RENEWABLE HYDROCARBON BIOFUELS

Renewable hydrocarbon biofuels (also called “green” or “drop-in” biofuels) are biofuels that are produced from biomass sources through a variety of biological, thermal, and chemical processes that yield fuel mixtures that are chemically identical to gasoline, diesel, jet fuel, propane, and natural gas derived from fossil fuels. Most are approved by the ASTM (an international technical standards organization) for use in the same (i.e., existing) applications as their identical fossil fuel-based versions.

Feedstocks for renewable hydrocarbon biofuels can include lipids (e.g., vegetable oils, animal fats, greases, algae) or cellulosic material (e.g., crop residues, woody biomass, and dedicated energy crops). Production methods include: traditional hydrotreating (reacting the feedstock with hydrogen under high temperatures and pressure); biological sugar upgrading (a biochemical deconstruction process in which organisms convert sugars to hydrocarbons); catalytic conversion of sugars (in which carbohydrates are converted to hydrocarbon fuels through a series of catalytic reactions); gasification (in which biomass is thermally converted to syngas and catalytically converted to hydrocarbon fuels); pyrolysis (in which biomass is chemically decomposed at high temperatures in the absence of oxygen to produce pyrolysis oil, which can then be upgraded to hydrocarbon fuels); and hydrothermal processing (in which biomass or wet waste materials are chemically decomposed at moderate temperatures and high pressures to produce an oil that can be catalytically upgraded into hydrocarbon fuels). Types of renewable hydrocarbon biofuels include renewable diesel, renewable gasoline, renewable natural gas, renewable propane, and sustainable aviation fuel.

Renewable diesel (not the same as biodiesel) is commercially produced at five plants in the U.S., but production capacity is set to expand from a combined capacity of 550 million gallons to a combined capacity of 2 billion gallons with the expansion of three plants and construction of eight new plants in the coming years. Nearly all renewable diesel is consumed within California, where a Low Carbon Fuel Standard incentivizes adoption of alternative fuels. Renewable diesel meets ASTM D975 (“Standard specification for diesel fuel”).

Renewable gasoline (also known as “biogasoline” or “green gasoline”) is a biomass-derived transportation fuel that meets ASTM D4814 (“Standard specification for automotive spark-ignition engine fuel”) and can be used in spark-ignition vehicles.

Renewable natural gas (also called “biomethane”), is chemically identical to fossil natural gas, but it yields fewer lifecycle emissions. Renewable natural gas can be blended with fossil natural gas. [1]

[1] DOE Alternative Fuels Data Center. “Natural gas vehicle emissions.” https://afdc.energy.gov/vehicles/natural_gas_emissions.html

Renewable propane is chemically identical to propane and is produced from biomass-based feedstocks, including used cooking oil, animal fats, or 20% dimethyl ether. Renewable propane is currently produced in biodiesel refineries.[2]

Sustainable aviation fuel (SAF) is synthesized from biomass and can be blended with conventional fuels to be used in existing aircraft. It has been in use at the Los Angeles airport since 2016 and at the San Francisco airport since 2020. Only one processing facility exists in the U.S., located in Los Angeles, but several more are under construction. There are seven technological pathways for synthesizing SAF that are approved under ASTM D7566 ("Standard specification for aviation turbine fuel containing synthesized hydrocarbons"). When blended with conventional aviation fuel, they meet ASTM D1655 ("Standard specification for aviation turbine fuels"), which allows them to be used in existing aircraft.

- Fischer-Tropsch (FT) hydroprocessed synthesized paraffinic kerosene (SPK) fuel using solid biomass resources (e.g., wood residues) (FT-SPK); maximum blend level 50%
- Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids (HEFA) fuel derived from used cooking oil, animal fats, algae, and vegetable oils (e.g., camelina) (HEFA-SPK); maximum blend level 50%
- Synthesized isoparaffin fuel from hydroprocessed fermented sugars (SIP), formerly known as direct-sugar-to-hydrocarbon fuel (HFS-SIP); maximum blend level 10%
- FT-SPK with aromatics fuel using solid biomass resources (e.g., wood residues) (FT-SPK/A); maximum blend level 50%
- Alcohol-to-jet SPK fuel produced from isobutanol or ethanol (ATJ-SPK); maximum blend level 50%
- Catalytic hydrothermolysis (or hydrothermal liquefaction) jet fuel derived from fats, oils, and greases (CHJ); maximum blend level 50%.
- HEFA with hydrocarbons (HC-HEFA) produced from esters and fatty acids at 10% maximum blend concentration.

Advantages of renewable hydrocarbon fuels include that they meet standards for use in existing vehicle and aircraft engines, they can be produced domestically from a variety of feedstocks, and they create fewer emissions than equivalent fossil-based fuels because plant-based feedstocks capture CO_2 while growing. They also have high degrees of flexibility, because they can be created from multiple different feedstocks through a variety of different processes.

- Fishery friendliness: Biofuel feedstock cultivation has a number of potential environmental impacts that may impact marine and aquatic resources. Potential impacts of terrestrial production include deforestation and runoff of nutrients, pesticides, and sediments. Potential impacts of marine production include spatial displacement of fishing activities and impacts to carbon cycling and food webs. Fishery-friendly impacts may also occur: for example, kelp can help buffer ocean water pH against acidification and provide habitat and refuge for marine organisms.

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[2] DOE Alternative Fuels Data Center. "Propane production and distribution." https://afdc.energy.gov/fuels/propane_production.html

- Co-benefits: When produced from waste products, such as recycled restaurant grease, wood chips, or algae grown in wastewater, biofuels can help repurpose a waste stream into a useful product.
- Environmental externalities: Production of biofuel feedstocks has a significant potential for environmental externalities that should be considered and guarded against. Potential impacts of terrestrial production include displacement of human food crops (with consequent increases in food prices), deforestation, and runoff of nutrients, pesticides, and sediments. Potential impacts of marine production include mammal entanglements and impacts to carbon cycling and food webs. Potential positive impacts may occur as well: for instance, kelp can help buffer ocean water pH against acidification and provide habitat and refuge for marine organisms.
- Policy catalysts: Production of biofuels can be promoted through grants, cash awards, tax credits, subsidies, and loans to promote biofuel research and development. Use and production of biofuels can be promoted through fuel economy or low-carbon fuels standards and carbon pricing.

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