


ODA – UNESCO Project

Promotion of Energy Science Education for Sustainable Development in Laos

# BIOFUEL



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# WHAT ARE BIOFUELS?



**Biofuels** are liquid fuels which have been derived from other materials

**Liquid biofuels** can be used for transportation purposes.

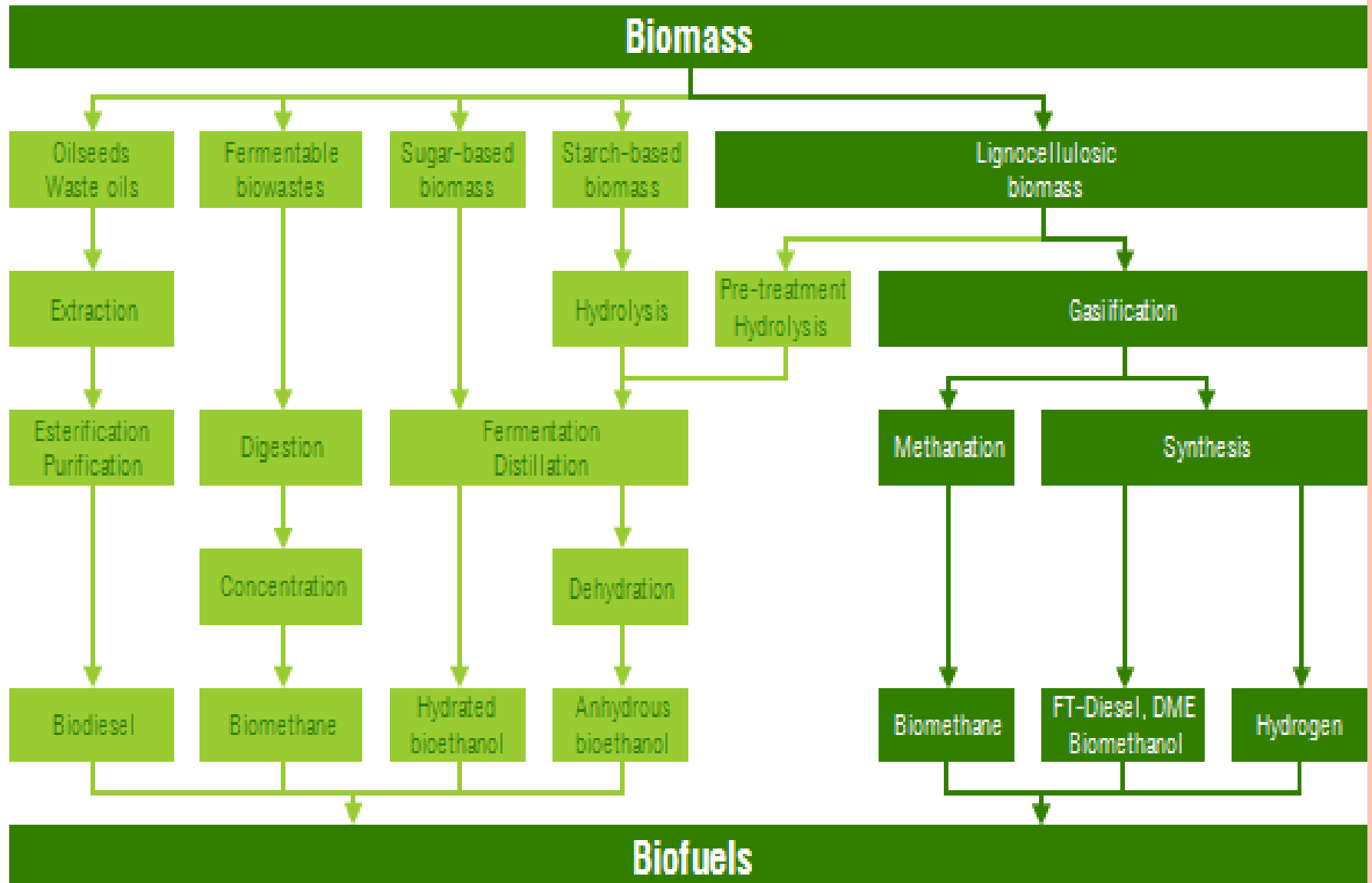
**Ethanol and biodiesel** are the two most used liquid biofuels for transportation use.

# DEFINITION OF BIOMASS

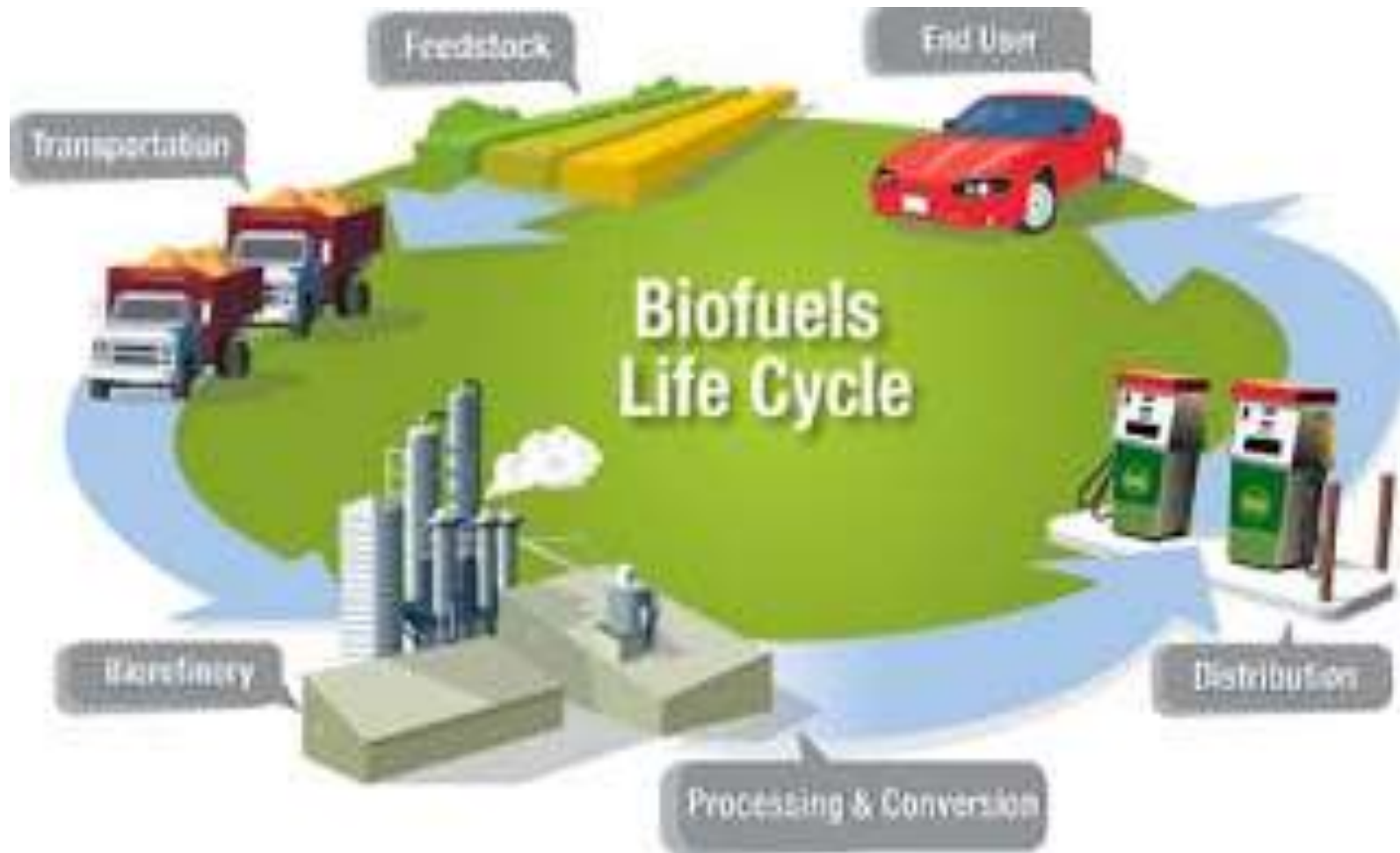
- **Biomass** is an organic compound
- A natural source of energy storage and can be used to produce energy
- Can be burned to create electricity;
  - Gases from decomposition can be collected and used,
  - Crops can be grown to make fuel, such as corn grown to make ethanol



# BIOFUELS PRODUCTION PATHWAYS



# BIOFUEL LIFE CYCLE

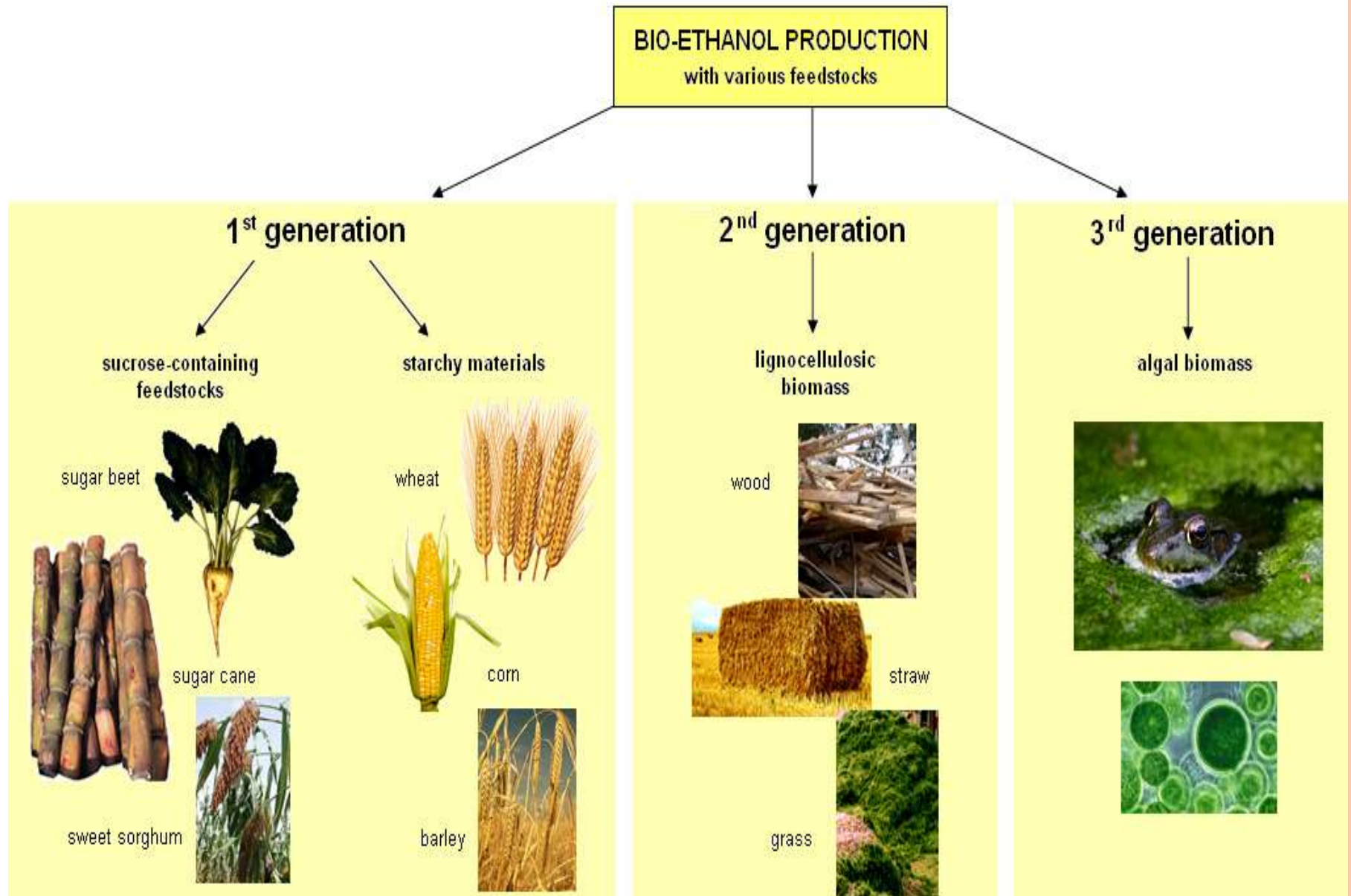


# DEFINITION OF BIOETHANOL

- **Bioethanol** is an alcohol (ethanol), used as a liquid fuel.
- **Bioethanol** is manufactured from plants
- **In first generation bioethanol** is produced from sugar crops and starch crops: sugar cane, sugar beet, corn, wheat crops...
- **In second generation bioethanol** is produced from non food crops and biomass source: waste wood, saw dust, straws, and grasses



# Schematic classification of used/converted feedstock for bioethanol production

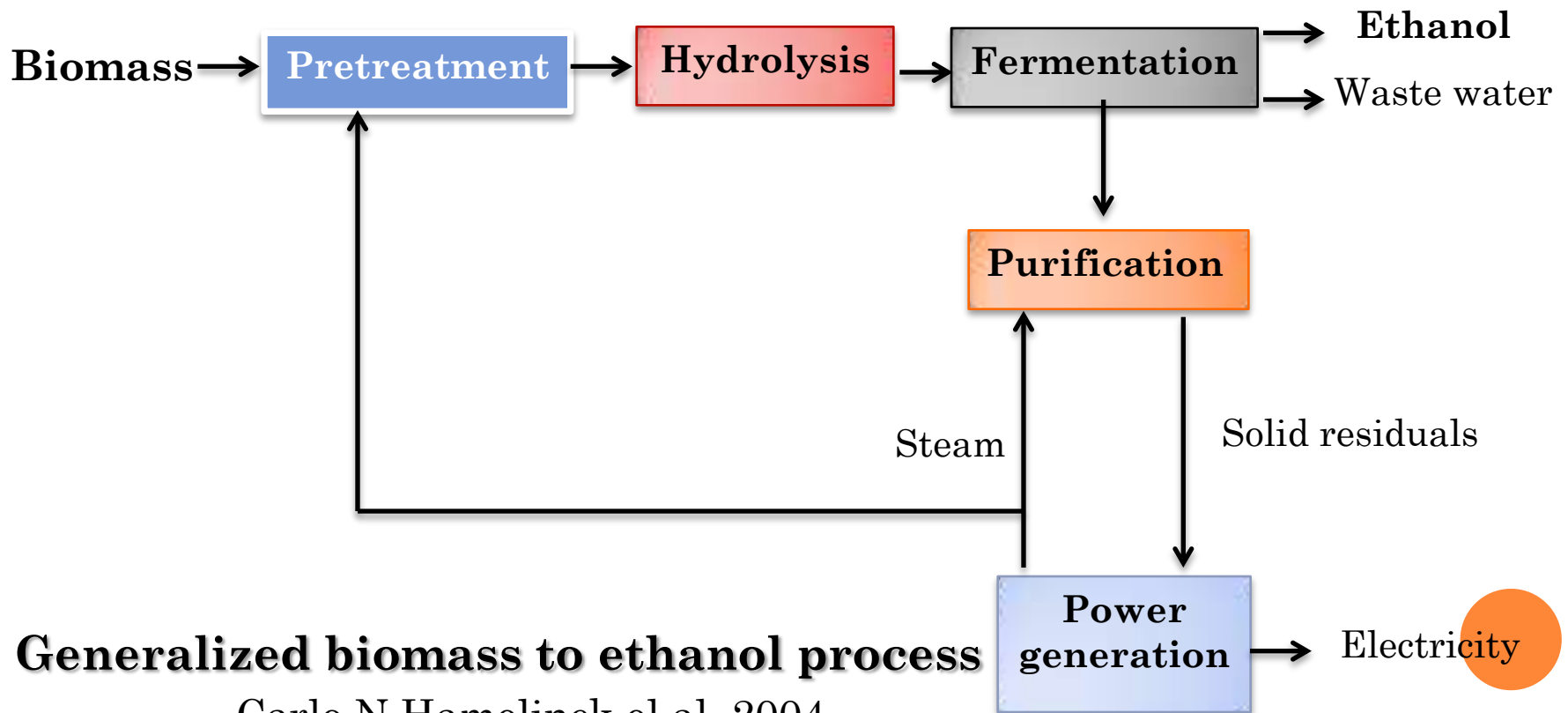


# FEEDSTOCK TYPES OF BIOETHANOL



# BIOETHANOL PRODUCTION

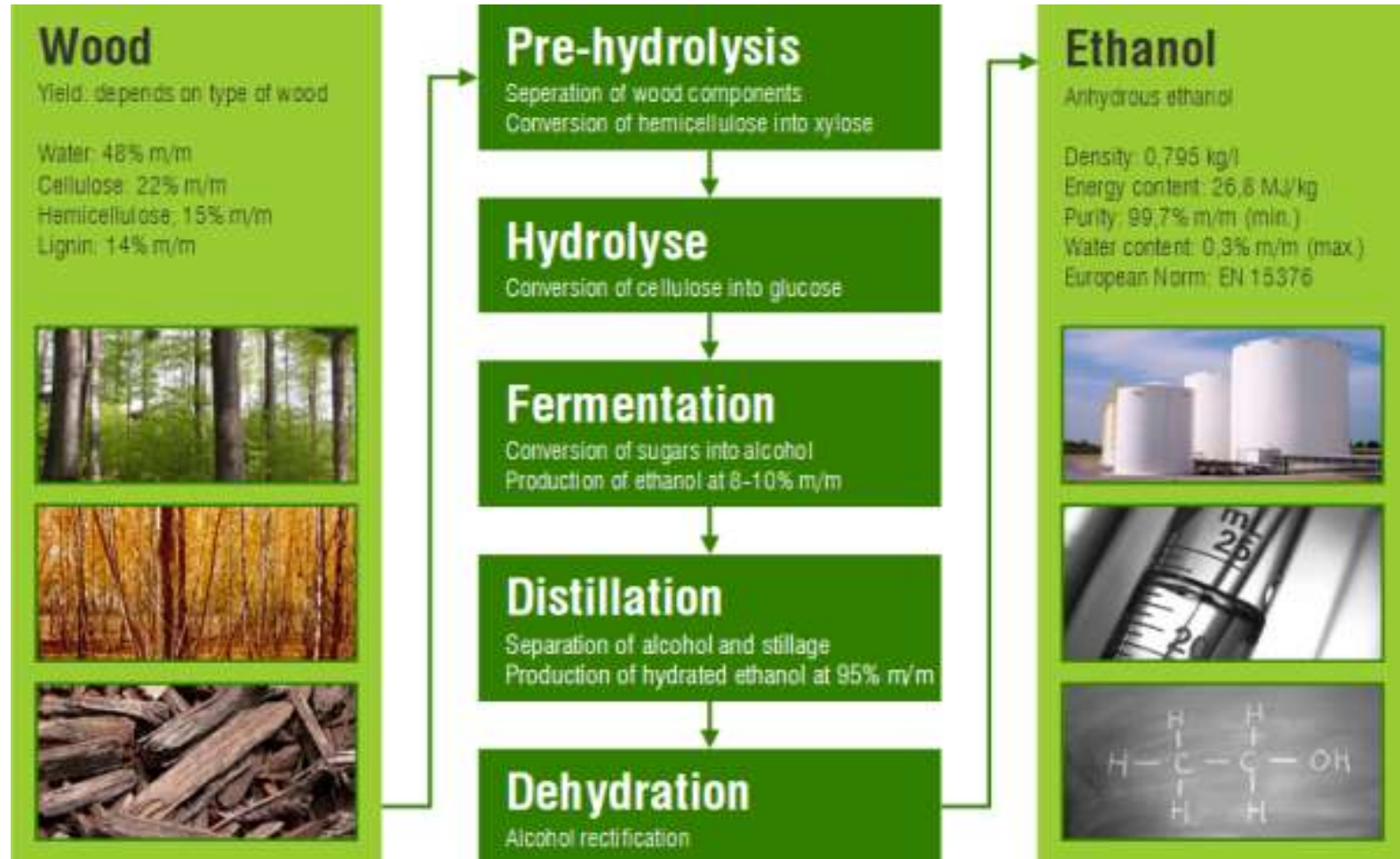
Substrates as Wheat/Grains/Corn/Sugar cane can be used to produce ethanol. (Basically, any plants that composed largely of sugars). Main method: Sugar fermentation



**Generalized biomass to ethanol process**

Carlo N Hamelinck et al. 2004

# PRODUCTION OF BIOETHANOL FROM WOOD



# PROPERTIES OF ETHANOL

Density and phase	0.789g/cm <sup>3</sup> , liquid
Solubility in water	Fully miscible
Melting point	- 114.3 °C (158.8 K)
Boiling point	78.4 °C (351.6 K)
Acidity (pKa)	15.9 (H + from OH group)
Viscosity	1.200 cP at 20 °C
Dipole moment	1.69 D (gas)

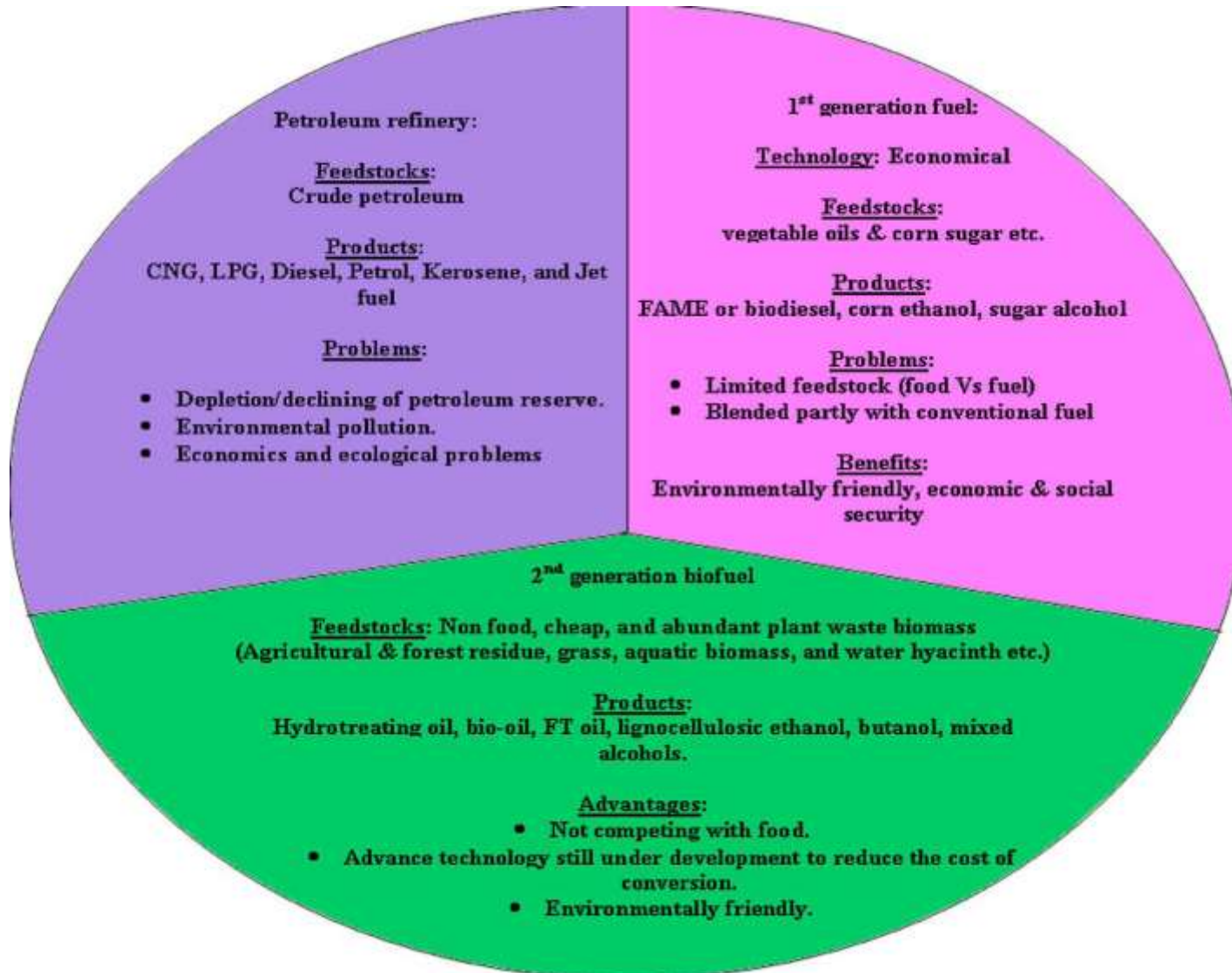
## Parameters of bioethanol in comparison with petrol(Paul & Kemnitz 2006)

	Density (Kg/l)	Viscosity (mm <sup>2</sup> /s)	Flash point (°C)	Caloric value (at 20 °C MJ/kg)	Caloric value (MJ/l)	Octane number (RON)	Fuel equivalence (l)
Petrol	0.76	0.6	<21	42.7	32.45	92	1
Bioethanol	1.5	1.5	<21	26.8	21.17	> 100	0.65

# Overview of biofuels of the first and second generation and their related feedstock and conversion processes

	Generic name	Chemical composition	Feedstocks	Technology
1 <sup>st</sup> generation	Biodiesel	Methyl or ethyl esters of fatty acids (FAME); Hydrocarbons (products of cracking)	Oil crops (e.g. rape, palm, soya, jatropha, canola, colza etc.), waste oil (e.g. frying oil), and animal fats	Cold/hot pressing, extraction & transesterification (Homogeneous, heterogeneous, and bio-catalysis); Hydrogenation (hydro-cracking)
	Bioethanol	Ethanol	Sugars (glycosides) and starch from bio-waste and woody biomass (sugarcane, sugar beet, cereals)	Hydrolysis & fermentation
	Vegetable oil	Straight Vegetable Oil (SVO) – triglycerides of fatty acids	Oil crops (e.g. rape, palm, soya, jatropha, canola, colza etc.)	Cold/hot pressing, extraction, and purification
	Biogas	Methan, hydrogen and light hydrocarbons	Biomass (humid)	Anaerobic digestion
2 <sup>nd</sup> generation	Cellulosic bioethanol	Ethanol	Lignin, cellulose and hemicellulose from bio-waste	Hydrolysis & fermentation
	Bio-SNG	Synthetic (substitute) natural gas – methane	Lignocellulosic biomass	Pyrolysis, gasification, methanation
	Synthetic biofuels	Hydrocarbons (BTL/FT), methanol (biomethanol), mixed heavy alcohols, dimethyl ether (bio-DME)	Lignocellulosic biomass	Pyrolysis, gasification, synthesis
	Bio-hydrogen	Hydrogen	Lignocellulosic , biomass	Pyrolysis, gasification, water gas shift reaction (WGSR)

# COMPARISON OF FIRST, SECOND GENERATION BIOFUEL AND PETROLEUM FUEL.



# USES OF BIOETHANOL

Bioethanol essentially has two types of application:

1. It can be used as a motor fuel

e5 bioethanol

e10 bioethanol

e85 bioethanol



2. Bioethanol is also used as an additive for traditional petrols in the form of Ethyl tertiary butyl ether (ETBE).



Ethanol available  
in filling station in  
Basil

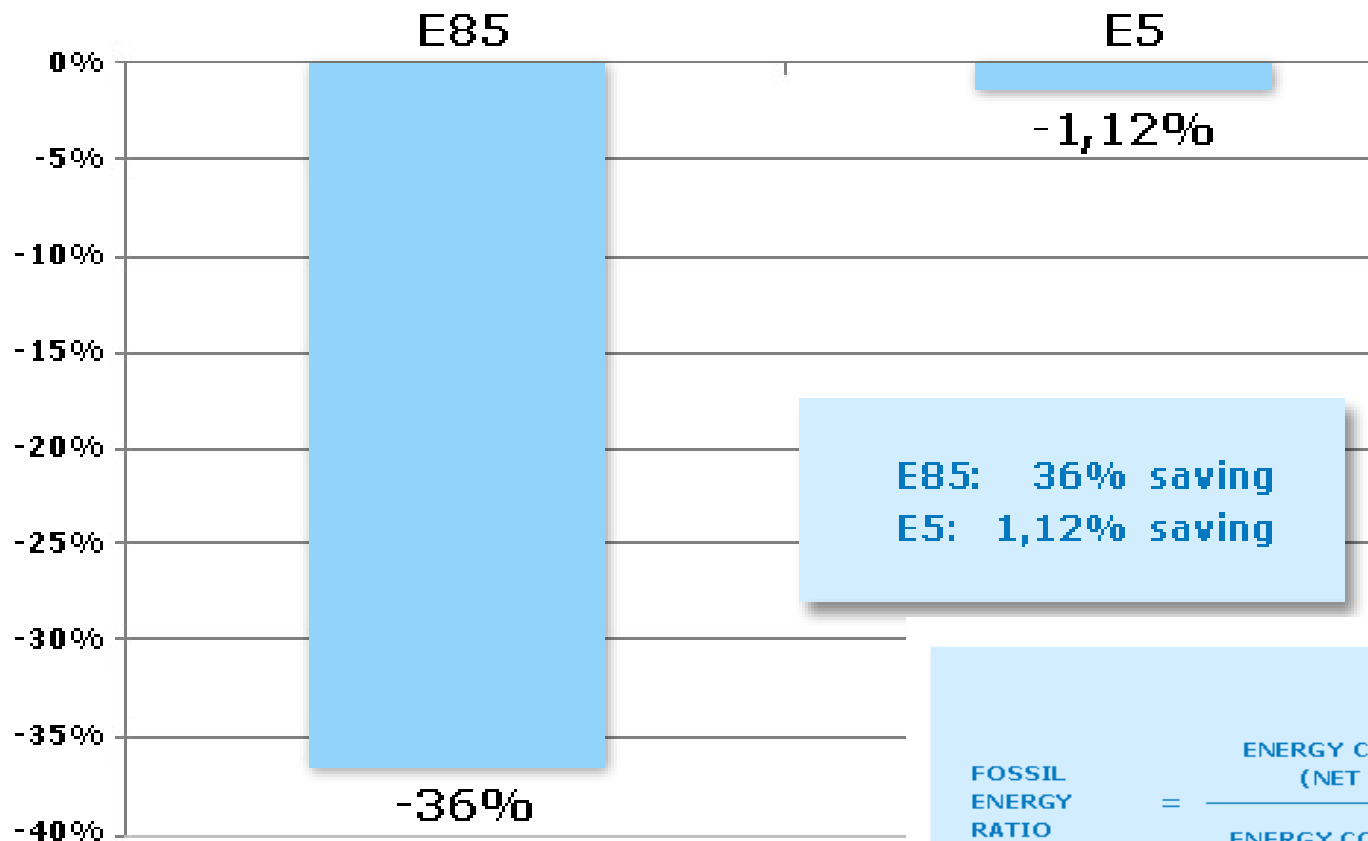


Car run by  
Blended ethanol

# ADVANTAGES OF BIOETHANOL

## Saving in fossil energy. (% of fossil energy per km)

(Source: Analysis of the life cycle of cereal-based ethanol and petrol Ciemat/Ministry for the Environment)

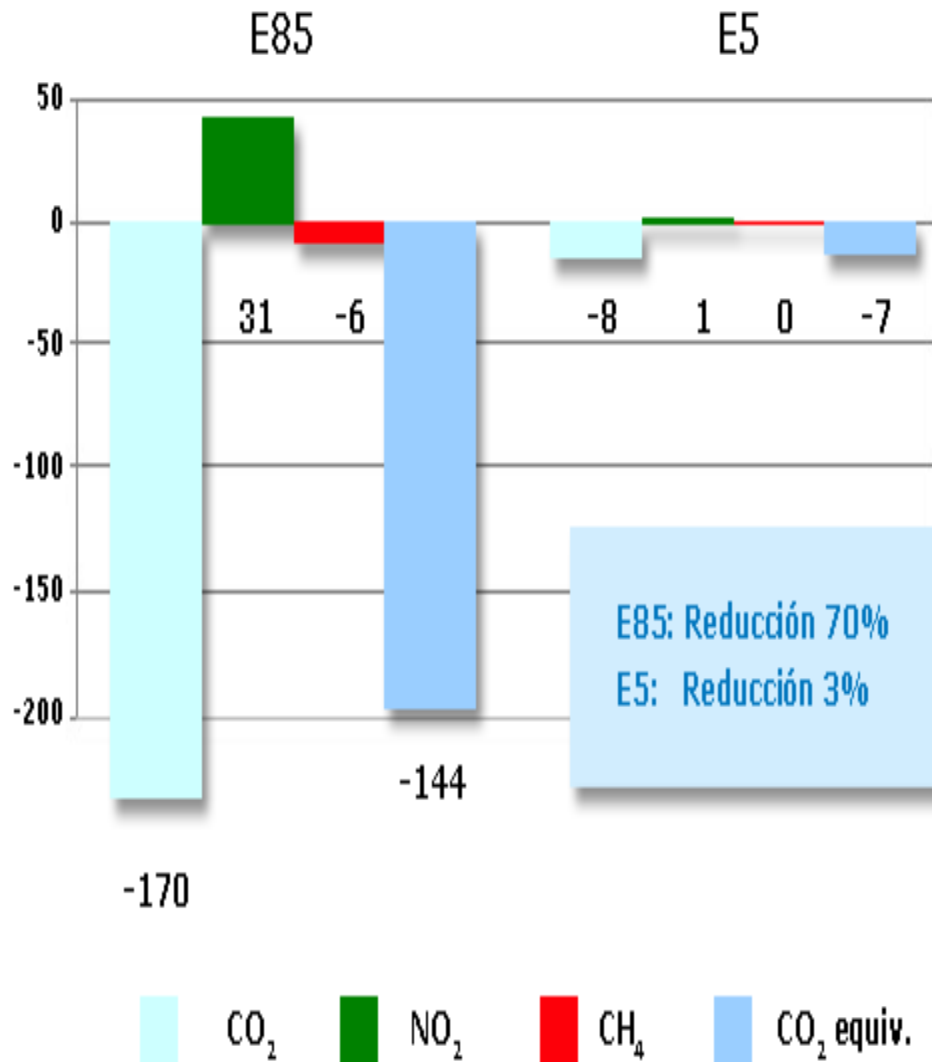


E85: 1 MJ per km travelled (36%)

E5: 0.031 MJ per km travelled (1.12%)

$$\text{FOSSIL ENERGY RATIO} = \frac{\text{ENERGY CONTAINED IN THE FUEL (NET CALORIFIC VALUE)}}{\text{ENERGY CONSUMED IN PRODUCING AND DISTRIBUTING IT}}$$

# Environmental advantages



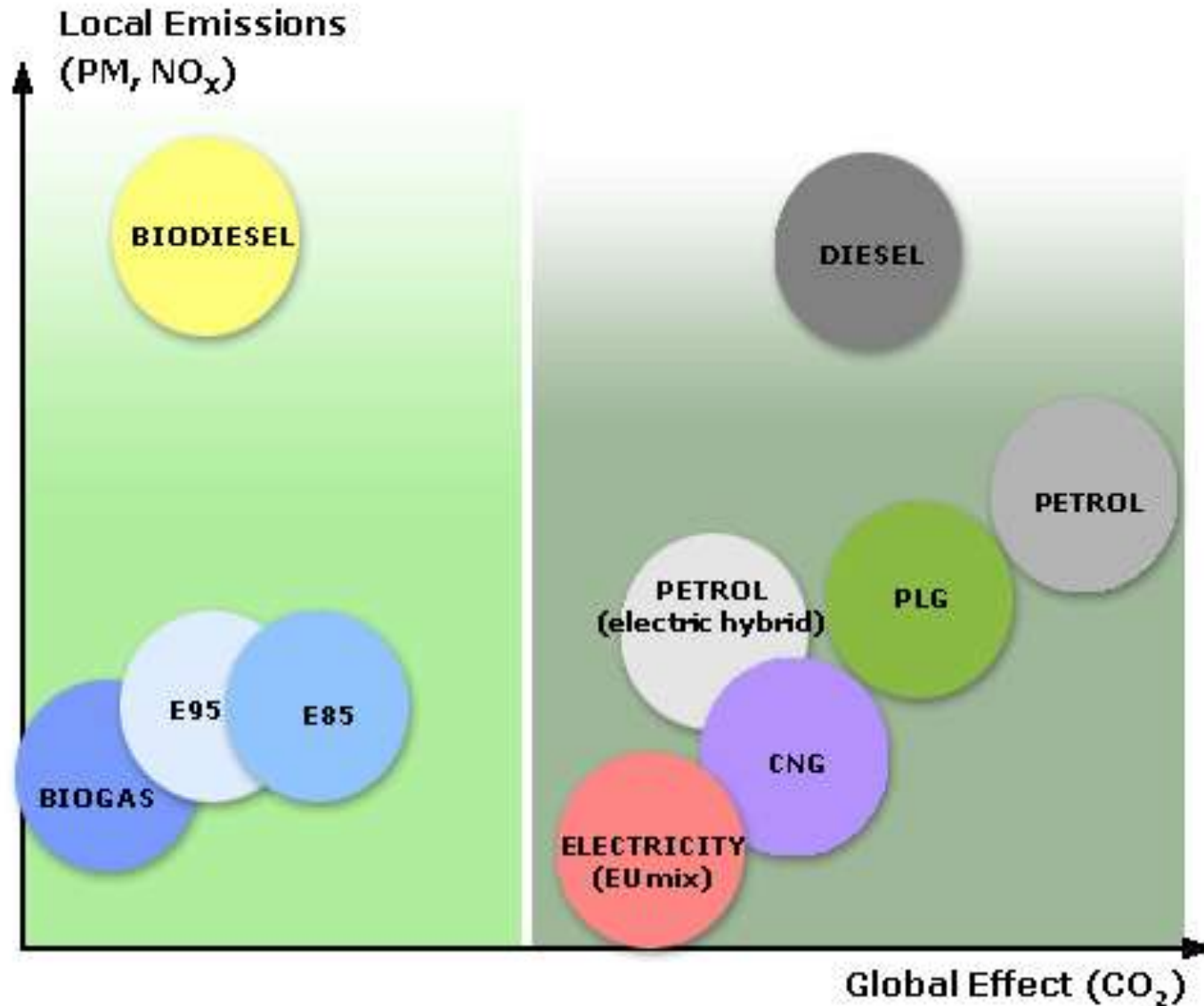
## Social advantages

Directly replaces fuel imported from third countries and thus reduces external dependency

Using biofuels creates jobs in agriculture and in the manufacture



the relative CO<sub>2</sub> emissions (horizontal axis), and emissions of particles and NO<sub>x</sub> (vertical axis) of different fuels used in transport



# ADVANTAGE AND DISADVANTAGE OF BIOETHANOL

## Advantage

### Exhaust gases of ethanol are much cleaner:

- It burns more cleanly as a result of more complete combustion

### Greenhouse gases reduce:

- Ethanol blended fuel such as E85 (85% ethanol and 15 % gasoline) reduce up to 37% of GHGs

### Positive energy balance, depending on the type of raw stock.

- Output of energy during the production is more than the input

### Any plant can be used for production of bioethanol

- It only has to contain sugar and starch

### Carbon neutral:

- The CO<sub>2</sub> released in the bioethanol production process is the same amount as the one the crops previously absorbed during photosynthesis

**Decrease in Ozone formation:** The emission produced by burning ethanol are less reactive with sunlight than those produced by burning gasoline, which results in a lower potential for forming ozone

## Disadvantage

**Biodiversity:** A large amount of arable land is required to grow crops, natural habitats would be destroyed

**Food vs Fuel debate:** due to the lucrative prices of bioethanol some farmers may sacrifice food crops for biofuel production which will increase food prices around the world

**Carbon Emissions (Controversial):** during production of bioethanol, huge amount of carbon dioxide is released. Emission of GHGs from production of bioethanol is combustion engines.

**Not as efficient as petroleum:** energy content of the petrol is much higher than bioethanol and its energy content is 70% of that of petrol

**Engines made for working on Bioethanol can not be used for petrol or diesel** due to high octane number of bioethanol, they can be burned in the engines with much higher compression ratio

**Used of phosphorous and nitrogen in the production:** negative effect on the environment



# ADVANTAGE AND DISADVANTAGE OF BIOETHANOL (CONT.1)

## Advantage

### Renewable Energy Source:

- Result of conversion of sun's energy into usable energy
- Photosynthesis → feedstock grow → processed into ethanol

### Energy Security:

- There are many countries that do not have access to crude oil sources
- Grow crops for energy use and gain some economic freedom

Reduces the amount of **high octane additives**

Fuel spills are **more easily biodegraded or diluted** to non toxic concentration

## Disadvantage

**Cold start difficulties:** pure ethanol is difficult to vaporize

**Transportation:** ethanol is hygroscopic, it absorbs water from the air and thus has high corrosion aggressiveness. Can only be transported by auto transport or railroad

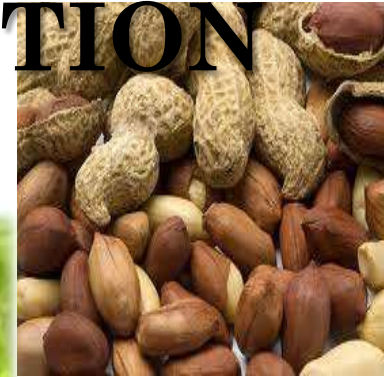
Many older cars unequipped to handle even 10% ethanol

Negatively affect electric fuel pumps by increasing internal wear and undesirable spark generation

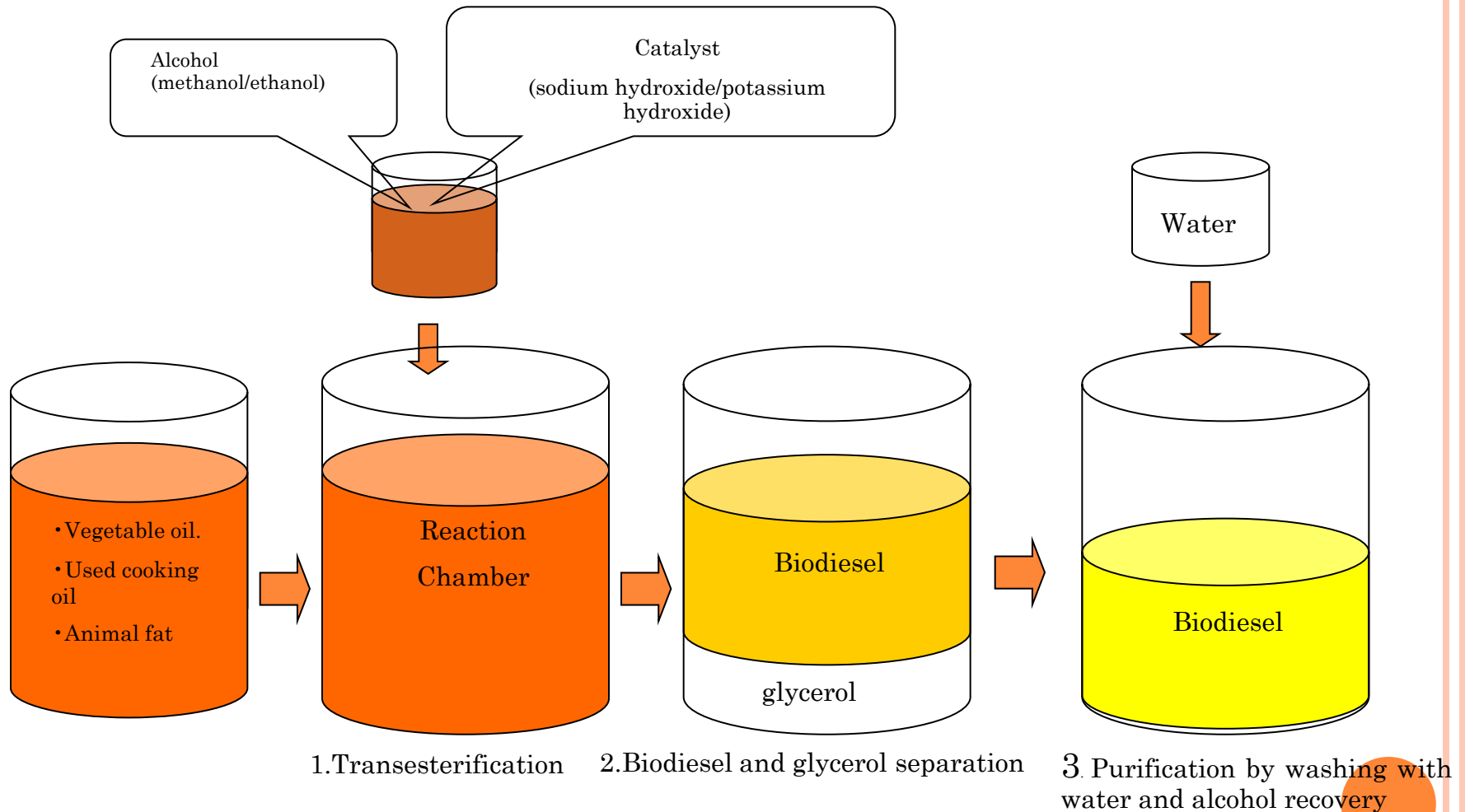
# WHAT IS BIODIESEL?



# FEEDSTOCK FOR BIODIESEL PRODUCTION

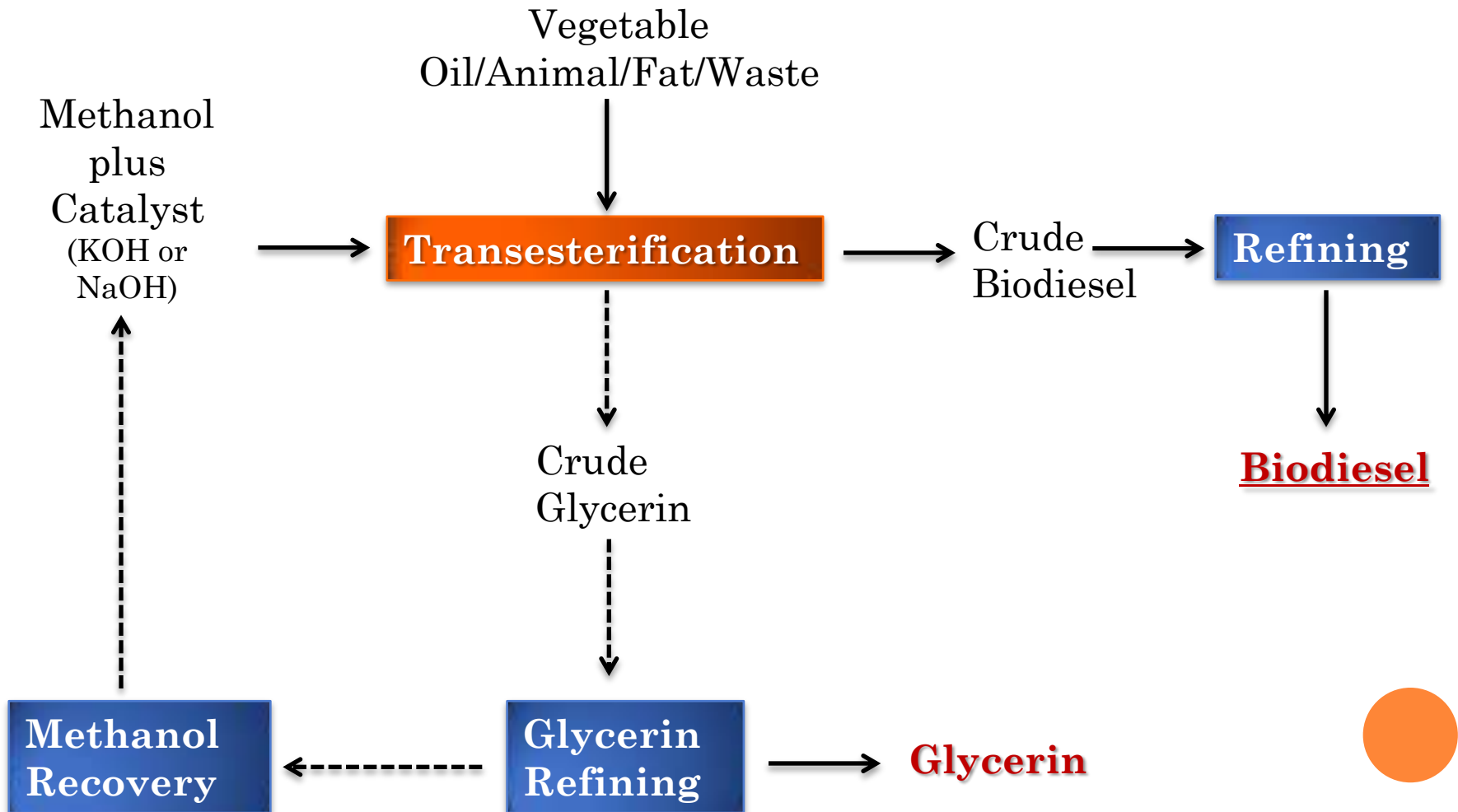


# Biodiesel production process

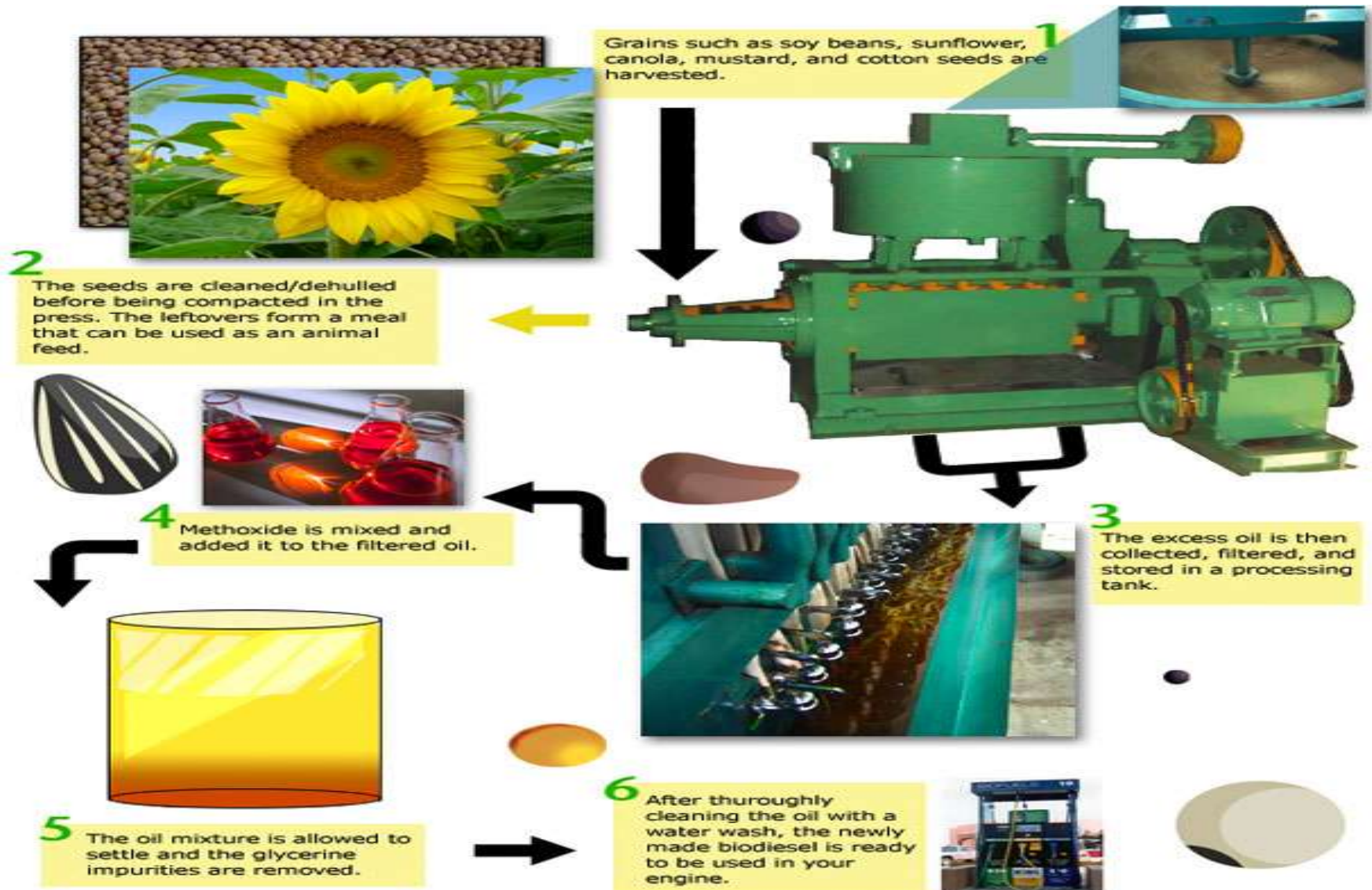


100kg oil + 10kg (alcohol and catalyst)  $\longrightarrow$  100Kg Biodiesel+10 Kg glycerin

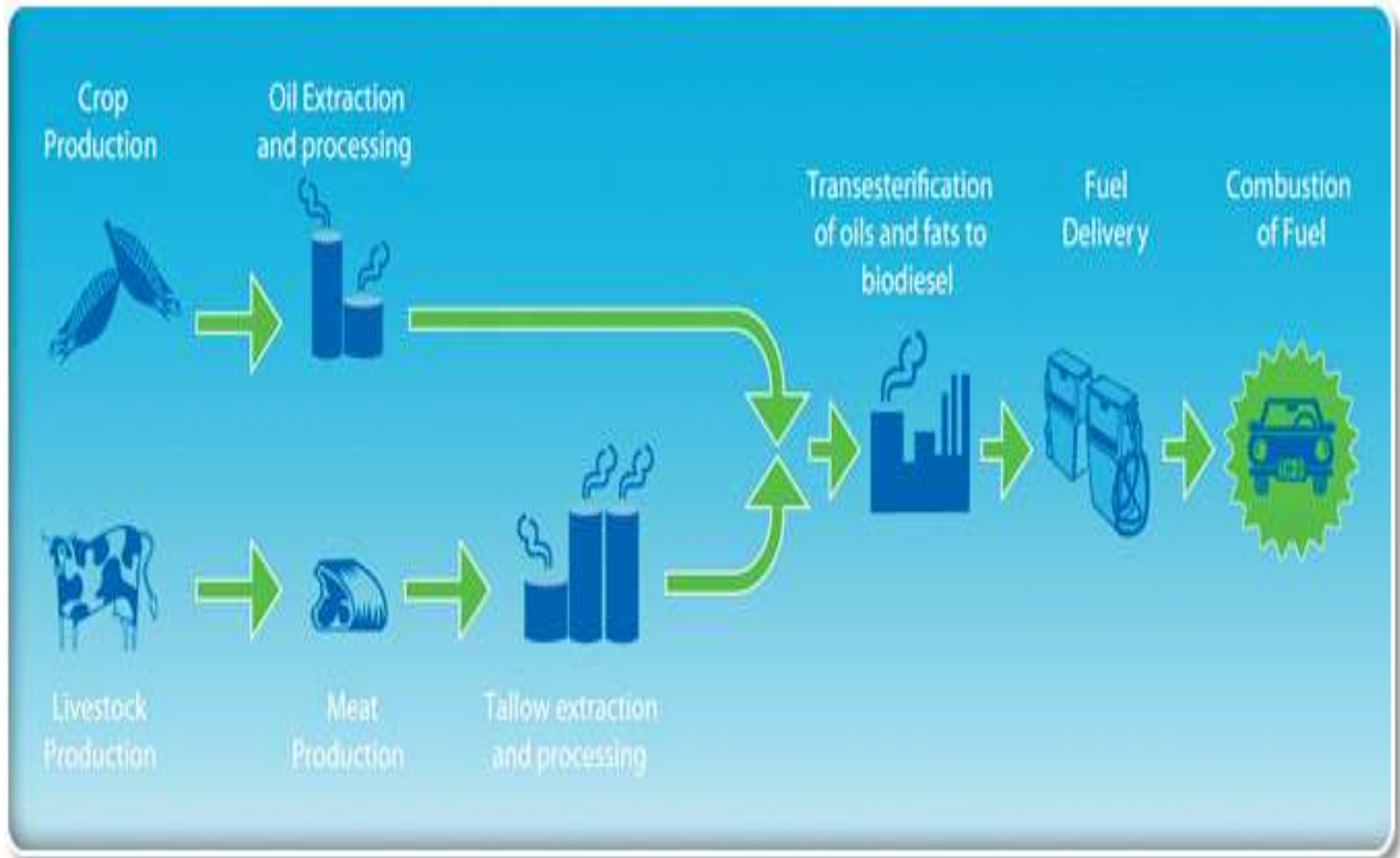
# BASIC TRANSESTERIFICATION PROCESS



# BIODIESEL PROCESS



# BIODIESEL LIFECYCLE

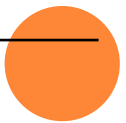


# PARAMETERS OF BIODIESEL AND PPO IN COMPARISON WITH FOSSIL DIESEL AND BTL (PAUL & KEMNITZ 2006)

	Density (Kg/l)	Viscosity (mm <sup>2</sup> /s)	Flash point (°C)	Caloric value (at 20 °C MJ/kg)	Caloric value (MJ/l)	Octane number (RON)	Fuel equivalence (l)
Diesel	0.84	5	80	42.7	35.87	50	1
Rapeseed oil	0.92	74	317	37.6	34.59	40	0.96
Biodiesel	0.88	7.5	120	37.1	32.65	56	0.91
BtL	0.76	4	88	43.9	33.45	>70	0.97

**BtL = Biomass to Liquid**

**PPO = Pure Plant Oil**



# BIODIESEL APPLICATIONS

- Biodiesel can be used in pure form (B100) or may be blended with petroleum diesel at any concentration in most modern diesel engines.
- B100 has energy content 5%-10% lower than typical petroleum diesel.
- Biodiesel has better lubricity than that of today's diesel fuels. Better combustion, reduce CO<sub>2</sub> emission
- Biodiesel can also be used as a heating fuel in domestic and commercial boilers





**Biodiesel fuelling**



**The bus run by biodiesel**



**Biodiesel generator**



**Portable biodiesel generator**



**Biodiesel power plant in USA**

# BIODIESEL IN LAO PDR



**Jatropha seeds**



**Vernicia Montana**



**Waste cooking oil**

# ADVANTAGES OF BIODIESEL

- Produced domestically. Thus, lessening our dependence on foreign oil.
- Not dangerous to the environment.
- It is both non-toxic and biodegradable.
- Contains virtually no sulfur and has an 80% lower carbon footprint compared to petroleum diesel
- Has a much higher cetane rating than petroleum diesel and improves engine performance when blended with petroleum diesel.
- Stimulates local economies through job creation in farming, transportation, and production.



# COMPARISON OF BIOETHANOL AND BIODIESEL

	Bioethanol	Biodiesel
Process	Dry mill method: yeast, sugars and starch are fermented . From starch, it is fermented into sugar, afterwards it is fermented again into alcohol	Transesterification: methyl esters and glycerin which are not good for engines, are left behind
Environmental benefit	<b>Both reduce greenhouse gas emissions as biofuels are primarily derived from crops which absorb carbon dioxide.</b>	
Compatibility	Ethanol has to be blended with fossil fuel like gasoline, hence only compatible with selected gasoline powered automobiles.	Able to run in any diesel generated engines
Costs	Cheaper	More expensive
Gallons per acre	420 gallons of ethanol can be generated per acre	60 gallons of biodiesel per acre soybeans. Cost of soybean oil would significantly increase if biodiesel production is increased as well.
Energy	Provides 93% more net energy per gallon	Produced only 25% more net energy
Greenhouse gas Emissions (GHGs)	12% less greenhouse gas emission that the production and combustion of regular diesel	41% less compared to conventional gasoline.



# REFERENCES

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