel choices based on the price relationship between blended gasoline (E20 to E25) and E100 pure ethanol.

[53] For more information, see the Renewable Fuels Association's E-85 online information site at http://www.ethanolrfa.org/pages/e-85.

Federal Programs That Support Biofuels

As described in the earlier sections on the growth of the ethanol and biodiesel industries, federal policy has played a key role in helping to close the price gap between biofuels and cheaper petroleum fuels. Initially, federal biofuels policies were developed to help kick-start the biofuels industry during its early development, when neither production capacity nor a market for the finished product were widely available. Now, as the industry has evolved, other policy goals (e.g., national energy security, climate change concerns, support for rural economies) are cited as justifications for continuing policy support.

Oversight and implementation of these policies is spread across several government agencies, but the primary responsibility lies with EPA, USDA, and DOE. As the number, complexity, and budgetary implications of federal biofuels policies have grown, so too has the number of proponents and critics. Many biofuels-related policy debates occur along geographic lines. For example, Midwest corn- and ethanol-producing states are major proponents of federal policy support, whereas many residents of the East and West Coast urban states perceive expensive biofuel usage mandates as being forced upon them while their access to cheaper Brazilian sugar-cane ethanol was, for many years, limited by an import tariff. Another source of biofuels policy conflict has emerged between the major users of corn. Livestock producers have seen their feed costs escalate with the growth in biofuels corn demand and are highly critical of further federal biofuels support.

Most of the biofuels policies developed and funded by Congress are subject to oversight and periodic reauthorization.[54] For most of the past three decades, three types of federal programs have provided the core support for the U.S. biofuels industry: blending and production tax credits to lower the cost of biofuels to end users, an import tariff to protect domestic ethanol from cheaper foreign-produced ethanol, and volume-specific usage mandates to guarantee a market for biofuels irrespective of their cost. In addition, the biofuels industry has been supported by several indirect policies in the form of research grants to stimulate the development of new technologies, and grants, loans, and loan guarantees to facilitate the development of biofuels feedstocks as well as market and distribution infrastructure.

Tax Credits

Various tax credits and other incentives have been available for the production, blending, and/or sale of biofuels and biofuel blends (**Table 4**). Tax credits vary by the type of fuel and the size of the producer. Because of their budgetary cost, the tax credits are rarely extended for more than a year or two at a time. As a result, they routinely require congressional action to be extended. On December 31, 2011, most biofuels blending and production tax credits expired, with the exception of the cellulosic biofuels production tax credit, which is set to expire at the end of 2012.

[54] For a more complete list of federal biofuels incentives, see CRS Report R40110, *Biofuels Incentives: A Summary of Federal Programs*.

Table 4. Federal Tax Credits Available for Qualifying Biofuels

Biofuel	Tax Credit: $/gallon	Details	Expiration Date
Volumetric Ethanol Excise Tax Credit (VEETC)	$0.45	Available in unlimited amount to all qualifying biofuels.	Expired
Small Ethanol Producer Credit	$0.10	Available on the first 15 million gallons (mgal) of any producer with production capacity below 60 mgal.	Expired
Biodiesel Tax Credit	$1.00	Available in unlimited amount to all qualifying biodiesel.	Expired
Small Agri-Biodiesel Producer Credit	$0.10	Available on the first 15 mgal of any producer with production capacity below 60 mgal.	Expired
Cellulosic Biofuels Production Tax Credit	$1.01	Available in unlimited amount to all qualifying biofuels.	Dec. 31, 2012

Source: CRS Report R40110, *Biofuels Incentives: A Summary of Federal Programs*, by Brent D. Yacobucci.

Import Tariff on Foreign-Produced Ethanol

Prior to 2012, most imported ethanol was subject to a most-favored-nation duty set of $0.54 per gallon of ethanol (for fuel use) and a 2.5% ad valorem tariff. The stated goal of the import tariff was to offset the ethanol blending tax credit which was also available for foreign-produced ethanol. However, the fixed $0.54-per-gallon most favored-nation duty (identified by 9901.00.50 and 9901.00.52 of the Harmonized Tariff System (HTS)) expired on December 31, 2011. The 2.5% ad valorem tariff (2207.10.60 of the HTS) does not expire but is permanent until or unless the HTS code itself is changed. In most years the tariff was a significant barrier to direct Brazilian imports. However, some Brazilian ethanol could be brought into the United States duty-free if it was dehydrated (reprocessed) in Caribbean Basin Initiative (CBI) countries.[55] Up to 7% of the U.S. ethanol market could be supplied duty-free in this fashion; historically, however, ethanol dehydrated in CBI countries has only represented about 2% of the total U.S. market.

The Renewable Fuel Standard (RFS)[56]

The RFS requires the blending of renewable fuels (including ethanol and biodiesel) in U.S. transportation fuel. The RFS includes specific quotas for advanced biofuels (i.e., non-corn-starch ethanol), cellulosic biofuels, and biomass-based diesel fuel, as well as a total biofuels mandate. The RFS also includes a cap on the eligible volume of corn-starch ethanol.

Under the overall biofuels RFS, fuel suppliers were required to supply 9 billion gallons (bgals) of renewable fuel in 2008. This requirement increases annually to 36 bgals in 2022, of which only 15 bgals can be ethanol from corn starch. The remaining 21 bgals are to be so-called "advanced biofuels"—fuels produced from non-corn-starch feedstocks—of which 16 bgals are to be from

[55] See CRS Report RS21930, *Ethanol Imports and the Caribbean Basin Initiative (CBI)*.

[56] RFS (referred to as RFS1) was begun by the Energy Policy Act of 2005, (§ 1501; P.L. 109-58). The RFS was greatly expanded (referred to as RFS2) by the Energy Independence and Security Act of 2007 (EISA, § 202, P.L. 110-140). For more information on the RFS, see CRS Report R40155, *Renewable Fuel Standard (RFS): Overview and Issues*.

cellulosic biofuels, 1 bgals from biomass-based diesel, and 4 bgals from other biofuels (most likely imported sugar-cane ethanol from Brazil).

The RFS is administered by EPA and involves tradable certificates—Renewable Identification Numbers (RINs)—assigned to each batch of biofuel.[57] A RIN is a unique 38-character number that is issued to each gallon of biofuel (in accordance with EPA guidelines) by the biofuels producer or importer at the point of biofuels production or the port of importation. When biofuels change ownership (e.g., are sold by a producer to a blender), the RINs are also transferred. When biofuels are blended for retail sale or at the port of embarkation for export, the RIN is separated from the fuel and may be used for RFS compliance or trade. At the end of the year, each blender must have enough RINs to show that it has met its share of each of the four mandated RFS standards. When the RFS is binding (i.e., the actual volume of biofuels used just equals the RFS mandated volume) the RIN value will reflect the full price gap between a biofuel producer's supply price and a biofuel blender's demand price.[58]

In addition to compliance demonstration, RINs can be used for credit trading. If a blender has already met its mandated share and has blended surplus biofuels of a particular RFS category, it can sell the extra RINs to another blender (who has failed to meet its blending mandate for that same biofuel) or it can hold onto the RINs for future use (20% of the current year's RFS obligation may be carried forward either to satisfy the succeeding year's blending requirement or for future sale).

In addition to volume mandates, EISA specified that the lifecycle greenhouse gas (GHG) emissions of a qualifying renewable fuel must be less than the lifecycle GHG emissions of the 2005 baseline average gasoline or diesel that it replaces.[59] Lifecycle GHG emission reduction thresholds were established for each of the four biofuels categories—20% for corn-starch ethanol from new refineries, 50% for advanced biofuels, 60% for cellulosic biofuels, and 50% for biomass-based diesel.

Other Indirect Federal Policies

Several additional biofuels programs have been created to provide various grants, loans, and loan guarantees in support of research and development of related technology, as well as support for biofuels infrastructure development. Many of these programs reside in the energy title (Title IX) of the 2008 farm bill (P.L. 110-246).[60] Federal programs also require federal agencies to give preference to bio-based products in purchasing fuels and other supplies. Cellulosic plant investment is further facilitated by a special depreciation allowance created under the Tax Relief and Health Care Act of 2006 (P.L. 109-432). Also, several states have their own incentives,

[57] "Renewable Identification Numbers Are the Tracking Instrument and Bellwether of U.S. Biofuel Mandates," by Wyatt Thompson, Seth Meyer, and Pat Westhoff, *EuroChoices*, vol. 8, no. 3, 2009.

[58] "Mandates, Tax Credits, and Tariffs: Does the U.S. Biofuels Industry Need Them All?" by Bruce A. Babcock, *CARD Policy Briefs 10-PB-1*, Center for Agricultural and Rural Development, Iowa State University, March 2010.

[59] For more information, see CRS Report R40460, *Calculation of Lifecycle Greenhouse Gas Emissions for the Renewable Fuel Standard (RFS)*.

[60] CRS Report R41985, *Renewable Energy Programs and the Farm Bill: Status and Issues*.

regulations, and programs in support of renewable fuel research, production, and use that supplement or exceed federal incentives.[61]

In addition to direct and indirect biofuels policies, the U.S. biofuels industry benefits from U.S. farm programs in the form of price and income support programs (i.e., marketing loan benefits and the counter-cyclical payment program) and risk-reducing farm programs (e.g., Acreage Crop Revenue Election (ACRE), Supplemental Revenue Assistance Payments (SURE), federal crop insurance, and disaster assistance), which encourage greater production and lower prices than would occur in the absence of federal programs in a free-market equilibrium.[62] As a result, agricultural feedstocks are both lower-priced and more abundant than without federal farm programs. This helps lower production costs for the U.S. biofuels sector, and makes U.S. biofuels more competitive with foreign-produced biofuels.

Current Biofuels Policy Issues

Most of the federal biofuels tax credit provisions, as well as the import tariff on foreign-produced ethanol, have short legislative lives and require frequent extension.[63] The primary energy-related issue for the next farm bill is the expiration at the end of FY2012 and lack of baseline funding going forward for all major energy-related provisions of Title IX. In addition, the appearance of substantial redundancy across renewable energy programs at USDA and DOE, the slow development of the U.S. cellulosic biofuels sector, and concerns about the emerging spillover effects of increasing corn use for ethanol production are issues that are likely to emerge during the next farm bill debate.

Pending Congressional Actions

2008 Farm Bill Expiration

Most of the biofuels policy provisions contained in the 2008 farm bill (P.L. 110-246) were extended through FY2012, at which time they will be reviewed as part of the next farm bill debate.[64] The 2008 farm bill authorized $1.1 billion in mandatory funding for energy programs, including $320 million for the Biorefinery Assistance Program, $300 million for the Bioenergy Program for Advanced Biofuels, and $255 million for the Rural Energy for America Program (REAP). The Biomass Crop Assistance Program (BCAP) was authorized to receive such sums as necessary (i.e., funding is open-ended and depends on program participation), although Congress eventually put limits on mandatory funding of $552 million in FY2010, $112 million in FY2011, and $17 million in FY2012. None of the major farm-bill energy programs have baseline funding

[61] For more information, see the "Federal & State Incentives & Laws," Alternative Fuels and Advanced Vehicles Data Center, Energy Efficiency and Renewable Energy (EERE), DOE, at http://www.afdc.energy.gov/afdc/laws/.

[62] For more information on U.S. farm programs, see CRS Report RL34594, *Farm Commodity Programs in the 2008 Farm Bill*; CRS Report R40422, *A 2008 Farm Bill Program Option: Average Crop Revenue Election (ACRE)*; CRS Report R40452, *A Whole-Farm Crop Disaster Program: Supplemental Revenue Assistance Payments (SURE)*; and CRS Report R40532, *Federal Crop Insurance: Background and Issues*.

[63] See CRS Report R40110, *Biofuels Incentives: A Summary of Federal Programs*.

[64] See CRS Report R41985, *Renewable Energy Programs and the Farm Bill: Status and Issues*.

after FY2012. As a result, the tight federal budget suggests that new revenues or offsetting cuts will likely be required to extend them beyond FY2012.

Cellulosic Biofuels Tax Credit

While most biofuels tax credits and and the import duty on foreign fuel ethanol expired on December 31, 2011, the cellulosic biofuel tax credit does not expire until December 31, 2012. The cellulosic biofuels industry is expected to lobby actively for extension of the cellulosic biofuel tax credit. However, a tight federal budget combined with lack of progress in developing commercial production of cellulosic biofuels are likely to work against an extension.

Cellulosic Biofuels Feedstock Program: BCAP

Investors have been reluctant to invest in what so far is a commercially unproven technology—the conversion of cellulosic biomass to biofuels. Development of the cellulosic biofuels industry hinges on effective use of new feedstocks. To this effect, the Biomass Crop Assistance Program (BCAP) was created under the 2008 farm bill to facilitate the development of those new feedstocks and kick-start the cellulosic biofuels industry.[65] BCAP (via USDA's CCC) provides financial assistance to producers or entities that deliver eligible biomass material to designated biomass conversion facilities for use as heat, power, bio-based products, or biofuels. Initial assistance will be for the collection, harvest, storage, and transportation (CHST) costs associated with the delivery of eligible materials.

Because BCAP is intended to underwrite an as yet nonexistent industry—the cellulosic biofuels industry—considerable uncertainty exists over how it should evolve so as to be most useful to jump-starting the commercialization of cellulosic biofuels production. USDA published the final rule for implementing BCAP on October 27, 2010.[66] However, BCAP is in the early stages of implementation, and concerns regarding eligibility, sustainability, and funding continue to be discussed. These issues could shape future congressional action on the program in the context of budgetary measures and possible reauthorization in the next farm bill. Congress will likely be monitoring closely both the implementation of BCAP and its effect on the development of the cellulosic biofuels sector.

Pending EPA Actions

Waiver of Mandated Use Requirements

The RFS mandates the use of over 15 bgals of biofuels in 2012. The mandate grows to 20.5 bgals of biofuels use by 2015. By 2022, 36 bgals of biofuels must be consumed under the RFS. Each year EPA must review the likelihood of outyear biofuel production meeting or failing to meet required RFS usage levels, and adjust the mandates accordingly. EPA's biofuels standards for each upcoming year are announced on a preliminary basis in the spring of the preceding year,

[65] See CRS Report R41296, *Biomass Crop Assistance Program (BCAP): Status and Issues*.

[66] USDA, CCC, "Biomass Crop Assistance Program," 75 *Federal Register* 66201, October 27, 2010.

when EPA issues a notice of proposed rulemaking, and on a final basis by November 30 of the preceding year, when EPA issues a final rule.[67]

The EPA has already waived the original RFS2 mandate for cellulosic biofuel for each of the first three years—2010, 2011, and 2012. The likelihood of future EPA waivers could deter capital investments in the sector and make future waivers become a self-fulfilling prophecy.

The likelihood of meeting RFS mandates for traditional biofuels hinges both on the "blend wall" and on the slow emergence of a national infrastructure needed to facilitate the distribution and use of the growing mandated biofuel volumes. Even with the expansion of the blending ratio to 15% for model year 2001 and newer passenger vehicles, the higher blend wall of approximately 20 to 21 bgals will become a real barrier to expanded biofuels use by 2015.

Estimation of GHG Emission Reductions

Under EISA, EPA is responsible for evaluating whether a renewable fuel meets the specific GHG reduction threshold assigned to its RFS category. Determining compliance with the thresholds requires a comprehensive evaluation of renewable fuels on the basis of their lifecycle emissions.[68] The concept of "lifecycle emissions" encompasses an evaluation of GHG emissions along the entire pathway of a biofuel from the production, harvesting, and marketing of its feedstocks to the processing and distribution of the biofuel, including any significant indirect emissions such as significant emissions from land uses changes that might result from changes in crop patterns due to the various biofuels incentives (as explicitly required in Section 201, P.L. 110-140).

More specifically, the concern is that expanded field crop production in the United States for ethanol production has led to commodity price increases that, in turn, have induced increased land cultivation in other countries, and as a result, have increased net global GHG emissions. The measurement of indirect land use changes (ILUC) is necessarily inexact because so many potential activities and countervailing forces are involved. As a result, inclusion of ILUC as part of the EPA's lifecycle GHG reduction analysis has been controversial.

Initially, EPA's lifecycle GHG reduction models proved very sensitive to assumptions regarding the extent of indirect land use changes, and suggested that some standard biofuels may not be eligible for inclusion under the RFS. EPA models were updated prior to the final RFS rule (February 2009) using newer data and produced more inclusive results. For example, corn-starch ethanol was determined to achieve a 21% reduction in GHG emissions compared to the gasoline 2005 baseline, thus just surpassing the 20% reduction threshold.[69] EPA models for estimating land use changes and other life-cycle factors involved in GHG emissions are continually re-evaluated as new or better data, methods, or analytical techniques become available. The nature of the future changes to EPA models, and their potential to include or exclude certain biofuels, remains a critical aspect of the RFS mandates and the U.S. biofuels industry's ability to meet the mandates.

[67] See CRS Report RS22870, *Waiver Authority Under the Renewable Fuel Standard (RFS)*.

[68] For more information, see CRS Report R40460, *Calculation of Lifecycle Greenhouse Gas Emissions for the Renewable Fuel Standard (RFS)*.

[69] "V. Lifecycle Analysis of Greenhouse Gas Emissions;" Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule, 40 CFR Part 80, *Federal Register*, March 26, 2010, p. 14786.

Endangerment Findings for Greenhouse Gases (GHGs)

On April 2, 2007, in *Massachusetts v. EPA* (549 U.S. 497 (2007)), the U.S. Supreme Court determined that GHGs are air pollutants covered under Section 202(a) of the Clean Air Act. The Court held that EPA must determine whether or not emissions of GHGs from new motor vehicles cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare, or whether the science is too uncertain to make a reasoned decision.[70] This court ruling allows EPA to regulate GHGs without further congressional action, and could bring into play the issue of indirect land use changes, given their alleged GHG emissions effects, which may put all ethanol production in question. On June 11, 2010, a Senate resolution (S.J.Res. 26) that would have blocked EPA from using the Clean Air Act to regulate GHGs was defeated (53-47).[71] Prior to the vote, on June 8, 2010, the White House had issued a statement saying that if S.J.Res. 26 reached the President's desk (i.e., passed both chambers of Congress), President Obama would veto it.

Other Pending or Emerging Biofuels Issues

CARB's LCFS Restriction on Midwestern Ethanol

In January 2007, then-Governor Schwarzenegger established a Low Carbon Fuels Standard (LCFS) by executive order for California.[72] The executive order directed the state's Secretary for Environmental Protection to coordinate the actions of the California Energy Commission, the California Air Resources Board (CARB), the University of California, and other agencies to develop protocols for measuring the "life-cycle carbon intensity" of transportation fuels.

Under the LCFS, CARB proposed reducing emissions of GHGs by lowering the carbon content of transportation fuels used in California. The LCFS established performance standards that fuel producers and importers must meet each year starting in 2011. As part of its LCFS modeling effort, CARB includes an estimate of the ILUC impact of grain-based ethanol. Largely because of the ILUC value assigned to corn-starch ethanol, most midwestern ethanol production does not qualify for use as a transportation fuel under California's LCFS.[73] This result has important implications for how or whether the federal RFS mandates can be met for the nation as a whole, since California is both the largest state (39 million people), the largest consumer of gasoline, and a major ethanol consumer of approximately 1.5 billion gallons annually.[74]

A 2010 analysis from Purdue University concluded that CARB overestimated the ILUC impact of grain-based ethanol by a factor of two in developing its LCFS.[75] In October 2011, researchers at

[70] For more information see "Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act," EPA, at http://www.epa.gov/climatechange/endangerment.html.

[71] DTN Ag Policy Blog, "Senators Face Emissions Test," Chris Clayton, June 9, 2010.

[72] For more information, see "Low Carbon Fuel Standard," California Energy Commission, at http://www.energy.ca.gov/low_carbon_fuel_standard/index.html.

[73] For more information see, "Proposed Regulation to Implement the Low Carbon Fuel Standard," Initial Statement of Reasons, Vol. 1, CARB, March 5, 2009, at http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

[74] Todd Neeley, "US Scientists Demand Revision of Biofuels Carbon Accounting," DTN Ethanol blog, May 25, 2010.

[75] "New Study Undercuts California Low Carbon Fuel Standard, Shows Evolving Land Use Change Debate," Renewable Fuels Association (RFA), news entry, April 28, 2010, at http://www.ethanolrfa.org. The final version of the Purdue study was released as, "Land Use Changes and Consequent CO2 Emissions due to US Corn Ethanol (continued...)

the Department of Energy's Oak Ridge National laboratory (ORNL) concluded that ILUC resulting from expanded corn ethanol production over the past decade has likely been "minimal to zero."[76] The ORNL research was presented to CARB in early October. On November 18, CARB adopted a resolution to integrate the latest ILUC research based on the Purdue study into the LCFS regulation. As a result it is anticipated that the ILUC penalty for corn ethanol will be cut by at least half by spring of 2011.[77] In light of the CARB revisions to its ILUC models and their consequent impact on GHG, the Renewable Fuels Association (RFA) wrote an open letter to the EPA on November 23, 2010, requesting that the EPA also incorporate the new research into modeling of lifecycle GHG emissions under the RFS2.[78]

On December 24, 2009, several ethanol groups (including RFA and Growth Energy) filed a lawsuit asserting that the California LCFS violated the U.S. Constitution by seeking to regulate farming and ethanol production practices in the United States under the "commerce clause," which leaves regulation of interstate commerce to the federal government.[79] On December 29, 2011, a U.S. district judge ruled that California's LCFS law did violate the U.S. Constitution's commerce clause. The U.S. District Court of the Eastern District of California then issued an injunction halting enforcement of California's LCFS. The judge ruled that CARB had failed to establish that there are no alternative methods to advance its goals of reducing GHG emissions to combat global warming. As a result, corn-based ethanol from the Midwest, which had been classified as a high-carbon fuel under the LCFS, will now be eligible for use in California. The ruling allows CARB to appeal the court's decision immediately to the U.S. Court of Appeals for the Ninth Circuit.

Trade Issues

Three trade issues (including Chinese anti-dumping charges against an ethanol by-product, an anti-dumping investigation against European Union imports of U.S. ethanol, and an unexpected surge in U.S. ethanol exports) have emerged in 2011 that, if realized, could slow further development of the U.S. biofuels sector.

China Anti-Dumping Investigation of U.S. DDGs

On December 28, 2010, China initiated an antidumping investigation into imports from the United States of distiller's dried grains (DDGs)—a by-product of the conversion of corn into

(...continued)

Production: A Comprehensive Analysis," Wallace E. Tyner, Farzad Taheripour, Qianlai Zhuang, Dileep Birur, and Uris Baldos, Dept of Agr. Econ., Purdue University, July 2010; at http://www.transportation.anl.gov/pdfs/MC/625.PDF.

[76] "Dept. of Energy Researchers: ILUC Impact 'Minimal to Zero'", RFA, 2010 Press Releases, October 20, 2010, at http://www.ethanolrfa.org; and "Empirical Analysis of the Sources of Corn Used for Ethanol Production in the United States: 2001-2009," presentation to National Corn Growers Assoc. by Debo Oladosu and Keith Kline, ORNL, November 4, 2010; at http://www.ornl.gov/sci/besd/cbes/Symposia/Empirical_Analysis_Source_Corn_Ethanol_Nov2010.pdf.

[77] "CARB Responds to Industry Urging, Will Cut LCFS Penalty for Ethanol in Half", RFA, 2010 Press Releases, November 19, 2010, at http://www.ethanolrfa.org.

[78] "RFA to EPA: Reevaluate Modeling of Lifecycle GHG Emissions Under RFS2", RFA, 2010 Press Releases, November 29, 2010, at http://www.ethanolrfa.org.

[79] Todd Neely, "Court Strikes Down California LCFS: Ruling Opens Door to Large Ethanol Market," *DTN: The Progressive Farmer*, December 29, 2011.

ethanol that is a relatively high-protein (30%) animal feed. In China DDGs are used primarily for feeding swine and poultry.[80] U.S. DDG exports grew rapidly during 2010, reportedly rising from about 530,000 tons in 2009 to 2.9 million tons (valued at over $450 million)—a surge of nearly 550%. Four Chinese firms that account for approximately 50% of Chinese ethanol production appear to be the petitioners. The Chinese firms allege that the U.S. is dumping DDG into their livestock markets whereas high internal corn prices make Chinese DDGs uncompetitive.

Several news sources report that the anti-dumping probe is a retaliatory response to a U.S. complaint filed at the WTO against Chinese wind power subsidies. Whatever the reason, U.S. DDG exporters could face duties as high as 50% while the investigation is ongoing and starting as early as June 2011.[81] Duties could be raised as high as 100% toward the end of the investigation. China is the third-leading importer of U.S. DDG exports. Loss of the Chinese DDG market could result in lower U.S. DDG prices and cut into the profit margin of U.S. ethanol producers. The U.S. Grains Council is organizing the industry response to China's DDG anti-dumping investigation.[82] As of January 17, 2012, China's anti-dumping case remains active, and Chinese purchases of U.S. DDGs slowed considerably year-to-year in June; however, no additional tariffs have been imposed.

EU Launches Trade Dispute Over Surging U.S. Ethanol Exports

U.S. ethanol exports surged to record levels during 2011 (**Figure 9**), driven in part by blending wall limits, but also motivated in part by a sharp fall-off in Brazil's ethanol exports due to high international sugar prices. Based on the export pace through the first 11 months of 2011, the United States will export over 1.1 billion gallons of ethanol, or about 8% of 2011 production. The top three destinations for U.S. ethanol exports in 2011 are Brazil (32%), Canada (26%), and the European Union (EU) (25%). Large U.S. ethanol exports are problematic in that they run counter to the often-cited policy goal of national energy security.

EU policy has promoted renewable energy use, along with GHG reductions and energy conservation, for much of the past decade.[83] As a result, EU policy support has engendered a substantial domestic renewable energy industry. As part of a "Renewable Energy Directive" adopted by the European Parliament on December 17, 2008, the EU established a 20-20-20 plan that calls for a 20% reduction in GHG emissions compared to 1990 levels, a 20% increase in renewable energy use, and a 20% reduction in overall energy consumption. As part of the 20-20-20 plan, the EU also adopted a mandate for renewable content in transportation fuels of 5.75% in 2010, rising to 10% by 2020.

The anti-dumping (AD) and countervailing duty (CVD) investigations were requested by ePURE, an association of European ethanol producers, which claimed that the importation of subsidized U.S. ethanol was hurting EU biofuel producers. The association argued that the surge in U.S. ethanol exports was the result of federal and state tax credits and other subsidy support provided

[80] "China Says It Will Investigate Dumping of U.S. Ethanol By-Products," China Update, *Inside U.S. Trade*, January 7, 2011.

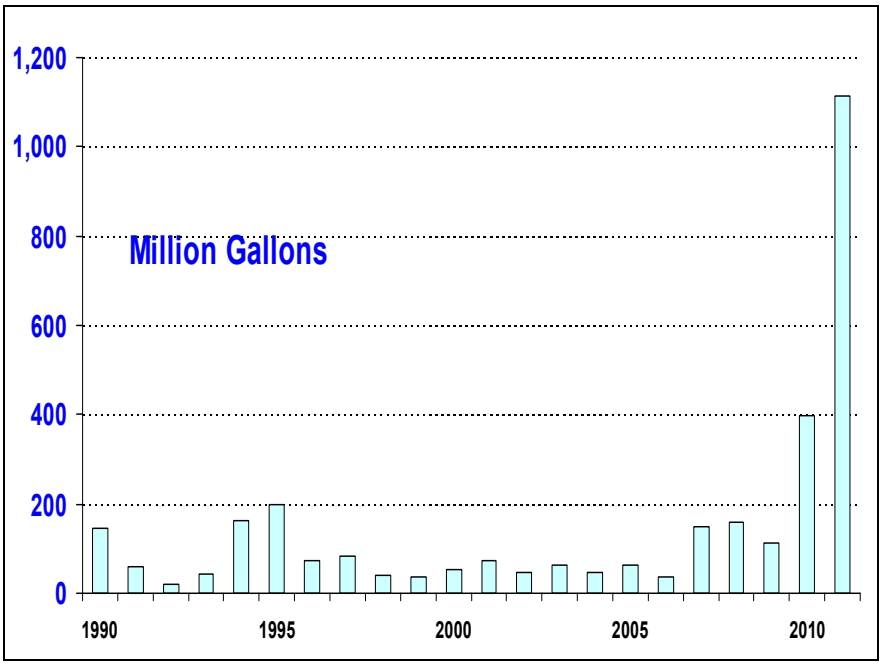
[81] "China Anti-Dumping Probe Concerns Ethanol Producers," Cheryl Anderson, *DTN News Service*, January 11, 2011.

[82] "US DDGS Industry Responds to China's DDGS Anti-Dumping Investigation," U.S. Grain Council, January 14, 2011, at http://www.grains.org/news-events/2846-us-ddgs-industry-responds-to-chinas-ddgs-anti-dumping-investigation.

[83] See the European Commission's official "Renewable Energy" website at http://ec.europa.eu/energy/renewables/.

to U.S. ethanol producers. On November 25, 2011, the EU initiated an anti-dumping investigation into whether U.S. exporters sold ethanol at unfair prices and were backed by subsidies in violation of international trade rules to the detriment of EU producers.[84]

Figure 9. U.S. Ethanol Exports Surge in 2011



Source: U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics.

Note: 2011 data are projected by CRS based on January through November export data.

At issue is a European allegation that international ethanol traders were exporting E90 (90% ethanol blends) to Europe to take advantage of the EU's lower tariff on such blends as well as the tax incentive for ethanol blending in the United States—the $0.45 per gallon incentive known as VEETC (which expired on December 31, 2011). In response to the EU anti-dumping investigation, the RFA pointed out that the ethanol tax credits (most of which expired on December 31, 2011) were not made available to U.S. ethanol producers, but "to gasoline blenders, marketers, and other end users."[85] If the EU finds the complaint viable, it could impose tariffs on U.S. ethanol, as it did in 2009 when similar complaints against U.S. biodiesel exports led to the imposition by the EU of 40% duties for a five-year period.[86]

[84] *World Trade Online*, "EU Launches AD, CVD Investigations into U.S. Ethanol Exports," December 8, 2011.

[85] "RFA Responds to EU Ethanol Investigation," RFA News Release, November 28, 2011; http://www.ethanolrfa.org.

[86] *Agri-Pulse*, "RFA Tells EU: 'It's Not Us!" November 30, 2011.

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