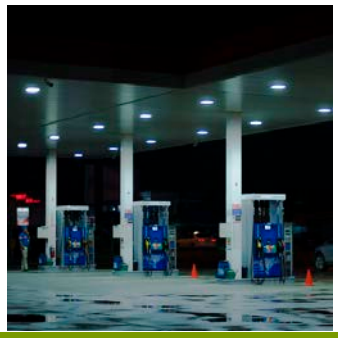
Clean Energy Extension

FACT SHEET

Alternative Fuel Vehicles for Municipal Fleets




This is one of a series of fact sheets designed to help rural municipalities reduce fuel usage in their town fleets. For more information, please visit the UMass Clean Energy Extension (CEE) website, https://ag.umass.edu/clean-energy.

What are Alternative Fuels?

Alternative fuel is a label applied to all vehicular fuels other than gasoline or diesel. This fact sheet focuses on biodiesel, ethanol, propane, natural gas, and hydrogen, due to their potential to power vehicles of all size classes, including heavy-duty machinery.

Alternative fuel station infrastructure is not well-established in many rural parts of Massachusetts, and few state incentives exist for liquid alternative fuel vehicles, retrofits or fueling infrastructure. *For municipalities located away from existing infrastructure, and not committed to installing their own alternative fueling stations, hybrid and electric vehicles may be a more attainable alternative to conventionally-fueled vehicles. For information on hybrid and electric vehicles, please see our fact sheet* Hybrid, Hybrid Plug-in, and Battery Electric Vehicles: A General Overview.

Types of Alternative Fuels

Biodiesel - Biodiesel is a biodegradable and renewable fuel, frequently produced domestically from vegetable oil. Biodiesel in its pure form is known as B100, but it is often blended with standard petroleum diesel in varying ratios (e.g. 20% biodiesel = B20). Studies have found that B100 produces approximately 74% fewer greenhouse gas emissions than standard diesel over its life-cycle. Most diesel engines (produced after 1993) can run biodiesel without the need for any modification, making biodiesel an attainable alternative for many drivers. Biodiesel also has superior lubrication abilities compared to standard petroleum diesel. One important consideration regarding use of this fuel is that biodiesel typically has a higher cloud point than diesel derived from petroleum, meaning that at blends above B20, users may run into performance issues in cold weather if proper precautions are not taken. Traditional cold weather solutions for diesel, including additives, kerosene, block or filter heaters, and indoor garaging, all work well for biodiesel.

Ethanol - Ethanol is a renewable fuel, commonly produced domestically from plant matter and feedstock, especially corn products. Ethanol is blended with traditional gasoline in mixtures of up to 85% ethanol (E85). Most internal combustion engines can run on ethanol blended gasoline mixtures of up to 15% ethanol (E15) or less without any modifications, and roughly 98% of the gasoline in America already contains at least a small portion of ethanol. Modified *flex-fuel vehicles* can run ethanol mixes

from E15-E85. While ethanol produces slightly less energy per gallon than gasoline, ethanol-blended gasoline is generally less expensive than pure gasoline, and ethanol has a much higher octane rating than conventional gasoline. Ethanol-based fuels emit fewer pollutants than conventional gasoline and diesel. A life-cycle analysis of ethanol fuels suggests that ethanol produces approximately 34% fewer greenhouse gas emissions than standard vehicle fuels.

Propane - After gasoline and diesel, propane is the third most commonly-used vehicle fuel globally. Also known as *liquefied petroleum gas* (LPG), propane is a high octane fuel derived from non-renewable sources. Because a large percentage of propane available in the U.S. is produced domestically, its price is not as subject to fluctuation as the price of gasoline or diesel. Propane is non-toxic, meaning that gas leaks pose little threat to soil, surface water, or groundwater. However, propane is extremely flammable, and careful handling and storage are necessary. Propane emits approximately 13% fewer greenhouse gas emissions over its life-cycle than standard fuels. While the fuel economy of propane is slightly lower than that of standard fuels, propane is usually significantly cheaper than gasoline or diesel, so that propane is typically as cost-efficient as gasoline or diesel on a dollars-per-mile basis. Using propane as a fuel is also reported to reduce maintenance costs, as propane leaves significantly less residue when combusted.

Natural Gas (CNG/LNG) – Approximately 80-90% of the natural gas used in the United States is produced domestically, and natural gas accounts for roughly 30% of all energy use in the country. While only a fraction of natural gas-based energy consumption comes from vehicular use, the natural gas fueling infrastructure is relatively well established in the U.S., in comparison to other alternative fuels. Natural gas as a vehicular fuel comes in two forms: *Compressed Natural Gas* (CNG) and *Liquefied Natural Gas* (LNG) are both stored in pressurized tanks on the vehicle. The large majority of natural gas available is a fossil fuel-derived product extracted from gas and oil wells, but renewable natural gas (also known as *bio-methane*) can also be produced from decaying organic materials. Both forms of natural gas emit fewer greenhouse gases than standard fuel: a light-duty vehicle running on conventional natural gas produces approximately 15% fewer greenhouse gas emissions during its life-cycle, while a light-duty vehicle running on renewable natural gas produces ~84% fewer greenhouse gas emissions. Both CNG and LNG-powered vehicles offer similar power and acceleration compared to conventionally-fueled vehicles. As with propane, vehicle range is slightly lower in natural gas vehicles than conventionally-fueled vehicles, assuming the same sized fuel tank, but larger tanks are often installed on CNG and LNG vehicles to accommodate this difference. Major vehicle manufacturers in the U.S. produce a wide variety of natural gas-powered vehicles, many of which are *bi-fuel*, meaning that they can run on both conventional fuels and natural gas.

Hydrogen Fuel Cells – Hydrogen-powered vehicles, also known as *fuel cell electric vehicles* (FCEVs), are a relatively new alternative to conventionally-fueled vehicles. California has 35 hydrogen fueling stations currently open to the public, and at least 22 additional stations in the planning stages. When used as a fuel, hydrogen is stored at a pressure of 5,000-10,000 PSI in a tank on the vehicle. The tank feeds into a fuel cell where the hydrogen is broken into protons and electrons, creating an electrical current which powers the vehicle. After the electrons are utilized to provide power to the vehicle, they are rejoined with protons and oxygen in a separate chamber, forming water molecules. The only emissions created by these vehicles at the tailpipe are water vapor and hot air, earning them the title of *zero emissions vehicles*. Of course, total life-cycle greenhouse gas emissions for these vehicles is dependent on the source of the hydrogen fuel, which requires energy input to be produced. Hydrogen is frequently produced domestically, using either a natural gas based process (~50% fewer greenhouse

gas emissions than gasoline) or by separating hydrogen from water in a procedure known as *electrolysis*, commonly utilizing solar or wind energy to power the process (~90% fewer GHG emissions compared to gasoline). Hydrogen-powered vehicles typically take less than 5 minutes to refuel, and have a range of 300 miles or more. Hydrogen fuel cells can be used in vehicles of all size classes, making this technology of interest in areas where the necessary infrastructure is available.

Fuel Type	**Renewable?**	**Approximate Reduced Greenhouse Gas Emissions** (%)[1]	**Retrofits Available?**	**Energy Comparison** (Gasoline Gallon Equivalents)[2]
Gasoline	No	N/A	N/A	1
Diesel	No	N/A	N/A	1.14
Biodiesel	Yes	74%	None Necessary	1.047 (B100)
		15%		1.122 (B20)
Ethanol	Yes	34%	Yes	0.731 (E85)
Propane	No	13%	Yes	0.744
Natural Gas (derived from fossil fuels)	No	15%	Yes	0.832 (CNG)
				0.636 (LNG)
Natural Gas (derived from anaerobic digestion)	Yes	84%	Yes	0.832 (CNG)
				0.636 (LNG)

[1] Values drawn from Argonne National Laboratory "GREET" model: https://greet.es.anl.gov/

[2] California Energy Commission. *Gasoline Gallon Equivalents for Alternative Fuels.* Retrieved from: http://www.energy.ca.gov/almanac/transportation_data/gge.html

After-Market Conversions and New Vehicle Purchases

After-market conversions and retrofits are available for propane, compressed natural gas (CNG), liquefied natural gas (LNG), and ethanol (for E15-E85 use) fuels; these can be used to convert existing conventionally-fueled vehicles into flex-fuel, bi-fuel or alternatively-fueled vehicles. When considering a retrofit, it is important to research and identify a *qualified system retrofitter* (QSR) and certified clean alternative fuel conversion systems. Taking the proper precautions to assure that both the retrofit system, as well as the party performing the installation, are up to code is essential to guarantee that the alternative fuel system performs well and meets vehicle emissions requirements. The Department of Energy maintains an Alternative Fuels Data Center (AFDC) with a variety of helpful resources, and the Environmental Protection Agency (EPA) has compiled a list of approved alternative fuel systems. Companies such as Ford offer lists of *qualified vehicle modifiers* (QVMs) to assist their customers in the conversion process. If you are having difficulty locating a QSR, or have questions about warranty coverage for conversions on an existing vehicle, contact your local dealer or the manufacturer.

- **Alternative Fuel Retrofit/Conversion Resources:** https://www.afdc.energy.gov/vehicles/conversions.html
- **Conversion Regulations**: https://www.afdc.energy.gov/vehicles/conversions_regulations.html
- **Certified Clean Alternative Fuel Conversion Systems Master List**: https://www.epa.gov/vehicle-and-engine-certification/lists-epa-compliant-alternative-fuel-conversion-systems
- **Vehicle and Engine Alternative Fuel Conversions:** https://www.epa.gov/vehicle-and-engine-certification/vehicle-and-engine-alternative-fuel-conversions

Ready-made alternative fuel vehicles are also available directly from vehicle manufacturers. The AFDC *Alternative Fuel and Advanced Vehicle Search Tool* can be used to find alternatively fueled vehicles by vehicle type and fuel type, as well as locate nearby dealers.

- **Alternative Fuel and Advanced Vehicle Search Tool**: https://www.afdc.energy.gov/vehicles/search/
- **Clean Cities 2016 Alternative Fuel Vehicle Buyer's Guide:** https://www.afdc.energy.gov/uploads/publication/vehicle_buyers_guide.pdf
- **Clean Cities Guide to Alternative Fuel and Advanced Medium- and Heavy-Duty Vehicles:** https://www.afdc.energy.gov/uploads/publication/medium_heavy_duty_guide.pdf

Alternative Fuel Station Infrastructure

Existing alternative fueling infrastructure can be identified using the Alternative Fuel Data Center station locator: https://www.afdc.energy.gov/stations/#/find/nearest

It should be noted that relatively few propane, natural gas, ethanol and biodiesel fueling stations are available in Massachusetts, particularly in rural parts of the state.

If alternative fuel stations are not available near your municipality, it may be worthwhile to consider installation of an alternative fueling station, depending on municipal fleet size. For more information on alternative fuel station installation, see these AFDC resources:

- Biodiesel: https://www.afdc.energy.gov/fuels/biodiesel_infrastructure.html
- Ethanol: https://www.afdc.energy.gov/fuels/ethanol_infrastructure.html
- Hydrogen: https://www.afdc.energy.gov/fuels/hydrogen_infrastructure.html
- Natural Gas: https://www.afdc.energy.gov/fuels/natural_gas_infrastructure.html
- Propane: https://www.afdc.energy.gov/fuels/propane_infrastructure.html

If a municipal installation of one of these systems cannot be justified, hybrid or electric vehicle technology may be a more feasible alternative. More information is available in our fact sheet *Hybrid, Hybrid Plug-in, and Battery Electric Vehicles: A General Overview*.

Financial Resources

- Compare prices of conventional and alternative fuel vehicles using the **AFDC Vehicle Cost Calculator:** https://www.afdc.energy.gov/calc/
- Compare prices of conventional and alternative fuels from recent **AFDC Fuel Price Reports**: https://www.afdc.energy.gov/fuels/prices.html
- **Biodiesel (B20) Massachusetts State Contract**: https://www.mass.gov/service-details/biodiesel-for-alternative-fuel-vehicles