

Propane Basics

Propane powers more than 143,000 vehicles in the United States and 23 million worldwide.^{1,2}

Fleets around the United States have successfully implemented propane vehicles in many types of applications, including school, shuttle, and transit buses as well as vans, taxis, law enforcement vehicles, street sweepers, and vocational trucks. 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 (C₃H₈) gas at normal pressures and temperatures. It is the same propane used for residential heating, cooking, and grills. 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.

How is propane produced and distributed?

Propane is a byproduct of natural gas processing and crude oil refining. As of 2014, more than 99% of the U.S. propane supply was produced in North America.³ 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.

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



An officer from the Sandy Springs Police Department in Georgia refuels a converted Crown Victoria cruiser. The Sandy Springs fleet has operated on propane 96% of the time since 2011. Photo courtesy of the Propane Education & Research Council (PERC), NREL 35256

temperature (the point at which a gas or vapor can ignite in air without a spark or flame being present), making unintentional autoignition less likely. 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.⁴ A list of applicable codes and standards is available on the Alternative Fuels Data Center (AFDC) website (afd.energy.gov/pdfs/48612.pdf).

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 (AHJ) regarding such modifications. The AHJ will also have

information about any local restrictions regarding the use or storage of gaseous fuels in underground parking garages or maintenance facilities.

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.

¹ U.S. Energy Information Administration, *Annual Energy Review 2011* (eia.gov/totalenergy/data/annual/)

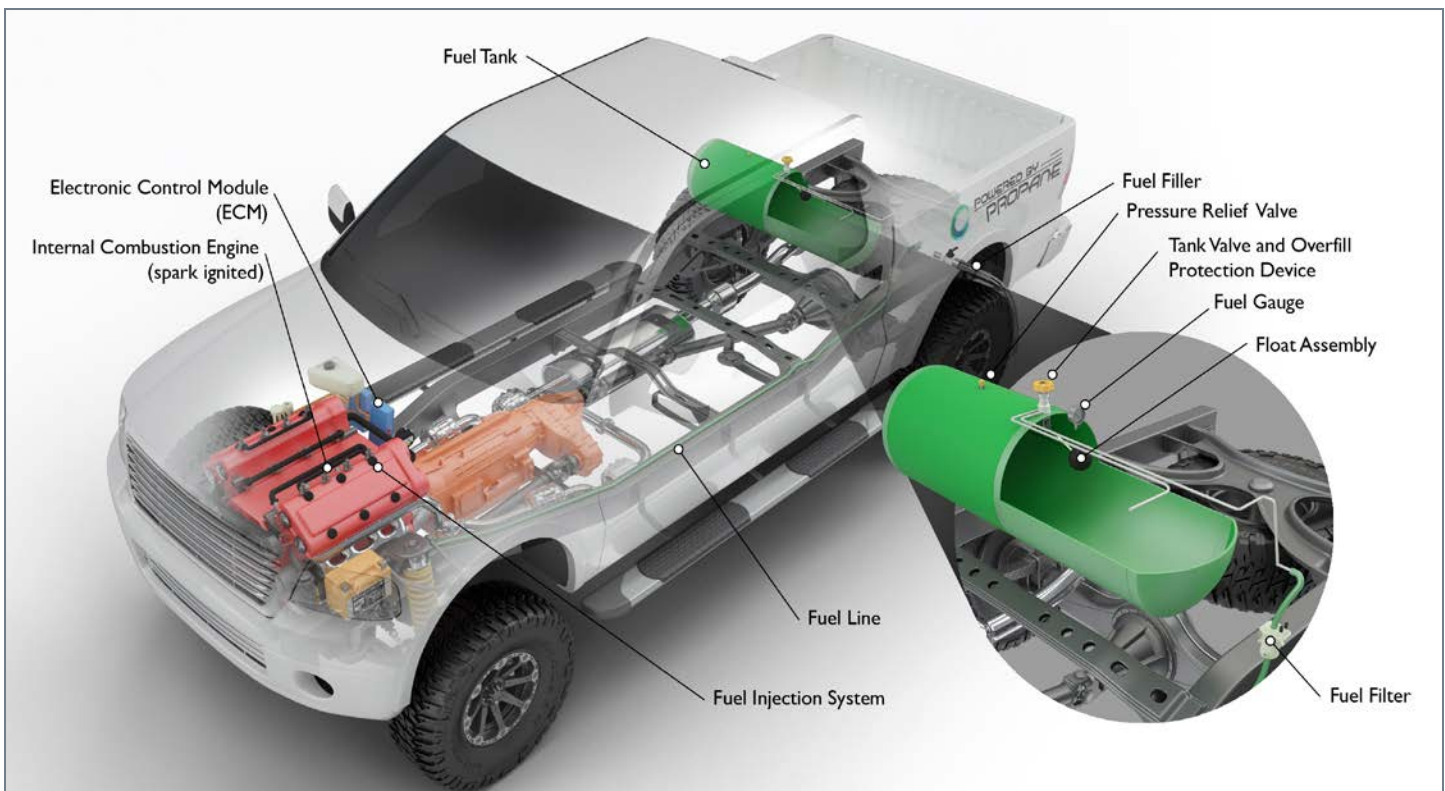
² World LP Gas Association (auto-gas.net/about-autogas/the-autogas-market#U6RsOpRdXwx)

³ ICF International for the Propane Education & Research Council (PERC), *2016 Propane Market Outlook* (afd.energy.gov/uploads/publication/2016_propane_market_outlook.pdf)

⁴ National Fire Protection Association, *NFPA 58*, (nfpa.org/codes-and-standards)



U.S. Department of Energy



This illustration of a dedicated propane-powered vehicle highlights the vehicle's unique fuel system components.

Illustration by Josh Bauer, National Renewable Energy Laboratory

- Performance.** Propane vehicles are similar to their gasoline counterparts with regard to power, acceleration, cruising speed, and driving range. 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 or both, and gives bi-fuel vehicles a much greater range than dedicated propane vehicles (which run solely on propane) or gasoline vehicles. Larger storage tanks can also increase range, but the additional weight displaces 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 (105 compared with 84–93 for gasoline) and some original equipment manufacturers (OEMs) offer dedicated engines optimized to take advantage of this higher rating.⁵ This can result in improved performance and fuel economy over non-optimized engines.

What propane vehicles are available?

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



The Kentucky Clean Cities Partnership coalition worked with Mammoth Cave National Park to put new propane buses into service for visitor tours. Read more about this and other successful projects at afdc.energy.gov/case. Photo courtesy of Mammoth Cave National Park, NREL 25207

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 light-, medium-, and heavy-duty propane vehicles and engines, see the AFDC’s Vehicle Search at afdc.energy.gov/afdc/vehicles/search or the Propane Education & Research Council (PERC) website at propane.com/on-road-fleets/products-that-use-propane/.

How can I find reliable and approved propane conversions?

All propane fueling systems must be certified to meet U.S. Environmental Protection Agency (EPA) or California Air Resources Board (CARB) emissions standards. For a list of EPA-approved propane conversion systems and engines, see the EPA website at epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm and epa.gov/otaq/certdata.htm#lsj. Note that, as EPA states, the list is not comprehensive and there may be certified conversions

⁵ AFDC Fuel Properties Comparison (afdc.energy.gov/fuels/fuel_properties.php)

that do not appear on the list. EPA adds conversion systems upon request of the system's manufacturer and advises checking the list periodically for updates. Customers should ask to see and 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 ask to review documentation on conversion practices, procedures, and training when considering any conversion equipment and services. For more information, consult the Propane Vehicle Conversions page on the AFDC at afdc.energy.gov/vehicles/propane_conversions.html.

Clean Cities coordinators can help draft requests for proposal (RFPs) that 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 dollars more than that of comparable conventional fuel vehicles, propane vehicles can provide an acceptable return on investment (ROI). A light-duty conversion may cost as little as \$6,000, while a new propane vehicle may have an incremental cost of \$15,000 or more. One exception is new propane school buses, which are comparable in price to new diesel buses. Fleet managers should consider costs for fueling infrastructure if they do not currently have access to propane fueling sites (see at right), 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 Federal and State Laws and Incentives section of the AFDC 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, 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 ROI, the 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-duty 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.⁶

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 no smoking—when fueling.

Because some training is required, propane can 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.

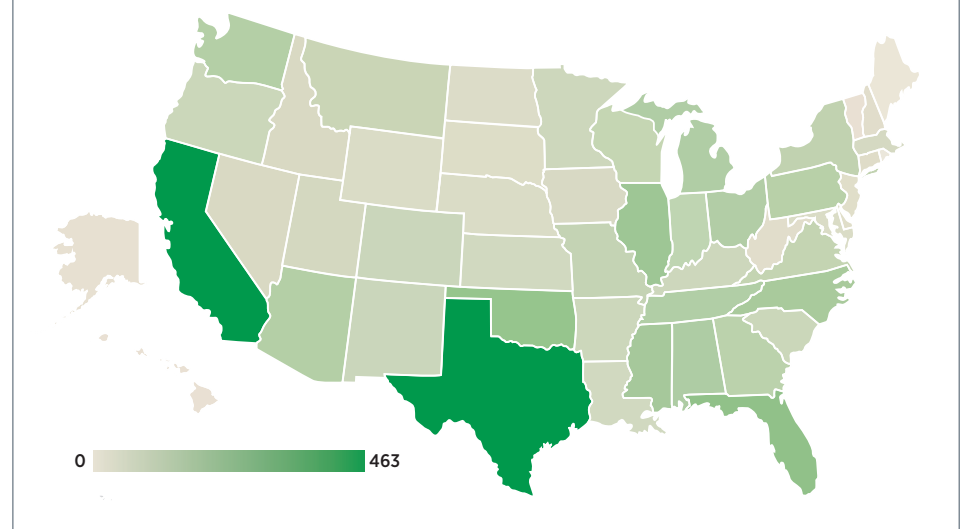
How much does propane fuel cost and where is it available?

Propane is typically priced lower than gasoline or diesel fuel. However, fleet managers should carefully consider their options when establishing private fueling or using public sites.

- **Public fueling stations.** There are more than 3,400 propane stations in the United States. To find stations in your area, visit the Alternative Fueling Station Locator or download the Station Locator mobile app from the AFDC website at afdc.energy.gov/stations. When using the Station Locator, you can expand your search to include

⁶ AFDC, *Propane Vehicles* (afdc.energy.gov/vehicles/propane.html)

Public Propane Fueling Station Locations by State



Thousands of fueling stations across the country provide propane, also known as LPG. 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

stations with “limited vehicle-specific fueling capabilities.” While many stations have fueling infrastructure dedicated—or purpose-built—for fueling vehicles, these stations do not. 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.

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.⁷



Lower maintenance costs are a prime reason behind propane’s popularity for high-use vehicles, such as school buses. Photo from MotorWeek/Maryland Public TV, NREL 17180

The cost of establishing propane infrastructure typically ranges from \$45,000 to \$300,000, 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.⁸

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* (afdc.energy.gov/uploads/publication/propane_costs.pdf).

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

Due to increasingly stringent emissions regulations, all new vehicles are now equipped with very effective emission control systems and must meet the same standards. Consequently, tailpipe

emissions from propane vehicles are comparable to those of gasoline and diesel vehicles equipped with modern emissions controls. However, according to the Argonne National Laboratory GREET model (greet.es.anl.gov), vehicles running on propane reduce life cycle greenhouse gas emissions by nearly 10%.

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).

^{7,8} New West Technologies and National Renewable Energy Laboratory, *Costs Associated with Propane Vehicle Fueling Infrastructure*, August 2014 (afdc.energy.gov/uploads/publication/propane_costs.pdf)

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