

**Department of Transportation White Paper:
Enabling the Effective Distribution of Biofuels in the United States**

Introduction

In May of 2010, the U.S. Department of Energy (DOE) and U.S. Department of Agriculture (USDA) issued a joint statement in which they highlighted the lack of logistics systems capable of handling and delivering sufficiently high volumes of biofuel products as a significant barrier to the expansion of a sustainable domestic biofuels industry.¹ Establishing a sustainable domestic biofuels industry is at the heart of the Revised Renewable Fuels Standard (RFS-2), and is a part of the mission of the Biomass Research and Development Board (BRDB).

In 2008, the BRDB tasked the U.S. Department of Transportation (DOT) with organizing a Federal Biofuels Distribution Infrastructure Interagency Working Group (DI-IWG) in accordance with the Board's *National Biofuels Action Plan (NBAP)*. The NBAP charged DOT, in coordination with other key agencies such as DOE and USDA, with researching myriad existing impediments to the transport of biofuels from the point of domestic production to the point of retail sale. The DI-IWG developed the following three draft products, soon to be published, to meet this mandate:

- *Pipeline Feasibility Study*, assessing the feasibility of pipeline use for biofuels transport;
- *Multimodal Infrastructure Analysis*, identifying short and long-term multimodal infrastructure bottlenecks inhibiting biofuels development; and
- *GIS-Based Tools Inventory*, documenting existing federal Geographic Information Systems (GIS) that may be integrated to better link biofuels transportation infrastructure, demand, feedstock location, water and other resources.

Through these products, the DI-IWG outlined a host of issues related to these areas. DOT has pursued and implemented several solutions that are noted in this summary paper, and also makes a number of key recommendations that, if implemented, would serve to move the Nation forward on high priority biofuel infrastructure needs.

Status of Biofuels Transport

At this time, cornstarch-based ethanol (also known as "conventional biofuel") is the most prevalent biofuel used for surface transportation in the United States. It is currently distributed from production sites in three ways:

1. by tank rail cars (29,400 gallons capacity each, over 2 million gallons per train);
2. by tank trucks over highways (8,000 gallons capacity each); and
3. by tank ships and barges (420,000 gallons capacity each).

¹ USDA and DOE joint funding announcement # DE-FOA-0000341, 2010.

Approximately 66 percent of this distribution is by rail, 29 percent by truck, and 5 percent by barge. Pipelines have been used infrequently. Each mode faces distribution challenges as well as distribution opportunities to make biofuels more competitive.²

In recent years the BRDB has recognized the importance of additional focus on the development of advanced biofuels. Under the RFS-2, advanced biofuels include cellulosic biofuel (ethanol produced from cellulose, hemicellulose or lignin, as opposed to starches), biodiesel, and a new class of biofuels developed from plant-oils, algae, and other emerging feedstocks known as hydrocarbon biofuels. Fuels of the latter type are also known as drop-in biofuels as they are expected to be seamlessly mixed with petroleum and “dropped in” to existing infrastructure and vehicles including cars, trucks, and aircraft without compatibility or performance issues.

Building upon industry experiences with transporting ethanol fuels, the development of advanced biofuels presents an opportunity to include distribution considerations early in the engineering and testing phases of these new fuels.

Rail

Because farms providing feedstocks were initially no further than 50 miles from biorefineries, ethanol feedstocks traditionally arrived at biorefineries by truck. The increased volumes of ethanol transported in recent years, however, have been sufficient to cause a shift from truck to rail. New biorefineries brought online since 2005-2006 generate 100 million gallons per year (mgy) per facility and now comprise about 50 percent of total production capacity. The size of these biorefineries has resulted in the need to use corn from farms outside a 50-mile radius. This has led to short-haul railroad service replacing trucks.

The 100 mgy plants now receive 60 percent of their corn by rail, consuming about 17 railcars of corn per day. These refineries also produce up to 10 railcars of ethanol per day and nine hopper railcars per day of distillers dried grains with solubles (DDGS) as a commercial byproduct. By 2022, annual shipping volumes by unit trains may reach 23.8 billion gallons. It is estimated that an additional 3.4 billion gallons of ethanol will be shipped annually by manifest car (less than unit train shipments of 80-100 cars) by 2022.³

Looking forward, competition for existing capacity will become more difficult. Even if these rail capacity issues are addressed, the projections for line capacity offer no relief. In 2002, very few lines were above capacity, but by 2035 the majority of rail lines are projected to be near or above capacity, and ethanol already moves along some of the higher density rail arteries in the Nation.⁴ This level of demand will be complicated by other stressors affecting the movement of biofuels.

² Interim Draft of Multi-Modal Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

³ Interim Draft of Multi-Modal Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

⁴ National Rail Freight Infrastructure Capacity and Investment Study, Cambridge Systematics, Inc., 2007.

Overall, rail tank car demand has risen, competing with growing demand for rail tank cars for ethanol. Rail tank car demand historically increases when oil prices rise, adding additional modal capacity uncertainty. Furthermore, for every gallon of ethanol produced, 6.34 lb of DDGS is produced as a commercial by-product. There may not be enough covered hopper cars to support DDGS quantities in the future, and some rail line companies won't allow DDGS because of the difficulties associated with cleaning cars after DDGS shipment.

In addition to congestion trends, the economies of using rail conveyance for ethanol may pose a challenge. Typically, rail tank cars are leased rather than purchased. Several years ago, it cost \$3 million annually to lease the necessary rail support for a 100 mgy ethanol facility. Now that cost is roughly \$12 million. Further, a 50 mgy facility takes 14-30 days to fill a unit train (80-100 cars of the same commodity)—a time delay that may aggravate rail congestion and increase the cost associated with using rail as a mode of ethanol transport, despite its general economic advantage over trucking.⁵

Trucking

Distribution of biofuels by trucks faces vehicle safety and capacity challenges that may need to be addressed by establishing best practices for the industry or other system approaches that go beyond existing compliance with codes, standards, and regulations. For example, one systems approach could address routing, driver training, and emergency response as follows⁶:

Because frequently there are long distances between biorefineries and the locations of greatest potential demand, bulk movement of ethanol by truck may be cost-prohibitive—tank trucks typically are used for hauls less than 250 miles and rarely more than 500 miles. However, a potential opportunity may lie within this constraint—trucks could be used to complete distribution from intermediate rail destinations of fuel outside of populated areas where the positioning of final rail destinations of biofuels may be difficult or undesirable.

Driver training for the operation of tank trucks carrying ethanol is a pressing issue in the midst of a projected shortage of 200,000 heavy truck drivers industry-wide by 2016. Drivers transporting ethanol need a commercial drivers license with a hazardous materials endorsement (and the background check that precedes that endorsement), as well as a tank vehicle endorsement. Drivers also need to have at least four hours of training on the hazards of ethanol.

DOT has been working with emergency responders to address the different responses needed for ethanol incidents and crashes for trucking as well as the other modes of biofuel distribution.

⁵ Interim Draft of Multi-Modal Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

⁶ Interim Draft of Multi-Modal Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

In addition to these challenges, trucking is subject to increasing congestion. Average Annual Daily Truck Traffic (AADTT) for roads with over 10,000 trucks per days is projected to triple between 2002 and 2035.⁷

Waterways

While shipment on waterways can be the most economical means to transport fuels other than by pipeline, there are limits to this mode. Many biorefineries do not have a water access point, and those that do may not have the production levels needed to justify use of the average capacity for barges (420,000 gallons each). Even if biorefineries have adequate production levels, receiving terminals may not have the existing storage for ethanol to justify larger volumes.

Waterway transport of ethanol also has seasonal considerations. Northern waterways may freeze, causing temporal congestion as ethanol shifts to other modes in order to maintain year-round service. In terms of the existing waterway infrastructure, the Nation's locks and dams need to be modernized to handle additional barge traffic, which might be exacerbated by additional volumes of ethanol transported by waterways.⁸

Pipelines

Pipelines are feasible transportation options for conventional fuels, but have seen limited use in the United States for the transport of biofuels because of where existing pipelines are located and biofuels impacts on pipeline integrity and safety.

A large percentage of gasoline is transported by pipeline, providing a nearly immediate economic advantage over the current transport of biofuels by rail, truck, and barge. If certain infrastructure challenges are overcome for pipeline transport, biofuels could enjoy similar economic competitiveness. However, pipeline use for biofuels is not a simple matter of transporting renewable fuels in existing pipelines. New pipelines are needed to connect Midwest production with coastal consumption, as the location of existing pipeline infrastructure entry points are not located in the Midwest where the majority of U.S. ethanol is produced. Existing hazardous liquid pipelines transport gasoline into the Midwest and cannot be redirected to transport biofuels to coastal markets.⁹

The chemical properties of biofuels also present challenges to pipeline infrastructure. DOT safety research indicates that ethanol blends up to E15 (15 percent ethanol) are not corrosive to existing pipelines used for fuel transport. However, fuel degradation issues are more prominent in ethanol fuel blends below E95 (95 percent ethanol). Consequently, pipeline operators have found it difficult to maintain ASTM International fuel mixture specifications for lower ethanol fuel blends, making pipeline

⁷ Freight Facts and Figures, 2009: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations.

⁸ Interim Draft of Multi-Modal Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

⁹ Interim Draft of Pipeline Feasibility Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

movements of these fuels impractical and uneconomical.¹⁰ This leaves transporting E95/Fuel Grade Ethanol (FGE) to terminals as the primary market for pipelines, with the blending process occurring after transport. As a result, the industry will have to replace certain existing pipeline materials with ones conducive with E95/FGE service and fuel additives to mitigate integrity threats such as stress corrosion and cracking.¹¹

Strong partnerships among DOT, the pipeline industry, other Federal and State agencies, and the emergency first response community are addressing pipeline safety challenges. These partnerships have resulted in a rapid removal of the technical and regulatory barriers for shipment of ethanol and other biofuels. Since 2006, DOT has been addressing pipeline safety with biofuels by providing guidance on incident response, pipeline markers, placard regulations for ethanol blended fuels, and emergency response and foam application to ethanol blended fuels. In 2007, the U.S. DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) outlined its jurisdiction over biofuel transport by pipelines, and notified the industry of its intent to monitor safety and environmental issues around biofuels and pipelines. In 2008, the agency requested that the industry provide 60 days voluntary notice of intent to transport biofuels.

Going forward, DOT has a comprehensive and collaborative research strategy that will continue to address pipeline safety and integrity threats, and will drive new knowledge in support of industry best practices and consensus standards. In addition, DOT has been meeting with industry representatives to gauge the market interest for transporting biofuels by pipeline. Since FY 2008, 11 new biofuel research projects have been awarded with \$2.9 million invested by DOT and matched with \$4.3 million of industry co-funding, reflecting a strong public-private interest to make pipeline transport of biofuels part of the overall plan of a sustainable biofuels industry.

Industry Trends

Conditions within the industry and policy drivers, such as the RFS-2, are going to force a move towards higher ethanol blends and the expanded use of advanced biofuels. Currently, 99 percent of ethanol consumed in the U.S. is blended with gasoline at levels of 10 percent or less. Only 1 percent of ethanol consumed is E85. At the same time, ethanol is approaching the “blend wall” (the volume of ethanol that can be expected to be marketed at current blending limits) as E10 is projected to begin reaching market saturation by 2013, necessitating a move to higher intermediate blends for future growth.¹²

The Southeast may have to contend with this soon, as it is experiencing rapid growth with a market of 3 billion gallons of E10 and a 66 percent growth in ethanol use from 2005 to 2007. In addition, State laws may have substantial regional impacts. California’s Low Carbon Fuel Standard (LCF) requires a reduction in the carbon content of fuels by 2020. If implemented, corn grain ethanol may not qualify as an LCF within the State, meaning there will be a need for more research on the transport of Fuel Grade Ethanol

¹⁰ Interim Draft of Pipeline Feasibility Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

¹¹ Pipeline and Hazardous Materials Safety Administration discussions with pipeline operator executives.

¹² Interim Draft of Multi-Modal Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

or the use of advanced biofuels instead. The higher volumes of ethanol that will need to be transported, as well as the introduction of advanced biofuels, make clear that the industry will have to contend with the commensurate challenges that will face each mode of transportation.¹³

Rail and aviation have their own special challenges with ethanol. Due to energy density and thermal requirements, ethanol is not suitable for these transport modes use. The alternative fuel strategy for these industries is the use of hydrocarbon or “drop-in” biofuels that do not require modification of existing fueling infrastructure, engines, or aircraft. Ethanol produces about two-thirds of the energy needed to move rail vehicles when compared to the same amount of diesel fuel. Railroads currently are testing “drop in” fuel biodiesel under ASTM standards for B6-B20 have been approved and can be used in locomotive engines.

For aviation, the challenge for this sector then lies in the availability of jet fuel appropriate agricultural feedstocks and the financing of commercial production facilities to produce jet biofuels. The aviation industry has made rapid strides in the development and advancement of hydrocarbon jet biofuels. Jet fuels made from biomass via the Fischer Tropsch (FT) process were approved for commercial use at a 50 percent blend with petroleum Jet fuel by ASTM International in September 2009. Jet fuels made from lipids from plant or animal sources are slated for approval by ASTM International by early 2011.

These approvals will be followed by testing, evaluation, and approval of advanced jet biofuels made via pyrolysis, advanced biological fermentation and catalytic processes in the next few years. As end users of jet fuel, airlines and the military have developed a “Strategic Alliance” to simplify their purchasing criteria for alternative jet fuels suppliers, and create a strong unified market demand signal from virtually all domestic jet fuel buyers. A potential benefit from these developments may be the transfer of fuel technologies to the surface transportation sectors that reduces the particular distribution challenges faced by each surface mode.¹⁴

Recommendations

The challenges facing the Nation’s ability to meet the distribution and end use needs of higher volumes of biofuels warrants several actions:

- Conduct research on the distribution of richer mixes of ethanol and various classes of advanced biofuels. Incorporate earlier involvement of distribution considerations in biofuel development processes. Increased DOT involvement in the planning process of biofuel development will help integrate the end-user properties of new biofuels with the potentially overlooked distribution issues that the attributes of those fuels may raise. Adopt best practices from international partners already experienced in transporting richer mixtures of ethanol to help enhance this research.
- Identify and analyze key transportation-related considerations affecting the upstream supply chain for the feedstocks used to produce advanced biofuels in the United States. These raw

¹³ Interim Draft of Multi-Modal Analysis: A Report by the Distribution Infrastructure Interagency Working Group, 2010.

¹⁴ Federal Aviation Administration discussions with stakeholders.

material feedstocks include woody biomass and grasses (both dedicated energy crops and wild flora), municipal solid waste, algae, and other non-food crop feedstocks. To date, there has been limited emphasis placed on transportation and logistics issues associated with the moving of advanced biofuel feedstocks to biorefineries for fuel production.

- Continue DOT support of land grant universities working through the Sun Grants Initiative to thoroughly catalogue the best locations of various ethanol and advanced biofuel feedstocks. Partially funded by DOT, this effort can help the industry better understand what optimal distribution scenarios are available depending on regional characteristics and transport distance thresholds associated with each feedstock.
- Current and future Geographic Information System (GIS) advances will help address challenges with distribution through route optimization, extraction of trends, and visual analysis. This will be essential for better identifying multimodal distribution solutions, and for using a network or systems approach for more efficient and intelligent decision making. To realize GIS's potential contributions to the biofuels industry, advances are needed in the following areas: awareness about the availability of GIS; understanding of the cost of doing business without GIS; and the necessary workforce adaptations to handle ever-changing technologies.
- Work collaboratively with industry stakeholders to enable end use of biofuels by all transportation modes through development of alternative fuels standards, aligning research, development, and distribution needs, and identifying commercialization opportunities.

Implementing these recommendations can advance biofuel use throughout the Nation. Working with its colleagues across the Federal Government, the Department and its stakeholders, through their transportation expertise, can be strong partners in this effort.