IEA-Advanced Motor Fuels
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United States

Drivers and Policies

The Energy Policy Act of 1992 (EPAct) requires certain centrally fueled fleets (federal, state, and alternative fuel provider fleets, such as those used by utility companies) acquire light-duty alternative fuel vehicles (AFVs) as most of their new vehicle acquisitions. AFVs are promoted for their benefits on emission reductions, energy diversification, and low operating costs.

The U.S. Department of Energy (DOE) Technology Integration Program (formerly the Clean Cities Program) is a government-industry partnership 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 most recent data from the Technology Integration Program are for 2018 and show that the program saved 1.06 billion gasoline gallons equivalent (gge), including 744 million gge from alternative fuels/vehicles and 97 million gge from electric and hybrid vehicles.

The transportation sector continues to use a large amount of renewable fuels. The primary driver of renewable fuel use in the U.S. is the Renewable Fuel Standard (RFS), which was adopted in 2005 and expanded in 2007 (RFS2). It requires increasing the volume of renewable fuel to be used in motor fuels. On December 19, 2019, the U.S. Environmental Protection Agency (EPA) finalized the volume requirements and associated percentage standards under the RFS program for calendar year 2020 for cellulosic biofuel, biomass-based diesel, advanced biofuel, and total renewable fuel. The EPA also finalized the volume requirement for biomass-based diesel for 2021.[1] These volumes were slightly higher than those for 2019 compliance. However, the values were significantly lower than those originally targeted in the RFS legislation, which envisioned much more growth in cellulosic fuel production than has materialized. In 2019, the EPA finalized a rule allowing E15 in place of E10 in gasoline year-round and nationwide, which will increase demand by overcoming the so-called blending wall for ethanol in gasoline.[2]

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 rulemakings in

[1] EPA, Final Renewable Fuel Standards for 2020, and the Biomass-Based Diesel Volume for 2021, December.

[2] EPA, 2019, Modifications to Fuel Regulations to Provide Flexibility for E15 June.

2013 and 2014, has dwarfed liquid fuels in that category. Biomass-based diesel is mainly traditional biodiesel, derived from soy, corn oil, canola, 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 starch- and sugar-based ethanol.

The State of California developed the Low-Carbon Fuel Standard (LCFS) to reduce the average carbon intensity of its transportation fuels by 10% from 2010 to 2020. In 2019, California extended the LCFS to 2030 with reduced carbon intensities for transportation fuels by additional 10% reduction. Using life-cycle analysis, different carbon intensities were developed for different fuels, including alternative fuels and biofuels. With both the RFS and LCFS, a significant amount of biofuels—about 1.9 billion gge—were used in California in 2018.

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 2019 was 23,719 trillion British thermal units (Btu), less than 1% lower than the same period in 2018.[3] More than 90% of this consumption is petroleum-based fuels (gasoline and diesel), with most of the remainder being ethanol blended into gasoline at 10%. Biomass accounted for 1,176 trillion Btu during these 10 months, natural gas for 791 trillion Btu, electricity for 22 trillion Btu, and propane for 7 trillion Btu.[4]

Biofuels

The best biofuel use data come from the EPA's recording of Renewable Identification Numbers (RINs) filed by refiner/marketers of liquid transportation fuels, as shown in Figure 1.[5] 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.

[3] *EIA Monthly Energy Review*, January 2020.
[4] Ibid.
[5] EPA, 2020, EPA Moderated Transaction System, February.

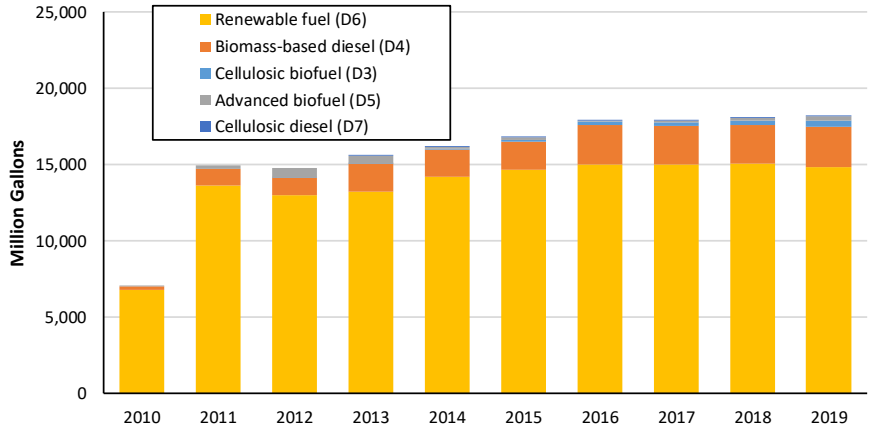

Fig. 1 Renewable Fuel Volumes Resulting from U.S. Renewable Fuel Standard

Electric Vehicles

Sales of plug-in electric hybrids (PHEVs) and battery electric vehicles (BEVs) in 2019, totaling 325,839, were down compared to 361,315 in 2018.[6] In addition, 400,746 hybrid electric vehicles (non-plug in) were sold in 2019, up from 343,285 in 2018.[7] Available plug-in models totaled 125 as of February 2020, up from 85 in February 2019.[8]

Alternative Fuel Infrastructure

The DOE's Alternative Fuels Data Center provides the number of alternative fuel refueling stations in the U.S.[9] As seen in Table 1, the total number of alternative fueling stations in the U.S., exclusive of electric recharging stations, increased by 31% between 2012 and 2019. However, the number of biodiesel (B20) and liquefied petroleum gas (LPG) stations decreased slightly in 2019. The total number of public and private nonresidential electric vehicle recharging outlets jumped by over 550% over this same 7-year period, with a large gain in 2019 as well.

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6 Argonne National Laboratory, 2020, "Light Duty Electric Drive Vehicles Monthly Sales Updates," anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates

7 Ibid.

8 DOE, 2020, Alternative Fuels Data Center, "Availability of Hybrid and Plug-In Electric Vehicles," afdc.energy.gov/vehicles/electric_availability.html

9 DOE, 2020, "Alternative Fueling Station Counts by State," afdc.energy.gov/fuels/stations_counts.html

Table 1 Number of U.S. Alternative Fuel Refueling Stations by Type, 2012 – 2019 (including public and private stations)

Year	B20	CNG	E85	Electric Outlets[a]	H2	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
2017	704	1,671	3,399	53,141	63	136	3,478	62,592	9,451
2018	670	1,574	3,632	67,957	64	114	3,328	77,339	9,382
2019	614	1,583	3,837	87,457	64	116	3,118	96,789	9,332

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

Research and Demonstration Focus

The DOE's Vehicle Technologies Office (VTO) sponsors research in fuels and advanced combustion engines for the purpose 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 summary provided here focuses on fuels and fuel effects and is based on annual program reports.[10,11]

Beginning in 2016, the Co-Optimization of Fuels and Engines, or Co-Optima, initiative was led jointly by DOE's VTO and Bioenergy Technology Office (BETO). The goal of Co-Optima is to identify and evaluate technology options for the introduction of high-performance, sustainable, affordable, and scalable co-optimized fuels and engines. The current Co-Optima program was designed to run for 10 years, including research on the relationship between fuels and engines to achieve optimum efficiency and emissions with consideration of fuel production pathways that can enable commercial introduction. For example, in 2019, researchers identified the top 10 biofuel-derived blendstock candidates to improve turbocharged spark-ignited engine efficiency at a competitive cost, after a comprehensive assessment of more than 400 bio-derived molecules and mixtures across many chemical families. Co-Optima includes both spark

[10] DOE, VTO, 2019, *Advanced Combustion Engines and Fuels 2018 Annual Progress Report*, DOE/EE-1833, April.

[11] DOE, VTO, 2019, *Co-Optimization of Fuels & Engines FY18 Year in Review*, DOE/GO-102019-5150, June.

ignition technologies targeted for commercialization by 2025, and compression ignition technologies targeted for commercialization by 2030. Identified metrics include:

- Enable additional 10% fuel efficiency in light-duty engines.
- Accelerate deployment of 15 billion advanced biofuel gallons/year.
- Enable an additional 9% to 14% fleet GHG reduction by 2040.

The DOE's BETO promotes the development of new fuels from initial concepts, laboratory research and development, and pilot and demonstration plant phases. Research areas include feedstocks, algae, biochemical conversion, and thermochemical conversion for both fuels and high-value chemicals.

Outlook

The EIA's *Annual Energy Outlook 2020* projects decreasing transportation energy use from 2020 through 2038 due to mandated increases in fuel efficiency. However, growth in travel demand will outpace these benefits and energy use will increase from 2039 to 2050.[12] BEV sales will increase from 2% to 11% of total light-duty vehicles sold in the U.S. over 2019 to 2050, due to falling battery costs. In 2050, PHEV and hydrogen fuel cell vehicle (FCV) projected sales are small, at 1.4% and 0.02% of sales, respectively. In 2025, projected sales of light-duty BEVs, PHEVs, and FCVs will reach nearly 700,000, or about 4% 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, 2020, "Transportation Energy Data Book," tedb.ornl.gov/
- DOE, 2020, Federal and State Laws and Incentives, afdc.energy.gov/laws/
- EIA, 2019, *Monthly Energy Review*, Energy Information Administration, eia.gov/totalenergy/data/monthly/
- DOE Technology Integration Program, www.cleancities.energy.gov/
- DOE BETO program, energy.gov/eere/bioenergy/

[12] Energy Information Administration, Annual Energy Outlook 2020, eia.gov/outlooks/aeo/