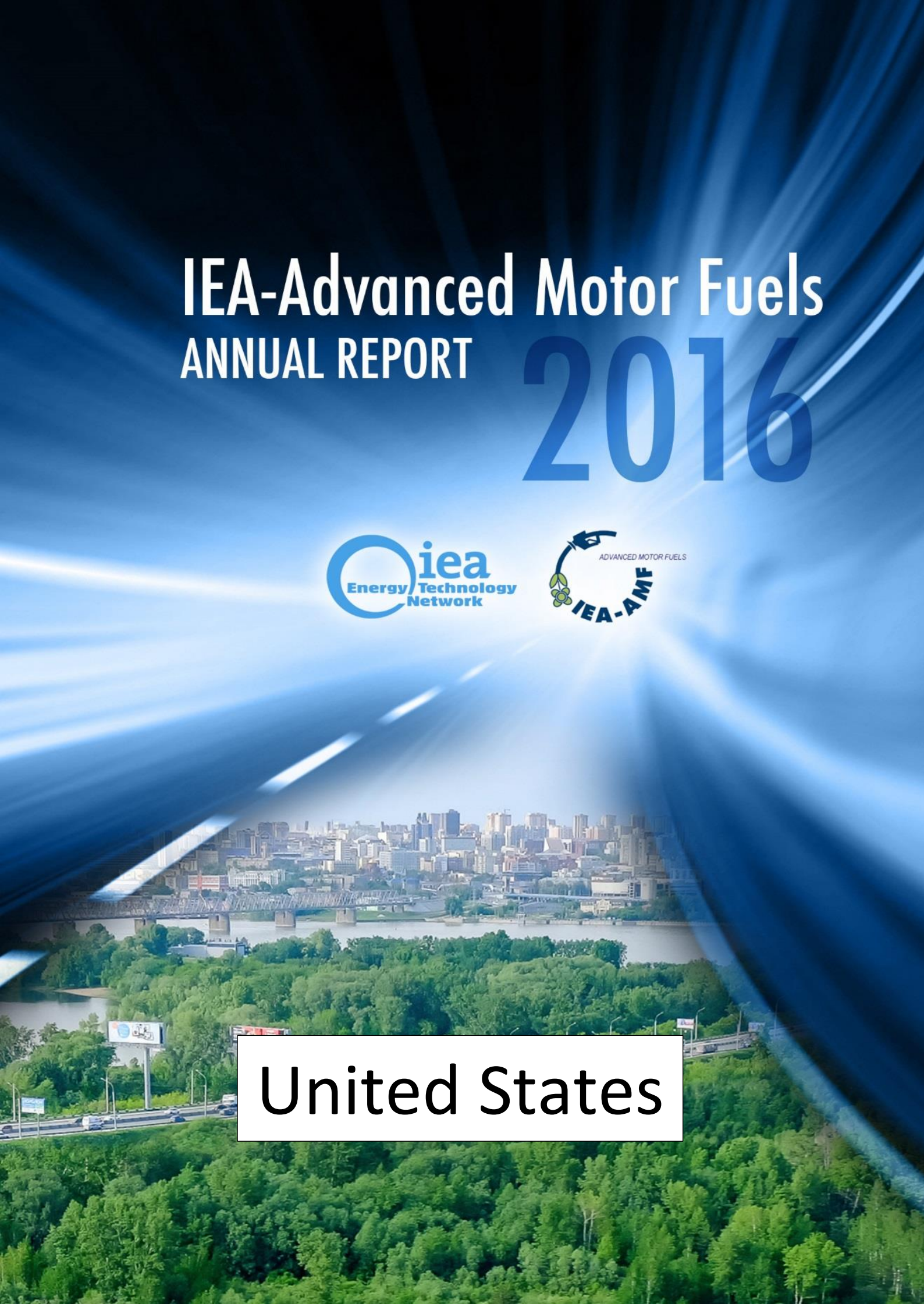
IEA-Advanced Motor Fuels
ANNUAL REPORT 2016



United States

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Drivers and Policies

The Energy Policy Act of 1992 (EPAct) requires that certain centrally fuelled 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.

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 through the use of alternative fuels, hybrid and electric-drive vehicles, idle reduction technologies, smarter driving practices, and improved fuel economy measures. The functioning of Clean Cities has been described in previous AMF annual reports. More information on the Clean Cities Program can be found at www.cleancities.energy.gov.

The most recent data from the Clean Cities Program are for 2015 and show that the program saved 1,079,200,000 gasoline gallons equivalent (gge), of which 640,500,000 gge came from alternative fuels/vehicles (27% increase from last year), 91,900,000 gge from electric and hybrid vehicles (8% increase), and 37,700,000 gge from idle reduction technologies. Of the total, 840,600,000 gge savings were from fleets belonging to Clean Cities coalitions, with the remainder coming from other fleets and vehicle owners utilizing Clean Cities services, resources, and infrastructure funded by Clean Cities. For additional data, see http://www.afdc.energy.gov/uploads/publication/2015_metrics_report.pdf.

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, which was adopted in 2005 and expanded in 2007 (RFS2). It requires increasing the volumes of renewable fuel to be used in motor fuels. On December 12, 2016, the EPA finalized the volume requirements and associated percentage standards under the RFS program for calendar year 2017 for cellulosic biofuel, biomass-based diesel, advanced biofuel, and total renewable fuel. The EPA also finalized the volume requirement for biomass-based diesel for 2018 (see Tables 1 and 2). These volumes were greater than those for 2016 compliance but significantly lower than those originally targeted in the RFS legislation, which envisioned much more robust growth in cellulosic fuel production than has as yet materialized.

The cellulosic biofuel category was created largely with cellulosic ethanol in mind. However, 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/.

Advanced Motor Fuels Statistics

The U.S. Energy Information Administration (EIA) estimated that total U.S. transportation energy consumption for the first 10 months of 2016 would be 23,286 trillion British thermal units (Btu), up from 22,859 trillion Btu for the same period in 2015.[1] More than 90% of this consumption would be petroleum-based fuels (gasoline and diesel), with almost the entire remainder being ethanol blended

[1] *EIA Monthly Energy Review*, p. 29, Table 2.1, Energy Consumption by Sector; p. 37, Table 2.5, Transportation Sector Energy Consumption.

into gasoline at 10%.[2] This biomass would account for 1,182 trillion Btu during these 10 months, natural gas for 605 trillion Btu, and electricity for 21 trillion Btu.[3]

Biofuels

The best data on the use of biofuels in transportation come from the EPA's recording of Renewable Identification Numbers (RINs) filed by refiner/marketers of liquid transportation fuels, as shown in Table 1. Each RIN is equivalent to 1 gallon of ethanol by Btu content; RINs are generated when a motor fuel refiner/blender blends or sells the renewable fuel or fuel blend.

Table 1 2016 RINs Generated

Fuel (D Code)	Net RINs Generated
Cellulosic biofuel (D3)	176,317,538
Biomass-based diesel (D4)	3,992,475,109
Advanced biofuel (D5)	96,920,307
Renewable fuel (D6)	15,145,664,554
Cellulosic diesel (D7)	480,988

Electric Vehicles

Sales of plug-in electric vehicles (EVs) (plug-in hybrids and battery electric models) in 2016 were up strongly overall from 2015, totaling 157,112 compared to 118,773 in 2015. In addition, 346,948 hybrid electric vehicles (non-plug-in) were sold in 2016, down from 384,404 in 2015.[4] Available plug-in models totaled 56 as of February 2017, down from 73 in March 2016.[5]

Alternative Fuel Infrastructure

Table 2 provides the number of alternative fuel refueling stations, including private stations, in the United States according to DOE's Alternative Fuels Data Center.[6]

Table 2 Number of 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
2016	718	1,703	3,147	46,886	59	139	3,658	56,310	9,424

[a] Total number of recharging outlets, not sites.

As can be seen in Table 2, the total number of alternative fueling stations, exclusive of electric recharging stations, in the United States increased by 33% between 2012 and 2016. The total number of public and private nonresidential electric vehicle recharging outlets jumped by more than 350% over this same 4-year period.

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[2] Ibid., p. 155, Table 10.3, Fuel Ethanol Overview.

[3] Liquefied petroleum gas, which the EIA treats as petroleum, accounted for 34 thousand barrels per day (bpd) equivalent average for that period. *EIA Monthly Energy Review*, p. 67, Table 3.7c, Petroleum Consumption: Transportation and Electric Power Sectors.

[4] http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952.

[5] http://www.afdc.energy.gov/vehicles/electric_availability.html. Updated information with a breakdown by state and individual station locations can also be accessed on the Alternative Fuels Data Center site (http://www.afdc.energy.gov/).

[6] See http://www.afdc.energy.gov/fuels/stations_counts.html.

Research and Demonstration Focus

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.[7,8]

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 emissions 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 the use of kinetically controlled and higher reactivity fuels), targeted for commercialization by 2030. Identified metrics include:

- Enable additional 15% fuel efficiency,
- Accelerate deployment of 15 billion gallons/year of advanced biofuels, and
- Enable an additional 9% to 1% fleet GHG reduction by 2040.

The DOE Bioenergy Technology Office promotes the development of new fuels from initial concepts, laboratory research and development (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. For additional information, see the AMF 2015 Annual Report.

Outlook

The EIA's *Annual Energy Outlook 2017* ("reference case") projects decreasing overall transportation energy use from 2018 through 2034 due to mandated increases in fuel efficiency. It projects that battery electric vehicle (BEV) sales will increase from less than 1% to 6% of total light-duty vehicles sold in the United States over 2016 to 2040, and plug-in hybrid electric vehicle (PHEV) sales will increase from less than 1% to 4% over the same period due to falling battery costs. Hydrogen fuel cell vehicle (FCV) sales will grow to approximately 0.6% of sales by 2040. In 2025, projected sales of light-duty battery electric, plug-in hybrid electric, and hydrogen fuel cell vehicles will reach 1.5 million, about 9% of projected total sales of light-duty vehicles. The use of natural gas in medium- and heavy duty-vehicles is also projected to increase its share of total sales.

Additional Information Sources

- Oak Ridge National Laboratory, 2016, Transportation Energy Data Book, October, http://info.ornl.gov/sites/publications/files/Pub44660.pdf
- EIA (Energy Information Administration), 2017, Annual Energy Outlook 2017, https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf
- EIA, 2017, Monthly Energy Review, Energy Information Administration, http://www.eia.gov/totalenergy/data/monthly/

Benefits of Participation in the AMF TCP

DOE's Vehicle Technologies Office is an active participant in the AMF TCP through the Advanced Combustion Systems and Fuels Program. The U.S. Government benefits from participation in several

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

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

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.