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Renewable Energy generation
Liquid biofuels for Gen-Sets

Liquid biofuels for Gen Sets

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1st generation biofuels

Biodiesel – Produced from plant oils via a process called transesterification; Feedstocks include, sunflower oil, oilseed rape, palm oil and soybean oil, (and also waste cooking oils). Typically 30-50% CO_2 footprint reduction (but 70% possible).

Bioethanol - Produced by fermentation of plant-derived sugars.; Feedstocks include sugar cane and sugar beet, and wheat and corn starch.

2nd generation biofuels

Advanced processing of non-edible feedstocks including wastes
& lignocellulosics e.g woods and grasses;
Processing includes both fermentation and syngas derived fuels

3rd generation biofuels

Harvesting and advanced processing of ultra high yield biomass (e.g. Algae);
Processing by trans-esterification, hydro-treating and hydrothermal routes

Factors effecting feedstock

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Yield:
How much oil is obtained per hectare?

Oil composition:
What type of oil is produced? Is it saturated or unsaturated? This affects the properties of the biodiesel produced e.g. clouding at low temperatures.

Sustainability:
Does cultivation of large amounts of the crop threaten the environment through overuse of fertilizers or destruction of habitats? How much fertilizer and pesticide is needed for a good yield of the crop?

Vegetable Oil recovery

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- Crushing of seeds
- Separation of oil from the meal (seed material)
- Mechanical press (for > 20% oil content)
- Solvent extraction (< 20% oil content)
- Combination of both
- “De-gumming” – removal of hydratable gums
- Further purification by conditioning with acid or alkali.
- No further purification needed for biodiesel production by transesterification

Straight vegetable oils

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Characteristics	**Rapeseed oil**	**Soyabean oil**	**No. 2 diesel**
Specific gravity	0.91	0.92	0.8495
Viscosity @ 40°C (mm^2/s)	**33**	**51**	2.98
Cloud point, °C		-4	-12
Pour point, °C	-21	-12	-23
Sulphur, wt%	0.01	0.01	0.036
Cetane number	32	38	49
Higher heating value, MJ/kg	40.17	39.3	45.42
Higher heating value, MJ/L	36.60	36.2	38.58

Implementation is difficult, particularly for low T conditions, due to:
Progression of combustion (high viscosity fuel droplets)
Deposits on injectors and in the combustion chamber

Straight vegetable oils

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Why SVO and UCO?

The transesterification process consumes the energy and produces CO_2 and increases the cost

Rejects about 10% of the feedstock as waste glycerol.

Although they present some challenges, straight vegetable oils (SVO) and used vegetable/cooking oils (WVO or UCO) can be used as fuels in diesel engines with a better carbon footprint compared to FAME.

These unprocessed (non-esterified) biofuels are not commonly used due to their high viscosity and low volatility, leading to poor atomisation and thus high particulate emissions as well as other problems such as handling problems and engine deposits and injector coking

Alternative liquid fuels

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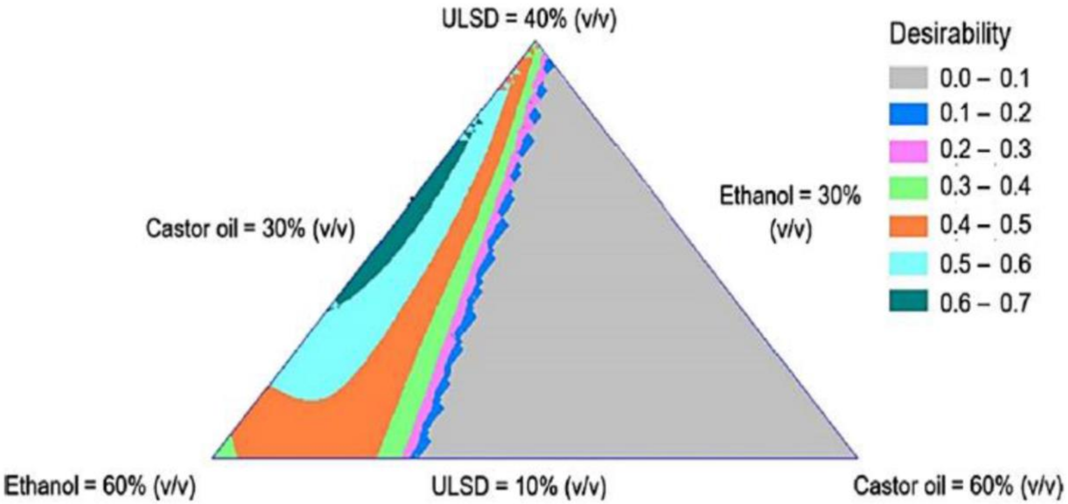
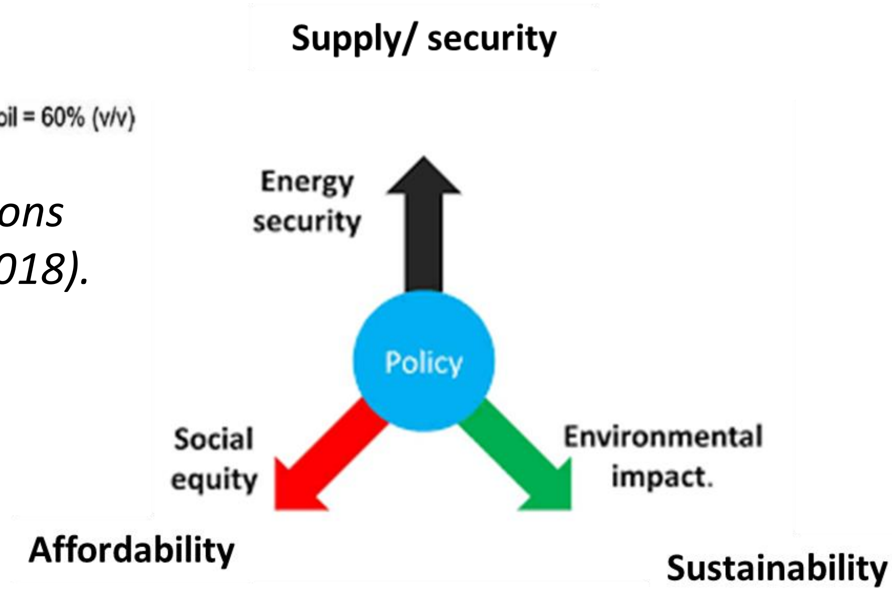


Desirability response of ternary blend compositions with 0.6-0.7 being most desirable (Pinzi et al., 2018).



Gen-Set performance

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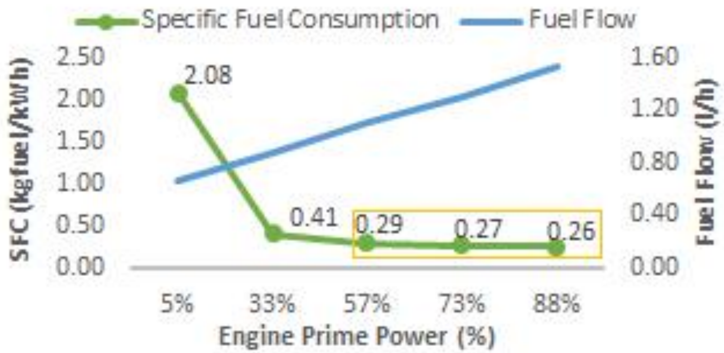
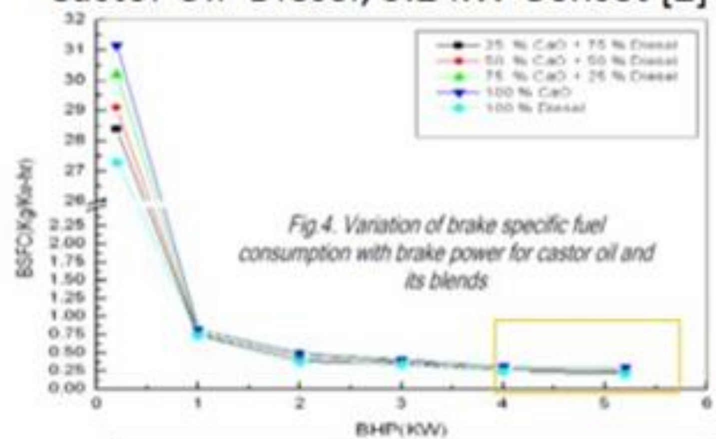
Diesel 5.7 kW Genset

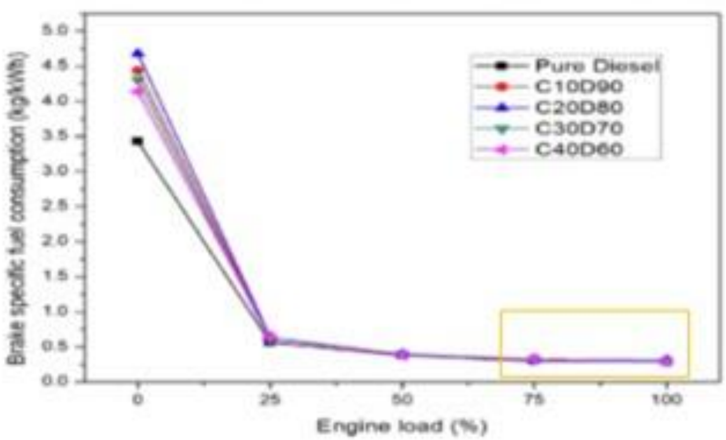


Castor Oil- Diesel, 5.2 kW Genset [2]



Power (kW)	Power Percentage (%)
5.2	100%
4	77%
3	58%
2	38%
1	19%

Castor Oil- Diesel, 3.5 kW Genset [1]



Acceptable Genset performance above 60% engine load

Biodiesel – 1st Generation

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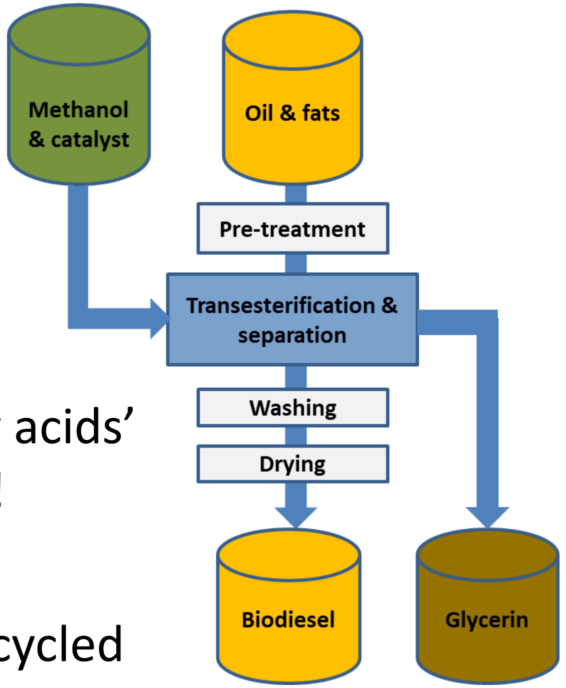
Made from oils extracted from oil seed crops such as:

- Sunflower oil
- Rape seed oil
- Palm Oil
- Jatropha oil
- Waste vegetable oil



- Normally use base catalyst (KOH) but if 'free fatty acids' present then use acid to avoid formation of soap!

- Free fatty acids sometime present when using recycled vegetable oil

- Relatively easy process to implement however requires methanol or ethanol

Biodiesel properties

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Characteristics	Rapeseed oil	Rapeseed methyl ester
Specific gravity	0.91	0.88
Viscosity @ 40°C (mm^2/s)	**33**	**4**
Cloud point, °C	-11	-3
Pour point, °C	-21	-12
Sulphur, wt%	0.01	0.01
Cetane number	**32**	**48**
Net heating value, MJ/kg	37.4	37.7
Net heating value, MJ/L	34.3	33.2

Bio-ethanol – 1st generation

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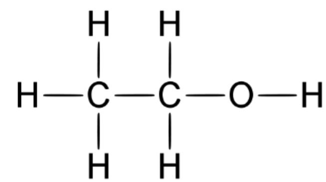
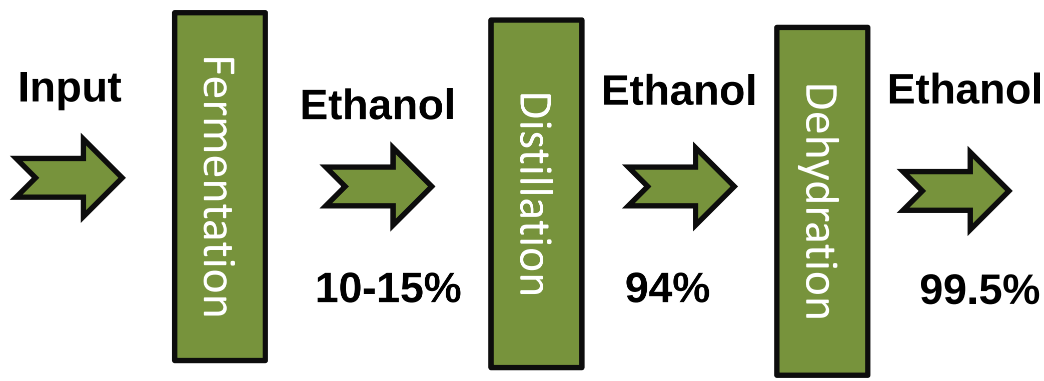
Bio-ethanol production



Sugar stream



starch stream

Ethanol (C_2H_5OH) is a clear colourless liquid produced by fermentation which can be blended with gasoline at 10% ethanol and 90% petrol (E10), to 85% ethanol and 15% petrol blends (E85).

Bio-ethanol – 1st generation

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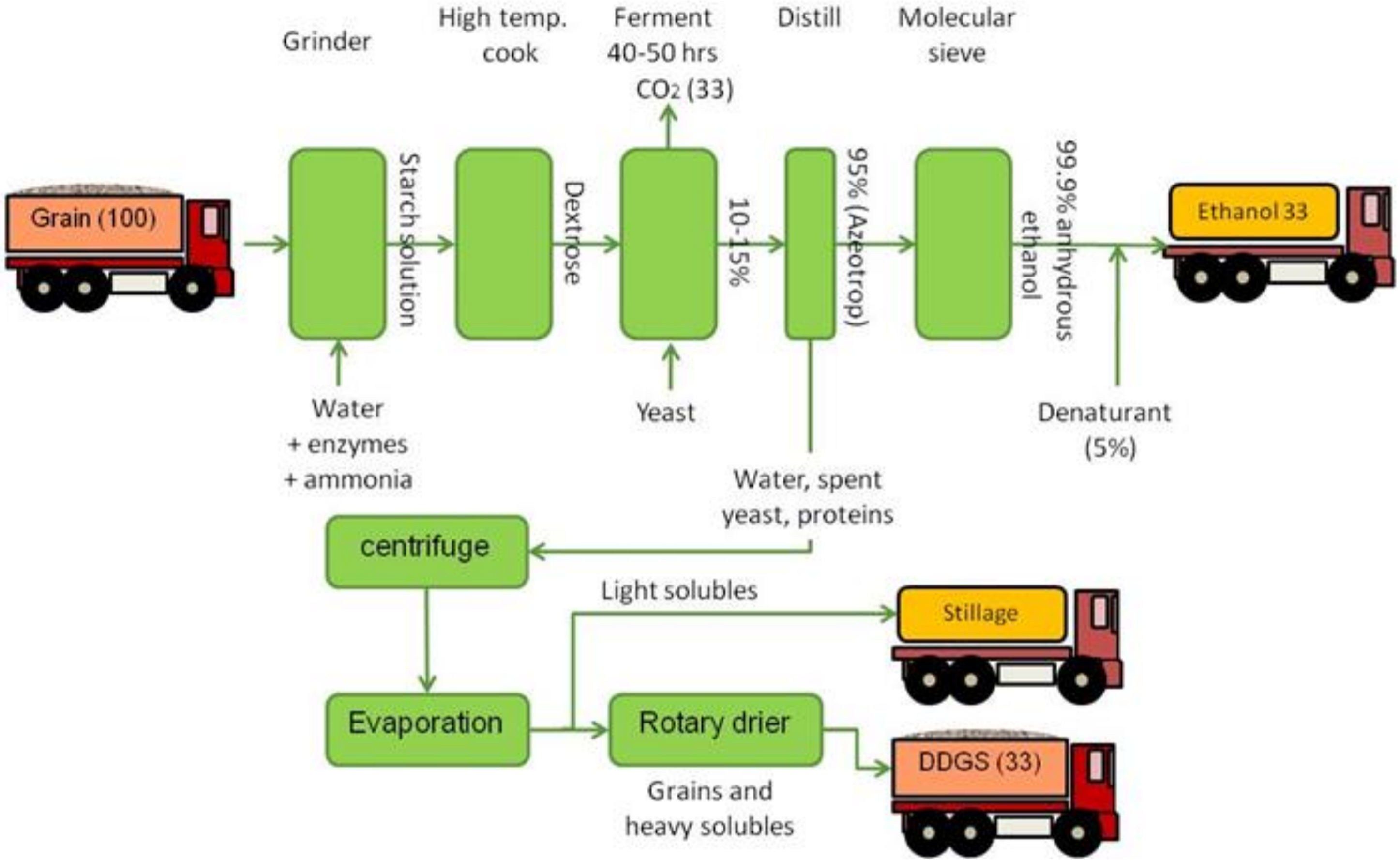
Dry Milling Process – decomposition of glucose to ethanol and CO_2



2nd generation biofuels

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Technologies for conversion of lignocellulosics have been developed on two platforms

Sugar platform – converted to fermentable sugars

Hydrolysis of carbohydrates by acids or enzymes yields fermentable sugars

Syngas platform – converted to CO and H_2 via gasification

Can be converted to ethanol by specific microorganisms or converted catalytically to ethanol

In the sugar platform only the carbohydrate fraction is used and the lignin is considered a waste and burnt whereas in the syngas platform the whole biomass is used

Feedstock for bio-ethanol

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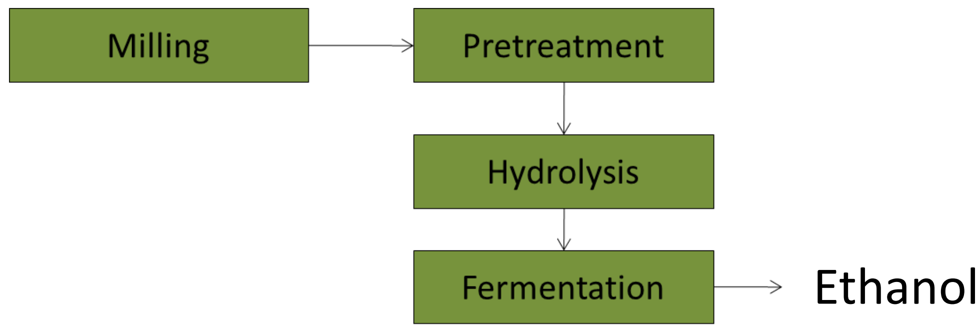
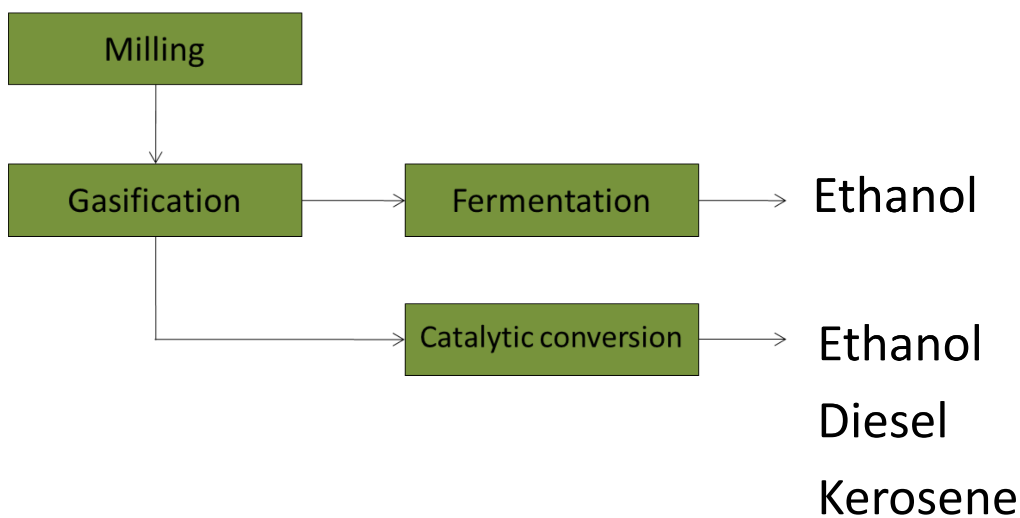
Sugar platform

Lignocellulosic biomass



Syngas platform

Lignocellulosic biomass



Microalgae – 3rd generation

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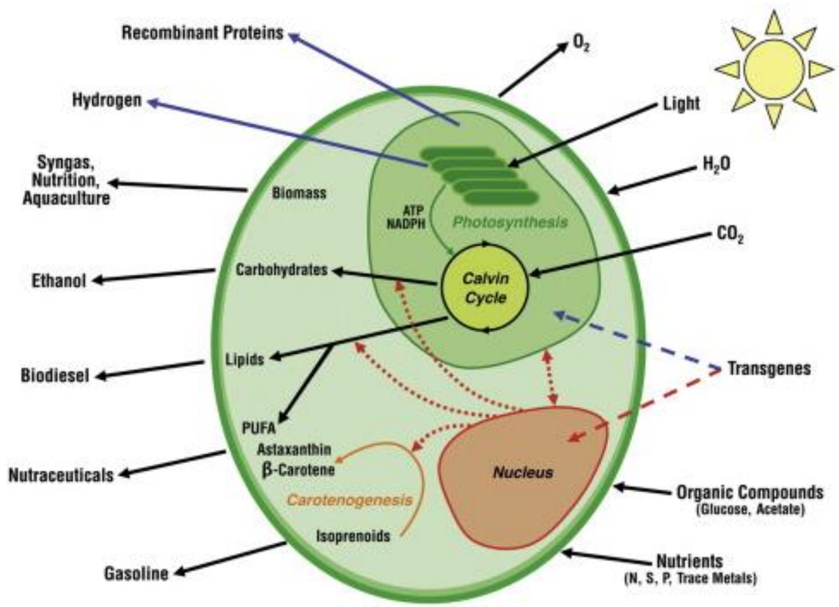
Light



Fast growing feedstocks such as microalgae have been proposed as new feedstocks for production of biofuels.

Microalgae contain oils (triglycerides), protein and carbohydrates.

- The triglycerides can be converted into bio-diesel
- The carbohydrates can be converted into bio-ethanol.

Ideally we want to use a marine strain although for small scale applications fresh water strains maybe possible.

Supply chain issues

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- The use of vegetable oils and first-generation biofuels are feasible for developing regions.
- 2nd generation cellulosic ethanol may also be feasible however BTL/GTL fuels based on the syngas platform require significant economies of scale
- Microalgae derived fuels are a long way from being commercially viable and are unlikely to make a significant contribution anytime soon.