COMPARISON AND ANALYSIS OF ALTERNATIVE FUELS FOR IC ENGINES.

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MY HEARTFELT THANKS TO EVERYONE!

~VERZEO

C0NTENTS:

Alternative fuels, Emissions and control:

A fuel is any material that can be made to react with other substances so that it releases energy as heat energy or to be used for work.

Most popular fuels used today are:
Petrol/gasoline fueled engine
Diesel fueled engine.

Alternative fuels that can be used are:

Natural gas
Biodiesel
Electricity
Hydrogen
Ethanol
Propane

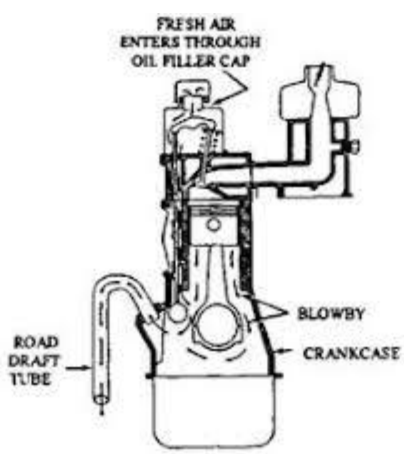
EMISSIONS: The by-products that harm the environment are called emissions. They are of three types:

i) ***Exhaust emissions***- The emissions from the exhaust of the vehicle are called as exhaust emissions.
ii) ***Evaporative emissions***- The emissions from the fuel are called as evaporative emissions.
iii) ***Crankshaft emissions***- The emissions from the blow by gases are known as crankshaft emissions.

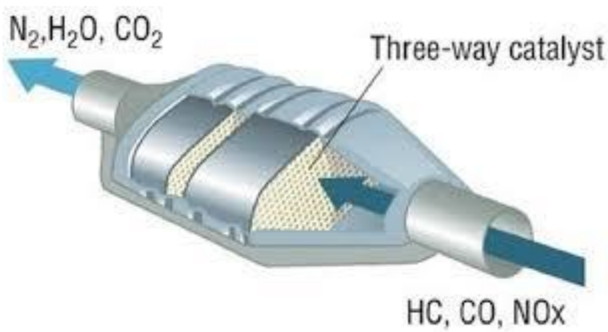
- ➔ To control exhaust emissions, catalytic converter is used.
- ➔ To control evaporative emissions, charcoal cannister is used.
- ➔ To control crankshaft emissions, positive crankcase ventilation is used.

→ Exhaust Emissions.

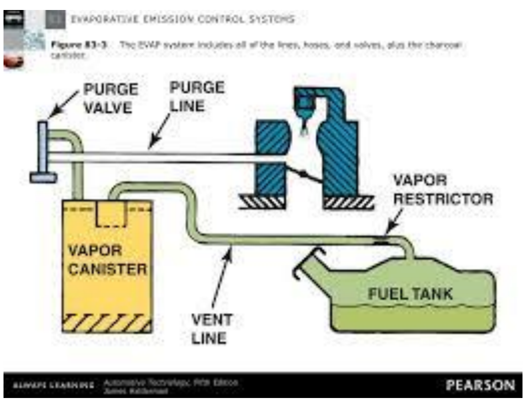
→ Evaporative emissions



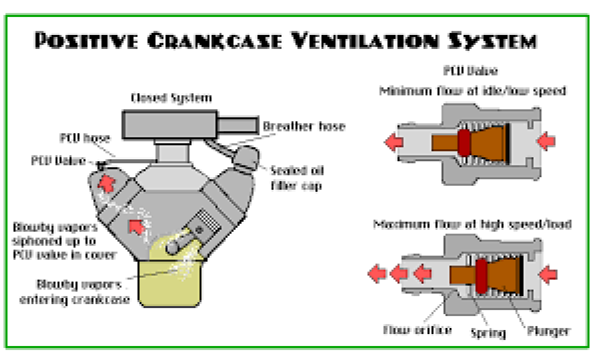
→ Crankshaft emissions



➔ Catalytic converter



➔ Charcoal cannister



➔ Positive Crankcase Ventilation

EXHAUST EMISSIONS

In theory, you should be able to burn a 'hydrocarbon' fuel (petrol, diesel, gas etc) with air in an engine to produce just carbon dioxide (CO_2) and water (H_2O). The rest of the exhaust would be the nitrogen (N_2) that came in with the air.

Unfortunately, the fuels we burn are made up of hundreds of differently structured hydrocarbons that burn in different ways and at different rates. In practice this means that your exhaust contains some that were partially burned, some that reacted with others and some that reacted with the nitrogen.

The amount of carbon dioxide (CO_2) produced is directly related to fuel consumption which is why car manufacturers have done a lot to improve new car fuel economy and why car tax rates have been based on official CO_2 emissions figures.

There's less you can do to affect toxic emissions apart from trying to run the newest car you can.

Euro emissions standards

New cars have to meet European emissions regulations.

- The so-called ‘Euro 1’ standard came into force in 1992 and set limits for petrol car carbon monoxide (CO) emissions that could effectively only be met by fitting a catalytic converter in the exhaust system.
- Each new standard is tougher than the last. Euro 5 came in in 2009 and effectively required diesels to be fitted with a diesel particulate filter in the exhaust to limit soot emissions.
- We're now up to Euro 6 which came into force in 2014 and sets broadly similar standards for both petrol and diesel.
- The newer the car, the better for the environment.

Exhaust emissions Analysis

These are the main exhaust products and their effects on the environment and our health.

- ***Nitrogen*** (N_2) – no adverse effects
- ***Oxygen*** (O_2) – no adverse effects
- ***Water*** (H_2O) – no adverse effects
- ***Carbon Dioxide*** (CO_2) – non-toxic but contributes towards acidification of our oceans and one of the most important greenhouse gases. Government policies around the world are aimed at reducing CO_2 emissions to combat global warming.
- ***Carbon Monoxide*** (CO) – results from incomplete combustion of fuel. CO reduces the ability of blood to carry oxygen and can cause headaches, respiratory problems and, at high concentrations, even death.
- ***Nitrogen Oxides*** (NO_x) – produced in any combustion process, NO_x emissions are oxidized in the atmosphere and contribute to acid rain. They react with hydrocarbons to produce low level ozone which can cause inflammation of the airways, reduced lung function and trigger asthma. They also contribute to the formation of particulate matter.
- ***Sulphur Dioxide*** (SO_2) – Sulphur occurs naturally in the crude oil from which petrol and diesel are refined. It forms acids on combustion leading to acid rain and engine corrosion. It also contributes to the formation of ozone and of particulate matter.
- ***Hydrocarbons*** (HC) – HCs are emitted from vehicle exhausts as unburnt fuel and also through evaporation from the fuel tank, from the nozzle when you fill up and also at stages through the fuel supply chain. They react with NO_x in sunlight to produce photochemical oxidants (including ozone), which cause breathing problems and increased symptoms in those with asthma.
- ***Benzene*** (C_6H_6) – occurs naturally in small quantities (less than 2%) in petrol and diesel, Benzene is emitted from vehicle exhausts as unburnt fuel and also through evaporation from the fuel system although modern fuel systems are sealed and have carbon canisters to hold the vapors. Benzene is toxic and carcinogenic and long-term exposure has been linked with leukemia.
- ***Particulate matter (PM) or soot*** – particulate matter is partly burned fuel associated mainly with diesel engines and is also formed by the reaction between other pollutants. Smaller particles can pass deep into your lungs causing respiratory complaints and contributing to the risk of developing cardiovascular diseases. Modern diesel cars are fitted with **Diesel Particulate filters** (DPF) to stop these particles passing into the atmosphere.

Emissions by different fuels.

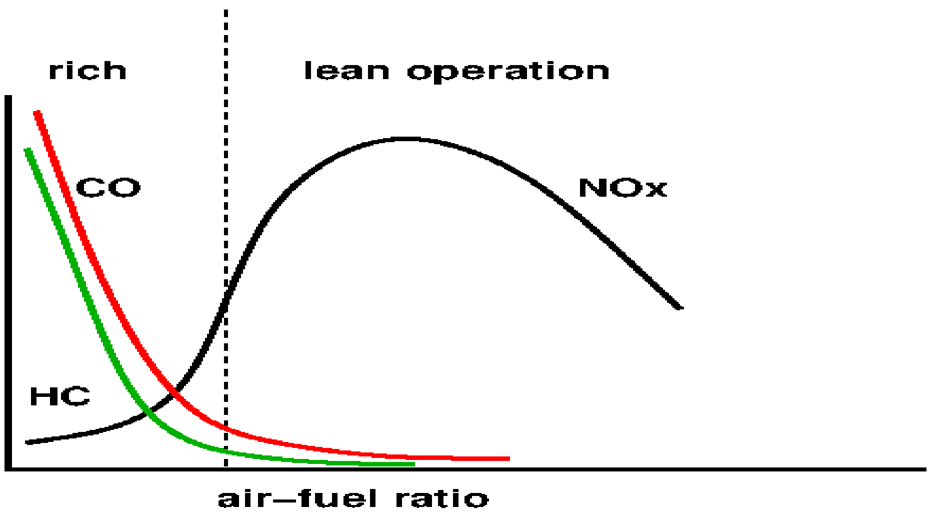
- **Petrol cars** generally use more fuel than diesel, and produce more carbon dioxide (CO_2). Petrol cars produce fewer toxic emissions.
- **Diesel cars** generally use less fuel than petrol cars, so give out less CO_2, but will produce more toxic emissions depending on the 'Euro' standard that applied when the car was new.
- **LPG (Liquid Petroleum Gas)** gives off lower toxic emissions than Diesel and older (pre-Euro 4) petrol engines, but fuel consumption isn't as good. less hazardous than any other petroleum based fuel and expected to produce less CO, NOx emissions and may cause less ozone formation than gasoline and diesel engines.
- The use of the **hydrogen** as fuel in the internal combustion engine represents an alternative to replace the hydrocarbons fuels, which produce polluting gases such as carbon monoxide (CO), hydrocarbon (HC) during combustion [2]. It is a long-term renewable and less-polluting fuel. In addition hydrogen with its clean burning characteristics and better performance drives more interest in it as a fuel. When it is burnt in an internal combustion engine, the primary combustion product is water with no CO_2 although NOx emissions are formed when hydrogen is used
- **bio-diesels** are non-toxic, degrade four times faster than diesel, pure bio-diesel degrades 85-88% in water, blending of bio-diesel with diesel fuel increases engine efficiency, their higher flash point makes the storage safer, they are an oxygenated fuel so its oxygen content makes its fatty compounds suitable as diesel fuel by "cleaner" burning, don't produce greenhouse
- The combustion of **bio-diesel** has reported to emit lesser pollutants compared to diesel as it has no sulphur content and shows decreasing emissions of PAH, CO, CO_2, HC, soot and aromatics . Biodiesel being an oxygenated and sulfur-free fuel lead to more complete combustion and lower emissions. But the energy content or the calorific value of biodiesel is less than that of diesel fuel; also it has higher viscosity and density. A considerable improvement in these properties can be obtained by mixing diesel and biodiesel and then using the blends. Biodiesel and biodiesel/ petro diesel blends, with their higher lubricity levels, are increasingly being utilized as an alternative fuel . Among the disadvantages of the bio-diesel is the slight decrease in fuel economy on energy basis (about 10% for pure bio-diesel), more expensive due to less production of vegetable oil . NOx emissions are slightly more than the conventional diesel fuel but could be reduced by EGR or dual fuel mode.
- **Ethanol (C_2H_5OH)** is a high performance, biomass fuel, which is produced mainly from biomass transformation, or bioconversion. It can also be produced by synthesis from petroleum or mineral coal. It is considered the most suited alcohol to be used as a fuel for spark ignition engines . It has a high octane number and a high laminar flame speed . It has a neutral CO_2 cycle. The results of the study show that 10% ethanol blends can be used in internal combustion engines without any negative drawbacks or major modifications to the air/fuel system. The fuel conversion efficiency remains the same, while CO emissions are greatly reduced. NOx and CO_2 emissions for 10% ethanol blends and gasoline are similar. 20% ethanol blends do not perform as well as pure gasoline does in spark ignition engines. It decreases the fuel conversion efficiency and brake power of an engine, but still reduces CO emissions.

Emission graphs of various fuels

➔ ***Petrol engine:***

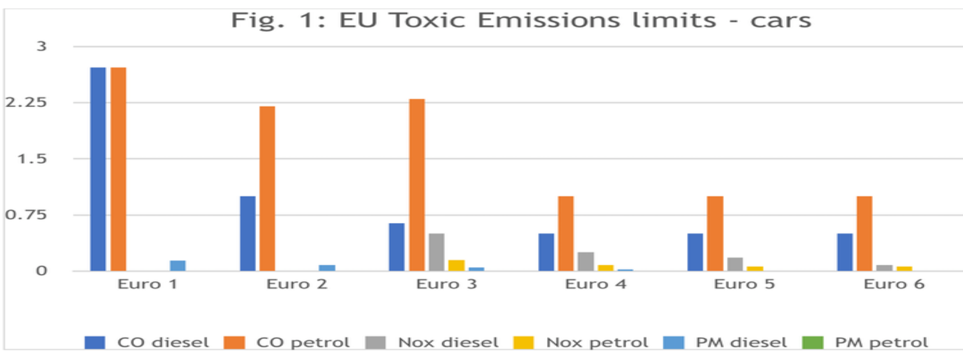
Pollutants	Operating Condition			
	Idling	**Acceleration**	**Cruising**	**Deceleration**
CO (%)	6.9	2.9	2.7	3.9
HC (ppm)	5300	1600	1000	10000
NO_x (ppm)	30	1020	650	20
Aldehyde (ppm)	30	20	10	290

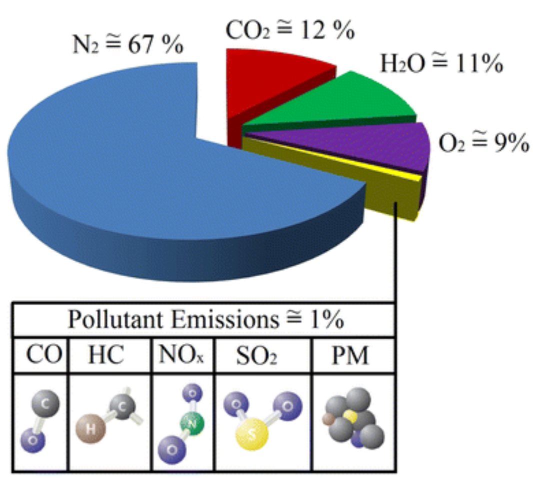
Source: Henderson-Sellers, 1984.



➔ ***Diesel vs petrol:***

Emissions	Gasoline engine (%)	Diesel engine (%)
CO	0.8–5.2%	0.1–1.6%
HC	0.03–0.04%	0.002–0.004%
NO_X	0.2–0.06%	0.15–0.04%
CO_2	9.0–12.5%	8.0–11.0%
O_2	3–5%	7–10%

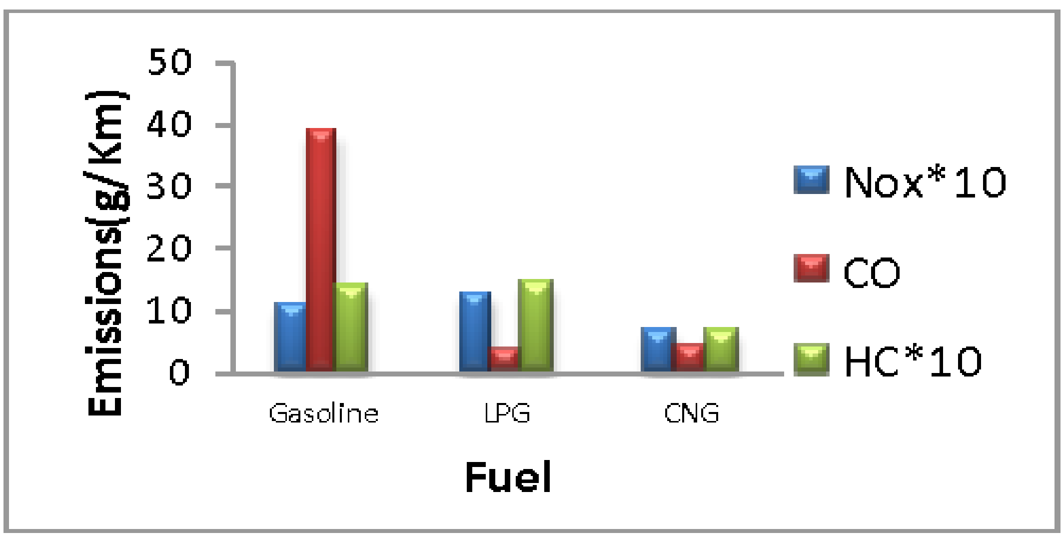




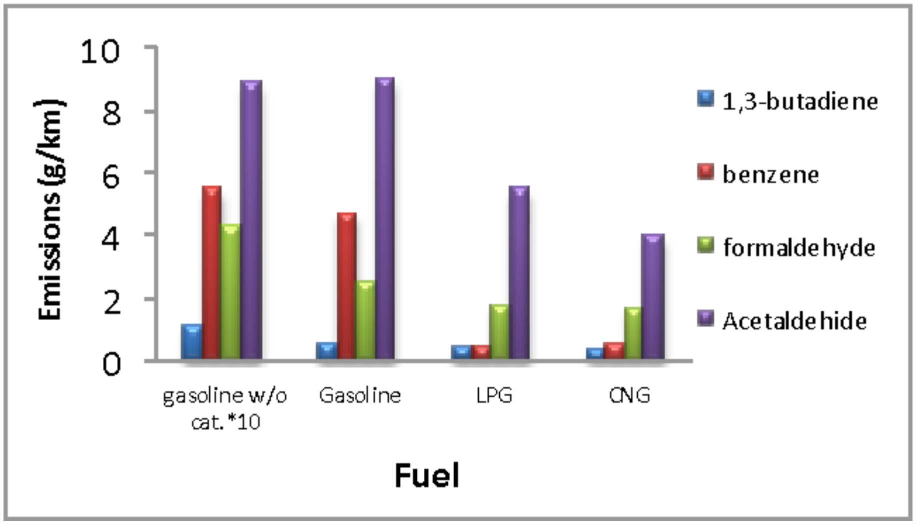
➔ *Emission limits of petrol and diesel engines:-*

	Year	CO	NO_x	HC	PM	Smoke
Diesel						
Euro1	1992	4.5	8	1.1	0.612	-
Euro2	1996	4	7	1.1	0.25	-
Euro3	2000	1.5	5	0.25	0.02	0.8
Euro4	2005	1.5	3.5	0.46	0.02	0.5
Euro5	2008	1.5	2	0.46	0.02	0.5
Petrol						
Euro1	1992	2.72	-	-	-	-
Euro2	1996	2.2	-	-	-	-
Euro3	2000	2.3	0.15	0.2	-	-
Euro4	2005	1.0	0.08	0.1	-	-
Euro5	2008	1.0	0.06	0.075	0.005	-

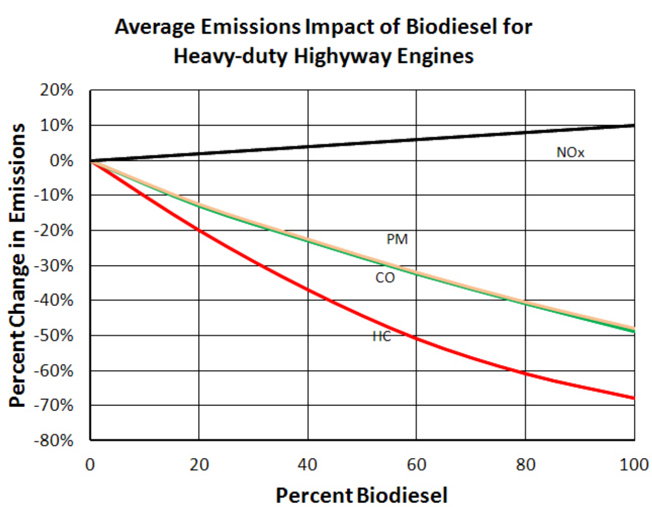
➔ *LPG:-*



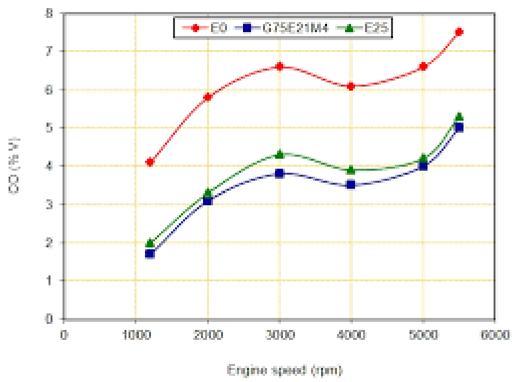
➔ *Lpg vs petrol vs diesel vs cng:-*

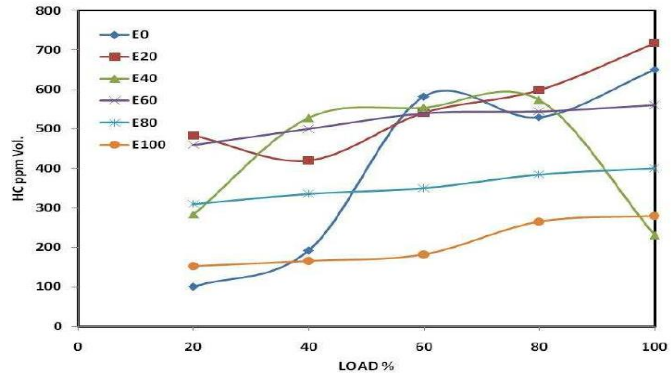


➔ *Biodiesel:-*

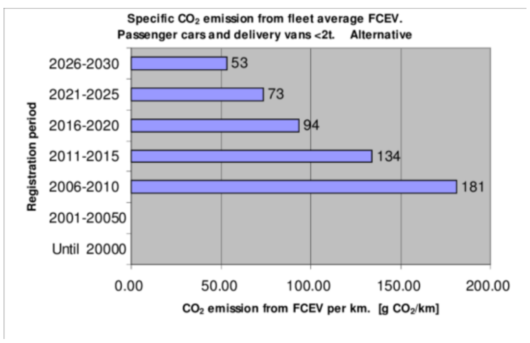


➔ ***Ethanol methanol blends:-***





➔ ***Hydrogen:-***



Effects of vehicle exhausts on global warming:

We know that vehicle emissions have a variety of negative effects on public health and the environment. So if we want more in-depth understanding the impact of vehicle exhausts, we can divide this large problem into two major areas:
The global scales and the local scales:

a) LOCAL EFFECTS:

Traffic represents one of the largest sources of primary air pollutants in urban areas. Large amount of vehicle exhaust emissions will have seriously adverse effects on human health. Assessing the effects of air quality management strategies in urban areas is a major concern worldwide. In addition, worldwide epidemiological studies show a consistent increase in cardiac and respiratory morbidity and mortality from exposure to vehicle exhaust pollution. Both in urban and residential regions, this has become the main areas of toxic compound emissions from the unrestrained use of vehicles burning fossil fuels. In these areas, the population is very sensitive to vehicular pollution.

b) GLOBAL EFFECTS:

On a global scale, people are more concerned about air pollution and global climate change which are contributed to by vehicle exhausts. Combustion engines contribute to greenhouse gas accumulation in the atmosphere. There are many climate researchers who support the view that emissions of heat trapping gases into the atmosphere, particularly CO_2, from the combustion of fossil fuel, cause global warming. The concentration of CO_2 are currently rising by 2 ppm (parts per million) annually (Patrick and Damon, 2008).

Transport contributed to an estimated 19% of global GHG (greenhouse gas) emissions in 1971, but rose to 25% in 2006. Reductions of CO2 emissions from transport can be achieved by using energy saving vehicle technologies, which relies on cleanly produced biofuels, such as biodiesel and ethanol.

Conclusion:

In summary, it is well known that gasoline and diesel engines are the major sources of Greenhouse Gases (GHG) emission. One of the main advantages of using biofuels instead of fossil fuel in the transportation sector is the ability to minimize the GHG emissions from vehicles. The combustion of biofuels itself can be regarded as CO2 neutral. Nonetheless, the biofuel production life cycle has to be assessed to reach a conclusion about the overall greenhouse gas balance. Hydrogen has clean burning characteristics and better performance. It has a wide range of flammability and high diffusivity compared to all other fuels. On the other hand it is difficult to quench a hydrogen flame than a flame of most other fuels. Also, it has a low density, which implies a reduction in the power output of the engine. Currently ethanol is the most widely used renewable fuel in the United States with up to 10% by volume blended into gasoline for regular spark ignition engines or up to 85% for use in Flex-Fuel vehicles designed to run with higher concentrations of ethanol. Biodiesel is similarly used with 5-20% by volume blended into petroleum-based diesel for compression ignition engines. Biodiesel fuel is methyl or ethyl esters derived from a broad variety of renewable sources such as vegetable oils, animal fats and cooking oil. One of the drawbacks of pure biodiesel is the reduction of power and maximum torque which may be due to the increase of the flame speed.

References:

i) Wikipedia
ii) Pandey RK, Reham A, Sarviva RM Impact of alternative fuel properties on fuel spray habavioe and atomization. Renewable and Sustainable Energy Reviews. 2012, 16, 1762-1778.
iii) Ciniviz M, Kose H Hydrogen use in internal combustion engine. International Journal of Automotive Engineering and Technologies. 2012, 1(1), 1-15.
iv) UNDP (United Nations Development Programme). World Energy Assessment. Energy and the Challenge of Sustainability. 2000.
v) Knothe G., Matheay AC., Ryan T.W Cetane numbers of branched and straight chain fatty esters determined in an ignition quality tester. Fuel. 2003, 82, 971-975.
vi) Gomes AMJ., Mikalsen R, Foskilly AP. An investigation of hydrogen fuelled HCCI engine performance and operation. International Journal of Hydrogen Energy.
vii) Kegl B, Kegl M, Pehan S. Optimization of a fuel injection system for diesel and biodiesel usage. Energy and Fuels. 2008, 22, 1046-1054.