Biofuels Transportation

Chapter 4

Chapter 4: Biofuels Transportation

Government ethanol policy began in the 1970's. Since the beginning of the 21st Century, legislation, tax incentives,[*] and the switch from MTBE[†] to ethanol have been among the major drivers in the increased production and use of biofuels in the United States. Biofuel use contributes to the broad policy goals of addressing climate change, assisting with domestic economic development, and decreasing the nation's dependence on imported petroleum. In fact, by 2008, U.S. ethanol production reached 9.3 billion gallons—equivalent on an energy basis to approximately 36 percent of the gasoline produced from crude oil imported from Persian Gulf countries.[57] The U.S. Government's broad energy policy includes strong support and funding for the development of biofuels.

Recent U.S. Biofuels-related Legislation:

- **2002:** Farm Security and Rural Investment Act
- **2005:** Energy Policy Act
- (EPAct 2005, RFS-1)
- **2007:** Energy Independence and Security Act of 2007 (EISA 2007, RFS-2)
- **2008:** Food, Conservation, and Energy Act of 2008

The agricultural sector has played a critical role in the development of the biofuel infrastructure. The current system is sometimes referred to as "first-generation," reflecting the fact that the system will be improved over time. It includes biofuel production facilities and distribution infrastructure, such as transportation, blending, and storage facilities. Many feedstock options are being explored in addition to corn for the next generation of biofuels. Factors that are likely to influence future transportation needs include location of feedstocks and production facilities, the lifecycle greenhouse gas (GHG) emissions associated with biofuel production, and the extent to which the next generation biofuels can use existing distribution infrastructure.

The United States is implementing the Energy Independence and Security Act of 2007 (EISA 2007) through the Renewable Fuels Standard (RFS2). On February 3, 2010, the Environmental Protection Agency (EPA) finalized regulations for the National Renewable Fuel Standard Program (RFS2) for 2010 and beyond. EPA's detailed analysis of transportation for feedstocks and renewable fuels are included in the Renewable Fuel Standard Program Regulatory Impact Analysis.[58] EPA analyzed transportation issues ranging from feedstock logistics for cellulosic ethanol and distillate fuels to biofuel distribution solutions. It found that, to reach the RFS targets by 2022, more unit train receipt facilities and storage tanks would be needed, E-85[‡] use must increase substantially, and large volumes of ethanol imports would be needed.

[*] Volumetric Ethanol Excise Tax Credit (VEETC) of 45 cents per gallon to petroleum blenders for blending ethanol with gasoline.

[†] Methyl tert-butyl ether (MTBE) is a gasoline additive that pollutes groundwater when gasoline containing it is spilled or leaked at gas stations. In spring 2006, the petroleum industry began to switch from MTBE to ethanol.

[‡] Each gallon of E-85 consists of 85 percent denatured ethanol and 15 percent gasoline.

Energy independence, climate change, and economic development issues are expected to dominate the U.S. energy policy objectives in the foreseeable future. To fulfill these policy goals, the biofuel industry will continue to depend on transportation services for reliable and efficient distributing of feedstocks to biorefineries, and for transporting biofuels and their co-products to end-user markets.

This chapter provides:

- An overview of the current distribution system for fuels, biofuels, and co-products.
- EPA's biofuel distribution analysis and conclusions.
- The current status of ethanol and co-product transportation.
    - Potential phases of biofuels expansion from the transportation infrastructure perspective.
- Factors widely believed to influence uncertainty in biofuel supply and demand and their implications for infrastructure investment.

The Current Distribution System

The biofuels commonly used in the United States include ethanol and biodiesel. The primary feedstock for ethanol is corn. Most biodiesel is made from soybean oil, but some is made from other plant and animal fats and recycled greases. Both ethanol and biodiesel are blended with gasoline and diesel at petroleum blending terminals. Currently, the distribution infrastructure for ethanol and biodiesel in the United States is not compatible with the pipeline-based petroleum distribution system. This chapter focuses on the ethanol and multi-modal portions because:

- Much more ethanol is produced than biodiesel. In 2008, over 9 billion gallons of ethanol and less than 500 million gallons of biodiesel were produced.
- Because ethanol use is projected to more than triple by 2022, distribution infrastructure issues will affect ethanol much more than biodiesel.
- Production areas for ethanol are more concentrated than those of biodiesel.
    - Both, ethanol and biodiesel have blending characteristics that may have an impact on pipeline integrity. DOT and the petroleum pipeline industry are conducting research into mitigating strategies for both ethanol and biodiesel.

Figure 4-1: Ethanol being loaded into rail tank cars.

Source: USDA

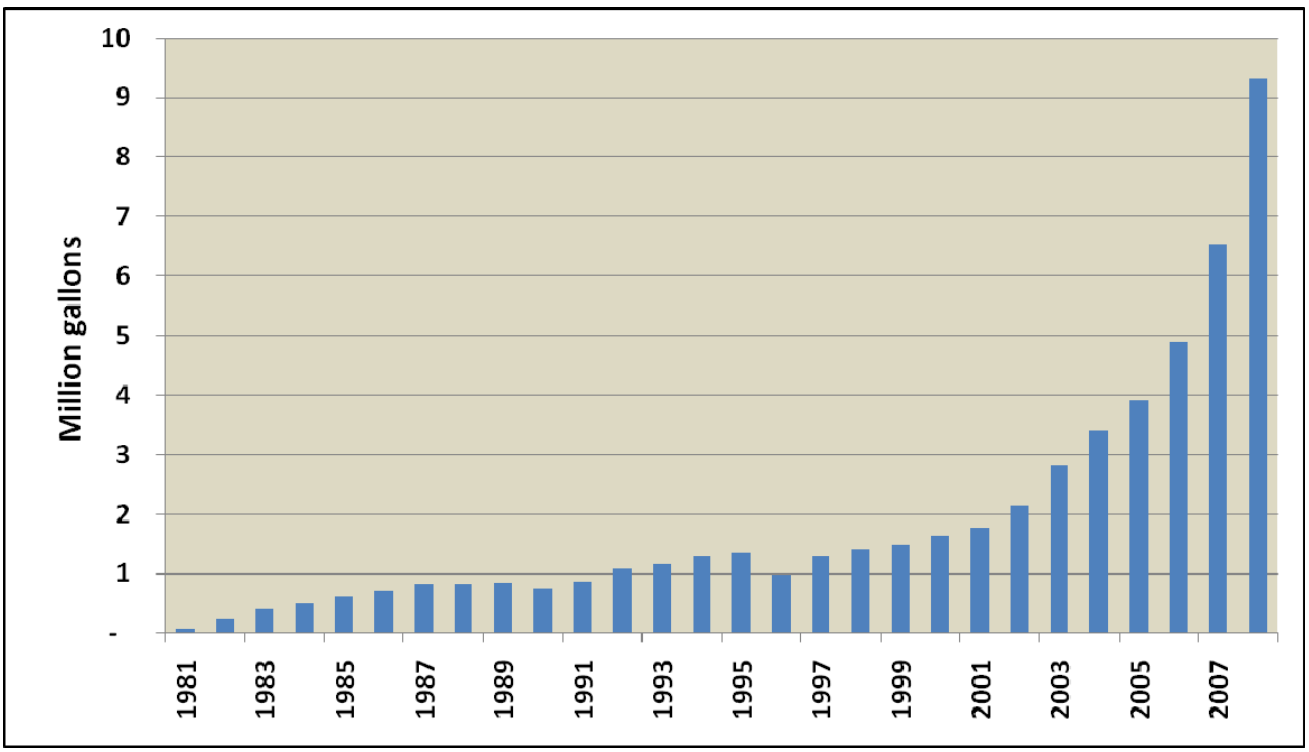
Crude Oil Imports

U.S. Crude Oil Imports from Persian Gulf Countries reached 856 million barrels, or 36 billion gallons in 2008. Approximately 17 billion gallons of gasoline can be produced from this amount of crude oil.

U.S. Crude Oil Imports from Saudi Arabia in 2008 reached 550 million barrels, or 23 billion gallons. Approximately 11 billion gallons of gasoline can be produced from this amount of crude oil.

The U.S. ethanol industry started before 1980 and has grown rapidly since 2002 (Figure 4-2). It utilizes all modes of transportation—truck, rail, barge, and, in one case, an existing pipeline[*]—to distribute its products and co-products. Almost all ethanol production is concentrated in the Midwest—mostly west of the Mississippi River—but most gasoline and E-10[†] is consumed in areas with high population densities, the East Coast, the West Coast, and along the Gulf Coast (Figure 4-3 and 4-4).

Figure 4-2: U.S. ethanol production, 1981-2008

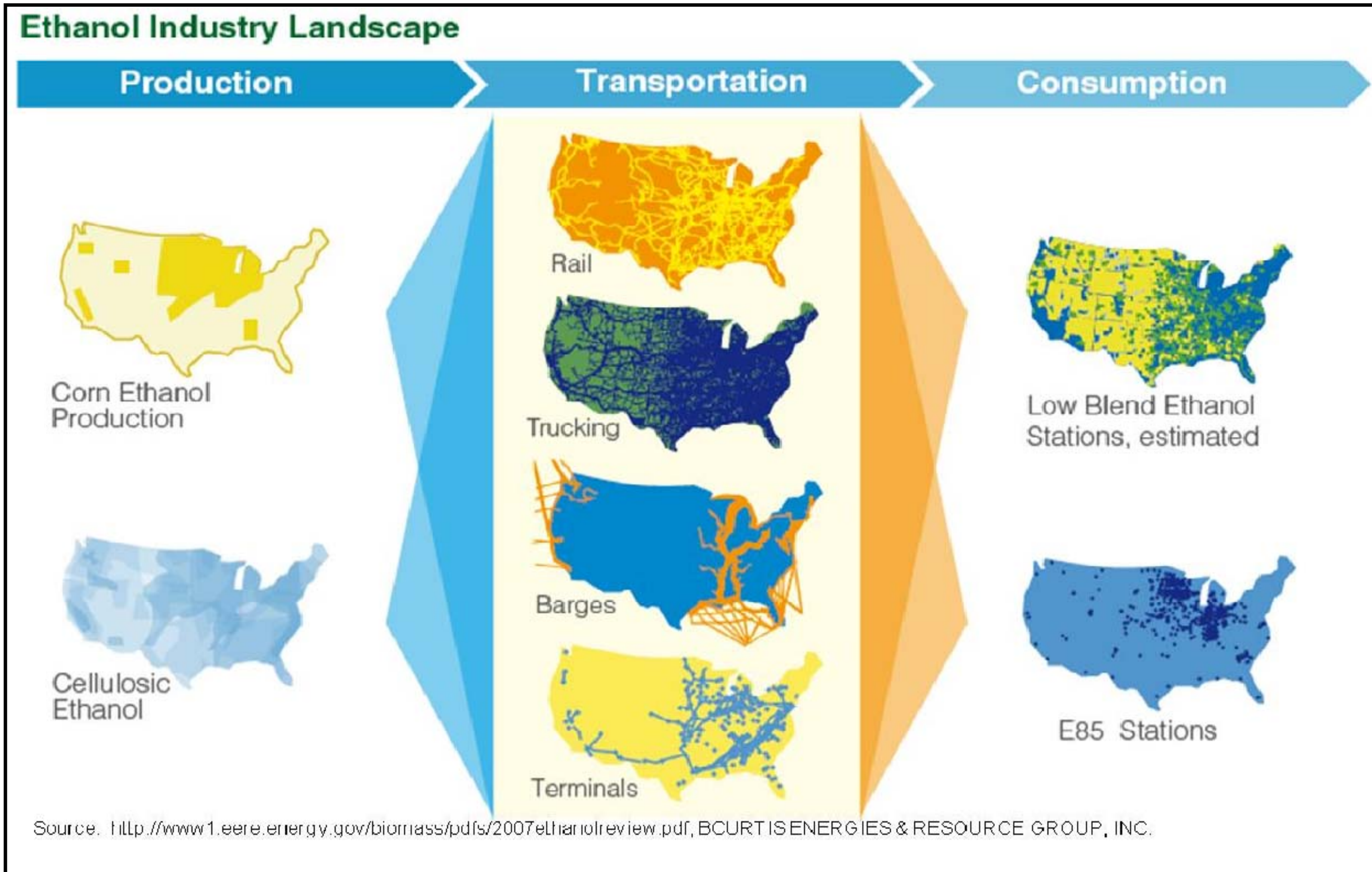


Source: Energy Information Administration

[*] In December 2008, for the first time, a commercial pipeline company successfully sent batches of ethanol between Orlando and Tampa, FL, in its pre-existing petroleum pipeline.

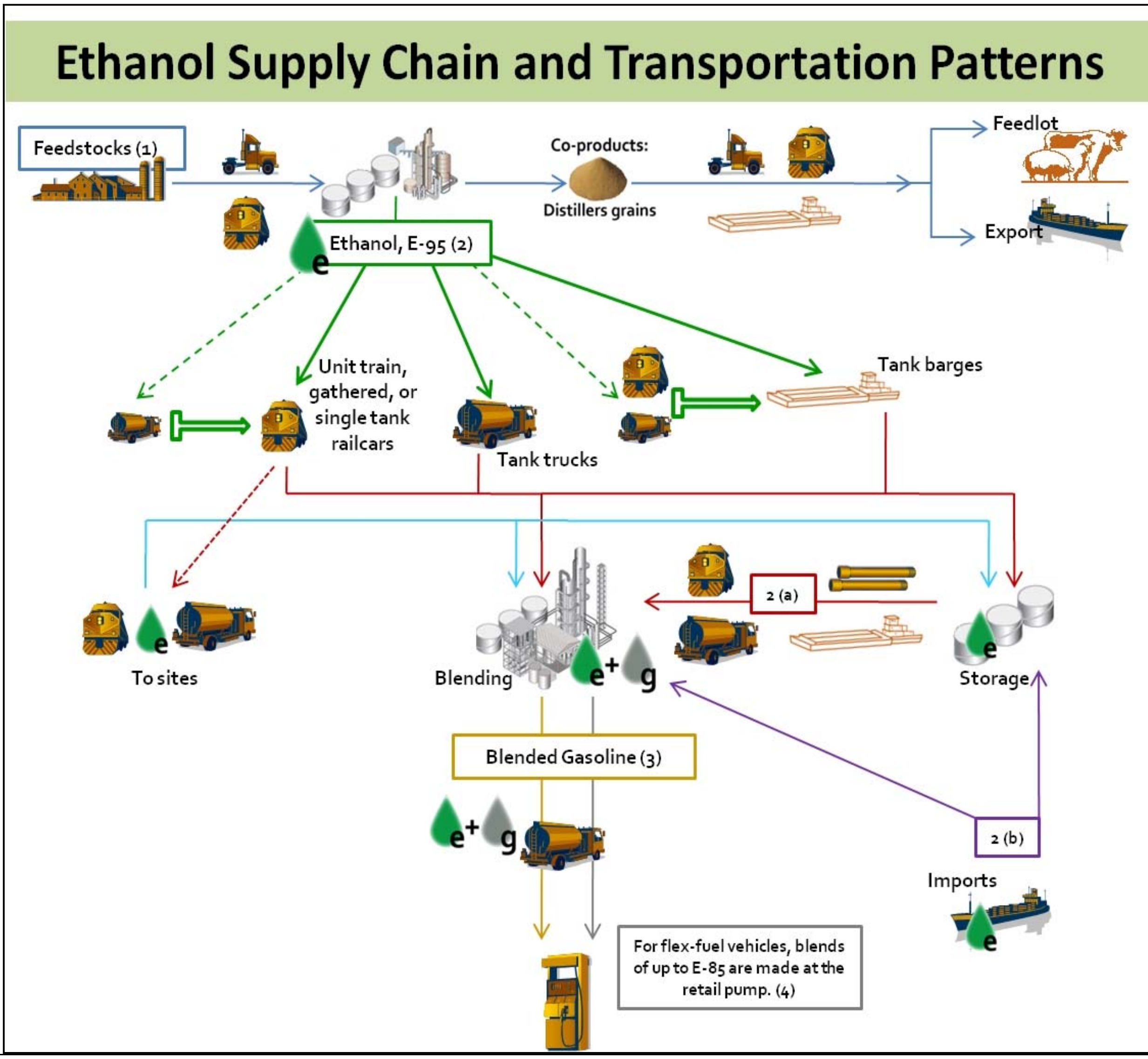
[†] E-10 fuel consists of 10 percent denatured ethanol and 90 percent gasoline.

Figure 4-3: The U.S. ethanol market landscape in 2007



Source: DOE, Biomass Programs, 2007 Ethanol Review

Figure 4-4: Ethanol Distribution



Legend

(1) Feedstocks via truck or rail to the biorefinery.

(2) Ethanol, which is denatured at the biorefinery, is shipped via truck, rail, or barge to a storage hub, petroleum or blending terminal, or rail-to-truck transloading (*truck-to-rail, and truck- or rail-to-barge are intermediate moves.*)

(a) Ethanol via truck, rail, barge, or pipeline from storage to blending terminal.

(b) Ethanol imports via ocean tanker vessel to storage or blending terminals.

(c) Ethanol via truck from rail-to-truck transloading to storage or blending.

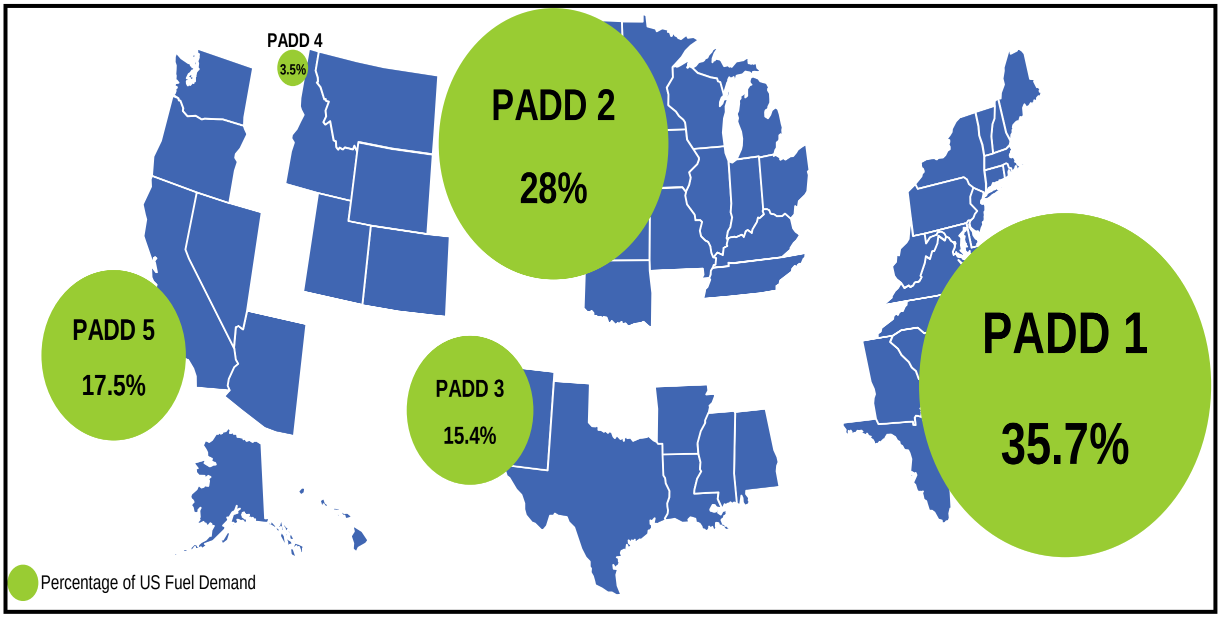
(3) Ethanol and gasoline are blended at the meter and shipped via gasoline trucks from blending terminal to service stations.

(4) E85 blends are currently typically blended at the service stations serving E85, implying that ethanol is also delivered via truck to the service stations.

Source: AMS, with data from National Bioenergy Center, National Renewable Energy Laboratory, and Energy Information Administration

The distribution system for U.S. transportation fuels evolved over many decades. Fuels are distributed from the major refining areas in the U.S. Gulf and, to a lesser extent, from ports to consumer markets. Petroleum fuels are transported by pipeline, ship, barge, and truck from petroleum refineries to petroleum terminals. For analysis purposes, the U.S. Energy Information Administration (EIA) reports fuel data by Petroleum Administration for Defense Districts or PADDs (Figure 4-5). Almost 70 percent of U.S. gasoline is consumed in the East Coast, West Coast and the Gulf States (PADDs 1, 3, and 5). Future demand for biofuels can reasonably be expected to be in the same geographical areas. In 2009, almost 500 petroleum terminals had storage for ethanol, but only 88 of those had access to rail—the mode that transports most ethanol today.[59]

Figure 4-5: The Petroleum Administration for Defense Districts (PADD) and their typical share of consumption of all U.S. motor gasoline consumption



Source: National Commission on Energy Policy's Task Force on Biofuels Infrastructure. <http://www.bipartisanpolicy.org/ht/a/GetDocumentAction/i/10238> (PDF)

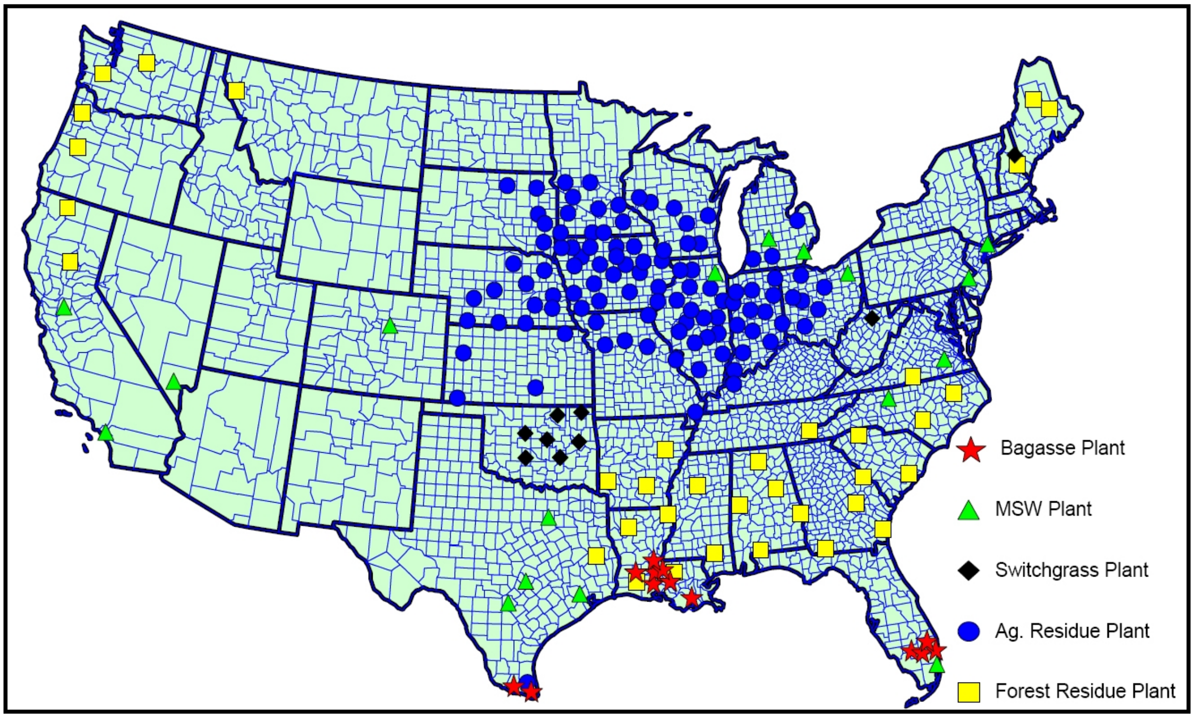
Ethanol production is expected to remain concentrated in the Midwest (PADD 2) even as cellulosic production expands. The Renewable Fuels Association (RFA) estimates that cellulosic production is currently under development in 26 places in the United States, with total production capacity of potentially 456 million gallons.[60] Cellulosic feedstocks may come from a variety of locations and sources, but EPA and the ethanol industry believe that the initial cellulosic ethanol is likely to appear from agricultural residues near current corn-based ethanol biorefineries and near papermills. Additionally, cellulosic and advanced biodiesel plants may be located near major cities where high levels of refuse, recycled oils, and greases can be collected (see Figure 4-6). EPA's expects that agricultural residue such as corn stover will make up a large portion of the cellulosic feedstocks used for biofuel production by 2022.[61] EPA estimates that by 2022, 7.8 billion gallons per year (bgy) of the projected 16 bgy cellulosic biofuel production will come from corn stover; 3.8 bgy from forestry biomass; 2.2 bgy from urban waste; and, the rest from other agricultural residues (1.3 bgy) and dedicated energy crops (.9 bgy).[62]

Figure 4-6: Corn stover being collected for ethanol production.

Source: National Renewable Energy Lab

Expanding production of ethanol will increase the demand for transportation services for feedstocks, biofuel, and co-products. In addition, feedstocks such as corn stover and woody biomass that have a lower density than corn may require different transportation than corn, with associated higher costs. EPA notes several alternative methods that could be developed to reduce the cost of biomass collection systems. Further discussion of feedstocks logistics can be found in EPA's FRIA.[63]

Figure 4-7: Projected U.S. cellulosic ethanol facilities



Source: EPA, FRIA, p. 198

EPA's Biofuel Distribution Analysis

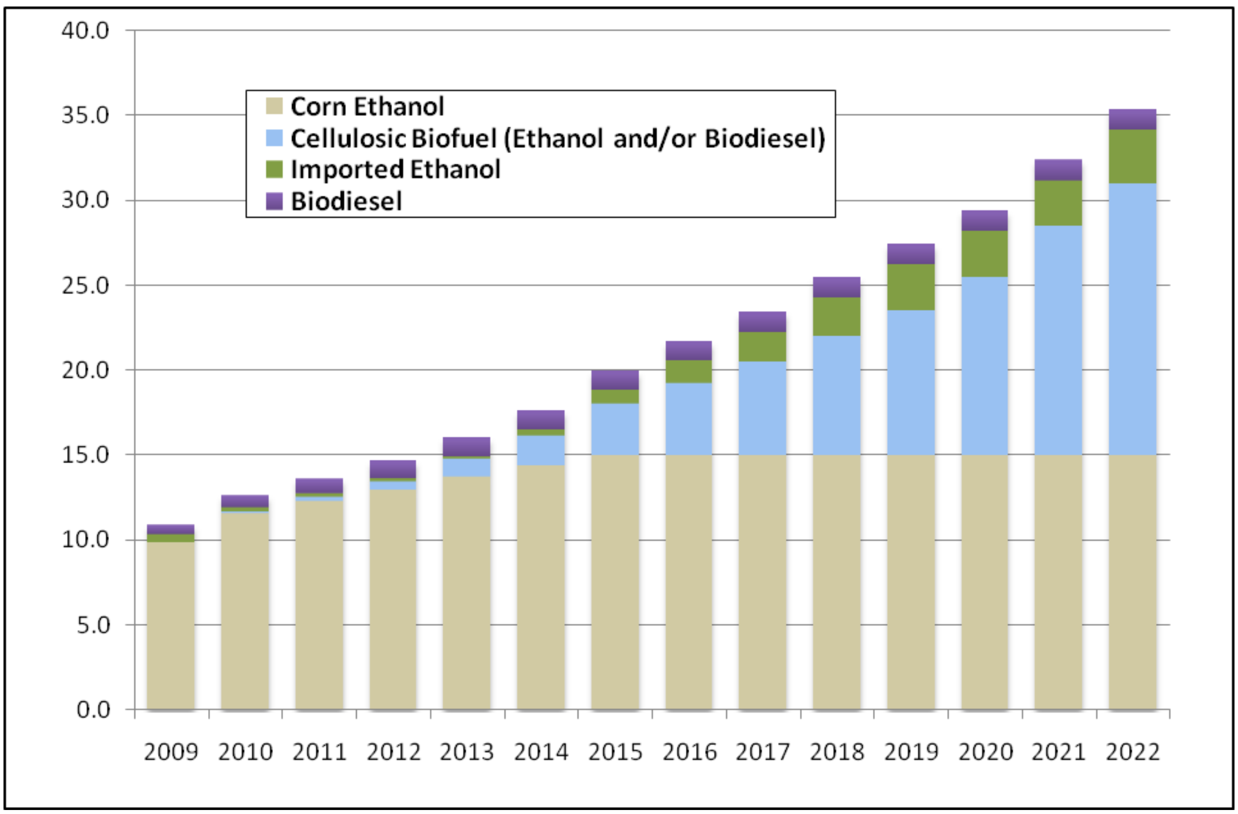
In its FRIA report, EPA published the results of a study recently completed for EPA by Oakridge National Laboratories (ORNL), which modeled the transportation of ethanol from production/import facilities to petroleum terminals. The ORNL model optimizes freight flows over rail, marine, and road distribution networks, and addresses the use of multiple shipping modes. The following section summarizes the EPA analysis and integrates USDA's analysis of the current status.

Projected Biofuel Consumption

EISA 2007 requires a fairly rapid increase in use of biofuels in the transportation fuel mix, reaching 36 billion gallons per year by 2022. In the Final Regulatory Impact Analysis, issued in February 2010, EPA developed a control case – a likely scenario of annual biofuel use projected to 2022 (Figure 4-8 and Tables 4-1 and 4-2). In this scenario:

- Corn-based ethanol use can grow to a capped-15 billion-gallon level by 2015.
- The cellulosic biofuels can consist of either ethanol or cellulosic biodiesel and are set to increase to 16 billion gallons by 2022.
- The remainder of the RFS2 required biofuel consumption is expected to come from imported ethanol and other biodiesel.

Figure 4-8: Energy Independence and Security Act 2007, Renewable Fuel Standard (RFS-2), EPA



Source: EPA, Table 1.2-1. Control Case Projected Renweable Fuel Volumes (billion gallons) Final Regulatory Impact Analysis, <http://www.epa.gov/otaq/renewablefuels/420r10006.pdf> (PDF), page 69

Table 4-1: EPA projected renewable fuel volumes (billion gallons)

	Advanced Biofuel					Non-Advanced Biofuel	
	Cellulosic Biofuel	Biomass-based Diesel		Other Advanced Biofuel			
Year	Cellulosic Biofuel (Ethanol and/or Biodiesel)	Biodiesel	Non-Co-Processed Renewable Diesel	Co-Processed Diesel	Imported Ethanol	Corn Ethanol	Total Renewable Fuel
2009	0	0.5	0	0	0.5	9.85	10.85
2010	0.1	0.64	0.01	0.01	0.29	11.55	12.6
2011	0.25	0.77	0.03	0.03	0.16	12.29	13.53
2012	0.5	0.96	0.04	0.04	0.18	12.94	14.66
2013	1	0.94	0.06	0.06	0.19	13.75	16
2014	1.75	0.93	0.07	0.07	0.36	14.4	17.58
2015	3	0.91	0.09	0.09	0.83	15	19.92
2016	4.25	0.9	0.1	0.1	1.31	15	21.66
2017	5.5	0.88	0.12	0.12	1.78	15	23.4
2018	7	0.87	0.13	0.13	2.25	15	25.38
2019	8.5	0.85	0.15	0.15	2.72	15	27.37
2020	10.5	0.84	0.16	0.16	2.7	15	29.36
2021	13.5	0.83	0.17	0.17	2.67	15	32.34
2022	16	0.81	0.19	0.19	3.14	15	35.33

Source: EPA, Table 1.2-1. Primary Control Case Projected Renweable Fuel Volumes (billion gallons) Regulatory Impact Analysis, <http://www.epa.gov/otaq/renewablefuels/420r10006.pdf> (PDF), page 71

Table 4-2: Summary of EPA-projected renewable fuel volumes (billion gallons)

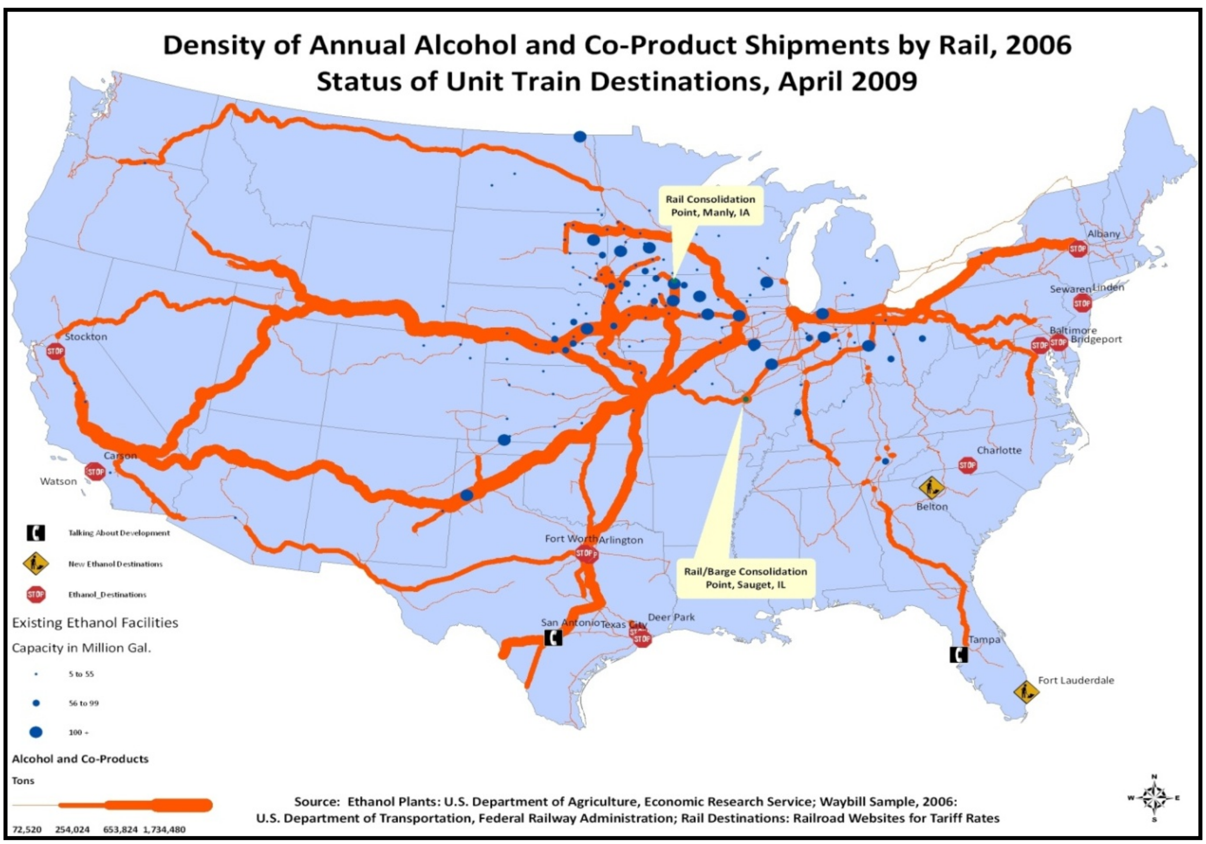
	Cellulosic Ethanol and/or Biodiesel	Corn Ethanol	Imported Ethanol	Total Ethanol	Biodiesel
2009	0	9.85	0.5	0.5	0.5
2010	0.1	11.55	0.29	0.39	0.66
2011	0.25	12.29	0.16	0.41	0.83
2012	0.5	12.94	0.18	0.68	1.04
2013	1	13.75	0.19	1.19	1.06
2014	1.75	14.4	0.36	2.11	1.07
2015	3	15	0.83	3.83	1.09
2016	4.25	15	1.31	5.56	1.1
2017	5.5	15	1.78	7.28	1.12
2018	7	15	2.25	9.25	1.13
2019	8.5	15	2.72	11.22	1.15
2020	10.5	15	2.7	13.2	1.16
2021	13.5	15	2.67	16.17	1.17
2022	16	15	3.14	19.14	1.19

Source: EPA, FRIA, page 69 <http://www.epa.gov/otaq/renewablefuels/420d09001.pdf> (PDF)

Based on the ORNL model, EPA projects that 40 unit train rail receipt facilities will be needed to achieve this goal.[64] Additional unit-train destinations would likely create more ethanol corridors on the rail network, possibly alleviating congestion points that could develop with increased biofuel shipments. In addition to unit trains, EPA expects manifest rail cars (shipments of less than 80–100 railcar unit trains) will continue to be used to ship ethanol and cellulosic biofuels. EPA estimates a total ethanol distribution infrastructure capital costs to total $12.066 billion.[65] When amortized, this translates to 6.9 cents per gallon of additional ethanol attributed to the RFS standards.[66] Developing unit train destinations is a time-consuming process, usually taking 3 to 5 years. The industry has responded to this challenge by developing rail-to-truck transloading facilities for smaller-than-unit train shipments of ethanol (see Text Box Schematic). Almost every Class I railroad is developing these facilities, but the number in existence today is difficult to determine.

In 2006, rail movements of ethanol and co-products were mainly along several distinct corridors, with fewer than the current 13 unit train destinations (Figure 4-9). To achieve EPA's objective of 40 unit train destinations in the next 13 years, the industry will need to determine future locations, permitting and financing availability, and increase the pace of building these unit train terminals. While these are not insurmountable challenges, the timeframe is short for development of this capital-intensive infrastructure. Terminals must be developed in tandem with other biofuel infrastructure expansion—more Flex Fuel Vehicles (FFV's), more retail stations offering higher blends, and more blending and storage capacity.

Figure 4-9: Key rail corridors for shipping ethanol and DDGS



Ethanol and Co-product Transportation

The primary feedstock for U.S. ethanol is corn, which is shipped to local biorefineries by truck—usually about 50 miles (Figure 4-9). Prior to the rapid growth of the ethanol industry, most ethanol plants produced 50 million gallons per year (mgy) or less. Most of the plants that have come online since 2005 have had a greater production capacity—typically 100 mgy or more. Larger plants now comprise almost 50 percent of total U.S. production capacity (Table 4-3). They use more corn, expanding the draw area for many plants well beyond the 50-mile radius normal with older plants. According to an article in the April 2009 issue of Ethanol Producer Magazine, this has provided an opportunity for railroad service that is still short-haul in nature and is suitable for the regional (shortline) railroads and, at times, Class I railroads. Analysis of the 2006 Waybill Sample showed that both regional and Class I railroads shipped corn to several of the large ethanol plants. According to the Renewable Fuels Association, a 100-mgy ethanol plant can expect to receive 60 percent of its corn by rail, or 17 railcars per day. It produces enough to ship 10 tank cars of ethanol and nine hopper cars of distillers dried grains with solubles (DDGS) per day.

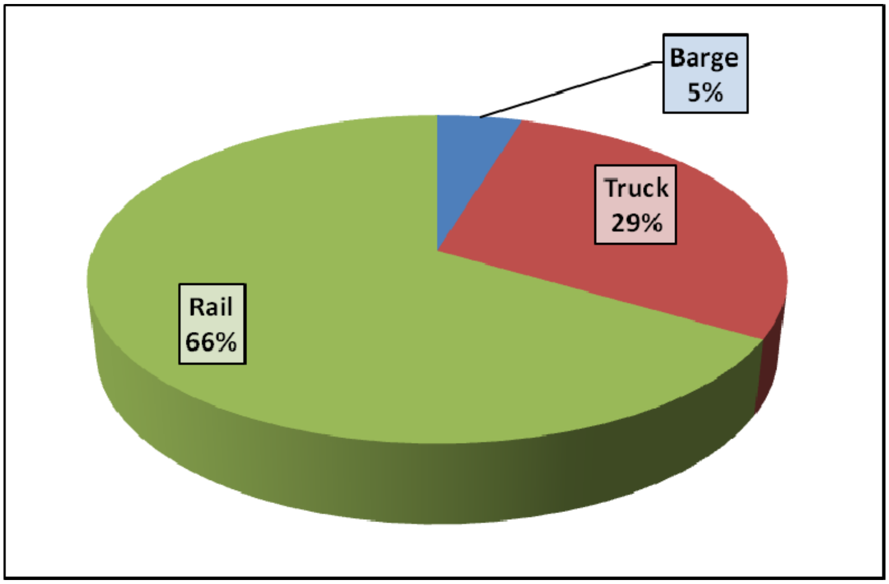
Table 4-3: Ethanol capacity distribution, March 2008

Category by mgy Capacity	Number of Plants	Total Capacity	Percent of Total	Average Capacity
100+	53	6,409	49.8%	121
56-99	32	2,271	17.6%	71
5-55	101	4,192	32.6%	42
Total	186	12,872	100%	69

Source: Developed by AMS, based on data from the RFA and Ethanol Producer Magazine, April 2009

After ethanol is produced, it is denatured at the biorefinery with up to 5 percent natural gasoline and then is moved to storage or blending terminals via rail, trucks, or barges (step 2 (a) in Figure 4-4). As can be seen in Figure 4-10, Class I railroads are the predominant mode of moving ethanol to distant markets; 66 percent of the ethanol produced in 2006 was moved by rail. Barges moving on the Mississippi River can ship some (about 5 percent in 2006) to the U.S. Gulf region but, since most ethanol plants are not near a navigable waterway, ethanol moved by barge is first shipped by truck or rail from a biorefinery and is then transloaded to a tank barge to be shipped to the terminal for storage or blending. Rail's share of ethanol movements is expected to increase as ethanol penetrates markets farther from producing regions.

Figure 4-10: Ethanol modal shares in 2006



Sources: Freight Commodity Statistics, Escalation Consultants; Surface Transportation Board, Waybill Sample, 2006; U.S. Army Corps of Engineers, Waterborne Statistics, 2006

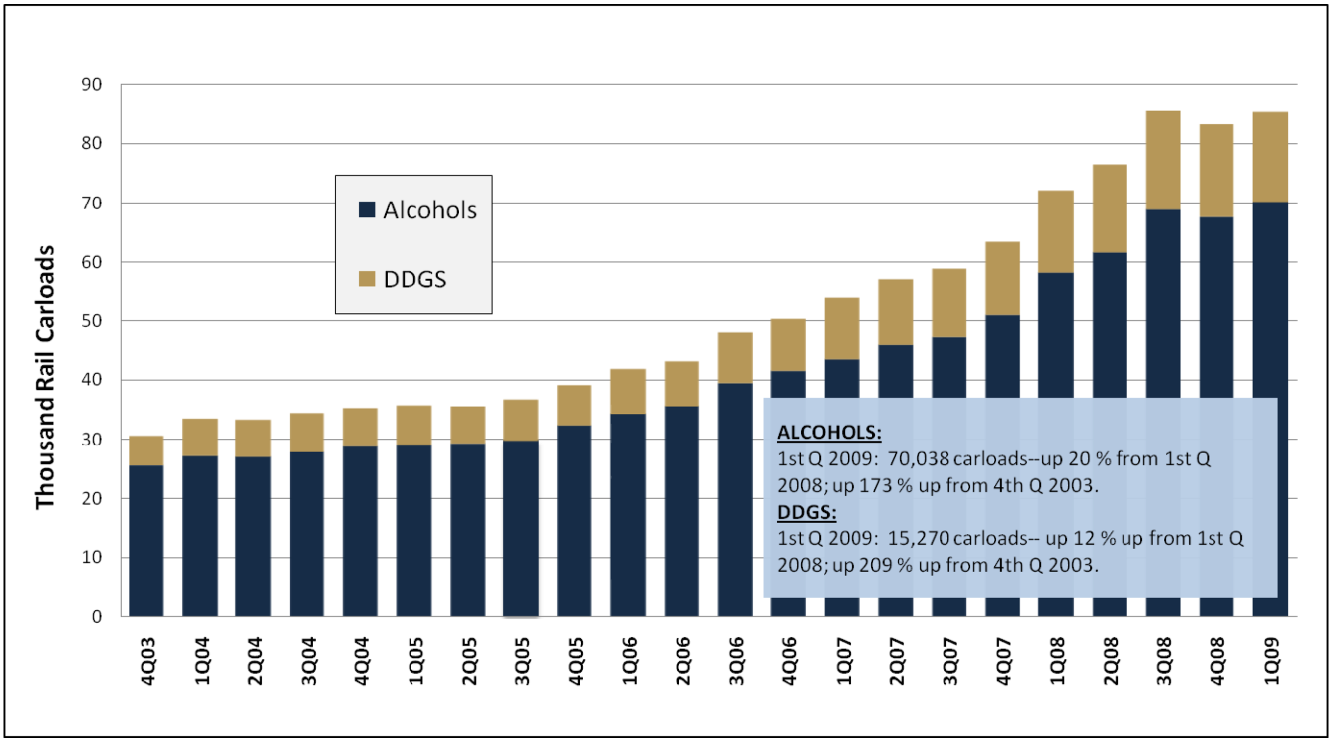
Current Status of Ethanol Transportation

Despite the turbulent economic conditions that have recently dampened the ethanol industry, railroads continue to play a major role in the ethanol supply chain and have been able to keep up with rapid ethanol production increases. According to the Freight Commodities Statistics (FCS), railroads moved almost 260,000 carloads of alcohols in 2008–almost 70,000 carloads or 36 percent more than in 2007, while U.S. ethanol production increased by over 40 percent. The railroads also shipped almost 61,000 carloads of DDGS for feed in the United States and abroad.

According to the most recent FCS data, during first quarter of 2009, major railroads in the United States delivered over 70 thousand carloads of alcohols (over 2 billion gallons) to their final destinations—20 percent higher than the first quarter of 2008 and 173 percent higher than the fourth quarter of 2003. (Ethanol accounts for over 80 percent of alcohols shipped by rail.) This implies that over 70 percent of ethanol produced in the first quarter 2009 was shipped by rail, slightly higher than in 2006 (the last available annual modal share data). Railroads also have increased their shipments of DDGS, a major co-product of ethanol production that is used as animal feed. During the first quarter, railroads terminated over 15 thousand carloads of DDGS—about 20 percent of the estimated quarterly distillers grains production (on a dried basis). This is up 12 percent from first quarter of 2008 and 209 percent higher than in the fourth quarter of 2003, the first available quarterly data (Figure 4-11).

Class I railroads (UP, BNSF, NS, and CSX) have been involved in developing more unit train and transloading receiving facilities, as well as investing in more track and improving interchanges at critical locations. This investment is necessary for their overall networks and helpful for moving the increasing quantities of ethanol expected in the near future.

Figure 4-11: Quarterly carloads of alcohol and co-products terminated by major railroads in the United States, 4th quarter 2003–1st quarter 2009



Source: Railratechecker.com, based on Quarterly Freight Commodity Statistics. First Available Data is the 4th Q 2003

According to the Association of American Railroads, the vast majority of ethanol is carried in 30,000 gallon all-purpose rail tank cars. In 2008, more than 50,000 of these cars were in service, but it is not clear what percentage of the cars are used to move ethanol, versus those used to move petroleum products and other chemicals. The EPA estimates that by 2022, 43,398 railcars will be needed solely for moving biofuels.[67] The EPA estimate is based on their assumption that 70 percent of the ethanol rail movements will be moved by unit trains, reducing cycle times, and increasing the utilization rates of existing rail cars. The remaining 30 percent will move in single car shipments, possibly requiring additional tanker cars. If unit train destinations do not materialize as quickly as EPA projects, it is possible that even more railcars and network capacity will be needed to move ethanol to all the needed market destinations.

Transportation of DDGS

About a third of every bushel of corn used to manufacture ethanol becomes DDGS, which contributes to the profitability of the biorefinery and reduces the impact of ethanol production on feed supplies. Railroads, trucks, and barges move this product to domestic feedlots, and to ports for export. The ethanol industry has successfully marketed DDGS overseas and exports have been growing in tandem with ethanol production (Figure 4-13). Figure 4-14 shows that the main destinations for exported DDGS are across our borders to Mexico and Canada. These movements are primarily land-based, by rail or truck. Ocean vessels ship the product in bulk or in containers to overseas destinations, including Korea, Thailand, Turkey, Japan, and other countries.

Figure 4-12: Loading a truck with DDGS in South Dakota.

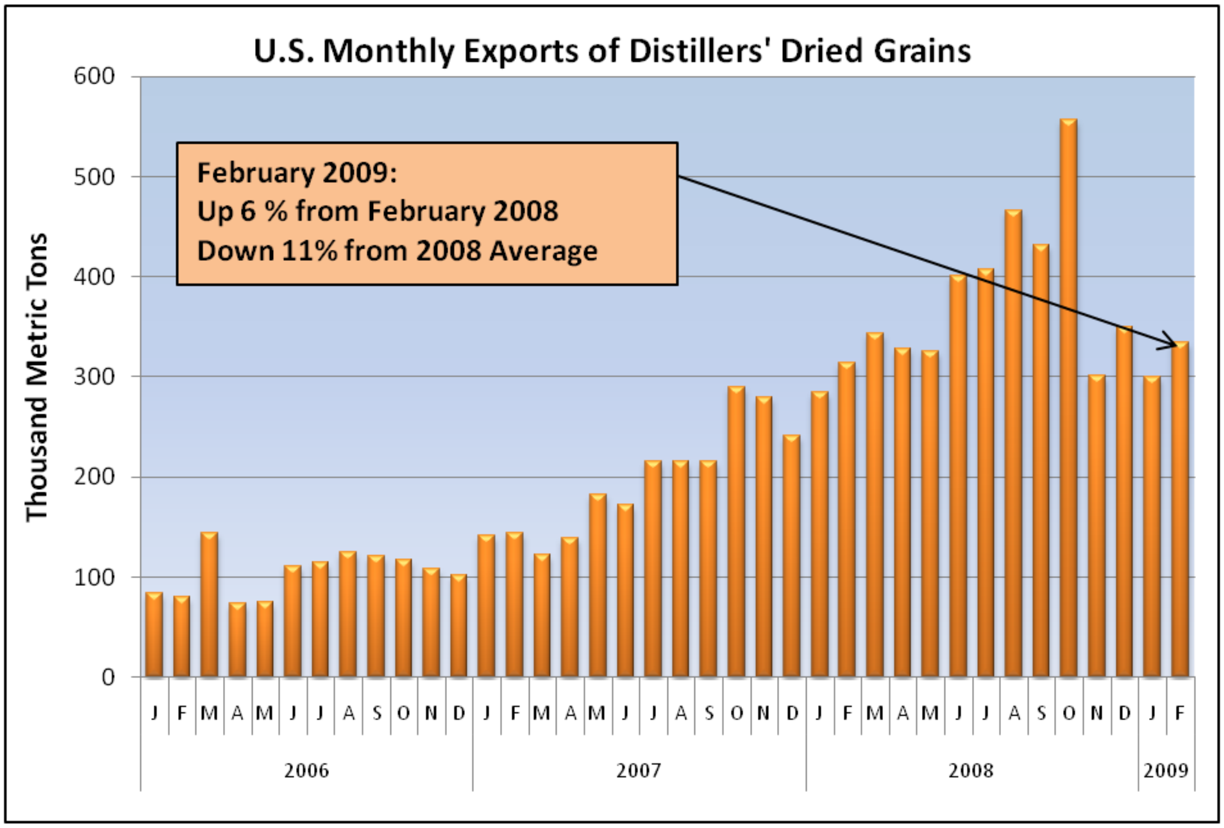
Source: USDA

DDGS as Animal Feed

Historically, the mash remaining after distilling alcohol was divided into two products: distiller's dried grains (the insoluble portion), and distiller's dried solubles (the soluble portion with the water evaporated). Modern ethanol plants blend these dried products to make distiller's dried grains with solubles (DDGS). Only the starch portion of the corn is used to make ethanol; the mash contains all the protein, oil, and fiber of the corn and the yeast used to distill the ethanol, and makes a nutritious feed. Eighty percent of DDGS used in the United States is fed to cattle. The remainder is fed to poultry and swine.*

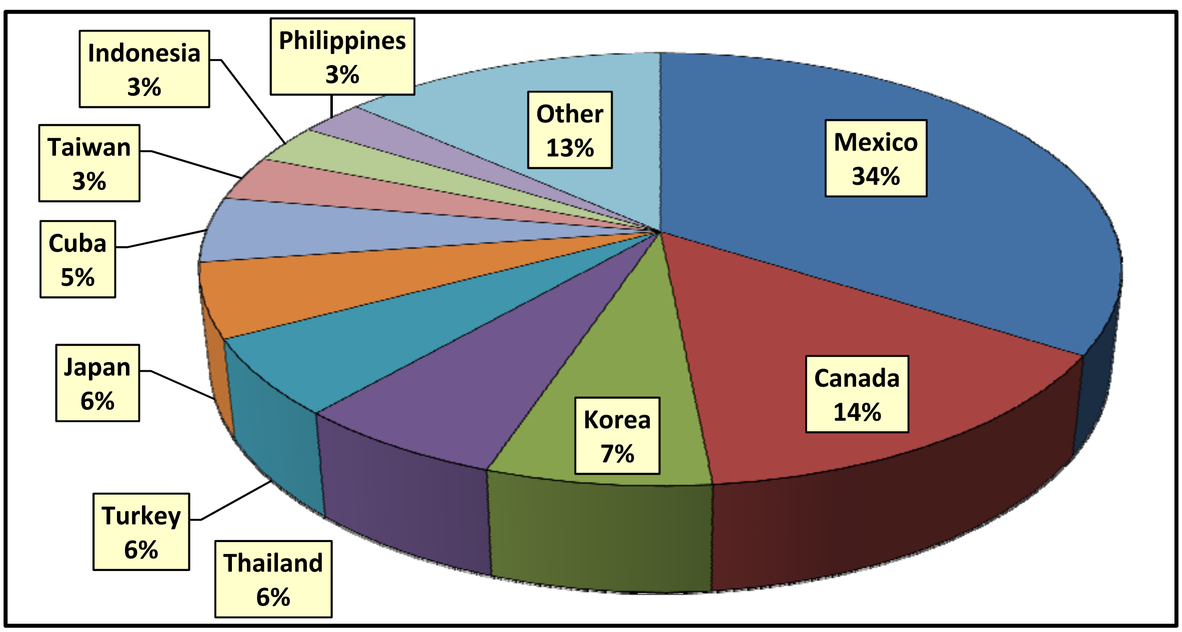
* University of Minnesota Department of Animal Science

Figure 4-13: U.S. exports of DDGS, Jan 2006–Feb 2009



Source: USDA/FAS/U.S. Trade Data

Figure 4-14: Major destinations of U.S. DDGS exports, Jan–Feb, 2009



Source: USDA/FAS/U.S. Trade Data

Potential Phases of Biofuels Expansion from the Transportation Demand Perspective

The National Commission on Energy Policy (NCEP) convened a Task Force on Biofuels Infrastructure, consisting of representatives from the petroleum and ethanol industries, academia, and the Federal Government. After three all-day meetings over the course of 6 months in 2008, a report was developed and released by the NCEP on April 16, 2009. The Task Force identified the need for infrastructure investments over 3 distinct phases:

Phase I (by 2010)

Ethanol production increases to 12 billion gallons per year. The existing multi-modal transportation network will be used to transport ethanol from production centers in the Midwest to demand centers on the coasts, with rail continuing to play a major role.

Phase II (2011–2015)

Corn ethanol use increases to 15 billion gallons per year. The additional 5.5 billion gallons of ethanol targeted to be produced from cellulosic feedstocks may not be commercially available. Assuming minimal imported ethanol, absorbing even the 15 billion gallons of corn-based ethanol would require 100 percent nationwide market penetration of E10 or a higher-ratio blend, with expanded use of E85. Transportation networks and receiving terminals may require additional infrastructure investment to prevent bottlenecks. Retail fueling infrastructure would probably need modification to accommodate higher-ratio ethanol blends.

Phase III (after 2015)

Ethanol and advanced biofuel production expands beyond 15 billion gallons per year. Further evolution of the associated transportation and distribution infrastructure will depend on several factors**:**

- Geographic distribution of supply and demand centers.
- Certainty in the RFS targets.
- Flex-Fuel Vehicle (FFV) production.
- Market penetration of E85 or higher-ratio fuels—especially when cellulosic ethanol production is brought to commercial scale.

After 2015, non-ethanol biofuels—often referred to as bio- or renewable hydrocarbon, which are similar to existing gasoline and diesel fuel—could potentially be developed. These would satisfy the RFS-2 requirements and mitigate many of the distribution infrastructure challenges because they would be fully compatible with conventional fuels and existing auto engines and distribution infrastructure.

Table 4-4: Renewable Fuels Standard-2 (as mandated by EISA 2007) and possible phases

Year	TOTAL RENEWABLE BIOFUELS	Conventional*	TOTAL ADVANCED BIOFUEL			
				Cellulosic	Unidentified Advanced	Biomass-based Diesel
Phase I						
2008	**9**	**9**				
2009	**11.1**	**10.5**	**0.6**		0.1	0.5
2010	**12.95**	**12**	**0.95**	0.1	0.2	0.65
Phase II						
2011	**13.95**	**12.6**	**1.35**	0.25	0.3	0.8
2012	**15.2**	**13.2**	**2**	0.5	0.5	1
2013	**16.55**	**13.8**	**2.75**	1	1.75	
2014	**18.15**	**14.4**	**3.75**	1.75	2	
2015	**20.5**	**15**	**5.5**	3	2.5	
Phase III						
2016	**22.25**	**15**	**7.25**	4.25	3	
2017	**24**	**15**	**9**	5.5	3.5	
2018	**26**	**15**	**11**	7	4	
2019	**28**	**15**	**13**	8.5	4.5	
2020	**30**	**15**	**15**	10.5	4.5	
2021	**33**	**15**	**18**	13.5	4.5	
2022	**36**	**15**	**21**	16	5	

*Ethanol derived from starch feedstocks, such as U.S. yellow corn #2.
Source: P.L. 110-140, Sec. 201, 202, and 205 (EISA, 2007)

Market Uncertainty and its Implications for Infrastructure Investment

EISA's Renewable Fuels Standard mandates increased biofuel consumption levels, but several supply and demand factors create uncertainty for the market to reach the RFS levels. Resolving these uncertainties is important to stimulate further investment into the capital-intensive distribution infrastructure. As discussed above, the short time-frame for meeting the RFS-2 targets will require coordination and collaboration between the petroleum industry, biofuel producers, and finance entities, as well as State and Federal Governments. Currently, the factors potentially limiting demand for biofuels—and the impact on biofuel producers and infrastructure developers—could be of greater concern than the factors influencing the supply of biofuels.

Sources of Demand Uncertainty

The long-term viability of the biofuels industry and the achievement of national energy policy goals require that market and policy signals work together to provide a stable environment for demand and supply growth. Resolving uncertainties on the demand side can help smooth the way for achieving the goals set by EISA. Market uncertainty about ethanol demand stems from:

- The reduction in U.S. consumption of transportation fuels as a result of both the current economic downturn and because of increased fuel efficiency and production of hybrids.
- The ability of the current blending infrastructure to reach nationwide use of E-10 and potentially higher ethanol blends—these are the "blend wall" issues. Recent trends in gasoline consumption suggest that the E10 blend wall will probably be reached by 2012, if not sooner, accelerating the need to modify existing policies and transportation infrastructure.
- The expected reduction in consumption of total transportation fuels as fuel efficiency and production of hybrids is expected to increase.

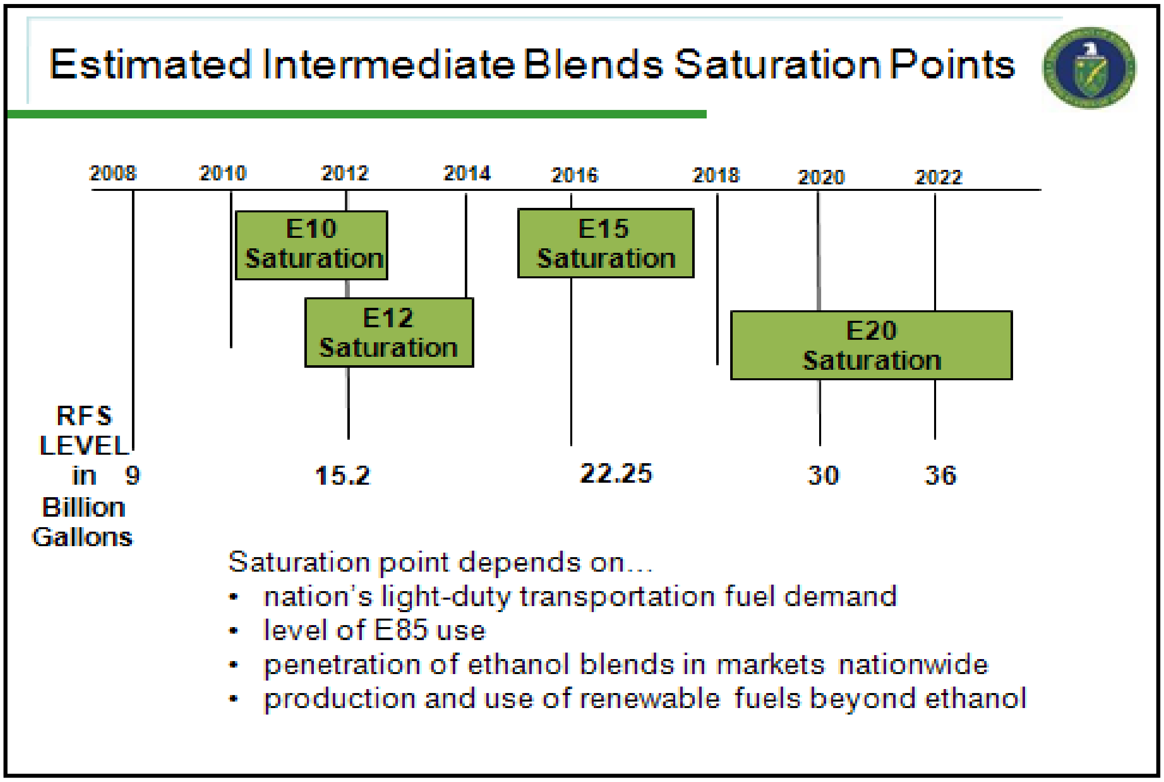
Blend Wall

The blend wall is the limit of annual ethanol use that is constrained by the legal blending limit with gasoline (currently 10 percent for regular engines and 85 percent for Flex Fuel engines). It is the volume of ethanol that can be expected to be marketed at current blending limits.

The recent economic crisis and high petroleum prices have reduced gasoline demand in the United States. The EIA is now forecasting that U.S. gasoline consumption in 2009 will reach 136 billion gallons, down from a previous forecast of over 140 billion gallons. Projected decreases in long-term demand are also driven by increased vehicle efficiency standards and a projected increase in electric hybrids. The concept of a "blend wall" stems from the idea that only a certain quantity of ethanol can be absorbed into the existing gasoline demand at the E10 blend level—12 to 13 billion gallons (about 10 percent of all blenders are exempt from the RFS).

Investments in receiving and blending infrastructure would improve the ability to reach nationwide use of E-10 and higher ethanol blends. Creating a market for the increased long-term biofuel target levels at the same time as expanding blending infrastructure are critical to achieving the RFS goals. DOE has developed the following timeline for market saturation (the blend wall) of ethanol. It expects that the E10 blend wall may occur as early as 2010, when the RFS target is 12.1 billion gallons of ethanol. In spring 2009, EPA received a request to increase the blend level from the current E10 maximum and is currently reviewing public comments to this request. From the blend wall issue perspective, if the EPA issues a waiver, allowing blend levels to go to 12 percent ethanol and 88 percent gasoline, the blend wall shifts to a 2011–2012 timeframe. It moves to 2015–2016 with E15 and to 2018–2022 with an E20 blend. This timeline implies that the E85 distribution infrastructure would need to grow in order to help create a ready-made demand for ethanol even if EPA decides to approve higher blends of ethanol; it is currently considering approving ethanol blends up to E15.

Figure 4-15: DOE's estimate of intermediate saturation points



Source: Presentation by Joan Glickman, DOE, at the Transportation Research Board, 2009 Annual Meeting. <http://projects.battelle.org/trbhazmat/Presentations/TRB2009-JG.pdf> (PDF)

Sources of Supply Uncertainty

Sources of uncertainty that may affect ethanol supplies and impact the pace of transportation infrastructure development include the production location and timing of the commercial scale availability of new biofuels, including cellulosic ethanol. The EPA expects most of the new facilities will be able to benefit from the efficiency of unit train shipments; however, smaller scale biorefineries may depend on trucking as the best mode of transporting the biofuels to petroleum terminals. The EPA's annual review of these supply factors will help clarify transportation demand and the need for further distribution infrastructure development.

Current Transportation Infrastructure

In addition to the additional unit train destinations that EPA estimates will be necessary by 2022, all modes of transportation will need extra capacity to distribute the increased ethanol by the RFS timeline. Fuel markets tend to be a least-cost commodity business; the petroleum industry will seek the least expensive options in providing fuel to the market. Improving transportation efficiency could lead to better prices for consumers. However, the cost of improving the long-term capital assets of the distribution infrastructure may offset some of the benefits gained in transportation efficiencies.

The Geographic Distribution of Biofuel Production

U.S. ethanol production is concentrated in the Midwest Corn Belt. Proximity simplifies the logistics for transporting feedstock inputs, such as corn, and DDGS from ethanol distillation. Location criteria that are often cited are a maximum of 50 miles from corn supplies and the intersection of two class I railroads that can be used for transporting ethanol and DDGS. Depending on location, inbound and outbound transportation costs for biorefineries can amount to as much as 20 percent of operating costs, suggesting the critical nature of strategic siting near transportation.

Location of future biorefineries and the successful deployment of the next generation ethanol will also rely on a structured cross-country transportation infrastructure. This infrastructure will be needed soon to integrate existing mid-continent biofuels facilities and the new cellulosic biorefineries with the existing petroleum industry facilities. Although co-products of future generation ethanol production are not known, the expansion of corn-based ethanol production to 15 billion gallons per year will create the need for a market for DDGS. Planning the location of feedlots capable of receiving unit trains of DDGS will benefit the industry by reducing transportation costs and improving the potential for profitability.

Conclusions

U.S. policies addressing climate change, supporting the domestic economy, and decreasing the nation's dependence on imported petroleum have driven the increased production and use of biofuels. By 2008, U.S. ethanol production had reached 9.3 billion gallons—equivalent on an energy basis to approximately 36 percent of the gasoline produced from crude oil imported from Persian Gulf countries. EPA expects U.S. production of cellulosic ethanol to become commercially available in 2010. Renewable Fuel Standard goals project increasing biofuel production to 36 billion gallons by 2022—a very brief time in which to develop the distribution infrastructure.

Collaboration between carriers, producers, marketers, and Federal and State governments will be needed for planning terminals capable of receiving unit trains of ethanol. In addition, expanding E85 infrastructure and increasing the number of Flex Fuel Vehicles will help increase the demand base for ethanol, which is needed to resolve the blend wall issues. Although the railroads have so far been able to handle ethanol production expansion, more destination terminals will have to be developed for the rail system to be able to accommodate continued rapid growth.

The long-term viability of the biofuels industry and the achievement of national energy policy goals require that market and policy signals work together to provide a stable environment for demand and supply growth. Resolving uncertainties on the demand and supply sides can help smooth the way for achieving the goals set by EISA.