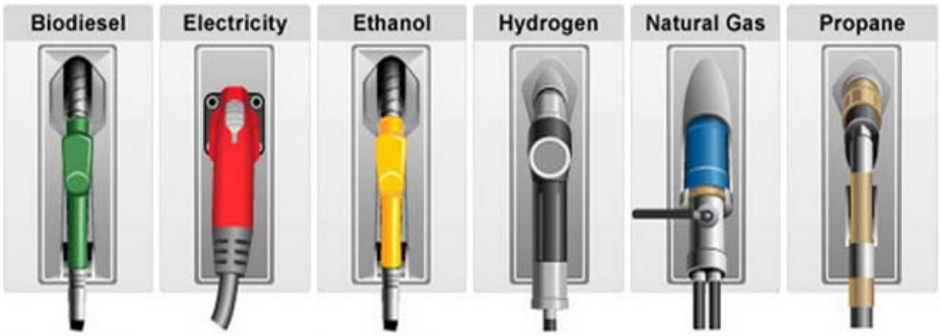
refuel



Alternative Fuels for Consumers

This toolkit was developed as part of the San Diego Regional Alternative Fuel Readiness Plan with support from the San Diego Regional Alternative Fuel Coordinating Council (Refuel), which seeks to reduce barriers to alternative fuel adoption in the region.

As California works toward achieving its ambitious climate goals, transitioning from gasoline and diesel vehicles into alternative fuel vehicles is an important facet in lowering greenhouse gas emissions (GHG).

Alongside public agencies, consumers can also begin to empower themselves with more knowledge about alternative fuel vehicles. This may encourage consumers to make more well-informed choices in their next vehicle purchase.

Driving an alternative fuel vehicle often has the following benefits:

- Cost savings
- Protection against petroleum price volatility and supply uncertainty
- Reduction of greenhouse gas emissions
- Improves local air quality
- Decreased reliance on foreign oil sources

How do I use this toolkit?

This toolkit provides resources and general information about alternative fuel vehicles for consumers. Within this toolkit, six different alternative fuels are discussed, detailing fuel-specific information such as:

- Guidance on availability of funding for alternative fuel vehicle purchases;
- Maps of public infrastructure locations;
- Diagrams of how an alternative fuel vehicle works;
- Fuel savings comparisons.

Biodiesel

FACTS ABOUT BIODIESEL

What is biodiesel?

Biodiesel is a non-petroleum-based diesel that is made from vegetable oil, recycled restaurant grease, or animal fats. Pure biodiesel is renewable, a clean-burning form of diesel, and growing in popularity.

Biodiesel is most often blended with petroleum diesel. Biodiesel blends range from B2 (2% biodiesel, 98% petroleum diesel) to B99 (99% biodiesel, 1% petroleum diesel). B20 is the most common biodiesel blend in the United States.

Renewable diesel also can be made from biomass feedstocks. This method uses a different process, making it more similar to diesel than biodiesel chemically.

How many public stations are in the San Diego region?

There is currently one public Biodiesel station in the San Diego region; however, there are many private fleets that have B20 delivered to their own facilities.

How much does it cost to fuel my vehicle?

Biodiesel is generally less expensive than diesel. Below are the 24-month averages of both diesel fuels.

24-month average*	
Diesel	$3.44
B20	$3.15
Savings	$0.31

*June 2013-June 2015

- Biodiesel is biodegradable, nontoxic, and safe for handling
- Biodiesel is produced from co-products and byproducts of crops already being grown
- B20 provides similar fuel economy, horsepower, and torque as diesel fuel
- 4.6 billion gallons of biodiesel have been produced in the U.S. since 2005, which have reduced lifecycle greenhouse gas (GHG) emissions by 56.2 billion gallons – the equivalent of removing almost 5 million passenger vehicles from America's roadways
- Biodiesel reduces lifecycle carbon emissions by up to 86%

What types of vehicles can use biodiesel?

Any vehicle that runs on diesel can also use biodiesel, including, but not limited to:

- Passenger vehicles
- Pickup trucks
- Vans
- Busses
- Refuse hauler
- Heavy Duty Trucks
- Construction equipment

Did you know…

Many light-duty diesel vehicles can also take low percentage blends of biodiesel. 85% of all manufacturers will allow B20 in newer model vehicles. Visit the National Biodiesel Board for more information: http://www.biodiesel.org/using-biodiesel/oem-information

Where can I learn more?

- Alternative Fuel Data Center - www.afdc.energy.gov/fuels/biodiesel.html
- National Biodiesel Board – www.biodiesel.org
- Biodiesel Education Network – www.askben.info
- Drive Biodiesel – www.drivebiodiesel.net
- National Biodiesel Foundation – www.biodieselfoundation.org

Using Biodiesel

You may not be sure if a biodiesel vehicle is right for you. The following tools and resources are available to help guide you through your decision-making process.

Where Can I Find Biodiesel?

You can buy biodiesel directly from biodiesel producers and marketers, petroleum distributors, or at some public retailers found throughout the nation.

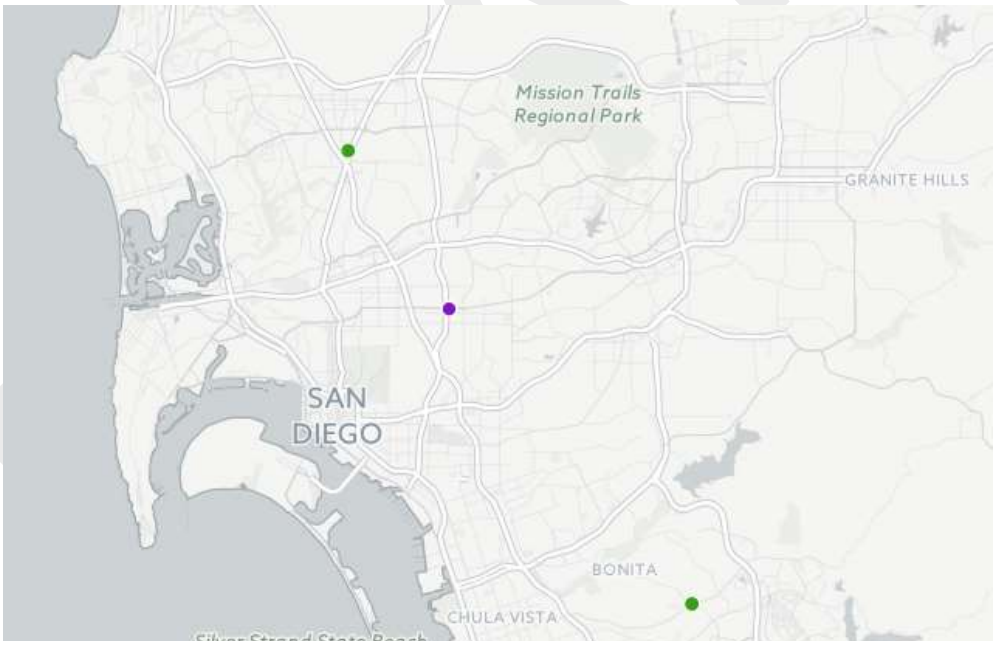
Is Biodiesel the Same as Vegetable Oil?[1]

Biodiesel is produced from fat or oils through a process called transesterification. This process removes the glycerin by reacting the oil/fat with an alcohol. Biodiesel must meet strict standards (ASTM D6751) in order to perform properly and not damage the vehicle.

What is Renewable Diesel?

Renewable diesel is also made from biomass feedstocks, but is processed in a different way that makes it more chemically similar to diesel than biodiesel. Renewable diesel has a higher cetane rating than biodiesel. There is ongoing research about renewable diesel, and more information can be found here: http://www.afdc.energy.gov/fuels/emerging_green.html.

Map of Public Biodiesel (B20 or higher) Fueling Stations in San Diego Region



Purple indicates biodiesel station; green indicates renewable diesel station
http://www.afdc.energy.gov/fuels/biodiesel_locations.html

[1] http://biodiesel.org/what-is-biodiesel/biodiesel-faq's

Electric Vehicles

What is an EV?

An electric vehicle (EV) is a generic term for a vehicle that is powered by electricity. A plug-in electric vehicle (PEV) is a vehicle in which there is an onboard battery that is powered by energy delivered from the electricity grid. There are two types of electric vehicles: a battery electric vehicle (BEV) and a plug-in hybrid electric vehicle (PHEV). BEVs run exclusively on the power from their onboard battery. PHEVs have both an onboard battery and an internal combustion engine that is used when the car's battery is depleted.

There are upwards of 17,500 PEVs in the San Diego region (as of Summer 2015).

How many stations are in the San Diego region?

Currently there are over 600 public charging stations in the San Diego region.

How much does it cost to fuel my vehicle?

It generally costs less than half as much to drive an electric vehicle as an internal combustion engine

24-month average*	
Gasoline	$3.35
Electricity**	$1.22
Savings	$2.13

*June 2013-June 2015
**Gasoline gallon equivalent at $0.12/kWh

WHAT IS CHARGING?

Level 1 Charging

Level 1 charging uses 120 volts AC. A PEV can be charged with just a standard wall outlet.

Level 2 Charging

Level 2 charging uses 240 volts AC. This is the same type of voltage as an outlet used for a dryer or washing machine.

DC Fast Charging

DC fast charging is a very quick level of charging. An EV can be charged up to 80% within 30 minutes of charging.

What types of vehicles can use electricity?

Electric vehicles come in all shapes and sizes. They are not limited to light-duty passenger vehicles (of which there are over 25 models!) anymore.

- Passenger vehicles
- Vanpool shuttles
- Pickup trucks
- Medium-duty vehicles
- Transit buses
- Forklifts
- Low-speed vehicles (like a golf cart)

TYPES OF ELECTRIC VEHICLES

Battery Electric Vehicle (BEV): Battery electric vehicles run entirely on the energy stored on an onboard battery. The vehicle is charged by electricity from the grid. On average, the vehicle's range is upwards of 80 miles on a single charge.

Plug-in Hybrid Electric Vehicle (PHEV): A plug-in hybrid electric vehicle runs on electricity and a gasoline. The vehicles onboard battery is charged by electricity from the grid, and when the battery is depleted, the gasoline engine is used.

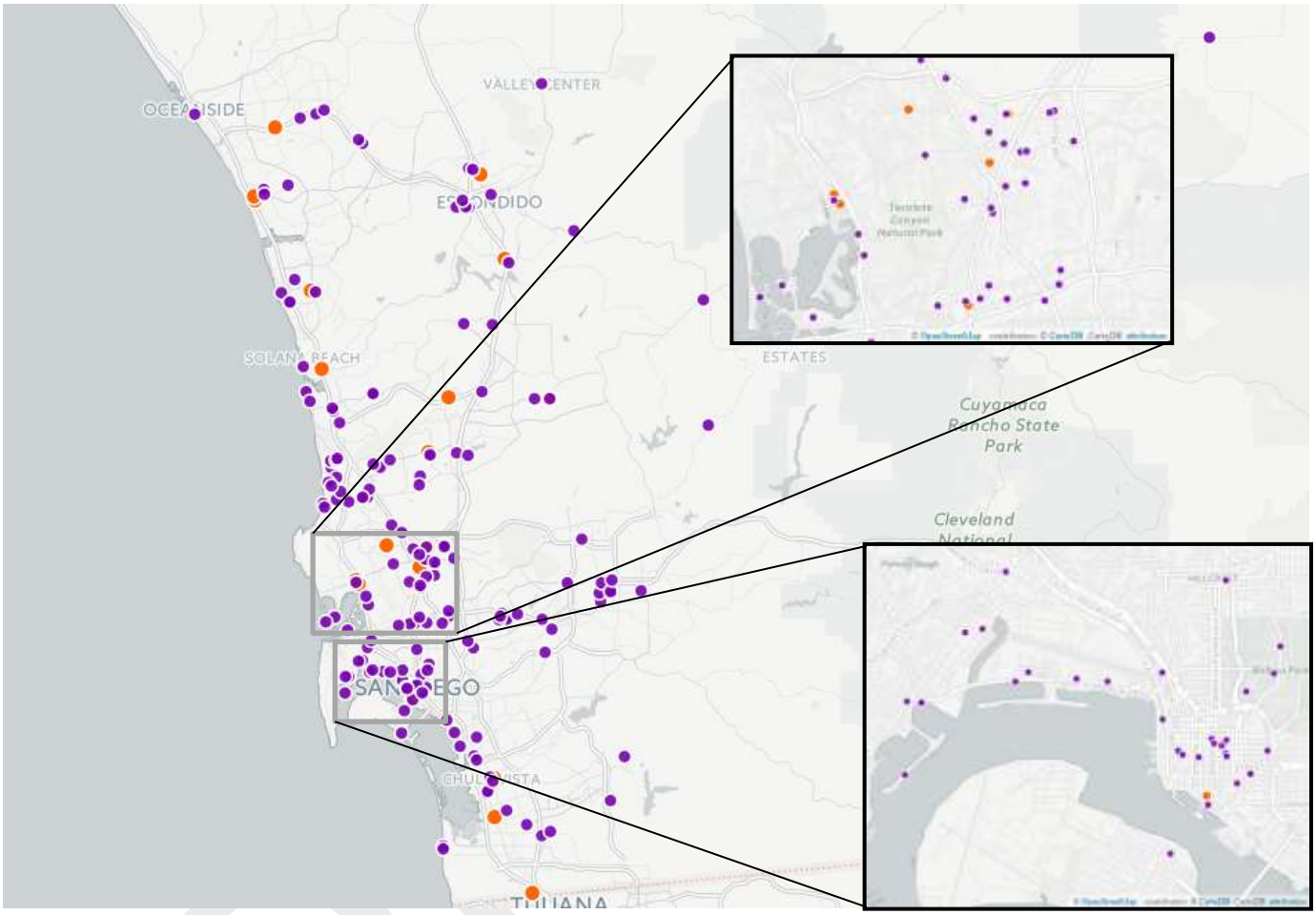
Where can I learn more about electric vehicles?

You can learn more about EVs on the following websites:

- Alternative Fuel Data Center – www.afdc.energy.gov
- Plug-in Electric Vehicle Collaborative- www.pevcollaborative.org
- Plug-in America – www.pluginamerica.org
- Plug-in Cars – www.plugincars.com
- Go Electric Drive – www.goelectricdrive.org

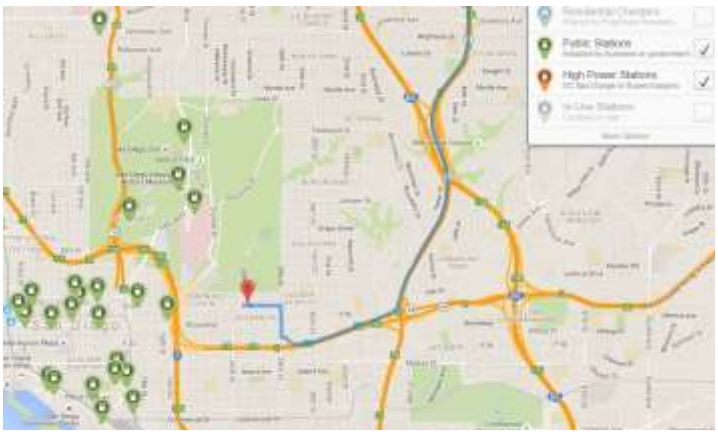
EV charging stations

Map of Public PEV Charging Stations in San Diego Region



*purple indicates Level 2 site; orange indicates DCFC site

http://www.afdc.energy.gov/fuels/electricity_locations.html



The website (and mobile app) PlugShare.com is a crowd-sourced website for gathering information about charging stations.

Users post comments, photos, and check-ins at charging locations for accurate, up-to-date information.

PlugShare.com also offers a trip planner tool which can provide information about charging stations on your travel route.

http://www.plugshare.com/

What are Charging Stations?

Level 1 Charging

Uses a 110/120-volt outlet
Low installation cost
Can use existing household outlet
Mostly used for home charging
Approx. 7-15 miles per hour of charging (depends on vehicle)

Level 2 Charging

Uses 220/240-volt outlet
Higher installation cost
Many different models and types
Found in public spaces
Approx. 2-4 hours for a full charge (depends on vehicle)

DC Fast Charging

Uses high voltage
Most expensive installation
Found alongside travel corridors
Approx. 30 minutes for 80% charge

Charging at Home

There are two types of home charging environments: single-family homes and multi-unit dwellings (MuDs). While both are private residences, they offer different types of considerations when installing charging stations.

Single-Family Homes

Single-family homes usually face basic and straight-forward installations. The steps to installation are:

1. Decide between Level 1 (120 volt outlet) vs. Level 2 (240 volt) charging
2. Research charging equipment options (visit http://www.goelectricdrive.org/charging/charging-equipment-virtual-showroom-new-ged)
3. Contact an electrical contractor to conduct a site assessment
    - Determine if a service upgrade is needed (if yes, contact San Diego Gas & Electric)
4. Contractor prepares cost estimate, applies for permits, and installs the charging station
5. Begin charging!

What EV Charging Station to Choose?

Visit Plug-in America's website to find a list of charging stations available for consumers: http://www.pluginamerica.org/accessories

Multi-Unit Dwellings

MuD charging offers a few more considerations when installing infrastructure. Though an individual wants to install a charging station at his/her parking spot, it is often the case that s/he must work with the homeowners' association or property manager to get approval for and complete the installation of a charging station.

The Plug-in Electric Vehicle Collaborative offers a comprehensive guide for MuD charging found here: http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/reports/MUD_Guidelines4web.pdf.

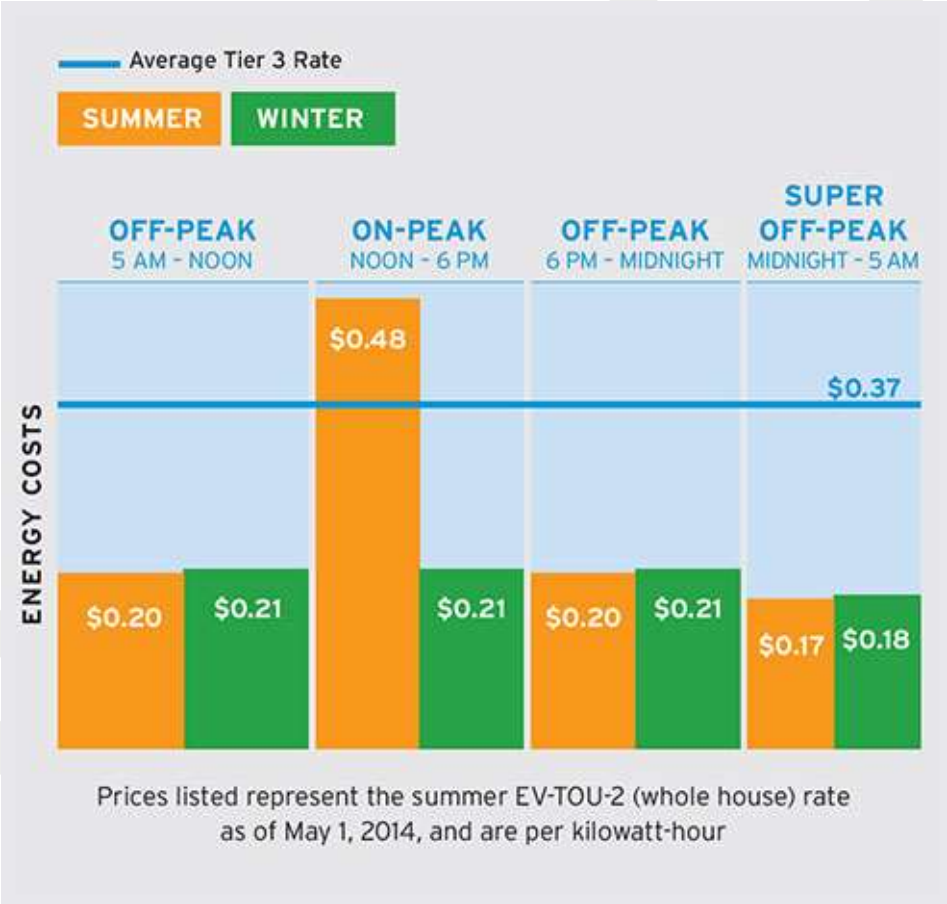
PEV drivers should also understand their legal rights for charging at an MuD:

1. AB 2565[1]: States that a person can void a term in lease renewed or extended on or after Jan 1, 2015 if the property does not allow an owner to install EV charging stations in their space. There are certain restrictions for this, though (ex: if property has fewer than 5 parking spaces, parking is not part of lease agreement, etc.)

2. SB 880[2]: Allows condos, apartment projects, etc. to install EV charging station in an owner's designated parking space. This also makes any provision that had said EV charging station installs are not allowed unenforceable.

Utility Rates

SDG&E offers special rates for PEV drivers who charge their vehicles at home. Learn more at www.sdge.com/ev.



[1] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB2565
[2] http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml;jsessionid=73210777ecf27e4ea7ed74add052?bill_id=201120120SB880

Plug-in Electric Vehicles

In California, there are over 25 models of PEVs for sale from a variety of manufacturers. To find the right vehicle for you, there are a few resources:

1. Clean Cities 2015 Buyer's Guide: http://www.afdc.energy.gov/uploads/publication/2015_vehicle_buyers_guide.pdf
2. Alternative Fuel and Advanced Vehicle Search : http://www.afdc.energy.gov/vehicles/search/
3. Plug-in America Vehicle Tracker: http://www.pluginamerica.org/vehicles

Incentives

The statewide Clean Vehicle Rebate Project offers $2,500 for the purchase or lease of a new battery electric vehicle and $1,500 for the purchase or lease of a new plug-in hybrid electric vehicle. Learn more by visiting cleanvehiclerebate.org.

E85/ Flex-Fuel

FACTS ABOUT ETHANOL

What is E85/ flex-fuel?

Ethanol is a renewable fuel made from various plant materials ("biomass") including corn, sugar cane, barley, and wheat.

There are several blends of ethanol: E10 (10% ethanol, 90% gasoline), which is standard in California gasoline, E15 (15% ethanol), and E85 85% ethanol). E85 can be used in flex-fuel vehicles.

How many public stations are in the San Diego region?

As of July 2015, there are seven public (E85) stations in the San Diego region. By 2016, three additional stations are expected to be open to the public.

How much does it cost to fuel my vehicle?

The chart below shows the average price of gasoline and E85 over the past 24-months.

24-month average*	
Gasoline	$3.35
E85	$3.09
Savings	$0.26

*June 2013-June 2015

- The use of 13.3 billion gallons of ethanol in 2012 reduced greenhouse gas (GHG) emissions from vehicles by 33.4 million metric tons – that's like removing 5.2 million vehicles from the road
- One bushel of corn equals approximately 2.8 gallons of ethanol
- Flex-fuel vehicles can use any blend between 0-85%.
- Flex-fuel vehicles account for one out of three vehicles in the entire federal fleet
- Advanced cellulosic ethanol could reduce life cycle GHG emissions by up to 86%

What types of vehicles can use ethanol?

- Passenger vehicles
- Pick-up trucks
- Police vehicles
- Vans
- Medium-duty trucks

Flex-fuel vehicles can use regular gasoline and E85 interchangeably.

Did you know…

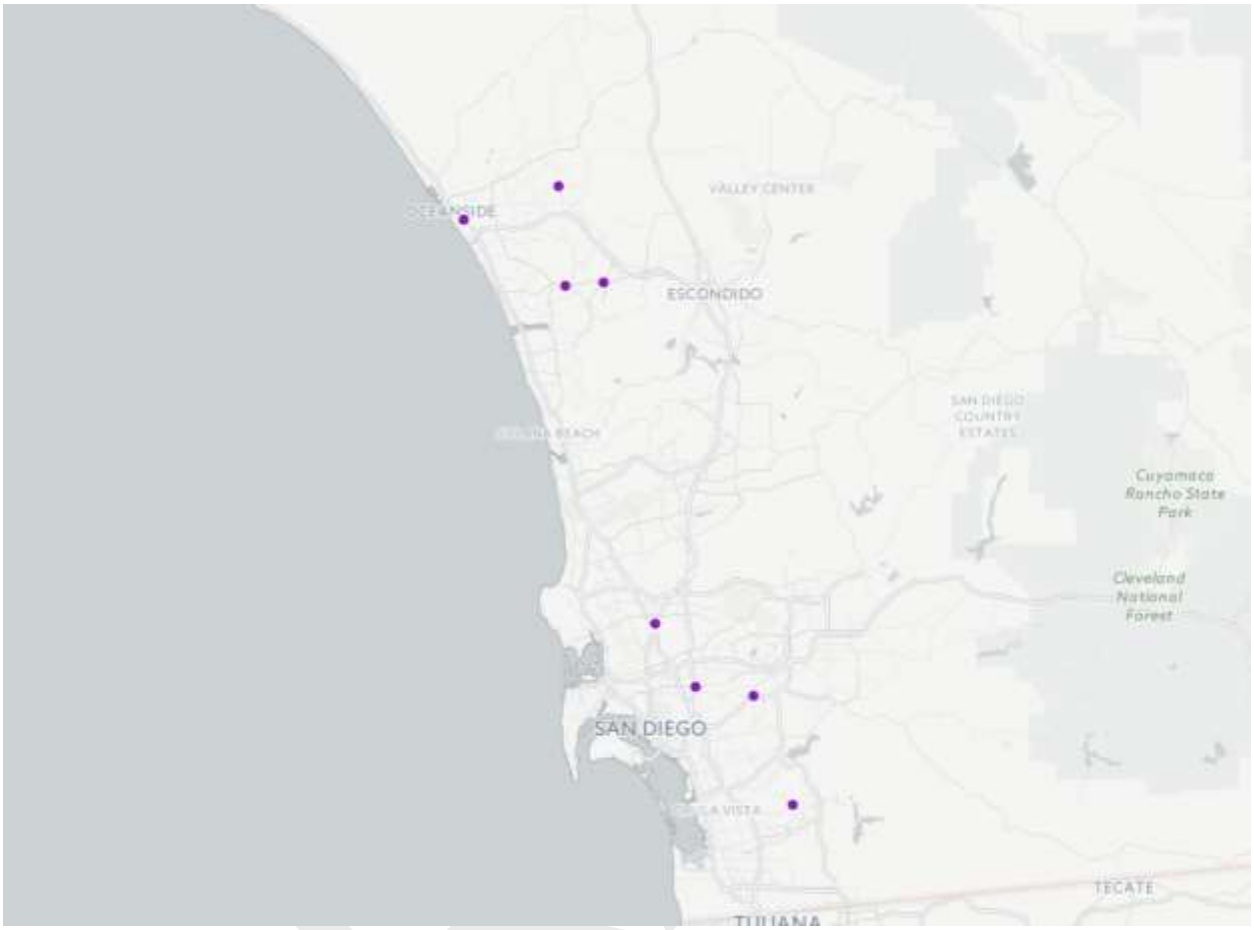
There are over 80 model year 2015 flex-fuel vehicles available in the U.S. You may already have a flex-fuel capable vehicle.

Where can I learn more?

- Alternative Fuel Data Center - www.afdc.energy.gov/fuels/ethanol.html
- Choose Ethanol - www.chooseethanol.com/
- American Coalition for Ethanol – www.ethanol.org
- Ethanol Across America – www.ethanolacrossamerica.net

Using E85/ flex-fuel

Map of Public E85 Fueling Stations in San Diego Region



http://www.afdc.energy.gov/fuels/e85_locations.html

What is a Flex-Fuel Vehicle?

Flex-fuel vehicles (FFV) run on both gasoline and ethanol. You typically know that you're driving a FFV if the gas cap is yellow and/or says "E85 compatible". The rear of the vehicle should have "Flex-Fuel" insignia.

A full list of FFVs can be found on: EthanolRetailer.com/ffv.

Using a FFV is no different than using a gasoline vehicle. FFVs have the same power, acceleration, payload, and cruise speed as a conventional vehicle.

Manufacturers

These are the biggest manufacturers of E85 vehicles. Look through the 2015 Clean Cities Vehicle Buyer's Guide for more details.[1]

BUICK
Cadillac
CHEVROLET
CHRYSLER
GMC
Ford
DODGE
NISSAN
TOYOTA

How a Flex-Fuel Vehicle Works

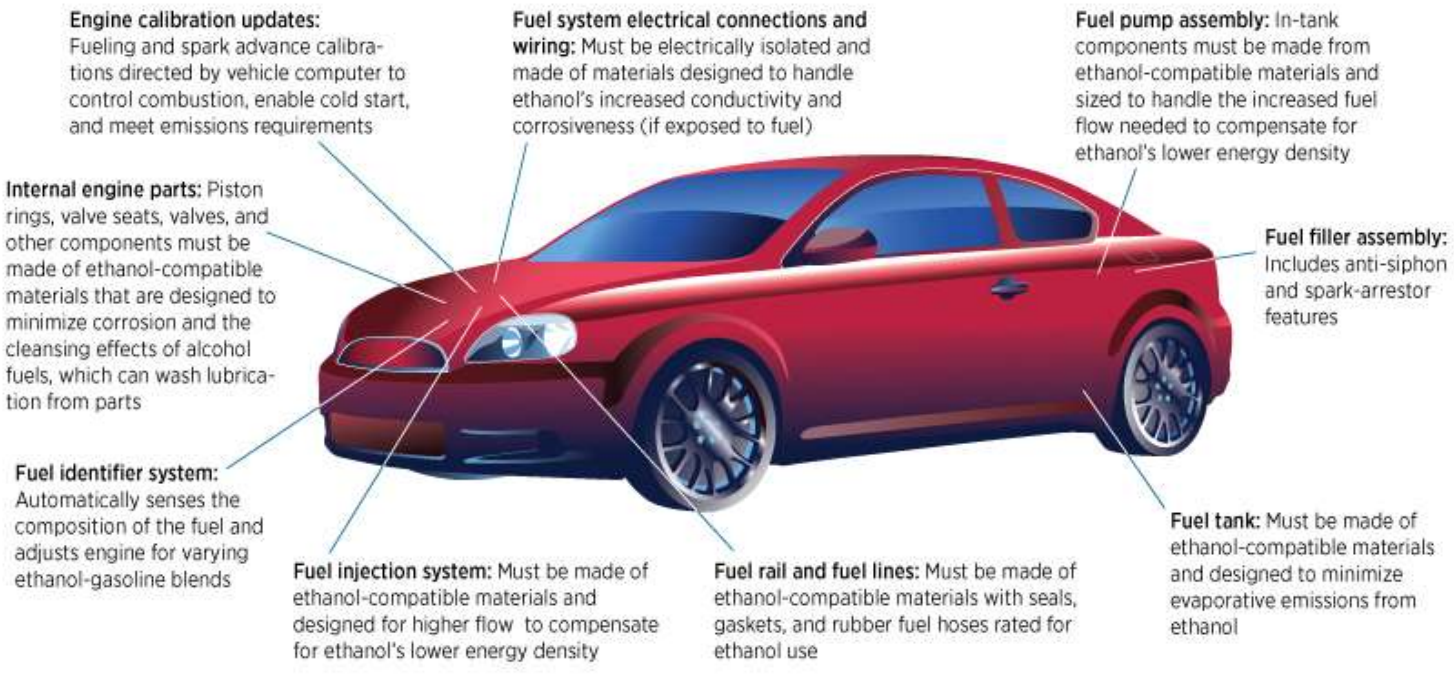


Image from http://www.afdc.energy.gov/vehicles/flexible_fuel.html.

[1] http://www.afdc.energy.gov/uploads/publication/2015_vehicle_buyers_guide.pdf

Hydrogen Fuel Cells

What is hydrogen and what are hydrogen fuel cells?

Hydrogen is found in organic matter and in water (H_20). The majority of hydrogen for transportation is produced by extracting it from natural gas. Hydrogen can also be extracted from water; however, this is a more energy intensive method.

A hydrogen fuel cell electric vehicle (FCEV) is a vehicle that is powered by hydrogen. Hydrogen is pumped into pressurized cylinders in the vehicle. The fuel cell converts the hydrogen into electrical energy to drive the motor.

Fuel cell vehicles are zero-emission vehicles that emit water vapor and warm air as exhaust.

How many public hydrogen stations are in the San Diego region?

The region's first public hydrogen station is scheduled to be installed by early 2016. More are expect by 2020.

How much does it cost to fuel my vehicle?

According to the Department of Energy (DOE), a full tank of compressed hydrogen will cost around $50 (and provide a range of approximately 300 miles). The DOE also estimates that the future costs will fall to $30 to fill a tank with hydrogen. The target price for hydrogen is $4.00/gallon of gasoline equivalent.

Auto manufacturers such as Toyota and Hyundai give owners free hydrogen for three years.

FACTS ABOUT HYDROGEN

- Much of the hydrogen in the US is produced in three states: California, Louisiana, and Texas (EIA)
- Approximately 10-11 million metric tons of hydrogen are produced in the US each year; enough to power 20-30 million cars or 5-8 million homes (EIA)
- Hydrogen fuel can be made from many sources, including wind, solar, biogas and biomass in addition to natural gas
- Hydrogen is transported safely through 700 miles of US pipelines and 70 million gallons of liquid hydrogen is transported annually by truck over US highways without major incident (DOE)

Courtesy of CA Fuel Cell Partnership.

What types of vehicles use hydrogen?

Hydrogen fuel cells are a fairly new technology; however, there are still a number of vehicles that can use this type of fuel.

- Passenger vehicles
- Shuttle buses
- Transit buses
- Forklifts

A sampling of the available vehicles can be found on the California Fuel Cell Partnership (CAFCP) website: http://www.cafcp.org/carsandbuses/makesandmodels.

Did you know…

More than 80 hydrogen-powered buses operate globally, including 15 in California.

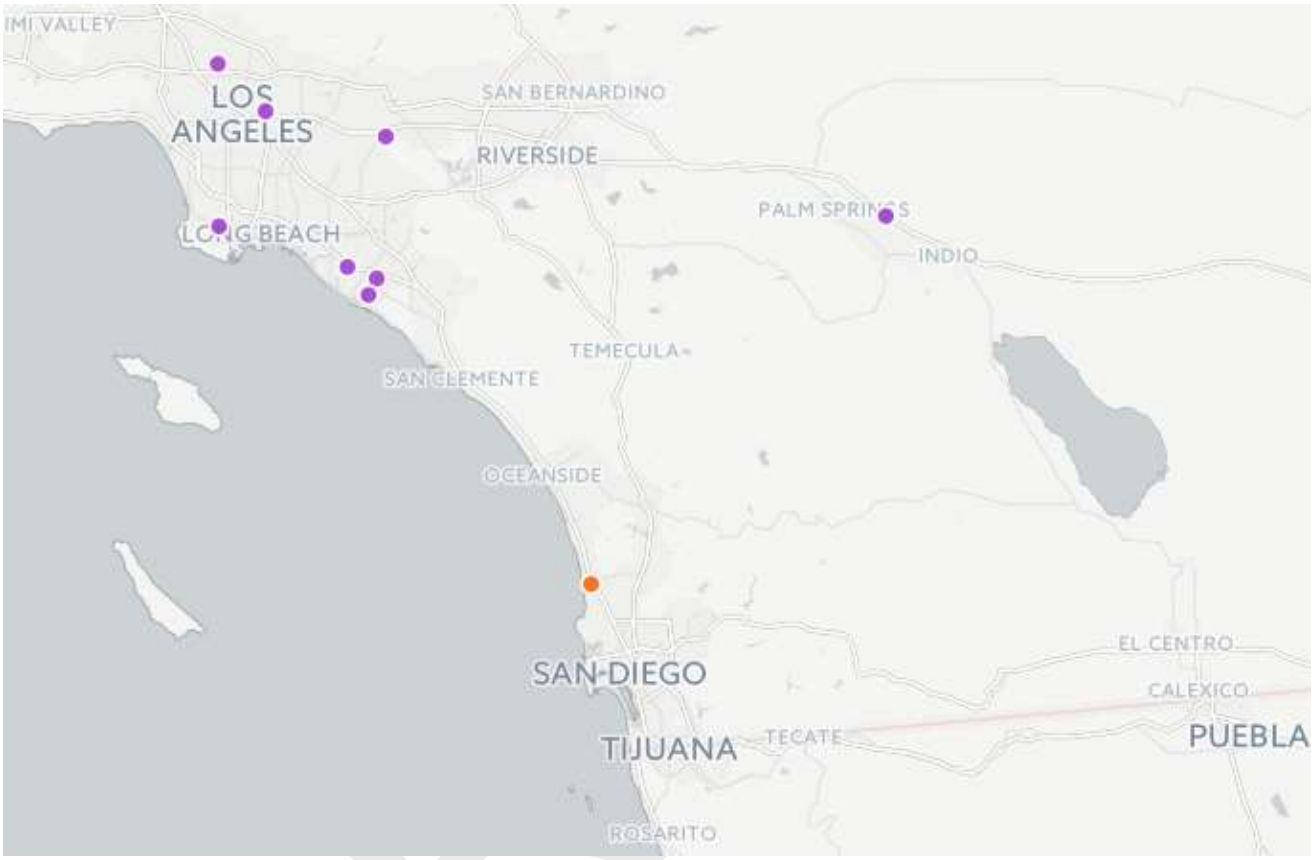
Learn about the Fuel Cell Electric Bus Roadmap for California here: http://www.cafcp.org/sites/files/FCEB-RoadMap-Infographic.pdf.

Where can I learn more about hydrogen?

- Alternative Fuel Data Center: http://www.afdc.energy.gov/fuels/hydrogen.html
- California Fuel Cell Partnership: http://www.fuelcellpartnership.org/
- DOE Fuel Cells Technology Office: http://energy.gov/eere/fuelcells/fuel-cell-technologies-office
- FuelCells.org: http://www.fuelcells.org/
- Fuel Cell & Hydrogen Energy Association: http://www.fchea.org/
- International Association for Hydrogen Energy: www.iahe.org
- Hydrogen Analysis Resource Center: http://hydrogen.pnl.gov/

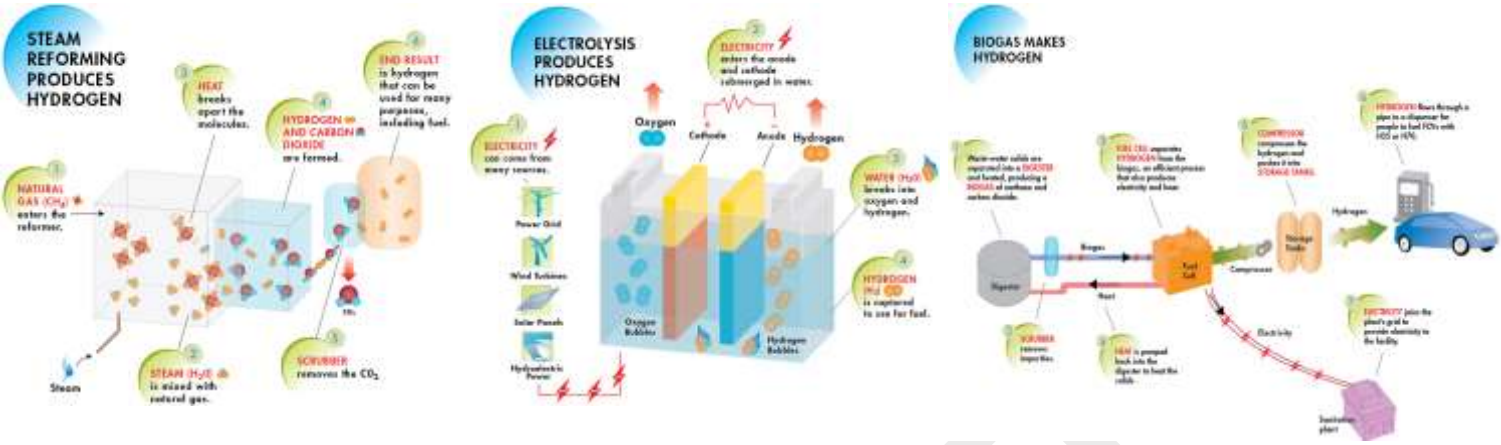
Fueling stations

Map of Existing and Future Hydrogen Fueling Stations



*purple indicates existing fueling stations; orange indicates planned stations
http://www.afdc.energy.gov/fuels/hydrogen_locations.html

How is Hydrogen Made?[1]

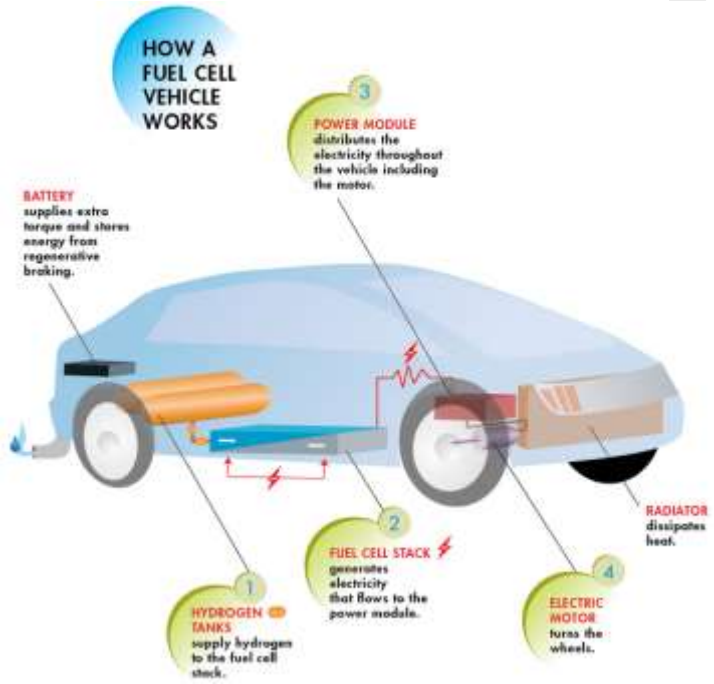


Steam reforming uses natural gas mixed with steam to produce hydrogen and carbon dioxide, of which the CO_2 is scrubbed, and then end result is hydrogen.

In Electrolysis, electricity enters an anode and cathode underwater, which helps the water break into oxygen and hydrogen.

Wastewater solids are separated into a digester and heated, producing biogas. A fuel cell separates hydrogen from the biogas. A compressor compresses the hydrogen into storage tanks.

How a Hydrogen Fuel Cell Vehicle Works[2]



Makes and Models of Available Vehicles

Honda FCX Clarity

Mercedes-Benz B-Class Fuel Cell

Toyota Mirai

Hyundai Tucson Fuel Cell

Receive up a rebate of $5,000 for the purchase or lease of a brand new hydrogen fuel cell electric vehicle from the **Clean Vehicle Rebate Project**. Learn more at cleanvehiclerebate.org.

[1] http://cafcp.org/carsandbuses/howitworks
[2] Ibid.

Natural Gas

FACTS ABOUT NATURAL GAS

What is natural gas?

Natural gas as a transportation fuel is used in one of two forms: compressed natural gas (CNG) or liquefied natural gas (LNG). Natural gas is a mixture of hydrocarbons, predominantly methane (CH_4).

CNG is natural gas that has been compressed and stored as a gas in high pressure tanks up to 3,600 pounds per square inch (psi). LNG is natural gas that is cooled to a temperature below -260˚F.

Nearly 87% of U.S. natural gas is domestically produced and boasts 20-40% less carbon monoxide and 80% particulate matter than gasoline. According to the natural gas vehicle coalition, there are about 112,000 natural gas vehicles on U.S. roads.

How many public natural gas stations are in the San Diego region?

There are approximately eight public CNG stations in the San Diego region, with two more in development.

How much does it cost to fuel my vehicle?

CNG is generally less expensive than gasoline. Further, the price per gallon equivalent of CNG does not experience volatile fluctuations like gasoline does.

24-month average*	
Gasoline	$3.35
CNG	$2.13
Savings	$1.22

*June 2013-June 2015

- On a well-to-wheels basis, natural gas vehicles (NGVs) produce 22% less greenhouse gas emissions than comparable diesel vehicles and 29% less than gasoline vehicles
- Nearly one in five transit buses in the county run on CNG
- CNG passenger vehicles are eligible for California's HOV lane access decal, which allows single-occupant vehicles to drive in the HOV lanes

What types of vehicles can use natural gas?

Natural gas is a versatile fuel. Several types of vehicles can use natural gas.

- Vans
- Pick-up trucks
- Refuse hauler
- Low-speed vehicle
- MD/HD trucks
- Transit Bus
- Light-duty vehicle

Types of natural gas vehicles

- **Dedicated**: These vehicles are designed to run only on natural gas.
- **Bi-fuel**: These vehicles have two separate fueling systems that enable them to run on either natural gas or gasoline.
- **Dual-fuel**: These vehicles are traditionally limited to heavy-duty applications, have fuel systems that run on natural gas, and use diesel fuel for ignition assistance.

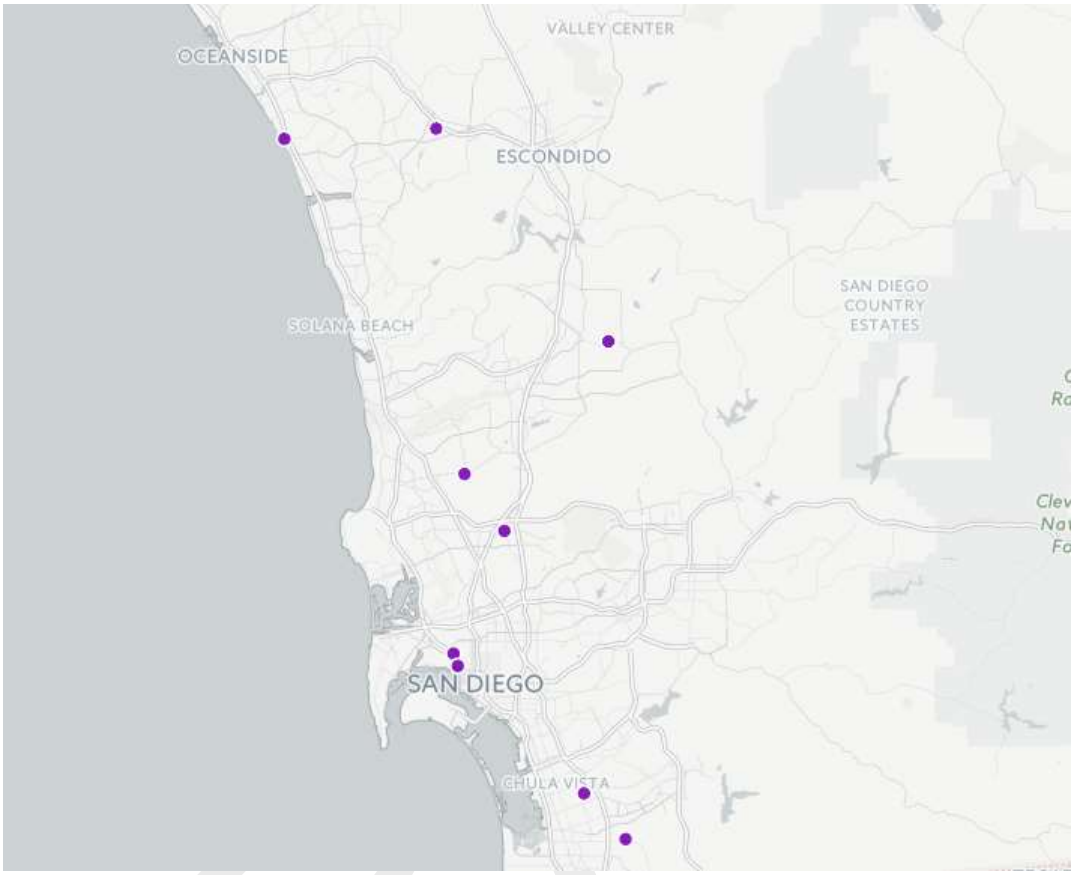
Renewable Natural Gas, also called biomethane, or sustainable natural gas, is produced from biogas (i.e., swamp gas, landfill gas, or digester gas). When processed to a higher purity standard, RNG can be used as an alternative fuel in NGVs.

Where can I learn more about natural gas?

- Alternative Fuel Data Center: www.afdc.energy.gov/fuels/natural_gas.html
- AFDC Renewable Natural Gas: www.afdc.energy.gov/fuels/emerging_biogas.html
- Natural Gas Vehicles for America: www.ngvamerica.org/
- CNG Now!: www.cngnow.com/
- California Natural Gas Vehicle Coalition: www.cngvc.org/
- Department of Energy: energy.gov/natural-gas
- American Gas Association: www.aga.org

Fueling stations

Map of CNG Fueling Stations in San Diego Region



http://www.afdc.energy.gov/fuels/natural_gas_locations.html

Natural gas vehicles

Natural gas vehicles can reduce the total cost of ownership for users. Fuel costs are low and overall maintenance costs are similar to that of gasoline vehicles.

Savings in Fuel Costs

Typically, natural gas costs $1 to $2 less than diesel and gasoline, and is projected to remain this way, as predicted by the U.S. Energy Information Administration. There are tools available to estimate your fuel savings when switching to a NGV. When using these tools, the following basic information is helpful to have on-hand:

- Average number of miles driven per year
- Average vehicle miles per gallon
- Number of vehicles to be switched to NGVs

The Alternative Fuel Data Center's Vehicle Cost Calculator shows the total cost of ownership and emissions for a large variety of makes and models of most vehicles, including alternative fuel vehicles. You can also create your own custom vehicle if you cannot find the model you want. The tool is available here: http://www.afdc.energy.gov/calc/.

CNG Now! has a CNG calculator that estimates fuel savings at the pump when switching from gasoline vehicles to CNG. The tool is http://www.cngnow.com/vehicles/calculator/pages/information.aspx.

There are options for consumers to refuel at home. Utilities such as SoCalGas offer NGV owners a home refueling appliance, which uses the customer's existing natural gas and electrical supply to refuel their NGV without having to go to a public station. Learn more at SoCalGas: http://www.socalgas.com/innovation/natural-gas-vehicles/policy/home-fueling.shtml.

Propane Autogas

What is propane autogas?

Propane autogas is also known as liquefied petroleum gas (LPG).

While gaining popularity as an alternative fuel in the United States, propane is the third most common transportation fuel in the world.

Nearly all U.S. propane is produced domestically and over half of it is a byproduct of natural gas purification.

Propane is a clean burning fossil fuel with lower greenhouse gas emissions than gasoline.

How many public propane stations are in the San Diego region?

There are 15 public propane stations in the San Diego region.

How much does it cost to fuel my vehicle?

Generally, propane autogas is less expensive than gasoline.

24-month average*	
Gasoline	$3.35
LPG	$2.86
Savings	$0.49

*June 2013-June 2015

FACTS ABOUT PROPANE AUTOGAS

- There are over 80,000 bus, taxi, and delivery services nationwide that use propane autogas in their fleets
- Propane autogas is the third most common transportation fuel in the world
- Propane accounts for 2% of the nation's energy use
- There are more propane autogas fueling stations available in the U.S. than any other alternative fueling stations (excluding electric charging stations)

What kind of vehicles use propane autogas?

- Forklifts
- Low-Speed Vehicles
- Buses
- School Buses
- Lawn equipment
- Trucks
- Shuttle Vans
- Delivery services

Where can I learn more?

- Alternative Fuel Data Center: www.afdc.energy.gov/fuels/propane.html
- National Propane Association: www.npga.org
- Propane Education and Research Council: www.propanecouncil.org
- Autogas USA: www.autogasusa.org
- Propane: www.propane.com

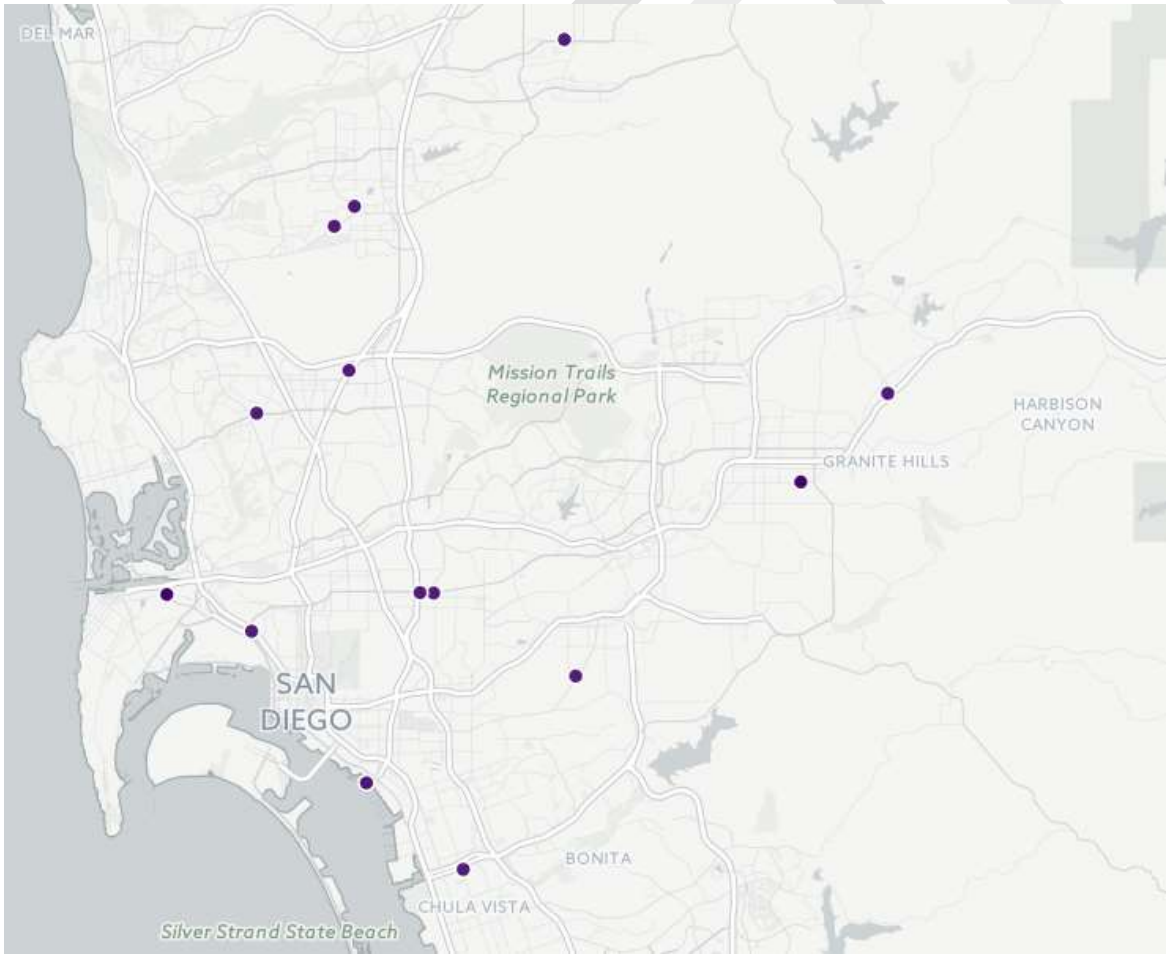
Propane autogas vehicles

There are many benefits to driving an LPG vehicle.[1]

- Save up to 40% on fuel costs
- LPG vehicles emit 70% less smog
- Propane autogas is made in America
- Horsepower and torque of propane autogas is greater than or equal to its gasoline equivalent
- Ample number of public fueling stations

Currently,Roush CleanTech, CleanFuel USA, and Isuzu offer light-duty vehicles that run on LPG. Roush and CleanFuel are upfits for Ford, GM, and Freightliner vehicles.

Map of LPG Fueling Station in San Diego Region



http://www.afdc.energy.gov/fuels/propane_locations.html

[1] http://www.cleanfuelusa.com/vehicles.html