FROM THE DISH TO THE ENGINE

transforming waste vegetable oil into biodiesel

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The energy needs of the world are steadily increasing. In the European Union (EU) the market amounted to about 1,370 Mtoe (million tonnes of oil equivalent) of which 42% actually derived from petroleum and the remainder came from natural gas, solid fuels and other sources.
The term biofuels refers to fuels, liquid or gaseous, for transport produced from biomass. The main biofuels are bioethanol, biodiesel and biomethane. Bio-diesel is a product used as a fuel for vehicles and for heating, obtained from renewable resources including: virgin vegetable oils; rapeseed and soybean oil (the most commonly used, although other crops like mustard, palm oil and algae are also promising); waste vegetable oil and animal fats. Its characteristics are very similar to those of diesel fuel, with the difference that the latter is derived from petroleum. In heating and above all in transport use, it is no longer in its experimental stages, but use is established and accepted, as can be seen in public transport in some countries for example.

rapeseed plants

soybean plants

mustard plants

In the nineties, France launched local production of bio-diesel obtained by transesterification of rapeseed oil for public transport. Using bio-diesel poses a considerable advantage in terms of environmental impact: its use for transport reduces carbon emissions by about 50%, CO_2 emissions by 78.45% and fine dust emissions by up to 65%.
For the reasons above, using bio diesel fits perfectly with the Directive 2009/28/CE - Bruxelles, 23.4.2009 concerning “promoting the use of energy produced from renewable sources” .
In making a comparison between advantages and disadvantages in using biodiesel for transport use some points can be highlighted:

ADVANTAGES	DISADVANTAGES
Reduces polluting emissions: PM10 (-30%), absence IPA	Higher nitrogen oxides emission
Reduces the input of greenhouse gases (GHG)	Greater dissolving power
completely biodegradable	
no heavy metals	
Higher cetane number	
Lower flammability	

IPA: polycyclic aromatic hydrocarbons.

Cetane number: number expressing the delay between injection and ignition.

Due to its high solvency power bio diesel can cause engine gaskets to stick; it has to be mixed with usual diesel fuel, except for use in the engine specifically designed.

The bio diesel production from vegetables shows some critical issues, both environmental and social.

Enviromental aspects:

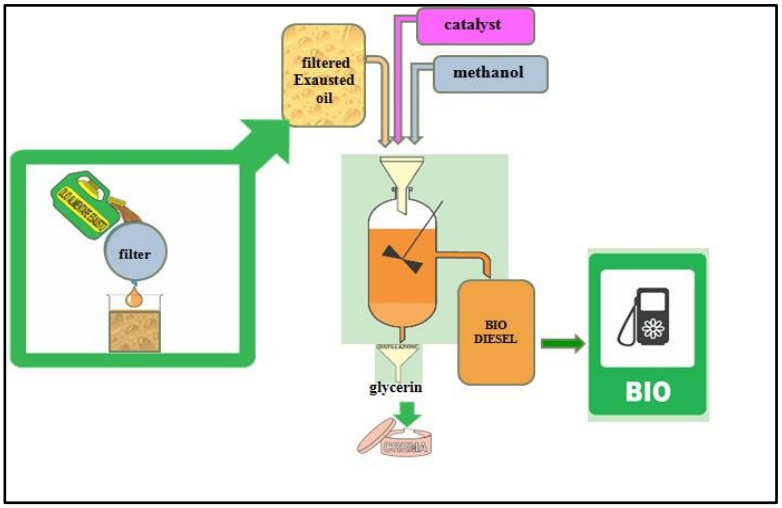
- Sourcing of raw materials from land that does not have a recognized high biodiversity value (forests untouched by human activities; areas designated for nature protection purposes; species-rich grassland, not fertilized and not degraded).
- Sourcing of raw materials from land that does not have a high carbon storage (wetlands, ie land that is covered or saturated by water permanently or for a significant part of the year; continuously forested areas).
- Sourcing of raw materials from crops that comply with EU environmental (Annex III of EC Regulation no. 1782/2003) and comply with the requirements for the maintenance of good agricultural conditions (art. 5, par. 1 of that Regulation):
    - Water consumption,
    - Quality / quantity of herbicides
    - Fertilizers (Nitrogen balance / excess phosphorus)

Social and ethical aspects:

- Competitiveness with food.
- Economic prosperity.
- Welfare (human rights, social and property).

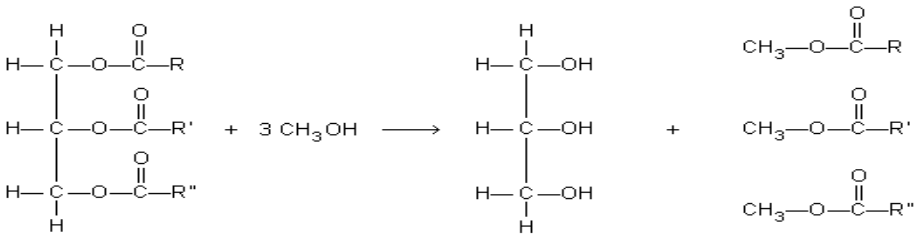
Rather than rubbish, waste vegetable oil is a fully recoverable "asset" that can be turned into a bio-fuel with a lower environmental impact than traditional fuels. So why treat the waste vegetable oil as simple waste matter and earmark it as refuse, when it's better to remove impurities in a recovery plant and turn waste into a new low environmental impact energy?
Although the production technology of bio-diesel from waste vegetable oil is an established reality from the technological point of view, as are the environmental advantages deriving from its use, there are still two areas with plenty of room for improvement: its widespread use, and recovery of the huge amounts of waste vegetable oils produced by users.
Few figures: in Italy, about 280.000 tonnes of exhausted olive and seed oil (CONOE - Consorzio Obbligatorio Nazionale di raccolta e trattamento Oli e grassi vegetali ed animali Esausti- estimate) are produced annually. At the moment, waste food oil is recovered almost only from large-scale users (restaurants, fast food chains, canteens etc.) amounting to about 120.000 tonnes per year. Therefore, we can calculate that about 160.000 tonnes per year of waste food oil ends up in the environment through the sewage system. Incorrect disposal of household waste vegetable oil represents a considerable source of pollution and in addition a considerable cost to the community to purify it from the household wastewater; this is an absolute "waste" if we consider that one litre of waste vegetable oil can be used to produce 1 litre of bio-diesel.
Incorrect disposal of waste vegetable oil (typically poured down the sink and flowing into the public sewage system) represents a considerable social cost: the removal of oil in household wastewater treatment plants, as well as the supplementary maintenance needed to the sewage pipes as a result of the presence of oily pollutants are procedures that place a great burden on and is paid for by the community.
Current techniques can be used to turn waste vegetable oil into low environmental impact fuel (bio-diesel) at a ratio of even 1:1; i.e. one litre of bio-diesel can be produced for every litre of waste vegetable oil.

Diagram of the biodiesel production cycle from exhausted vegetable oil



At first the oil is filtered to remove food residue, the filtered oil is put into the reactor with methanol and a base (usually NaOH *sodium hydroxide*). The reaction can be carried out at low temperature. From the reaction are obtained biodiesel and glycerin. The glycerin is not only a byproduct, but itself represents a useful product in the pharmaceutical and cosmetic industry.

The chemical reaction

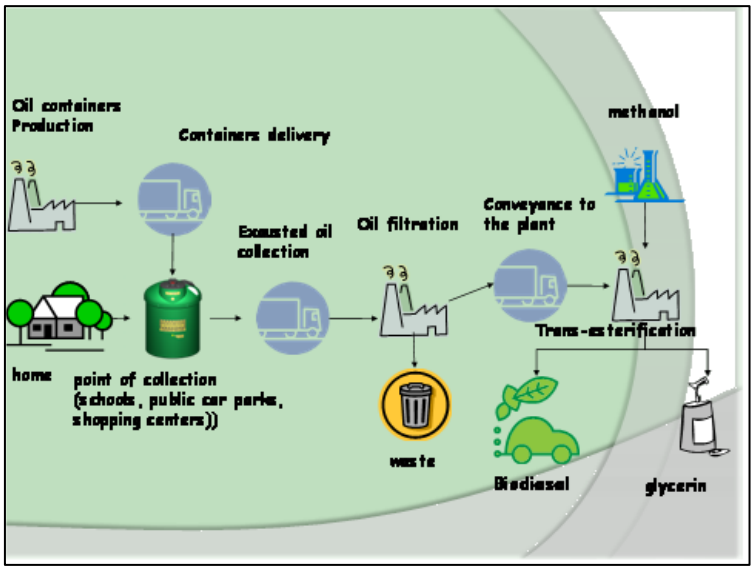


The biodiesel is mase up of a mixture of the esters of the fatty acids that were present in the vegetable oil used.

Waste oil + *methanol* ⟶ *glycerin* + *bio-diesel*

Is it convenient?

As collecting the exhausted vegetable oil costs both in economic and environmental terms, an energy audit has to be done before embarking upon a cycle of this waste gathering and transforming. The balance must take into account all the energy used to collect and transport the exhausted oil from the collecting point to the plant, also including the cost for production and distribution of the oil containers. In the figure is shown a typical system for which can draw up the energy and environmental balances.



Energy balance: Energy gained (*using biodiesel as fuel*) – Energy consumed *(to produce biodiesel following this way).*

Environmental balance: CO_2 (*emitted to produce biodiesel following this way*) - CO_2 (*not emitted using biodiesel as fuel*).

In all the cases in which the balances have been done the results have come down on the side of recovery/conversion, even if they could be even further improved.