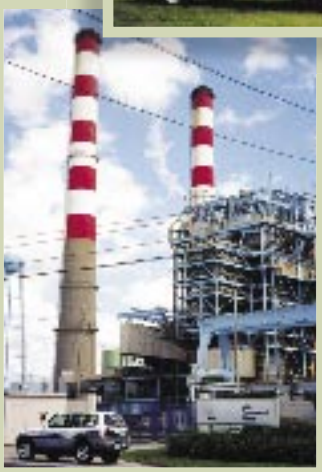
A Guide to Alternative Fuel Transportation in Florida



Clean Fuel Florida Advisory Board

A Guide to Alternative Fuel Transportation in Florida

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Guide to Alternative Fuel Transportation in Florida

I. Setting a Direction

Over time, the modes of transportation have changed dramatically and with these changes have come important environmental and economic impacts on our world.

Getting About in Florida

In 1513, Juan Ponce de Leon [1] sailed from Spain and discovered the land we now call Florida. Since then, people have used many forms of transportation. Early settlers came by sailing ships, and were soon followed by pioneers arriving on horses and in covered wagons. As the era of industrialization arrived, the means of transportation to and within Florida changed. Steam-powered trains and boats dominated Florida transportation until the discovery of oil in Pennsylvania and its refinement into gasoline in 1885 [2]. This new fuel changed the face of the transportation industry, as advances in automotive design established the gasoline-powered automobile as the most accepted form of transportation. In the late 1880's, gasoline was the alternative fuel. Today, gasoline-powered vehicles dominate the market.

Commercial business demands and the general public's desire to travel greater distances in less time drove the automotive industry to introduce higher-performance vehicles. Private cars such as the GTO, Mustang and Camaro – the muscle machines of the late 1960's - arrived on the scene. America's appetite for speed and distance was severely impacted in the 1970's when the energy crises occurred and the flow of gasoline diminished sharply. In short, America received a wake up call. To our surprise, there was not an endless supply of crude oil. About the same time, we learned that gasoline-powered vehicles accounted for a significant portion of the polluted air affecting our health. Along with the benefits gained from the use of gasoline powered vehicles comes a price that must be paid.

Citicar charging at Photovoltaic Test Facility at Florida Solar Energy Center (1991)

Since the oil crisis of the 1970s, greenhouse gases, energy security and global warming have become factors in the design of the modern car. As a result, manufacturers began to recognize the need for the automobile to be "environmentally friendly." Detroit auto manufacturers worked at reducing emissions of greenhouse gases and other pollutants into the air and engineered greater miles-per-gallon fuel efficiency. Hence, a movement was on to develop a cleaner, more energy-efficient vehicle. The need for alternative fuels, fuels other than gasoline and diesel, was becoming recognized. In 1973, a new company in Sebring, Florida, named Sebring Vanguard [3], produced an electric vehicle call the "Citicar." Both the car and the company were short-lived, as oil began to flow again and attention to the energy crisis lessened.

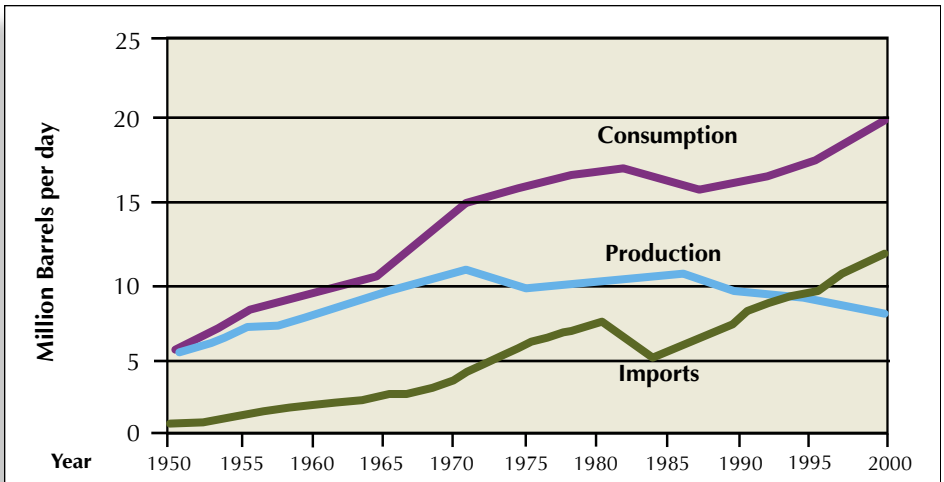
The United States highway transportation sector is essentially dependent on external petroleum fuels, because oil consumption has exceeded domestic oil production. Our country is slowly coming to the realization that oil-producing nations that hold the majority of the world's reserves have the power to dictate the price and availability of what has become a critical international commodity. Oil is a finite commodity. Increasing development of domestically produced alternative fuels and alternatively-fueled vehicles is key to a secure future. Development efforts to date have resulted in production of durable and reliable vehicles that are safe and less damaging to the environment. While Florida now has several thousand alternatively-fueled vehicles on the road, the utilization trend is modest, primarily due to reluctance to fund cost factors associated with some vehicles.

Let's All Go to Florida

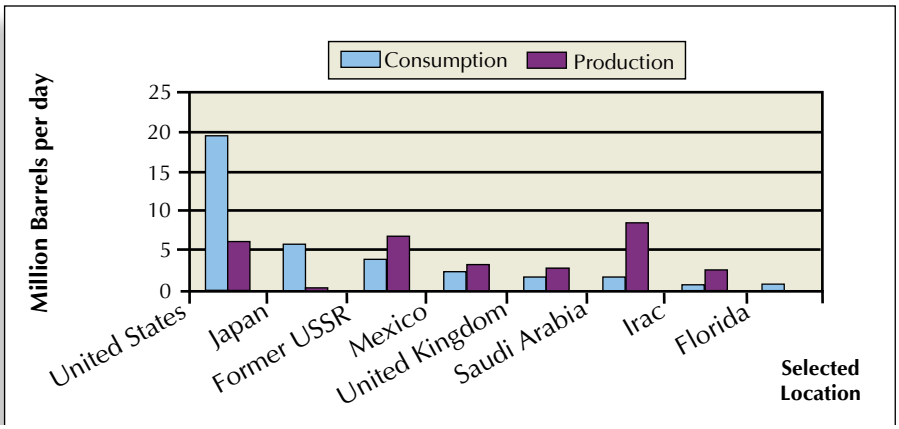
Florida has the fourth largest population in the country with over 15.9 million people [4]. The state has experienced a 23.5 percent increase in population since the 1990 census. Fourteen million Floridians hold a driver's license and operate 11.9 million vehicles on the state's 115 thousand miles of highway. In 2000, over 71.4 million visitors came to Florida to do business, enjoy tourist attractions, attend car races and relax on the beaches. Tourists add another 5.9 million rental vehicles to our highways. How do we provide the energy to power so many vehicles?

CNG powered tour bus at Kennedy Space Center

The United States' dependence on oil as a transportation fuel source has grown dramatically. In 1994, the U.S. imported more crude oil than it produced. Today, our country consumes more than one-fourth of the world's oil, yet produces less than one-tenth domestically. In 2000, world crude oil production amounted to 67 million barrels per day and the U.S. consumed more petroleum than any other country [5].

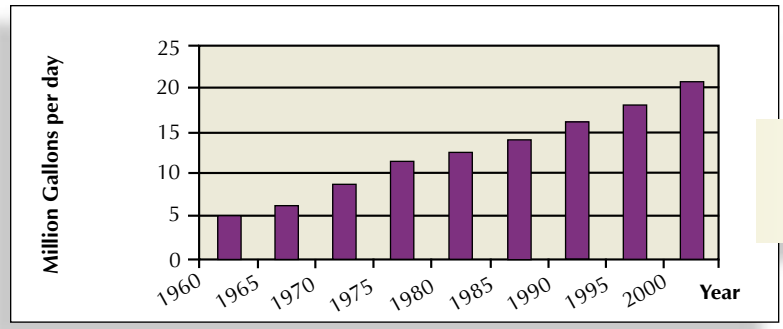


Graph 1 - History of U.S. petroleum consumption and supply. EIA 2000 [6]

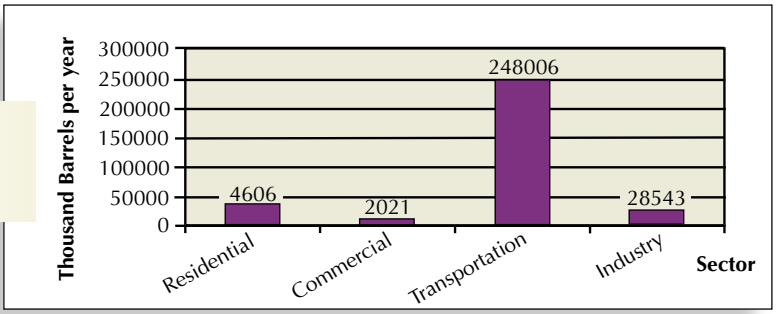


Graph 2 - World oil/petroleum consumption and production. - EIA 2000 [5,7,8]

Consumers in Florida use over 20.6 millions gallons of gasoline each day and the state ranks third in the country in consumption of petroleum yearly. Large volumes of gasoline are transported into Florida to meet this demand, as Florida produces only enough crude oil to refine 1.9 million gallons of gasoline annually. U.S. consumption patterns are not matched by reserves of petroleum, and imports exceed domestic supplies in an ever increasing percentage. The U.S. holds approximately 6 percent of known oil reserves in the world [9], of which Florida holds a percentage too small to mention.

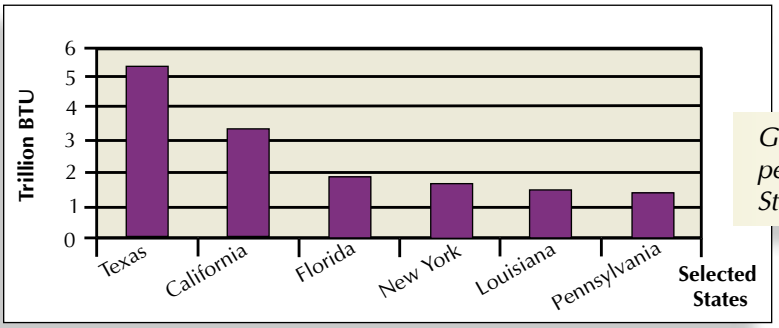


Graph 3 - Florida Daily Motor fuel consumption for highway use. EIA/CUTR [10]



Graph 4 - Florida Petroleum Consumption by sector. EIA State [11]

Transportation is an integral part of our daily living. The rural nature of Florida yields a transportation system mostly dependent on individual vehicles rather than mass transit. The vast majority of these vehicles use gasoline or diesel, thus creating a dependence on petroleum. The U.S. spends $55 billion each year on oil imports, and 60 percent of those imports are used for transportation. This represents 18 percent of the Gross National Product (GNP) [12].



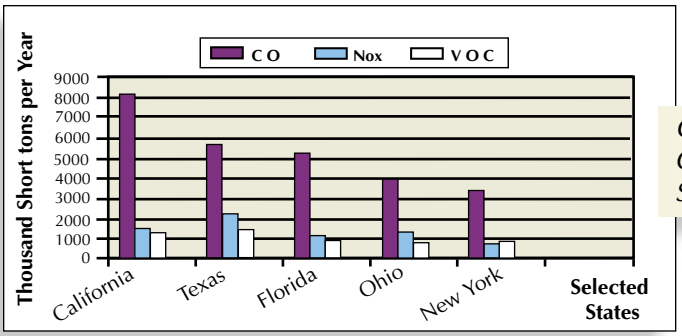
Graph 5 - Energy consumption in petroleum for selected states. EIA State [13]

What Beautiful Skies We Have

One of the greatest attractions in Florida is the weather. Florida is known as the Sunshine State due to its beautiful blue, sunny skies and warm temperatures. While many people enjoy walking along the beach, the view may be breath-taking in more than one way, as exhaust from passing cars fills the air. The automobile is a major source of pollution. In numerous cities across the country and in Florida, the personal automobile is the single greatest contributor of carbon monoxide and ground level ozone. When sunlight reacts with nitrogen oxides and volatile organic compounds, ozone or smog is produced. Air pollution ruins our beautiful scenery, damages the environment and creates health risks.

What impact does our state and others have on air quality? The U.S. is the world's largest producer of carbon dioxide (CO_2), which is the principle cause of global warming. The transportation sector in the U.S. accounts for about 33 percent of CO_2 and nitrogen oxide (NO_x) [14] emissions, 77 percent of carbon monoxide (CO) emissions and more than 33 percent of the volatile organic compounds (VOC) found in the air we breathe. California is the most populated state in the country and leads all other states in vehicle registrations and polluting emissions. Florida is in the top four states in population and number three in registrations and emissions. California has long been plagued by Los Angeles' smog

and is a leader in research and legislation on air pollution. Residents suffer from poor air quality caused by the large concentration of pollutants. The situation is aggravated by stagnant air in a mountainous terrain, while Florida's flat terrain and tropical breezes cause most pollutants to be blown away. It is mainly during the summer, when the air is stagnant, that we feel the effects of pollution before it is passed on to our neighbors. Five states lead the country in transportation-related pollution (see Graph 6 below).



Graph 6 - State-level Emissions for Criteria Pollutants Transportation Sector 1998. TEDB [15]

The atmosphere surrounding the earth is a mixture of gases composed primarily of 21 percent oxygen and 78 percent nitrogen. Water vapor, argon, carbon dioxide, hydrogen, neon, helium, krypton and xenon make up the rest. Many processes affect the atmosphere, such as human and animal activities, the decay of vegetation and combustion. The automobile's internal combustion engine (ICE) adds water vapor and carbon dioxide to the atmosphere during complete combustion of a hydrocarbon fuel, such as gasoline. Incomplete combustion adds to the exhaust carbon monoxide, nitrogen oxide, nitrogen dioxide, ozone, sulfur dioxide, hydrogen and hydrogen sulfide, as well as innumerable classes of unburned hydrocarbons and particulates. Leaks and evaporation from fuel systems add to the pollution. With these sobering facts in mind, the importance of seeking alternatives to our existing patterns of energy consumption becomes clear. And those alternatives are available. Alternative fuels vehicles (AFV) produce less of the emissions described above, while the electric vehicle (EV) produces none on-board. The use of renewables to produce the fuel, and photovoltaics to generate electricity, decreases emissions even further.

Emission testing of a hybrid.

Utility interactive photovoltaic power system charging an electric vehicle in New Smyrna Beach.

Given present population trends, as more and more people come to Florida, emissions will be generated beyond the capability of nature to handle. The use of cleaner fuels and a decrease in petroleum fuel consumption would reduce the impact transportation has on our air quality. Then, we would be able to breathe easier and continue to enjoy the natural beauty of our state.

Pollution reaches beyond the air we breathe. The environmental impact of automobiles and the fuel they use starts with their birth and continues beyond their death and disposal. Ecological concerns exist with the factories that manufacture vehicles and the parts and materials that go into them. Vehicle disposal contaminates the air, water, and land except for components that are recycled. Cars can leak oil, brake fluid, transmission fluid, coolant, fuel, grease and other materials. Petroleum fuels are

poisonous to humans, plants, and animals. Air and water pollution occurs at oil wells, refineries, filling stations, underground storage tanks and during distribution. Also, non-point source water pollution occurs when rains washes leaked automotive fluids into lakes, rivers, and the ocean.

II. Clean Transportation

As the technology of individual modes of transportation changes, environmental issues, challenges and opportunities change as well.

Electric Eco-tour boat on the Indian River Lagoon

Maintaining the Beauty of Florida with Clean Transportation

What kind of transportation do you use to travel to the places you frequent in your daily life? Perhaps you are a traveling salesperson, or you may live in the country and work in the city. You may be a parent transporting children to school or various activities. Your daily routine defines your transportation needs. In your travels, do you drive a car or truck, ride a bike, use mass-transportation or even walk to the places you need to go?

ElectroWave, Electric bus moving people on Miami Beach.

Gasoline and diesel-powered vehicles make up over 95 percent of the vehicles traveling on the roads today. Each vehicle adds to the smog over our cities and affects our place in the international economy of the world. One can ask, what part do my transportation needs play in this big picture?

As awareness of air quality issues grows, individuals can employ many creative ways to positively impact the environment, such as car pooling, use of mass-transportation and walking. But what can you do if your lifestyle requires your own individualized transportation? You can consider making a change to an Alternatively Fueled Vehicle (AFV). Vehicles that use biodiesel, electricity, ethanol, hydrogen, liquefied petroleum gas, methanol, or natural gas offer one solution to environmental and economic problems, while meeting transportation needs with little change in present lifestyle. Alternative fuels are substantially non-petroleum and yield energy security and environmental benefits.

AFVs look, drive, handle and function similarly to conventional cars and trucks. AFVs are designed to utilize fuel in five major categories listed in Table 1. In Florida, the flat topography and relatively warm climate are ideal for many types of alternative fuel vehicles.

Table 1 - Major categories of AFVs and fuel supply. [20]

- Dedicated - designed to use only one specific fuel or energy source
- Bi-fuel - capable of operating on two different fuels, but not at the same time
- Dual fuel - capable of operating on two different fuels simultaneously in one engine
- Flex-fuel - capable of operating on two different fuels blended into one tank: an alternative fuel and one conventional fuel
- Hybrid - uses two or more energy sources; either or both sources would provide power

Gasoline/electric hybrid car and an electric kit car at AFV Odyssey Day Workshop.

Propane fueled police car with an electric bike at Coconut Creek.

A dedicated fuel vehicle is similar to the one you probably drive today, except that it utilizes an alternative fuel or energy source. Many fleets use dedicated propane and natural gas vehicles, such as the Post Office.

Bi-fuel/flex-fuel/dual fuel vehicles are capable of operating on an alternative fuel and conventional petroleum fuel. An example of a bi-fuel vehicle would be a vehicle that uses gasoline and natural gas in the same engine and where the on-board computer draws from the selected fuel tank based on fuel volume.

A hybrid vehicle represents quite a different technology, with multiple power sources such as a gasoline engine and an electric motor powering the drive train. Hybrid vehicles are either parallel or series configuration. Parallel hybrids use either or both sources of power at the same time, depending on load conditions. An example of a parallel system would be an electric motor coupled to a gasoline engine. A series hybrid uses only one source of power to the transmission or drive train and the additional power source would provide backup or range extension. An example of a series system would be an electric motor drive train and a compressed natural gas engine generator. The current average fuel efficiency of a conventional gasoline car is 20 miles per gallon (mpg), while a few of the latest hybrids are getting approximately 60 mpg. Hybrids also include advanced technology vehicles that use a hydrogen fuel cell power source in combination with another fuel or energy source.

Fuel Types and Characteristics

Each fuel type has specific characteristics, which should be carefully examined with respect to the operating needs of the vehicle. Some fuel sources have been available for many years, while others are more recent in adaptation to public and private use. Ongoing research is being conducted to develop innovative and advanced automotive technologies and fuel sources. A comparative description of the most widely used alternative fuels is provided in Table 2.

Table 2 - Summary Comparison of Fuels. Clean Cities [17]

	Primary Elementary Components	Octane Rating	Energy per gallon BTU	Liquid or Gas
Gasoline	C4 to C12	83-98	114,000	Liquid
Compressed Natural Gas (CNG)	CH4	120-127	29,000	Gas
Liquefied Natural Gas (LNG)	CH4	120-127	73,500	Liquid
Liquefied Petroleum Gas (LPG)	C3H8	89-104	84,000	Liquid
Ethanol (E85)	CH3CH20H	92-111	80,460	Liquid
Methanol (M85)	CH3OH	91-112	65,350	Liquid
Hydrogen	H2	130+	61,000	Gas
Electric	Electron	NA	3413 BTU/kWh	NA

Yesterday and Today

Thirty years ago, most AFVs looked quite different from conventional cars, as manufacturers attempted to redesign the whole automotive concept to address environmental concerns and maintain fuel efficiency. Now, the most noticeable difference is under the hood or in the tank and not in the body of the car. Three distinct fuel forms may be used: liquid, gas, and electricity. Liquid and gas fuels, such as natural gas, propane, biodiesel, P-series, ethanol and methanol are used in an internal combustion engine (ICE) similar to the engine in a gasoline car. The electric-powered car uses components radically different from a conventional gasoline car and stores electricity in batteries as a fuel source to power an electric drive motor. AFV maintenance and operating costs are often less than with conventional gasoline cars. As for safety, many AFVs have proven to be safer than gasoline vehicles.

Electric bus and hydrogen pickup truck at Kennedy Space Center

Compressed Natural Gas fueling station at Patrick Air Force Base.

Alternative fuel vehicles come in a variety of sizes and types. There are light and heavy-duty trucks, including garbage and semi trucks, and sporty and traditional-looking cars. They originate from one of two sources: Original Equipment Manufacturer (OEM) and Conversions companies. OEM's vehicles are *new* vehicles built by companies like Ford, Chrysler, General Motors, Honda and Toyota. These vehicles are typically sold through authorized dealerships. *Conversions* are vehicles modified by the owner or a third party into an AFV. Conversion is sometimes the only way of getting a particular model of vehicle. Conversions may not perform as well as OEM vehicles, but they are required to meet the same government regulations (as described in EPA Memorandum1A).

A difference in the process of fueling may not be noticeable when pumping ethanol or methanol.

However, gaseous fuels are pumped in a similar fashion to putting air in tires or filling a propane gas tank, but require the use of a pressure hose and connector. An electric car plugs into an electrical receptacle just like electrical appliances in your home, but at higher current ratings.

A new concept for an electric car was recently approved by the Federal Highway Administration and is called the Neighborhood Electric Vehicle (NEV). This new class of vehicle is street legal on roads marked 25 miles per hour or less. These vehicles are being used for community watch activities and social events because they are non-intrusive and quiet.

Sheriff's Department using an NEV in Cape Canaveral.

Some performance differences exist between an AFV and its petroleum counterparts that affect range, fueling, and cargo space. The range of an electric car may be less because the battery pack does not hold as much energy per volume as gasoline. Hybrid vehicles offer a variety of energy sources; therefore, a user may need to be familiar with handling multiple fuel sources, depending on what kind of car is owned. Another difference is in measuring the amount of fuel on-board. Natural gas and hydrogen are not liquids and are contained in pressure vessels that impact cargo space. Their volume is measured in cubic feet rather than gallons. A way of comparing volumes of liquid and gas fuels is to use the Gasoline Gallon Equivalent (GGE) where equivalent volumes of fuel are compared based on energy content in British Thermal Units (BTUs). All of the liquid fuels' BTUs are based on the energy in one liquid gallon.

Finding Information

There are many avenues to follow to obtain information on types and models of Alternative Fuel Vehicles. Each manufacturer maintains a web site with the latest specifications on available models.

To encourage the use of Alternative Fuel Vehicles, the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) have developed several programs to help take the guess work out of acquiring AFVs. Over 80 DOE Clean Cities Coalitions have been organized and are located in metropolitan areas across the country. In addition, a number of EPA Clean Air Teams exist. These groups conduct various educational and outreach activities to promote the use of AFVs. Florida has two coalitions (Gold Coast and Space Coast) and one Clean Air Team. The coalitions maintain a formal program plan for implementing AFVs in the marketplace, which includes information on funding opportunities through the State Energy Program. Another educational organization is the National Alternative Fuels Training Consortium (NAFTC) which hosts two of their 19 training centers in Florida.

AFV workshop conducted jointly by Space Coast Coalition and NAFTC at Brevard Community College.

DOE developed the Alternative Fuels Data Center (AFDC) which is maintained by the National Renewable Energy Laboratory. The center maintains data on AFV research, provides AFV information, supports the Clean Cities Program and maintains a hotline and web site on AFV technology. The web site provides two useful interactive tools: the Alternative Fuel Refueling Station Locator and AFV Fleet Buyers' Guide programs. The Buyers' Guide walks through a step-by-step decision-making process for purchasing a vehicle and includes specifications, regulations, incentives and more.

Local governments conduct and participate in various programs. The Florida Energy Office (FEO), the Department of Environmental Protection (DEP) and other state agencies are additional sources of information. The DEP Division of Air Resource Management maintains over 200 monitors throughout Florida that measure air quality. Data is displayed on the web for anyone to access. The Division of Management Services (DMS) maintains a list of vehicles and their suppliers on contract to the state with a set purchase price for government fleets. Check with your local county or city government, as some provide air quality and AFV information and conduct their own AFV programs.

Information may also be available in the public library or at a local environmental or health

organization. Several organizations publish buyers' guides and almanacs for use by the general public, some of which are available through local book stores. The American Council for an Energy-Efficient Economy (ACEEE) Green Book (™) has calculated a Green Score for each car, van, pickup and sport utility vehicle on the market. The Green Score measures the environmental impact of vehicles. Some environment and health organizations, such as the American Lung Association, conduct community AFV awareness activities with exhibits, and rides and drives supported by auto manufacturers.

Another source of support in Florida is an organization called EV Ready Broward (EVRB). EVRB is one of 11 nationally designated electric vehicle market launch sites for the EV Ready program administered by the Electric Vehicle Association of America (EVAA). In addition to EVAA, national fuel providers associations will help locate fueling stations in support of their members.

Purchasing a Vehicle

Purchasing a vehicle can be as easy as going to your local automobile dealership, as all the major manufacturers produce AFVs. As with the purchase of any vehicle, it is wise to select a salesman and mechanic who is trained in AFV technology and make sure repair parts are available. Manufacturers have established support programs, so look for AFV-authorized dealers. Because the present volume of AFV sales is relatively small, you may need to order the vehicle you want, as not all dealers know about AFVs.

Fleet buyers can contact the fleet sales office of any of the manufacturers. Local government agencies can use the DMS contract vehicle list. Some used car dealers obtain vehicles through auctions and resell AFVs. The Federal Government General Services Administration (GSA) is required to purchase AFVs for their fleets. Several times a year, the GSA replaces some vehicles in their fleet based on age and program requirements. If you are interested in a used AFV, contact the GSA for the time and location of the next auction near you.

All new vehicles for sale in the U.S. must meet either the Federal Tier 1 emission standards or the California emission standards. Many models are now available nationwide that meet one of the low-emission vehicle type standards. Automotive manufacturers are required to note that the vehicle is a "low emission vehicle (LEV)" or "ultra low emission vehicle (ULEV)" by using special labels or window stickers on qualified vehicles. California, Massachusetts, New York, Vermont, and Maine require stickers noting the emission package and which standard the vehicle meets.

The potential buyer's objective should be to select a vehicle that does the least harm to the environment while still meeting transportation needs. A buyer should research more than just price, as the sticker price is offset by the cost of environmental damage caused by conventional modes of transportation. The ACEEE's Green Book, AFDC Buyers Guide and other tools can help you make a good decision.

Once the purchase is made, the buyer must register the vehicle and pay required taxes. If the vehicle is CNG or Propane, a highway tax decal must be purchased. Be sure to review State incentives and Federal tax benefits to help defray costs.

Ethanol plant in Bartow.

Biodiesel plant in Lakeland.

Locating Fuel Sources

Once you have a vehicle, where do you get fuel? There are five major categories of refueling stations list in Table 3:

Table 3 - Fueling Station Categories

- Centralized public, accessible to the public in a central location
- Centralized fleet, accessible to fleet operators only and centrally located
- Mobile, non-stationary truck, tank or trailer for private and commercial use
- Residential, located at private residences
- Distributed, multiple fueling sites to support commercial fleet operations

Infrastructure needs to be developed to provide an adequate number of refueling and charging stations. In 2000, the Center for Urban Transportation Research (CUTR) conducted an inventory of AFVs and alternative fuel refueling stations (see Table 4). Since the CUTR study, five new E-85 refueling sites have been built in Florida and another three are under construction. Presently, most ethanol refueling stations are private and dedicated to supporting fleets, as local gasoline stations have not added ethanol to existing pumps. Ethanol, methanol and biodiesel refueling stations are similar to gasoline or diesel stations. The changes required to handle these AFV fuels are minor in relation to other alternative fuels.

Natural Gas Pipeline Gate Station in Titusville.

How do I find a station? The Alternative Fuels Data Center (AFDC) mentioned earlier maintains information on refueling sites. This information can be obtained through the hotline or on their web site using the interactive tool "Alternative Fuel Refueling Station Locator." The Station Locator can be used to locate refueling and recharging stations available for fleet, public and private use. Knowing the city name or the Zip Code, the Station Locator will provide a map, the address, and related station operating information for fueling stations in the area. This information should be verified before taking a long trip as changes occur.

In addition to the AFDC, Gold Coast and Space Coast Clean Cities Coalitions and EVRB will offer assistance in locating stations, along with the various national fuel provider associations. Florida has the added advantage of having facilities that produce ethanol, methanol, and biodiesel along with hydrogen. Extensive natural gas pipelines extend across Florida. In the case of electric vehicles, the grid is everywhere and so is the sun.

Photovoltaic charging station for electric vehicles at University of South Florida.

The Florida AFV Market

There are 222 million registered vehicles in the U.S. Of those registered throughout the country, DOE estimates that 430,000 are alternative fuel vehicles [18]. AFVs represent a small percentage of the total registered vehicles in Florida and the country.

Determining the exact number of AFVs is difficult, as registration forms do not always indicate fuel type. At the direction of CFFAB, DCA and FEO, the Center of Urban Transportation Research Center (CUTR) conducted an inventory of AFVs and alternative fuel refueling stations in Florida. The study, identified 5,731 AFVs and 516 refueling sites illustrated in Table 4.

Table 4 - Florida Vehicle and Refueling Inventory - CUTR [18]

Fuel Type	Total Vehicles	Total Sites
CNG	2,151	94
LPG	2,466	320
LNG	6	2
Ethanol - E85	601	2
EV	352	93
Biodiesel - B20	128	2
Methanol - M85	11	2
Hybrid/electric transit	5,731	516

Several factors affected the percentage of vehicles in fuel types and models in the CUTR inventory study. In 1999, auto manufactures started making some selected E-85 flex-fuel vehicle standard models. Therefore, flex-fuel and bi-fuel vehicles are capable of operating on conventional petroleum products, allowing some vehicles to be reported as AFVs, that may not actually operate on alternative fuels or support an alternative fuel refueling site. Table 4 does not account for this and puts an estimated 98,000 E-85 vehicles on the road in Florida [18]. Table 4 does account for vehicles actually using E-85 as a fuel.

Fuel station for ethanol and methanol at Florida Institute of Technology

Opening of electric vehicle maintenance facility at Florida Power and Light fleet maintenance.

Another factor is that EPAct mandated a certain percentage of vehicle acquisitions in Federal, State and energy provider fleets be alternatively fueled, which accounts for the CUTR study finding that about half of the AFVs in Florida were operated by government agencies. The other half of the AFVs are private, business or local fleet operated vehicles not subject to any mandate. The greatest concentration of vehicles is in Clean Cities Coalitions and EVRB. Since the CUTR study, over a thousand new AFVs have been placed in service.

III. Government Regulations

Automobiles available on the market today are required to meet many government regulations covering a wide range of categories including safety, fuel economy, and emission. Automobile manufacturers seek to earn pollution credits in the manufacture and sale of AFVs.

Federal Government Regulations

Fleet managers are especially aware of government guidelines, as penalties are levied when regulations are not met. There are two federal laws fleet operators need to keep in mind: 1) the 1990 Clean Air Act Amendments (CAAA) and (2) the Energy Policy Act of 1992 (EPAct) [19]. These Acts came into existence in response to concerns about the environment and our country's dependence on imported petroleum. They require certain fleets to acquire vehicles that operate on alternative fuels.

First in a series of CNG fueling stations forming a corridor of refuel sites.

In 1970, the CAAA sought to improve air quality nation wide. The Act's original goals were to reduce mobile source pollutants by requiring use of cleaner fuels. Several programs were created as initiatives to reinforce these objectives. Among these programs is the Clean Fuel Fleet Program (CFFP) administered by the U.S. Environmental Protection Agency (EPA). This program requires fleets in metropolitan areas with high ozone and/or carbon monoxide levels to acquire Clean Fuel Vehicles (CFV). These fleets can use any fuel as long as the vehicles acquired are certified to meet the EPA's low emission vehicle (LEV) standards or better, which are stricter emission standards than otherwise required by law.

The Clean Air Act set prescribed concentration limits for pollution emitted from cars, buses and trucks. The U.S. Environmental Protection Agency (EPA) established maximum concentration levels called National Ambient Air Quality Standards (NAAQS) for six criteria pollutants in ambient or open air in order to protect public health. The Act requires areas where pollutant concentration exceed the NAAQS to develop State Implementation Plans (SIP) to control emissions. Emission levels are classified marginal, moderate, serious, severe, and extreme for affected areas and designated as non-attainment when a level is not met for one or more contaminant.

Tour bus using biodiesel.

EPAct's primary purpose is to increase energy security through energy conservation and increased use of domestic alternative fuels. The U.S. Department of Energy implements the EPAct by directing certain fleets in larger metropolitan areas to acquire Alternative Fuel Vehicles. An added benefit of EPAct is that most of the required vehicles exhibit lower emissions and meet the CFFP emission standards.

Fleets Covered by EPAct or CAAA

Federal, state and alternative fuel provider fleets are currently mandated by both EPAct and CAAA, whereas, municipal and private fleets are presently mandated only by CAAA. Coverage includes vehicles owned, operated, leased or controlled by the fleets. The law defines the criteria in number of vehicles, duty type, fueling capability and model years that qualifies fleets for this mandates. The laws do exempt certain vehicles such as law enforcement, emergency vehicles, non-road vehicles, those used for military purposes and other special cases.

Fleets affected are located in Consolidated Metropolitan Statistical Areas (CMSA) or cities that had a population of at least 250,000 at the time of the 1980 U.S. census. Table 5 contains a list of Florida CMSAs covered by CAAA or EPAct.

Table 5 - Consolidated Metropolitan Statistical Areas in Florida . [19]

CSMA Location	County
Daytona Beach	Flagler, Volusia
Jacksonville	Clay, Duval, Nassau, St. Johns
Lakeland-Winter Haven	Polk
Melbourne-Titusville-Palm Bay	Brevard
Maimi-Ft. Lauderdale	Broward, Dade
Orlando	Lake, Orange, Osceola, Seminole
Pensacola	Escambia, Santa Rosa
Tampa-St. Petersburg-Clearwater	Hernando, Hillsborough, Pasco, Pinellas
West Palm Beach-Boca Raton-Delray Beach	Palm Beach

Fuels and Vehicles Defined by Federal Acts

CAAA defines a clean fuel as any power source for which a vehicle is certified to meet federal Clean Fuel Vehicle emissions standards. Clean fuels include alternative fuels, oxygenated fuels, reformulated gasoline and conventional gasoline. A CFV is a vehicle that is certified to meet low emission vehicle standards or better, and operates on the fuel for which the vehicle was certified as a LEV. The fleet operator must always use the clean fuel in the affected geographic area. In addition, EPAct defines an alternative fuel as any fuel that is substantially non-petroleum and yields energy security and environmental benefits. EPAct currently recognizes alternative fuels as defined in the Federal Register. Both, EPAct and CAAA defines the number of new CFVs or AFV acquisitions needed by qualified fleets to meet requirements (see Appendix).

Programs and Policies

Clean Cities is a U.S. DOE nationwide initiative, begun in 1994, to encourage the use of alternative fuels, infrastructure and vehicles through grassroots groups in designated areas throughout the country. The program is a voluntary, locally based government and industry partnership to mobilize local stakeholders in the effort to expand the use of alternatives to gasoline and diesel fuel. The program seeks to improve the quality of life by using clean domestic fuels for transportation.

Under DOE's State Energy Program (SEP), individual states promote the conservation of energy, adoption of renewable energy technologies, as well as the reduction of energy demand and dependence on imported oil through the development and implementation of a comprehensive State Energy Plan. States may choose to allocate grant funds for activities that increase transportation efficiency, including programs to accelerate the use of alternative transportation fuels for government vehicles, fleet vehicles, taxis, mass transit and privately-owned vehicles. The Florida Energy Office of the Department of Community Affairs administers the SEP for Florida.

The U.S. Internal Revenue Service (IRS) oversees a regulation in EPAct that can help you purchase an AFV. A $2,000 to $50,000 federal income tax deduction is available for the incremental cost to purchase or convert qualified business or personal clean fuel vehicles, except EVs eligible for the federal EV tax credit. The deduction is not amortized and must be taken in the year the vehicle is acquired with each fleet location having a limit of $100,000. The amount of the tax deductions for qualified clean fuel vehicles is based on the gross vehicle weight (GVW) and types of vehicles and are listed in Table 6.

Table 6 - Tax deduction for weight and type of vehicle. [21]

Vehicle	Weight	Tax deduction
Truck or van	GVW of 10,000-26000 lb	$5,000
Truck or van	GVW more than 26,000 lb	$50,000
Buses	seating capacity of 20+adults	$50,000
All other vehicles, off-road vehicles excluded		$2,000

Also, EPAct provides a tax credit up to $4,000 or 10% of the purchase price of an EV used for business or personal use. Beginning in 2001, the size of the credit is reduced by 25% per year until the credit is fully phased out. To qualify for the credit, the vehicle must be powered primarily by an electric motor drawing current from batteries or other portable sources of electric current. All dedicated, plug-in only EVs and all series HEVs qualify. Also, some parallel HEVs qualify for a deduction. Information is available in IRS publication 535. IRS form 8834 can be used for this tax benefit.

The U.S. Department of Transportation administers the Congestion Mitigation and Air Quality (CMAQ) Improvement Program authorized by the Transportation Equity Act (TEA-21) until 2003. The CMAQ program funds projects and programs in non-attainment and maintenance areas to reduce transportation-related emissions.

State Legislation

In 1999, Governor Jeb Bush signed the Florida Clean Fuel Act, that established the Clean Fuel Florida Advisory Board to study alternative fuel vehicles and formulate and provide policy recommendations. The Board provides the Secretary of the Department of Community Affairs (DCA) with recommendations on how to expand and fund the use of AFVs in the state. The Board will dissolve in 2004 (F.S. § 403.42).

Florida presently does not have any incentives for promoting the use of AFV's. Several other states do have incentives, such as California and New York. At this time, the Clean Fuels Florida Advisory Board is developing a Transportation Plan that will include such recommendations.

The Department of Transportation receives excise taxes on gasoline and diesel sold at the pump to fund construction of highways, but some AFVs do not pay excise tax on their gas fuel. In order to offset the loss of excise tax on gasoline from AFVs, a person operating an AFV must purchase a decal annually from the Florida Department of Revenue as defined in State Statutes. The decal must be properly displayed on the vehicle in order to use gas refueling stations. State and local government AFV fleets are exempt from paying the decal fee (F.S. § 206.874 and F.S. § 206.877). Also, anyone who wishes to be a wholesale distributor of an alternative fuel must first obtain a license from the Florida Department of Motor Vehicles (rF.S. § 206.89).

Florida Institute of Technonlgy student designed University solar race car.

In years past, electric vehicle owners had difficulty getting insurance at a reasonable cost. Now, electric vehicles are protected from insurance surcharges based on factors such as new technology, passenger payload, weight-to-horsepower ratio and the types of materials used to manufacture the vehicle (F.S. § 627.06535).

County governments can receive waste reduction credits for using yard clippings, clean wood waste or paper waste as feedstock for the production of clean-burning fuels such as ethanol (F.S. §. 403.706).

GM EV1 at start of SunDay Challenge 1997

IV. Making a Difference

Many transportation options exist today and a variety of fuels are available to power them. Each option presents a choice of benefits and cost. Alternative fuel vehicles usually cost more to purchase than conventional gasoline vehicles, from a few hundred to several thousand dollars. As an example; ethanol fueled vehicles were previously priced about three hundred dollars more than the gasoline version, but now are priced the same. Full-size electric vehicles are still the most costly with incremental costs averaging over 15 thousand.

As the price of AFVs varies, so does the cost of fuel. Some alternative fuels cost less than conventional gasoline or diesel fuel, which also affects the life cycle cost of the vehicle. The cost of fueling stations varies from a few thousand to over one hundred thousand based on the fuel type as infrastructure for AFVs is still being deployed. Maintenance expenses also vary, with some AFVs actually being less costly to service than gasoline vehicles due to the cleaner burning fuel. Electric vehicles have low periodic maintenance cost, but high battery replacement cost. Costs are dependent on the user's needs, the economy, and political and environment issues. As cost has continued to be a variable, so has no one fuel or vehicle proven to be the perfect choice for all needs and applications.

The major benefits AFVs offer over gasoline and diesel vehicles are reduced dependence on foreign oil and reduced emission of polluting gases. While a collective shift in favor of AFVs is needed, by being willing to make minor changes in activities and in some cases accept a slightly higher cost to use a personal AFV, an individual can make a difference. Change is never easy, but automotive manufacturers and fuel providers have made significant progress in making the differences described above reasonably transparent and cost-effective. It is up to each of us individually to make personal transportation choices that include both financial and environmental considerations. While policies may evolve over time, the basic issues remain the same: AFVs are an integral part of the solution.

Home fueling station for hydrogen/CNG powered car.

Appendix

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Biodiesel Fuel

Fuel Description:

- Liquid produced from such renewable sources as vegetable oils, animal fat, and used oil and fats. Biodiesel (mono alkyl esters) has physical properties very similar to conventional diesel, but produces lower emissions.

Fuel Source

- 100% domestic
- Peanuts, cottonseed, sunflower seeds, rapeseed, canola and animal fat are potential oil sources.

Fuel Production

- Fuel is domestically produced by a chemical process called transesterification. Peanuts, cottonseed, sunflower seeds, rapeseed and canola are potential oil sources. The fuel is mixed with an alcohol (usually methanol) and a catalyst (usually sodium). The oil's triglycerides react to form esters and glycerol, which are then separated from each other and purified. Neat Biodiesel is the name of the chemical produced from the process. When soybean oil reacts with methanol, Methyl soyate, or SoyDiesel, is made.

Engine Description

- Biodiesel, like petroleum diesel, operates in combustion-ignition diesel engines with little or no engine modification required.

Vehicle Fueling

- Fuel is pumped the same as with diesel fuel.

Fuel Availability

- Available in bulk from an increasing number of biodiesel suppliers and petroleum marketers as a B20 (20% biodiesel and 80% petroleum diesel) blend or as B100 (neat (pure) biodiesel).
- Can be distributed through the same systems as petroleum.

Marketplace Usage

- More than 20 million miles have been driven on neat biodiesel and biodiesel blends.
- Neat biodiesel has been designated as an alternative fuel for EPAct programs. For biodiesel fuel providers, the AFV requirement is 100%. A covered fleet will be awarded one AFV acquisition for each 450 gallons of biodiesel purchased. To receive credit for an AFV acquisition, the biodiesel must be used in blends that contain, by volume, at least 20% biodiesel.

Operational Performance

- Horsepower, torque, and fuel economy are similar to those for diesel fuel.
- B100 meets low-sulfur, low-aromatic clean diesel standards established by the California Air Resource Board.
- Similar practices employed with Number 2 diesel should be used to ensure an adequate cold-flow performance in certain climates. This involves blending with Number 1 diesel or using anti-gel additives.

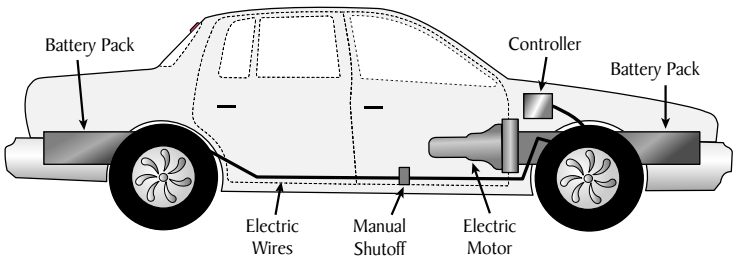
Maintenance Considerations

- In older vehicles, high-percent blends of biodiesel can affect fuel hoses and pump seals containing certain elastomers. The effect is lessened with lower-percent blends.
- Biodiesel-compatible elastomers (such as hoses and gaskets) are required for use with neat biodiesel and high-percentage biodiesel blends.
- Heaters for fuel tanks and filters may be needed in cold climates.
- All biodiesel (B100) should meet the ASTM provisional specifications before being used (or blended with diesel fuel) to protect equipment and to ensure trouble-free operation.

Safety

- Training required to operate and maintain vehicles is the same as for petroleum diesel.
- Flashpoint is significantly higher than that of conventional diesel fuel.
- Neat biodiesel is nontoxic and biodegradable.
- Biodiesel can be transported, delivered, and stored using the same equipment as for diesel fuel.

Electric



Fuel Description

- Onboard rechargeable batteries or other electrical power source to energize an electric motor.

Fuel Source

- More than 95% domestic, based on current mix of input energy (coal, oil, natural gas nuclear, hydropower and renewables) for electric power generation.
- Produced by investor owned and public utilities.

Fuel Production

- Electric generators produce utility grade electrical energy at a power plant input to a utility grid or distribution system.
- Hydrogen or a source of hydrogen processed by a Fuel cell to produce electricity.
- Photovoltaics or wind energy produced by the sun.
- On-board electric generator powered by another alternative fuel or petroleum.

Engine Description

- Single or three phase electric drive motor at 48 VDC to 480 VAC. Accelerator pedal inputs to an electronic controller that manages the energy from a battery or other electrical source to the motor.

Vehicle Fueling

- A cord and plug (conductive) or cord and paddle (inductive) system connects to a 120-volt, 240-volt, or higher-voltage electrical source. The connecting device may be located aboard the vehicle or in a fixed, off-vehicle location.
- Time needed for charging depends on voltage of the electrical source, power output, temperature, and size, type, and remaining state-of-charge of the batteries. Times typically vary from minutes for fast charge to hours for slow charge.

Fuel Availability

- Most homes, government facilities, fleet garages and businesses have adequate electrical capacity for charging. Special hookups or upgrades may be required.
- About 500 public charging facilities are available in selected areas, mainly in southern California and Arizona with a few in Florida.

Marketplace Usage

- More than 6,000 electric vehicles (EVs) are operating in the United States (most in California and the western United States). Few EVs are available in Florida.
- A few major automakers are producing EVs, with more planned for the future.
- Most EVs are cars and pickup trucks, but buses, bicycles, scooters and neighborhood vehicles are also available.
- Most hybrids and all fuel cell vehicle use an electrical drive systems.

Operational Performance

- The range for OEM EVs is 50 to 130 miles. Variables include the vehicle's weight, engineering and design features, and type of battery.
- Weather extremes and use of accessories (such as heating and air conditioning) will reduce the range.
- Electric drivetrains are more energy efficient than internal combustion engines.
- OEM EVs can travel at the same speeds as conventional vehicles and provide the same performance capabilities.

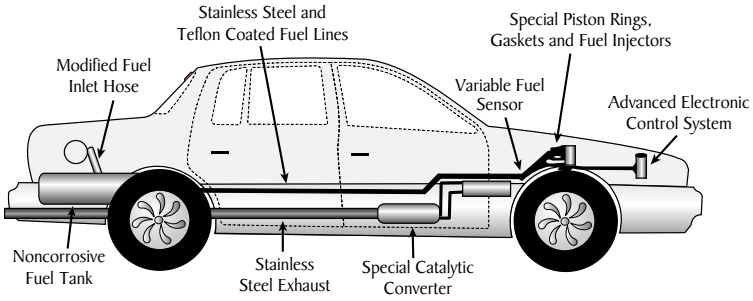
Maintenance Considerations

- Different types of batteries (such as lead-acid, nickel-metal hydride and lithium-ion) are available depending on the manufacturer and the vehicle.
- Service requirements are expected to be reduced. No tune-ups, oil changes, timing belts, water pumps, radiators, fuel injectors or tailpipes are required, but there is minor electric maintenance.

Safety

- Auto suppliers may assist fleets with technical training. Some community colleges offer training for EV mechanics.
- OEM EVs must meet all the same vehicle safety standards as conventional vehicles.

Ethanol



Fuel Description

- Clear, colorless liquid alcohol produced from grain or agricultural waste. E85 (a blend of 85% denatured ethanol and 15% gasoline) is used for light-duty applications; E95 (a blend of 95% denatured ethanol and 5% gasoline) is used for heavy-duty applications.
- Also known as ethyl or grain alcohol.

Fuel Production

- Grain is milled into meal and mixed with water and alpha-amylase and passed through cookers where the starch is liquefied. A secondary enzyme (gluco-amylase) is added to the mash from the cookers to produce dextrose. Yeast is added to ferment the sugars to ethanol and carbon dioxide. The fermented mash is distilled into alcohol where solids and water are removed. The ethanol is then denatured with a small amount of a product, making it unfit for human consumption.

Fuel Source

- 100% domestic, depending on world price.
- Produced from grain or agricultural waste.

Engine Description

- Ethanol, like gasoline, operates in internal combustion-ignition engines with little engine modification required.
- Ethanol reacts with some plastics and metals, therefore certain hoses and metal parts need to be exchanged.
- Dedicated, bi-fuel or flex-fuel systems.

Vehicle Fueling

- Ethanol vehicles are fueled the same as gasoline vehicles.

Fuel Availability

- Most fueling stations are located in the Midwest, but in all, more than 100 public E85 stations are available in 17 states.
- E95 is available only through bulk suppliers.

Marketplace Usage

- Available E85 vehicles are flexible-fuel, meaning that they can be operated on E85 (a blend of 85% ethanol and 15% gasoline), on gasoline, or on blends of the two.
- Some manufacturers are making entire production runs of selected model vehicles ethanol compatible (flexible-fuel).
- In addition to LDVs, heavy-duty line-haul and medium-duty municipal trucks have been successfully demonstrated on E95. At this time, no heavy-duty engines are available from OEMs that operate on ethanol.
- The National Ethanol Vehicle Coalition estimated that 750,000 E85 vehicles were produced for MY 2000. That estimate excludes E85 vehicles already on the road.

Operational Performance

- Vehicles may require more frequent fueling depending on installed tank size and options. Some auto manufacturers are installing larger fuel tanks in the E85 vehicles, resulting in ranges similar to those of the gasoline models.
- Power, acceleration, payload, and cruising speed provided are comparable with those for equivalent conventional fuels.

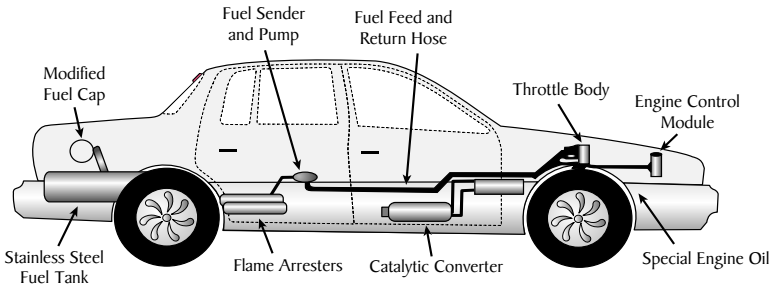
Maintenance Considerations

- Special lubricants may be required. Check the owner's manual or consult with the manufacturer to ensure that the correct oil is used.
- Identify E85 as the fuel when ordering replacement parts.
- Maintenance assistance is available from local dealers; practices are very similar, if not identical, to those for conventionally fueled operations.

Safety

- Ethanol-fueled vehicles require the same fuel handling practices as conventionally gasoline fueled vehicles.

Methanol



Fuel Description

- Odorless clear liquid that is commonly used in industry as a solvent, produced from natural gas, coal, or biomass.
- M85 (a blend of 85% methanol and 15% gasoline) is for light-duty applications.
- M100 (pure methanol) is for heavy duty applications.

Fuel Production

- Produced by steam reformation of natural gas in the presence of a catalyst under high pressure to form carbon monoxide and hydrogen which also removes sulfur. A second catalyst process makes the methanol.
- Similar production process used for coal and biomass.

Fuel Source

- About 90% domestic, depending on world market price.
- Produced from natural gas, coal and biomass.

Engine Description

- Methanol, like gasoline, operates in internal combustion engines with little engine modification required.
- Methanol reacts with some plastics and metals, therefore certain hoses and metal parts need to be exchanged.
- Dedicated, bi-fuel or flex-fuel systems.

Vehicle Fueling

- Fueling is the same as conventional gasoline.

Fuel Availability

- Methanol remains a qualified alternative fuel as defined by EPAct, but it is not commonly used. Automakers have ceased supplying methanol-powered vehicles. A handful of methanol fueling stations exist in California and Florida, where some state fleet vehicles and school buses run on methanol.
- Individual users without access to public fueling stations may find methanol through bulk chemical suppliers in major cities.
- Methanol remains a good candidate to provide hydrogen for fuel cell vehicles, when they emerge in the auto market.

Marketplace Usage

- The number of methanol vehicles has declined substantially from the approximately 20,000 on U.S. roads in the early 1990s. Some estimates place the current number at 1,000 or perhaps even less.

Operational Performance

- Vehicles will require more frequent fueling than gasoline vehicles because of methanol's lower energy content.
- Power, acceleration, payload, and cruising speed are comparable with those for equivalent conventional fuels.

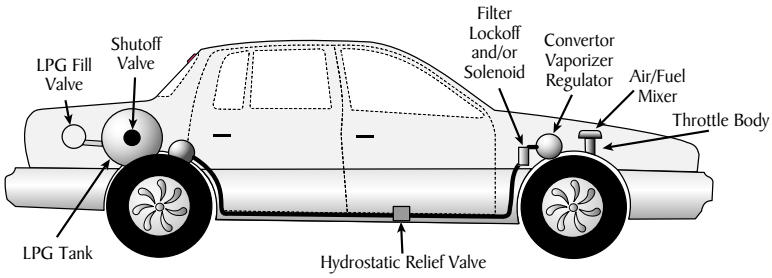
Maintenance Considerations

- Use special lubricants available by direct order from supplier (significant cost premium over conventional motor oils).
- Use M85-compatible replacement parts (that is, identify M85 as fuel when ordering).

Safety

- Methanol-fueled vehicles require the same fuel handling practices as conventional gasoline fueled vehicles.
- The fuel is corrosive and toxic.
- Flame is not visible in direct sunlight.

Propane



Fuel Description:

- Liquefied petroleum (LP) gas, or LPG (commonly called propane), is a liquid mixture of at least 90% propane and the balance is butane, ethane, propylene and other hydrocarbons.
- Under a modest pressure (>300 psi) the propane gas becomes a liquid.

Fuel Production

- Produced in the production of natural gas and crude oil refining.

Fuel Source

- Approximately 90% domestically produced, when produced from natural gas processing.
- Increasing percentage produced from petroleum refining.

Engine Description

- Operates in internal combustion ignition engine with some vehicle modifications.
- Fuel is regulated to low pressure from median pressure vessels and injected into engine as a vapor. Conversion kits are available.
- Dedicated or bi-fuel systems,. Engine is optimized for one fuel on bi-fuel systems.

Vehicle Fueling

- Pumping station equipment is comparable with that of gasoline or diesel vehicles except uses screw-on connection device.
- Pressure tanks are filled to no more than 80% capacity to allow for liquid expansion as the outside temperature rises.
- Pumping equipment uses low pressure (<300 psi) hoses and connectors.

Fuel Availability

- Propane is the most accessible of the liquid and gaseous alternative fuels in the United States.
- There are publicly accessible fueling stations in all states operated separate from gasoline and diesel refueling stations.

Marketplace Usage

- It is estimated that there are more than 350,000 on and off-road propane-powered vehicles in the United States, and about 4 million worldwide.
- Propane is used mainly as a fuel for fleets. It has been used as such for more than 60 years.

Operational Performance

- Range on LPG is somewhat less than that of comparable gasoline-powered vehicles. Manufacturers often provide larger fuel tanks to compensate and allow vehicle ranges similar to gasoline.
- Power, acceleration, payload and cruising speed are comparable to those obtained with an equivalent internal combustion engine.

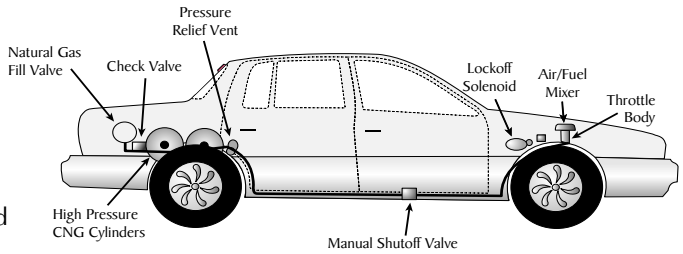
Maintenance Considerations

- Some fleets report service lives that are 2 to 3 years longer than similar vehicles using gasoline or diesel.
- Service reports indicate less carbon build-up and over 80,000 miles between spark plug changes.
- Some fleets report extended intervals between required maintenance sessions. However, manufacturers and conversion companies recommend conventional maintenance intervals.

Safety

- Adequate ventilation is important for fueling a propane-fueled vehicle. Fueling in a closed-in space can be hazardous, but proper air circulation dissipates the fumes, as propane is heaver than air.
- Propane tanks are 20 times more puncture-resistant than gasoline tanks and can withstand high impact.
- Boiling temperature is -44 degrees F and would create a freezing hazard if touched.

Natural Gas



Fuel Description

- Extracted from underground petroleum reservoirs, composed primarily of methane. Compressed natural gas (CNG) is compressed to 2,400-3,600 pounds per square inch in specially designed and constructed cylinders. Liquefied natural gas (LNG) is cooled to -260EF and stored in insulated cryogenic tanks.

Fuel Production

- Produced by extraction from underground reservoirs or in production of crude oil and oil refining.
- Natural gas is processed to remove water vapor, sulfur and heavy hydrocarbons, leaving mostly methane.
- Methane is formed from organic matter decomposed in the presence of heat or microorganisms. Also, processed from coal and oil.

Fuel Source

- Production is about 85% domestic when extracted from underground petroleum sources and oil refining pocesses.

Engine Description

- Operates in internal combustion ignition engine with some vehicle modifications.
- Fuel is regulated to low pressure from high pressure vessels and injected into engine as a vapor. Conversion kits are available.
- Dedicated or bi-fuel systems. Engine is optimized for one fuel on bi-fuel systems.

Vehicle Fueling

- "Slow" fill (as long as 8 hours) and "quick" fill (3 to 5 minutes) are available for CNG. LNG (stored at 260EF) fueling times are comparable with those for gasoline or diesel fuels.
- Pumping station equipment uses high pressure hoses and connectors (2,400-3,600psi).

Fuel Availability

- CNG fueling stations are located in most major cities and in many rural areas. Nearly 1,300 fueling stations are available across the country.
- Public LNG stations are limited. LNG is available through several suppliers of cryogenic liquids.

Marketplace Usage

- Estimates indicate there are more than 75,000 natural gas vehicles in the United States used mainly for fleets and more than 1 million worldwide.
- Auto manufacturers offer many types and styles of CNG vehicles.
- HDV manufacturers can install one of several available CNG or LNG engines in products they offer.
- Medium-duty and heavy-duty CNG vehicles operate in many applications including federal, state, and local government fleets; commercial fleets such as grocery stores; and package delivery fleets, such as United Parcel Service.
- One of every five new transit buses in the United States is powered by natural gas. Many new school buses are natural gas-fueled.

Operational Performance

- Vehicle range for CNG and LNG depends on fuel storage capacity, but generally it is less than that of comparable gasoline or diesel vehicles.
- Power, acceleration, and cruising speeds are comparable with those of gasoline or diesel.
- Energy density of CNG is less, requiring more fuel for similar range as gasoline. Storage cylinder location and number may displace some payload capacity.

Maintenance Considerations

- High-pressure tanks require periodic inspection and certification.
- Some fleets report 2 to 3 years longer service life and extended time between required maintenance. However, manufacturers and conversion companies recommend conventional maintenance intervals.

Safety

- Pressurized tanks have been designed to withstand severe impact, high external temperatures, and automotive environmental exposure. Design changes have resolved problems responsible for earlier in-service failures.
- It is important to fuel a natural gas-fueled vehicle in a well-ventilated area. Natural gas dissipates quickly in air when circulated.
- Natural gas is relatively non-reactive when it is not contained.

Advanced Technology Vehicles

- Certain vehicle technologies do not qualify for EPAct credits, but may play a significant part in reducing petroleum use and exhaust emissions. Among them are hybrid-electric vehicles, which are already available commercially; and fuel cell vehicles, which are still in development.

Hybrid Electric Vehicle (HEV) Description

- HEVs are powered by two energy sources-an energy conversion unit (such as an internal combustion engine or fuel cell) and an energy storage device (such as batteries or ultra capacitors). The energy conversion unit may be powered by gasoline, methanol, CNG, hydrogen, or another alternative fuel. HEVs have the potential to be two to three times more fuel efficient than conventional vehicles.
- HEVs can have either a parallel or a series design. In a parallel design, the energy conversion unit and electric propulsion system are connected directly to the vehicle's mechanical drive train. The primary engine is used for highway driving; the electric motor provides added power during hill climbs, acceleration, and other periods of high demand. In series design, the primary engine is connected to a generator that produces electricity. The electricity charges batteries and drives an electric motor that powers the wheels.
- Two of the earliest entries in the commercial market for HEVs are the Honda Insight and the Toyota Prius. Both are economical subcompacts.

Fuel Cell Vehicle Description

- A fuel cell converts the chemical energy of a fuel into usable electricity and heat without combustion as an intermediate step.
- A vehicle powered by a fuel cell can be highly efficient and can reduce emissions significantly. Because hydrogen reacts with oxygen to produce electricity and has only water vapor and heat as by-products, it is the optimal fuel for powering fuel cells. Storing hydrogen onboard a fuel cell vehicle (FCV) greatly simplifies the fuel system design and results in a greater energy efficient system because onboard fuel processing is unnecessary. Hydrogen is normally a gas so a relatively large volume is required to contain enough energy to provide the driving range we expect from today's automobiles. Currently, two methods of storing hydrogen onboard a vehicle are receiving the most attention: compressed gas in storage tanks at high pressure or liquid hydrogen in insulated storage tanks at low temperature and pressure. Research and development of chemical storage systems using metal hydride compounds and advanced carbon storage media are also under way. Researchers are also investigating the use of liquid fuels such as methanol or gasoline as sources of hydrogen. This approach solves the problems associated with storing hydrogen, but requires additional equipment to chemically strip the hydrogen from the liquid fuel.
- Fuel cell technology is in development by automakers in the U.S., Europe, and Asia, but FCVs are not yet available commercially.

Operational Performance

- HEVs and FCVs are being developed to meet the performance expectations of today's consumers. FCVs are extremely quiet and have very little vibration.

Safety

- The goal is to develop these vehicles with levels of safety, comfort, and cost comparable to those of a conventional vehicle. Meeting consumers' cost expectations, especially when the vehicles are introduced, will be difficult. But incentives, rebates, and possible auto manufacturer price adjustments will help reduce the purchase price of these vehicles.

Sources of Information

Florida Contacts

Florida Space Coast Clean Cities Coalition
http://clean-cities.org
Bill Young,
Phone: 321-638-1443
young@fsec.ucf.edu

Florida Energy Office,
Department of Community Affairs
http://www.dca.state.fl.us
Norm Gempel
Phone: 850-488-2475
Norm.gempel@dca.state.fl.us

Center for Urban Transportation Research, USF
Phone: 813-974-3120
http://www.cutr.eng.usf.edu

Florida Gold Coast Clean Cities Coalition
http://sfrpc.com
Carlos Gonzalez
Phone: 954-985-4416
carlosg@sfrpc.com

Federal Contacts

DOE and EPAct:
National Alternative Fuels Data Center
http://www.afdc.doe.gov

National Alternative Fuels
Hotline 800-423-1363
hotline@afdc.nrel.gov

Infrastructure locator
http://www.afdcmap.nrel.gov/nel

DOE/EPAct Fleet Information - Regulations,
http://www.ott.doe.gov/epact
Linda Bluestein
Phone: 202-586-9171
regulatory_info@afdc.nrel.gov

DOE Federal Fleets Program
Phone: 202-586-7011
fed_fleets@afdc.nrel.gov

DOE Atlanta Regional Office,
Dave Dunagan
Phone: 404-562-0561
david.dunagan@ee.doe.gov
Shelley Launey
Phone: 202-586-1573
shelley-launey@ee.doe.gov

National Clean Cities Program
http://ccities.doe.gov

Clean Cities Hotline
Phone: 800-CCITIES
ccities@nrel.gov

U.S. EPA and CAAA
U.S. EPA Office of Mobile Sources contacts:
http://www.epa.gov/OMSWWW
Jim Linder
Phone: 734-214-4558
linder.jim@epa.gov
Sally Newstead
Phone: 734-214-4474
newstead.sally@epa.gov

U.S. EPA State Contact for Florida, Region 4 office,
http://www.epa.gov/region4
Lynorac Benjamin
Phone: 404-562-9040
benjamin.lynorac@epa.gov

EPA Clean Fuel Fleets Program
http://www.epa.gov/oms/cff.htm

EPA/DOE Fuel Economy Data
http://fueleconomy.gov

U.S. Internal Revenue Service
Phone: 202-622-3110
http://www.treas.gov

Argonne National Laboratory
http://www.anl.gov

Clean Cities Website
http:www.ccities.doe.gov

Idaho National Engineering and Environmental Laboratory
http://www.inel.gov and
http://ev.inel.gov/

Office of Transportation Technologies (USDOE)
http://www.ott.doe.gov

National Renewable Energy Laboratory
http://www.nrel.gov

Fuel Associations

Biodiesel

National Biodiesel Board
http://www.nbb.org
Phone: 573-635-3893

United Soybean Board
http://www.unitedsoybean.org
Phone: 800-989-USB1 or 636-530-1777

Electric

Electric Drive Transportation Association of the Electric Vehicle Association of the Americas
http://www.evaa.org
Phone: 202-508-5995

WesStart-CALSTART
http://www.calstart.org
Phone: 626-744-5600

Ethanol

National Ethanol Vehicle Coalition
http://www.E85fuel.com
Phone: 877-485-8595 or 573-635-8445

Renewable Fuels Association
http://www.ethanolrfa.org
Phone: 202-289-3835

Hydrogen and Fuel Cells

Fuel Cells 2000
http://www.fuelcells.org
Phone: 202-785-4222

National Hydrogen Association
http://www.ttcorp.com/nha/index.htm
Phone: 202-223-5547

Liquified Petroleum Gas

Propane Vehicle Council
http://www.proganegas.com/vehicle
Phone: 202-530-0479

National Propane Gas Association
http://www.npga.org
Phone: 630-515-0600

Gas Research Institute
http://www.gri.org

Methanol

American Methanol Institute
http://www.methanol.org
Phone: 888-275-0768
or 202-467-5050

Oxygenated Fuels Association
http://www.ofa.net
Phone: 703-841-7100

Natural Gas

Natural Gas Vehicle Coalition
http://www.ngvc.org
Phone: 703-527-3022

American Gas Association
http://www.aga.org
Phone: 202-824-7000

AFV Contacts

American Honda Motor Corporation
http://www.honda.com
Phone: 1-888-CCHONDA

Daimler Chrysler Corporation
http://www.fleet.chrysler.com
Phone: 1-800-999-3533

Ford Motor Company
http://www.fleet.ford.com/get_started, Phone: 1-877-ALT-FUEL

General Motors Corporation
http://www.gmaltfuel.com
Phone: 1-888-462-3848

Mazda North America
http:/www.mazdausa.com
Phone: 1-800-248-0459

Nissan North America
http://www.nissan-na.com
Phone: 1-800-NISSAN1

Solectria Corporation
http://www.solectria.com
Phone: 978-658-2231

Toyota Motor Sales, USA.
http://www.toyota.com
Phone: 1-800-468-6968

Volvo Cars of North America
http://www.volvocars.com
Phone: 1-800-970-0888

National Automobile Dealers Association (NADA)
http://www.nada.org
Phone: 703-821-7000
or 800-252-6232

Education Resources

Energy Education Resources (K-12)
http://ww.eia.doe.gov/bookshelf/eer/kiddietoc.html
Phone: 202-586-8800

Northeast Sustainable Energy Association
http://www.nesea.org
Phone: 413-774-6051 ext. 21

Training Resources

National Institute for Automotive Service Excellence (ASE)
http://www.asecert.org
Phone: 877-ASE-TECH
or 703-713-3800

National Fire Protection Association (NFPA)
http://www.nfpa.org
Phone: 617-770-3000

National Alternative Fuels Training Consortium (NAFTC)
http://naftp.nrcce.wvu.edu
Phone: 304-293-7882

Traviss Technical Center
Phone: 863-499-2700

Other

SAE International
http://www.sae.org/index.htm

National Highway Traffic Safety Administration
http://www.nhtsa.gov

Federal Purchasing Requirements

Fleets covered by CAAA or EPAct programs must determine how many qualified vehicles must be acquired. Determine the number of covered acquisitions made for the fleet during the model year, then multiply that total by the percentage requirement of CFVs or AFVs for that year (see tables below). The two laws use different schedules of acquisition requirements: Table 7 lists CAAA requirements and Table 8 lists EPAct requirements.

Table 7 - The Clean Fuel Fleet Program
as part of the *Clean Air Act Amendments* (CAAA)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
GVWR less than 8,500 lb (%of CFVs)	N/A	N/A	30%	50%	70%	70%	70%	70%	70%	70%
GVWR less than 26,000 lb (% of CFVs)	N/A	N/A	50%	50%	50%	50%	50%	50%	50%	50%

Table 8 - The Energy Policy Act
Public Law 102-486 Titles III-VI

Year	Federal	State	Alternative Fuel Provider	Municipal and Private*
1997	33%	10%	30%	
1998	50%	15%	50%	
1999	75%	25%	70%	
2000	75%	50%	90%	
2001	75%	75%	90%	
2002	75%	75%	90%	20%
2003	75%	75%	90%	40%
2004	75%	75%	90%	60%
2005	75%	75%	90%	70%
2006	75%	75%	90%	70%

*Precentages listed for municipal and private fleets tentative; there are currently no mandates under EPAct.

Glossary

A

aftermarket conversion - A standard, conventionally fueled, factory-produced vehicle to which equipment has been added that enables the vehicle to operate on an alternative fuel; also, the process of converting such a vehicle.

alcohol - The family name of a group of organic chemical compounds composed of a hydrocarbon plus a hydroxyl group (OH). The two simplest alcohols are methanol and ethanol.

alternative energy source - An environmentally friendly source of energy not traditionally used for a particular application.

alternative fuel - Any fuel for vehicles other than the petroleum-based fuels now in conventional use; for cars, trucks, and buses, conventional fuels are considered to be gasoline and diesel. Generally, alternative fuels are alcohols, natural gas, propane, hydrogen, and electricity. A more stringent definition is set forth in the federal Energy Policy Act of 1992: methanol, denatured ethanol, and other alcohols, separately or in mixtures of 89% by volume or more (or other percentage not less than 70% as determined by U.S. Department of Energy rule) with gasoline or other fuels; compressed natural gas; liquified natural gas; propane (liquefied petroleum gas); hydrogen; coal-derived liquid fuels; other than alcohols derived from biological materials; electricity; or any other fuel determined to be substantially not petroleum and yielding substantial energy security and environmental benefits.

alternative-fuel vehicle - A vehicle designed and manufactured or converted to operate in dedicated or multi-fuel modes on fuels other than gasoline or diesel as defined by EPAct.

atmosphere - The envelope of air surrounding the earth and bound to it by the earth's gravitational attraction.

B

barrel - A unit of measure (volume) for crude oil and petroleum products, equivalent to 42 U.S. gallons.

bi-fuel vehicle - A vehicle with two separate fuel systems designed to run on an alternative fuel and gasoline, using only one fuel at a time.

biodiesel - A biodegradable transportation fuel for use in diesel engines that is produced through transesterification of oil from plants such as soybeans, rapeseed, or sunflowers; animal fat; or agricultural byproducts such as rice hulls.

biogas - A mixture of carbon dioxide and methane produced from the anaerobic decomposition of organic material; typically a low-quality gas with numerous contaminants.

biomass - Organic matter such as plant materials and animal waste used for the production of energy. Examples include agricultural crops; crop-waste residues; wood, animal, and municipal wastes; aquatic plants; and fungal growth.

British thermal unit - A standard unit for measuring heat energy. One Btu is the amount of heat required to raise one pound of water 1EF at sea level.

C

CNG - Compressed natural gas. CNG has been pressurized to between 2,000 and 3,600 psi in a container and expands when released for use as a fuel.

carbon dioxide - A colorless, odorless, non-poisonous gas normally present in air. One source of carbon dioxide is fossil-fuel combustion. Although CO_2 does not directly impair human health, it is a greenhouse gas that traps the earth's heat and contributes to the potential for global warming. It is vital to plants, which absorb it from the air.

carbon monoxide - A colorless, odorless gas, slightly lighter than air, produced by the incomplete combustion of fuels with a limited oxygen supply, as in automobile engines. Carbon monoxide is poisonous if inhaled, entering the bloodstream through the lungs and forming a compound that inhibits the blood's capacity to carry oxygen to organs and tissues. Carbon monoxide can impair exercise capacity, visual perception, manual dexterity, and learning functions. Severe CO poisoning can result in death.

carcinogenic - Known to cause cancer.

coal - A black or brownish-black solid combustible substance formed by the partial decomposition of vegetable matter without access to air. See also *anthracite, bituminous coal and lignite.*

combustion - Burning; a chemical change, usually oxidation, accompanied by the production of heat and light.

compressed natural gas - Natural gas that has been pressurized to between 2,000 and 3,600 psi. It is held in a container and expands when released for use as a fuel.

compressor - A machine that compresses a gas into a smaller volume of space.

crude oil - A mixture of hydrocarbons that exists in liquid phase in underground reservoirs and remains liquid at atmospheric pressure after passing through a separating facility. Includes liquid hydrocarbons produced from tar sands, oil shale, and other sources.

D

dedicated vehicle - A vehicle designed to operate solely on one alternative fuel.

denatured alcohol - An alcohol that otherwise could be safely consumed by humans that contains a small amount of a toxic substance, such as methanol or gasoline, which cannot be removed easily by chemical or physical means. Alcohols intended for industrial use, including ethanol, must be denatured to discourage abuse by ingestion and to avoid alcoholic beverage regulation and taxation.

dispenser - A machine that dispenses a fuel. A dispenser may include more than one pump. Today, many filing station dispensers have six pumps - three on each side.

dual-fuel vehicle - A vehicle designed to run on a combination of alternative fuel and conventional fuel at the same time. Dual-fuel systems have separate fuel tanks, and both fuels are injected into the combustion chamber simultaneously.

E

E10 - Ethanol/gasoline mixture containing 10% denatured ethanol and 90% gasoline, by volume. See also *gasohol.*

E85 - Ethanol/gasoline mixture containing 85% denatured ethanol and 15% gasoline, by volume.

efficiency - The ratio of the effective or useful output to the total input of any system.

electric vehicle - Vehicle powered by electricity, whether stored in batteries or produced within a fuel cell.

electrical energy - Energy generated by moving electrons.

emissions - Substances discharged into the air, especially by an internal-combustion engine.

energy - As defined in physical science, the capacity to do work and change matter. Energy is neither created nor destroyed, but can change from one form into another.

energy source - A supply of energy that can be used for a particular application.

ethanol - Otherwise known as ethyl alcohol, alcohol, or grain-spirit. A clean, colorless, flammable oxygenated hydrocarbon. It is used in the United States as a gasoline octane enhancer and oxygenate (up to 10 percent concentration). It is commonly derived from biomass sources such as corn. See also E-10, E-85, *gasohol.*

evaporative emissions - Hydrocarbon vapors that escape from a gasoline storage tank, from a vehicle tank during refueling, or from a vehicle fuel system. See also *exhaust emissions*.

exhaust emissions - Sometimes called tailpipe emissions. Any substances, gases, or particles, that result from fuel combustion, e.g., water vapor, carbon monoxide, and soot particles. See *evaporative emissions*.

F

fast fill - A type of natural gas refueling, requiring a compressor and a storage tank that allows quick dispensing of fuel.

flexible-fuel vehicle - A vehicle designed to operate on methanol or ethanol, gasoline, or any combination thereof.

fossil fuel - Fuel derived from materials formed over millions of years from organic debris. Fossil fuels include coal, distillates of petroleum, and natural gas and its components.

fuel cell - A system that converts the chemical energy of a fuel, such as hydrogen and oxygen, directly to electricity. The principal components of a fuel cell are catalytically activated electrodes for the fuel (anode) and the oxidant (cathode) and an electrolyte to conduct ions between the two electrodes.

G

gaseous fuel - A combustible mixture that has neither independent shape nor volume; unless contained, it would expand indefinitely. Gaseous fuels used for transportation, such as propane and natural gas, have an advantage over liquid fuels, which must be vaporized for efficient ignition. Their disadvantage is that they must be stored in pressurized tanks.

gasification - Any chemical or heat process used to convert a feedstock to a gaseous fuel; especially, a method for turning coal into a gas. This can be accomplished by burning the coal or extracting and gasifying the coal at a plant.

gasohol - In the United States, gasohol refers to gasoline that contains 10% ethanol by volume. This term was common in the late 1970s and early 1980s. Future gasohol will contain 5.7% and 7.7% ethanol.

gasoline - A mixture of volatile hydrocarbons used to operate an internal-combustion engine, produced through the distillation and other chemical transformation of petroleum.

H

hybrid vehicle - A vehicle that can run on electricity and another fuel.

hydrocarbon - An organic chemical compound of hydrogen and carbon in either gaseous, liquid, or solid phase. The molecular structure of hydrocarbon compounds varies from the simple (e.g., methane, a constituent of natural gas) to the heavy and complex (e.g., benzene, a constituent of gasoline).

hydrogen - The simplest and lightest of the elements; exists as a colorless, odorless, diatomic gas as well as in combination with other elements.

I

internal-combustion engine - A heat engine in which the combustion that generates the heat takes place inside the engine instead of in an external furnace.

L

liquefaction - The process of making, or state of being, a liquid.

liquefied natural gas - Natural gas that has been condensed to a liquid, typically by cooling the gas to -259EF.

liquefied petroleum gas (LPG) - Several gases extracted from natural gas or petroleum that liquefy under pressure. The term is often used to substitute for the name of an individual gas, especially propane. See also *butane* and *propane*.

M

M85 - 85% methanol and 15% unleaded gasoline by volume; used as a motor fuel for light-duty applications.

M100 - 100% (neat) methanol, used as a motor fuel for heavy-duty engines.

methane (CH_4) - The simplest of the hydrocarbons and the principal constituent of natural gas. Also, the principal gas derived from landfills. Pure methane has a heating value of 1,012 Btu per cubic foot.

methanol (CH_3OH) - Also known as methyl alcohol, wood alcohol. A colorless, poisonous liquid with essentially no odor and very little taste. The simplest alcohol, it is extremely flammable, burning with a nearly invisible blue flame. Methanol is produced commercially by catalytically combining carbon monoxide (CO) with hydrogen (H_2) under high temperature and pressure or by steam-reforming natural gas.

miles per gallon equivalent - The average number of miles a vehicle can travel on a gallon equivalent of an alternative fuel, i.e., an amount of fuel equal in energy content to one gallon of gasoline.

mobil-source emissions - Emissions of pollutants from cars, trucks, buses, and other motor vehicles. This category includes both exhaust and evaporative emissions.

N

natural gas - A mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the earth, used principally as a fuel in the production of heat, electricity, or in transportation. For vehicular use, natural gas is compressed in special tanks to a pressure of 2,000-3,600 psi. It can also be liquified by cooling to -259EF.

nitrogen - A non-metallic element that occurs naturally as a colorless, odorless, diatomic gas (N_2). Nitrogen constitutes nearly 4/5 of the volume of the earth's atmosphere.

non-attainment area - A region that exceeds minimum federal air-quality standards for certain pollutants. See also *Clean Air Act of 1970, criteria pollutants.*

non-renewable fuel - Fuel that takes millions of years to make, such as a fossil fuels. At current rates of consumption, these sources will be depleted long before more are available for use.

O

octane rating - Also called octane number; a numerical representation of the anti-knock properties of motor fuel.

original equipment manufacturer - Manufacturer that provides the original design and materials for making a product. OEMs include the major U.S. auto manufacturers. In the context of alternative fuels, OEM refers to a manufacturer that produces a vehicle that leaves the assembly line ready to use an alternative fuel without further conversion.

oxygenated gasoline - Gasoline with an oxygen content of 2.7% by weight. Oxygenated fuel tends to burn more completely, converting its carbon into carbon dioxide rather than carbon monoxide. This reduces air pollution from exhaust emissions.

ozone (O_3) - A molecule consisting of three oxygen atoms that occurs naturally at both ground level and high in the atmosphere. It is a blue, pungent-smelling gas at room temperature. Ground-level ozone if formed naturally when water vapor reacts with lightning. It is formed in greater quantities when sunlight acts on nitrogen oxides and volatile organic compounds emitted by fuel combustion. Ozone is the principal component of the brownish haze called smog. Ozone is a lung irritant, causing particular health problems for growing children, some elderly people, and people with lung conditions such as asthma.

P

particulates - Small particles of polluting compounds.

parts per million - A measurement of the concentration or density of one substance compared to another. If 50 ml of carbon monoxide is present in 1 million ml of air, the concentration of CO is 50 ppm by volume.

petroleum - See *crude oil.*

photovoltaic cell - Device that converts sunlight directly into electric current.

pollution - The contamination of soil, water, or air by the discharge of harmful substances.

propane - Colorless, gaseous simple hydrocarbon extracted from natural gas or crude oil, used as a fuel and as a raw material in chemical manufacturing. One of the alternative fuels specified in the Energy Policy Act of 1992. Also called liquefied petroleum gas (LPG).

R

rapeseed - The seed of the rape plant, a European plant. Oil is extracted from the rape seed and used as a lubricant and in food products.

reactive emissions - Compounds emitted by evaporation or combustion of fuels that react with the atmosphere to form harmful pollutants, such as ozone. Includes reactive hydrocarbons, e.g., benzene, and other compounds such as sulfur dioxide.

refinery - An industrial plant that manufactures finished products from crude oil, natural gas, natural gas liquids, other hydrocarbons, and oxygenates.

reformulated gasoline - Gasoline whose composition includes oxygenates and reduced content of olefins, aromatics, volatile components, and heavy hydrocarbons. The goal is to reduce ozone formation and the release of toxic substances into the air from both evaporation and tailpipe emissions. In cities that do not meet air-quality requirements for ozone set forth in the 1990 amendments to the federal Clean Air Act, only reformulated gasoline can be sold during months when ozone pollution is most serious.

refueling station - A facility that sells or distributes fuels to motor vehicles.

renewable fuel - Fuel that is created naturally, or by human intervention at a relatively rapid rate, and therefore does not run out.

reserves - Identified deposits or reservoirs of natural resources, such as coal, forests, or water.

S

smog - A brownish haze seen over polluted cities. The name was coined as a combination of “smoke” and “fog,” both of which it resembles. A principal component is ozone.

T

toxic - Poisonous or harmful to human life.

toxicity - The degree to which a substance is poisonous.

V

volatile - Describes a substance that readily turns to vapor at normal temperatures.

Acknowledgements

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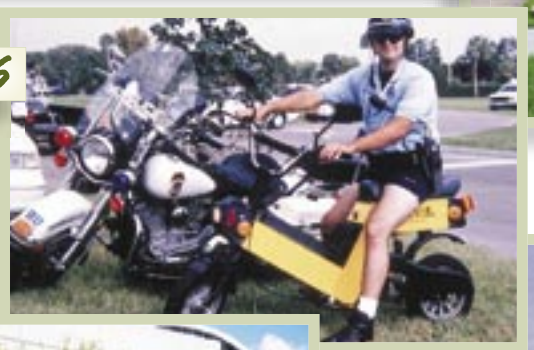

1. Ford fuel-cell car at CFFAB meeting at CUTR
2. GSA Mobile CNG fueling station
3. GSA - Honda CNG and Chrysler Ethanol cars at Kennedy Space Center
4. Used vegetable oil being collected to make Biodiesel
5. Electric vehicle charging station at OUC
6. Electric scooter for police patrol
7. AFV display at an "Advancing the Choice" workshop
8. GM EV1 and 1918 Milburn EV displayed at FSEC

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