Overview of Alternative Fuels

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

State Transportation Fleet Adoption of AFVs

Austin, TX

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Mike Scarpino
US Department of Transportation
Volpe National Transportation Systems Center

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Overview of Alternative Fuels: Agenda

- Natural Gas
- Propane
- Biodiesel
- Electric
- Ethanol
- GHG Comparisons
- Resources

Basics: What is Natural Gas?

Mixture of Hydrocarbons, Predominantly Methane (CH_4)

Conventional Natural Gas

- Extracted from domestic gas and oil wells
- Uses existing pipeline distribution system

Renewable Natural Gas

- Produced from decomposing organic matter, including sewage, animal byproducts, and agricultural, industrial, and municipal solid waste
- Biogas already being produced is upgraded to a purity standard

Images: U.S. Department of Energy, *Producing Natural Gas From Shale*, http://energy.gov/articles/producing-natural-gas-shale; NREL Image Gallery #06331

Basics: Benefits and Considerations

Benefits

- Abundant domestic resource
- High octane rating
- Nontoxic, noncorrosive, and noncarcinogenic
- Lower emissions
- Low and consistent fuel prices
- Proven and established

Considerations

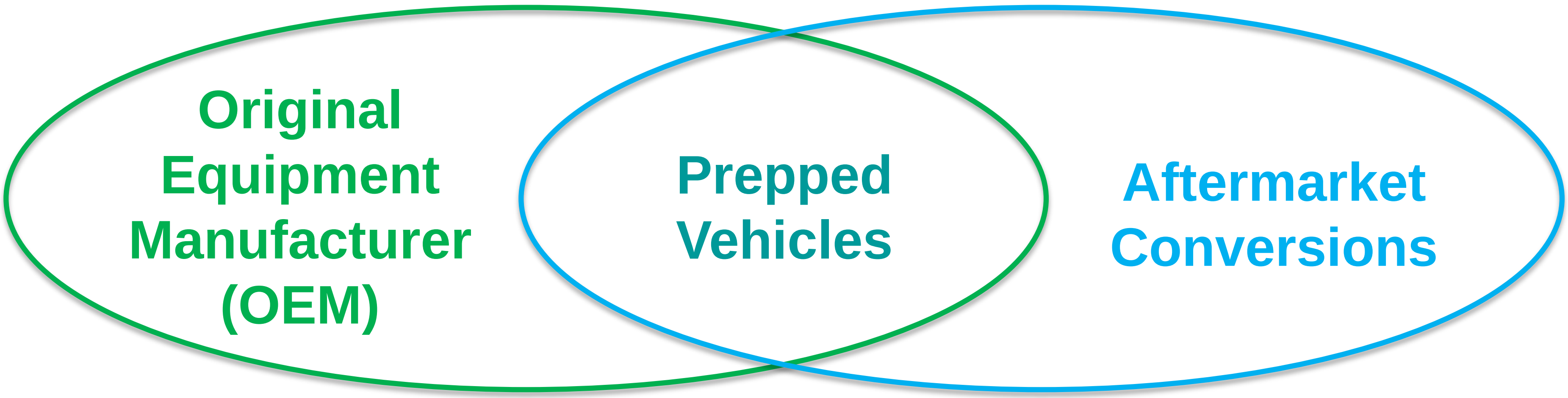
- Reduced driving range on dedicated vehicles
- Incremental vehicle or conversion costs
- Infrastructure availability and costs

Image: NREL Image Gallery #28003

Basics: CNG and LNG

	Storage	Applications	Energy Content
Compressed Natural Gas 	Stored as a gas in onboard tanks under high pressure	Light-, medium-, and heavy-duty vehicles	1 gasoline gallon equivalent (GGE) = 5.66 pounds (lb) or 126.67 cubic feet
Liquefied Natural Gas 	Stored as a liquid at cold temperatures (-260°F) Stored in double-wall, vacuum-insulated pressure vessels	Heavy-duty vehicles	1 GGE = 1.5 gal LNG

Vehicles: OEMs versus Conversions



- More **OEM** models becoming available
- **Aftermarket conversions** provide additional options
  - Must meet federal and state requirements, and be installed by a qualified system retrofitter (QSR) in accordance with National Fire Protection Association (NFPA) 52
- Vehicles with **factory-installed engine prep packages** are converted by a qualified vehicle modifier (QVM) before delivery to the customer

Vehicles: Applications

Light-Duty

- Passenger cars and light-duty trucks in private and government fleets
- Personal vehicles

Medium-Duty

- Vans and shuttles
- Airports and taxi fleets

Heavy-Duty

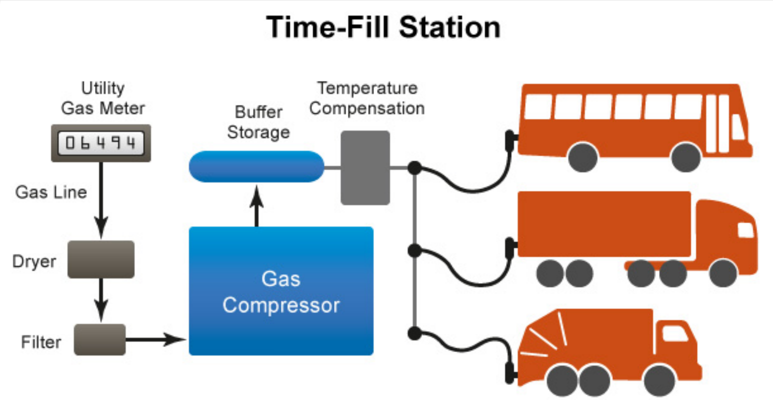
- Refuse haulers
- Transit buses
- School buses
- Long-haul trucks
- Street sweepers
- Snowplows
- Short-haul delivery trucks

Images: NREL Image Gallery #18285, #07351, #17174

Infrastructure: Station Ownership and Operation

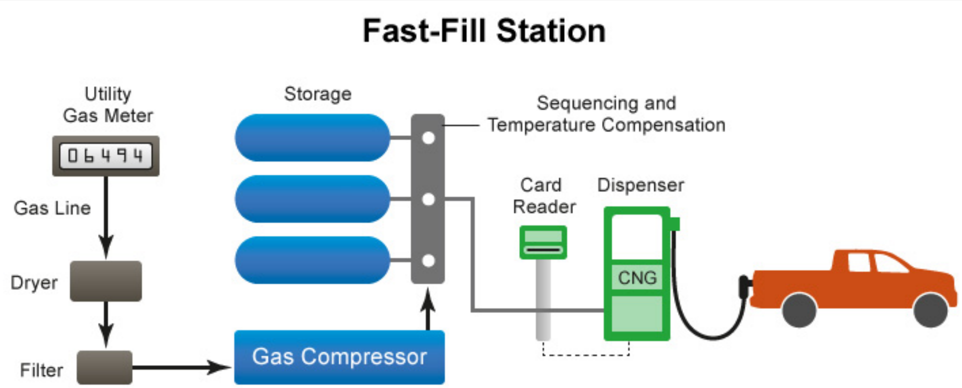
		Station Ownership	
		Fleet	**Independent Provider**
Station Operation	**Fleet**	Fleet owns and operates station Fleet works with vendors on station development	
	Independent Provider	Fleet owns the station, but relies on experienced operator Reduces fleet risk Usually a 5-7 year contract	Outside development, ownership, and operation Fleet provides demand threshold Long-term price agreement Public access possible

Infrastructure: CNG Fueling



- Good for centrally based fleets with consistent schedules
- CNG is dispensed slowly, often overnight
- Lower cost investment

- Fueling takes place in minutes
- Necessary for public-access stations
- Good for vehicles with little downtime



Helpful Resource:

AFDC interactive fueling animation: *http://www.afdc.energy.gov/vehicles/cng_tank_animation.html*

Images and More Information: AFDC CNG Fueling Stations, http://www.afdc.energy.gov/fuels/natural_gas_cng_stations.html

Case Study: Kansas City Public Schools Invests in CNG Buses

- Replaced 47 of its 120 buses with a transit-style bus with a CNG engine; also converted three Type A buses to CNG

- $3.6 million in grant funding for the buses, a fueling station, a mobile refueler, and maintenance facility modifications

Just the Numbers

- **CNG School Buses**: 50
- **Fuel Cost Savings**: $20,000 to $30,000 per month
- **Petroleum Displacement**: 15,000 gallons of diesel fuel per month
- **Greenhouse Gas Emissions Reduction:** 27,789 lbs per month

"Our primary motivation for doing this was fuel costs. They're high, and getting higher, and we're facing budget cuts. Also, CNG is a clean fuel and benefits the environment."

—George Taylor, Director of Transportation

Image and More Information: AFDC Case Study Search, Kansas City Kansas Public Schools Invests in CNG Buses, http://www.afdc.energy.gov/case/1016

Three-carbon alkane gas: C_3H_8

Liquefied Petroleum Gas (LPG) or Autogas

- By-product of natural gas processing and crude oil refining
- Gaseous fuel that is compressed to a liquid

Image: NREL Image Gallery #17180

Basics: Benefits and Considerations

Benefits

- Abundant domestic resource
- Vehicle technology and fueling stations widely available
- High energy density
- Low flammability
- Safe, puncture-resistant tanks
- May reduce particulate matter (PM), carbon monoxide (CO), and life cycle greenhouse gas emissions

Considerations

- Reduced driving range on dedicated vehicles
- Incremental vehicle or conversion costs
- Methane and NOx emissions equivalent or slightly higher than gasoline

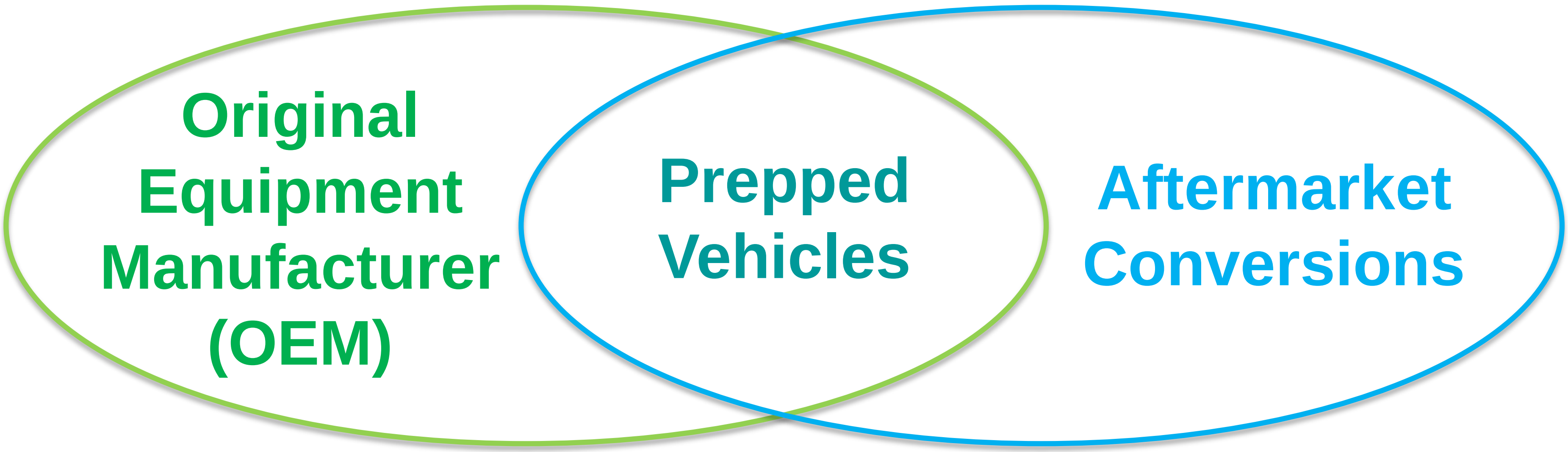
Image: NREL Image Gallery #13689

Basics: Propane in Vehicles

Propane	Applications	Storage	Energy Content
	Light-, medium-, and heavy-duty vehicles	Stored as a gas in onboard tanks between 125–150 pounds per square inch (psi)	73% of the Btu of gasoline

Image: NREL Image Gallery #20655

Vehicles: OEMs Versus Conversions



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Vehicles: Applications

Light-Duty

- Passenger cars and light-duty trucks in private and government fleets
- Personal vehicles

Medium-Duty

- Vans and shuttles
- Airport and taxi fleets
- Cargo trucks

Heavy-Duty

- School buses
- Transit buses
- Street sweepers
- Snowplows
- Short-haul delivery trucks

Images: NREL Image Gallery #12692, #17419, #26955

Infrastructure: Types

Off-site, Public Access

- Operated by retailer, utility, or other fleet
- Fleet may be an anchor fleet or part of a pool of multiple fleets who make a case for station to add propane refueling

On-site, Private Access

- Exclusive use by participating fleets

On-site, Public Access

- Built outside of restricted areas
- Benefit from economy of scale
- Promotes public use of propane vehicles

City of Austin Infrastructure:
Using five city fueling sites, Austin is able to operate more than 200 F150 propane trucks and more than 30 propane mowers. Infrastructure is shared with Travis County, the State of Texas, and other entities.

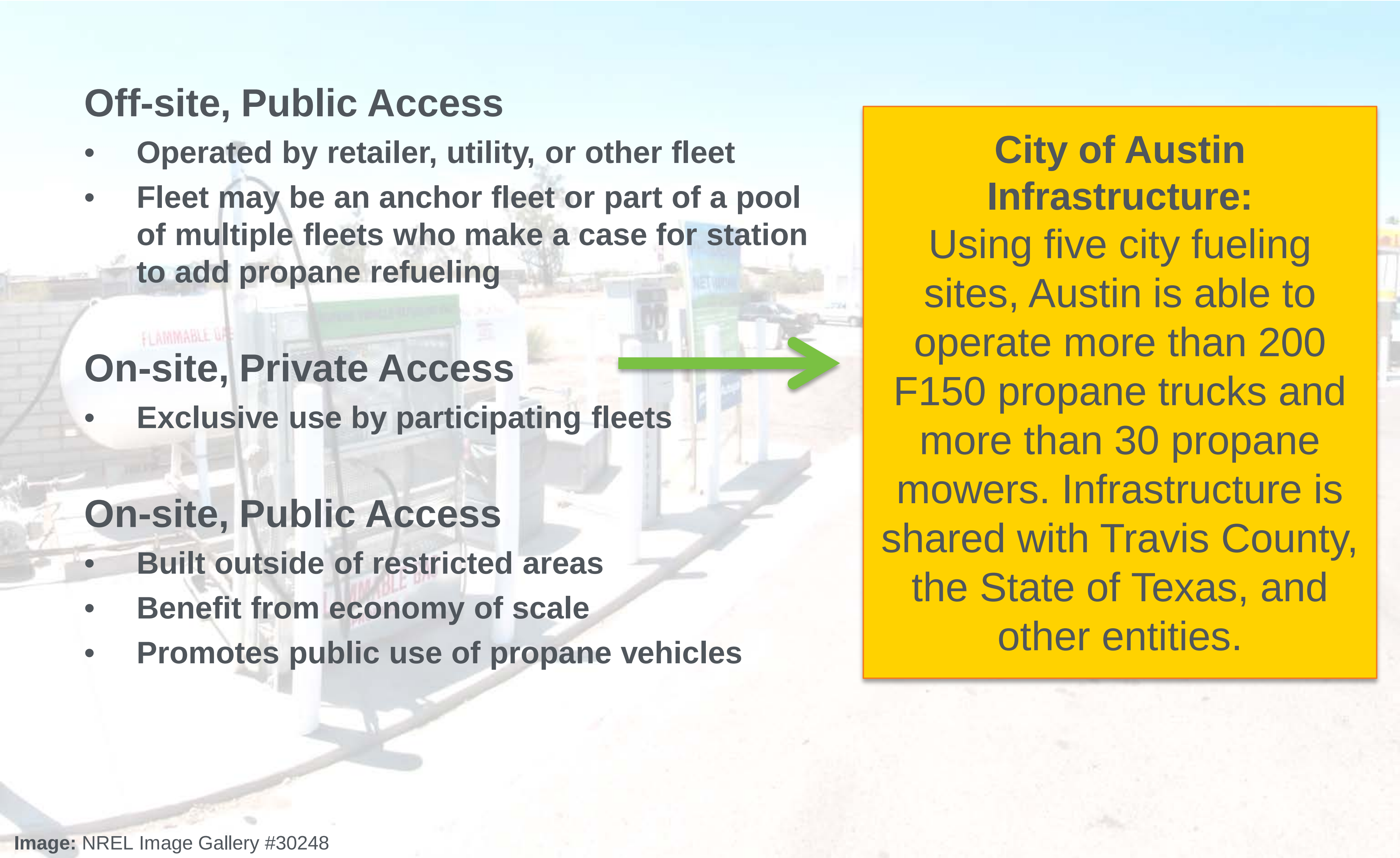


Image: NREL Image Gallery #30248

Infrastructure: Propane Fueling

Containerized	• Turnkey solution with standard storage tank, dispensing, metering, and containment equipment
Customized	• Larger storage tanks, multiple dispensers, other customization
Mobile	• Propane delivery truck with metering and dispensing equipment

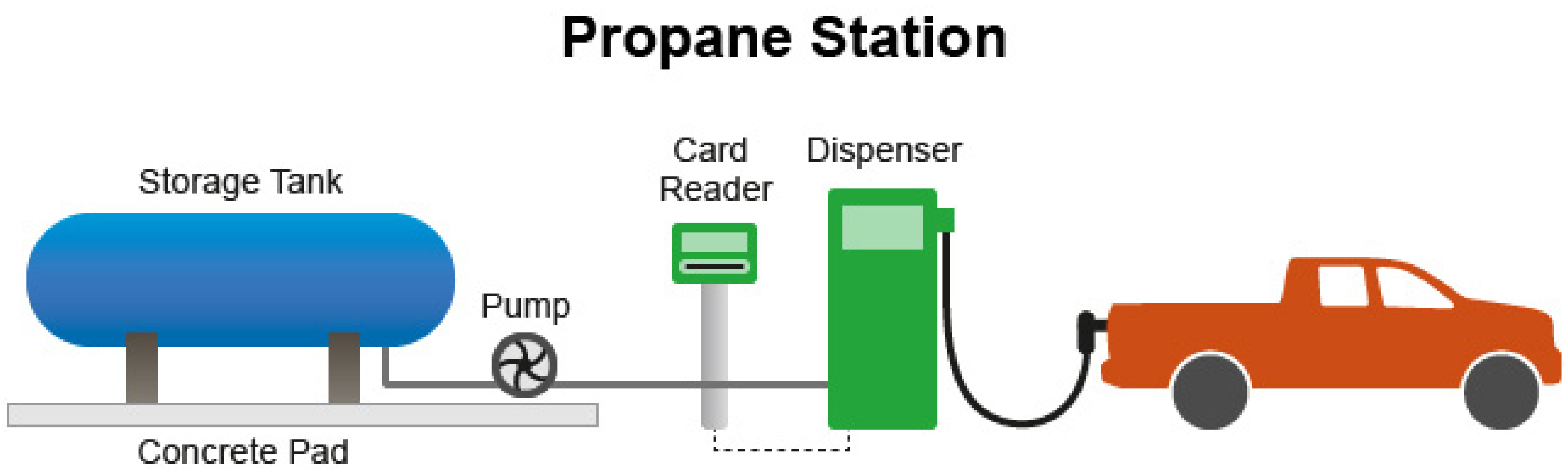


Image and More Information: AFDC Propane Fueling Infrastructure Development, http://www.afdc.energy.gov/fuels/propane_infrastructure.html

Case Study: Indiana DOT

- Since 2011, INDOT has deployed over 575 small and full-size pickup trucks and vans that have been converted to run on bi-fuel propane.
- INDOT installed 115 propane fueling sites at its facilities across the state

Just the Numbers

- **Propane Trucks & Vans**: 575+
- **Fuel cost savings:** $1.17 million in FY 2013 and more than $2.75 million since the program's inception

Image and More Information: National Clean Fleets Partner: Schwan's Home Service, http://www1.eere.energy.gov/cleancities/schwans.html

Basics: What is Biodiesel?

Feedstocks:

Vegetable oils, yellow grease, used cooking oils, tallow

Transesterification:

Oil or fat is reacted with a short-chain alcohol (usually methanol) and a catalyst (usually sodium hydroxide or rarely, potassium hydroxide)

Biodiesel

(fatty acid methyl esters or FAME)

+ Glycerin

Images: NREL Image Gallery #10504, #26449, #10568

Basics: Benefits and Considerations

Benefits

- Produced domestically
- Renewable substitute for petroleum diesel in conventional diesel engines
- Reduces greenhouse gas emissions
- Non-toxic, non-corrosive, and non-carcinogenic
- Improves fuel lubricity and raises the cetane number of the fuel
- Less combustible than petroleum diesel.

Considerations

- The higher the percentage of biodiesel above 20%, the lower the energy content per gallon
- B100 has a solvent effect and can release deposits that may clog filters (avoided by frequent filter replacements in the first few tanks of high-level blends)
- Gelling (or freezing) in cold temperatures.

Images: NREL Image Gallery #21940

Basics: Blends and Specifications

Blends	Description	Engine Modifications	Operation Considerations
Low-Level Biodiesel Blends	Blends B5 (5% biodiesel, 95% petroleum diesel) and below	None - safe for operation in any diesel compression-ignition engine	ASTM D975: petroleum diesel
B20	20% biodiesel, 80% petroleum diesel *1 diesel gallon equivalent (DGE) = 1.02 gallons of B20*	Generally, none - check engine warranty	ASTM D7467: blends between B6 and B20 Similar fuel consumption, horsepower, and torque to diesel
B100	100% biodiesel *1 DGE = 1.10 gallons of B100*	Check engine warranty Must use in vehicles with B100 compatible parts	ASTM D6751: B100 Can clean fuel systems and clog filters Gelling can occur in cold temperatures

Basics: Engine Compatibility

Biodiesel vehicles and conventional diesel vehicles are one and the same.

Before using biodiesel, **check your engine warranty** to ensure that higher-level blends will not void or affect it. All manufacturers accept the use of B5 and many accept the use of B20.

Helpful Resources:

- To determine which OEMs warranty their vehicles for biodiesel use above B5, visit the National Biodiesel Board's OEM Statement Summary Chart (biodiesel.org/using-biodiesel/oem-information/oem-statement-summary-chart). This website allows users to assess which vehicle models are capable of using biodiesel blends under warranty.
- For additional information on biodiesel, refer to the Clean Cities Biodiesel Handling and Use Guide (http://www.nrel.gov/docs/fy09osti/43672.pdf)

Images: NREL Image Gallery #17048

Vehicles: Applications

Light-Duty

- Light-duty trucks and passenger cars in private and government fleets
- Personal vehicles.

Medium-Duty

- Vans and shuttles
- Airports and taxi fleets.

Heavy-Duty

- Transit buses
- School buses
- Emergency responder vehicles
- Short-haul delivery trucks
- Bucket trucks
- Long-haul trucks
- Street sweepers.

Images: NREL Image Gallery #25206, #21775, #27237

Infrastructure: Storage Tanks

Underground Storage Tanks (UST)

- B100 can be stored underground in most cold climates without additional considerations. Storage temperatures should be at least 40º to 45ºF.
- All UST manufacturers have issued statements of compatibility with blends of up to 100% biodiesel.
- UST compatibility letters are available from the Petroleum Equipment Institute and the Steel Tank Institute.

Above Ground Storage Tanks (AST)

- B100 should not be stored aboveground (without proper insulation) at temperatures below 30º to 32ºF
- ASTs and handling systems should be protected with insulation, agitation, or heating systems if temperatures regularly fall below the cloud point of the blend being stored.
- All AST manufacturers have issued statements of compatibility with blends of up to 100% biodiesel.

Case Study: Partnerships Spark Biodiesel Success for Essential Baking Co. (Seattle, WA)

- Began running 11 long-term lease cargo vans on biodiesel in 2007
  - nine MY2005 Dodge Sprinters
  - two MY2008 Dodge Sprinters
- Uses a blend of 99% biodiesel and 1% petroleum diesel (B99) in most of its leased diesel vans without compromising the warranties or modifying the vehicles.

Just the Numbers

- **Number of Vehicles**: 11 leased delivery cargo vans
- **Emissions Reductions:** 320,000 pounds of CO_2 as of June 2012
- **Petroleum Displacement**: 400 barrels of oil as of June 2012

"The Essential Baking Company's success with biodiesel is the result of close collaboration among the fleet, leasing company, and fuel provider. This highlights the benefit of a 'coalition' approach to alternative fuel adoption. All three entities are key ingredients in the ongoing success of the project."

—George Taylor, Director of Transportation

Image and More Information: Alternative Fuels Data Center (AFDC) Case Study Search, Partnerships Spark Biodiesel Success for Essential Baking Co, http://www.afdc.energy.gov/case/1204

Basics: Electricity as a Fuel Source

Electricity is considered an alternative fuel under the Energy Policy Act of 1992.

Electric drive vehicles use electricity from on- or off-board electrical power sources and store it in batteries.

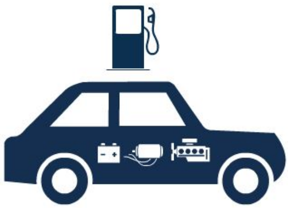
Images: Alternative Fuels Data Center (AFDC) and NREL Image Gallery #26685

Basics: Benefits and Considerations

Benefits	Considerations
• Increased energy security • Improved fuel economy • Lower fuel costs • Low or zero tailpipe emissions	• Higher initial vehicle cost • Limited infrastructure availability • Battery life • Reduced all-electric range

Image: NREL Image Gallery #28974

Basics: Electric Drive Vehicles



Hybrid Electric Vehicle (HEV)

- **Powered by an engine and electric motor**
- **Does not use electric vehicle supply equipment (EVSE) to charge the battery**

Plug-In Hybrid Electric Vehicle (PHEV)

- **Powered by an electric motor and engine**
- **Uses EVSE to charge the battery**

All-Electric Vehicle (EV)

- **Powered by an electric motor**
- **Uses EVSE to charge the battery**

Images: NREL Image Gallery #24508, #18563, #24516

Vehicles: Vehicle Availability

Light-Duty

- HEVs, PHEVs, and EVs widely available
- New models rolling out nationwide

Medium-Duty

- Variety of HEVs, PHEVs, and EVs available
- New models becoming available
- Certified conversions an option

Heavy-Duty

- Several HEV makes and models available
- Light hauling, delivery, and off-road service

Images: NREL Image Gallery #29832, #22849, #25210

Infrastructure: Electric Vehicle Supply Equipment (EVSE)

	Current Type	Voltage (V)	Charging Time	Primary Use
Level 1	Alternating Current (AC)	120V	2 to 5 miles of range per hour of charging	Residential
Level 2	AC	240V	10 to 20 miles of range per hour of charging	Residential Commercial
Level 3 *(Pending Industry Consensus)*	*Undefined*	*Undefined*	*Undefined*	*Undefined*
DC Fast	Direct Current (DC)	480V	60 to 80 miles of range per 20 minutes of charging	Commercial
Wireless	AC	240V	10 to 20 miles of range per hour of charging	Residential Commercial

Image: NREL Image Gallery #26453

Case Study: Seattle Rideshare Fleet

- Largest publicly owned and operated commuter van program in the nation
- Introduced first EVs (20 Nissan Leafs) into the 1,300-vehicle fleet in 2011

Just the Numbers

- **Fleet Type:** Publicly owned and operated commuter van program
- **Fuel:** Electricity
- **Vehicles:** 25 Nissan Leafs
- **Greenhouse Gas Emissions Reduction:** 24 metric tons per month
- **Petroleum Reduction:** 218,000 gallons over seven years

"The project successfully demonstrated that EVs can compete head-to-head with conventional gasoline vehicles in the rideshare duty cycle; EVs generated cost savings and big environmental wins."

— Syd Pawlowski, King County Metro Rideshare Operations

Image and More Information: AFDC Case Study Search, Seattle Rideshare Fleet Adds EVs, Enjoys Success, http://www.afdc.energy.gov/case/1843

Basics: What Is Ethanol?

C_2H_5OH

Plant Materials (Biomass)

- Blended at low levels into more than 95% of gasoline sold in the United States
- Increasingly available as E85 for use in flexible fuel vehicles (FFVs)

Image: NREL Image Gallery #21776

Basics: Benefits and Considerations

Benefits

- Domestically produced
- Net positive energy production
- Increased vehicle power and performance
- Job creation in rural areas
- Lower life cycle greenhouse gas (GHG) and criteria pollutant emissions
- Affordable vehicle options widely available

Considerations

- Lower fuel economy
- Blends above E10 require modification of some infrastructure materials

Image: NREL Image Gallery #18090

Basics: Blends

Category	Blend	Applications
E10 **Low-level blend**	10% Ethanol 90% Gasoline	• Most common blend in the United States • Can be used in any gasoline vehicle
E15 **Low-level blend**	10.5%-15% Ethanol 85%-89.5% Gasoline	• U.S. Environmental Protection Agency (EPA) approved for Model Year (MY) 2001 and newer vehicles
Mid-level or blender-pump blends	Variable (E20, E30 most common)	• Used in FFVs
E85	51%-83% Ethanol	• Qualifies as an alternative fuel under Energy Policy Act of 1992 (EPAct) • Used in FFVs

Vehicles: Flexible Fuel Vehicles (FFVs)

FFVs

- Qualify as alternative fuel vehicles under EPAct
- Operate on gasoline, E85, and lower-level blends
- Comparable acceleration, payload, and speed to gasoline vehicles

Images: NREL Image Gallery #1809 and #17156

Infrastructure: Types

Existing E85 Stations

- Ask about fleet discounts
- Communicate potential E85 demand

Converting Existing Equipment to E85

- Use newer equipment that is clean and in good condition
- Use a contractor that knows state and local rules

Installing New E85 Equipment

- Research local regulations
- Hire a professional with E85 experience
- Contact the state energy office, industry associations, and Clean Cities

Image: NREL Image Gallery #17138

Case Study: City of Hoover Fleet

- Significantly increased FFVs
- Installed a 12,500-gallon E85 tank in 2004
- Improved local air quality, decreased GHG emissions, and increased energy security

"In 2006, our use of alternative fuels earned a visit from the president of the United States. Over the years, more than 100 representatives of local governments, fleets, and other organizations have come to Hoover to see how a progressive Southern city successfully uses alternative fuels."

—Mayor Gary Ivey, City of Hoover, Alabama

Just the Numbers

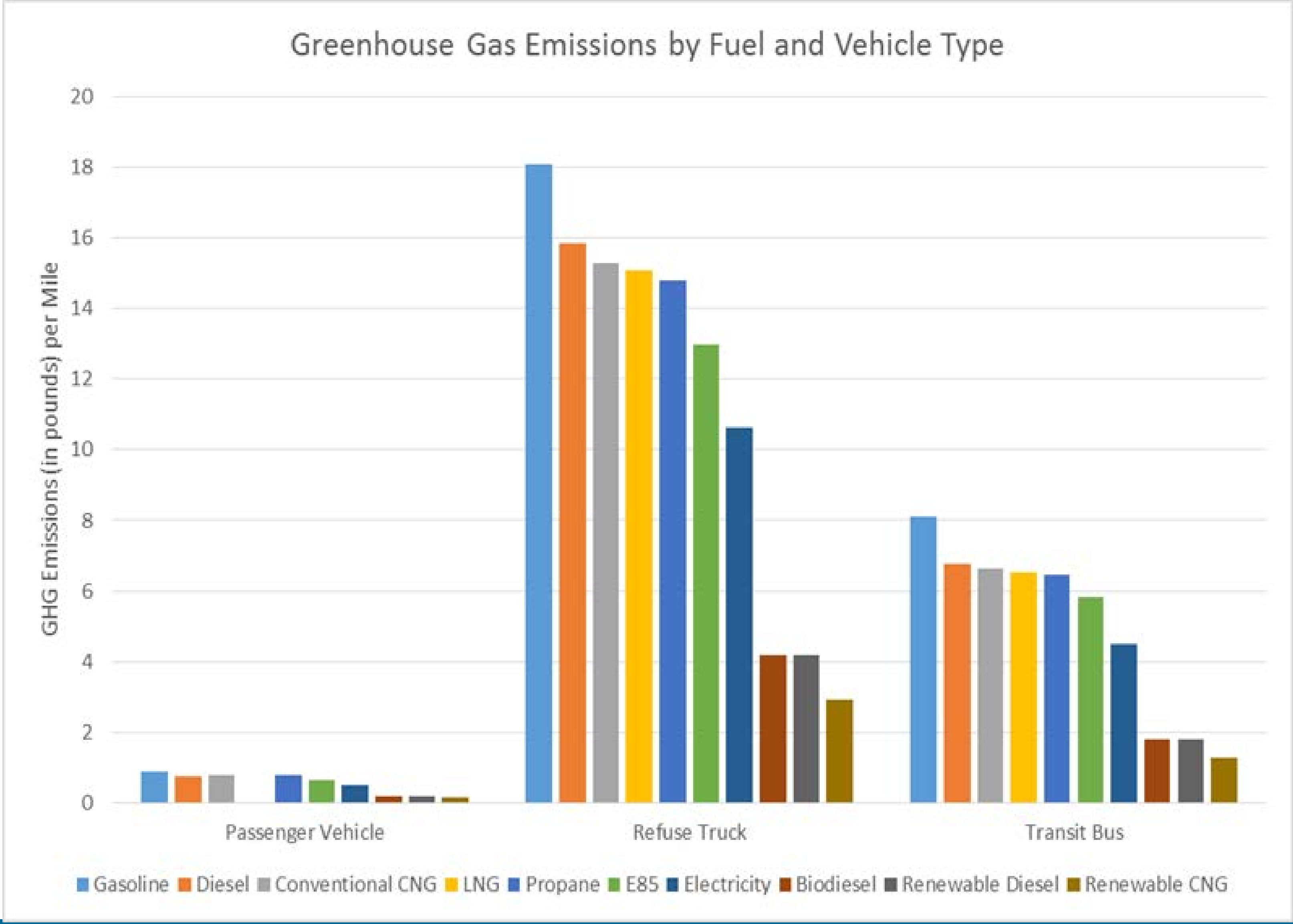
- **FFVs in 2003**: 9
- **FFVs in 2013:** 212
- **Gallons of E85 used:** More than 1.5 million

Image and More Information: AFDC Case Study Search, City of Hoover Fleet Boasts 200-Plus Flex Fuel Vehicles, http://www.afdc.energy.gov/case/1423

Sample Fuel GHG Comparisons

	Life Cycle GHG Emissions (lb) per Mile		
Fuel	Passenger Vehicle	Refuse Truck	Transit Bus
Gasoline	0.88	18.08	8.11
Diesel	0.74	15.85	6.79
CNG – Conventional	0.78	15.29	6.63
Renewable CNG – Landfill	0.15	2.93	1.27
LNG – Conventional	N/A	15.07	6.53
Propane	0.77	14.78	6.47
E85 – Corn	0.63	12.98	5.83
Electricity	0.49	10.62	4.51
Biodiesel – B100, Soy	0.20	4.17	1.80
Renewable Diesel – Soy	0.20	4.17	1.80

Sample Fuel GHG Comparisons



State DOT Fleet Alt Fuel Consumption

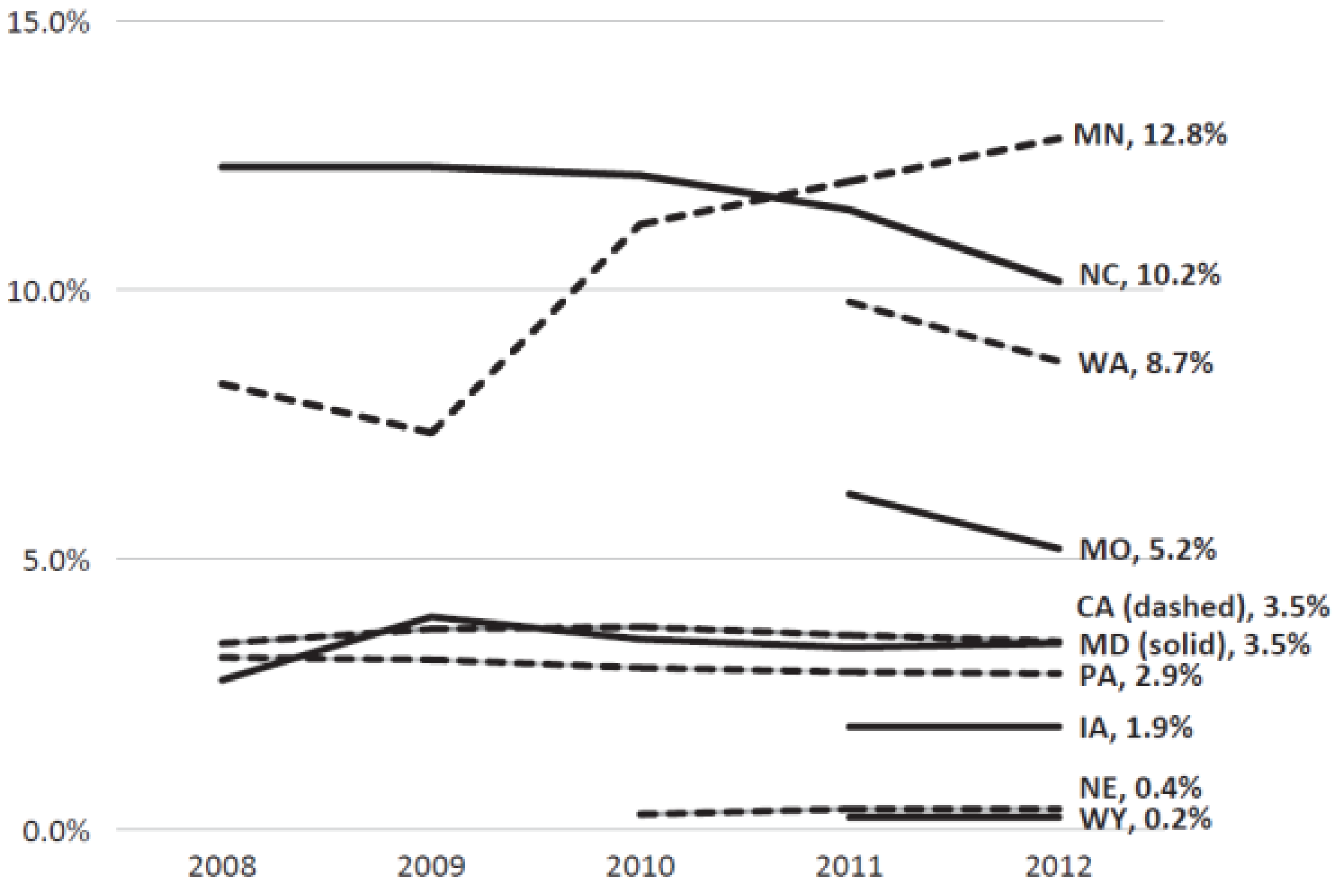


Figure 3. Alternative fuels as percentage of total DOT fleet fuel consumption volume basis: 2008 through 2012.

Natural Gas References and Resources

- AFDC Light-Duty Vehicle Search (http://www.afdc.energy.gov/vehicles/search/light/)
- AFDC Heavy-Duty Vehicle and Engine Search (http://www.afdc.energy.gov/vehicles/search/heavy)
- AFDC Station Locator (http://www.afdc.energy.gov/locator/stations/)
- AFDC Vehicle Cost Calculator (http://www.afdc.energy.gov/calc/)
- AFDC Federal and State Laws and Incentives (http://www.afdc.energy.gov/laws/)
- AFDC Natural Gas Fueling Infrastructure Development (http://www.afdc.energy.gov/fuels/natural_gas_infrastructure.html)
- AFDC interactive fueling animation (http://www.afdc.energy.gov/vehicles/cng_tank_animation.html)
- Clean Cities, *Costs Associated with CNG Vehicle Fueling Infrastructure* (http://www.afdc.energy.gov/uploads/publication/cng_infrastructure_costs.pdf)
- Clean Cities, *Case Study – CNG Refuse Fleets* (http://www.afdc.energy.gov/uploads/publication/casestudy_cng_refuse_feb2014.pdf)
- NREL, VICE 2.0 (http://www.afdc.energy.gov/uploads/publication/vice2-0.pdf)
- Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool (https://greet.es.anl.gov/afleet)
- Clean Vehicle Education Foundation, *Guideline for Determining Modifications Required for Adding CNG and LNG Vehicles to Existing Maintenance Facilities* (http://www.cleanvehicle.org/committee/technical/PDFs/GuidelinesDocumentFinal.pdf)
- Natural Gas Vehicle Institute, *Facilities Modification for Natural Gas Vehicles* (http://www.ngvi.com/Documents/FacilitiesModificationforNaturalGasVehiclesPaper_000.pdf)
- NFPA 52, Vehicular Gaseous Fuel Systems Code, and NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages (http://www.nfpa.org/)

Propane References and Resources

- AFDC Alternative Fuel and Advanced Vehicle Search (http://www.afdc.energy.gov/vehicles/search)
- AFDC Alternative Fueling Station Locator (http://www.afdc.energy.gov/locator/stations/)
- AFDC Vehicle Cost Calculator (http://www.afdc.energy.gov/calc/)
- AFDC Petroleum Reduction Planning Tool (http://www.afdc.energy.gov/prep/)
- AFDC Federal and State Laws and Incentives (http://www.afdc.energy.gov/laws/)
- AFDC Propane Fueling Infrastructure Development (http://www.afdc.energy.gov/fuels/propane_infrastructure.html)
- AFDC Propane Vehicles (http://www.afdc.energy.gov/vehicles/propane.html)
- Argonne National Laboratory's (ANL's) Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool (https://greet.es.anl.gov/afleet)
- CARB Certified Conversions List (http://www.arb.ca.gov/msprog/aftermkt/altfuel/altfuel.htm)
- Clean Cities Costs Associated With Propane Vehicle Fueling Infrastructure (http://www.afdc.energy.gov/uploads/publication/propane_costs.pdf)
- EIA Propane Delivery (http://www.eia.gov/energyexplained/index.cfm?page=propane_delivery)
- EPA Certified Conversions List (http://epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm)
- PERC Certified Propane Autogas Vehicles List http://www.propane.com/uploadedFiles/Propane/On_Road_Fleets/Propane_Conversions/Octobe2014OTRManufacturerListingPublicView.pdf
- PERC Propane Autogas Repair and Maintenance Facility Requirements (http://www.propane.com/uploadedFiles/Propane/On_Road_Fleets/Safety/autogas%20repair%20and%20maintenance1.pdf)

Biodiesel Reference and Resources

- *Biodiesel Handling and Use Guide,* NREL (http://www.nrel.gov/docs/fy09osti/43672.pdf)
- AFDC Light- and Heavy-Duty Vehicle Searches (afdc.energy.gov/tools)
- AFDC Station Locator (http://www.afdc.energy.gov/locator/stations/)
- AFDC Federal and State Laws and Incentives search (http://www.afdc.energy.gov/laws/)
- AFDC Petroleum Reduction Planning (PREP) Tool (http://www.afdc.energy.gov/prep/)
- National Biodiesel Board Original Equipment Manufacturer Statement Summary Chart (biodiesel.org/using-biodiesel/oem-information/oem-statement-summary-chart)
- Argonne National Laboratory AFLEET Tool (https://greet.es.anl.gov/afleet)
- U.S. Environmental Protection Agency (EPA) Renewable Fuels Standard (RFS2) website (http://www.epa.gov/otaq/fuels/renewablefuels/) and RFS2 Data page (http://www.epa.gov/otaq/fuels/rfsdata/2014emts.htm)
- U.S. Energy Information Administration Annual Energy Outlook (http://www.eia.gov/forecasts/aeo/)
- Petroleum Equipment Institute (PEI) Tank Compatibility Letters (http://www.pei.org/PublicationsResources/ComplianceFunding/USTComponentCompatibilityLibrary.aspx)
- Steel Tank Institute (STI) Tank Compatibility Letters (http://www.steeltank.com/Publications/E85BioDieselandAlternativeFuels/ManufacturerStatementsofCompatibility/tabid/468/Default.aspx)

Electric Vehicle References and Resources

- AFDC Vehicle Cost Calculator (http://www.afdc.energy.gov/calc/)
- AFDC EV Emissions page (http://www.afdc.energy.gov/vehicles/electric_emissions.php)
- AFDC Alternative Fuel and Advanced Vehicle Search (http://www.afdc.energy.gov/vehicles/search)
- AFDC Station Locator Database (http://www.afdc.energy.gov/locator/stations/)
- FuelEconomy.gov's Alternative Fuel Vehicles (AFV) page (http://www.fueleconomy.gov/feg/alternatives.shtml)
- Clean Cities Plug-In Electric Vehicle Handbook for Fleet Managers (http://www.afdc.energy.gov/pdfs/pev_handbook.pdf)
- Clean Cities Plug-In Electric Vehicle Handbook for Workplace Charging Hosts (http://www.afdc.energy.gov/uploads/publication/pev_workplace_charging_hosts.pdf)
- Clean Cities Plug-In Electric Vehicle Handbook for Public Charging Station Hosts (http://www.afdc.energy.gov/pdfs/51227.pdf)
- Clean Cities 2015 Vehicle Buyer's Guide (http://www1.eere.energy.gov/cleancities/publications.html)
- Argonne National Laboratory's (ANL) *Well-to-Wheels Energy Use and Greenhouse Gas Emissions Analysis of Plug-in Hybrid Electric Vehicles* report (http://www.transportation.anl.gov/pdfs/TA/559.pdf)
- Electric Drive Transportation Associations (EDTA) Electric Drive Sales Dashboard (http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952)
- National Fire Protection Association EV Safety Training (http://www.evsafetytraining.org)
- National Alternative Fuels Training Consortium First Responder Safety Training (http://www.naftc.wvu.edu/course_workshop_information/first_responders)
- Plug In America's Vehicle Tracker (http://www.pluginamerica.org/vehicles)

Ethanol References and Resources

- Clean Cities *Handbook for Handling, Storing, and Dispensing E85 and Other Ethanol-Gasoline Blends* (http://www.afdc.energy.gov/uploads/publication/ethanol_handbook.pdf)
- AFDC Alternative Fueling Station Locator (http://www.afdc.energy.gov/locator/stations/)
- AFDC Federal and State Laws and Incentives search (http://www.afdc.energy.gov/laws)
- AFDC Alternative Fuel and Advanced Vehicle Search (http://www.afdc.energy.gov/vehicles/search)
- AFDC Vehicle Cost Calculator (http://www.afdc.energy.gov/calc/)
- AFDC Petroleum Reduction Planning Tool (http://www.afdc.energy.gov/prep/)
- FuelEconomy.gov Hybrids, Diesels, and Alternative Fuel Vehicles (http://www.fueleconomy.gov/feg/alternatives.shtml)
- Argonne National Laboratory's (ANL's) AFLEET Tool (https://greet.es.anl.gov/afleet)
- EPA Alternative Fuel Conversion (http://www.epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm)
- Congressional Budget Office (CBO) *The Impact of Ethanol Use on Food Prices and Greenhouse-Gas Emissions* (http://www.cbo.gov/ftpdocs/100xx/doc10057/04-08-Ethanol.pdf)
- National Renewable Energy Laboratory (NREL) *Water Usage for Current and Future Ethanol Production* (http://www.swhydro.arizona.edu/archive/V6_N5/feature4.pdf)

For More Information

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Clean Cities Website: www.cleancities.energy.gov

Alternative Fuels and Advanced Vehicles Data Center: www.afdc.energy.gov

Fuel Economy: www.fueleconomy.gov

Clean Cities Coordinator Contact Information and Coalition Web Sites:
www.afdc.energy.gov/cleancities/progs/coordinators.php

Clean Cities Technical Response Service: technicalresponse@icfi.com, 800-254-6735

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