National Commission on Energy Policy

NATIONAL COMMISSION ON ENERGY POLICY'S

TASK FORCE ON BIOFUELS INFRASTRUCTURE

Disclaimer

This report is a product of a Task Force with participants of diverse expertise and affiliations, addressing many complex and contentious topics. It is inevitable that arriving at a consensus document in these circumstances entailed compromises. Accordingly, it should not be assumed that every member is entirely satisfied with every formulation in this document, or even that all participants would agree with any given recommendation if it were taken in isolation. Rather, this group reached consensus on these recommendations as a package, which taken as a whole offers a balanced approach to the issue.

It is also important to note that this report is a product solely of the participants from the NCEP convened Task Force on Biofuels Infrastructure. The views expressed here do not necessarily reflect those of the National Commission on Energy Policy.

Acknowledgements

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Special appreciation is due to NCEP Commissioner Norm Szydlowski, Chairman of the Task Force, for his invaluable wisdom and leadership. Additionally, the NCEP staff gratefully acknowledge the substantial guidance, research, and support offered by Deloitte Consulting, LLP throughout the course of this effort. In particular, Rebecca Ranich, Director, and Shanelle Evans, Consultant, were essential members of the project team.

Recognizing that the nation's commitment to a large-scale increase in the use of biofuels presents formidable technological, economic, and regulatory challenges, the National Commission on Energy Policy (NCEP) convened a Biofuels Infrastructure Task Force in April 2008. The specific aim of the Task Force was to examine critical issues for implementing the expanded federal Renewable Fuel Standard (RFS) adopted as part of the Energy Independence and Security Act of 2007.

This paper presents the recommendations and findings of the Task Force, a group comprised of fuels and transportation experts with wide-ranging perspectives. Task Force members came together to identify key hurdles to the timely, cost-effective, and efficient deployment of biofuels infrastructure and vehicles and to develop practical, politically feasible proposals for overcoming them.

The recommendations described in this report reflect the deep expertise of Task Force members and the unbiased, bi-partisan character of NCEP itself, which draws from a broad spectrum of leading industry, government, academic, labor, consumer and environmental protection organizations.[1] NCEP Commissioner Norm Szydlowski, formerly the President and CEO of Colonial Pipeline, led the Task Force.

[1] For more information see www.energycommission.org.

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EXECUTIVE SUMMARY

Under the federal Renewable Fuels Standard (RFS) adopted in 2005 and amended in 2007, the United States is committed to a substantial (five-fold) increase in its use of biofuels by 2022. The National Commission on Energy Policy (NCEP) convened a Biofuels Infrastructure Task Force in 2008 to examine the infrastructure implications of this relatively swift and unprecedented shift in the composition of the nation's transportation fuel supply. Specifically, the Task Force explored issues and developed recommendations for advancing the infrastructure investments needed to support timely and cost-effective implementation of the current biofuels mandate.

Although biodiesel is included in the RFS, the Task Force focused on corn ethanol, cellulosic ethanol, and advanced biofuels. Hence, the term "biofuel" should be understood to mean ethanol unless otherwise specified throughout this report. Notably, the Task Force did not debate the merits of existing biofuels policies, nor did it address some of the controversies that have arisen with regard to the land-use, food-price, and climate-change impacts of biofuels production.

The Task Force concluded that significant efforts will be needed to achieve the RFS mandate, which essentially requires that the nation transition to broad-based use of a 10 percent ethanol-blend (E10), while supplying and using an additional 21 billion gallons of biofuels on an annual basis. A market shift of this magnitude will have broad, cross-cutting impacts on the entire transportation-fuels refining and delivery network.

Adding to this challenge, the country's economic outlook has deteriorated dramatically since the Task Force began its work. It may be difficult for businesses to access capital and make large commitments to new infrastructure investments for some time to come. In addition, a weak economy is likely to mean reduced demand for transportation fuels more broadly, and for gasoline in particular. This means that there may be a problem meeting targeted RFS volumes as E10 saturation may occur sooner than originally expected, otherwise known as "hitting the blend wall."[2] Increased usage of higher-ratio blend fuels would delay the blend wall; however, there has been little progress to date in developing the E85 market (the National Ethanol Vehicles Coalition estimates only 1% of stations nationwide currently market this fuel and automakers' statistics suggest that 90% of the nearly 7 million E85 capable flex fuel vehicles on the road today do not have a station selling E85 in their zip code).[3]

E10 SATURATION MAY OCCUR SOONER THAN ORIGINALLY EXPECTED, OTHERWISE KNOWN AS "HITTING THE BLEND WALL."

[2] The "blend wall" is defined as the point in time when ethanol production meets the ethanol blending capacity. At current E10 blending levels and E85 usage, the United States is expected to hit the blend wall between 2011 and 2013.
[3] NEVC Press Release. October 2008. Available http://www.e85fuel.com/news/2008/101308_1800station_release.htm

Government and industry stakeholders are aggressively pursuing research into the compatibility of higher-ratio fuel blends in conventional vehicles—such as E15 and E20—but technical issues remain and complete testing must be conducted to understand the system-wide impacts. Though the EPA has authority to adjust annual volumes and higher ratio blends need to be thoroughly tested to successfully meet the long-term RFS targets and offset the blendwall constraint, it is likely that some combination of increased E85—given it is proven to be commercially viable—and higher-ratio blends will be needed.

Over three day-long meetings in the spring and summer of 2008, Task Force members focused on identifying optimal pathways toward an integrated transportation and distribution network for conventional and ethanol fuels. After extensive discussion and analysis, the Task Force identified three likely phases of biofuels infrastructure expansion:

- **Phase Ia** (2008–2010): In this phase, ethanol production increases to 12 billion gallons per year. The existing multi-modal transportation network is used to transport ethanol from production centers in the Midwest to demand centers on the coasts, with rail playing a major role.

- **Phase Ib** (2010–2015): In this phase, corn ethanol production increases from 12 to 15 billion gallons per year. Absorbing this level of biofuels production requires nationwide use of E10 with expanded use of E85 (or higher-ratio blend) fuels. Transporting and blending this much ethanol will stress existing networks and require additional infrastructure investment. Modifying retail fueling infrastructure to accommodate higher-ratio ethanol blends will be an added challenge in the early part of this period.

- **Phase II** (after 2015): In this phase, ethanol and advanced biofuel production expands beyond 15 billion gallons per year. Further evolution of the associated transportation and distribution infrastructure will depend on a number of factors, including the geographic distribution of supply and demand centers, mandate certainty, import volumes, Flex-Fuel Vehicle (FFV) production, and successful market penetration of E85 or higher-ratio fuels (if ethanol becomes the cellulosic biofuel of choice). Non-ethanol biofuels, often referred to as bio or 'Renewable' hydrocarbons, which are similar to existing gasoline and diesel fuel, could potentially be developed after 2015. These would satisfy the RFS requirements and mitigate many of the infrastructure challenges as they would be compatible with conventional fuels and existing infrastructure.

Task Force Recommendations

Task Force members next worked to identify a set of market and regulatory conditions that will be critical to enable the infrastructure investments needed to promote a smooth transition through these phases:

- **RFS Mandate Certainty—** Market confidence in the government's commitment to the long-term goals of the RFS is essential to provide the basis for further large-scale capital investments in fuels technology pathways including first and second generation biofuels and renewable hydrocarbons and the necessary infrastructure to transport, distribute and use these fuels.

- **Deployment of Flex Fuel Vehicles (FFV) and Fuel Distribution Infrastructure—** A growing FFV fleet will be needed to absorb mandated biofuels quantities beyond what can be blended in conventional fuels. Further consumer and manufacturer incentives may be needed to accelerate the market penetration of FFVs. At the same time, consumer acceptance of these vehicles and fuels will depend on a number of factors including the expansion of access to E85 (or higher-ratio blends) retail stations in urban and rural areas.

- **Standardized fuel specifications—** Reducing or limiting the number of different blends that fuel refiners must produce to meet state-level specifications will enable a more efficient biofuels transition. In particular, now that the RFS has been enacted, we recommend rethinking the use of state-based renewable fuel mandates, which could compromise the efficiency and reliability of biofuel distribution.

- **Greater permitting efficiency—** Streamlining and simplifying permitting processes along all aspects of the biofuels supply chain would help to reduce costs and lead times for undertaking the infrastructure investments needed to support increased biofuels use nationwide.

- **Federal support for critical infrastructure investments—** Refocusing current public incentives and subsidies to include a greater emphasis on biofuels transport, refueling infrastructure, and related vehicle technologies makes sense given the industry's current state of development. Loan guarantees or tax credits could be effective ways to support needed infrastructure investments. These infrastructure investments would likely provide greater flexibility and enhanced capacity for handling a range of conventional and alternative fuels. Only certified equipment should be supported.

In sum, U.S. biofuels policy to date has tended to emphasize production incentives and volume mandates. Going forward, it will be increasingly important to focus on other aspects of the equation—notably the need for efficient and reliable infrastructure networks to transport, blend, and distribute biofuels; the interaction with other fuels policies and existing fuel networks; and the importance of ensuring that consumer demand for biofuels—and especially for higher-ratio ethanol blends—grows at a pace commensurate with RFS mandates.

The difficulty of the task and the potential magnitude of the infrastructure investments it entails must not be underestimated, especially in light of the current economic downturn. A significant national effort will be required to overcome these challenges and to ensure that progress toward the nation's long-term energy security and fuel diversity goals continues in an efficient and cost-effective manner.

U.S. biofuels policy to date has tended to emphasize production incentives and volume mandates. Going forward, it will be increasingly important to focus on other aspects of the equation.

CHAPTER I.

INTRODUCTION

Recent years have witnessed a resurgence of concern about U.S. dependence on petroleum: high world oil prices, instability in the Middle East and in other key oil-producing regions, and growing attention to environmental problems like climate change have all re-animated interest in developing domestic transportation fuel alternatives. One result has been a dramatic expansion of the nation's commitment to biofuels. Under legislation passed in 2005 and later amended in 2007, current law mandates a five-fold increase in the nation's use of renewable transportation fuels, including ethanol and biodiesel, over the next 14 years—from 6.89 billion gallons of biofuels in 2007 to 36 billion gallons by 2022.

Recognizing that this mandate presents a formidable technological, economic, and regulatory challenge, the National Commission on Energy Policy (NCEP)[4] convened a special task force in April 2008 to examine one critical aspect of that challenge. Specifically, the Biofuels Infrastructure Task Force sought to examine the infrastructure implications of a substantial increase in the domestic production and use of biofuels and to develop recommendations aimed at ensuring that the physical capacity to cost-effectively transport, blend, and distribute biofuels would exist at the scale and within the timeframe needed to support current policy commitments.

This report presents findings and recommendations developed by the Task Force over the course of three meetings held between April 2008 and July 2008. As such, it reflects the collective judgment of fuels and transportation experts from industry, finance, government, environmental organizations, and academia. A complete list of Task Force members can be found on page ii of this report. We begin by sketching the regulatory and policy context for the Task Force's discussions before turning to a discussion of current fuel refining and distribution networks, options for transporting biofuels, and likely infrastructure constraints and challenges. Later sections describe likely scenarios for future biofuels production and discuss key sources of uncertainty with regard to future patterns of domestic biofuels production and demand, along with the implications of uncertainty for orderly and timely infrastructure investments. The final section summarizes findings and policy recommendations.

Current law mandates a five-fold increase in the nation's use of renewable transportation fuels, including ethanol and biodiesel, over the next 14 years.

[4] NCEP has a long-standing interest in biofuels, which were prominently included in its original (2004) recommendations for comprehensive U.S. energy policy. More information about NCEP and access to previous Commission reports and recommendations are available at www.energycommission.org.

CHAPTER II.

CURRENT BIOFUELS POLICIES: BACKGROUND AND CONTEXT

Congress first adopted the RFS as part of the Energy Policy Act of 2005 (EPACT05). EPACT05 required refiners, blenders, and importers to use specified volumes of renewable fuels in the nation's overall transportation fuel mix, starting with 4.0 billion gallons in 2006 and increasing to 7.5 billion gallons in 2012. Two years later the RFS was substantially expanded under the Energy Independence and Security Act of 2007, which mandated a rapid ramp-up in the volume of renewable transportation fuels used in the United States from 9 billion gallons of corn ethanol or advanced biofuels in 2008 to 12 billion gallons in 2010, 15 billion gallons in 2015, and 36 billion gallons in 2022.

As part of the overall RFS, current law also establishes separate requirements for a rapid ramp-up in the production and use of "advanced" biofuels—understood to be primarily ethanol produced from cellulosic (i.e., woody or fibrous) feedstocks, rather than from starch feedstocks like corn.[5] Specifically, cellulosic ethanol production—which has not yet been commercialized on a large scale—is mandated to increase 30-fold over a five-year period, from 0.1 billion gallons in 2010 to 3 billion gallons in 2015 and 16 billion gallons in 2022.

The RFS is supported by three other federal policies that have played and continue to play an important role in expanding domestic supply and demand for biofuels:

- **The Volumetric Ethanol Excise Tax Credit (VEETC):** Provides a 45-cent[7] tax credit for each gallon of pure[8] ethanol blended into gasoline. The credit is available only to registered blenders and is paid out of general U.S. Treasury funds (prior to 2005, excise

Table I. RFS Mandated Biofuel Schedule (billion gallons per year)[6]

Year	Total RFS, All Fuel	Actual Corn Ethanol	RFS Corn Ethanol	Cellulosic Ethanol	Other Advanced Biofuels
1998		1.40			
1999		1.47			
2000		1.63			
2001		1.77			
2002		2.13			
2003		2.80			
2004		3.40			
2005		3.90			
2006	4.00	4.86			
2007	4.70	6.89			
2008	9.00		9.0		
2009	11.10		10.5		0.1
2010	12.95		12.0	0.10	0.2
2011	13.95		12.6	0.25	0.3
2012	15.20		13.2	0.50	0.5
2013	16.55		13.8	1.00	1.75
2014	18.15		14.4	1.75	2.0
2015	20.50		15.0	3.00	3.0
2016	22.25		15.0	4.25	3.5
2017	24.0		15.0	5.5	4.0
2018	26.0		15.0	7.0	4.5
2019	28.0		15.0	8.5	4.5
2020	30.0		15.0	10.5	4.5
2021	33.0		15.0	13.5	4.5
2022	36.0		15.0	16.0	5.0

[5] Advanced biofuel includes any biofuel from "renewable biomass," except corn starch, with lifecycle greenhouse gas emissions at least 50% less than baseline. In contrast, cellulosic biofuel is defined as fuel derived from "cellulose, hemicelluloses, or lignin" that is derived from renewable biomass and has lifecycle GHG emissions 60% less than baseline.

[6] The RFS also requires increased use of biodiesel, up to 1 billion gallons in 2012. Therefore corn and cellulosic ethanol volumes are not equal to total RFS volumes.

[7] The VEETC changed from 51 cents to 45 cents in the 2008 Farm Bill. This change will take effect when 7.5 billion gallons of ethanol are produced or imported.

[8] When referring to "pure" or "neat" ethanol, we are generally referring to denatured, fuel-grade ethanol (with a small percentage of gasoline).

Uncertainty about the future stability and sustainability of the industry has the potential to create significant barriers to the infrastructure investments needed to support continued expansion of the biofuels market.

tax credits for ethanol were available only for certain specified blend levels and were taken out of the Highway Trust Fund).

- **Import Tariffs:** Levied on biofuels produced in other countries. With some exceptions, ethanol imported to the United States is subject to a tariff of 2.5 percent of its value, plus an additional duty of 54 cents per gallon. This policy has had the effect of limiting imports from large overseas ethanol producers, such as Brazil. As a result, it directly influences demand for domestically-produced biofuels and is therefore relevant from the standpoint of assessing domestic infrastructure needs. Refer to Appendix D for more information.

- **Clean Air Act:** Federal air quality regulations have played a role in the recent growth of the U.S. ethanol industry. Specifically, demand for ethanol increased in recent years as states, responding to concerns about adverse water quality impacts, began to limit the use of the fuel additive methyl tertiary butyl ether (MTBE)—at present, MTBE blending in the United States is effectively banned. MTBE had been widely used to fulfill oxygenate requirements for reformulated gasoline (RFG)[9] under the Clean Air Act; without this option, refiners have overwhelmingly employed ethanol as their new oxygenate.

Though ethanol production has expanded rapidly since 2005, the industry has also encountered market challenges. Since the summer of 2008, additional investments in new ethanol production capacity have slowed as the industry has had to contend with dramatic swings in both energy and feedstock costs coupled with the difficult credit situation. At the same time, new concerns have emerged about the indirect impacts of expanded ethanol production on food prices and climate change. As discussed at greater length in later sections, uncertainty about the future stability and sustainability of the industry has the potential to create significant barriers to the infrastructure investments needed to support continued expansion of the biofuels market.

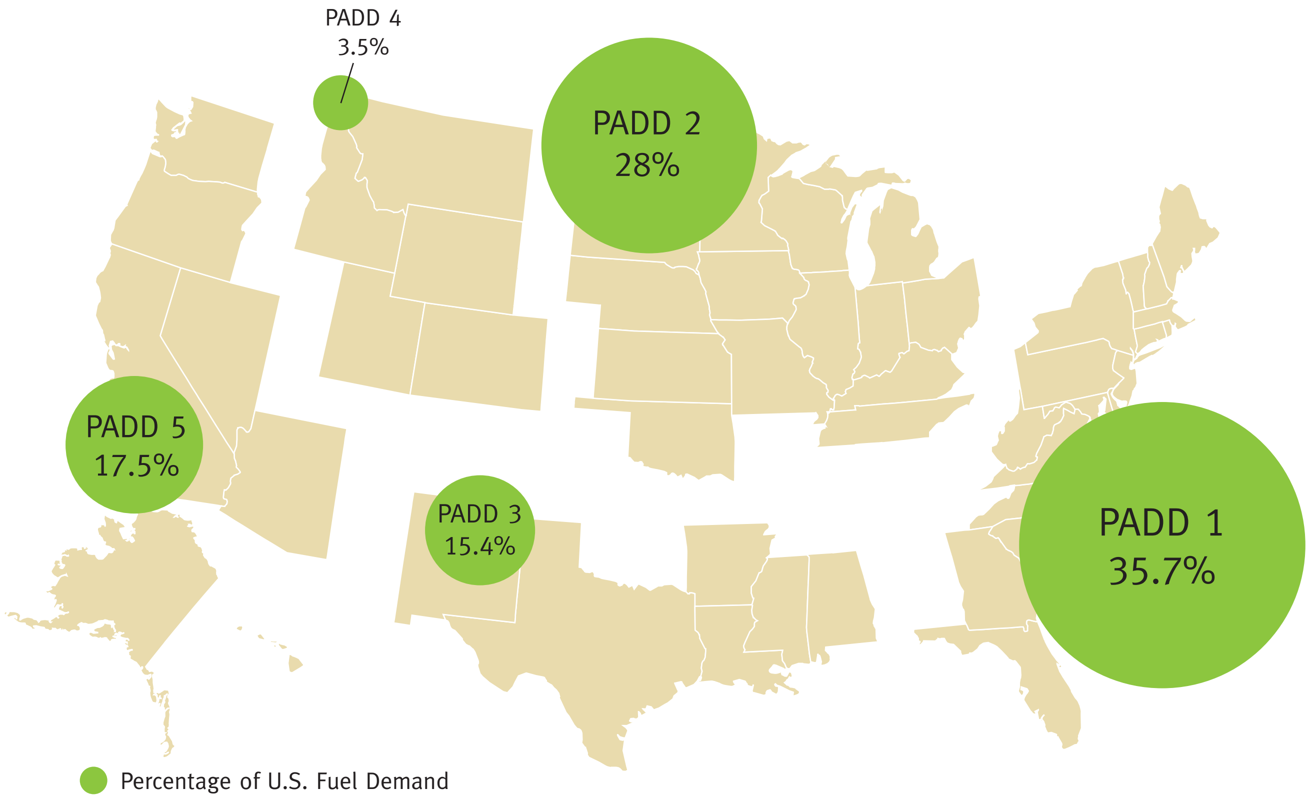
[9] The Clean Air Act requires the use of RFG in certain markets where ambient air quality standards are being violated. RFG accounts for more than 30 percent of total U.S. gasoline sales.

CHAPTER III.

THE CURRENT TRANSPORTATION FUELS INFRASTRUCTURE

The current U.S. transportation fuels infrastructure evolved over many decades. Fuels are distributed from the major refining areas and, to a lesser extent, from ports to consumer markets. The major modes of transportation are pipeline, ship, barge and truck.

Figure 1. The Petroleum Administration for Defense Districts and their consumption of all U.S. motor gasoline consumption



For analysis purposes, the U.S. Energy Information Administration (EIA) tracks fuel movements by Petroleum Administration for Defense Districts or PADDs. PADD 1, the East Coast, has historically consumed the most motor gasoline in the United States, as shown in Figure 1.

The infrastructure used to produce, transport and deliver motor vehicle fuels in the United States consists of four primary components: refineries, pipelines, distribution terminals, and retail establishments (i.e., gas stations). The processing of crude oil into various refined products, including gasoline and gasoline components or blendstocks, occurs at refineries; the fuel is then transported, primarily by pipeline, to terminals in the major consuming regions, where it may undergo further blending to meet applicable fuel specifications, which vary in different areas. Tanker trucks are used to move blended petroleum to retail stations. Terminals may also receive direct shipments of fuel via tanker ship, either from domestic refineries or overseas suppliers. Petroleum terminal facilities on the East coast have storage capacity for imported refined products. These terminals are large integrated facilities with both marine, pipeline and truck receiving and dispatching capabilities. Although some have rail access, the terminals were not originally designed to support rail as a major mode for transporting fuel.

There are more than 160,000 retail vehicle-fueling locations in United States, of which about 1,800 provide E85 pumps. The industry is dominated by single-store companies, which

Figure 2. Current U.S. Gasoline Consumption and Distribution

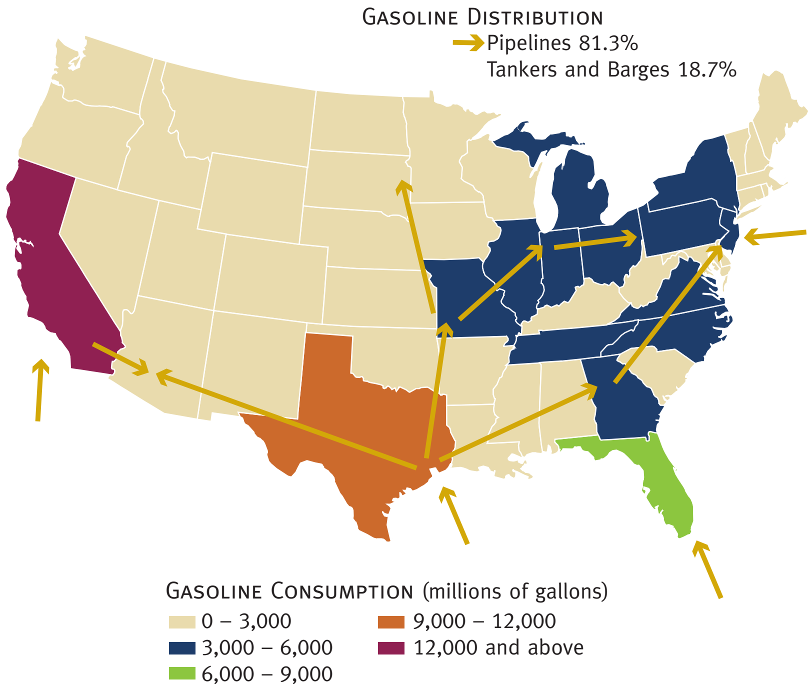
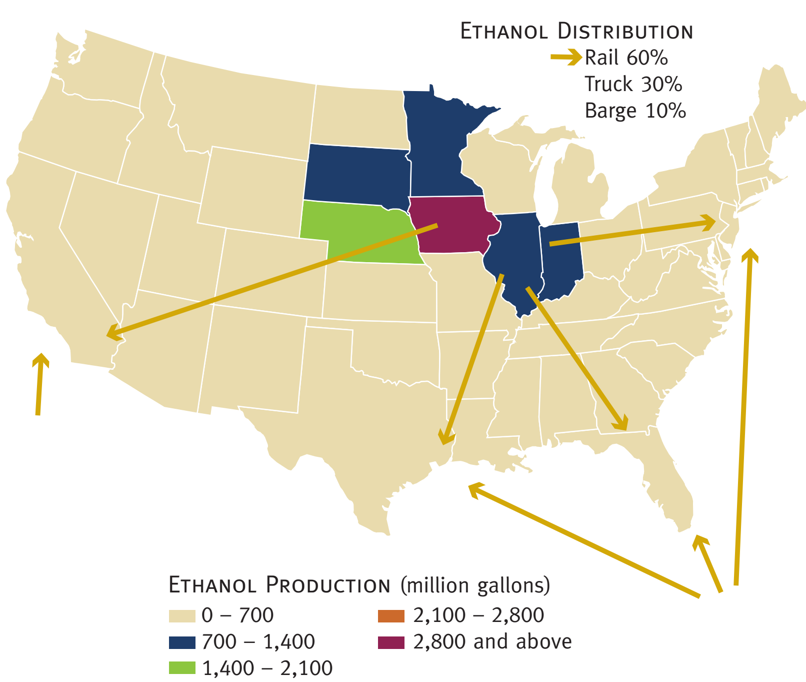


Figure 3. Current U.S. Ethanol Production and Distribution



operate nearly 60 percent of these retail operations. Contrary to public perception, major oil companies have a minimal presence in retail (less than 5 percent) and this presence has been shrinking. The decision to offer E85 is up to the individual retailer based on expected profitability given the investment required. Typically, owners of retail facilities are not large entities; in fact, the average convenience/petroleum retail store reported a 2007 pre-tax profit of $23,335. This observation is relevant in connection with a discussion of biofuels infrastructure needs because it means that many retailers may find it difficult to finance the infrastructure investments needed to accommodate new fuels without additional incentives or government support.

Figure 2 shows the routes by which gasoline flows from the Gulf Coast, where most oil refining in the United States occurs, to the major consuming regions of the nation. (Note that the map also shows fuel deliveries by tanker ship to ports in California, the Northeast, and Florida.) Notably, pipeline transport accounts for the vast majority of gasoline distribution (more than 80 percent). By contrast, as shown in Figure 3, the transport of ethanol from production facilities in the Midwest to other regions of the country is currently accomplished entirely by rail, truck, or barge. These modes are generally more costly and less efficient than pipelines for the large-scale, long-distance transport of liquid fuels. Comparing Figure 2 and Figure 3, it is evident that existing petroleum networks are not optimally aligned for the transport of tens of billions of gallons of ethanol from mid-continent production centers to coastal demand centers. Whether current arrangements can physically scale to handle increasing volumes, and at what cost, is unclear at this point. Pipelines may need to assume a significant role in ethanol transport, through utilization of the existing network and the development of a dedicated system where infrastructure does not currently exist. Until now, however, technical hurdles and economies of scale have precluded much activity in this area. This and other infrastructure barriers to the large-scale expansion of biofuels are the focus of the next section of this paper.

CHAPTER IV.

INFRASTRUCTURE CHALLENGES FOR LARGE-SCALE BIOFUELS DEPLOYMENT

This section reviews infrastructure challenges related to meeting current biofuels commitments. We begin by reviewing potential stresses on existing systems for refining and distributing transportation fuels, before describing some of the transport options available for moving large volumes of biofuels around the country.

A. Implications for the Existing Fuels Infrastructure

The current system for refining and distributing transportation fuels in the United States has evolved over several decades, is generally flexible, and operates on relatively low unit costs. Modifying the current integrated system to handle large quantities of biofuels, however, will be challenging. Prior to 2004, petroleum refiners for the most part produced final blended products which were shipped to destination markets primarily by pipeline. For markets where air quality regulations require "reformulated gasoline" or RFG, refiners produce a blendstock known as "RBOB." As noted in Section II, MTBE was—until 2006—the primary fuel additive used to meet federal oxygenate requirements for RFG. Because MTBE could be blended with RBOB at the refinery, RFG could be shipped as a finished product to destination markets.

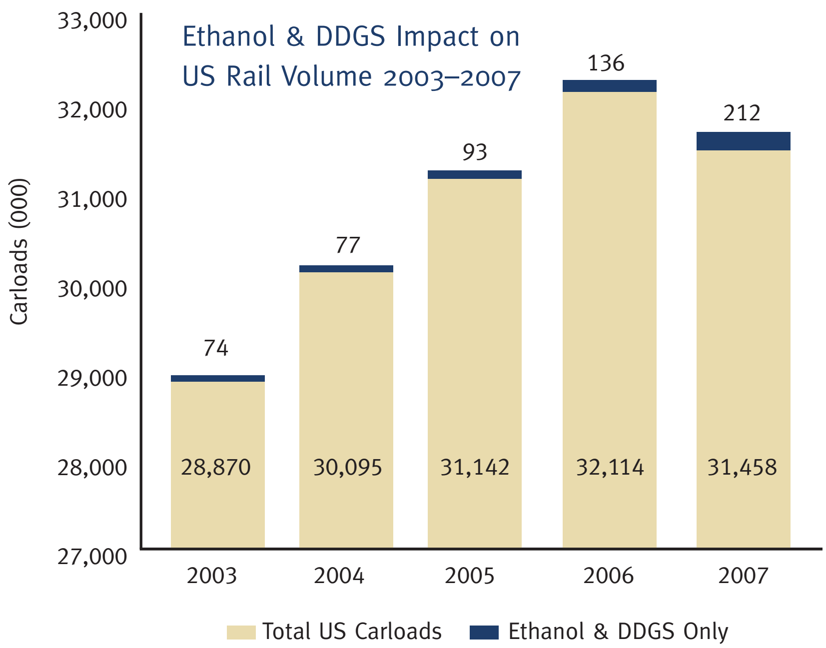
Beginning in the spring of 2006, however, the widespread phase-out of MTBE and its replacement by ethanol as the primary oxygenate in RFG supply necessitated some important changes. Unlike MTBE, ethanol had to be blended at the terminal rather than at the refinery—in part because of technical challenges associated with maintaining product quality in the multi-product pipeline system. Ethanol has an affinity for absorbing water and other impurities. (There were other pipeline integrity concerns related to shipping alcohol fuels that will be discussed later.) This meant that refiners had to transition from shipping a finished product to shipping a product that required additional handling at blending terminals prior to retail distribution. It also meant that terminal operators had to have the capacity to receive, store, and blend large quantities of ethanol. Finally, it required new networks for transporting ethanol from production centers in the Midwest to blending terminals on the coasts.

Large investment in ethanol blending infrastructure in RFG markets began almost immediately as MTBE phased out in the spring of 2006. Similar investments have lagged, however, in non-RFG markets like the Southeast, where the oxygenate requirement did not apply. After EPACT05 established the first RFS requirement, the industry began the planning and investment necessary to blend 7.5 billion gallons of renewable fuels by 2012. As the volumes of biofuels mandated under the RFS continue to grow, ethanol transport, storage, and blending capacity will need to keep pace.

B. Options for the Large-Scale Transport of Ethanol and other Biofuels

As already noted, ethanol today is transported almost exclusively via rail, truck, and barge. Pipeline transport may become a preferred option for some markets as larger volumes of ethanol are required. The Task Force reviewed existing transport networks and potential options for moving significantly increased volumes of biofuels within the United States over the next decade with a particular focus on four issues: time, capacity, cost/investment, and congestion.

Figure 4. Ethanol & Distillers' Dried Grains with Solubles Carload Volume as Compared to Total U.S. Rail Volume (carload volume values are not to scale)



Source: http://www.farmfoundation.org/news/articlefiles/365-HAMMES.pdf

Rail

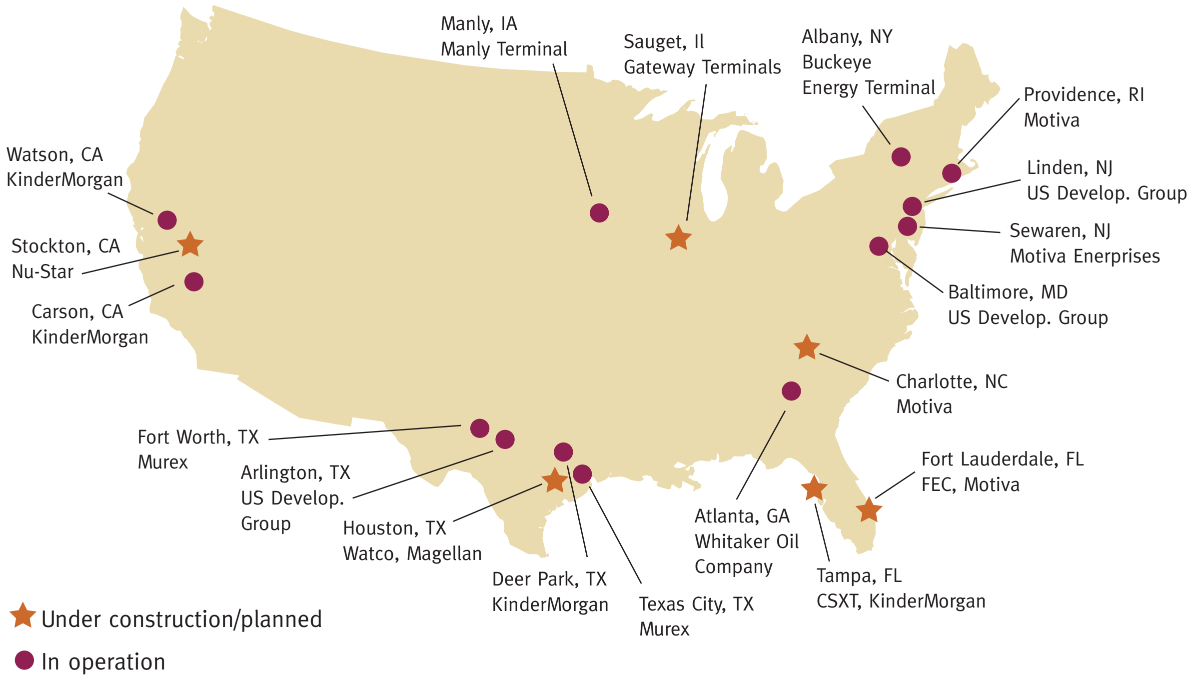
Today, about 70 percent of ethanol shipments are moved by rail; in 2007, ethanol shipments totaled approximately 164,000 carloads or well under 1 percent of total rail volume.

Figure 4 shows recent trends in rail shipments of ethanol and related animal feed by-products (specifically, distillers' dried grains with solubles or DDGS, a by-product that is obtained in the ethanol distillation process) relative to other rail cargo and overall rail volume.

Given that ethanol today constitutes a relatively small share of overall rail volume, there is room to expand the volume of biofuels transported via this mode. Indeed, rail carriers have already made significant investments to accommodate increased rail movements of ethanol. For larger volumes of ethanol, the use of unit trains comprising 65 to 100 cars, all carrying ethanol from one point of origin to one destination, would be more efficient and less costly. Because rail carriers give unit trains priority over single car (manifest) shipments, unit trains enjoy time and cost advantages—indeed, rail rates for single car shipments of ethanol can exceed unit train rates by 20 percent or more. Similarly, a tank car in unit train service will typically complete a shipment and return for another load in about 12–14 days, whereas a tank car in manifest train service will take 20–30 days to complete a cycle.

To take advantage of these efficiencies, however, blending terminals must have the off-loading capacity to receive unit train shipments. This is not typically the case, since most fuel terminals were not sited with the expectation that rail transport would play a major role in delivering fuels. The investment required to accommodate unit train shipments can be substantial for the

Figure 5. Unit Train Capable Terminals



terminal owner. There are currently only 19 terminals nationally, either in operation or under construction that are capable of receiving unit trains. Figure 5 shows the unit train capable terminals.

Investments in terminal expansion have been significant along the east coast where RFG markets require blended fuel, but non-RFG markets have endured congestion, time delays, and increased costs as terminal operators expand their capacity to off-load and store ethanol.

Compliance with the RFS will require the production and transport of 36 billion gallons of biofuels per year by 2022. If 70 percent of this volume moves by rail, rail shipments would increase to over 800,000 carloads per year. Overall rail cargo volume would be increasing at the same time, however—with current projections indicating a near doubling (88 percent growth) by 2035. In that case, biofuels would still represent at most a few percent of total rail shipments.

Increased rail shipments of biofuels would also require more tanker cars. Orders for new tanker cars to transport ethanol increased sharply in recent years, along with the cost to purchase or lease cars. The recent cancellation or postponement of several proposed new ethanol plants has eased demand, however, and prices have dropped significantly. Current projections suggest that sufficient tank cars are available to handle anticipated ethanol volumes in the near term. Starting in 2010 and beyond, however, additional tank cars will likely be needed to handle expected ethanol volumes. By 2021, as many as 34,000 general tank cars would be needed to maintain the current rail transport mix without shifting cars from other uses.

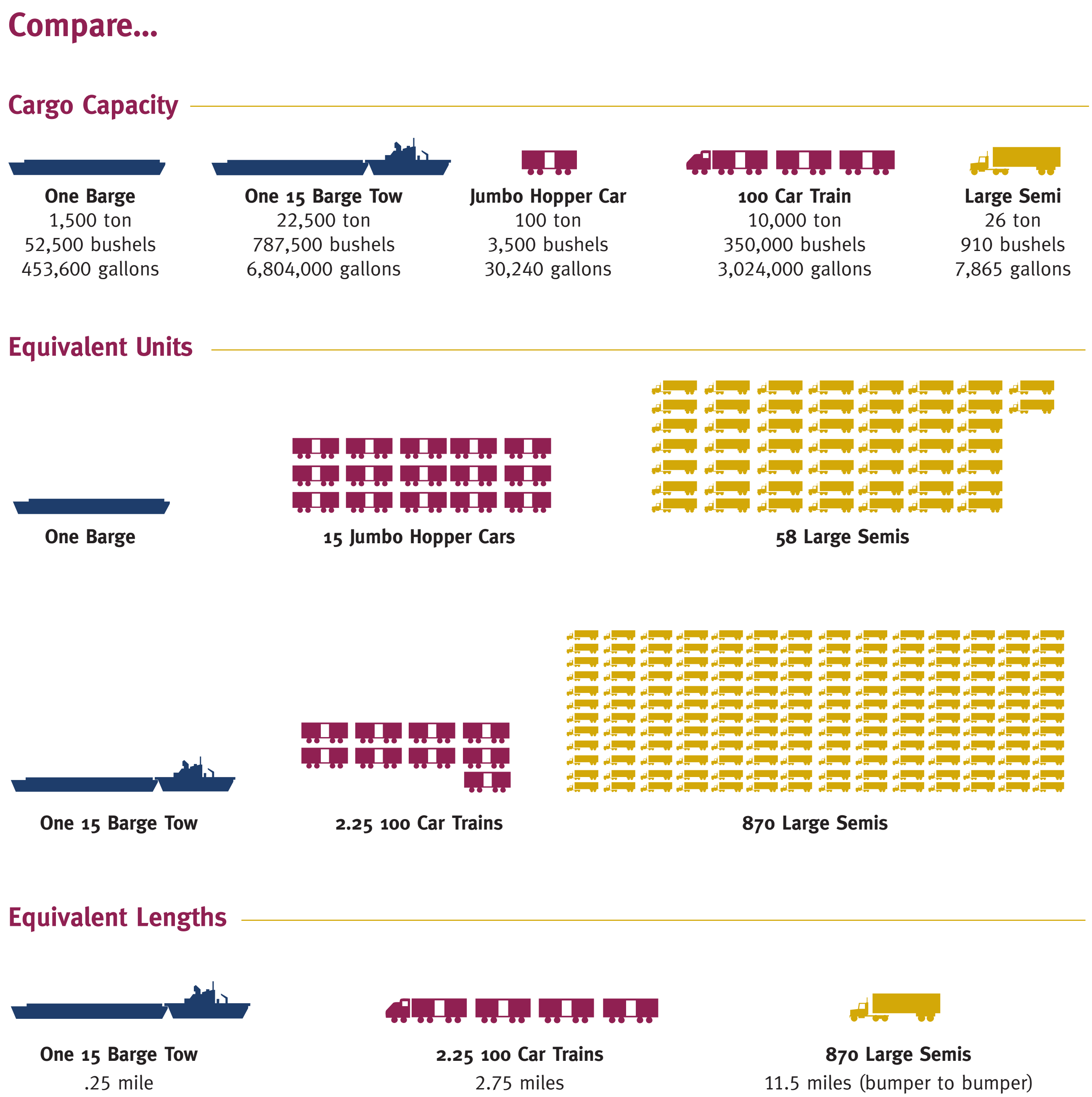
Water Transport

Barges are the most efficient mode for transporting fuel when pipelines are not feasible.

In 2004, barges operating in domestic waterways hauled roughly 818 million tons of cargo in the United States. Thirty-one percent of this total consisted of petroleum or petroleum products. Existing marine infrastructure on the coasts is well designed to accommodate barge deliveries, whereas inland waterways require continuous upgrades to maintain shipping channels. The U.S. Army Corps of Engineers is responsible for maintaining inland waterways but recent natural disasters have caused the Corps to re-allocate resources from routine waterway maintenance to other priorities.

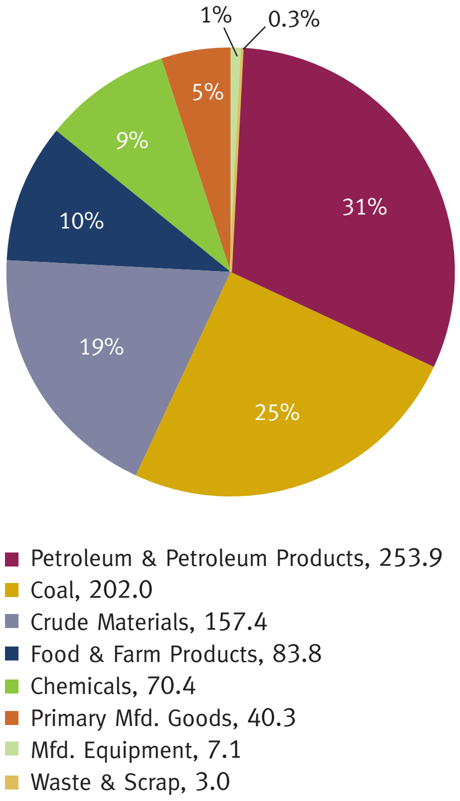
The importance of barge transport in meeting future biofuels needs will depend on a number of factors, including particularly the feasibility of expanded pipeline transport. In general, the American Waterways Operators projects that expanded ethanol production in coming years will increase demand for barge capacity. As with rail transport, however, biofuels shipments, even if they increase substantially from current levels, are likely to remain relatively small as a percent of total barge traffic. Concerns or potential constraints related to barge transport include the availability of vessels that are compliant with applicable requirements for transporting fuel (including requirements under the Jones Act and the Oil Pollution Act of 1990), the potential for congestion or delays due to increased traffic through locks and

Figure 6a. Volume Comparisons by Transport Mode



Source: Iowa Department of Transportation, 800 Lincoln Way, Ames, IA 50010, 515.239.1520

Figure 6b. Barge Traffic by Major Commodity Group in 2004 (short tons)



http://www.americanwaterways.com/industry_stats/type_amount/index.html#

dams, and susceptibility to weather (including the potential for freezing on northern portions of the Mississippi River during winter months). Overall, however, barge transport is likely to present an attractive option for moving large volumes of ethanol and other biofuels given its cost-competiveness, fuel efficiency, and accessibility to existing petroleum infrastructure.

Barge transportation of ethanol would be greatly advantaged if blended ethanol could be transported through the existing product pipeline network. In that case, barge transport could be used to deliver ethanol from the Midwest to Gulf Coast refineries for blending and pipeline transport could be used to deliver finished product to destination terminals. This approach would reduce capacity constraints, allow for shorter delivery timeframes, and present fewer congestion obstacles. Issues relevant for pipeline transport are discussed below.

Trucking

The U.S. trucking industry has played a significant role in supporting increased biofuels shipments to date. With more than 550,000 registered carriers, the vast majority of them small businesses with fewer than 20 trucks, the industry is highly competitive. It will likely fill a number of related transport needs as the domestic biofuels industry grows, including demand for moving feedstocks, industrial chemicals, finished biofuels, and byproducts and waste products.

Challenges for the U.S. trucking industry in handling a substantial further expansion of biofuels shipments include overcoming a significant driver shortage, coping with infrastructure constraints, and accommodating increased demand for tanker trucks. The impacts of a driver shortage have been partly masked by the current economic downturn, which has reduced overall demand for freight services. But this issue is expected to re-emerge in the future as the economy recovers. Moreover, the shortage of drivers for hazardous materials, which would include finished biofuels as well some chemicals used in related production processes, is likely to be particularly acute. This shortage is partly attributable to the additional, and sometimes duplicative, security credentials that are now required to qualify drivers for transporting hazardous materials. Other constraints could be ameliorated by continued investments in highway infrastructure to alleviate congestion and unnecessary bottlenecks in our highway transportation system, which collectively cost consumers billions of dollars in lost time, lost wages, and increased fuel consumption each year.

The shortage of drivers for hazardous materials, which would include finished biofuels as well some chemicals used in related production processes, is likely to be particularly acute.

Pipelines

Pipelines offer an efficient, low-cost, and reliable means of moving large quantities of conventional liquid fuels over long distances. Several unique characteristics relative to ethanol have presented challenges for pipeline transport thus far. First, because some terminal tanks and pipes used for ethanol have experienced stress corrosion cracking (SCC) and failure there is concern that pipelines may be at an increased risk servicing ethanol. Second, the properties of ethanol as a solvent and its hydrophilic nature cause problems with maintaining product quality as ethanol blends or straight denatured ethanol are transported through the multi-product pipeline system (these same concerns are greatly diminished when the denatured ethanol is transported through a dedicated pipeline). Another issue for further study as the market moves to E85 is the compatibility of ethanol with pipeline Drag Reducing Agents (DRAs). DRAs are used to reduce friction thereby increasing the capacity of pipelines and improving the efficiency of gasoline transport.[10] Third, the existing infrastructure is not geographically oriented for transportation from biofuel production centers. Fourth, the existing infrastructure for transporting refined products is near capacity in many markets, so pipeline expansions and additions will be required to accommodate any growth in consumption. Fifth, siting a new ethanol pipeline of any significant length will likely require eminent domain authority, which currently does not exist for ethanol pipelines. This authority can be granted by the federal government or by individual states. Ethanol is, of course, routinely handled in pipes and tanks within ethanol plants and downstream terminals. Though problems have been rare, the consequences of a

[10] DRAs are soluble in gasoline; however, there are still questions surrounding their solubility in ethanol. Early reports indicate that DRA precipitates when ethanol concentration exceeds a critical level thus possibly clogging engine filters.

SCC related incident could be significant. Thus, research is ongoing to explore the potential compatibility of large quantities and concentrations of ethanol with existing pipeline-system materials and to identify potential short and long-term risks for operational and system integrity as a result of shipping ethanol/gasoline blends. Much of this research is already underway, with several carriers experimenting with test runs and some industry studies nearing completion. Among the different ethanol shipment schemes being investigated are batch shipments of neat ethanol in hydrocarbon pipelines (which are less likely to cause SCC if they are relatively small and if additives or other treatments are included), shipments of 90 percent ethanol blends, and dedicated ethanol pipelines. Obviously, the construction of new dedicated pipelines could solve a number of problems, but this strategy would also raise formidable challenges related to the timely financing, siting, and construction of such pipelines.

In October 2008, Kinder Morgan announced plans to begin commercial shipments of unblended ethanol batches in its Central Florida pipeline. The company, having identified an additive to prevent SCC problems, used these tests to assess the feasibility of maintaining product quality on shipments between Tampa and Orlando. The Pipeline and Hazardous Materials Safety Administration (PHMSA) within the U.S. Department of Transportation actively monitored the Kinder Morgan test with an eye toward facilitating the transition to commercial operation and reducing regulatory delays. On December 2, 2008, Kinder Morgan announced the first transportation of commercial batches of denatured ethanol along with gasoline shipments in the Central Florida Pipeline (CFPL), making CFPL the first trans-market gasoline pipeline in the United States to do so.

Going forward, a strong partnership between PHMSA, the pipeline industry, other federal and state agencies, and the emergency first response community will be critical for addressing technical and regulatory barriers to the safe pipeline transport of ethanol and other biofuels. Such a partnership is well established. Though expanded capacity for pipeline transport would represent a major breakthrough for the continued growth of the biofuels industry, concerns remain surrounding the timing, capacity and investment needed to develop or adapt pipeline networks to ship rapidly increasing volumes of ethanol. Of paramount importance to all stakeholders in contemplating investments of this scale and impact is the certainty of a sustained RFS mandate.

In sum, the successful, large-scale integration of ethanol into the national fuels portfolio requires substantial investment at each phase of the value chain. In particular, the interdependency between ethanol and gasoline creates the need for both components to be present at the delivery point in the quantities needed to reliably sustain a continuous supply. This in turn demands careful judgments about where and when to commit capital to fixed asset infrastructure such as pipelines, ports, rail facilities and fuels terminals. Such judgments will be difficult if not impossible to make without a reasonable degree of certainty about future patterns of biofuels supply and demand.

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CHAPTER V.

A PHASED APPROACH TO BIOFUELS EXPANSION

To develop insights into the infrastructure and related challenges that are likely to accompany a large-scale increase in the use of biofuels to serve U.S. transportation energy needs, the Task Force discussed a range of probable scenarios for biofuels production, transportation, and consumption. Task Force members agreed that the "most likely" scenario should serve as the base case for its findings and recommendations.

A number of assumptions defined this base case scenario:

- No major negative ethanol life cycle environmental issues
- Ethanol production continues to expand on track with current RFS requirements (i.e., 15 billion gallons per year of conventional biofuels used by 2015; 36 billion gallons per year of conventional, cellulosic, and undifferentiated advanced biofuels used by 2022)
- As auto manufacturers increase production of FFVs, an increasing number of service stations provide E85 or higher-ratio ethanol refueling capacities

To assess how the nation's transportation-fuel infrastructure might evolve to accommodate the volumes of biofuels needed to meet an expanding RFS mandate over time, the Task Force found it useful to break this planned expansion into several discrete phases. Each phase corresponds to different consumption volumes and incorporates assumptions about the likely geographic distribution of supply and demand centers.

- **Phase Ia** (2008–2010): In this phase, ethanol production increases to 12 billion gallons per year. The existing multi-modal transportation network is used to transport ethanol from production centers in the Midwest to demand centers on the coasts, with rail playing a major role.
- **Phase Ib** (2010–2015): In this phase, corn ethanol production increases from 12 to 15 billion gallons per year. Absorbing this level of biofuels production requires nationwide use of E10 with expanded use of E85 (or higher-ratio blend) fuels. Transporting and blending this much ethanol will stress existing networks and require additional infrastructure investment. Modifying retail fueling infrastructure to accommodate higher-ratio ethanol blends will be an added challenge in the early part of this period.

Transporting and blending this much ethanol will stress existing networks and require additional infrastructure investment.

- **Phase II** (after 2015): In this phase, ethanol and advanced biofuel production expands beyond 15 billion gallons per year. Further evolution of the associated transportation and distribution infrastructure will depend on a number of factors, including the geographic distribution of supply and demand centers, mandate certainty, import volumes, FFV production, and successful market penetration of E85 or higher-ratio fuels (if ethanol becomes the cellulosic biofuel of choice). Non-ethanol biofuels, often referred to as bio or 'Renewable' hydrocarbons, which are similar to existing gasoline and diesel fuel, could potentially be developed after 2015. These would satisfy the RFS requirements and mitigate many of the infrastructure challenges as they would be fully compatible with conventional fuels and existing infrastructure.

Task Force members agreed that Phase Ia, illustrated in Figure 7, is likely to feature continued reliance on current transportation infrastructure and modes. Rail transport is projected to continue to account for roughly 70 percent of ethanol shipments from the Midwest to the eastern, western, and southern United States even as volumes increase. Unit train shipments will begin to become more common as larger blending terminals with unit train capacity are brought on line in key regions. Trucking movements are projected to stay flat at approximately 20 percent of ethanol transportation—truck transport will continue to be used mainly for short distances and to move chemicals, byproducts and waste products associated with the production of renewable fuels. Barge transport, while accounting for a very small portion of ethanol shipments in 2008, will also continue to play a role and may grow in importance in Phases Ib and II.

In the transition from Phase Ia to Ib, continued investment will be needed to expand storage facilities at blending terminals, reduce rail-car turn times, and further expand E85 infrastructure. To absorb the volume of biofuels mandated by the RFS, E10 will have to expand to a national blend, necessitating careful attention to ensure that requisite handling and storage capacity is available at blending terminals in all parts of the country.

The role of pipeline transport becomes a critical question in Phase Ib (see Figure 8). If some existing pipelines can be used to transport ethanol/gasoline blends, rail shipments of ethanol to regional terminals might decline, while barge shipments to Gulf Coast refineries would likely increase. Alternatively, a dedicated pipeline could be used to deliver neat ethanol from Midwest production centers to regional blending terminals on the East Coast. A dedicated pipeline would provide greater predictability and reliability for ethanol producers and terminal operators; however, it would also require a major investment and entail significant construction lead times. For these reasons, Task Force participants reached the two-fold conclusion that (1) a decision on shipping ethanol via pipelines must be made in the near future,

Figure 7. Phase Ia

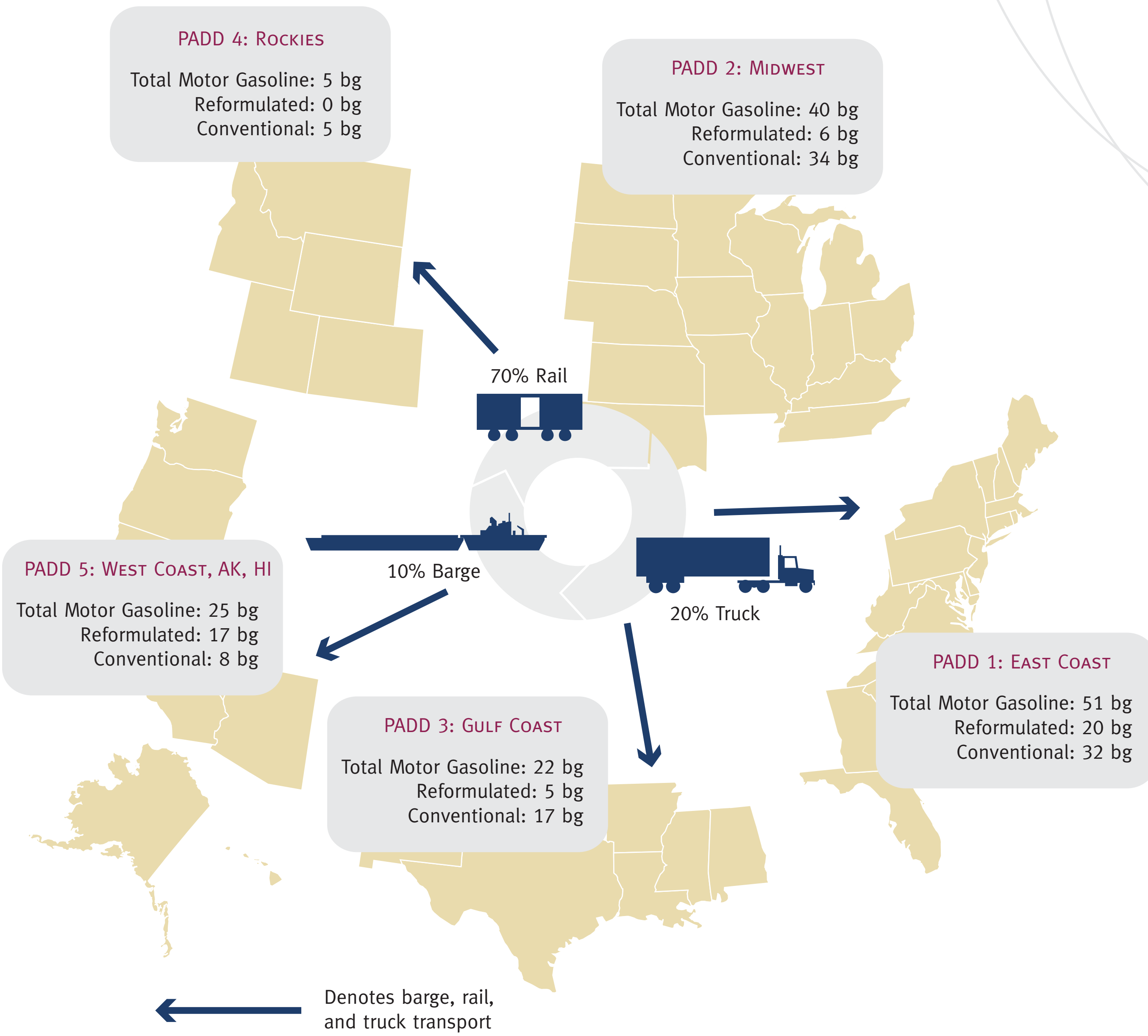
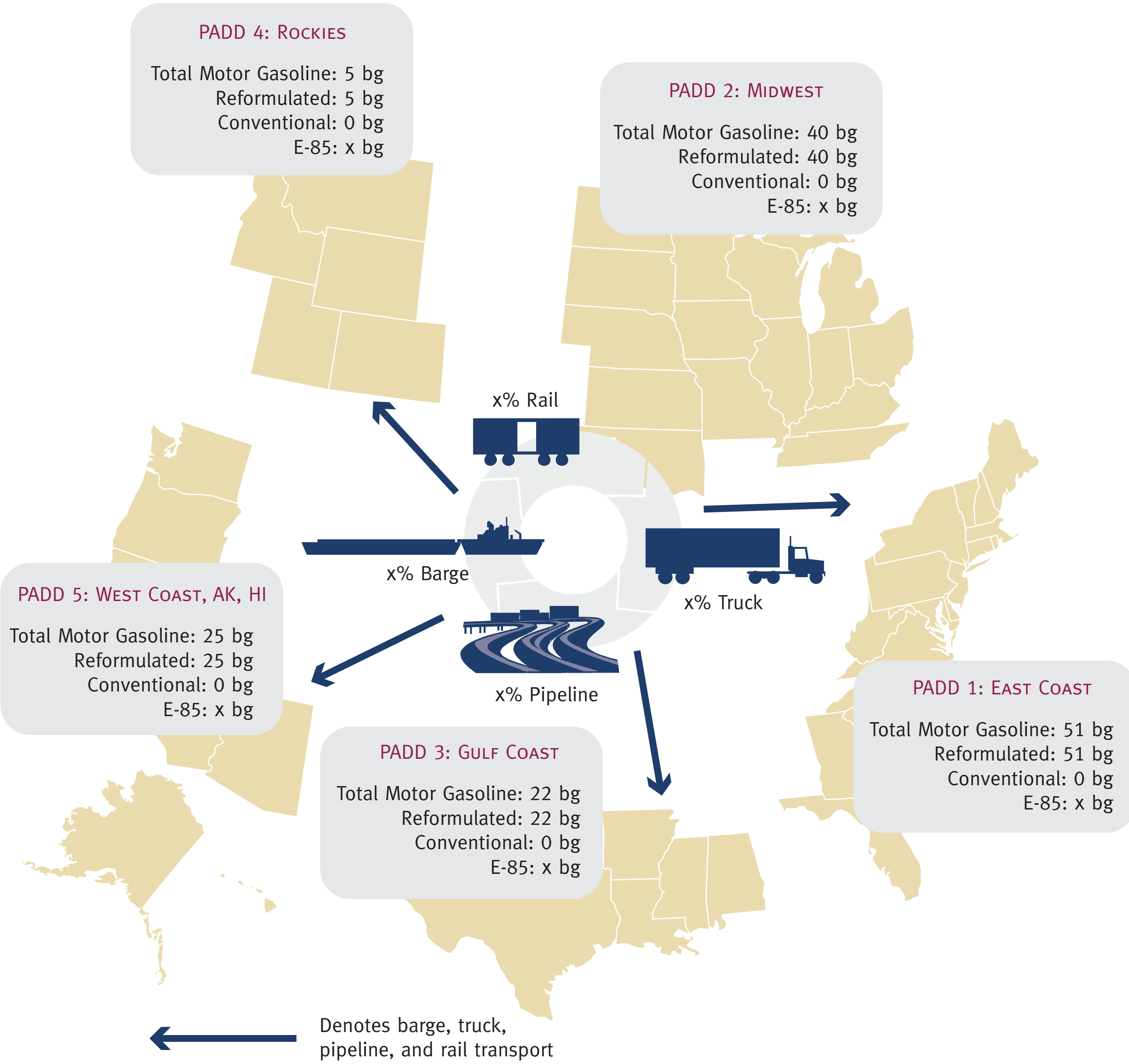


Figure 8. Phase Ib[11]



with commitments from the private and public sectors and (2) this decision cannot be delayed beyond 2009 because of the long permitting and right-of-way acquisition lead times associated with building a dedicated pipeline

Given the investment requirements associated with a new pipeline, certainty about the RFS mandate and other incentives and regulatory initiatives, such as loan guarantees for pipeline construction, will be essential.

[11] Phase 1b is a national 10 percent ethanol blend, meaning that all volumes are RFG.

Phase Ib is expected to be short lived as industry stakeholders optimize and expand their investments. As depicted in Figure 8, some pipeline movements are expected to commence, but at the same time the use of unit trains and terminal storage is also expected to continue to grow, quite possibly with an increase in marine deliveries. Two vital questions that must be addressed in Phase Ib concern the shipping methods for ethanol (e.g. dedicated pipeline or multi-modal network) and the role of cellulosic ethanol, which may be produced in different regions than existing corn ethanol.

The importance of RFS certainty in Phase Ib cannot be overstated, given the investments that will be needed to manage the transition to Phase II. Moreover, as the mandated volume of biofuels under the RFS expands to 15 billion gallons per year and beyond, an increasingly important

challenge emerges with respect to the plethora of state fuel specifications that currently characterizes the U.S. transportation-fuels market. As conventional petroleum refiners adapt their chemistry to produce national blendable-grade fuels, these state specifications will prove increasingly challenging, could preclude potential cost reductions, and could reduce both production and delivery efficiencies in the marketplace (we return to the subject of regulatory harmonization in the next section).

Phase II commences in 2015 with a corn ethanol mandate of 15 billion gallons and an advanced and cellulosic ethanol mandate of 8.5 billion gallons per year. Beyond 2015, it is anticipated that a fixed asset or pipeline will be a primary mode of transportation for ethanol, in either neat or blended form. Meanwhile, though corn ethanol is expected to account for the vast majority of base domestic biofuels production to this point, cellulosic ethanol will play an increasing role beyond 2015. In fact, cellulosic production should account for most of the increase in domestic ethanol output above the 15 billion gallon per year mark.

If most cellulosic biorefineries are near or co-located with existing corn ethanol production facilities in the Midwest, distribution infrastructure at a national scale will need to further develop to accommodate the movement of what could eventually be double 2015 volumes. Ethanol could be shipped via rail or truck to a consolidation/injection point to a pipeline or it could be shipped by barge down the Mississippi River to Gulf Coast petroleum refineries for blending and onward shipment. If, on the other hand, cellulosic production facilities are distributed more widely throughout the United States, it is likely that smaller-scale, regional-level distribution and refining networks will develop. In this instance, modes of distribution

with lower economies of scale, such as truck or rail, may continue to play a larger role.

In any case, multi-mode transportation assets will still be needed for purposes of regional distribution and to serve less densely populated areas in the western and central United States. Although E10 will already have a stable national market, E85 demand will need to be expanded to accommodate the RFS mandate. Increased national use of E85 or higher-ratio blends (beyond E10) presents investment requirements that will need to be made across current delivery channels. This means that retail stations will need to be able to dispense the higher-ratio blends and vehicles will need to be on the road that can operate on those blends. Currently, the number of FFVs and retail stations compatible with the use and delivery of higher-ratio ethanol blends such as E85 are insignificant: less than 3 percent of the U.S. vehicle fleet and roughly 1 percent of retail gas stations have this capability.

E85 DEMAND WILL NEED TO BE EXPANDED TO ACCOMMODATE THE RFS MANDATE.

CHAPTER VI.

SOURCES OF MARKET UNCERTAINTY AND THEIR IMPLICATIONS FOR INFRASTRUCTURE INVESTMENT

As is evident from the foregoing discussion, many questions remain about the future evolution of the systems needed to incorporate large volumes of biofuels in the nation's vehicle fuel supply. The petroleum industry is accustomed to making large-scale investments. Even small refinery modifications can involve large sums of capital, while adding new infrastructure (such as new pipelines) entails not only large costs but long lead times and extensive siting, permitting, and construction processes. At the same time, the magnitude and lumpiness of these capital commitments creates potent incentives to delay or defer investments to reduce the risk of stranded assets.

The response of refiners to recent legislative developments provides a case in point and highlights the importance of adequate investment in both conventional and renewable fuels infrastructure for assuring the adequacy of future vehicle fuel supplies. Under the Energy Independence and Security Act of 2007, Congress adopted more stringent automobile fuel economy standards, which if met, will reduce future demand for motor vehicle fuel more generally. Faced with the prospect of a shrinking market, refiners are already beginning to review and, in some cases, defer investments in expanding refinery capacity. If investments in biofuels production and distribution capacity do not materialize as anticipated, it is possible that the United States could confront domestic fuel shortages in the future.

Uncertainty therefore emerges as a key cross-cutting barrier to the infrastructure investments that will be needed to allow for a smooth transition through the deployment phases described in the previous section. This section reviews some of the most important sources of uncertainty relevant to prospects for future investment in biofuels infrastructure.

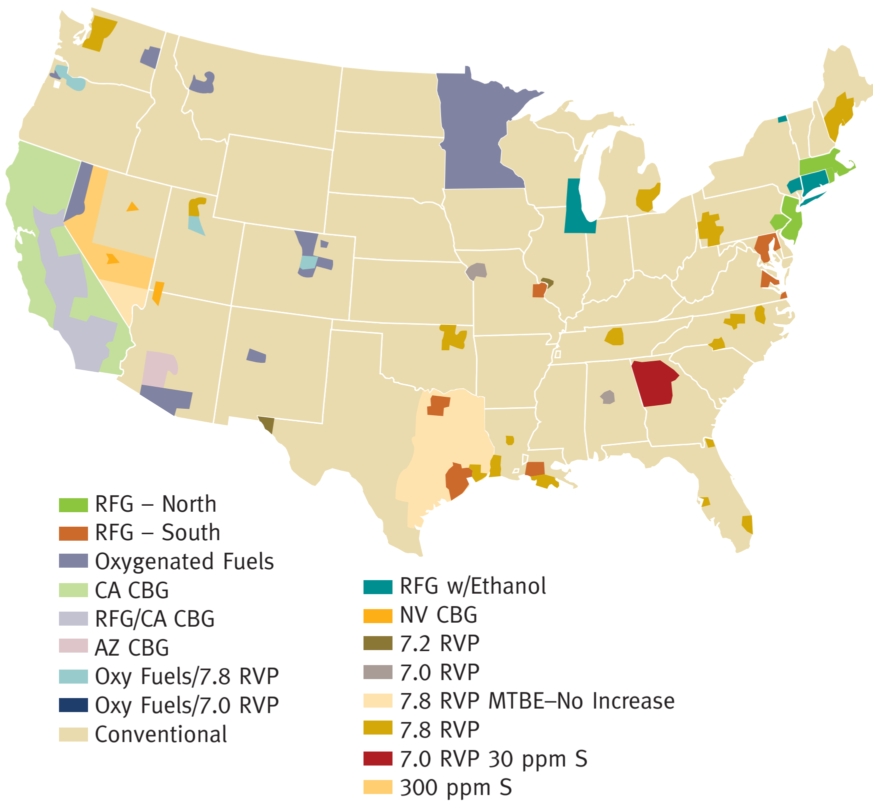
A. Sources of Demand Uncertainty

Even assuming certainty about the RFS mandate, important questions remain about the compatibility of the mandate with other state and federal regulatory requirements and future trends in the nation's vehicle fleet.

For example, current federal government regulation inhibits the introduction of higher-ratio ethanol blends (E10+). EPA must grant waivers for states that propose ethanol blends beyond E10. Moreover, the process for updating these regulations does not align with the RFS timeline. Similarly, several states have, or are discussing, requirements that terminals make available both neat and ethanol-blended fuel in addition to meeting state-specific fuels requirements. By precluding refiners from delivering a single, low-cost, sub-grade fuel to regional

MANY STATES HAVE ADOPTED FUEL SPECIFICATIONS THAT INHIBIT THE ABILITY TO INTRODUCE E10 OR HIGHER-RATIO ETHANOL BLENDS.

Figure 9. The various state and local fuels specifications



United States Department of Transportation Federal Highway Administration
http://www.fhwa.dot.gov/environment/aqfactbk/page16.htm

terminals for blending with ethanol, these requirements could interfere with system optimization and ultimately raise fuel costs to the consumer. Some states, moreover, impose additional requirements that may pose further challenges. For example, California's use of ethanol blends in the future may be constrained by the state's adoption of a Low Carbon Fuel Standard. Depending on California's assessment of the life-cycle carbon impacts of corn-based ethanol, this standard may constrain the state's use of ethanol blends. Because California accounts for approximately 11% percent of the overall U.S. gasoline market, any limitations it imposes on ethanol use could complicate attainment of the RFS at the national level.

More generally, the variation in federal and state standards coupled with the aggressive roll-out schedule of the RFS make it extremely difficult to optimize gasoline manufacturing, thereby increasing market volatility and uncertainty. Without some form of federal harmonization, this problem will persist throughout the RFS ramp-up period. Figure 9 shows the various state and local fuels specifications.

The ethanol blending and distribution system is still in its infancy and continues to evolve with challenges not uncommon to the roll-out of new products, including state policy changes and credit risk. With ethanol industry expansion and further consolidation over time, these credit worthiness issues are expected to go away. However, individual state legislative actions and initiatives may create delays for terminal infrastructure investments. Progress toward harmonizing blending codes and developing rigorous quality standards and fuel quality enforcement will support investment in state-of-the-art ethanol blending infrastructure and will help ensure that blended fuel meets required specifications.

Two other market developments have the potential to affect long-term demand for biofuels and thus the ability to achieve the RFS mandate. These include the availability of retail refueling capacity certified for higher-ratio ethanol blends and the availability of (and consumer demand for) vehicles capable of operating on higher-ratio ethanol blends. As we have already noted, the expansion of E85-certified pumps at gas stations is critical once ethanol volumes begin to exceed 12 billion gallons per year. At the same time, it goes without saying that consumers will only buy fuels their vehicles can use. Consequently, if sufficient numbers of vehicles are not certified and warranted by the auto manufacturers to operate on higher concentrations of ethanol, very few fuel retailers will offer these products.

The U.S. light-duty vehicle fleet turns over roughly every 15 to 16 years, assuming that consumers keep their cars on average for 10 years and that approximately 16 million new vehicles are sold each year. The availability of vehicles that can use fuel blends with ethanol concentrations higher than 10 percent is critical to meeting the RFS mandate toward the end of Phase Ib (2015 and beyond). The combined impact of reduced demand for gasoline due to high prices at the pump, increased penetration of diesel and hybrid cars in the U.S. auto fleet, and implementation of more stringent CAFE standards will mean that annual consumption of transportation fuels will likely fall below 138 billion gallons per year as early as 2012. This suggests that compliance with a 15 billion gallon per year RFS mandate will require ethanol sales above and beyond the volume that would be absorbed by nationwide use of E10 blends. As the RFS mandate increases to 36 billion gallons per year in 2022, a growing share of ethanol demand will have to come from the consumption of E85 or higher-ratio blends. This in turn means that significant numbers of FFVs will need to be on the road to accommodate the 22–26 billion gallons of additional ethanol that will need to find a market after the 10 percent blend wall has been hit nationwide. For this reason, expanded production and fleet penetration of FFVs is critical to smooth implementation of the RFS.

The U.S. EIA estimates that there are currently more than 7 million FFVs on the road today—a number that according to their projections could increase to over 8 million by 2010 and more than 15 million by 2014.[12] The fleet issue figures as a long-term challenge in making a successful transition to an integrated infrastructure for meeting the RFS mandate. To address this challenge, the domestic automakers have committed to the production of 50% of their fleet as FFVs by 2012.[13]

[12] EIA Annual Energy Outlook 2009: http://www.eia.doe.gov/oiaf/aeo/supplement/suptab_58.xls
[13] This commitment is subject to infrastructure/market development, but the domestic automakers' recent viability plans to Congress have reinforced this commitment which would make considerable progress towards the FFV fleet challenge.

B. Sources of Supply Uncertainty

Along with demand uncertainty, uncertainty about future supply—including the geographic distribution of suppliers and the role of domestic production vs. imports—can impact biofuels-related infrastructure investments. Production of conventional corn ethanol in the United States is, and will likely remain, fragmented over the near term, with the “Big Three” of 134 total producers nationwide contributing 35 percent of industry capacity. While ethanol production is fragmented, marketing is much more consolidated with the ten industry leaders marketing 90 percent of the total ethanol volume. Figures 10–13 describe the current distribution of market share by producer and the geographic distribution of production facilities.

Current U.S. ethanol production is concentrated in the Midwest Corn Belt confirming that proximity to available biomass feedstocks is a major factor in locating production facilities. This simplifies the logistics for transporting feedstock inputs (e.g., corn) and animal feed by-products (such as DDGS) obtained in the ethanol distillation process. Although specific siting determinants vary across the industry, typical criteria include a 50 mile radius to local

Figure 10. 2008 Ethanol Producer Market Share

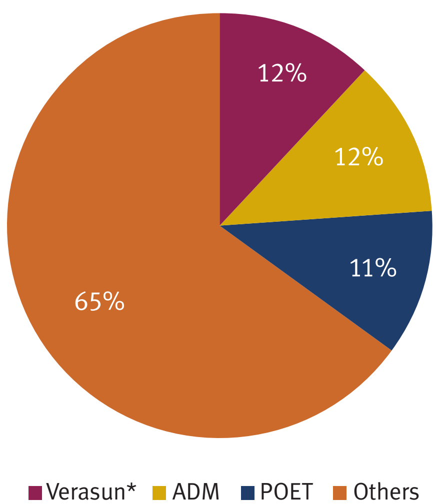
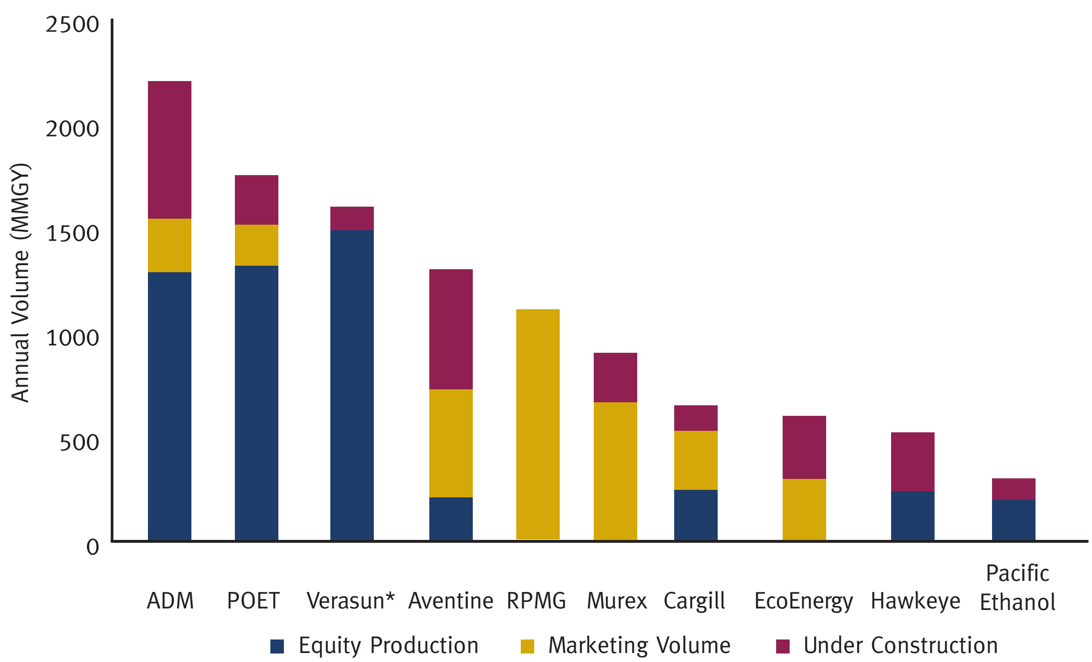


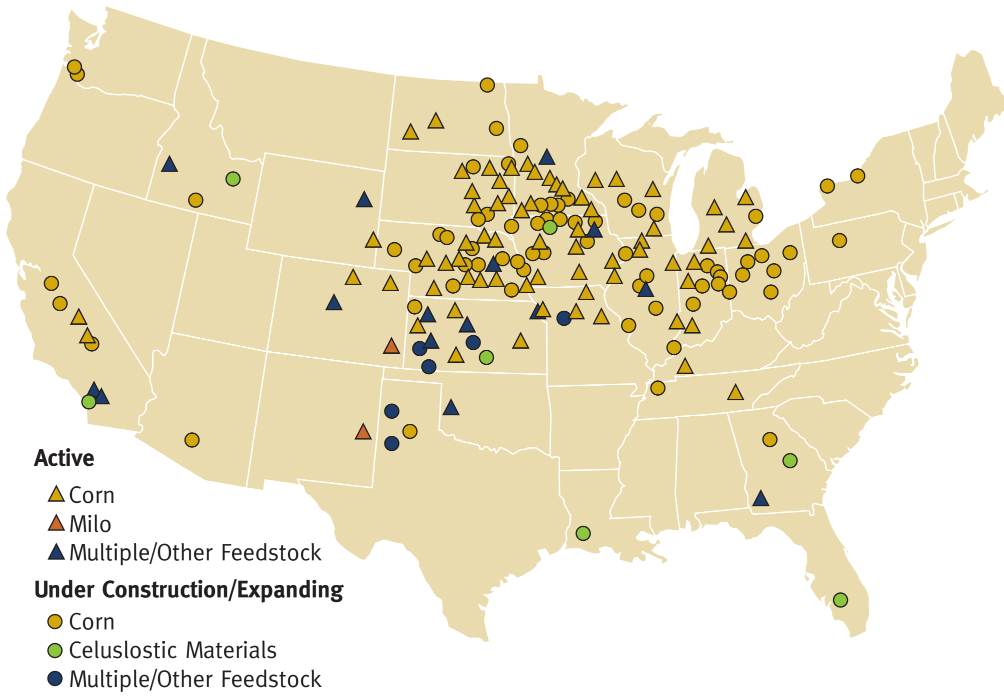
Figure 11. Top 10 Industry Leaders in 2008



*Verasun is in Chapter 11 bankruptcy

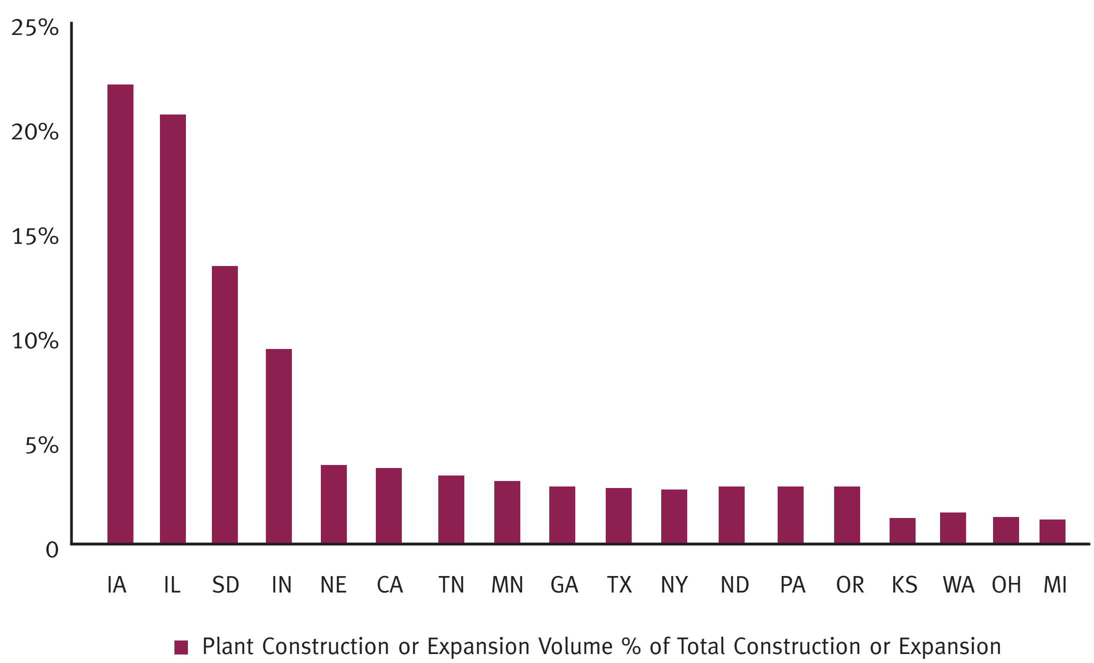
Uncertainty about future supply—including the geographic distribution of suppliers and the role of domestic production vs. imports—can impact biofuels-related infrastructure investments.

Figure 12. Biorefineries: Existing and Under Construction



Source: Renewable Fuels Association and Ethanol Producer Magazine June 2008

Figure 13. Biorefineries Under Construction By State (Total: 4,258 Million Gallons/Year)



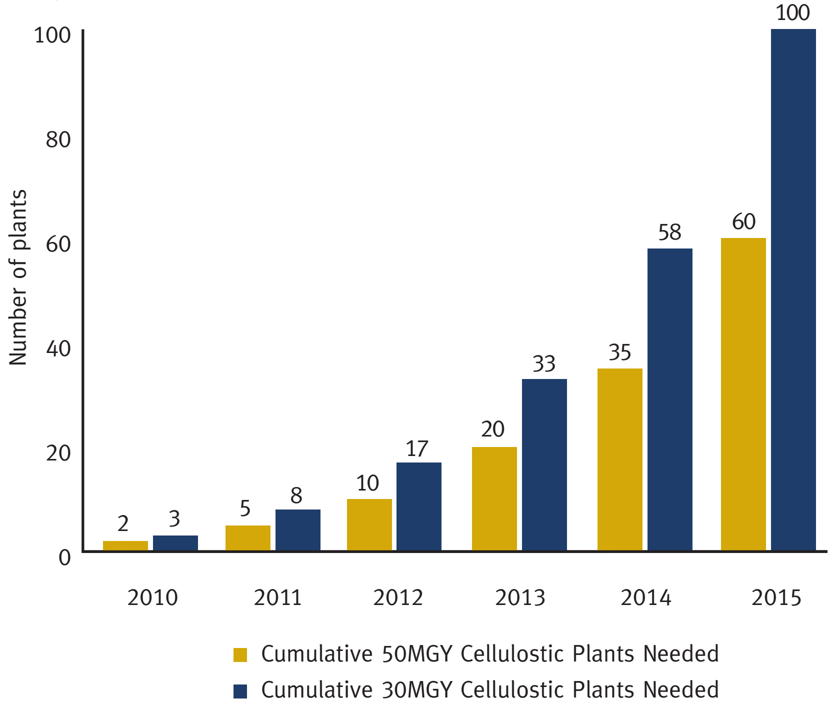
corn supplies as well as the intersection of two Class I railroads that can be used for transporting ethanol and DDGS.

Raw material costs also play a role in plant siting decisions. Ethanol plants require energy and both coal and natural gas costs have exhibited significant volatility since the winter of 2007. Access to natural gas may become more important if climate/carbon legislation advances and reliance on coal becomes less attractive. Depending on location, inbound and outbound transportation costs for biorefineries can amount to as much as 20 percent of operating costs. This suggests that strategic siting relative to transport opportunities is a critical element of profitable operations. The figures above underscore the need for a structured cross-country transportation infrastructure that would integrate mid-continent biofuels production facilities with existing petroleum industry assets.

Under the current RFS mandate, targeted production volumes for cellulosic ethanol ramp up dramatically in the 2010–2015 timeframe, increasing from 0.1 billion gallons per year to 3 billion gallons per year over a five-year period. This implies that between 60 and 100 new cellulosic biorefineries with an average production capacity of 30–50 million gallons per year will need to be in place (see Figure 14). It is anticipated that the majority of these plants will be located at or near existing grain refineries to capitalize on crop residues and perennial energy crops as feedstock sources. Further

Strategic siting relative to transport opportunities is a critical element of profitable operations.

Figure 14. Cumulative Number of Cellulosic Plants Needed to Comply with RFS



expansion and concentration of biorefinery capacity in the Midwest would improve the economics in favor of a fixed asset biofuels transportation infrastructure, such as a dedicated pipeline system.

As we have noted repeatedly, confidence in the integrity of the underlying RFS mandate itself is the first prerequisite for providing the certainty needed to support large-scale biofuels investments. If investors perceive that the mandate is likely to change, they will hesitate to commit large sums of capital to related infrastructure. In that case, infrastructure expansion is likely to proceed in an ad hoc way, with industry making only the minimal incremental investments needed to meet near-term needs.

In the case of corn ethanol refineries, construction lead times can be as short as 12–14 months with permitting times on the order of 6 months. Assuming no change in these lead times, planned expansions in production capacity through 2013 should be sufficient to meet RFS requirements to 2015.

The construction of cellulosic refineries, however, appears already to be falling short of the ramp-up needed to achieve RFS targets for advanced biofuels production. With construction lead times on the order of 1.6 to 4 years, it should be possible to meet advanced biofuels requirements for 2009 and 2010 with improved technology and continued progress toward cost-effective production, but the trajectory beyond 2010 is less clear. To supply the 16 billion gallons of cellulosic ethanol mandated by 2022 will require as many as 300–500 new plants with capacities ranging from 30 to 50 million gallons per year. This means that an average of 20–40 new plants must be brought on line every year until 2022.

As of 2008, a number of cellulosic ethanol projects totaling 2.1 billion gallons of production capacity have been proposed. This number is misleading, however, because it includes many pilot and research projects that are not for commercial use. Moreover, as of August of 2008, only three of these proposed projects were in the actual construction phase.

In sum, there is reason to question the feasibility of a rapid ramp-up in cellulosic ethanol production on the scale envisioned under the RFS mandate given the current status of the technology and the fact that no commercial-scale cellulosic plant has yet been brought on line. Substantial investments in new production capacity will be needed, along with rapid progress along the technology learning curve, in light of the fact that many of the challenges of producing at scale are as yet unknown. Siting cellulosic ethanol production facilities near feedstocks will be critically important to reduce feedstock transport costs.

Confidence in the integrity of the underlying RFS mandate itself is the first prerequisite for providing the certainty needed to support large-scale biofuels investments. If investors perceive that the mandate is likely to change, they will hesitate to commit large sums of capital to related infrastructure.

CHAPTER VII.

POLICY RECOMMENDATIONS

Domestically produced biofuels are expected to play an increasingly significant role in meeting U.S. transportation energy needs over the next two decades. With the adoption of an ambitious renewable fuels mandate and strong growth in corn ethanol production capacity in recent years, it is vital that more attention be focused on the infrastructure investments that will be needed to successfully integrate biofuels on a large scale in the nation's motor vehicle fuel supply. Consistent with this shift, it may also be appropriate to consider re-orienting some of the public incentives that have been successfully used to promote corn-based ethanol production to promote investments in delivery and distribution infrastructure.

In identifying priority policy recommendations, Task Force participants focused on the importance of reducing uncertainty and promoting market stability as key to creating the conditions in which biofuels-related infrastructure investments can be made in a timely and efficient way. Top priorities in this regard include assuring the continuity of the RFS itself and promoting the introduction of adequate numbers of FFVs on a timeframe compatible with absorbing mandated volumes of biofuels. If industry is going to make the kinds of large, long-term investments needed to establish an efficient national biofuels supply infrastructure, certainty about the RFS mandate is essential, as is adequate market demand for biofuels. In the event that oil consumption continues to decline and biofuels production surpasses 10–11 billion gallons per year, the national E10 market may become saturated as early as 2010. At that point, demand for additional biofuels will most likely need to come from E85 or higher-ratio blends, which require a FFV fleet.

Additional policy measures are also important to smooth the transition to large-scale biofuels use and promote the conditions for needed infrastructure investments. The Task Force recommends efforts to improve permitting across all points in the biofuel value chain, simplify and harmonize fuel specifications, and expand retail delivery infrastructure for higher-ratio ethanol blends. Given the compressed timeframes implicit in current RFS requirements, efficient permitting is essential to reduce long lead times for necessary infrastructure improvements. Similarly, the large number of state fuel specifications for current fuel products inhibits optimal national distribution; at the least, the adoption of new fuel specifications in different parts of the country should be kept to a minimum. Congress should actively pursue consistent national standards and guard against the proliferation of specialized renewable fuel formulations (often called boutique fuels) imposed through state and local jurisdictions. This multiplicity of fuels can contribute to tight

If industry is going to make the kinds of large, long-term investments needed to establish an efficient national biofuels supply infrastructure, certainty about the RFS mandate is essential, as is adequate market demand for biofuels.

supplies and price volatility especially when there is a supply disruption. Allowing unique grades of fuels both diminishes the efficiency of the system—because of their incompatibility with the larger distribution network—and increases the vulnerability of supply by reducing the capacity and increasing the complexity of the system. Biofuels and all the transportation energy resources that can be brought to bear will be needed to meet future demand. Avoiding the unintended consequences of additional implementation hurdles is critically important.

Another priority is the deployment of pumps and tanks that can accommodate E85 at retail establishments. As we have already noted, recent trends in gasoline consumption suggest that the E10 blend wall will most likely be reached on a nationwide basis by 2012, if not sooner, accelerating the need to add or modify existing infrastructure. This means that the investments in new retail infrastructure needed to accommodate expected volumes of E85 or higher-ratio blend fuels must be underway in the next few years. To reduce the cost of these changes and the economic burden imposed on retailers, gas station equipment manufacturers should be provided with incentives to deploy materials that will meet certification standards for higher concentrations of ethanol while keeping prices down. "Blender pumps" are one example of a technology that provides flexibility and thus can help reduce costs in the long run. These are pumps that have one intake line to a gasoline tank and one intake line to an ethanol tank and so can produce any blend up to E-85. Currently, blender pumps are being used particularly in the Midwest E85 stations; however, the pumps are not Underwriter Laboratory (UL) certified and, therefore, expose those retailers to significant liability associated with using non-certified equipment. Manufacturers will need to apply for certification before blender pumps will become attractive to the majority of retailers. In addition, retailers will need to ensure that all connected equipment is likewise properly certified. With certification and a possible incentive to off-set the higher cost of the compatible equipment gas station owners may be able to install blender pumps and mitigate the need to keep replacing pumps as increasingly higher-ratio ethanol blends enter the market over time. Given the average expected life of retail delivery equipment (an average of 20 years for underground equipment and 12 years for dispensers), it should be feasible to substantially expand retail capacity for handling higher-volume ethanol blends over the next 10 to 15 years simply by facilitating the replacement of existing equipment with E85-compatible pumps and dispensers.

The U.S. EPA has not yet proposed rules for RFS implementation beyond 2009. This leaves the industry with no lead time and little certainty in planning for future provisions. The EPA is also directed to update complex models and perform anti-backsliding evaluations on new gasoline reformulations designed to compensate for the higher volatility and other properties of ethanol blends. Continued uncertainty about these important elements of the RFS program constitutes a potentially large hurdle to successful implementation.

Finally, legislation being considered in both the House and Senate would add a federal low-carbon fuel standard to gasoline and perhaps diesel fuel requirements as well. The technologies and methodologies used to assess the life-cycle carbon impacts of different fuels are still evolving and there is significant debate about some elements of such assessments. In this context, adding new—and to some extent overlapping—fuel requirements is likely to promote greater uncertainty and result in sub-optimal approaches to achieving stated public policy objectives.

In sum, the implications of moving to a national E10 retail gasoline, while supplying and using an additional 21 billion gallons of biofuels on an annual basis, cannot be understated. The Task Force's priority recommendations for ensuring that this historically unprecedented shift can be achieved in an efficient and cost-effective manner are summarized below.

THE IMPLICATIONS OF MOVING TO A NATIONAL E10 RETAIL GASOLINE, WHILE SUPPLYING AND USING AN ADDITIONAL 21 BILLION GALLONS OF BIOFUELS ON AN ANNUAL BASIS, CANNOT BE UNDERSTATED.

Task Force Recommendations

- **RFS Mandate Certainty—**Market confidence in the government's commitment to the long-term goals of the RFS is essential to provide the basis for further large-scale capital investments in fuels technology pathways including first and second generation biofuels and renewable hydrocarbons and the necessary infrastructure to transport, distribute and use these fuels.

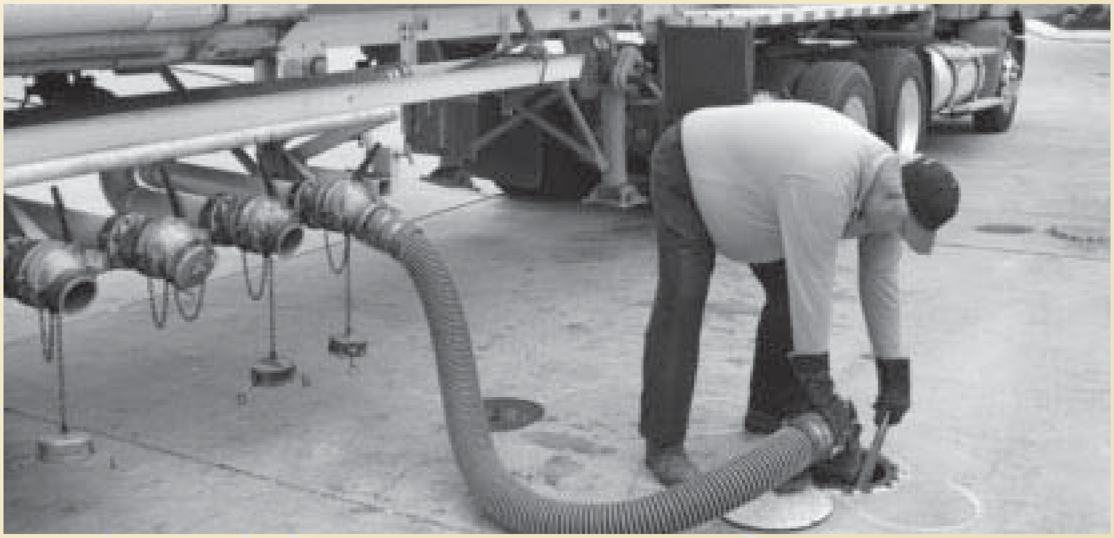
- **Deployment of Flex Fuel Vehicles (FFV) and Fuel Distribution Infrastructure—**A growing FFV fleet will be needed to absorb mandated biofuels quantities beyond what can be blended in conventional fuels. Further consumer and manufacturer incentives may be needed to accelerate the market penetration of FFVs. At the same time, consumer acceptance of these vehicles and fuels will depend on a number of factors including the expansion of access to E85 (or higher-ratio blends) retail stations in urban and rural areas.

- **Standardized fuel specifications—**Reducing or limiting the number of different blends that fuel refiners must produce to meet state-level specifications will enable a more efficient biofuels transition. In particular, now that the RFS has been enacted, we recommend rethinking the use of state-based renewable fuel mandates, which could compromise the efficiency and reliability of biofuel distribution.

- **Greater permitting efficiency—**Streamlining and simplifying permitting processes along all aspects of the biofuels supply chain would help to reduce costs and lead times for undertaking the infrastructure investments needed to support increased biofuels use nationwide.

- **Federal support for critical infrastructure investments—**Refocusing current public incentives and subsidies to include a greater emphasis on biofuels transport, refueling infrastructure, and related vehicle technologies makes sense given the industry's current state of development. Loan guarantees or tax credits could be effective ways to support needed infrastructure investments. These infrastructure investments would likely provide greater flexibility and enhanced capacity for handling a range of conventional and alternative fuels. Only certified equipment should be supported.

Refocusing current public incentives and subsidies to include a greater emphasis on biofuels transport, refueling infrastructure, and related vehicle technologies makes sense given the industry's current state of development.



APPENDICES

Appendix A: Conventional Refining Issues

Implementing the fuels provisions of the Energy Independence and Security Act of 2007 (EISA) presents several challenges to the conventional refining industry. The industry is extremely capital intensive. It is not unusual for capital investments to exceed $1 billion or more for upgrades, expansions or additions to existing facilities. Given the size of these investments the refining industry necessarily considers them to be very long lived. Also, given their size and complexity these investments normally require several years to plan, permit and execute. Even small projects can take more than 2 years to permit and implement. Given the long lead times and large capital outlays involved, these investments must be made with certainty that they are needed and can be sustained with little risk of becoming stranded or obsolete in the future.

After enactment of the EPACT 2005 RFS the refining industry began the planning and investment necessary to incorporate 7.5 billion gallons of renewable fuels by 2012. By the end of 2007, many terminal improvements had been started when the much larger EISA RFS placed new and expanded demands on the ethanol blending and refining infrastructure.

To facilitate the increase in ethanol blending, refiners will be required to invest in new gasoline processing and blending equipment. These changes can be as simple as a change of cut-point to eliminate butanes and pentanes for volatility control (provided outlets for light end materials are available) to as complex as new desulphurization or even olefin saturation to comply with the CARB predictive model. Unfortunately the pace of the increase in ethanol blending required by the new RFS exceeds the ability to plan, permit and modify refining infrastructure in an optimized manner or to allow for fully formulated blends that utilize all characteristics of the renewable components.

Another concern about the pace of the RFS is its incompatibility with state and other federal regulations. Some states have fuel specifications that inhibit the ability to introduce E-10 or higher-ratio blends. This is in the area of fuel parameters like RVP, T V/L and T50. Also, states like California do not recognize E-85 as a registered fuel for advanced vehicle emission control programs. Federally, ethanol cannot move without denaturant through pipelines because of IRS alcohol tax codes, this creates a necessity for hydrocarbons to be in the production process. The feasibility of updating these regulations does not align with the RFS timeline and, barring some form of harmonization or federalization, these state specific rules will make achieving the RFS targets more problematic. In addition to reacting to individual state mandates for selected biofuels, the refining industry also has to plan for anticipated changes to gasoline volatility caused by changes to the NAAQS ozone standards. To reduce ozone formation and allow ethanol, states will likely further reduce the RVP of gasoline in new non-attainment areas. This could create new state-by-state fuel requirements within already complex fuel markets.

Although on the state level, renewable fuels will need to be recognized in order to be marketable, the elimination of state-by-state fuels requirements will provide a more national push toward ethanol blended fuels and will eliminate state-to state-confusion regarding fuel standards.

In addition, California is planning implementation of a low carbon fuel standard and other states are implementing volumetric renewable fuel mandates. These standards are independent of the EISA RFS. Of particular concern is the uncertainty of how California will assess the Life Cycle Carbon impact of corn based ethanol. If this ethanol does not show CO_2 benefit it may not be used effectively or will be restricted beyond current NOx limits in California gasoline. California consumes approximately 11% of US gasoline, so any incomplete use of ethanol there will make EISA RFS compliance volumes harder to attain.

Appendix B: Retailers' Investment Requirements

To supply E85 or an intermediate blend of ethanol above E10 is considered worrisome and daunting to many fuels retail/convenience stores owned by small businesses which make up the largest percentage of gas stations in the country While existing retail equipment accommodates blends up to 10%, without recertification of existing infrastructure or new equipment, retailers run the risk of exposure to gross negligence liability for operating non-compatible infrastructure if they sell intermediate blends of ethanol.

To accommodate the RFS mandates beyond the E10 blend wall, retailers will need to sell higher level blends requiring officially certified equipment which may prove financially burdensome to these small business owners. Estimates on upgrading systems vary widely as evidenced by the following benchmarks:

- Upgrading part of a system installed in 2007 to service E-85 in the Texas/Oklahoma market was estimated to cost at least $11,000.

- Installing a 6,000 gallon diesel fuel tank system in California was estimated to cost more than $200,000.

- Replacing an entire system can be expected to cost substantially more than $150,000 per facility depending upon the market.

Provided that compatibility issues are addressed to satisfy the economic and legal considerations facing retailers, the degree to which consumers desire to buy these fuels remains a primary consideration. Consumers will only buy what their vehicles can use, consequently, if the existing vehicle fleet cannot be certified and warranted by the auto manufacturers to operate on higher concentrations of ethanol, very few retailers will offer the product. In order to provide retail access, investment incentives may be needed. If intermediate blends do not provide the expected demand, retailers will not look favorably on upgrading to these specialized pumps.

Appendix C: Sources of Market Uncertainty

Flex Fuel Vehicles

The U.S. EIA estimates that there are currently more than 7 million FFVs on the road today—a number that according to their projections could increase to over 8 million by 2010 and more than 15 million by 2014.[14] The fleet issue figures as a long-term challenge in making a successful transition to an integrated infrastructure for meeting the RFS mandate. To address this challenge, the domestic automakers have committed to the production of 50% of their fleet as FFVs by 2012.[15]

While the domestic vehicle fleet has historically turned over every 15 years, the current economic challenges may impact this statistic resulting in dramatically fewer auto sales and/or consumers keeping older models longer than planned. This scenario would necessitate converting the existing vehicle fleet for E85 compatibility, which requires further analysis for cost and delivery practicality. Under more stable economic scenarios, a conversion program similar to the transition from leaded to unleaded gasoline may prove a likely solution with a specific model year by which all vehicles must be compatible with the higher concentrations of ethanol.

[14] EIA Annual Energy Outlook 2009: http://www.eia.doe.gov/oiaf/aeo/supplement/suptab_58.xls

[15] This commitment is subject to infrastructure/market development, but the domestic automakers' recent viability plans to Congress have reinforced this commitment which would make considerable progress towards the FFV fleet challenge.

Appendix D: International Experience—Brazil

Brazil's experience with substantially expanding its ethanol infrastructure may be instructive for efforts to assess biofuels infrastructure issues in the U.S. context. Brazilian ethanol production began at scale in 1978 and today can arguably be ramped up to enable a 100% increase in exports over 15 years. Regarding transportation, distribution, and delivery, at the end of 2006 the Brazilian ethanol industry could store and transport a little over 1 billion gallons of exports per year. Transporting ethanol for future expansion from center-west regions to the coast will require between 500 to 1,200 miles of new pipelines and railways. These additions will enable increased exporting; however, additional storage capacity will also be required to support seasonal production of up to 4 billion gallons of ethanol per year.

However, it is important to consider the magnitude of Brazil's fuel consumption relative to that of the United States in the proper context. As the figure below illustrates, Brazil consumes substantially less gasoline than the United States, hence the implications of an equivalent percentage penetration of biofuels are of a different order of magnitude than in the United States.

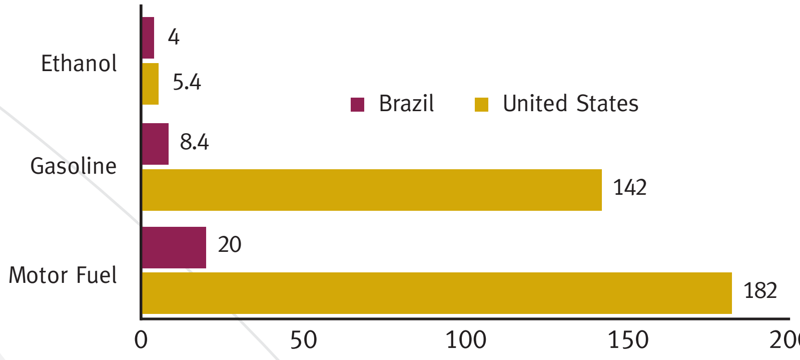
Brazil has over 30 years of experience with the logistics of integrating ethanol in its fuel supply and distribution networks, which include 45 marine and land terminals (13 of which handle ethanol) as well as 16,000 km of pipelines. Currently, there are three ethanol pipelines in Brazil which are owned and run by Petrobras (via their pipeline company, Transpetro). High tariffs (similar to trucking costs) and limited access reduce the benefits of these pipelines, none of which currently connects to port facilities. Three separate plans for new pipelines have been proposed, however, it will take years for a new pipeline to be built and put into service.

To date, there have been no reports of stress corrosion cracking in carbon steel equipment used to handle Brazilian ethanol. A difference in distribution handling practices is believed to make SCC less of a problem for Brazil; nevertheless, as a precaution, Brazil has taken detailed operational and procedural steps to avoid water and scale issues in its ethanol batches.

Virtually all gas stations have both gasoline and ethanol pumps. Strong government support has been a fundamental ingredient in developing the Brazilian ethanol industry.

In 1978, the first 35 service stations pumps for ethanol were installed and, by 1997, the government ruled that gasoline must include 20–25 percent ethanol. The percentage is set by the government within this 20–25 percent range, and is determined by pricing ethanol compared to gasoline—if ethanol is cheap compared to gasoline, the required percent is increased. Petrobras and UNICA (representing the sugar/ethanol industry) lobby the government to decrease/increase the percent, respectively. Currently, Flex Fuel Vehicles make up about 15 percent of the car fleet, but are 90 percent of new-car sales—so the fleet is rapidly changing over.

Figure 15. Fuel consumption in the U.S. and Brazil (billions of gallons)



Sources: Energy Information Administration, International Energy Annual 2004, Washington, June 2006; Renewable Fuels Association, Industry Statistics, [http://ethanolrfa.org/industry/statistics], accessed July 20, 2007.

Appendix E: Trucking HAZMAT

The driver shortage for hazardous materials is particularly acute. Many finished biofuels and chemicals needed to produce biofuels will require drivers with hazardous materials endorsements to their commercial driver's licenses. The industry has a proven track record of training qualified drivers resulting in an impressive safety record; however, new security credentials have resulted in a larger than expected attrition rate for drivers qualified to transport hazardous materials. This is not due to the individuals failing to pass background checks, but rather to the expense and inconvenience of duplicative security credentials that are required by federal, state, local and even private entities.

The same concerns as in the near term apply to trucking in the long term, i.e., a significant driver shortage, infrastructure constraints and a need to increase the number of tank trucks. If these constraints have not begun to be mitigated in the near term, as RFS volumes nearly double from 2015 to 2022, they will become more pronounced. Moreover, much of the volume currently moving long distances by rail may be displaced by the pipeline mode of distribution. For the short hauls less than 400 miles between the biorefinery and the terminal (i.e., primary biofuel distribution moves) as well as the move from the destination terminal and/or refinery to retail (i.e., secondary biofuel distribution moves), mode shifts are not possible, thereby reducing any downside mitigation that may be available from other modes.

Appendix F: Safety and Testing

The increasing demand for cleaner transportation fuels and increased dependencies on foreign oil creates opportunity for biofuels such as ethanol. Ethanol production—both corn and cellulosic-based—is a key component for a diversified solution to America's energy problems. As the nation continues to invest in new technology and expand alternative fuel solutions, the Pipeline and Hazardous Materials Safety Administration's focus is to address the infrastructure and safety challenges associated with the transportation of biofuels.

Emergency Response Issues

One of PHMSA's biggest safety concerns with ethanol is that it is produced and transported from and through communities which sometimes have limited, or no experience, in handling the risks associated with ethanol. These risks are related to the introduction of new vehicles, new ethanol blends with gasoline, and the introduction of new routes through communities not experienced with ethanol. PHMSA has identified risks dealing with ethanol spills and fires. But risks may multiply because of congestion on the transportation network. Emergency responders and community leaders in rural communities, in many cases, do not have the resources, equipment, training or experience to properly handle or address these new risks in their communities.

Pipeline Safety Issues

The introduction of ethanol into the liquid petroleum pipeline infrastructure brings both opportunities and challenges. The challenges are related to the potential incompatibility of large quantities and concentrations of ethanol with existing pipeline system materials and potential short and long-term risks to operational and system integrity of shipping ethanol/gasoline blends. Overcoming the challenges associated with the pipeline transportation of Fuel Grade Ethanol and more potent ethanol blends will likely require significant long-term research in order to understand whether ethanol-rich products can be transported through existing pipelines, what mitigation strategies might be necessary to transport such products through existing systems, and how new pipelines might be designed in order to transport ethanol-rich products.

PHMSA is addressing infrastructure challenges and removing identified barriers to the safe transportation of ethanol through pipelines. A strong partnership between PHMSA, the pipeline industry, other Federal and State agencies and the emergency first response community is rapidly removing the technical and regulatory barriers for the safe transportation of ethanol and other biofuels. These initiatives are critical for enabling ethanol usage to grow nationwide and reach government production targets.

Glossary

EISA: Energy Independence and Security Act of 2007—aims at reducing America's dependence on oil by (1) increasing the supply of alternative fuel sources by setting a mandatory Renewable Fuel Standard (RFS) requiring fuel producers to use at least 36 billion gallons of biofuel by 2022 and (2) reducing U.S. demand for oil by mandating a national fuel economy standard of 35 miles per gallon by 2020. EISA changed the RFS levels from EPACT2005.

EPACT2005: Energy Policy Act of 2005—encourages energy conservation and efficiency by (1) promoting residential efficiency, (2) increasing the efficiency of appliances and commercial products, (3) reducing federal government energy usage, (4) modernizing domestic energy infrastructure, (5) diversifying the nation's energy supply with renewable sources, and (6) supporting a new generation of energy-efficient vehicles. EPACT2005 set the original RFS, which has been updated by EISA.

FFV: Flexible Fuel Vehicle—a vehicle designed to run on gasoline or a blend of gasoline and 85% ethanol (E85).

Jobbers: Jobbers purchase gasoline from refiners and importers for resale in both the wholesale and retail markets often operating their own retail units. Products may be sold as branded product (major oil brand) or unbranded (private brand).

RBOB: Reformulated Blendstock for Oxygenate Blending—Specially produced reformulated gasoline blendstock intended for blending with oxygenates downstream of the refinery.

RFG: Reformulated Gasoline—gas blended to burn cleaner by reducing smog-forming and toxic pollutants in the air we breathe. Mandated in many urban/metro areas.

RFS: Renewable Fuels Standard—mandated the increase of the volume of renewable fuel required to be blended into gasoline. Started in 2008 through EPACT2005, which mandating 4.7 billion gallons, the revised RFS in EISA increased to 36 billion gallons by 2022.

SCC: Stress Corrosion Cracking—the deterioration of material due to a corrosive or stressed/high-pressure environment. SCC is known to be caused by ethanol in terminal infrastructure.

VEETC: Volumetric Ethanol Excise Tax Credit —Provides a 45 cent tax credit per gallon of ethanol to the blender. The credit was decreased from 51 to 45 cents when the United States exceeded 7.5 billion gallons of ethanol production and importation in the United States.

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