

VEGETABLE OIL POWER STATIONS



Introduction With this document *MGM Engineering & Contracting* wishes to provide a brief overview on the features and advantages of small-to-medium (1 -50 MW), vegetable oil power stations, based on low-speed diesel reciprocating engines.

The combination of bio-fuels and this particular power system takes advantage of many interesting features:

- Vegetable oils are extracted from oily seeds (jatropha, sunflower, rapeseed, oil palm, soybean), some of which require minimal care and can be profitably grown in arid environments not suitable to other crops.
- Vegetable oils are environment-friendly fuels, which do not contribute to global greenhouse effect (they are considered a renewable energy source) and contain low levels of other pollutants.
- Vegetable oils can be used in low-speed diesel reciprocating engines undergoing minimal processing after extraction, thus reducing the complexity of the treatment plant and requiring no change in the engine design.
- Low-speed diesel reciprocating engines are a long-time proven technology, being a derivation of naval engines. They combine a sturdy, reliable and cost-effective design with efficiencies unmatched by other technologies in the mid-low power segment.

The result is an integrated agricultural and energetic system, which uses locally available plantations to produce low-emissions and relatively low-cost electricity. This grants the neighbouring areas several benefits:

- The fuel demand stimulates the development of local plantations, creating working places both in the fields and in the fuel treatment plant.
- The by-products of oil extraction can be used as livestock food, as a soil fertilizer or as a further source of energy in an incinerator power station with steam turbogenerator.
- The power plant itself creates more working places, besides being a source of electricity for areas not reached by the power transmission network.

In the following paragraphs both the fuel cycle and the power station technology issues will be addressed in deeper detail.

In depth:

The plants and the fuel cycle

Several plant species can produce oily seeds which are suitable for fuel oil extraction, like

- Soybean (*Glycine max*)
- Sunflower (*Helianthus annuus*)
- Rapeseed (*Brassica napus*)
- Oil palm (*Elaeis guineensis*)
- Jatropha (*Jatropha curcas*).



Rapeseed



Sunflower



Oil palm



Jatropha



Soybean

Among the named species the most interesting is surely **jatropha**. It is a non-edible, mildly poisonous shrub, very resistant to aridity (it can grow on as low as 250 mm of rain a year) and thus is not a competitor of food crops. Moreover this plant requires minimal care, thanks to its natural pesticidal and fungicidal properties, its prolonged lifespan (it starts producing fruits in four years and can live up to fifty years) and its sturdiness.

The yield of jatropha is very variable: a mean is estimated in about 5 ton of seeds per hectare per year, although productivity can be significantly higher if the soil is properly watered and fertilized. Jatropha plantations have already been successfully started in many tropical and subtropical areas around the world, including the South East of Asia, Africa, the Indian subcontinent from the northern states down to the Ocean.

After collection the seeds are removed from the fruit and undergo a simple extraction process:

- The seeds are mechanically pressed (mild heating reduces viscosity of the oil and enhances extraction). This allows extracting about 95% of the oil.
- Afterwards the solid remnant can be triturated and washed with hydrocarbon solvents (usually hexane or heptane) which remove the remaining oil. The solution is then heated to about 150°C, in order to evaporate the solvent and recover the oil. Finally, the solvent is condensed and used for another extraction batch.
- The seed press cake (what remains after the second extraction step – i.e. the shell and fibrous parts of the seed and fruit) can be fed to the livestock, used as a soil fertilizer or even as a fuel in an incineration plant to produce electricity.

The oil thus extracted (the yield is about 400 kg raw oil for 1000 kg of jatropha seeds) is then to be partially refined before use in the engine:

- First, the oil must be filtrated, in order to remove gummy fats molecules, phospholipids and complex carbohydrates.
- Then the oil is mixed with caustic soda, to lower its acidity and remove fatty acids.

After refining, the oil is ready to use in the power stations. Its characteristics are very similar to those of common diesel fuel except for viscosity, which is about 10 times more. This means that vegetable oil is more viscous and cannot be made working properly in unmodified injection systems (such as those of automotive diesel engines). On the other hand, large low-speed engines are specifically designed to run on heavier fuels, which means that their injection system is not as delicate and can use the refined oil directly.

On a last note, vegetable fuel oil claims several advantages over its fossil counterpart:

- Deriving from a living plant, it has zero net impact on greenhouse effect (the amount of carbon dioxide released in the atmosphere is the same as that fixed by the plant into its tissues, including the seed).
- It contains (and releases when burnt) very low amounts of pollutants, for example, it is almost totally sulphur free.
- It is completely biodegradable and non-toxic (i.e. accidental release in the environment is not a serious issue).
- It is less harmful for the engine, because it leaves less deposits and produces fewer aggressive compounds in the flue gas.

In depth:
The power station

The power station is based on diesel reciprocating engines. Several manufacturers produce low-speed diesel engines, size ranging from less than 1 MW to as much as 17 MW per single unit, designed to run on heavy fuels, just like refined vegetable oil.



Reciprocating engines of this size are often a derivative of naval models. As such, they inherit many of the appreciated assets of ship engines:

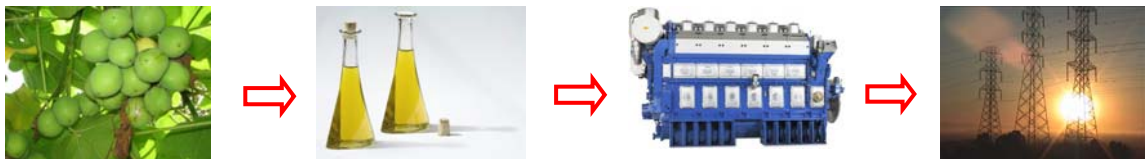
- Proved reliability and sturdy design.
- Low maintenance requirements.
- Net electrical efficiencies as high as 45% (far better than gas turbines or other fuelled power stations).
- Compact packaging. They usually come on a single power skid which houses the engine, its auxiliaries, the power generator and control electronics.

The power skid itself contains almost all required equipment for running the power station. Only a few auxiliaries need to be added:

- Fuel tanks and transfer pumps.
- Lubricating oil tank and transfer pumps.
- Power transformer.
- Additional control electronics for managing the rest of the power station.
- Heat dissipation exchangers.
- Engine starting equipment (compressor or starting electric motor, depending on the size of the reciprocating engine).

The use of integrated control electronics and the simple design of the power station (the engine is the only complex machinery and it has its own control and security logics) make it possible to leave it unattended during normal operation and manage it remotely.

All this makes low-speed diesel engines the perfect choice for small or medium sized decentralized power stations, placed near the vegetable oil production areas.



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experience
and services

During past years **MGM Engineering & Contracting** focused on renewable energy power plants, tailoring investments on the customer's needs.

MGM Engineering & Contracting can offer the customers complete projects and engineering services, thanks to managers and technicians with long time proven experience in the energy area.

Consulting, engineering and expert services can be provided to energy and utility companies, municipalities and power plant investors. Fields of expertise include, integrated or separately, the following:

- Technical and economical feasibility studies
- Investment cost definition
- Owner engineering
- Conceptual and basic design
- Front-end engineering
- Detail engineering, including all related technical disciplines
- Design review
- Procurement, including purchasing, sub-contracting, expediting, inspection and logistics
- Tender evaluation, negotiation and contract preparation
- Construction management, including field supervision and testing
- Plant commissioning and start-up, including personnel training
- Project management, planning and cost control
- Proposal management and bid document preparation
- Energy audit and services
- Permits, authorizations and certifications