OTHER ALTERNATIVE FUELS

In addition to ethanol, biodiesel, and renewable hydrocarbon fuels, there are several other alternative fuels that may provide pieces of the puzzle to a lower-carbon transportation future. These include established alternative fuels, such as natural gas and propane, and emerging fuels, such as biobutanol, dimethyl ether, methanol, and P-series fuels.

Natural gas is a fossil fuel, and its use as a transportation fuel emits GHGs and other tailpipe pollutants. However, these emissions are generally lower than for equivalent petroleum-based fuels. How much lower depends on upstream and vehicle methane leakage. GHG emissions can be further reduced by blending fossil natural gas with biomass-based renewable natural gas (see "Renewable hydrocarbon fuels"). Natural gas currently powers 175,000 vehicles in the U.S. Most of these vehicles are part of centrally-fueled fleets such as delivery trucks. Natural gas is also common as a fuel for forklifts and commercial lawn equipment.[1]

Propane is the world's third most common transportation fuel, behind gasoline and diesel. Also known as "liquified petroleum gas" (LPG), propane is a clean-burning fuel that is produced as a byproduct of natural gas processing and crude oil refining. GHG emissions can be further reduced by blending fossil propane with biomass-based renewable propane (see "Renewable hydrocarbon fuels"). Propane can be distributed using the existing infrastructure of pipelines and pressurized tank trucks, and the U.S. is a net exporter of propane. Propane can power light, medium, and heavy-duty vehicles, and while these vehicles are generally more expensive than gasoline-powered vehicles, the lower costs of propane relative to gasoline can enable a quick return on investment. These cost savings are less significant when propane is used in place of diesel.[2]

Biobutanol is an emerging fuel that is produced from the same feedstocks as ethanol, such as corn grain and other biomass. Biobutanol has several benefits over ethanol as a gasoline substitute/additive: it has a higher energy content (although still about 10-20% lower than gasoline); it has lower volatility and evaporative emissions; and it is immiscible with water, meaning that it can be transported in pipelines to reduce transport costs.[3]

Dimethyl ether (DME) is an emerging synthetically produced alternative to diesel for use in specially designed compression ignition diesel engines. Under normal atmospheric conditions, DME is a gas that is also used in the chemical industry and as an aerosol propellant. Like propane, DME must be kept in pressurized storage containers in order to remain at liquid form. DME can be produced from biomass, methanol, and fossil fuels (e.g., synthesis gas from natural gas or coal). DME has several benefits for use in diesel engines: it is very ignitable, has energy efficiency and power ratings equal to those of diesel, and has virtually no participate emissions.

[1] DOE Alternative Fuels Data Center. "Natural gas." https://afdc.energy.gov/fuels/natural_gas.html
[2] DOE Alternative Fuels Data Center. "Propane." https://afdc.energy.gov/fuels/propane.html
[3] DOE Alternative Fuels Data Center. "Biobutanol." https://afdc.energy.gov/fuels/emerging_biobutanol.html

One downside is that it has about half the energy content of diesel, meaning that a vehicle can only travel half as far on the same amount of fuel. DME is not yet produced commercially in the U.S.[4]

Methanol, also called wood alcohol, can be used as fuel in ways that are similar to ethanol. Methanol is produced using steam reformatting of natural gas to produce synthesis gas, which is then reacted with a catalyst to produce methanol and water vapor. Methanol can be produced from a variety of feedstocks, but natural gas is the most economical one. Methanol was commercially produced in the 1990s as an alternative fuel, and at its peak, nearly 6 million gasoline gallon equivalents of methanol were used annually in the U.S. However, it is no longer in commercial use.[5]

P-series fuels are a category of emerging alternative fuel that consist of blends of byproducts from natural gas (called "pentanes-plus") with ethanol and biomass. P-series fuels can be produced in part from municipal solid waste, and since the feedstock is chemically digested rather than incinerated, using waste in this way does not release any toxic air pollutants. P-series fuels are substitutable for gasoline in flexible-fuel vehicles, which are designed to operate on alcohol, gasoline, or on any mixture of the two. Flexible fuel vehicles are already in commercial production in the U.S., with 3 million produced since 1996. Although existing flexible-fuel vehicles have not been specifically approved for use with P-series fuels, trials have shown that fueling them with P-series is highly effective. P-series fuels release fewer GHG emissions and conventional air pollutants than gasoline. Although P-series fuels are very new, evidence suggests that they may be more affordable than gasoline on a volumetric basis; however, due to the lower energy density of P-series, their fuel mileage is about 10% than gasoline.[6]

- Fishery friendliness: The alternative fuels that have been reviewed in this section vary widely in terms of feedstocks, production processes, emissions, and environmental impacts. For those that use fossil fuels as a feedstock, potential negative impacts include GHG emissions, mining and extraction, methane leakage, and air pollution. For those produced from biomass, potential negative impacts include deforestation and runoff of nutrients, pesticides, and sediments, or when produced in the marine environment, spatial displacement of fishing activities and impacts to carbon cycling and food webs.
- Co-benefits: Most of the fuels that have been reviewed in this section are cleaner burning than gasoline or diesel, and some make use of byproducts or waste streams to generate efficiencies.
- Environmental externalities: The alternative fuels that have been reviewed in this section vary widely in terms of feedstocks, production processes, emissions, and environmental impacts. For those that use fossil fuels as a feedstock, potential negative impacts include GHG emissions, mining and extraction, methane leakage, and air

[4] DOE Alternative Fuels Data Center. "Dimethyl ether." https://afdc.energy.gov/fuels/emerging_dme.html
[5] DOE Alternative Fuels Data Center. "Methanol." https://afdc.energy.gov/fuels/emerging_methanol.html
[6] Institute for the Analysis of Global Security. "P-series fuels." http://www.iags.org/pseries.htm

pollution. For those produced from biomass, potential negative impacts include deforestation and runoff of nutrients, pesticides, and sediments, or when produced in the marine environment, mammal entanglements and impacts to carbon cycling and food webs.

- Policy catalysts: Production of alternate fuels 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.
- More information:
    - DOE Alternative Fuels Data Center: "Dimethyl ether."
    - DOE Alternative Fuels Data Center: "Biobutanol"
    - DOE Alternative Fuels Data Center: "Methanol."
    - Institute for the Analysis of Global Security: "P-series fuels."

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