

# Alternative Fuel Driver Training Companion Manual



EPAct Regulated Fleets



U.S. Department of Energy

**Energy Efficiency  
and Renewable Energy**

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is clean, abundant, reliable, and affordable



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## Acknowledgment

The information in this training manual was taken from a series of presentations written by the Alternative Fuel Vehicle Institute (AFVI) under subcontract to the U.S. Department of Energy. This booklet serves as a companion manual to the AFVI presentations.

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## Introduction

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The Energy Policy Act of 1992 (EPAct) was passed by Congress to reduce our nation's dependence on imported petroleum by requiring certain fleets to acquire alternative fuel vehicles (AFVs). The U.S. Department of Energy administers the regulations through the State & Alternative Fuel Provider Rule and Federal Fleet Requirements.

EPAct requires fleets owned or operated by federal and state governments and alternative fuel providers to meet a portion of their light-duty vehicle acquisitions with AFVs. EPAct further requires fuel providers to use alternative fuels in their AFVs. Since 1992, regulated fleets have helped build a core market for AFVs and displaced more than 100 million equivalent gallons of conventional fuels.

DOE's Clean Cities initiative is the voluntary side of EPAct. Clean Cities was created in 1993 to provide technical, informational, and financial resources to both regulated fleets and voluntary adopters of alternative fuels. Clean Cities also has a successful track record and has demonstrated significantly higher deployment rates for alternative fuels in areas involved in the program than for the nation as a whole. In fact, in 2005 Clean Cities announced it had reached 1 billion gasoline gallon equivalents (GGE) displaced since the beginning of the initiative.

In the summer of 2004, EPAct and Clean Cities worked together to develop a course to teach trainers how to educate fleet drivers on the use of alternative fuels and vehicles. The class was held in Minneapolis, Minnesota; Denver, Colorado; Sacramento, California; and Washington, D.C.

This manual features the information presented in the classes, including the safe use of four alternative fuels: biodiesel, compressed natural gas (CNG), E85 (85% ethanol, 15% gasoline), and propane.

These presentations are available for download on the Alternative Fuels Data Center (AFDC) Web site at [www.eere.energy.gov/afdc/resources/altfueltraining/driver\\_training.html](http://www.eere.energy.gov/afdc/resources/altfueltraining/driver_training.html). Although this manual was designed to support the presentations, it can also be used on its own as a self-contained study guide that covers the facets of alternative fuels.

While this manual and related slides provide a basic overview of alternative fuels and AFVs, it's also a good idea to give trainees "hands-on" competency training in fueling their AFVs. This training should include making three fuel transactions and locating the station's fire extinguisher and emergency shutdown device and the vehicle's manual shutoff device.

For more information on alternative fuels, visit the following Web sites:

- AFDC: [www.eere.energy.gov/afdc](http://www.eere.energy.gov/afdc)
- National Biodiesel Board: [www.nbb.org](http://www.nbb.org)
- Natural Gas Vehicle Coalition: [www.ngvc.org](http://www.ngvc.org)
- National Ethanol Vehicle Coalition: [www.e85fuel.com](http://www.e85fuel.com)
- Propane Education and Research Council: [www.propanecouncil.org](http://www.propanecouncil.org)



# Alternative Fuels Driver Training: Companion Manual



## Biodiesel as a Vehicle Fuel

Module 1: What is Biodiesel? .....	1
Module 2: Properties and Characteristics of Biodiesel .....	3
Module 3: Biodiesel Fueling Stations .....	3
Module 4: Safety Practices and Emergency Action Plan Biodiesel .....	4

## Compressed Natural Gas as a Vehicle Fuel

Module 1: Introduction to Compressed Natural Gas (CNG) .....	5
Module 2: Properties and Characteristics of CNG .....	5
Module 3: CNG Fueling Station Equipment .....	6
Module 4: Fire Safety and Emergency Action Plan .....	6
Module 5: Correct Use of Safety Equipment .....	7
Module 6: Natural Gas Vehicle Technology and Safety Features .....	7
Module 7: How to Fuel a CNG Vehicle .....	8

## E85 as a Vehicle Fuel

Module 1: What Is E85? .....	9
Module 2: Ethanol and E85 Production .....	10
Module 3: E85 Fueling Stations .....	11
Module 4: Safety Practices and Emergency Action Plan .....	11
Module 5: What Makes an FFV Different? .....	12

## Propane as a Vehicle Fuel

Module 1: Introduction to Propane .....	13
Module 2: Properties and Characteristics of Propane .....	13
Module 3: Propane Fueling Stations .....	14
Module 4: Safety and Emergency Action Plan .....	14
Module 5: Correct Use of Safety Equipment .....	15
Module 6: Propane Vehicle Technology and Safety Features .....	15
Module 7: How to Fuel a Propane Vehicle .....	16



## Biodiesel as a Vehicle Fuel

### Biodiesel Module 1: What Is Biodiesel?

Biodiesel is a domestic, renewable fuel for diesel engines. It is derived from natural oils in plants. In the United States, most biodiesel comes from soybeans. In Europe, the most common feedstock is canola (or rapeseed).

Biodiesel is increasingly made from recycled cooking oil, which originates from soybeans or vegetables. A misconception is that biodiesel is simply raw vegetable oil. Biodiesel is composed of fatty acid methylesters, which are the product of a chemical reaction between vegetable oils and/or animal fats and an alcohol. The National Biodiesel Board recommends using only biodiesel fuel that meets a specific set of standards called ASTM D6751, which were created by the American Society of Testing and Materials (ASTM).

Biodiesel can be mixed in any concentration with petroleum-based diesel fuel. It is often sold in a blend called B20, which is 20% biodiesel and 80% petroleum diesel. But it is blended at various ratios, sometimes for proprietary use by truck fleets. Concentrations as low as B2 and B5 (2% and 5% biodiesel, respectively) can be sold to individual motorists and fleets.

Many fleets are covered under law<sup>1</sup> and required to use nonpetroleum alternative fuels. Fleet operators like biodiesel because it requires little or no engine modification—at least in concentrations up to B20. Pure biodiesel, called B100, is sometimes used as a vehicle fuel, but it can gel at low temperatures and block the fuel system. Such problems can occur in underground tanks and vehicle fuel systems, particularly in cold climates.

#### Why Biodiesel?

Like all fuels, biodiesel has its own list of inherent advantages. It is nontoxic and does not contaminate groundwater or soil. Its air pollution emissions in general compare favorably to petroleum diesel, as shown in the following table.

**Biodiesel Emissions Compared to #2 Diesel Fuel**

Emission Type	B100	B20	B2
Total Unburned Hydrocarbons	67%	20%	2.2%
Carbon Monoxide	48%	12%	1.3%
Particulate Matter	47%	12%	1.3%
Oxides of Nitrogen	110%	102%	102%

Source: National Biodiesel Board

<sup>1</sup>EPAAct requires certain federal, state, and alternative fuel provider fleets to acquire a percentage of AFVs each year. The regulation is administered by DOE.



Pure biodiesel is stored in tanks like this and mixed with diesel to make blends of B2, B5, or B20.

Indiana Soybean Board

Biodiesel is produced domestically from renewable sources, and is now used in all 50 states. Biodiesel is an EPA<sup>2</sup> alternative fuel—one of a handful of qualified nonpetroleum fuels. Fleets can use biodiesel to comply with their EPA requirements.

Under EPA, covered fleets can earn credits to use toward up to 50% of their annual AFV acquisition requirements by purchasing and using biodiesel. A credit is given for each 450 gallons of pure biodiesel purchased for use in blends of 20% or higher. No credits are granted for the petroleum portion of biodiesel fuel blends. Biodiesel credits cannot be banked or traded.

The use of B20 requires no modification, making it relatively easy and inexpensive for a fueling station to sell biodiesel. B20 can be stored in diesel tanks and pumped with diesel equipment. Filling up with biodiesel is seamless. Fill time is the same as it is for conventional diesel fueling.

Storing and using B100 is another story. According to the *2004 Biodiesel Handling and Use Guidelines* ([www.nrel.gov/docs/fy05osti/36182.pdf](http://www.nrel.gov/docs/fy05osti/36182.pdf)), a booklet published by the U.S. Department of Energy (DOE), “If your existing equipment or engine components are not compatible with B100, they should be replaced with those that are. Materials such as Teflon, Viton, fluorinated plastics, and nylon are compatible with B100. B100 suppliers and equipment vendors should be consulted to determine material compatibility. It is advisable to set up a monitoring program to visually inspect the equipment once a month for leaks, seeps, and seal decomposition. It would be wise to continue these inspections even after one year.”

With prolonged exposure, B100 will degrade some hoses, gaskets, seals, elastomers, glues, and plastics. Before handling or using B100, contact the equipment vendor or original equipment manufacturer (OEM), and ask if the equipment is suitable for B100.

In the past, biodiesel has cost more than petroleum diesel. The difference was approximately “a penny a point,” meaning that B20 fuel cost \$.20 more than petroleum diesel and B5 was \$.05 more. But federal legislation, H.R. 4520, signed in 2004, has created a new tax incentive for biodiesel producers, which may reduce or eliminate the price premium.<sup>3</sup>

The fuel economy, horsepower, torque, and hauling capacity of biodiesel are similar to those of conventional petroleum diesel. Blends as high as B20 result in similar startup and cold weather performance. Not all diesel-powered vehicles can use biodiesel, but B20 can be used in many models produced since 1994.

Most manufacturer warranties permit the use of biodiesel blends as high as B5; higher concentrations are used at the owner’s risk. However, “federal law prohibits the voiding of a warranty just because biodiesel was used—it has to be the cause of the failure,” says the *2004 Biodiesel Handling and*

<sup>2</sup>EPA-authorized alternative fuels include methanol, ethanol, and other alcohols; blends of 85% or more of alcohol with gasoline; natural gas and liquid fuels domestically produced from natural gas; liquefied petroleum gas (propane); coal-derived liquid fuels; hydrogen; electricity; biodiesel (B100), and P-Series fuels.

<sup>3</sup>This incentive is available through December 31, 2006. However, the biodiesel industry is seeking to have it extended.

### DID YOU KNOW....

#### Rudolph Diesel

designed the diesel engine in 1894 to run on peanut oil.





*Use Guidelines.* Furthermore, “damage directly attributable to biodiesel will not be covered by an engine OEM’s warranty, but should be covered by the fuel

supplier’s general liability insurance. New biodiesel users should be sure that their suppliers provide liability coverage on their biodiesel and blends.”

Many fleets are successfully using blends of B20 with few problems reported. The key is getting biodiesel that meets ASTM specifications from an experienced fuel dealer. For more information, download the *2004 Biodiesel Handling and Use Guidelines*.

## Biodiesel Module 2: Properties and Characteristics of Biodiesel

Biodiesel is refined from vegetable oils, which in the United States most commonly come from soybeans. In Europe, rapeseed (canola) is the most common source of oil for biodiesel. Other biodiesel feedstocks include recycled cooking oil and used yellow grease. Biodiesel is formed in a chemical process called transesterification, which produces methylesters and glycerin.

As previously mentioned, ASTM has established a standard for biodiesel. ASTM D6751 applies specifically to B100 when it is used as a mixing fuel. ASTM is developing a separate standard for B20.

In appearance, biodiesel fuel is transparent and usually yellow. It is odorless except when made from recycled cooking grease, which may produce a nonoffensive smell like French fries.

Biodiesel has higher lubricity than petroleum diesel. Adding biodiesel to petroleum diesel at a concentration of just 2% can improve lubricity by as much as 66%. This protects the engine and may extend its life. Biodiesel has a higher flash point than petroleum diesel (260°F, compared to 125°F), which makes it particularly safe to use, handle, and store.

One advantage of using biodiesel blends (B20, B5, B2) is that they operate in conventional diesel engines and fuel injection equipment with little or no modifications. B100 can gel in temperatures lower than 30°F. However, additives, filters, or underground storage can easily remedy this. B20 requires no more special storage or handling than #2 petroleum diesel.

## Biodiesel Module 3: Biodiesel Fueling Stations

Fueling practices for biodiesel blends of B20 or less are identical to normal diesel fueling. Also identical are the essential components, including storage tanks and dispensers, found at conventional diesel fueling stations. Like any petroleum fueling station, a biodiesel station should be equipped with an emergency shutdown system. Drivers and attendants should receive formal training on how to use the system.

## DID YOU KNOW.....

Soybeans are the number one U.S. biodiesel feedstock, and the United States is the world’s number one soybean producer. In 2003, the United States produced 145 billion pounds of soybeans—34% of world production.

(Source: [www.soystats.com](http://www.soystats.com))

AFV/



Fuel pumps require no modification to dispense biodiesel. Here, B20 and conventional diesel are dispensed side by side.

National Biodiesel Board/PIX 13807



Heavy-duty vehicle engines—like the one in this Missouri dump truck—also require no modification to run on biodiesel blends.

A private station may have a facility layout plan on file. This document includes important information such as:

- Biodiesel storage tank locations
- Emergency equipment switches
- Fire extinguishers
- Preplanned evacuation routes
- Designated assembly areas
- Street address of the facility

## Biodiesel Module 4: Safety Practices and Emergency Action Plan

Biodiesel fueling station safety practices are essentially the same as those for a conventional petroleum fueling station. They include:

- Posting safety signs, including emergency telephone numbers for the fire department, emergency medical help, police, maintenance, and adjoining facilities.
- Regularly inspecting all equipment, including dispenser hoses, fueling nozzles, and receptacles. (*Report and stop using defective equipment immediately.*)
- Keeping ignition sources away from the fuel. (*This means no match lighting or cigarette smoking on the premises.*)
- Turning off cell phones.
- Refraining from re-entering a vehicle during fueling.

If a biodiesel fire occurs, do not attempt to disconnect the nozzle from the vehicle. Evacuate the immediate area; trigger the emergency safety device and contact the fire department.

Supervisors should draft an emergency action plan, and regularly discuss it with personnel. The plan should include:

- Notification procedures
- Evacuation procedures
- The operation of safety systems
- Emergency action items

## Compressed Natural Gas as a Vehicle Fuel

### CNG Module 1: Introduction to Compressed Natural Gas (CNG)

As a vehicle fuel, CNG has many advantages. It is an EPA alternative fuel—one of a handful of qualified nonpetroleum fuels that help regulated fleets meet their EPA mandates.

To a large extent, it is domestically produced. There is a relatively large base of CNG vehicles in the United States, and a large underground distribution network is in place. CNG has environmental and clean air benefits. CNG vehicles produce about 66% less carbon monoxide, 68% less nonmethane hydrocarbons, 87% less oxides of nitrogen, and 40% less particulate matter than gasoline vehicles. CNG does not contaminate groundwater or soil.

Although natural gas is primarily sourced from fossil fuel reservoirs, it can be produced from renewable sources. Sometimes called biogas, this renewable natural gas is derived from landfills, sewage treatment plants, and animal waste. One report predicts that Sweden, a world leader in biogas, could meet 5% of its automotive fuel needs with biogas by 2020.<sup>4</sup> DOE is sponsoring research and development aimed at making landfill gas a viable fuel for refuse trucks.

### CNG Module 2: Properties and Characteristics of CNG

Natural gas is a mixture of methane (85% to 96%), ethane, propane, and butane. This blending usually happens underground.

The specific gravity of natural gas is .55 to .65 (and air = 1). Since natural gas is lighter than air it rises when released into the atmosphere. Natural gas is colorless and tasteless. It has no natural odor, but it is odorized for safety to aid in the detection of leaks. It is nontoxic and a simple asphyxiate. Inhalation is the primary route of exposure. Overexposure symptoms may include shortness of breath or unconsciousness. CPR training may be beneficial to anyone who regularly works near CNG.

To allow maximum fuel storage, CNG is compressed to pressurization levels of 3,000 to 3,600 psi. It is measured for sale in mass weight. One GGE of CNG weighs 5.66 pounds. The octane rating of CNG is 117, compared to gasoline's octane range of 86 to 94.

CNG burns with a pale, faintly luminous blue flame at 1,100°F, compared to 630°F for gasoline and 1,250°F for diesel fuel. The fuel-to-air ratio of a CNG flame ranges from 4% lower flame limit to 16% upper flame limit, compared to 1.3% to 7.6% for gasoline and 0.3% to 10% for diesel.

### DID YOU KNOW

Natural gas vehicles have the toughest tanks on the road. CNG fuel tanks are thicker and stronger than gasoline and diesel tanks. They undergo federally required "severe abuse" tests and can withstand a gunshot at close range. After a crash ruptured the gasoline tank of one of its police cars, the Dallas Police Department converted some of its cars to CNG because of the safety advantages of the tougher tanks.

<sup>4</sup>Source: *Fleets & Fuels*, April 11, 2005; Brookhaven National Lab/Natural Gas Vehicle Technology Forum

For safety, a fire extinguisher should be located at or near a CNG fuel dispenser. Only a specially trained person should use a fire extinguisher on a CNG fire. If the flame is extinguished without stopping the fuel flow, it may re-ignite.



NREL/PIX 03830

Fast-fill CNG pumps look much like a conventional gasoline pump. Fast-fill dispensers fuel CNG vehicles quickly.

## CNG Module 3: CNG Fueling Station Equipment

There are two types of CNG fueling dispensers: fast fill and time fill.

Fast-fill CNG dispensers perform much like public gasoline stations and typically serve large fleets or public customers who can't wait overnight for fueling. Pressurized fuel is stored in tanks that are continually refilled by compressors. Multiple tanks may be configured in a cascading arrangement, in which tanks come into service as needed.

In a time-fill CNG facility, fueling requires an extended period—usually overnight—because the vehicles are filled directly from the compressor. This usually requires overnight parking. Such equipment, which includes compressors but no storage tanks, typically serves small fleets. Slow-fill CNG fueling appliances, which draw fuel directly from residential gas lines, are available to individual motorists in California.

The components of a fueling station are the gas dryer, one or more compressors, CNG storage tanks, and dispensers. Modern stations also include credit card readers and should have an emergency shutdown device.



AVFI

Time-fill pumps fuel vehicles over a longer period of time—usually overnight.

## CNG Module 4: Fire Safety and Emergency Action Plan

The mixture of CNG and air is flammable. Therefore it is critical to keep ignition sources away from CNG. When on CNG fueling station premises, do not light matches, smoke cigarettes, or use cell phones. Although CNG systems are sealed (no air enters the fuel systems of the station or vehicle), it is still important to play it safe. That means turning off cell phones and refraining from re-entering a vehicle during fueling.

In the unlikely event of a CNG fire, evacuate the immediate area of the fire, press the emergency shutdown device and call the fire department. Do not attempt to disconnect the nozzle from the vehicle. Furthermore, do not try to extinguish the fire unless you are specifically trained to do so—especially if the fire is near fueling or storage equipment.

If you suspect a gas release at the dispenser, close the nozzle valve and turn the dispenser shutoff valve a quarter-turn to the “off” position. Next, disconnect the fueling nozzle from the vehicle, and reattach it to the mounting bracket on the dispenser. Once the leak is stopped, report the situation to the maintenance technician and the station attendant.

Every fueling station should have an emergency action plan. The plan should first identify what constitutes an emergency. The list of emergency action

items should include:

- Specific evacuation procedures
- The phone numbers of local police, fire, and maintenance departments and medical providers
- Descriptions of safety systems and practices

Fueling stations should also have a facility layout plan that includes:

- Locations of fuel storage tanks, pumps, and dispensers
- Locations of the emergency shutdown device (also known as ESD) and fire extinguishers
- A preplanned evacuation route
- At least one designated assembly area
- The street address of the facility
- Descriptions of adjoining facilities

### CNG Module 5: Correct Use of Safety Equipment

Two key pieces of safety equipment warrant special attention:

- The emergency shutdown device, which is typically located on or adjacent to the fueling island. Activating it will close at least two isolation valves, causing the compressor and gas flow from storage to the dispenser to stop.
- Fire extinguishers, which are usually located on or adjacent to the fueling island. These are used to eliminate oxygen from a fire. The driver must be properly trained to extinguish a natural gas fire.

### CNG Module 6: Natural Gas Vehicle Technology and Safety Features

A typical natural gas vehicle includes several components:

- A fuel receptacle that allows fuel to flow from the dispenser nozzle into the vehicle's fuel storage cylinders
- High-pressure fuel lines that allow fuel to flow from onboard storage cylinders to a pressure regulator
- A shutoff valve that can stop the flow of CNG from the fuel storage cylinders to the pressure regulator

The natural gas vehicle fuel system is sealed and contains no air. If the fuel leaks, it will float upward. Escaped CNG requires a temperature of 1,100°F to ignite. That's considerably higher than what's required to ignite gasoline, diesel, or even propane.



The emergency shutdown device stops the flow of natural gas to the pump. Drivers should take notice of the location of the emergency shutdown device at the stations they frequent.

There are four types of onboard CNG fuel storage cylinders:

- Type 1: All-metal steel or aluminum
- Type 2: Hoop-wrapped steel or aluminum
- Type 3: Fully-wrapped steel or aluminum
- Type 4: All composite (nonmetallic)

The difference is a matter of cost versus weight. Type 1 cylinders are relatively inexpensive but are very heavy, whereas Type 3 and 4 are the lightest and cost the most. For more information on cylinder types, visit the Natural Gas Vehicle Forum Web site at [www.ngv.org/ngv/ngvorg01.nsf/bytitle/ngvcylinderselection.htm](http://www.ngv.org/ngv/ngvorg01.nsf/bytitle/ngvcylinderselection.htm).

The useful life of a CNG fuel storage cylinder is 15 years. The National Highway Transportation and Safety Administration requires CNG storage cylinders to be visually inspected every 36,000 miles or 36 months. Fuel storage cylinders hold CNG at 3,000 or 3,600 psi at 70°F.

For more information on natural gas vehicles, visit the Vehicle Buyer’s Guide (VBG) for Fleets at [www.eere.energy.gov/cleancities/vbg/fleets/about\\_naturalgas.html](http://www.eere.energy.gov/cleancities/vbg/fleets/about_naturalgas.html). For a list of available light-duty natural gas vehicles, use the VBG search at [www.eere.energy.gov/cleancities/vbg/fleets/search\\_type.html](http://www.eere.energy.gov/cleancities/vbg/fleets/search_type.html).



This Type 1 nozzle is typically what drivers will find at a public CNG fueling station.

## CNG Module 7: How to Fuel a CNG Vehicle

There are two types of CNG dispenser nozzles. Type 1 is typically used in public fueling, while Type 2 is used in fleet fueling.

- Open the fuel door and remove the protective cap on the vehicle fuel receptacle.
- Remove the fueling nozzle from the dispenser.
- Inspect the fueling hose and nozzle for damage.
- Place the nozzle on the receptacle and pull back to ensure it is secure.
- Turn the fueling valve handle on the nozzle to the “open” position.
- Swipe the fueling card through the card reader.
- Turn the dispenser fueling handle to the “on” position.
- After the fuel stops flowing, turn the dispenser fueling handle to the “off” position.
- Turn the fueling valve handle on the nozzle to the “vent” position.
- Remove the nozzle from the receptacle and place it back on the dispenser.
- Replace the protective cap on the vehicle fuel receptacle.



Type 2 nozzles are usually found in onsite fleet fueling facilities.

## E85 as a Vehicle Fuel

### E85 Module 1: What Is E85?

E85 is an EPA-act alternative fuel—one of a handful of EPA-act-approved fuels that help regulated fleets meet their EPA-act mandates. E85 is a mixture of 85% ethanol, 15% gasoline.

There are more than 3.5 million vehicles on the roads today that are capable of running on E85; they are called flexible fuel vehicles (FFVs) and can run on any blend of ethanol or straight unleaded gasoline.

There are more than 400 E85 fueling sites in this country. A large portion of these stations are located in Minnesota but the number is growing in other parts of the country.

According to the *Handbook for Handling, Storing, and Dispensing E85* ([www.nrel.gov/docs/fy02osti/30849.pdf](http://www.nrel.gov/docs/fy02osti/30849.pdf)), a booklet published by DOE's National Renewable Energy Laboratory, ethanol in the United States is produced mainly from corn grown in the Midwest. One bushel of corn (approximately 56 lbs) produces roughly 2.7 gallons of ethanol.

Biofuels such as ethanol could make a big dent in U.S. petroleum consumption. A 2005 study sponsored by DOE and the U.S. Department of Agriculture found that by making changes in land use, farming, and forestry practices, enough biomass could be generated to produce biofuels meeting more than one third of the current demand for transportation fuels. Today, biofuels account for only about 1% of transportation fuels.<sup>5</sup>

#### Why E85?

Like all fuels, E85 has its own list of inherent characteristics and advantages. Its main ingredient, ethanol, is domestically produced and renewable. Most ethanol is made from corn. E85 is an approved alternative fuel under EPA-act, meaning many regulated fleets can meet their mandates by buying E85-capable FFVs—the most common AFVs among new cars.

Ethanol is 35% oxygen by weight, which gives it one of the highest oxygen contents of any fuel available. E85 contains 80% fewer gum-forming compounds than gasoline. And ethanol is highly biodegradable, which makes it safer than gasoline if it is spilled.

Because the ethanol molecule contains oxygen, it allows an automobile engine to more completely burn fuel, resulting in fewer emissions. Ethanol fuel blends of 10% are successfully used in all types of vehicles and engines that require gasoline.

For more information on E85, download the *Handbook for Handling, Storing, and Dispensing E85*.

<sup>5</sup> Source: *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, Oak Ridge National Laboratory, U.S. Department of Agriculture ([http://feedstockreview.ornl.gov/pdf/billion\\_ton\\_vision.pdf](http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf))

### DID YOU KNOW.....

Approximately 30% of all gasoline consumed in the United States was blended with ethanol in 2004. Most ethanol is blended at concentrations of 10% or lower. Unlike E85, however, such blends are not considered alternative fuels by EPA-act.

## E85 Economics

E85 has lower fuel economy than gasoline. In tests conducted at the National Renewable Energy Laboratory, two E85 vehicles had 73% of the fuel economy of otherwise identical gasoline-fueled vehicles. (Source: *Do You Own a Flexible-Fuel Vehicle?* Clean Cities, 2003). Lower by the same proportion, of course, is the driving range per tank of fuel when a vehicle operates on E85. The lower energy content of E85 accounts for its lower fuel economy. “One gallon of E85 contains 27% less energy than one gallon of gasoline. However, while science shows that a gallon of E85 contains 27% less energy, experience shows that a motor vehicle will experience only a 5% to 12% decline in fuel mileage,” according to the *Handbook for Handling, Storing, and Dispensing E85*.

Ethanol’s power, acceleration, payload, and cruise speed are comparable to those of gasoline. Pure ethanol has an octane rating of 113, considerably higher than gasoline, which ranges from 86 to 94. E85 fuel typically has 100-plus octane ratings, and may be as high as 105. Pure ethanol is used in many racing leagues because of these high-performance characteristics.

Manufacturer warranties of FFVs are identical to those of gasoline vehicles, and maintenance procedures are almost identical. Certain vehicles (from DaimlerChrysler and its predecessor, Chrysler Corporation) require different motor oil. Oil change intervals are unaffected by E85 fueling.

Automakers produce a wide range of FFVs. Many pickup trucks and vans have been offered with FFV fueling, at least as an option, since the late 1990s. Other popular vehicles include the Ford Taurus and Explorer and minivans from Chrysler. When it’s optional, FFV fueling capability typically adds little or nothing to the purchase price of a new car.

For more information on E85 and FFVs, download *Do You Own a Flexible Fuel Vehicle?* ([www.nrel.gov/docs/fy03osti/33058.pdf](http://www.nrel.gov/docs/fy03osti/33058.pdf)). For a list of currently available FFVs, visit the Vehicle Buyer’s Guide for Fleets at [www.eere.energy.gov/cleancities/vbg/fleets](http://www.eere.energy.gov/cleancities/vbg/fleets).

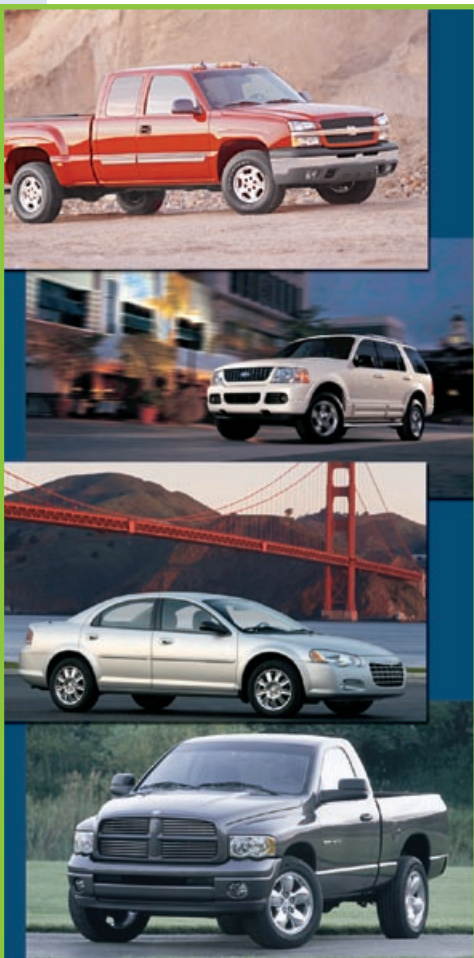
## E85 Module 2: Ethanol and E85 Production

Ethanol is a renewable fuel most commonly produced from corn. It can also be made from other grains and starchy wastes. It is fermented into a grain alcohol, then denatured with conventional gasoline or “natural” or “drip” gasoline, which is a product of natural gas refining.

Ethanol is colorless and has a pleasing odor. In its pure form, ethanol is not considered a contaminant to groundwater or soil. Ethanol motor fuel is denatured with unleaded gasoline or poisoned to prevent people from drinking it.

Like many other motor fuels, it emits CO<sub>2</sub> when burned. But that amount of CO<sub>2</sub> is consumed by growing the plants from which ethanol is made.

Wreck Media Service



E85 flexible fuel vehicles.



However, emissions are produced when converting corn to ethanol.

Why isn't ethanol used as a motor fuel in its pure form, rather than being blended with gasoline in the form of E85? Gasoline increases flame luminosity and improves cold-start performance. In cold climates, the proportion of gasoline may be seasonally raised as high as 30%. With an ethanol content of perhaps 70%, winter blends sometimes carry labels such as E70.

### E85 Module 3: E85 Fueling Stations

Unlike gaseous fuels such as CNG, E85 fueling does not require high-pressure equipment. E85 tanks and storage are essentially the same as for gasoline, and fueling practices are identical. The cost of selling E85 is also similar to that of gasoline.

Fuel dispensers, however, need to be modified to handle E85. Aluminum parts—specifically nozzles, knobs, etc.—should be replaced with stainless steel to prevent corrosion. An E85 dispenser should also be equipped with a Teflon hose and a 1-micron filter. The cost of upgrading an existing dispenser for E85 is approximately \$2,500. The installation of a new ethanol facility can range from \$10,000 to \$60,000, according to the E85 Fleet Toolkit. For more information on E85 infrastructure costs, visit [www.eere.energy.gov/afdc/e85toolkit/cost.html](http://www.eere.energy.gov/afdc/e85toolkit/cost.html).

Like any fueling station, an E85 station should be equipped with an emergency shutdown system and should have a facility layout plan on file that includes the locations of fuel storage tanks, emergency equipment switches, and fire extinguishers; evacuation routes and designated assembly areas; and the street address of the facility.

### E85 Module 4: Safety Practices and Emergency Action Plan

Every fueling station should have an emergency action plan. The plan should first identify what constitutes an emergency. The list of emergency action items should include:

- Specific evacuation procedures
- The phone numbers of local police, fire, and maintenance departments and medical providers
- Descriptions of safety systems and practices

Fueling stations should also have a facility layout plan that includes:

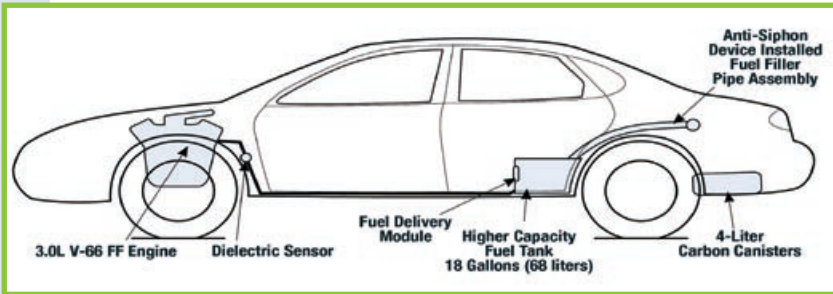
- Locations of fuel storage tanks, pumps, and dispensers
- Locations of the emergency shutdown device (also known as ESD) and fire extinguishers
- A preplanned evacuation route
- At least one designated assembly area
- The street address of the facility
- Descriptions of adjoining facilities



E85 pumps look much like gasoline dispensers, but their parts must be made of stainless steel to prevent corrosion.

Drivers should periodically inspect E85 fueling equipment, including dispenser hoses, fueling nozzles, and receptacles. Report and immediately stop using defective equipment. Like all fuels, keep ignition sources away from ethanol. Do not light matches or smoke cigarettes on a fuel station premises. Turn off cell phones and do not re-enter a vehicle during fueling.

In the unlikely event of an E85 fire, do not attempt to disconnect the nozzle from the vehicle. Evacuate the immediate area, trigger the emergency safety device, and contact the fire department.



The main difference between ethanol FFVs and conventional vehicles is the materials used in the fuel management and the engine calibration systems. Because the alcohol in ethanol corrodes aluminum, FFV components are made of stainless steel.

## E85 Module 5: What Makes an FFV Different?

FFVs run on gasoline or a mixture of gasoline and up to 85% ethanol. Most vehicles that run on E85 experience a reduction in fuel economy. Driving range is affected by the same proportions. A vehicle that can travel 400 miles on a tank of gasoline, for example, can travel 300 to 340 miles on a tank of E85.

Like any modern vehicle, an FFV is equipped with an onboard computer (or engine control module). The computer controls fuel injection and ignition timing, and makes constant adjustments in response to conditions. One such condition in an FFV is the concentration of ethanol in the fuel.

Since FFVs can run on any mix of E85 and gasoline, no special fuel blending is required. There is only one fuel tank, one filler neck, and one fuel gauge. There is no need for a switch to change from using one fuel to the other.

## Propane as a Vehicle Fuel

### LPG Module 1: Introduction to Propane

Propane (also called liquefied petroleum gas or LPG) is produced as part of petroleum refining and natural gas processing. There is a large base of propane-powered vehicles in the United States, and millions more worldwide.

The fuel is delivered to stations by truck, like gasoline and diesel fuel. Propane may be the most readily available alternative fuel. Nearly every state has propane stations, and some states have more than 100 stations.

Propane has many environmental benefits. It is nontoxic and does not contaminate groundwater or soil. It is an EPA Act alternative fuel—one of a handful of fuels that help regulated fleets meet their EPA Act mandates. Compared to their gasoline counterparts, propane vehicles emit fewer total hydrocarbons, nitrogen oxides, and particulate matter.

Propane vehicles get about 85% the fuel economy of gasoline vehicles. The driving range of propane vehicles is lower by the same proportion compared to gasoline vehicles. One GGE of gasoline is equivalent to 1.35 physical gallons of propane. The time required to fuel a propane vehicle is similar to that of a gasoline vehicle.

### LPG Module 2: Properties and Characteristics of Propane

Propane is not a naturally occurring petrochemical. It is refined from both natural gas and petroleum. Technically, propane is just one part (the predominant component) of LPG. Other chemical components of LPG include propylene, N- and I-butane, and ethane.

HD-5 motor fuel standards were developed by the Gas Processors Association to determine the best grade of propane. The standards require LPG to be at least 90% propane to ensure adequate fuel to vehicle engines. That standard also mandates a maximum of 5% propylene (which lowers octane). In the United States, almost all LPG, including the fuel used for home heating and recreation, meets the HD-5 standards.

Propane is a liquid when pressurized in a fuel tank. It becomes gaseous when released from the tank, either via the fuel system or through unintended leaks. Propane liquid is lighter than water, but propane vapor is heavier than air.

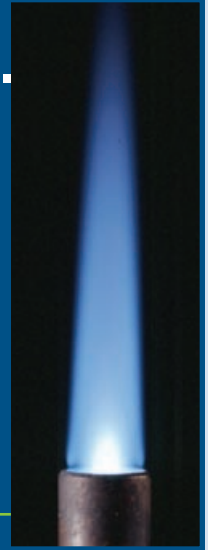
Propane is colorless. It has no natural odor, but it is odorized for safety to aid in the detection of leaks. The most commonly used odorant is ethyl mercaptan.

Its octane rating is 104 to 112, compared to gasoline's octane range of 86 to 94. Propane has an energy content of 91,500 Btu/gallon, compared to 117,500 Btu/gallon of gasoline.

### DID YOU KNOW.....

Propane has been used in transportation vehicles since the 1960s. Today there are more than 7 million propane vehicles on Earth.

Source: Global Autogas Industry Network



AFVI



Propane is stored in above-ground tanks.

Propane burns with a pale, faintly luminous blue flame at 865°F, compared to 1,100°F for natural gas and 630°F for gasoline. The fuel-to-air ratio of a propane flame ranges from 2.1% lower flame unit to 9.6% upper flame unit, compared to 4% to 16% for natural gas and 1.3% to 7.6% for gasoline.

Propane is nontoxic, but it is a simple asphyxiate. Inhalation is the primary route of exposure. Overexposure symptoms may include shortness of breath or unconsciousness. CPR training may be beneficial to anyone who regularly works near propane.

## LPG Module 3: Propane Fueling Stations

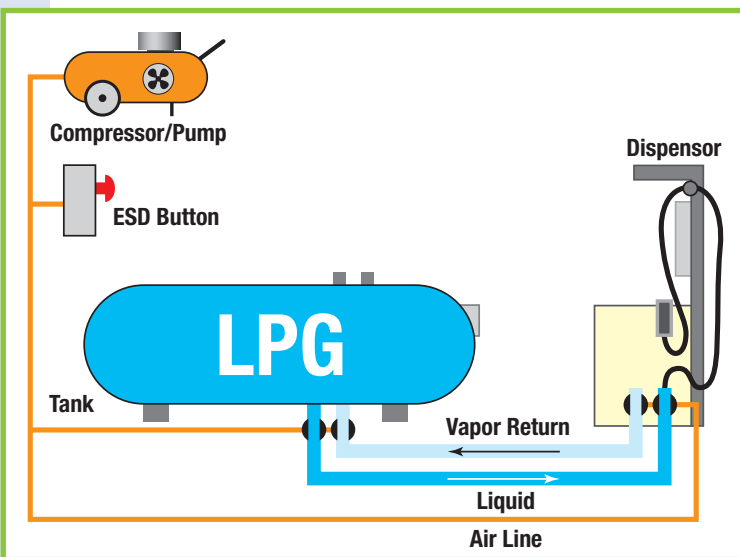
The components of a propane fueling station include onsite fuel storage tanks, a pump, a dispenser, a credit card reader, and an emergency shutdown system. Propane fueling tanks are cylindrical, and may be configured horizontally near the dispenser, or vertically, towering above the dispenser.

## LPG Module 4: Safety and Emergency Action Plan

Every fueling station should have an emergency action plan. The plan should first identify what constitutes an emergency. The list of emergency action items should include:

- Specific evacuation procedures
- The phone numbers of local police, fire, and maintenance departments and medical providers
- Descriptions of safety systems and practices

Source: Gogas Pty Ltd.



Propane station components.

Fueling stations should also have a facility layout plan that includes:

- Locations of fuel storage tanks, pumps, and dispensers
- Locations of the emergency shutdown device (also known as ESD) and fire extinguishers
- A preplanned evacuation route
- At least one designated assembly area
- The street address of the facility

Regularly inspect all equipment, including dispenser hoses, fueling nozzles, and receptacles. Report and stop using defective equipment immediately.

### Fire Safety

It is critical to keep ignition sources away from propane. When on the premises of a propane fueling station, do not light matches, smoke cigarettes, or use cell phones. Although propane systems are sealed (no air enters the fuel systems of the station or vehicle), it is still important to play it safe. That means turning off cell phones and refraining from re-entering a vehicle during fueling.

In the unlikely event of a propane fire, evacuate the immediate area of the fire, press the emergency shutdown device and call the fire department. Do not attempt to disconnect the nozzle from the vehicle. Furthermore, do not try to extinguish the fire unless you are specifically trained to do so—especially if the fire is near fueling or storage equipment.

### LPG Module 5: Correct Use of Safety Equipment

Two key pieces of safety equipment warrant special attention:

- The emergency shutdown device, which is typically located on or adjacent to the fueling island. Activating it will close at least two isolation valves, causing the compressor and gas flow from storage to the dispenser to stop.
- Fire extinguishers, which are usually located on or adjacent to the fueling island. These are used to eliminate oxygen from a fire. The driver must be properly trained to extinguish a propane fire.

### LPG Module 6: Propane Vehicle Technology and Safety Features

A propane fueling system includes key components:

- A vaporizer, which converts liquid propane to gas by using an engine coolant as a heat source.
- A regulator, which provides fuel pressure regulation to the mixer. Propane vehicles, like most modern gasoline vehicles, are equipped with fuel injection.

Onboard fuel storage cylinders in propane vehicles come in one, two, or three pieces. The three types are defined more specifically by the U.S. Department of Transportation. Propane is stored onboard the vehicle at 130 to 170 psi. Propane tanks are filled to only 80% of their capacity, to allow for heat expansion.



In liquid form, propane is more compact than its gaseous form. This allows propane to be stored as an energy-dense liquid in a vehicle's fuel tank while providing the benefits of a clean, gaseous fuel when burned in the engine.



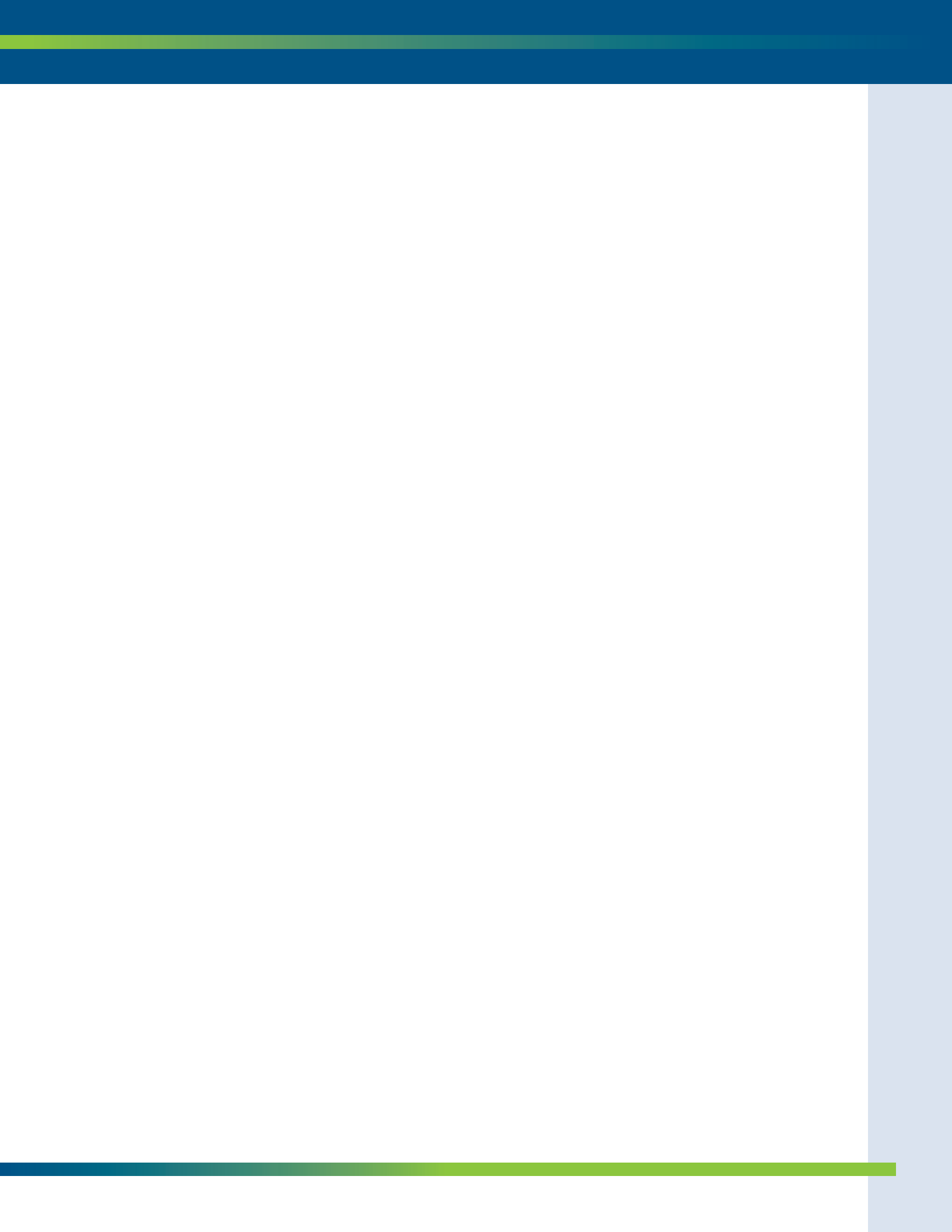
To dispense propane using a Gas Guard nozzle, secure the nozzle's trigger to the vehicle's fuel valve, and press the handle.

### LPG Module 7: How to Fuel a Propane Vehicle

Many types of LPG nozzles are used at fueling stations. A Gas Guard nozzle, which operates much like a standard nozzle, may be found at public fueling stations.

- Remove the cap from the vehicle receptacle.
- Remove the nozzle from the dispenser holder.
- Position the nozzle over the lugs on the vehicle-fill receptacle.
- Turn the front of the nozzle one-third turn clockwise.
- Squeeze the nozzle trigger and push down the catch to retain the trigger. (This will secure the nozzle to the fill receptacle and open the fill valve.)
- Press and hold in the delivery button on the dispenser. (This will start the filling process.)
- Release the button to stop the flow.
- Support the nozzle, turn the front of it counterclockwise, withdraw it, and replace it in the holder on the dispenser.
- Replace the cap on the vehicle fill receptacle.

Dispensers at older stations may have screw-on nozzles. After fueling with this type of nozzle, a small valve must be opened to release any remaining fuel.



## **A Strong Energy Portfolio for a Strong America**

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