IEA-Advanced Motor Fuels

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ADVANCED MOTOR FUELS IEA-AMF

UNITED STATES

United States

Introduction

The U.S. Energy Information Agency (EIA) estimated that total U.S. transportation energy consumption in 2015 was about 27,713 trillion Btu.[1] More than 90% of this consumption was petroleum-based fuels (gasoline and diesel), with almost the entire remainder being ethanol blended into gasoline at 10% volume or about 7% by Btu content (>95% of U.S. gasoline in early 2015 consisted of such blends).[2]

The EIA's Annual Energy Outlook for 2015 projects that U.S. light-duty vehicle (LDV) fuel use peaked in 2012 and will decline through 2040 due to increasingly stringent fuel economy/greenhouse gas (GHG) regulations (Figure 1).[3] The EIA projects that total transportation energy consumption will peak in 2017 and decline until around 2034, largely due to the decline in LDV fuel use. Despite Phase 2 fuel economy standards being implemented for medium and heavy-duty vehicles, heavy-duty fuel use is projected to increase through 2040, though not dramatically (from approximately 5.5 quadrillion to 7 quadrillion Btu).[4]

The U.S. net dependence on foreign oil has dropped from approximately 60% of U.S. petroleum use in 2005 to about 27% for 2015, as shown in Figure 2.[5,6] This large reduction was due mainly to increased domestic production of "tight oil," including shale deposits, enhanced recovery at mature conventional fields, rising energy prices, and increases in vehicle efficiency.

The collapse in world oil prices continues to be the main obstacle to additional penetration of alternative fuels in the United States. Much of the impetus for converting to the use of natural gas (almost entirely in heavy-duty vehicles) and other fuels (ethanol and propane) for transportation has been drastically reduced, as has the incentive for purchasing light-duty electric vehicles. Unfavorable economics are expected to continue in the

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1 http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_11.pdf.

2 http://www.eia.gov/totalenergy/data/monthly/pdf/sec10_7.pdf. The EIA shows 1,111 trillion Btu of fuel ethanol consumed in 2014 and 1,056 trillion Btu consumed in the first 11 months of 2015, which is roughly 7% of motor gasoline Btus.

3 http://www.eia.gov/todayinenergy/detail.cfm?id=17171.

4 https://www.eia.gov/forecasts/aeo/workinggroup/transportation/pdf/AEO2016%20Transportation%20Working%20Group%202%20Presentation.pdf, pp. 30–32.

5 http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTTNTUS2&f=M.

6 See http://www.eia.gov/tools/faqs/faq.cfm?id=727&t=6.

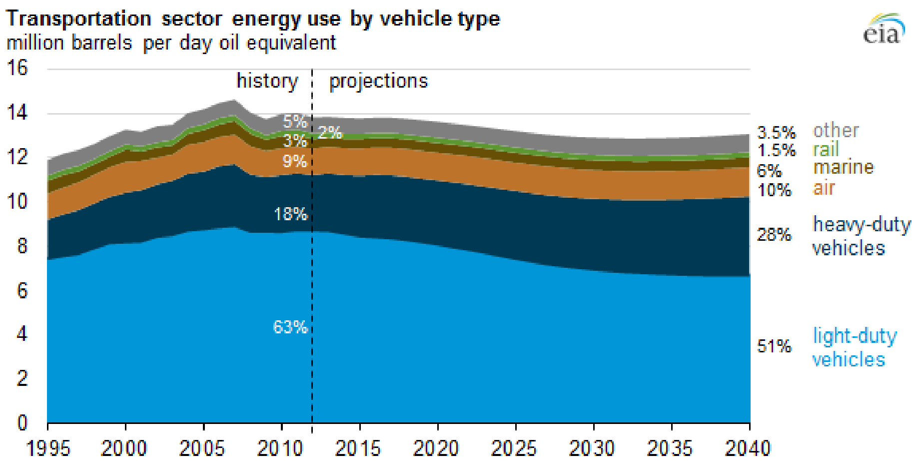

Fig. 1 Transportation Sector Energy Use by Vehicle Type

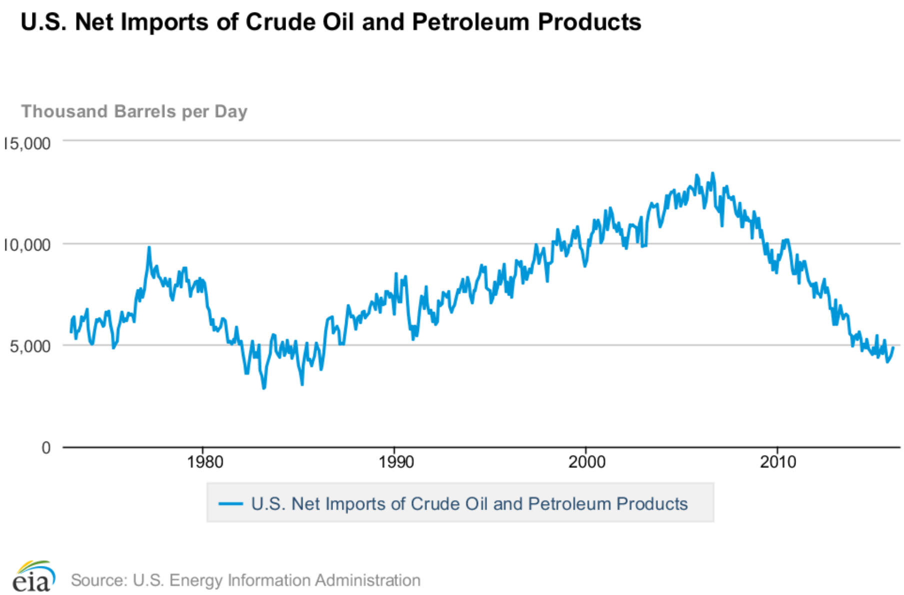

Fig. 2 U.S. Net Imports of Crude Oil and Petroleum Products

near term. Interest in advanced motor fuels continues to be vigorous, despite the likelihood that low prices and abundance will not persist in the long term.

Policies and Legislation

The U.S. Federal Government and state governments provide many incentives for the development, deployment, and use of alternative fuels and alternative fuel vehicles. While they are too numerous to catalog here, some of the more important ones are described below.

The Energy Policy Act of 1992 (EPAct) requires that certain centrally fueled fleets (federal, state, and alternative fuel provider fleets, such as utility companies) acquire light-duty alternative fuel vehicles as most of their new vehicle acquisitions. Fleets of alternative fuel providers must also use alternative fuels in the vehicles, where available for use.

The U.S. Department of Energy (DOE) Clean Cities Program is a government-industry partnership program that supports local decisions to reduce petroleum use in the transportation sector. To accomplish this goal, the program encourages the public and private sectors to reduce petroleum consumption by using alternative fuels and by increasing vehicle efficiency through technologies such as alternative-fueled vehicles, hybrid and electric-drive vehicles, fuel blends, idle reduction technologies, and fuel economy measures. Clean Cities carries out its mission by working in cooperation with nearly 100 geographically diverse, community-based coalitions nationwide. Coalitions form partnerships within their communities to design projects to suit their area's needs, resources, and strengths. At the national level, Clean Cities gives manufacturers, trade associations, national fleets, government agencies, and other stakeholders coordinated strategies and resources that they can leverage to implement effective petroleum reduction practices. Clean Cities also gives coalitions access to information and incentives from DOE, other federal and state agencies, and industry partners that can help fund significant, high-impact projects.

As shown in Figure 3, the Clean Cities coalition users of alternative motor fuels displaced 390 million gallons of gasoline equivalent (MGGE) in 2013 (most recent data), an increase of about 15% from 2012 levels. Over half of the savings came from natural-gas-powered vehicles, typically heavy-duty trucks and city buses. The savings comes from approximately 475,000 vehicles tracked by the Clean Cities coalitions. Note that the consumption quoted by Clean Cities was mainly calculated for fleet vehicles that were in an area tracked by a Clean Cities coalition partner. The

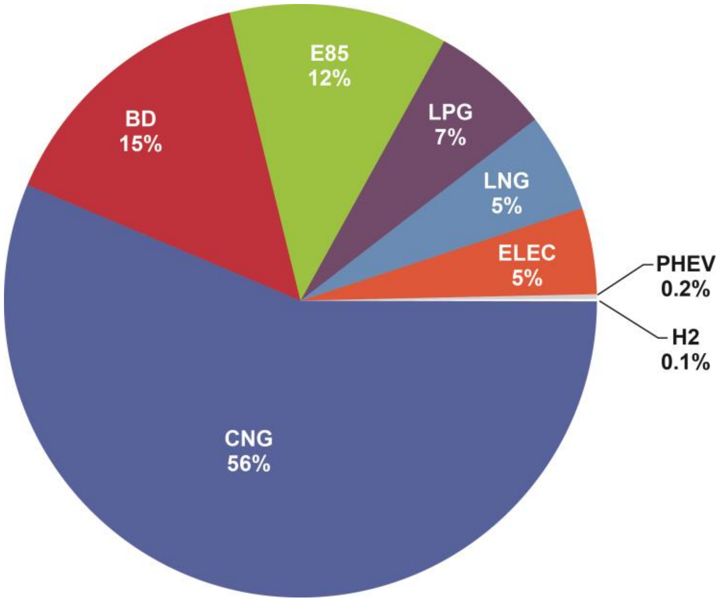

Fig. 3 Clean Cities 2013 Data for Advanced Fuel Vehicles (AFVs) and Petroleum Displacement[7]

U.S. Federal Government does not have an active role in operating the majority of these fleets. More information on the Clean Cities program can be found at www.cleancities.energy.gov.

U.S. Environmental Protection Agency (EPA) Requirements under the Renewable Fuels Standard (RFS)

The primary driver of renewable fuel use in the United States is the RFS, adopted in 2005 and expanded in 2007 (RFS2). It requires increasing volumes of renewable fuel to be used in motor fuels.

On November 30, 2015, the EPA finalized the volume requirements and associated percentage standards under the RFS program in calendar years 2014, 2015, and 2016 for cellulosic biofuel, biomass-based diesel, advanced biofuel, and total renewable fuel. The EPA also finalized the volume requirement for biomass-based diesel for 2017 (see Tables 1 and 2). These volumes were greater than those proposed in 2013 for 2014 compliance, but significantly lower than those originally targeted in the RFS legislation,

[7] See http://www.afdc.energy.gov/uploads/publication/2012_metrics_report.pdf. BD = biodiesel, E85 = ethanol 85, LPG = liquefied petroleum gas, LNG = liquefied natural gas, Elec = electricity, PHEV = plug-in hybrid electric vehicle, H2 = hydrogen, and CNG = compressed natural gas.

which envisioned much more robust growth in cellulosic fuel production than has as yet materialized.

Table 1 EPA Final Renewable Fuel Volumes[a]

Fuel	2014	2015	2016	2017
Cellulosic biofuel (million gallons)	33	123	230	NA[b]
Biomass-based diesel (billion gallons)	1.63	1.73	1.90	2.00
Advanced biofuel (billion gallons)	2.67	2.88	3.61	NA
Renewable fuel (billion gallons)	16.28	16.94	18.11	NA

[a] Units for all volumes are ethanol-equivalent, except for biomass-based diesel volumes which are expressed as physical gallons.

[b] NA = not applicable.

Table 2 EPA Final Percentage Standards

Fuel	2014	2015	2016
Cellulosic biofuel	0.019%	0.069%	0.128%
Biomass-based diesel	1.41%	1.49%	1.59%
Advanced biofuel	1.51%	1.62%	2.01%
Renewable fuel	9.19%	9.52%	10.10%

The final 2016 standard for advanced biofuel is nearly 1 billion gallons, or 35% percent, higher than the actual 2014 volumes, while the total renewable standard requires growth from 2014 to 2016 of more than 1.8 billion gallons of biofuel, or 11% higher than 2014 actual volumes. Biodiesel standards are expected to increase steadily over the next 2 years, increasing to 2 billion gallons in 2017.

The EPA divides renewable fuels into several categories for regulatory purposes, some of which are nested. Liquid cellulosic biofuel is fuel derived from biomass by enzymatic conversion and fermentation, by pyrolysis, or by gasification. The category was created largely with cellulosic ethanol in mind, but cellulosic ethanol production continues to be plagued with problems. Renewable natural gas from landfills and anaerobic digesters, treated as cellulosic biofuel by the EPA through a combination of rulemakings in 2013 and 2014, has dwarfed liquid fuels in that category. Biomass-based diesel is mainly traditional fatty acid methyl ester (FAME) biodiesel, derived from soy, corn, canola, camellia oils, and other vegetable and animal fats and oils. These categories are nested into the category of advanced biofuels, which also includes renewable diesel, biogas, renewable heating oil, and renewable fuels co-processed in petroleum refining. Finally, the broad category "Renewable fuel" includes all of these categories combined with (and dominated by) starch- and sugar-based ethanol.

Other alternative and advanced motor fuels are incentivized by various federal and state programs. Lists of these are available at http://www.afdc.energy.gov/laws/.

Co-Optimization of Fuels and Engines

In fall 2015, DOE introduced a new initiative known as the Co-Optimization of Fuels and Engines, or Co-Optima. The initiative is led jointly by DOE's Vehicle Technologies Office and Bioenergy Technology Office. The goal of Co-Optima is to identify and rigorously evaluate co-optimized technology options for the introduction of high-performance, sustainable, affordable, and scalable fuels and engines. DOE envisions that the effort will span more than 15 years, including not only research on the relationship between fuels and engines to achieve optimum efficiency and GHG reductions, but also fuel production research and pathways for successful commercialization of the products. It includes both spark ignition (SI) technologies (focusing on high-knock resistance for efficiency), targeted for commercialization by 2025, and compression ignition (CI) technologies (including use of kinetically controlled and higher reactivity fuels), targeted for commercialization by 2030. Identified metrics include:

- Reduce per-vehicle petroleum consumption 30%,
- Accelerate deployment of 15 billion gallons/year of advanced biofuels, and
- Enable an additional 9%–14% fleet GHG reduction by 2040.

Program activity is currently organized into six integrated and coordinated teams for:

- Low GHG Fuels: identifying promising bio-derived blendstocks, developing selection criteria for fuel molecules, and identifying viable production pathways.

- Fuel Properties: identifying critical properties and allowable ranges, systematically cataloguing properties, and predicting fuel blending behavior.
- Advanced Engine Development: quantifying interactions between fuel properties and engine design and operating strategies, and enabling optimal design of efficient, emission-compliant engines.
- Modeling and Simulation Tool Kit: extending the range, confidence, and applicability of engine experiments by leveraging high-fidelity simulation capabilities.
- Analysis of Sustainability, Scale, Economics, Risk, and Trade: analyzing energy, economic, and environmental benefits at the U.S. economy level and examining routes to feedstock production at scale through existing biomass markets.
- Market Transformation: identifying and mitigating challenges of moving new fuels and engines to markets and engaging with the full range of stakeholders.

The first major decision point of the program is targeted for March 31, 2017, which marks the end of the fuel discovery phase of "Thrust I" of the program — the low-knock SI fuel and engine. At that point, it will be determined whether any candidate fuel components (other than ethanol) can realistically be expected to be commercially available at large scale in the early 2020s. Though SI fuel and engine research and development (R&D) activities will continue thereafter, regardless of the result, they may not be realistic candidates on the aggressive Co-Optima timeline. The result of this fuel discovery phase of Thrust I will inform the degree to which attention will be shifted to Thrust II — advanced compression ignition (CI) fuels and engines. (Thrusts I and II are being executed in parallel already.)

Smart Mobility

In 2015, the U.S. government announced a broad new inter-agency initiative called Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility. It will utilize a consortium of stakeholders in government and the private sector to examine the nexus of energy and mobility for future transportation systems. Initial research will focus on connected and automated vehicles, urban science, decision science, multi-modal transport, and integrated vehicle-fueling infrastructure systems. DOE's participation in the program will include $5 million in new R&D funding.

Zero Emission Vehicle Sales Mandates

The State of California has adopted requirements that percentages of automaker sales in the state be zero emission vehicles (ZEVs – including battery electric vehicles and fuel cell vehicles), allowing partial credits for various other types of vehicles, including plug-in hybrid electric vehicles and natural gas vehicles. Ten other states have opted to participate in the program — Connecticut, Maine, Massachusetts, Vermont, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, and Oregon. The requirements apply differently based on the sales volumes of manufacturers, but from 2012–2017 they have been only in the thousands of vehicles for the large manufacturers. Effective in 2018, the ZEV requirements triple and then ramp up annually to reach about 15% of new car sales in these states by 2025. This is expected to result in substantially greater volumes of advanced fuel vehicles (AFVs) being sold in these key states.

Implementation: Use of Advanced Motor Fuels

Biofuels

In 2012, the first commercial production of cellulosic ethanol in the United States came on line. Although the total volume remains very small (less than 1 million gallons), several facilities came on line in 2013 and 2014. In order to encourage the use of advanced biofuels, the EPA has defined a system of credits based on the energy content of ethanol. The credit, known as the Renewable Identification Number (RIN), is equivalent to the energy content of 1 U.S. gallon (3.78 L) of ethanol. There are different categories of RINs. Table 3 shows the ones relevant to liquid transportation fuels.

Table 3 RINs Relevant to Liquid Transportation Fuels

Fuel (D Code)	Net RINs Generated
Cellulosic biofuel (D3)	141,309,507
Biomass-based diesel (D4)	2,793,985,198
Advanced biofuel (D5)	146,837,088
Renewable fuel (D6)	14,825,741,926
Cellulosic diesel (D7)	247,785

The EPA shows RINs for 2015 (representing the Btu equivalent of a gallon of ethanol) for “Renewable Fuel” (mostly corn ethanol) at 14,825,741,926 for total “Advanced Biofuel” (mostly sugarcane ethanol imports) at

146,837,008.[8] Of the 142,038,566 cellulosic biofuel (D3) RINs, 139, 857,470 were from renewable natural gas, with the other 2,181,096 (or about 1.5%) being from cellulosic ethanol, and 44,168 were from cellulosic gasoline.[9] Renewable natural gas includes both landfill gas and gas from anaerobic digesters using partial cellulosic feeds.

Biomass-based diesel RINs generated in 2015 totaled 2,793,985,198, of which 2,273,100,834 were for biodiesel and 6,877,749 were for other (non-ester) renewable diesel components. No RINs were generated in 2015 for cellulosic diesel fuel.[10]

Blends of greater than 15% ethanol are marketed in the United States at special dispensers for use only in flex-fuel vehicles (FFVs) designed for use with up to E85. There were an estimated 2,815 stations selling FFV fuel in the United States by December 2015, up from 2,472 in 2014. This includes “blender pumps,” which sell blends for conventional vehicles and a range of blends for FFVs (e.g., E20, E30, and E85). The FFVs using high-ethanol blends have experienced problems with starting and drivability in winter months in some regions. In 2011, American Society for Testing and Materials (ASTM) International revised its Specification D5798-11 (Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines) to allow for blends of down to 51% ethanol to be used as FFV fuel.[11] There is, however, no legal barrier to marketing blends of even lower than 51% for use in FFVs. As noted previously, some marketers are offering lower blends year-round through blender pumps.

In September 2015, the U.S. Department of Agriculture (USDA) announced its Biofuel Infrastructure Partnership (BIP) program to increase availability of higher blends of ethanol. Almost $100 million is directed toward installation of blender pumps under this program.

Natural Gas

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[8] https://www.epa.gov/fuels-registration-reporting-and-compliance-help/2015-renewable-fuel-standard-data.

[9] Ibid.

[10] Ibid.

[11] Of this D3 RIN total, the EPA shows 729,059 RIN correction errors for a corrected total of 141,309,507. It does not show such corrections for the specific fuel types generating RINS, however. Thus the uncorrected number is shown above to illustrate how the specific fuel types compare as shares of the total. See http://www.afdc.energy.gov/fuels/ethanol_locations.html.

The growth of hydraulic fracking in the United States has revolutionized the energy industry, created infrastructure problems, and been the focus of political and economic debate. Natural gas production in the United States has increased steadily in recent years and is projected to continue grow, though at reduced rates of growth (Figure 4).

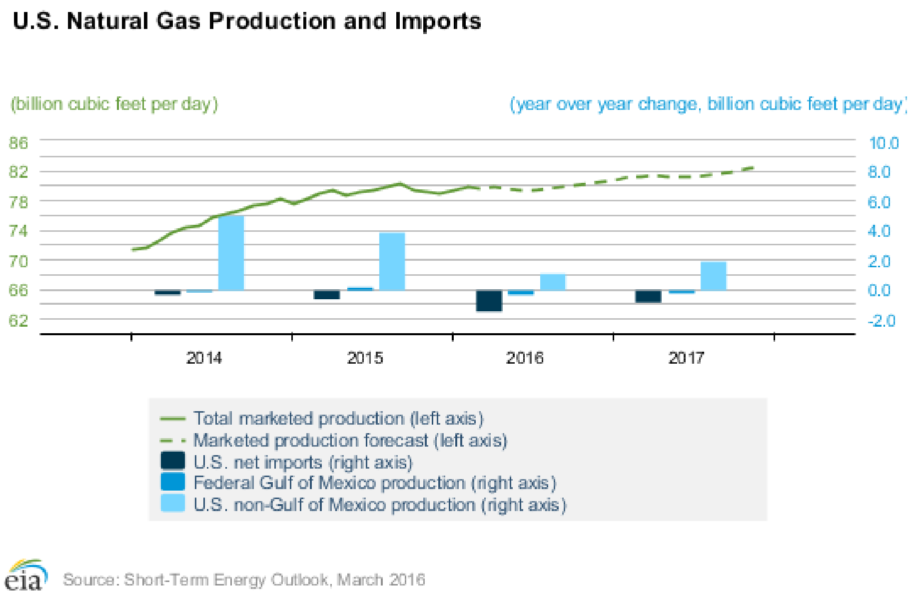

Fig. 4 Natural Gas and Crude Oil Production in the United States, 2014–2017[12]

Use of natural gas for transportation had been expected to grow in the coming decades, mainly in the heavy-duty vehicle sector, but the collapse of oil prices has called those projections into question, at least regarding the rate of such growth. Other problems surrounding the use of natural gas as a motor fuel are mainly infrastructure-related rather than vehicle-related.

In 2011, the EPA revised its regulations governing the conversion of conventional vehicles to alternative fuels, making it easier for conversion systems for natural gas and propane to get approval for vehicles older than 2 years. This revision has resulted in many more AFV conversion systems being registered with the EPA.

Electric Vehicles

[12] EIA, 2015, Short Term Energy Outlook, March 2016, https://www.eia.gov/forecasts/steo/report/natgas.cfm.

Sales of plug-in electric vehicles (EVs) (plug-in hybrids and battery electric models) in 2015 continued to fluctuate on a month-to-month basis but were down slightly overall from 2014, totaling 114,022 compared with 118,773 in 2014. In addition, 384,404 hybrid electric vehicles (non-plug-in) were sold in 2015, down from 452,172 in 2014.[13] Available plug-in models totaled 73 as of the end of March 2016.[14]

Alternative Fuel Infrastructure

Table 4 provides the counts of alternative fuel refueling stations, including private stations, in the United States according to DOE's Alternative Fuels Data Center.[15] Updated information, with a breakdown by state and individual station locations, can also be accessed on the Alternative Fuels Data Center site.

Table 4 Counts for U.S. Alternative Fuel Refueling Stations by Type in 2012–2013, and 2014 (including public and private stations)

Year	B20	CNG	E85	Electric Outlets[a]	H_2	LNG	LPG	Total	Total Non-electric
2012	675	1,107	2,553	13,392	58	59	2,654	20,498	7,106
2013	757	1,263	2,639	19,410	53	81	2,956	27,159	7,749
2014	784	1,489	2,780	25,511	51	102	2,916	33,633	8,122
2015	721	1,563	2,990	30,945	39	111	3,594	39,963	9,018

[a] Numbers for 2012 and 2013 and the first number for 2014 are total number of recharging outlets, not sites.

As can be seen in Table 4, the total number of alternative fueling stations, exclusive of electric recharging stations, in the United States increased by 27% between 2012 and 2015. The total number of public and private nonresidential EV recharging outlets jumped by more than 131% over this

13 See http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952.

14 http://www.afdc.energy.gov/vehicles/electric_availability.html.

15 See http://www.afdc.energy.gov/fuels/stations_counts.html.

same 3-year period, indicating not only an emphasis being placed on vehicle electrification by public and private entities, but the rapid growth in the number of motorists choosing EVs.

Advanced Fuels and Engines

The DOE Vehicle Technologies Office sponsors research in fuels and advanced combustion engines for the purposes of displacing petroleum-derived fuels, matching engines and fuel characteristics better, and increasing engine and vehicle efficiencies. This research covers a very broad range of fuel, engine, and vehicle technologies. The brief summary provided here focuses on fuels and fuel effects and is based on recent DOE annual program reports.[16,17] Fuels can affect combustion and efficiency by altering in-cylinder mixing of fuel and air, enabling a higher compression ratio through high octane, and changing other important properties, such as burning velocity and ignitability.

Much of the research on the benefits of higher octane in the United States for SI engines has centered on ethanol, a readily available, high-octane gasoline component. In one study by Anderson et al.,[18] ethanol blends were found to outperform high-octane gasoline relative to knock-limited spark timing at high loads, thus allowing for both higher loads and improved fuel economy. In several studies,[19] it was also proposed to use ethanol selectively in a vehicle for high-load operation, either through the use of two fuel tanks or onboard separation. These studies reported a significant margin for further engine optimization by spark advance, an increase in the compression ratio, and engine downsizing for blends of ethanol in gasoline from 51% to 85%, such as those used in FFVs.

While high-octane fuel is desirable for traditional SI engines, it might not be ideal for kinetically controlled engines using homogeneous charge compression ignition (HCCI) or premixed charge compression ignition

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[16] DOE Vehicle Technologies Office, 2013, *Fuels and Lubricant Technologies 2012 Annual Progress Report*, DOE/EE-0911, June.

[17] DOE Vehicle Technologies Office, 2012, *Advanced Combustion Engine Research and Development 2012 Annual Progress Report*, DOE/EE-0872, December.

[18] Anderson, J.E., et al., 2012, “High Octane Number Ethanol–Gasoline Blends: Quantifying the Potential Benefits in the United States,” *Fuel* 97:585–594, July, http://www.sciencedirect.com/science/journal/00162361/97.

[19] Blumberg, P.N., et al., 2008, “Simulation of High Efficiency Heavy Duty SI Engines Using Direct Injection of Alcohol for Knock Avoidance,” SAE paper 2008-01-2447, October 6; Partridge, R.D., et al., 2014, “Onboard Gasoline Separation for Improved Vehicle Efficiency,” SAE paper 2014-01-1200, April 1; Moore, W., et al., 2011, “Engine Efficiency Improvements Enabled by Ethanol Fuel Blends in a GDi VVA Flex Fuel Engine,” SAE paper 2011-01-0900, April 12.

(PCCI) combustion. Such engines depend on a combination of fuel volatility and ignitability to allow optimum fuel-air mixing before combustion. Although the research regarding this conclusion is still preliminary, HCCI or PCCI engines will likely not benefit from higher-octane fuels. They may, however, actually benefit from lower-octane fuels that are somewhere between current diesel and gasoline for cetane and octane ratings. The more likely scenario would be HCCI or PCCI engines benefiting from a range of octane and cetane for different operating conditions.

For diesel engines, efficient, dilute combustion can be achieved by delaying ignition in the diesel spray, resulting in a combustion mode described as "lifted flame." Several projects (DOE-Sandia National Laboratories and Ford Motor Company through DOE award under solicitation DE-FOA-0000239) are investigating this strategy, including the use of oxygenated fuel components that could be derived from bio-feedstocks.

Several DOE and industry projects are developing surrogate fuels for new or emerging fuels. Surrogate fuels allow more accurate kinetic modeling of fuel effects, since they are normally built of components for which detailed kinetic mechanisms exist. The development of surrogates also leads to a deeper understanding of the relative importance of fuel properties, chemistry, and molecular structure in engine combustion. This knowledge can then be used to predict performance and optimize fuels and fuel components for emerging fuels.

The DOE Bioenergy Technology Office promotes the development of new fuels from initial concepts, laboratory R&D, and pilot and demonstration plant phases. Research areas include feedstocks, algae, biochemical conversion, and thermochemical conversion for both fuels and high-value chemicals.[20]

The Bioenergy Technologies Office has estimated there is the potential for converting 1 billion tons/year of biomass. Various pricing and yield assumptions predict there is the potential for producing 20 to 70 billion gal/year of advanced biofuels by 2022.[21] Other highlights[22] include demonstrating that cellulosic ethanol is cost-competitive with petroleum, assisting in the support of 25 integrated bio-refineries, and

[20] DOE Bioenergy Technologies Office, 2013, *Peer Review 2013*, May 20–23.

[21] Perlack, R.D., and B.J. Stokes (leads), 2011, *2011 US Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, ORNL/TM-2011/224, Oak Ridge National Laboratory, Oak Ridge, TN, Aug.

[22] DOE Bioenergy Technologies Office, *Bioenergy Successes*, www.eere.energy.gov.

helping support the development of co-processing of pyrolysis oil with petroleum.

Standards for Alternative Fuels

The ASTM published standard specifications for a number of alternative fuels. These include the ones shown in Table 5.

Table 5 ASTM Fuel Specifications

Fuel	Specification No.
Ethanol fuel blends for flexible fuel SI engines (51–83%)	ASTM D-5798-13a
Mid-level ethanol fuel blends for SI engines (16–50%)	ASTM D-7794-12
Biodiesel blends (6–20%)	ASTM D-7467-13
Biodiesel 100% stock for blending	ASTM D-6751-12
Dimethyl ether (for CI engines)	ASTM D-7901-14
Methanol (for SI engines)	ASTM-D5797-13

Outlook

The outlook for all alternatives to petroleum motor fuel has been made uncertain by the 2014 collapse of oil prices. The EIA's Annual Energy Outlook 2015 shows the net ratio of import share of U.S. total crude oil to petroleum product supplied continuing to decline in all scenarios through 2018. Beyond that, it levels off in the reference case and starts rising slightly in the low oil price case, while continuing to decline in the high oil price case (until 2027) and high resource case (indefinitely).[23]

Apart from being affected by lower oil prices, it is expected that ethanol, the principal U.S. alternative fuel, will continue being constrained in 2016 by the challenges associated with blending at levels over 10% in gasoline, as well as concerns over misfueling, compatible systems, and other issues.

[23] http://www.eia.gov/forecasts/aeo/executive_summary.cfm.

Benefits of Participation in the AMF TCP

DOE's Vehicle Technologies Program is an active part of the AMF TCP through the Fuels and Lubricants subprogram. The U.S. Government benefits from participation in several ways. One major way is through its ability to leverage finances and technical expertise on research programs of mutual interest. U.S. Government researchers also benefit from their ability to maintain contacts with international experts and to interact with them in research and policy discussions. Many of the countries participating in the AMF TCP are facing the same fuel-related issues as the United States and are active in international import and export markets for fuels, renewable fuels, and fuel components. Mutual cooperation has proven beneficial in the past and should continue to do so in the future.