U.S. DEPARTMENT OF
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Propane Basics

Propane powers nearly 60,000 vehicles in the United States.[1] Fleets around the United States have successfully implemented propane vehicles in many types of applications, including school buses, shuttle buses, step vans, and law enforcement vehicles. Propane is also frequently used in off-road applications, such as forklifts, commercial landscape mowers and equipment, and other farm equipment. The advantages of propane include its domestic availability, performance, and emissions benefits.

What is propane?

Also known as liquefied petroleum gas (LPG), propane is an odorless hydrocarbon (C_3H_8) gas at normal pressures and temperatures. It is the same propane used for residential heating, cooking, and grills. Propane that is marketed and sold exclusively for use in motor vehicles is sometimes branded as Autogas, to reflect that it is measured, taxed, and dispensed as a vehicle fuel. But it is virtually identical to conventional propane. When pressurized in a tank to 150 pounds per square inch, it becomes a liquid with an energy density 270 times greater than that of its gaseous form.

Propane is a popular choice for many fleet vehicle applications, including school, shuttle, paratransit, and transit buses as well as delivery trucks, vans, taxis, law enforcement vehicles, and vocational trucks. *Photo by Propane Education & Research Council.*

How is propane produced and distributed?

Propane is a byproduct of natural gas processing and crude oil refining. As of 2020, more than 93% of the U.S. propane supply was produced in North America.[2] Propane is shipped from its point of production to bulk distribution terminals via pipeline, railroad, barge, truck, or tanker. Propane marketers then purchase propane at terminals and distribute the fuel to customers, including retail or private fueling stations.

Chemically identical to conventional propane, renewable propane is produced from biomass-based feedstocks, including used cooking oil, animal fats, or 20% dimethyl ether. Renewable propane is currently produced in limited quantities at biodiesel refineries.

Is propane safe for vehicle use?

Just like conventional vehicles, propane vehicles must comply with all applicable regulations, including Federal Motor Vehicle Safety Standards (FMVSS). Compared to gasoline and diesel, however, propane has a higher autoignition temperature, so it takes significantly more heat for the fuel to ignite without a flame or spark. Propane tanks are also 20 times more puncture-resistant than gasoline tanks. Propane vehicle tanks are equipped with pressure relief devices that release fuel in a controlled manner in the event of overfilling, heat expansion, or fire. The National Fire Protection Association (NFPA), U.S. Department of Transportation, and other organizations provide safety guidelines for propane vehicles, as well as propane fueling equipment.[3] A list of applicable codes and standards is available on the Alternative Fuels Data Center (AFDC) website (afdc.energy.gov/pdfs/48612.pdf), and the Propane Education & Research Council (PERC) provides training on vehicle maintenance[4] and fuel dispensing.[5]

Fleets implementing propane vehicles should consider maintenance facility modifications. These may be required based on several factors, including the degree of repair work done in the facility and the facility's physical configuration and layout. Fleet managers should also be aware of the applicable codes and engage their local Authority Having Jurisdiction

[1] Propane Education and Research Council. 2021. (propane.com)

[2] EIA U.S. Propane Production by Source, 2008-2019 (eia.gov/energyexplained/hydrocarbon-gas-liquids/where-do-hydrocarbon-gas-liquids-come-from-in-depth.php) and EIA U.S. Imports of Propane (eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MPAIM_NUS-Z00_2&f=A)

[3] National Fire Protection Association, NFPA 58, (nfpa.org/codes-and-standards)

[4] Propane Autogas Technician Training (propane.com/safety/safety-articles/propane-autogas-technician-training)

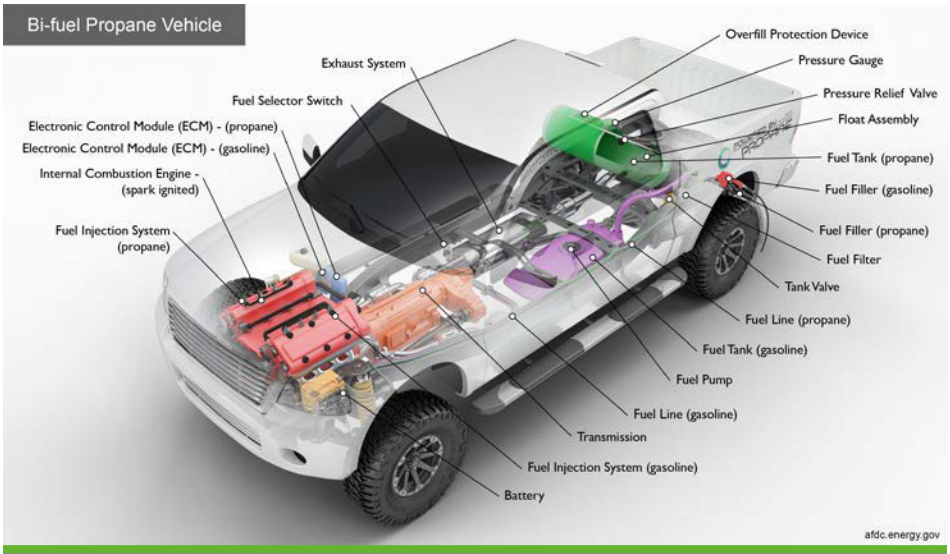
[5] Dispensing Propane Autogas Training Program (propane.com/safety/safety-articles/dispensing-propane-autogas-training-program)

(AHJ) regarding such modifications. The AHJ will also have information about any local requirements regarding the use or storage of gaseous fuels in underground parking garages or maintenance facilities. The PERC website includes informational videos that cover these topics.[6]

How do propane vehicles work?

Propane vehicles have been widely used and refined for decades.

- **Operation.** Propane vehicles operate much like gasoline vehicles with spark-ignited engines. There are two types of propane fuel-injection systems available: vapor and liquid injection. In both types, propane is stored as a liquid in a relatively low-pressure tank. The liquid injection technology allows more precise control of the fuel delivery, resulting in improved engine performance and efficiency.
- **Performance.** A propane vehicle's power, acceleration, and cruising speed are similar to those of a conventionally fueled vehicle. Bi-fuel vehicles have two separate fueling systems, enabling the vehicle to run on either propane or gasoline. This provides the flexibility of using either fuel, which typically provides bi-fuel vehicles a greater range than dedicated propane or gasoline vehicles. Extra storage tanks can increase range, but the tank size and additional weight affect payload capacity. Because a gallon of propane has 27% less energy than a gallon of gasoline, the fuel economy of propane vehicles is slightly lower. However, propane has a higher pump octane number than gasoline (104–112 compared to 87–92 for gasoline[7]) and some original equipment manufacturers (OEMs) offer dedicated engines optimized to take advantage of this higher rating. This can result in improved performance and fuel economy over non-optimized engines.



This illustration of a bi-fuel vehicle highlights both the propane and gasoline fuel system components. *Photo from AFDC.*

What propane vehicles are available?

Light-, medium-, and heavy-duty propane vehicles are available for various applications in either dedicated or bi-fuel configuration. Buyers can purchase vehicles through OEM dealerships or have existing in-service vehicles converted to propane.

Certain OEMs also offer propane "prep packages," which allow a qualified system retrofitter or vehicle modifier (QSR or QVM) to install a propane fuel delivery system before the vehicle is delivered to the customer.

To find available propane vehicles and engines, see the AFDC's Vehicle Search at afdc.energy.gov/afdc/vehicles/search.

How can I find reliable and approved propane conversions?

Conversion systems must be compliant with all safety and emissions regulations for the states or regions where the vehicle is intended to operate (e.g., emissions certified as compliant in accordance with U.S. Environmental Protection Agency (EPA) or California Air Resources Board (CARB) regulations for applicable states, and FMVSS for the appropriate vehicle weight classification). For a list of EPA compliant propane conversion systems and engines, see the EPA website at epa.gov/vehicle-and-engine-certification/lists-epa-compliant-alternative-fuel-conversion-systems.

Note that the list is not necessarily comprehensive. EPA adds conversion systems upon request of the system's manufacturer and advises checking the list periodically for updates. Customers should ask to verify a manufacturer's EPA or CARB certificate.

System manufacturers may perform the conversion themselves or work closely with a QSR/QVM, also referred to as an "upfitter" or "installer." A well-qualified QSR/QVM will have established procedures, best practices, and technical training for the installation process. It is important to understand these and review documentation on conversion practices, procedures, and training when considering any conversion equipment and services. For more information, consult the AFDC Propane Vehicle Conversions page (afdc.energy.gov/vehicles/propane_conversions.html) or *What Fleets Need to Know About*

[6] Fleet Garaging Requirements (propane.com/safety/safety-articles/fleet-garaging-requirements)

[7] AFDC Fuel Properties Comparison (afdc.energy.gov/fuels/fuel_properties.php)

Alternative Fuel Vehicle Conversions, Retrofits, and Repowers (afdc.energy.gov/files/u/publication/afv_conversions_retrofits_repowers.pdf).

Clean Cities coordinators can help prepare vehicle specification and locate reliable providers to ensure a quality installation. Clean Cities also provides technical assistance to help fleets ensure quality control for converted vehicles.

How much do propane vehicles cost?

While the initial purchase price of propane vehicles may be several thousand more than that of comparable conventional vehicles, propane vehicles can provide an acceptable return on investment. A light-duty conversion may cost several thousand dollars, while a new propane vehicle may have incremental costs greater than $10,000. However, propane school buses are close to cost parody with comparable conventional diesel buses. Fleet managers should also consider costs for fueling infrastructure if they do not currently have access to propane fueling sites (see station map image), as well as the potential cost of any upgrades that may be required to their maintenance facilities.

Today, many states offer incentives and tax credits that reduce the cost of propane vehicles and infrastructure, and shorten the payback period. For the latest information on these types of incentives and tax credits, visit the AFDC's Federal and State Laws and Incentives section at afdc.energy.gov/laws. Also contact your Clean Cities coordinator to learn about other local incentives and tax credits that may be available.

Thanks to typically lower fuel costs, particularly for fleets that negotiate fuel contracts, the upfront cost of vehicles and infrastructure can be recovered relatively quickly because of the lower cost per mile to operate vehicles. For help determining return on investment, the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool (greet.es.anl.gov/afleet) helps estimate petroleum use, emissions, and cost of ownership of light- and heavy-duty vehicles for a variety of fuels.

Lower maintenance costs are also often reported, particularly for high-mileage vehicles. Also, propane's low-carbon and low oil-contamination characteristics may result in longer engine life.[8]

Is it easy to fuel a propane vehicle?

Fueling a propane vehicle is similar to fueling a conventional vehicle and takes about the same amount of time. There are minimal concerns around spillage and ground contamination because the fuel is dispensed through a sealed fueling connector and hose assembly. As with all vehicles, however, individuals should recognize proper safety precautions—such as not smoking—when fueling.

The "Type K15" quick-release nozzle improved the fueling experience by allowing one-handed fueling and not requiring the use of personal protective equipment such as gloves and face shield, which are required for the older ACME connector. The K15 also substantially limits fugitive emissions compared to other connectors. NFPA 58 requires all new vehicles to be equipped with the quick-release "Type K15" connector beginning on January 1, 2020.[3] For vehicles with the ACME connector, there is an adapter for the Type K15 nozzle.

Fueling a propane vehicle is similar to fueling a conventional vehicle and takes about the same amount of time. Some attendant training is required, however. *Photo by Werner Slocum, NREL 57379.*

Because some training is required, propane may only be dispensed at public stations by a qualified attendant (similar to a full-service gasoline or diesel pump). Likewise, drivers or attendants will need some training to operate private pumps.

Thousands of fueling stations across the country provide propane. To map propane stations near a specific address or city, use the Alternative Fueling Station Locator (afdc.energy.gov/locator/stations). *Source: AFDC Alternative Fueling Station Locator Data.*

[8] AFDC, Propane Vehicles (afdc.energy.gov/vehicles/propane.html)

How much does propane fuel cost and where is it available?

Propane can be priced lower than gasoline or diesel fuel. However, fleet managers should carefully consider their options when establishing private fueling or using public sites. To find stations in your area, visit the Alternative Fueling Station Locator or download the mobile app from the AFDC website at afdc.energy.gov/stations. The Station Locator includes both public and private stations.

- **Public fueling stations.** There are more than 2,600 public propane stations in the United States. The Station Locator tool allows users to search for public and private propane fueling stations and defaults to showing only public "primary" stations. Primary stations must be staffed during regular business hours, must not require drivers to call ahead to fuel, must accept credit cards as a payment type, and must be able to fuel vehicles at a rate of 8–12 gallons per minute or faster, or at a rate similar to filling a gasoline vehicle. Users may expand their search to include all propane stations by using the "include stations with limited fueling" checkbox. To obtain the best fuel price at public fueling stations, fleet managers should negotiate competitive pricing. Using stations without such an agreement may result in paying higher prices.
- **Private fueling stations.** The price of propane is typically based on the volume that a fleet uses. Local propane marketers are present in most every community across the United States. In addition to providing fuel, they can provide expertise in establishing private fueling infrastructure. A local Clean Cities coordinator can also provide assistance for establishing infrastructure. It's important to consult with a number of local fuel providers and establish a fuel contract that secures fuel at a fixed cost, regardless of seasonal commodity price or supply fluctuations.

This Colorado school district started with one 1,000-gallon storage tank and later expanded its capacity by adding a second tank. *Photo by Dennis Schroeder, NREL 31321.*

For current information on retail fuel prices, refer to the Clean Cities Alternative Fuel Price Report (afdc.energy.gov/fuels/prices.html). This report provides regional average retail prices for both public and private stations, so it can potentially serve as a barometer on retail fuel pricing in your area.

How much does it cost to install a propane fueling station?

Propane fueling infrastructure is very similar to that of gasoline and diesel. The fuel is stored onsite, typically in aboveground tanks ranging from 1,000 to 30,000 gallons.[9]

The cost of establishing propane infrastructure can be as low as $40,000, depending on the size and number of storage tanks and dispensers, whether infrastructure is already in place (e.g., electricity lines), and payment system requirements.[9]

However, local propane marketers often provide new fueling infrastructure at little or no cost for customers under a fuel supply contract. Note that all infrastructure must comply with local codes and standards, and it's important to involve the local AHJ early in the process. Infrastructure costs are documented in the report, *Costs Associated with Propane Vehicle Fueling Infrastructure.*[9]

How do propane vehicle emissions compare with those of gasoline vehicles?

Tailpipe emissions from propane vehicles are often comparable or even lower than those of conventionally fueled vehicles with modern emissions controls, depending on vehicle type, drive cycle, and engine calibration. Based on calculations from Argonne National Laboratory's AFLEET tool, for example, school buses running on propane can reduce nitrogen oxides (NO_x) emissions by nearly half compared to diesel vehicles. Vehicles with near-zero NO_x engines can enable even larger reductions. When considering a wells-to-wheels emissions analysis, propane use reduces GHG emissions by nearly 13% compared to gasoline vehicles. For renewable propane, life cycle GHG emissions are approximately half of conventional propane, according to estimates from the Propane Education & Research Council (PERC).

Where can I learn more about propane?

To learn more about propane as a transportation fuel, visit the AFDC's Propane Fuels and Vehicles section (afdc.energy.gov/fuels/propane.html), contact your local Clean Cities coordinator (cleancities.energy.gov/coalitions.html), or visit the PERC website (propane.com). For case studies and successful stories about propane vehicles, see the AFDC Case Studies page (afdc.energy.gov/case). ■

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For more information, visit:
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[9] Costs Associated with Propane Vehicle Fueling Infrastructure. 2014. (afdc.energy.gov/files/u/publication/propane_costs.pdf)