



नेपाल कृषि तथा वातावरण मंच
National Agricultural & Environmental Forum

Appropriate Technologies for the Rural Poor

BIODIESEL

A Guide for Policy Makers and Enthusiasts

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Diesel Engines

There are many types of internal combustion engines. Different types run on different type of fuel. Petrol, hydrogen, methanol, ethanol, liquefied petroleum gas (LPG), biodiesel as well as other fuels. But the most common are petrol with electronic ignition, spark ignition (SI) and the simpler diesel with compression ignition (CI). Yet both run on petroleum based products. Diesel from petroleum is also known as petrodiesel or even "dino-diesel", when there is a need to distinguish it from diesel obtained from other sources such as biodiesel.

Petrol, also known as petroleum spirit (USA - gasoline, British- petrol) and diesel are both produced from fractional distillation of petroleum oil (fossil fuel). Diesel is a hydrocarbon mixture, obtained from crude oil between 200 °C and 350 °C at atmospheric pressure.

Both petrol and diesel can be wholly replaced by biofuels or mixed to certain extents. Petrol can be replaced by Ethanol and diesel can be replaced by biodiesel.

Mixtures and Blending

100% ethanol is often marked as E100, and 85% ethanol and 15% petrol is marked as E85.

100% biodiesel is often marked as B100, and a 20% biodiesel and 80% petrodiesel mix is marked as B20.

Diesel engine, Dr. Diesel.



"Dr. Diesel demonstrated his engine at the Exhibition Fair in Paris, France in 1898. This engine stood as an example of Diesel's vision because it was fueled by peanut oil - the "original" biodiesel. He thought that the utilization of a biomass based fuel was the real future of his engine. He hoped that it would provide a way for the smaller industries, farmers, and "common folk" a means of competing with the monopolizing industries, which controlled all energy production at that time, as well as serve as a n alternative for the inefficient fuel consumption of the steam engine.

The diesel engine was invented by German engineer Rudolf Diesel (1858-1913).

As a result of Diesel's vision, compression ignited engines were powered by a "bio" fuels or vegetable oil, until the 1920's and are being powered again, today, by biodiesel." Source: http://www.ybiofuels.org/bio_fuels/history_diesel.html

Straight Vegetable Oil for Diesel Engines

Straight vegetable oil (SVO), vegetable oil that has not been modified (transesterified) can many times be used in more simple diesel engines.

SVO is usually more viscous (thicker) then diesel or biodiesel and its viscosity also depends on the temperature. Lower the temperature, more viscous is the oil. If the oil is too viscous it then will not flow properly within the fuel pipes and the pump will also have trouble working properly. Vegetable oil

also has very different chemical properties and combustion characteristics to those of conventional diesel fuel (diesel or biodiesel).

If the fuel is too thick it will not atomize properly when the fuel injectors spray it into the combustion chamber and it will not combust properly -- the injectors get coked up, leading to poor performance, higher exhaust emissions and may reduced engine life. It does not burn the same way in the engine.

There are mainly 4 options to run a diesel engine on SVO.

1. Single fuel tank with engine modification. One way to get around this viscosity problem is to retrofit an engine with injectors and glowplugs designed for SVO, as well as fuel heating. An example is the German Elsbett single-tank SVO system which allows for use of dino-diesel, biodiesel or SVO, in any combination. Just start up and go, stop and switch off, like any other car. The "secret" is specially made injector nozzles, increased injection pressure and hotter glow-plugs, in addition to fuel pre-heating.
2. Single fuel tank without engine modification. This could work but it is not recommended as starting could be an issue. Also many studies have shown that it could damage the engine. If the fuel is too thick it will not atomize properly when the fuel injectors spray it into the combustion chamber and it will not combust properly -- the injectors get clogged, leading to poor performance, higher exhaust emissions and may reduced engine life.
3. Double fuel tank. With two-tank system, one tank holds the vegetable oil and the other petro-diesel (or biodiesel). The engine is started on the petro-diesel tank and runs on petro-diesel for the first few minutes while the vegetable oil is heated to lower its viscosity. Fuel tank heaters can be electrical or use the engine coolant as a heat source. When the vegetable oil reaches the required temperature, usually 70-80 deg C (160-180 deg F), the engine is switched over to the second tank and runs on SVO. Before the engine is shut down, it must be switched back to petro-diesel and the fuel system "purged" of vegetable oil before switching off, so that there's no cold SVO left to clog up the injectors next time you start the engine. Some systems have manual fuel switches, some do it automatically.
4. Blended or mixed SVO and diesel or kerosene. There is no recipe for blend SVO. It depends on the engine type, on the temperature, on the oil used and probably other un-mastered parameters. At this point the proper mix as to be find experimentally and it will probably vary during the year as temperature vary. More petro-diesel less viscous is the mix.

Whatever their technical merits and shortcomings, two-tank kits are obviously better for longer-distance driving than for short stop-and-start trips.

But for both single or dual tank, running SVO there are controversies. Some sources say there is no problem and other say there are issues. It also depends on the engine (DI-direct injection, Indirect injection, Common rail, Rotary inline, unit injectors, computer controlled, slow speed or high speed engine). High Performance High Speed Diesel engine used more recently in cars but also in other applications are more "sensitive" to SVO then slower speed diesel engine. Slow speed Diesel engine are typically used as propulsion unit for merchant ships. The solution is to turn the oil into Biodiesel.

What is Biodiesel?

Biodiesel is a cleaner burning alternative fuel produced from renewable vegetable oil resources such as soy beans, palm and waste vegetable oil (cooking oil) or any other source of organic oil (animal fat). Biodiesel is suitable for modern, high performance diesel engines. Biodiesel contains no petroleum product but can be blended with petroleum diesel to create a biodiesel blend. This type of fuel is gaining popularity not only due to its environmental advantages but also because of how easy it is to use as it can be used in current compression-ignition (diesel) engines with little or no modifications. Biodiesel is not only easy to use; it is biodegradable, non-toxic and free of sulfur and aromatics. Replacing conventional diesel with biodiesel in engines results in considerable reduction of unburned hydrocarbons, carbon monoxide, and particulate matter. Moreover, with flash point over 260°F (127 °C), biodiesel is safer to handle and to store than petroleum based diesel fuel, which has a flashpoint of around 125°F (52°C).

Biodiesel is defined as the mono-alkyl esters of fatty acids derived from vegetable oils or animal fats. In more general terms, biodiesel is the product you get when a vegetable oil or animal fat is chemically reacted with an alcohol to produce a new compound that is known as a fatty acid alkyl ester. A catalyst such as sodium or potassium hydroxide is required. Glycerol (glycerin) is produced as a byproduct. The process is known as transesterification.

Soybean oil and methanol are the most popular feedstock in the United States. Soybeans are a major U.S. crop and government subsidies/reduced taxes are available to make the fuel economically attractive to consumers who need or want to use a non-petroleum based fuel. In Europe, most biodiesel is made from rapeseed (*Brassica napus*) oil and methanol and it is known as rapeseed methyl esters (RME).

Advantages of Biodiesel

Biodiesel has some clear advantages over SVO: it works in any diesel, without any conversion or modifications to the engine or the fuel system -- just put it in and go. It also has better cold-weather properties than SVO (but not as good as petro-diesel). Unlike SVO, it's backed by many long-term tests in many countries, including millions of miles on the road. It has as well many advantages over petro-diesel.

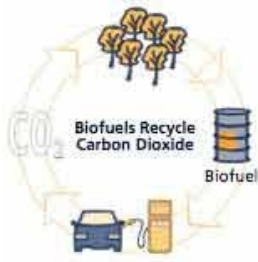
- Biodiesel substantially reduces unburned hydrocarbons, carbon monoxide and particulate matter in exhaust fumes
- Sulphur dioxide emissions are eliminated (biodiesel contains no sulphur)
- Biodiesel is plant-based and adds no CO₂ to the atmosphere. As a sustainable energy source it merely recycles carbon, with the help of the sun and photosynthesis.
- The ozone-forming potential of biodiesel emissions is nearly 50% less than conventional diesel fuel
- Nitrogen oxide (NO_x) emissions could slightly increase but can be reduced to well below conventional diesel fuel levels by adjusting engine timing and other means
- Biodiesel can be used in any diesel engine
- Fuel economy is about the same as conventional diesel fuel
- Biodiesel has a high cetane rating, which improves engine performance: 20% biodiesel added to conventional diesel fuel improves the cetane rating 3 points, making it a Premium fuel

- Biodiesel can be mixed with ordinary petroleum diesel fuel in any proportion, with no need for a mixing additive.
- Even a small amount of biodiesel means cleaner emissions and better engine lubrication
- Biodiesel can be produced from any fat or vegetable oil, including waste cooking oil.

See the US National Biodiesel Board's complete evaluation of biodiesel emissions and potential health effects at

http://www.biodiesel.org/pdf_files/fueelfactsheets/emissions.pdf

Why Biodiesel does not add CO₂ to the atmosphere.



When burning petrodiesel the CO₂ release in the atmosphere is in fact the CO₂ that was "stored" underground in the petroleum layers for many years. Thus this process increases the overall CO₂ in the atmosphere as the CO₂ does not return underground.

Using vegetable oils or animal fats as fuel for motor vehicles is in effect running them on solar energy. All biofuels, including ethanol, are derived from the conversion of sunlight to energy (carbohydrates) that takes place in the green leaves of plants.

Plants take up carbon dioxide (CO₂) from the atmosphere; burning plant (or animal) products in an engine or burning it any other way releases the CO₂ uptake back into the atmosphere, to be taken up again by other plants. The CO₂ is recycled, atmospheric CO₂ levels remain constant.

Thus biofuels do not increase global warming -- unlike fossil fuels, which release large amounts of new (or rather very old) CO₂ which has been locked away from the atmosphere.

Biofuels and Water quality: Water pollution associated with petroleum product includes ground water contamination from spills. Biofuels can replace the most toxic parts of gasoline with fuels that quickly biodegrade in water, reducing the threat to waterways and groundwater. Spills or leaks of biofuels do not constitute an environmental hazard.

The process of making biodiesel

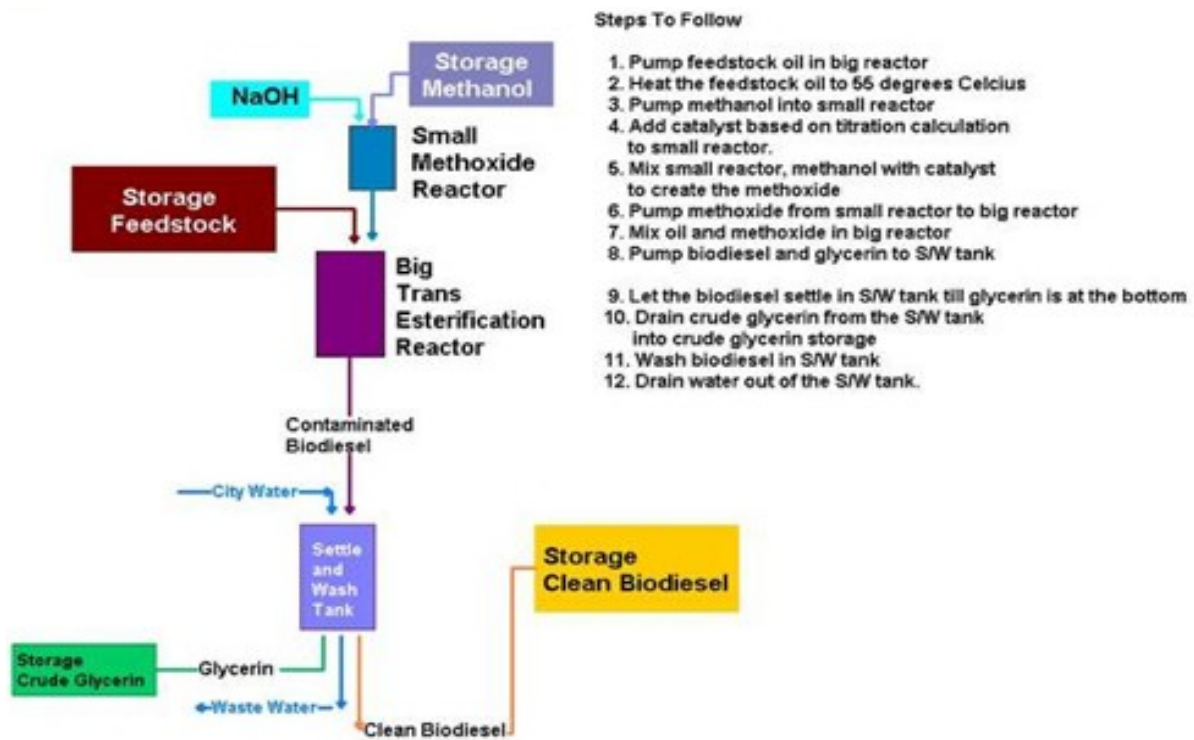
Biodiesel can be made following various but similar processes. A simple process is to use vegetable oil, methanol and sodium hydroxide.

Again in general terms vegetable and animal fats and oils are triglycerides, containing glycerine. The biodiesel process turns the oils and fats into esters, separating out the glycerine. The glycerine sinks to the bottom and the biodiesel floats on top and can be syphoned off. The process is called transesterification, which substitutes alcohol for the glycerine in a chemical reaction, using a catalyst. The result is usually a 90% biodiesel and 10% glycerine.



source: www.biodieselpictures.com

1. Reacted biodiesel with glycerol on the bottom and biodiesel on top
2. Washed biodiesel with water on the bottom



Of course they are different scales and sizes of plants from small-private home types, to the larger industrial processing plant

Biodiesel processing plants

A small home made processor. USA



<http://biodieselcommunity.org/appleseedprocessor/>

A farmer cooperative in Switzerland



<http://www.ecoenergie.ch/>



An industrial plant in USA



An industrial Biodiesel plant in Czech republic.



The first "home based" biodiesel processor made in Nepal.



Jatropha curcus L. (Physic nut)

The main "ingredient" to produce biodiesel is organic oil either vegetable or animal (fat). Vegetable fats and oils are substances derived from plants that are composed of triglycerides. Nominally, oils are liquid at room temperature, and fats are solid. Although many different parts of plants may yield oil, in actual commercial practice oil is extracted primarily from the seeds of oilseed plants. There are many types of commercial and wild plants that can produce oil (oil plant) depending on the specific region. *Jatropha curcus*, castor, *pongamia pinnata* (Indian beech tree), rapeseed, sunflower, palm tree, etc... *Jatropha curcus* have been the choice in many countries while Indonesia and Malaysia prefers mainly palm trees.

The genus *Jatropha* belongs to genus *Joannesieae* of *Crotonoideae* in the *Euphorbiaceae* family and contains approximately 170 known species. According to Correll and Correll (1982) and Heller (1994), *curcus* is the common name for physic nut in Malabar, India.

The physic nut is a drought-resistant species which is widely spread by the Portuguese in colonial times and is currently cultivated throughout the tropics as a living fence. Many parts of the plants are used in traditional medicine. The seeds, however, are toxic to humans and many animals. Considerable amounts

of physic nut seeds were produced on Cape Verde during the first half of this century, and this constituted an important contribution to the country's economy. Seeds were exported to Lisbon and Marseille for oil extraction and soap production. Today's global production is, however, negligible. (Joachim Heller, physic nut)



It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. In heavy soils, root formation is reduced. Physic nut is a highly adaptable species, but its strength as a crop comes from its ability to grow on poor, dry sites.

Source: Palm plantation of Australia <http://www.palimplantations.com.au>

Jatropha Curcas is Predominately a Bio Diesel crop, as well as having pharmaceutical and industrial values.

- 3Kg(6.6lb) Jatropha seed will yield 1 litre of Bio Diesel
- Jatropha Curcas prefers temperatures averaging 20 - 28degrees C.
- Recommended planting rates are 2,500 plants /Hectare
- Jatropha Curcas will produce a small crop after 2 years and reach full production at 5 years
- Jatropha Curcas will grow for 50 years and bear seed for up to 40 years.
 - o There is approximately 1000 seeds per kilogram
 - o Contains 34-36% oil content
 - o Dried seeds should have 7-8% moisture content

Source: <http://www.jatrophaworld.org/>

Planning Commission of India has nominated it as ideal plant for biodiesel and the Government of India has selected the plant for National Program compared to others, due to following reasons:

- Low cost seeds
- High oil content
- Small gestation period
- Growth on good and degraded soil
- Growth in low and high rainfall areas
- Seeds can be harvested in non-rainy season
- Plant size is making collection of seeds more convenient
- Income generation from previously Unusable areas
- Provide huge opportunities from new sustainable and renewable land resources
- And crops Creating employment Nursery development, soil preparation, irrigation systems, Plantation maintenance, seed collection,

Noted Controversy

Rapeseed biofuel 'produces more greenhouse gas than oil or petrol'

Source: <http://www.timesonline.co.uk/tol/news/uk/science/article2507851.ece>

September 22, 2007

A renewable energy source designed to reduce greenhouse gas emissions is contributing more to global warming than fossil fuels, a study suggests.

Measurements of emissions from the burning of biofuels derived from rapeseed and maize have been found to produce more greenhouse gas emissions than they save.

Other biofuels, especially those likely to see greater use over the next decade, performed better than fossil fuels but the study raises serious questions about some of the most commonly produced varieties.

Rapeseed and maize biodiesels were calculated to produce up to 70 per cent and 50 per cent more greenhouse gases respectively than fossil fuels. The concerns were raised over the levels of emissions of nitrous oxide, which is 296 times more powerful as a greenhouse gas than carbon dioxide. Scientists found that the use of biofuels released twice as much as nitrous oxide as previously realised. The research team found that 3 to 5 per cent of the nitrogen in fertiliser was converted and emitted. In contrast, the figure used by the International Panel on Climate Change, which assesses the extent and impact of man-made global warming, was 2 per cent. The findings illustrated the importance, the researchers said, of ensuring that measures designed to reduce greenhouse-gas emissions are assessed thoroughly before being hailed as a solution.

"One wants rational decisions rather than simply jumping on the bandwagon because superficially something appears to reduce emissions," said Keith Smith, a professor at the University of Edinburgh and one of the researchers.

Maize for ethanol is the prime crop for biofuel in the US where production for the industry has recently overtaken the use of the plant as a food. In Europe the main crop is rapeseed, which accounts for 80 per cent of biofuel production.

Professor Smith told Chemistry World: "The significance of it is that the supposed benefits of biofuels are even more disputable than had been thought hitherto."

It was accepted by the scientists that other factors, such as the use of fossil fuels to produce fertiliser, have yet to be fully analysed for their impact on overall figures. But they concluded that the biofuels "can contribute as much or more to global warming by N₂O emissions than cooling by fossil-fuel savings".

The research is published in the journal Atmospheric Chemistry and Physics, where it has been placed for open review. The research team was formed of scientists from Britain, the US and Germany, and included Professor Paul Crutzen, who won a Nobel Prize for his work on ozone.

Dr Franz Conen, of the University of Basel in Switzerland, described the study as an "astounding insight".

"It is to be hoped that those taking decisions on subsidies and regulations will in future take N₂O emissions into account and promote some forms of 'biofuel' production while quickly abandoning others," he told the journal's discussion board.

Dr Dave Reay, of the University of Edinburgh, used the findings to calculate that with the US Senate aiming to increase maize ethanol production sevenfold by 2022, greenhouse gas emissions from transport will rise by 6 per cent.

NAEF ambitions

<http://www.naef-nepal.org/>

National Agricultural & Environmental Forum (NAEF) is attempting to make biodiesel available even when there is no Jatropha available yet in sufficient quantity in Nepal by using other type of oil seeds and used oil. It buys oil seeds from individuals who collect in small quantities from planted or wild plants. Doing so it attracts interest of farmers and communities as well as indirectly promote cultivation of oil seed plant such as Jathropha, castor and others. NAEF is promoting "backyard" or "home brew" biodiesel production at community level as it believes oil, therefore liquid biofuel and biodiesel can be manufactured at the grassroots level for local use. In addition NAEF with its expertise in agriculture mechanization thus two wheels tractor and small low speed engines, is promoting the use of SVO for those type of engines. NAEF is as well collaborating with the private sector.

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