2012-2013

Transportation Fuels Infobook

Fact sheets and suggested activities to educate students about the economic, environmental, and societal impacts of using conventional and alternative transportation fuels.

TRANSPORTATION

Grade Level:

- Intermediate
- Secondary

Subject Areas:

- Science
- Language Arts
- Technology

NEED

National Energy Education Development Project

Hybrid Electric Vehicles

Hybrid Electric Vehicles (HEVs) are powered by two energy sources—an energy conversion unit (such as a combustion engine or fuel cell) and an energy storage device (such as a battery, flywheel, or ultra capacitor). The energy conversion unit can be powered by gasoline, compressed natural gas, hydrogen, or other alternative fuels.

HEVs can have either a parallel or series design. In a parallel design, the energy conversion unit and electric propulsion system are both connected directly to the vehicle's wheels. The electric propulsion system never drives the wheels alone, unlike a series design. 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 a series design, the primary engine is connected to a generator that produces electricity. The electricity charges the batteries and drives an electric motor that powers the wheels.

Hybrid power systems were designed as a way to compensate for the limitations of **dedicated** EVs. Because batteries can only supply power for short trips, a generator powered by an internal combustion engine was added to increase range. An HEV can function as a purely electric vehicle for short trips, only using the internal combustion engine when longer range is required.

HEVs on the market today combine an internal combustion engine with a battery and electric motor, resulting in vehicles with 1.5 times the fuel economy of comparable conventional vehicles. Depending on driving conditions, one or both are used to maximize fuel efficiency and minimize emissions, without sacrificing performance.

An HEV battery is continually recharged by on-board sources. It has a generator powered by the internal combustion engine to recharge the batteries whenever they are low. A **regenerative braking** system captures excess energy when the brakes are engaged. This recovered energy is used to recharge the batteries.

Environmental Impacts

The HEV provides extended range and rapid refueling compared to conventional vehicles, as well as significant environmental benefits, reducing emissions by one-third. Their range and fuel economy make them attractive to consumers.

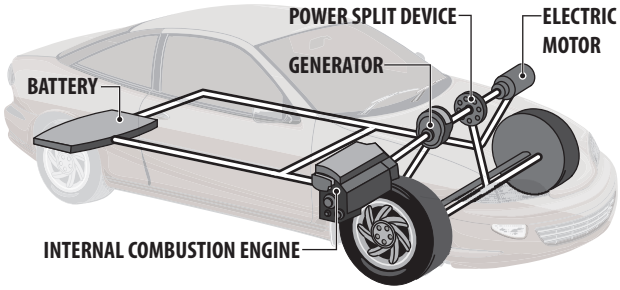
Hybrids Today and Tomorrow

In 2006, there were eight hybrid models available to the general public. In 2012, there are over 30 hybrid models available from almost every manufacturer. Today's hybrid vehicles include two seat passenger cars, four and five seat sedans, SUVs, and even full size pick up trucks capable of towing.

TOYOTA PRIUS

Image courtesy of NREL

How a Hybrid Electric Vehicle Works



Hybrid electric vehicles combine the benefits of gasoline engines and electric motors. Typically, the wheels are powered by an electric motor, and in some cases, the internal combustion engine assists. Hybrid electric vehicles do not need to be plugged in to charge the battery because they are charged by an onboard generator.

Plug-In Hybrid Vehicles (PHEVs)

PHEVs are very similar to HEVs. They have an internal combustion engine, an electric motor and a large battery pack. The larger battery pack in the PHEV gives it a range of 10-40 miles on an electric only range. When the battery is depleted the car continues to operate as a hybrid or gasoline vehicle.

The battery pack in a PHEV can be recharged by plugging it into a regular 120-volt electric outlet. People using a PHEV in an urban setting may be able to make their daily commute using all-electric power and then recharge the battery overnight to be ready for the next day's commute.

In 2012, there are only a few two PHEV models available on the market, but more are expected to be available soon.

Electric Vehicles

In 1891, William Morrison of Des Moines, Iowa, developed the first electric car. By the turn of the century, dedicated electric vehicles (EVs) outnumbered their gasoline-powered counterparts by two-to-one. Today, there are over 57,500 dedicated EVs in use in the United States, mostly in the West and South.

Rather than using gasoline, **electric vehicles** run solely on **electricity**. A battery stores the electrical energy that powers the motor. When a battery needs charging, EV owners can plug their cars into a charging station at home. A full charge can take four to eight hours, but there are options that allow for a faster charge, which only takes about 30 minutes. Fast charging stations will be public charging stations as they will be too expensive for home use. California currently has the most public charging stations available, but the number of public charging stations is quickly growing across the country. There are currently 9,980 electric charging units at public refueling stations.

The batteries limit the range of a dedicated EV, which is determined by the amount of energy stored in its battery pack. The more batteries a dedicated EV can carry, the more range it can attain, to a point. Too many batteries can weigh down a vehicle, reducing its load-carrying capacity and range, and causing it to use more energy. The typical dedicated EV can only travel 50 to 130 miles between charges. This driving range assumes perfect driving conditions and vehicle maintenance. Weather conditions, terrain, and some accessory use can significantly reduce the range.

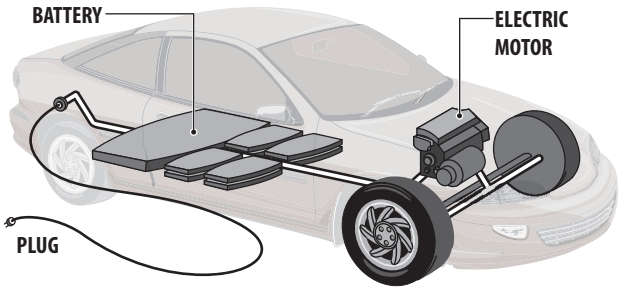
Dedicated EVs, therefore, have found a niche market as neighborhood or low speed vehicles for consumers going short distances at speeds of 35 mph or less. However, this is changing. Tesla Motors has developed an electric sports car capable of accelerating 0-60 in 3.9 seconds and traveling 236 miles on one charge. The major car manufacturers have announced plans to put dedicated EVs on the market with a target range of 100 miles. By 2015, Nissan, Ford, Honda, Toyota, Chrysler, and Chevrolet all expect to have EVs available to consumers. Nissan's Leaf electric vehicle is one of the first to be mass produced and marketed in the United States.

The batteries most commonly used in new EVs are lithium-ion. Nickel-metal hydride batteries are also found in some electric vehicles. Extensive research is being conducted on advanced batteries such as lithium-polymer and lithium-air batteries. Such advanced batteries could double the current range of electric vehicles, reduce the cost of batteries, and hold promise for being longer lived.

2011 NISSAN LEAF ELECTRIC VEHICLE

Image courtesy of Nissan

How an Electric Vehicle Works



Electric vehicles store electricity in large battery banks. They are plugged into a wall outlet (either a 240-volt or standard 120-volt) for several hours to charge. An electric motor powers the wheels, and acts as a generator when the brakes are applied, recharging the battery.

Environmental Impacts

Dedicated electric vehicles produce no tailpipe emissions, but producing the electricity to charge them can produce emissions. EVs are really coal, nuclear, hydropower, oil, and natural gas cars, because these fuels produce most of the electricity in the U.S. Coal alone generates nearly half of our electricity. When fossil fuels are burned, pollutants are produced like those emitted from the tailpipe of a gasoline-powered automobile. Power plant emissions, however, are easier to control than tailpipe emissions. Emissions from power plants are strictly regulated, controlled with sophisticated technology, and monitored continuously. In addition, power plants are usually located outside major centers of urban air pollution. Using electricity generated from renewable energy produces near zero emissions.

Driving EVs in more populated cities will help decrease the emissions in that city and will help reduce petroleum consumption.

Maintenance

The low maintenance of dedicated electric vehicles is appealing to many consumers. Dedicated EVs require no tune-ups, oil changes, water pumps, radiators, injectors, or tailpipes, so no more trips to the service station.

National Ambient Air Quality Standards

The U.S. Environmental Protection Agency (EPA) uses six pollutants as indicators of air quality and has established maximum threshold concentrations for each. When areas do not meet the standard for one of these pollutants, they may be designated as non-attainment areas and required to implement plans to reach acceptable levels within certain time frames or be subject to penalties.

Ozone

Ozone (O_3) is a photochemical oxidant and the major component of smog. Ozone in the upper atmosphere is beneficial because it helps shield the Earth from ultraviolet radiation, but high concentrations of ozone in the lower atmosphere is detrimental to public health and the environment. Ozone can damage lung tissue, reduce lung function, and sensitize the lungs to other irritants.

Ozone is formed through a chemical reaction between volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight, especially in warm seasons. Both VOCs and NO_x are emitted by transportation and industrial sources.

The ozone threshold value is 0.075 parts per million (ppm), measured over eight hours. Attainment is met by the annual fourth-highest daily maximum eight-hour concentration, averaged over three years.

Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless, poisonous gas produced by incomplete combustion of carbon in fuels. When CO enters the bloodstream, it reduces the delivery of oxygen to the body's organs and tissues.

Seventy-seven percent of CO emissions nationwide are from transportation sources, especially highway motor vehicles. Major urban areas have, therefore, been the focus of CO monitoring.

The NAAQS for carbon monoxide is 9.0 ppm, measured as an eight-hour nonoverlapping average concentration. An area meets the standard if no more than one eight-hour value exceeds the threshold per year.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish, highly reactive gas present in all urban atmospheres. The three major emissions sources are transportation, electric utilities, and industrial boilers. Oxides of nitrogen are important precursors of ozone and acid rain and can affect aquatic and terrestrial ecosystems. They are formed when fuels are burned at high temperatures. Nitrogen dioxide can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections.

The NAAQS for NO_2 is 0.053 ppm, measured as an average annual concentration. An area meets the standards when the mean concentration in a calendar year is below the threshold.

Sulfur Dioxide

Sulfur dioxide (SO_2) is mainly produced by stationary sources of coal and oil combustion, steel mills, refineries, pulp and paper mills, and non-ferrous smelters. SO_2 is a primary contributor to acid rain and can impair visibility. High concentrations of SO_2 can affect breathing and aggravate existing respiratory and cardiovascular disease.

The NAAQS for SO_2 are:

- a one-hour level of 0.075 ppm met by the 99th percentile of one-hour daily maximum concentrations averaged over three years.
- a 3-hour level of 0.50 ppm, not to be exceed more than once per year.

Particulate Matter

Air pollutants designated as particulate matter (PM) include dust, dirt, soot, smoke, and liquid droplets emitted directly into the air by factories, power plants, cars, construction, fires, and natural windblown dust. Particles formed in the atmosphere by condensation or transformation of emitted gases such as SO_2 and VOCs are also considered particulate matter.

Particulate matter can have major effects on human health, including breathing and respiratory symptoms, damage to lung tissue, alteration of defense systems, carcinogenesis, and premature death. Particulate matter also soils and damages materials and is a major cause of visibility impairment.

The NAAQS for particulate matter are measured in several ways. The maximum annual level of 15 micrograms per cubic meter is measured as an annual mean, averaged over three years.

Lead

Lead is a heavy metal dangerous to human health. Exposure to lead (Pb) can occur through inhalation of lead-polluted air and ingestion of lead-polluted food, water, soil, or dust. Lead gasoline additives, non-ferrous smelters, and battery plants are the biggest contributors to atmospheric lead.

Regulations issued in the early 1970's required gradual reduction of the lead content of all gasoline over a period of years. These regulations have essentially eliminated violations of the lead standard in urban areas except those areas with lead point (localized) sources.

Programs are also in place to control lead emissions from stationary point sources. Significant and ambient problems still remain around some lead point sources, which are now the focus of new monitoring initiatives.

National primary and secondary ambient air quality standards for lead and its compounds, measured as elemental lead, are not to exceed 0.15 micrograms per cubic meter, measured as a rolling three month average.

Ozone Non-Attainment Areas

Data: U.S. Environmental Protection Agency

Glossary

additives	chemicals added to fuel to improve and maintain fuel quality; detergents and corrosion inhibitors are examples of gasoline additives
alternative fuel	as defined by the Energy Policy Act of 1992 (EPACT) - methanol, denatured ethanol and other alcohols (separately or in mixtures of 85% or more by volume with gasoline or other fuels), CNG, LNG, LPG, hydrogen, "coal-derived liquid fuels", fuels other than alcohols derived from biological materials, electricity, neat biodiesel, and any other fuel "substantially not petroleum" that yields substantial energy security benefits and substantial environmental benefits
alternative fuel vehicle (AFV)	as defined by EPACT, any dedicated, flexible-fueled, or dual-fueled vehicle designed to operate on at least one alternative fuel
biodiesel	a biodegradable transportation fuel for use in diesel engines that is produced using organically derived oils or fats as feedstock; biodiesel is used as a component of diesel fuel, and in the future it may be used as a replacement for diesel; B100 is 100 percent biodiesel, B20 is 20 percent biodiesel blended with diesel
biomass	renewable organic matter such as agricultural crops, crop-waste residues, wood, animal and municipal wastes, aquatic plants, fungal growth, etc., used for the production of energy
british thermal unit (Btu)	a standard unit for measuring heat energy; one Btu represents the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit (at sea level)
carbon dioxide	a product of combustion, a greenhouse gas
catalyst	a substance whose presence changes the rate of a chemical reaction without undergoing permanent changes in its composition
cetane number	the cetane number is a measure of the ignition quality of diesel fuel based on ignition delay in an engine; fuels with a higher cetane number have shorter ignition delay, better ignition quality, and less tendency to knock when burned in a compression-ignition engine
Clean Air Act (CAA)	originally enacted in 1963, the law set emissions standards for stationary sources, such as factories and power plants; the amendments of 1970 introduced motor vehicle emissions standards; in 1990, reformulated gasoline (RFG) and oxygenated gasoline provisions were added; the RFG provision requires the use of RFG all year in certain areas; the oxygenated gasoline provision requires the use of oxygenated gasoline during certain months, when CO and ozone pollution are most serious; the regulations also require certain fleet operators to use clean-fuel vehicles in certain cities
clean fuel vehicle (CFV)	any vehicle certified by the EPA as meeting federal emissions standards; there are three categories of CFV standards—LEV, ULEV, and ZEV
compressed natural gas (CNG)	natural gas that has been compressed under high pressures of 2000 to 3600 psi in a pressurized container
converted or conversion vehicle	a vehicle originally designed to operate on gasoline or diesel that has been modified to run on an alternative fuel
corporate average fuel economy (CAFE)	a law passed in 1975 that set federal fuel economy standards; CAFE values are an average of city and highway fuel economy
dedicated vehicle	an alternative fuel vehicle that operates on only one fuel; usually, dedicated vehicles have lower emissions and better performance than vehicles that can use more than one fuel
domestic fuel	domestic fuel is derived from resources within the United States, Canada, and Mexico
dual-fuel vehicle	vehicle designed to operate on a combination of an alternative and conventional fuel
CAA	vehicle with two separate fuel systems designed to run on either an alternative fuel or conventional gasoline, using only one fuel at a time
E10 (gasohol)	ethanol/gasoline mixture containing 10% denatured ethanol and 90% gasoline, by volume
E85	ethanol/gasoline mixture containing 85% denatured ethanol and 15% gasoline, by volume
E95	ethanol/gasoline mixture containing 95% denatured ethanol and 5% gasoline, by volume

electricity	electric current used as a power source; in electric vehicles, on-board rechargeable batteries power an electric motor
electric vehicle	a vehicle powered by electricity, generally provided by storage batteries, but may also be provided by photovoltaic cells or fuel cells
emissions	gaseous products of combustion, some are pollutants
Energy Policy Act of 1992 (EPACT)	a broad-ranging act that deals with many aspects of alternative fuels and alternative fuel vehicles
ethanol (also known as ethyl alcohol, grain alcohol, CH_3CH_2OH)	an alcohol fuel produced from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood; when used as a gasoline octane enhancer and oxygenate, it increases octane by 2.5 to 3 numbers at 10% concentration; ethanol can also be used in higher concentration in AFVs that have been designed or converted for its use
feedstock	any material that is converted to another form of fuel or energy product; corn, for example, is used as a feedstock for ethanol production
fermentation	the enzymatic transformation by microorganisms of organic compounds such as sugars into alcohols; the process by which organic material is converted into ethanol, for example
flexible fuel vehicles (FFV)	vehicles with a common fuel tank designed to run on varying blends of unleaded gasoline with either ethanol or methanol
fuel cell	an electrochemical engine (no moving parts) that converts the chemical energy of a fuel, such as hydrogen, and an oxidant, such as oxygen, directly into electricity
gasification	a chemical or thermal process used to convert a feedstock (such as coal) into a gaseous fuel
gasohol (E10)	gasoline that contains 10% ethanol by volume
global warming	the escalation of global temperatures caused by an increase in greenhouse gas emissions in the lower atmosphere
greenhouse effect	a warming of the Earth and its atmosphere as a result of the thermal trapping of incoming solar radiation
hybrid electric vehicle (HEV)	a vehicle that is powered by two or more fuels, one of which is electricity
hydrocarbon	a compound made up of hydrogen and carbon
inherently low emission vehicle (ILEV)	a vehicle that meets ILEV federal standards
internal combustion engine	an engine in which a fuel is burned within the chamber to create motion
knocking (pinging)	knocking in internal combustion engines occurs when fuel in the cylinder is ignited by the firing of the spark plug but burns too quickly, combusting completely before the optimum moment during the compression phase of the four-stroke cycle; the resulting shockwave collides with the rising piston, creating a characteristic metallic "pinging" sound
liquefied natural gas (LNG)	natural gas that has been condensed to a liquid by cooling
liquefied petroleum gas (LPG)	gaseous hydrocarbon mixture separated from natural gas and petroleum, commonly called propane
low emission vehicle (LEV)	vehicles that meet federal standards for LEVs
low speed vehicle (LSV)	small battery-powered electric vehicle with a 30 mph speel limit, sometimes referred to as a neighborhood vehicle
M85	fuel with 85% methanol and 15% gasoline by volume, no longer used as an alternative fuel
M100	neat (100%) methanol, no longer used as an alternative fuel
methane (CH_4)	the simplest hydrocarbon and principal constituent of natural gas
methanol (also known as methyl alcohol, wood alcohol, CH_3OH)	a liquid fuel usually manufactured from natural gas

methyl tertiary butyl ether (MTBE)	a high-octane ether used as a fuel oxygenate
National Ambient Air Quality Standards (NAAQS)	standards for air pollutants regulated under the Clean Air Act, including ozone, CO, NO_2, lead, particulate matter, and SO_x
natural gas	a mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the earth and used as a fuel
neat fuel	fuel that is free from additives or dilution with other fuels; M100, for example, is 100% methanol and is called neat methanol
neighborhood electric vehicle (NEV)	battery-powered electric vehicle with top speed of 30 mph
nitrogen oxides (NO_x)	regulated air pollutants, primarily NO and NO_2, which are precursors of smog and acid rain
non-attainment area	a region of the country that exceeds minimum acceptable National Ambient Air Quality Standards (NAAQS) for one or more pollutants; such areas are required to seek modifications to their State Implementation Plans (SIPs), setting forth a reasonable timetable using EPA-approved means to achieve attainment; under the Clean Air Act, if a non-attainment area fails to meet NAAQS, the EPA may impose stricter requirements or impose fines, construction bans, and cutoffs in federal grant revenues until attainment is achieved
octane enhancer	a substance such as MTBE that is added to gasoline to increase octane and reduce engine knock
octane rating (octane number)	a measure of a fuel's resistance to self-ignition; a measure of the antiknock properties of the fuel
ozone	tropospheric ozone, or smog, at ground level is a respiratory irritant and considered a pollutant produced from the interaction of hydrocarbon fuel emissions and sunlight—this is different from the stratospheric ozone in the upper atmosphere that protects the Earth from ultraviolet radiation
particulate matter	diverse substances that exist as discrete particles and are considered pollutants according to NAAQS
petroleum fuels	gasoline and diesel fuels
propane	see Liquefied Petroleum Gas
reformulated gasoline (RFG)	gasolines that have been altered to reduce emissions of pollutants
regenerative braking	converts wasted energy from braking into electricity that can be stored in a battery
smog	a visible haze caused primarily by particulate matter and ozone in the lower atmosphere
State Implementation Plan (SIP)	every state must submit a plan to the EPA demonstrating compliance with NAAQS, according to the Clean Air Act
super ultra low emission vehicle (SULEV)	a California vehicle that produces fewer emissions than an ULEV; there is no federal standard for a SULEV
tax incentives	a reduction in taxes to encourage people and businesses to invest in socially desirable economic objectives, such as using alternative fuel vehicles
toxic emission	any pollutant emitted from a source that can negatively affect human health or the environment
transitional low emission vehicle (TLEV)	a vehicle that meets federal TLEV standards; TLEVs have fewer emissions than Tier 1 vehicles but are not eligible for the Clean-Fuel Fleet Program
ultra low emission vehicle (ulev)	vehicle that meets federal and California standards for ULEVs
U.S. Department of Energy (DOE)	department of the Federal Government that coordinates and manages energy conservation, supply, information dissemination, regulation, research, development, and demonstration
U.S. Department of Transportation (DOT)	department of the Federal Government that handles national transportation issues
U.S. Environmental Protection Agency (EPA)	government agency responsible for protection of the environment and public health, regulating air, water, and land pollution, as well as pollution from solid waste, radiation, pesticides, and toxic substances; EPA also controls emissions from motor vehicles, fuels, and fuel additives
volatile organic compounds (VOC)	reactive gases released during combustion or evaporation of fuel and regulated by EPA VOCs; react with nitrogen oxides (NO_x) in the presence of sunlight to form ozone
zero emission vehicle (ZEV)	vehicle meeting federal or California standards for ZEVs; ZEVs standards, usually met by electric vehicles, require zero vehicle emissions (though not zero power plant source emissions)

Transportation Fuel Acronyms

AFV	alternative fuel vehicle
B20	20% biodiesel/diesel blend
Btu	British thermal unit
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CAFE	corporate average fuel economy
CFV	clean fuel vehicle
CNG	Compressed Natural Gas
CO	carbon monoxide
CO_2	carbon dioxide
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
E85	85% ethanol/gasoline blend
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act of 1992
FFV	flexible fuel vehicle
HEV	hybrid electric vehicle
HC	hydrocarbon
ILEV	inherently low emission vehicle
LEV	low emission vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas (propane)
LSV	low speed vehicle
MSW	municipal solid waste
MTBE	methyl tertiary butyl ether
NAAQS	National Ambient Air Quality Standards
NEV	Neighborhood Electric Vehicle
PM	particulate matter
PPM	parts per million
PSI	pounds per square inch
RFG	reformulated gasoline
SULEV	super ultra low emission vehicle
TLEV	transitional low emission vehicle
ULEV	ultra low emission vehicle
ULSD	ultra low sulfur diesel
VOC	volatile organic compound
VFV	variable fuel vehicle
ZEV	zero emission vehicle

TRANSPORTATION

Selected Light Duty Vehicles, 2012

MODEL	FUEL	VEHICLE	EMISSION CLASS	FUEL ECONOMY
Buick LaCrosse FFV	Flex Fuel E85	Sedan	Tier 2 Bin 4	13 mpg city, 19 mpg highway
Cadillac Escalade ESV	Flex Fuel E85	SUV	Tier 2 Bin 5	10 mpg city, 15 mpg highway
Cadillac Escalade Hybrid	Hybrid Electric	SUV	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Chevrolet Equinox	Flex Fuel E85	SUV	Tier 2 Bin 4	15 mpg city, 22 mpg highway
Chevrolet Malibu	Flex Fuel E85	Sedan	Tier 2 Bin 4	15 mpg city, 23 mpg highway
Chevrolet Silverado 1500 Hybrid	Hybrid Electric	Pickup Truck	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Chevrolet Tahoe 1500 Hybrid	Hybrid Electric	SUV	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Chevrolet Volt	Plug-in Hybrid Electric	Sedan	SULEV	95 mpgge city, 93 mpgge highway
Chrysler Town & Country	Flex Fuel E85	Minivan	Tier 2 Bin 4	12 mpg city, 18 mpg highway
Dodge Grand Caravan	Flex Fuel E85	Minivan	Tier 2 Bin 4	12 mpg city, 18 mpg highway
Ford Escape FFV	Flex Fuel E85	SUV	Tier 2 Bin 4	13 mpg city, 17 mpg highway
Ford Escape Hybrid	Hybrid Electric	SUV	SULEV, Tier 2 Bin 3	34 mpg city, 31 mpg highway
Ford F150	Flex Fuel E85	Pickup Truck	Tier 2 Bin 4	12 mpg city, 17 mpg highway
Ford Focus EV	Electric (Dedicated)	Sedan	ZEV, Tier 2 Bin 1	100 mile range city
Ford Fusion Hybrid	Hybrid Electric	Sedan	SULEV, Tier 2 Bin 3	41 mpg city, 36 mpg highway
GMC Yukon 1500 Hybrid	Hybrid Electric	SUV	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Honda Civic NGV	Natural Gas (Dedicated)	Sedan	LEV II AT-PZEV, Tier 2 Bin 2	24 mpgge city/ 36 mpgge highway
Honda Fit EV	Electric (Dedicated)	Two-Seater	CARB ZEV, Tier 2 Bin 1	100 mile range city
Honda Insight	Hybrid Electric	Two-Seater	LEV II AT-PZEV, Tier 2 Bin 2	40 mpg city, 43 mpg highway
Jeep Grand Cherokee	Flex Fuel E85	SUV	Tier 2 Bin 4	13 mpg city, 17 mpg highway
Kia Optima Hybrid	Hybrid Electric	Sedan	LEV II SULEV	35 mpg city, 40 mpg highway
Lexus CT 200h	Hybrid Electric	Sedan	LEV II SULEV, Tier 2 Bin 3	43 mpg city, 40 mpg highway
Nissan Altima Hybrid	Hybrid Electric	Sedan	LEV II SULEV, Tier 2 Bin 5	33 mpg city, 33 mpg highway
Nissan Leaf	Electric (Dedicated)	Sedan	CARB ZEV, Tier 2 Bin 1	100 mile range city
Porsche Cayenne S Hybrid	Hybrid Electric	SUV	LEV II ULEV, Tier 2 Bin 5	20 mpg city, 24 mpg highway
Tesla Motors Model S	Electric (Dedicated)	Sedan	CARB ZEV, Tier 2 Bin 1	300 mile range city
Toyota Highlander Hybrid	Hybrid Electric Flexible Fuel	SUV	LEV II SULEV, Tier 2 Bin 3	28 mpg city, 28 mpg highway
Toyota Prius Hybrid	Hybrid Electric	Sedan	LEV II AT-PZEV, Tier 2 Bin 3	51 mpg city, 48 mpg highway
Toyota Prius Plug-in Hybrid	Plug-in Hybrid Electric	Sedan	LEV II AT-PZEV, Tier 2 Bin 3	95 mpgge city
Toyota RAV4 EV	Electric (Dedicated)	SUV	CARB ZEV, Tier 2 Bin 1	100 mile range city

mpgge = miles per gallon gasoline equivalent

mpkg = miles per kilogram

For a complete list, visit www.fueleconomy.gov.

TRANSPORTATION

Transportation Fuel Comparison

	GASOLINE	DIESEL	PROPANE	CNG	LNG	ETHANOL	ELECTRICITY	BIODIESEL	HYDROGEN
Chemical Formula	C_4 to C_{12}	C_8 to C_{25}	C_3H_8	CH_4	CH_4	C_2H_5OH	N/A	C_{12} TO C_{22}	H_2
Energy Content (Btu/gallon)	116,090	128,450	84,950	20,268 Btu/lb	74,720	E85 – 80,460 E100 – 76,330	3,414 Btu/kWh	B20 – 126,000 B100 – 119,550	51,585 Btu/lb
Octane	84-93	Cetane: 40-55	105	120+	120+	110	N/A	Cetane: 48-65	130+
Number of Vehicles (2010)	239,700,000	4,800,000	143,037	115,863	3,354	618,506	57,462	N/A	421
Number of Fuel Stations	159,000	68,880	2,661	1,014	52	2,499	9,980 electric changing units	618	56
Advantages	Many fuel stations; vehicles designed to use gasoline; familiarity.	Many fuel stations; vehicles designed to use diesel fuel; familiarity; more fuel-efficient than gasoline; near zero emissions.	Inexpensive fuel; most widely available clean fuel; lower emissions of ozone-forming hydrocarbons and toxics; very good for fleets.	Very low emissions of ozone-forming hydrocarbons, toxics, and carbon monoxide. Very good fuel for fleets; can be made from renewables.	Very low emissions of ozone-forming hydrocarbons, toxics, and carbon monoxide. Very good fuel for fleets; can be made from renewables.	From renewable feedstocks; very low emissions of ozone-forming hydrocarbons and toxics; can be domestically produced.	Zero vehicle emissions; power plant emissions easier to control; can recharge at night when power cost and demand is low.	Reduces sulfur emissions; increases lubricity; uses renewable waste products; no vehicle changes required.	Near zero emissions; can be produced domestically from renewable sources
Challenges	Polluting emissions; unpredictable price; nonrenewable; limited and possibly unreliable supply.	Unpredictable price; nonrenewable; limited and possibly unreliable supply.	Nonrenewable; cost may rise with increasing demand; limited supply; no energy security or trade balance benefits.	Higher vehicle cost; lower vehicle range; limited fueling stations; nonrenewable at present.	Higher vehicle cost; lower vehicle range; limited fueling stations; nonrenewable at present.	Variable fuel cost; somewhat lower vehicle range; not widely available.	Current technology is limited; higher vehicle cost; lower range and performance; less convenient refueling.	Limited availability; higher cost.	Production is still in research stage; distribution infrastructure is not in place.