IEA-Advanced Motor Fuels ANNUAL REPORT 2021

United States

Technology Collaboration Programme
by iea

United States

Drivers and Policies

The Biden Administration seeks to reduce U.S. greenhouse gas (GHG) emissions to net-zero on an economy-wide basis by 2050. Transportation, as the largest contributing sector to U.S. GHG emissions, plays a critical role. At the same time, consumer utility and affordability must be maintained, especially as the administration focuses on the redress of historical inequities. This monumental effort is seen as a vital response to the climate crisis.

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) to 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 and GHGs 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 2019 and show that the program saved 1.0 billion gasoline gallons equivalent (GGE), including 666 million GGE from alternative fuels/vehicles and 74 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 7, 2021, the EPA proposed to retroactively reduce 2020 total renewable fuel volumes from 20.1 billion gallons to 17.1 billion gallons, as the previous value was set before the pandemic.[1] In 2020, U.S. gasoline consumption was 20% lower than in 2019. In addition, the EPA proposed the 2020 and 2022 volumes be set to 18.5 billion gallons and 20.8 billion gallons, respectively. Both the 2020 and 2021 proposed values represent a reduction from the pre-pandemic 2019 volume, 19.9 billion gallons, while the 2022 proposal marks a slight increase. The 2022 proposed value is significantly lower than the original target of 36 billion gallons in the RFS legislation, which envisioned much more robust growth in cellulosic fuel production than has 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 rulemakings in 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 volume of biofuels — about 2.0 billion GGE — was used in California in 2020, although this value was about 6% lower than 2019.

In 2021, the U.S. Congress enacted the Bipartisan Infrastructure Law (BIL)[2]. The law establishes aggressive goals of transportation electrification and decarbonization with significant federal government investments in battery electric vehicles, charging stations, hydrogen fuel cell vehicles, and hydrogen production deployment. Under the law, the federal government will develop partnerships and provide financial assistance through competitive grants to state governments and industry to meet these goals.

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1 EPA, 2021, EPA Proposes Comprehensive Set of Biofuels Program Updates and Improvements, December 7, 2021.
2 The White House, Building a Better America, www.build.gov

Advanced Motor Fuels Statistics

The U.S. Energy Information Administration (EIA) estimated that total U.S. transportation energy consumption for 2021 was 26,935 trillion British thermal units (Btu), 9% higher than the same period in 2020.[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 1,477 trillion Btu during 2021, natural gas for 1,095 trillion Btu, electricity for 66 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. Renewable fuel volumes grew from 16.6 billion gallons in 2020 to 18.0 billion gallons in 2021, as fuel consumption rebounded after the first year of the pandemic.

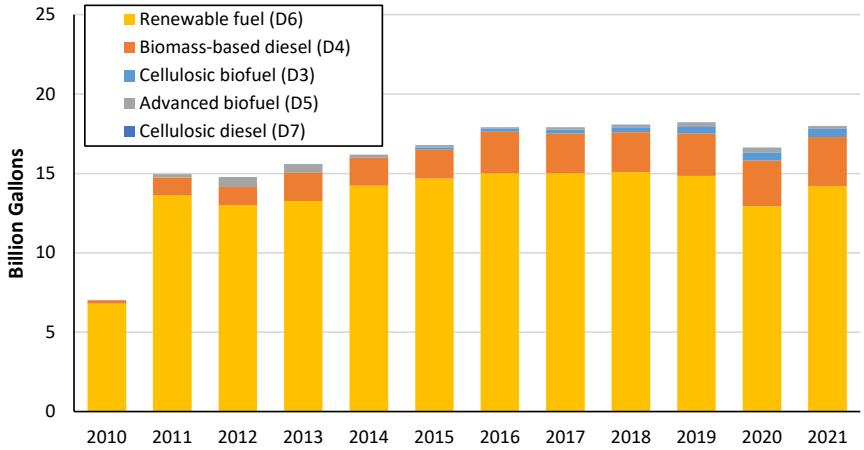

Fig. 1. Renewable Fuel Volumes Resulting from U.S. Renewable Fuel Standard

Electric Vehicles

Sales of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) in 2021, totaling 607,567, resulted in the largest sales year in U.S. history by far. For comparison, sales stagnated at about 320,000 per year from 2018 to 2020.[6] Similarly, hybrid electric vehicles (non-plug in) had record sales in 2021, totaling 800,381, up from 454,890 in 2020.[7] Available plug-in models totaled 185 as of February 2022, up slightly from 129 in February 2021.[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, exclusive of electric recharging stations, the total number of alternative fueling stations in the U.S. increased by 40% between 2012 and 2021. However, the number of compressed natural gas (CNG) and liquefied petroleum gas (LPG) stations decreased slightly in 2021. The total number of public and private nonresidential electric vehicle recharging outlets jumped by over 800% over this same 10-year period, with a 20% gain in 2020 as well.

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3 *EIA Monthly Energy Review*, March 2022.
4 Ibid.
5 EPA, 2022, EPA Moderated Transaction System, February 2022.
6 Argonne National Laboratory, 2022, "Light Duty Electric Drive Vehicles Monthly Sales Updates"
7 Ibid.
8 DOE, 2022, Alternative Fuels Data Center, "Availability of Hybrid and Plug-In Electric Vehicles"
9 DOE, 2022, "Alternative Fueling Station Counts by State"

Table 1. U.S. Alternative Fuel Refueling Stations by Type, 2012–2021 (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
2020	703	1,549	3,949	108,190	64	103	2,967	117,525	9,335
2021	1102	1,506	4,378	130,241	67	103	2,804	140,201	9,960

[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 an annual program report.[10]

Beginning in 2016, the Co-Optimization of Fuels and Engines (Co-Optima) initiative was led jointly by DOE's VTO and Bioenergy Technology Office (BETO). The goal of Co-Optima was to identify and evaluate technology options for the introduction of high-performance, sustainable, affordable, and scalable co-optimized fuels and engines. For example, researchers assessed 14 mixing-controlled compression ignition (MCCI) blendstocks that revealed strong potential for most to meet production and operational cost requirements, while seven demonstrated the ability to cut GHG emissions by more than 60%. Co-Optima included both spark ignition and compression ignition.

Identified metrics include:

- Enable additional 10% fuel efficiency in light-duty engines.
- Reduce criteria pollutant emissions by 50% in heavy-duty engines.
- Accelerate deployment of 15 billion advanced biofuel gallons/year.
- Enable an additional 9% to 14% fleet GHG reduction by 2040.

Research under the Co-Optima initiative concluded in September 2021 with final results to be published over the next several months.

Looking forward, VTO research and development in engines and fuels will focus exclusively on off-road applications, including rail, marine, aviation, and off-road equipment for agriculture, mining, construction, and forestry. While it is recognized that engines will continue to be used in on-road transportation for years, VTO powertrain research for such applications will focus on battery electrification and hydrogen fuel cell powered vehicles.

In addition, BETO will continue to promote 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 aviation and marine fuels and high-value chemicals.

The DOE has begun to make significant investments in sustainable aviation fuels (SAF) to help decarbonize the U.S. aviation sector. The U.S. federal government has established a SAF Grand

[10] DOE, 2021, *Co-Optimization of Fuels & Engines FY20 Year in Review*, DOE/EE-2055, June 2021.

Challenge with a goal of 3 billion gallons of SAF by 2030 and 35 billion gallons by 2050.[11] The DOE, the Department of Transportation, and the Department of Agriculture are leading the grand challenge to develop a comprehensive strategy for scaling up new technologies to produce SAF on a commercial scale.

Outlook

The EIA's *Annual Energy Outlook 2022* projects increasing on-road transportation energy use from 2021 through 2023 as the U.S. rebounds from the pandemic and then decreasing energy use from 2024 to 2037, due to mandated increases in fuel efficiency. However, growth in travel demand will outpace these benefits and energy use will increase from 2038 to 2050.[12] The new GHG emission standard for light-duty vehicles proposed by the EPA will incentivize introduction of efficient vehicle technologies and electrified vehicles including PHEVs, BEVs, and FCEVs. The federal government and the auto industry anticipate electrification of the US LDV fleet by 2050. Low-carbon fuels in internal combustion engines can help decarbonize long-haul trucks, the aviation sector, and the marine sector.

Additional Information Sources

- Oak Ridge National Laboratory, "Transportation Energy Data Book" tedb.ornl.gov/
- DOE, Federal and State Laws and Incentives afdc.energy.gov/laws/
- EIA, *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/

[11] DOE, 2021, www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge
[12] Energy Information Administration, Annual Energy Outlook 2021, eia.gov/outlooks/aeo/