WEST POMERANIAN UNIVERSITY OF TECHNOLOGY, SZCZECIN,POLAND

WIMiM

THE FACULTY OF MECHANICAL ENGINEERING AND MECHATRONICS

Anna Majchrzycka

BIOFUELS AND BIOTECHNOLOGY I

HISTORY OF ENERGY CONSUMPTION

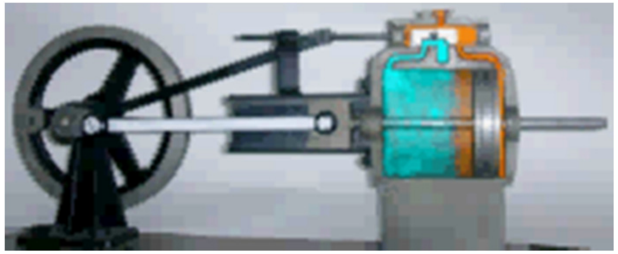
9-10 MJ/24 HOURS

20 MJ/24 HOURS

(3 TYS.YEARS B.CH)

50 MJ/24 HOURS

GronowiczGospodarka energetyczna w transporcie ladowym, Wyd.Politechniki Poznanńskiej 2006



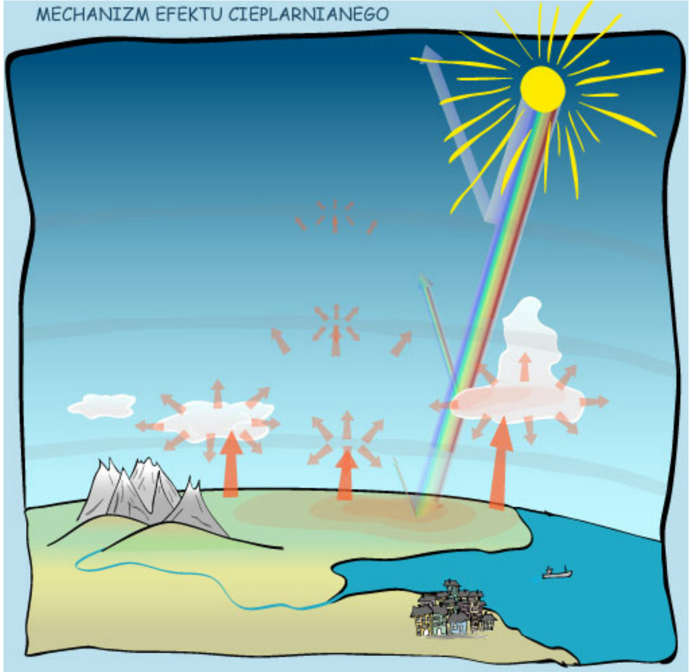
AFTER THE FIRST TECHNICAL REVOLUTION (END OF XVIII –TH CENTURY.)

200MJ/24 HOURS

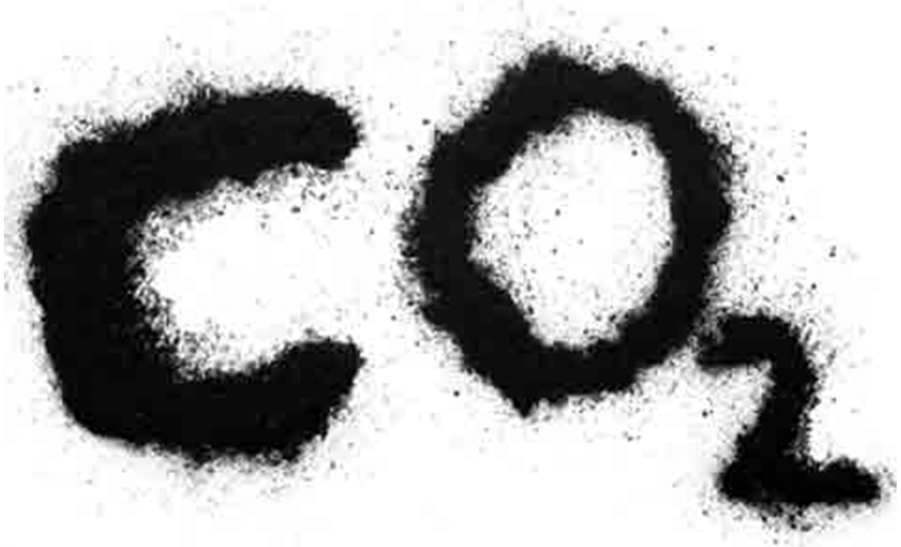
INDUSTRIAL COUNTRIES (XX W.)

300-1000 MJ/24 HOURS

GronowiczGospodarka energetyczna w transporcie ladowym, Wyd.Politechniki Poznanńskiej 2006



- **18% WORLD'S EMISSION** OF GREENHOUSE GASES COMES FROM INDUSTRIAL SWINE AND CATTLE FARMING.
- TO 2050 WORLD'S ANIMAL FARMNG WILL BE **TWICE GREATER** AS NOWADAYS.



Currently in the world over than 80 % energy is being produced from fossil fuels.

http://www.theecologist.org/siteimage/scale/800/600/108286.png

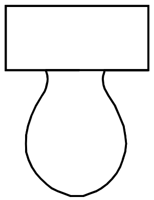
N=2000 W

10 min / 24H

5 kg CO_2 / DAY

166 kg CO_2 / MONTH

1 933 kg CO_2 / rok YEAR



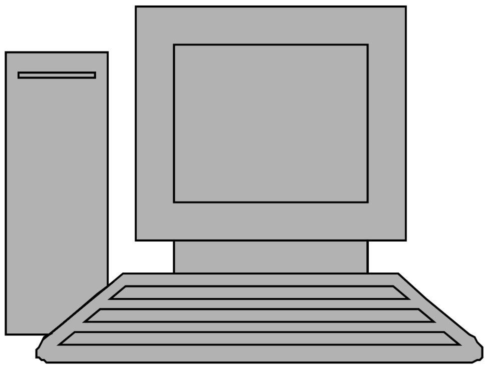
N=100 W

1H / 24H

3 kg CO_2 / DAY

93 kg CO_2 / MONTH

1 111 kg CO_2 / YEAR



N=300 W

1,5H / 24H

7 kg CO_2 / DAY

209 kg CO_2 / MONTH

2 511 kg CO_2 / YEAR

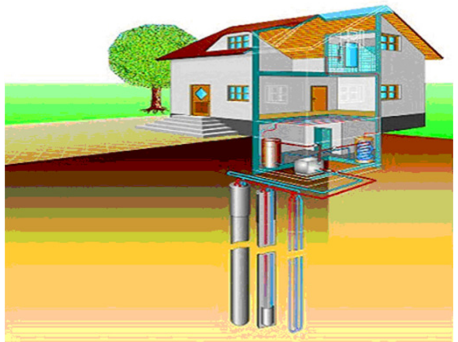
N= 1500 W

0,5 H/24H

7 kg CO_2 /DAY

226 kg CO_2 /MONTH

2 717 kg CO_2 /YEAR



N=3000 W

5h/24h

50 kg CO_2 / DAY

1524 kg CO_2 / MONTH

18 287 kg CO_2 /YEAR

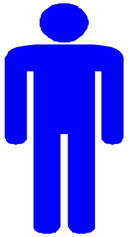
N=6000W

5h/24h

35 kg CO_2 / DAY

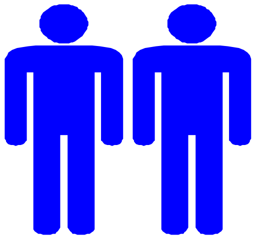
1067 kg CO_2 / MONTH

12 809 kg CO_2 / YEAR



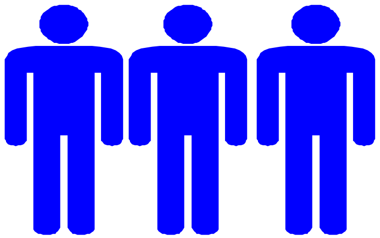
1 PERSON – 1 050 KWh

Emission CO_2 1101,0 kg – absorbed by132 spruces



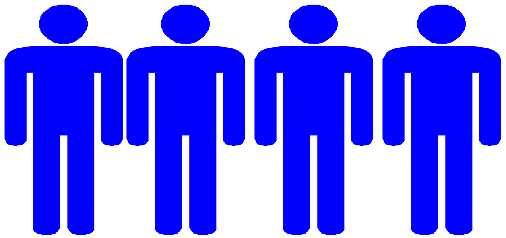
2 PERSONS -1300 KWh

Emission CO_2 1332,0 kg – absorbed by 159 spruces



3 PERSONS 1 600 KWh

Emission CO_2 1553,6kg – absorbed by132 184 spruces



4 PERSONS 1 900 KWh

Emission CO_2 1865,6kg– absorbed by132 224 spruces

Annual consumption of electriciy without heating and preparation of warm water !!!!!!!

Ecological Footprint

•is a measure of human demand on the Earth's ecosystems.

•is a standard measurement of a unit’s influence on its habitat based on consumption and pollution

•it compares human demand with planet Earth's ecological capacity to regenerate.

• it represents the amount of biologically productive land and sea area needed to regenerate the resources a human population consumes and to absorb and render harmless the corresponding waste.

Using this assessment, it is possible to estimate how much of the Earth (or how many planet Earths) it would take to support humanity if everybody lived a given lifestyle.

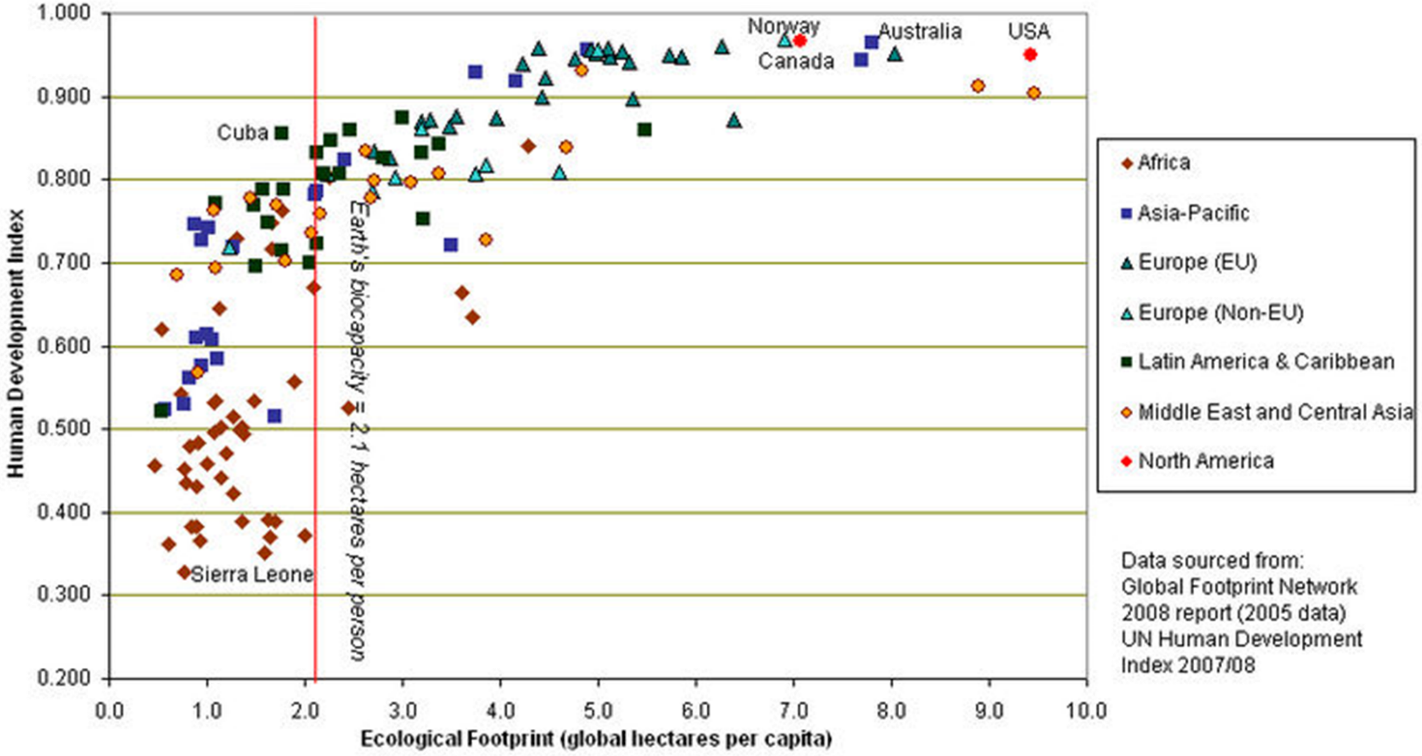
Mean ecological footprint:

EU COUNTRIES 4,5 gha/ capita,

POLAND - 3,9 gha/capita (20 in EU)

- **HDI** (Human Development Index).
- determines level of life**:** income /capita, level odf education, length of life .
- is a composite statistic used to rank countries by level of "human development" and separate "very high human development", "high human development", "medium human development", and "low human development" countries.
- in POLAND **HDI = 0,86.**
- sustainable development is possible if countries will fulfill pararelly two critria : ecological footprint < 1,8 gha/capita and **HDI> 0,8.**

Human Welfare and Ecological Footprints compared



http://upload.wikimedia.org/wikipedia/commons/b/be/%C5%9Alad_ekologiczny_a_wska%C5%BAnik_rozwoju.JPG

Carbon footprint

is "the total set of greenhouse gas (GHG) emissions caused by an organization, event, product or person”.

Greenhouse gases can be emitted through transport, land clearance, and the production and consumption of food, fuels, manufactured goods, materials, wood, roads, buildings, and services.

For simplicity of reporting, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted.

Efectt of 1 t CH_4 = 25 t of CO_2.

- **ACCORDING TO KYOTO PROTOCOL**

  in 2008-2012 Poland is obligated to reduce greenhouse gases of 6% emissions compared to 1988.

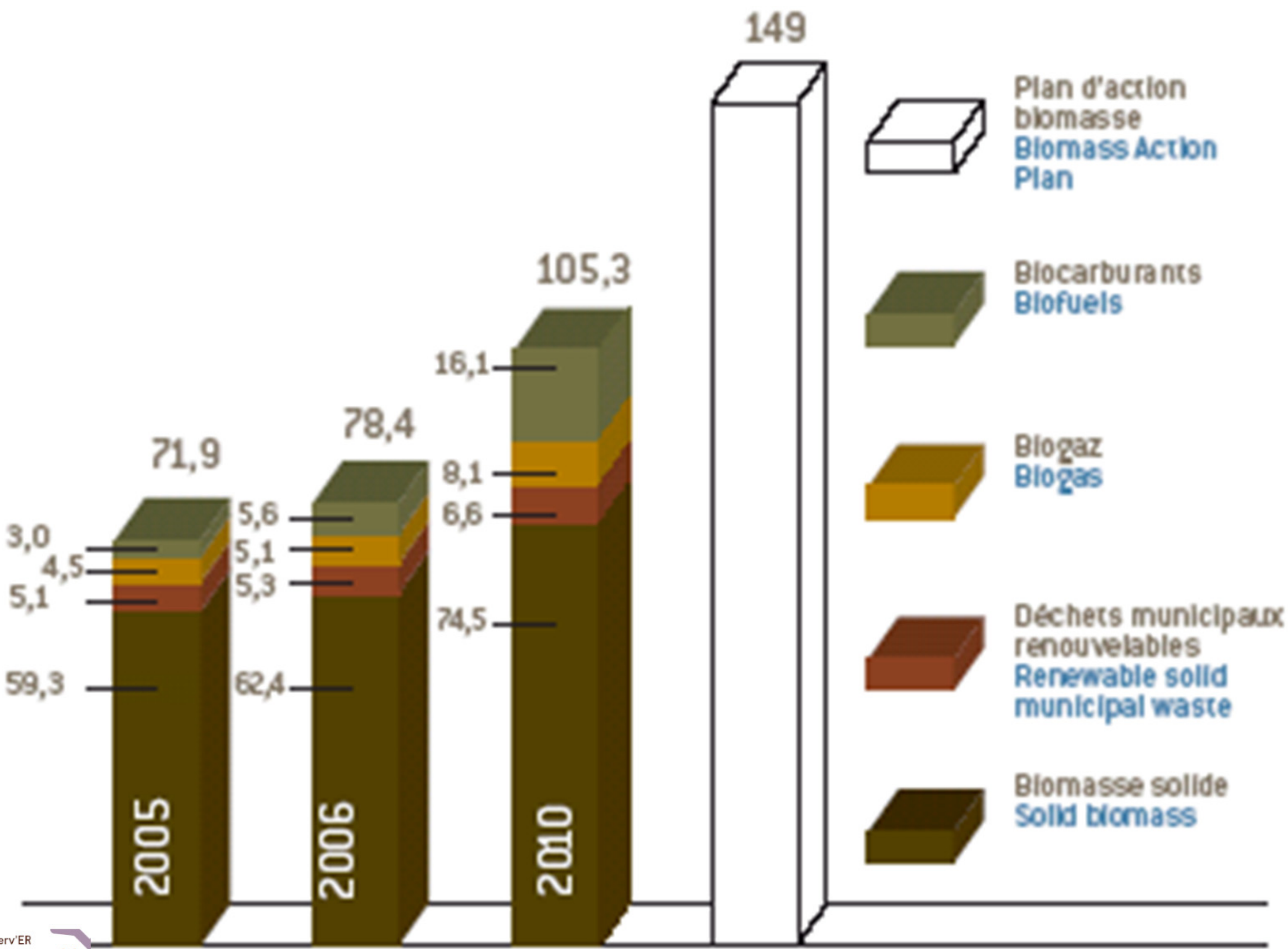
- **ACCORDING TO UE DIRECTIVE 2001 / 77 / WE**

  by 2020 energy produced in Poland from renewable sources of energy is to be 15% of total energy consumption.

5 Comparaison de la tendance actuelle avec le scénario du Plan d'action biomasse (en Mtep).

Comparison of the current trend with the Biomass Action Plan scenario (in Mtoe).

Source EurObserv'ER



Data of total area and areas of interest for biomass production for each member of EU-27; area data in millions of hectares

	Total area (10^6 Ha)	Agricultural area (10^6 Ha)	Arable land (10^6 Ha) (% of total area)		Hectares of agricultural land per capita
Austria	8.4	3.4	1.4	17	0.42
Belgium	3.1	1.4	0.8	27	0.13
Bulgaria	11.1	5.3	3.3	30	0.68
Cyprus	0.9	0.1	0.1	11	0.18
Czech Republic	7.9	4.3	3.1	39	0.42
Denmark	4.3	2.7	2.3	53	0.49
Estonia	4.5	0.8	0.5	12	0.63
Finland	33.8	2.2	2.2	7	0.43
France	55.2	29.7	18.5	33	0.49
Germany	35.7	17.0	11.8	33	0.21
Greece	13.2	8.4	2.7	20	0.77
Hungary	9.3	5.9	4.6	50	0.60
Ireland	7.0	4.4	1.2	17	1.09
Italy	30.1	15.1	8.0	26	0.26

Jens Bo Holm-Nielsen ,P.Oleskowicz-Popiel: The future of biogas in Europe:visions and targets 2020.

Data of total area and areas of interest for biomass production for each member of EU-27; area data in millions of hectares

	Total area (10^6 Ha)	Agricultural area (10^6 Ha)	Arable land (10^6 Ha) (% of total area)		Hectares of agricultural land per capita
Latvia	6.5	2.5	1.8	28	1.08
Lithuania	6.5	3.5	2.9	45	1.02
Luxemburg	0.3	0.1	0.06	24	0.28
Malta	0.03	0.01	0.01	31	0.03
Netherlands	4.2	1.9	0.9	22	0.12
Poland	31.3	16.2	12.6	40	0.42
Portugal	9.2	3.7	1.6	17	0.37
Romania	23.8	14.7	9.4	39	0.66
Slovakia	4.9	2.4	1.4	29	0.45
Slovenia	2.0	0.5	0.2	9	0.26
Spain	50.5	30.2	13.7	27	0.73
Sweden	45.0	3.2	2.7	6	0.36
U. K.	24.4	17.0	5.7	23	0.28
EU-27	**433.1**	**196.6**	113.5	26	**0.41**

Jens Bo Holm-Nielsen ,P.Oleskowicz-Popiel: The future of biogas in Europe:visions and targets 2020.

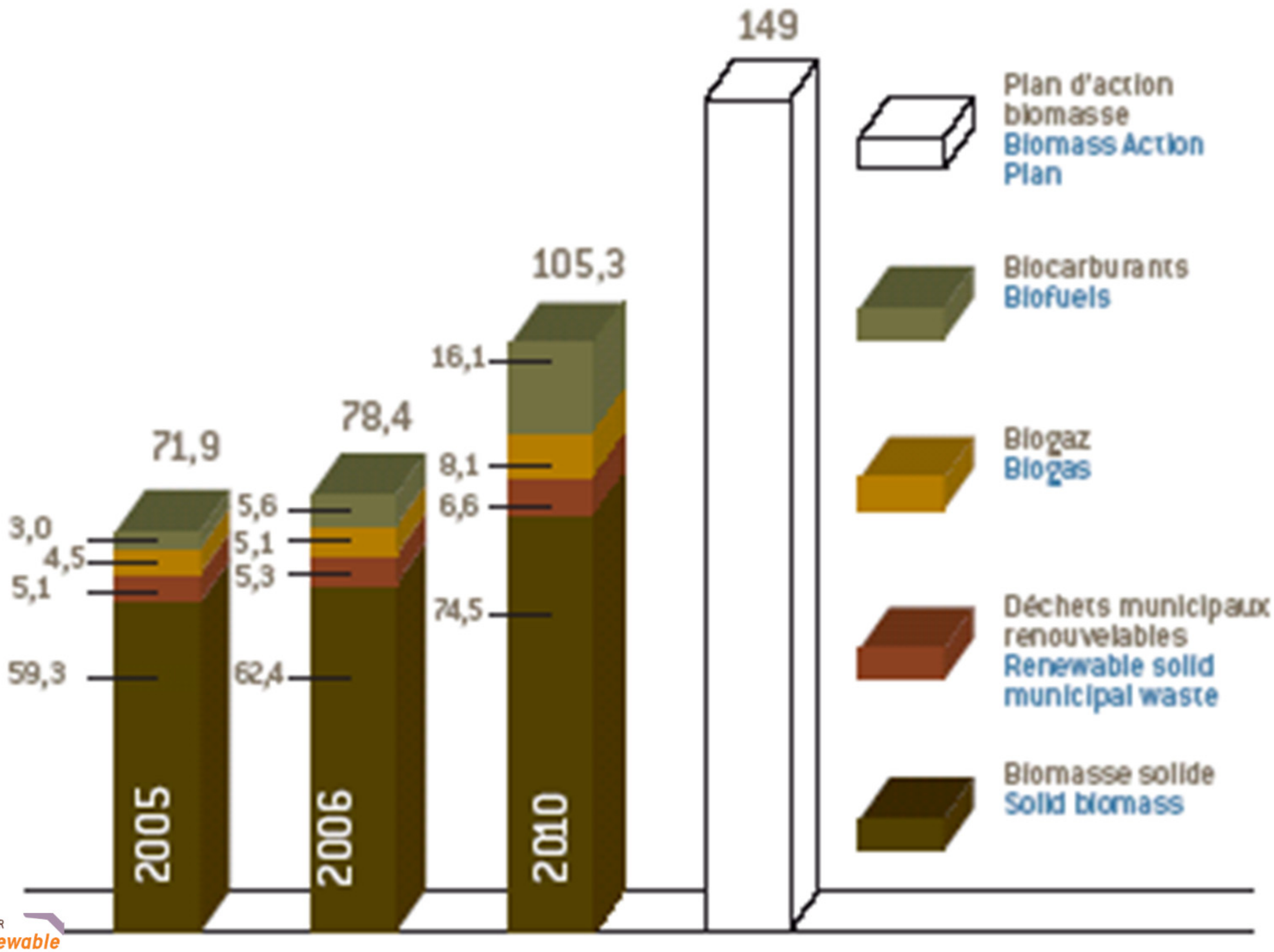
Methane potential originated from energy crops from 5% of the arable land in EU-27 with the cropping yield equal to 10, 20, and 30 tTS/ha

Energy crop yield	10 tTS/ha	**20 tTS/ha**	30 tTS/ha
Methane potential	**25.3 billion m^3CH_4**	**50.7 billion m^3CH_4**	**76.0 billion m^3CH_4**
	22.8 Mtoe	**45.5 Mtoe**	**68.5 Mtoe**

5 Comparaison de la tendance actuelle avec le scénario du Plan d'action biomasse (en Mtep).

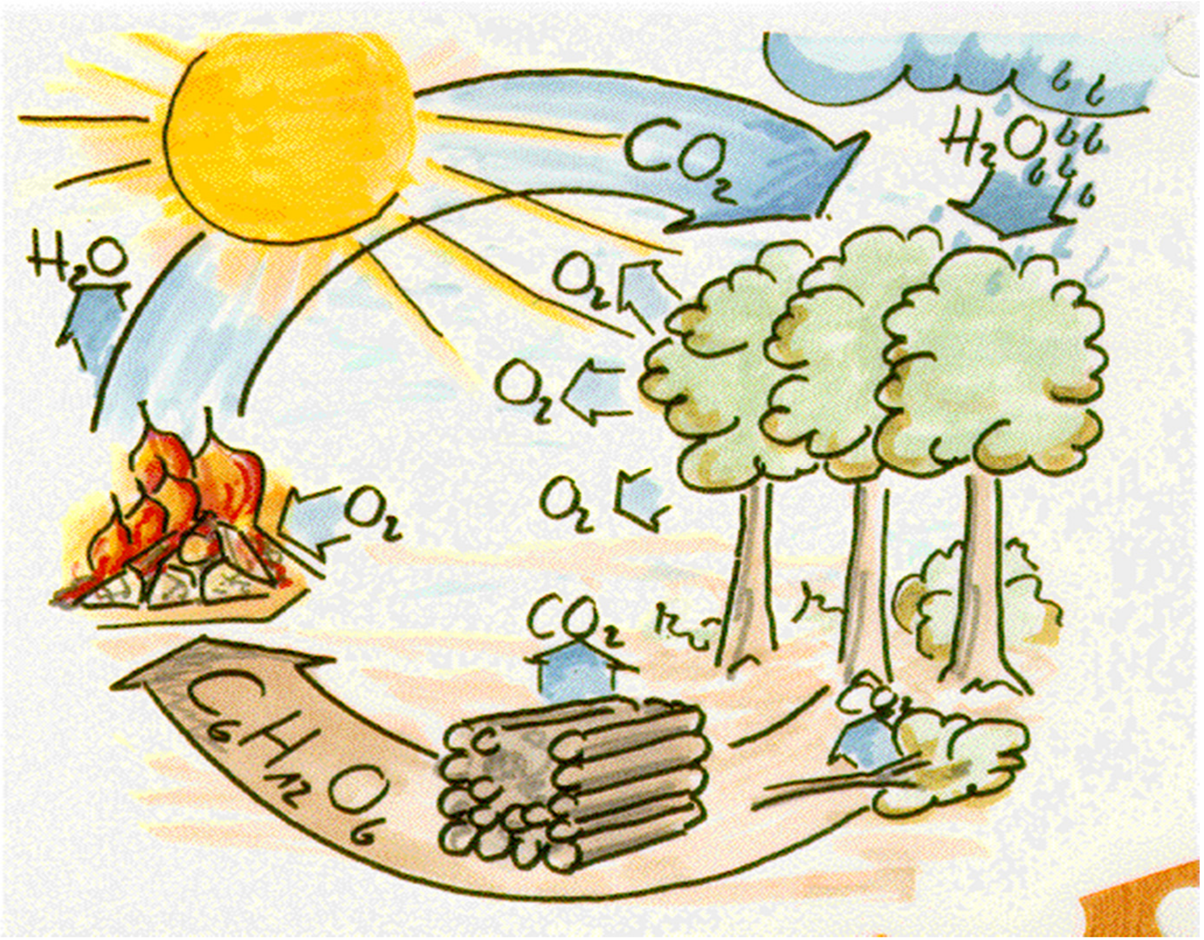
Comparison of the current trend with the Biomass Action Plan scenario (in Mtoe).

Source EurObserv'ER 2007.



THE MOTIVATION FOR USING BIOMASS & BIOFUELS

- REDUCING DEPENDENCE ON IMPORTED OIL,
- MAKING NON-FOSSIL FUEL (RES) AVAILABLE,
- REDUCING AIR POLLUTION AND GREENHOUSE GAS EMISSIONS AND MAINTAINING AGRICULTURAL LAND IN PRODUCTION,
- INCREASING DEMAND FOR DOMESTIC AGRICULTURAL PRODUCTS, MAINTAINING RURAL EMPLOYMENT, ETC.

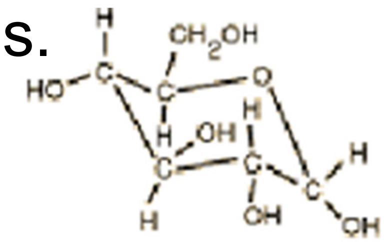


BIOMASS

Biomass is any living or recently dead material that can be used as fuel.

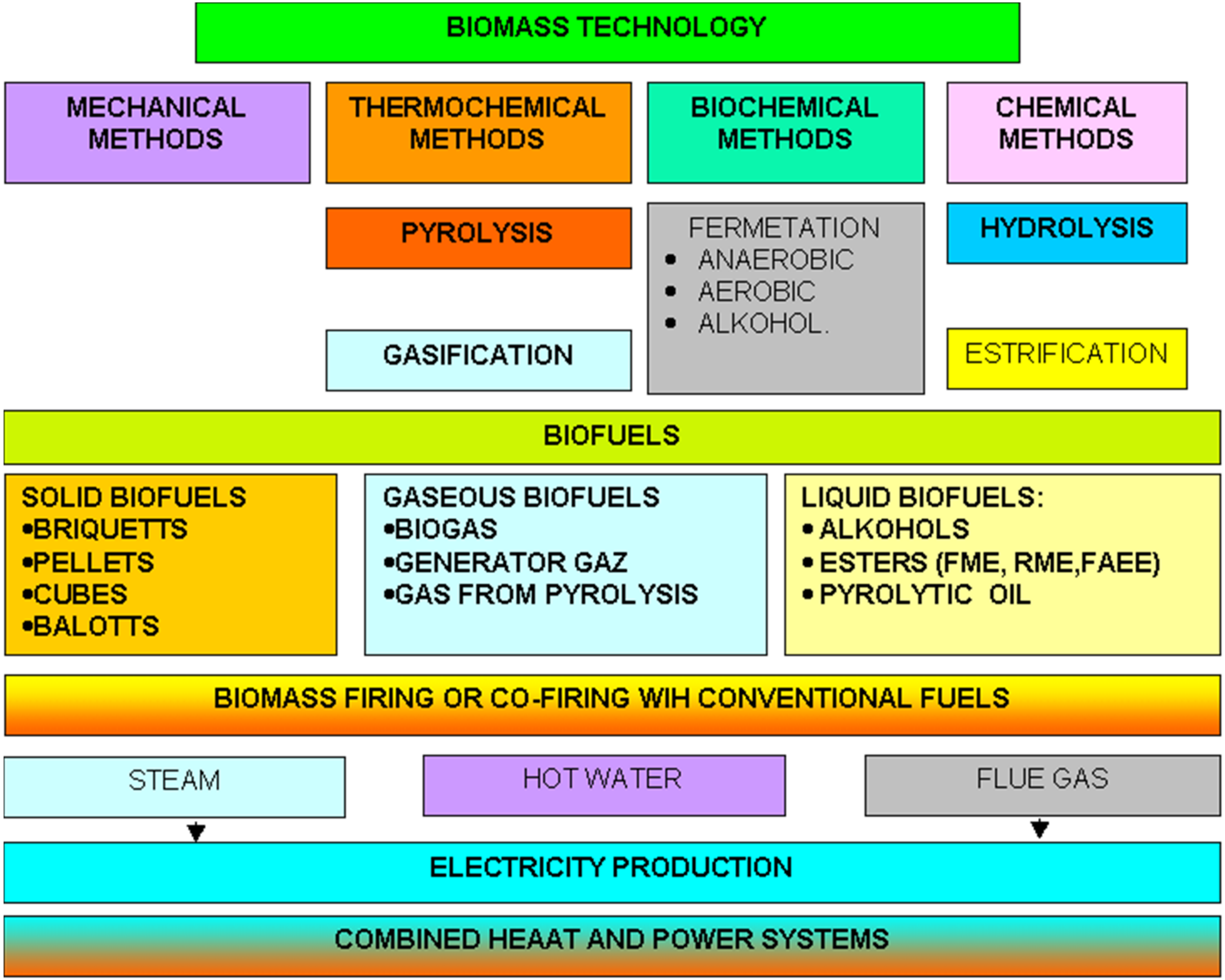
Biomass is

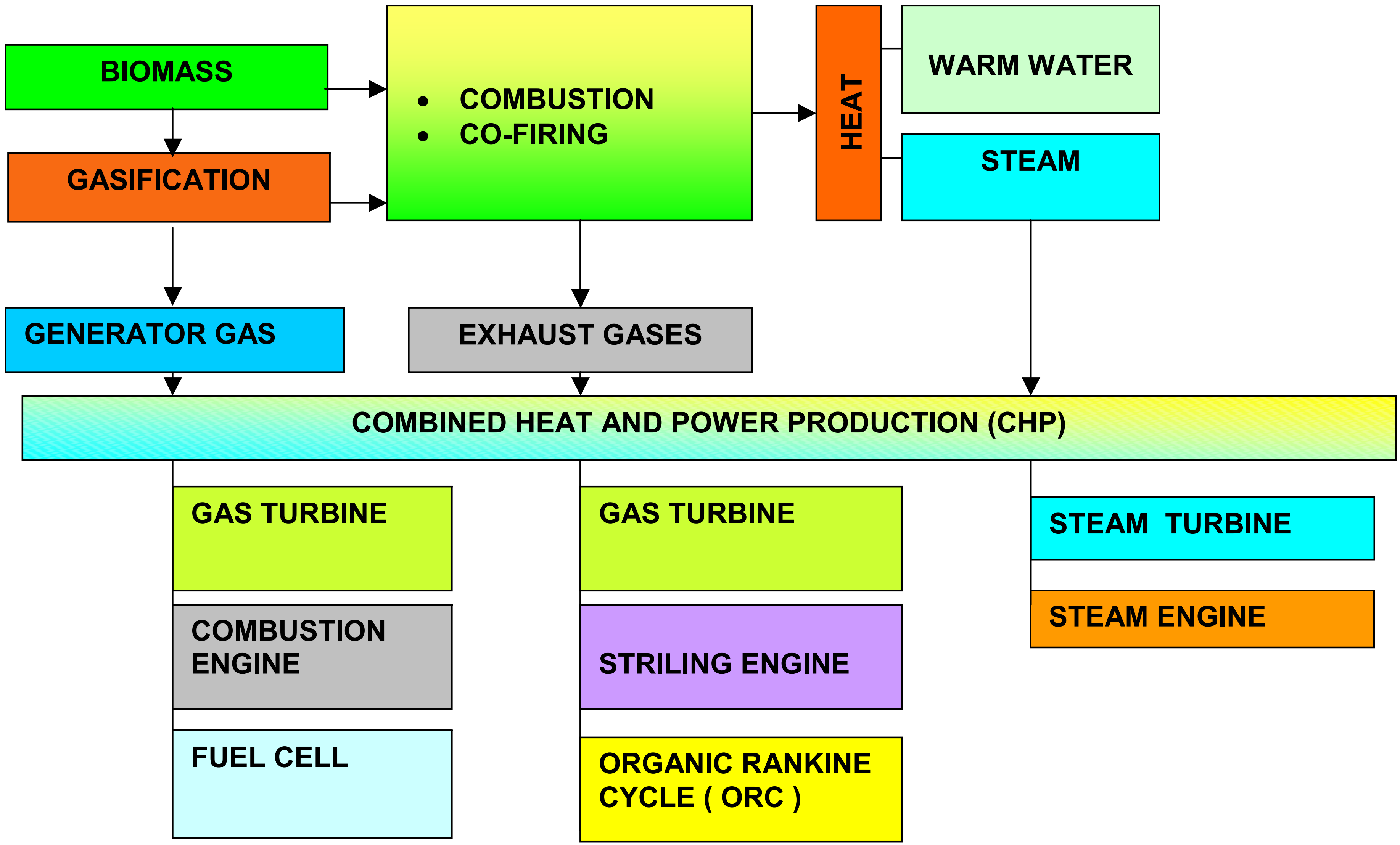
- a carbon dioxide neutral (?) fuel (CO_2 released into the atmosphere when burnt is assimilated by plants) ,
- a cheap fuel to produce,
- a lot of biomass is free, in the different froms,
- can be converted to the other forms of fuels.



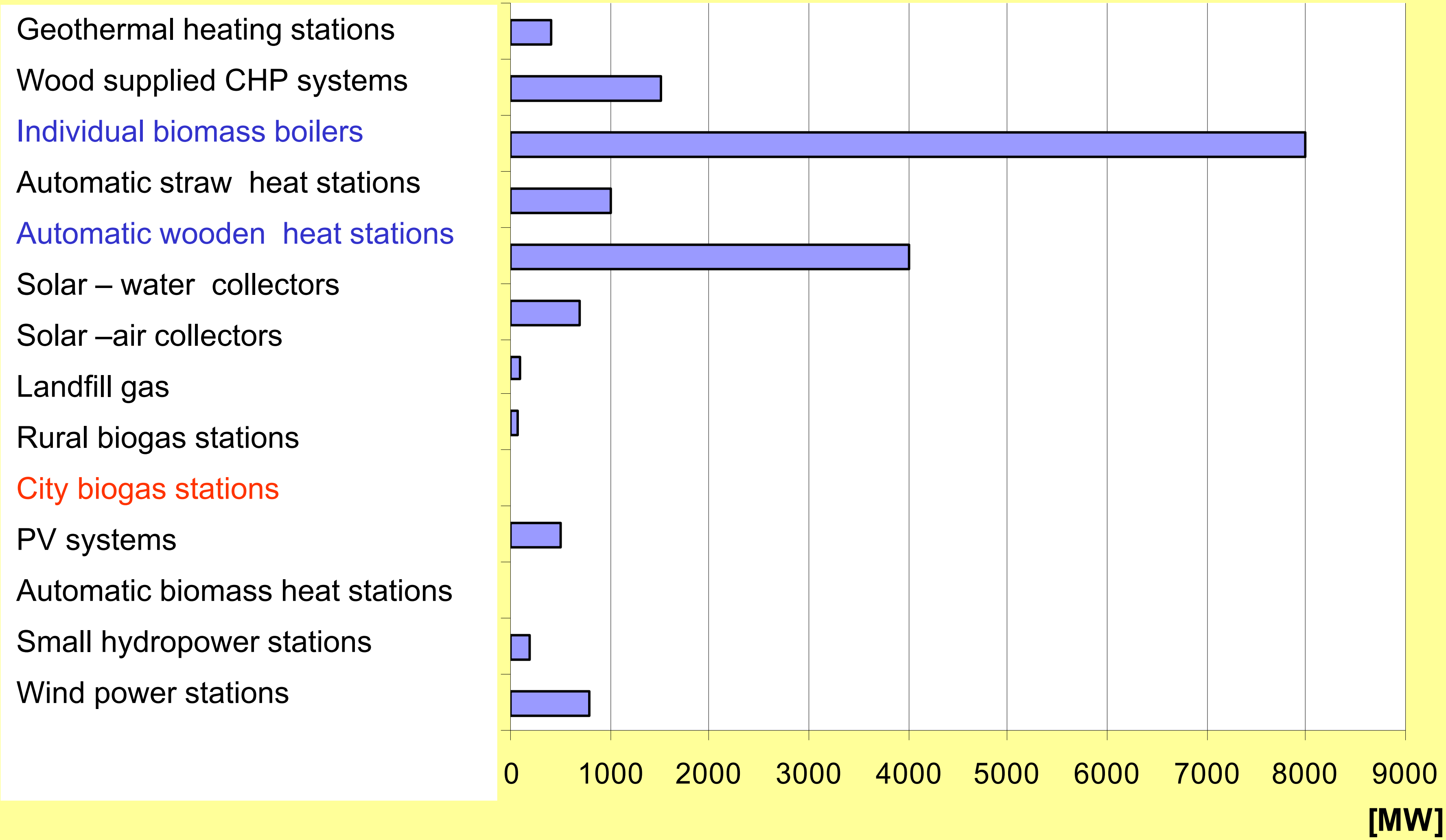
Glucose

$$6\,CO_2 + 6\,H_2O \rightarrow (CH_2O)_6 + 6\,O_2$$


BIOMASS TECHNOLOGY
MECHANICAL METHODS
THERMOCHEMICAL METHODS
BIOCHEMICAL METHODS
CHEMICAL METHODS
PYROLYSIS
GASIFICATION
FERMETATION
• ANAEROBIC
• AEROBIC
• ALKOHOL.
HYDROLYSIS
ESTRIFICATION
BIOFUELS
SOLID BIOFUELS
•BRIQUETTS
•PELLETS
•CUBES
•BALOTTS
GASEOUS BIOFUELS
•BIOGAS
•GENERATOR GAZ
•GAS FROM PYROLYSIS
LIQUID BIOFUELS:
• ALKOHOLS
• ESTERS (FME, RME,FAEE)
• PYROLYTIC OIL
BIOMASS FIRING OR CO-FIRING WIH CONVENTIONAL FUELS
STEAM
HOT WATER
FLUE GAS
ELECTRICITY PRODUCTION
COMBINED HEAAT AND POWER SYSTEMS


BIOMASS
GASIFICATION
COMBUSTION
CO-FIRING
HEAT
WARM WATER
STEAM
GENERATOR GAS
EXHAUST GASES
COMBINED HEAT AND POWER PRODUCTION (CHP)
GAS TURBINE
COMBUSTION ENGINE
FUEL CELL
GAS TURBINE
STRILING ENGINE
ORGANIC RANKINE CYCLE (ORC)
STEAM TURBINE
STEAM ENGINE

R.E.S. STRUCTURE OBJECTIVES TILL 2010 FOR POLAND



h_kruczek –biomasa[1].ppt

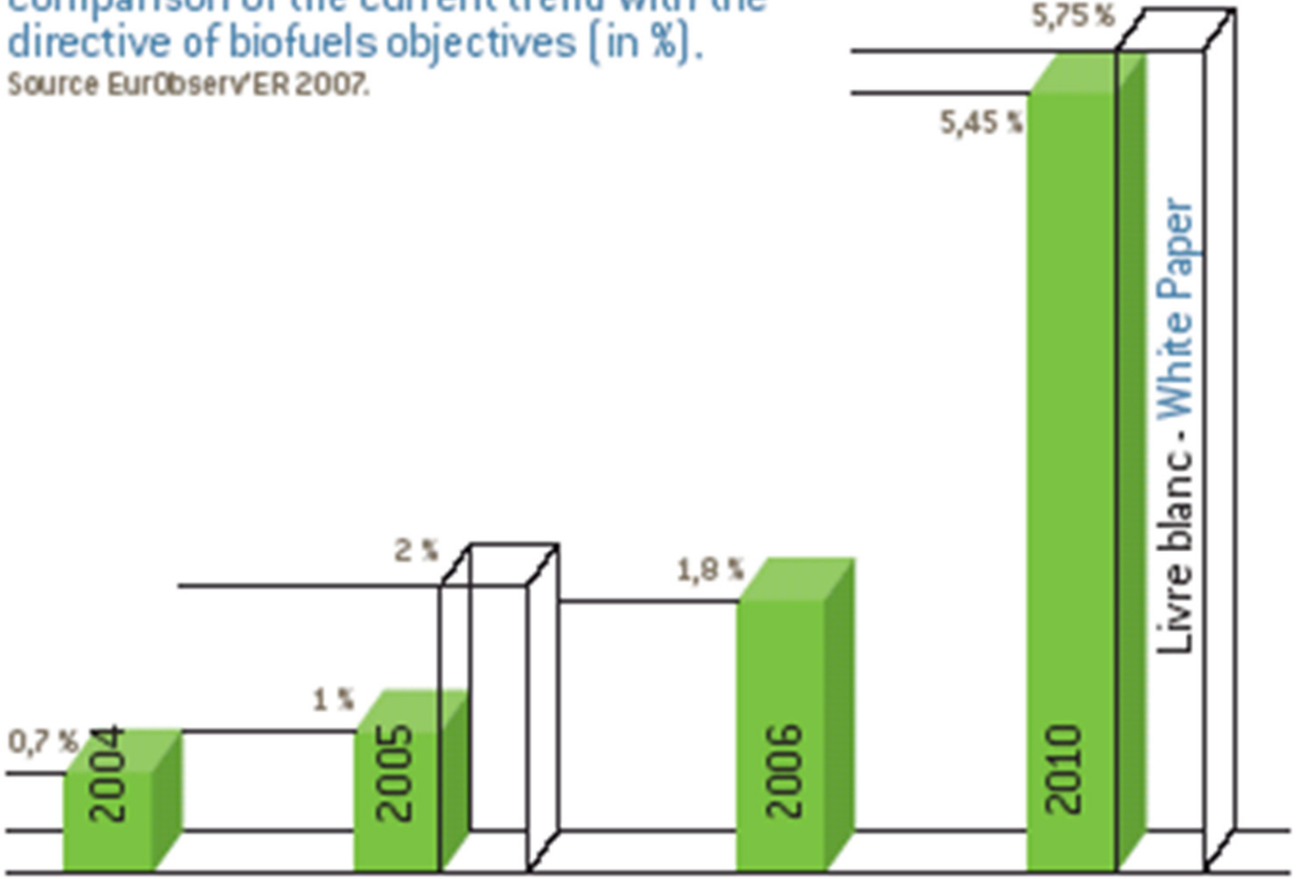
LIQUID BIOFUELS

BIOFUELS

3 Comparaison de la tendance actuelle avec les objectifs de la directive sur les biocarburants (en %).

Comparison of the current trend with the directive of biofuels objectives (in %).

Source EurObserv'ER 2007.



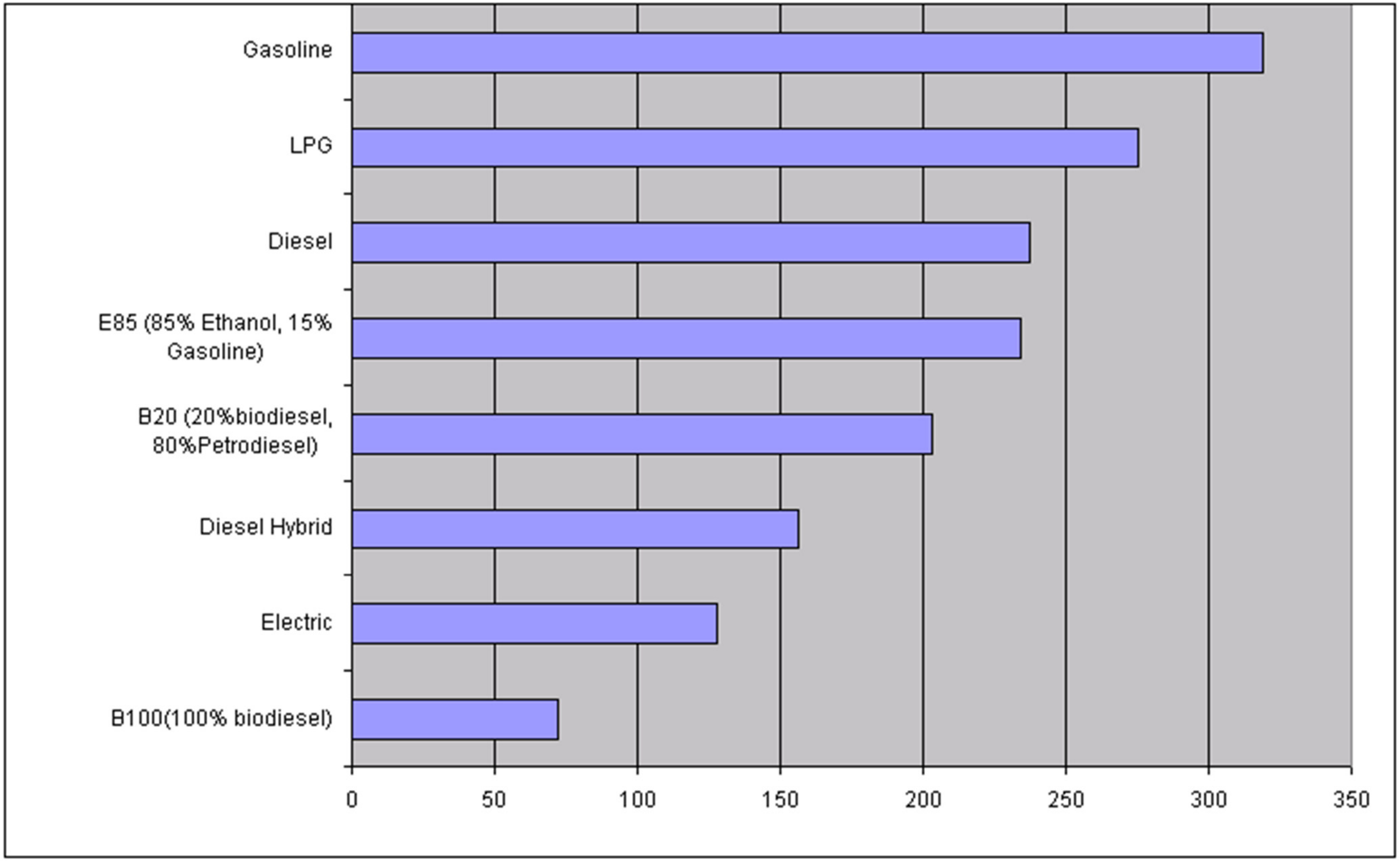
7e report EurObserv'ER
State of Renewable Energies in Europe

R. Diesel

In any case, they make it certain that motor-power can still be produced from the heat of the sun, which is always available for agricultural purposes,even when all our natural stores of solid and liquid fuels are exhausted.

Gerhard Knothe of the U.S. Department of Agriculture's National Center for Agricultural Utilization Research in Peoria, Illinois- Historical perspectives on vegetable oil-based diesel fuels, Volume 12 • November 2001 • inform

Grams CO_2 Equivalent / Km



http://www.biofuel.be/whatisbiodiesel.html

- **PURE VEGETABLE OIL (PURE PLANT OIL , PPO)**

Production of vegetable oils for use as fuels is theoretically limited only by the agricultural capacity of a given economy.

- **WASTE VEGETABLE OIL**

Waste vegetable oil, as byproducts from industrial deep fryers in potato processing plants,snack food factories and fast food restaurants.

- **ANIMAL FAT**

Waste industrial animal fat, fatty byproducts etc.

Table 3 Gross energy potential of oil-producing crops[4]

Fuel	*Heating value* (MJ/kg)	*Approximate oil yield* (T/ha)
Sunflower oil	35.3	0.88 to 1.67
Rape oil	37.2	1.26
Linseed oil	36.9	
Palm oil		7.8
Olive oil		0.4 to 5.0
Diesel fuel	38.4	

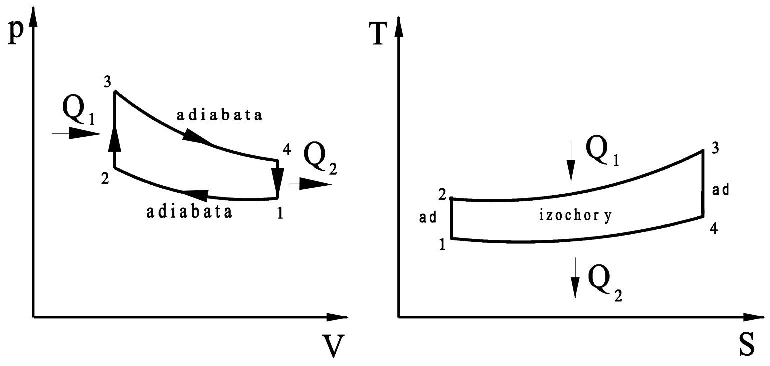
Source :

Landfill Gas and Related Energy Sources: Anaerobic Digestion; Biomass Energy Systems

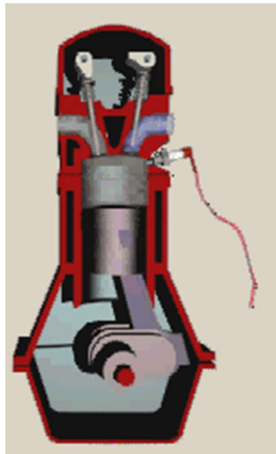
ADRIAN LOENING

- **GASOLINE,**
- **ALCOHOLS,**
- **ETHERS,**
- **GASOLINE + ALCOHOLS**
- **GASOLINE + ETHER**
- **BIOGAS**

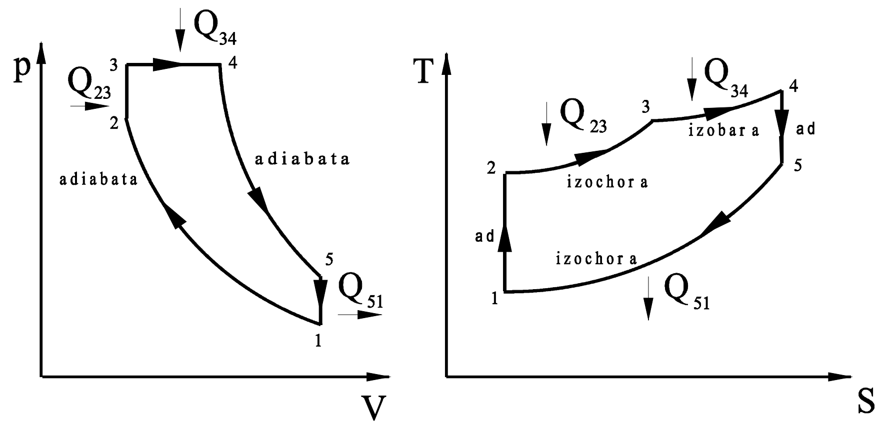
SPARK IGNITION ENGINES



Otto cycle

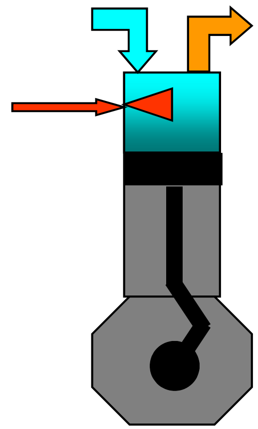


- OIL
- FAME
- FAEE
- RME
- RME + OIL
- RME+ ALCOHOL
- DME
- METHYL ALCOHOL
- ETHYL ALCOHOL
- BIOGAS



Sabathe cycle

DIESEL ENGINES



OXYGEN ORGANIC COMPOUNDS

$A_LCO^HOL_s$

$_And$

$eThER_s$

ALCOHOLS (R-OH)

- ~~methanol CH_3OH,~~
- ethanol C_2H_5OH,
- izopropanol C_3H_7OH,
- butanol $C_2H_5CH(OH)CH_3$,
- izobuthanol $(CH_3)_2CHCH_2OH$,
- tertbutanol $(CH_3)_3COH$

Ethers (R-O-R) , where C>5:

- Methyl tertiary butyl ether **(MTBE)** -$CH_3OC(CH_3)_3$,
- Ethyl tertiary buthyl ether **(ETBE)** - $C_2H_5OC(CH_3)_3$,
- methyltertamyl ether **(TAME)-** $CH_3OC(C_2H5)(CH_3)_2$,
- ethylterthamyl ether **(TAEE)-** $C_2H_5OC(C_2H)_5(CH_3)_2$,
- diizoprophyl ether **(DIPE)** - $(CH_3)_2CHOC(CH_3)_3$.

ETHANOL & METHANOL CAN BE PRODUCED FROM CARBOHYDRATES: SUGAR, STARCH , CELLULOSE BY FERMENTATION USING YEAST OR OTHER ORGANISMS.

ETHANOL AND METHANOL CAN BE USED AS A GASOLINE EXTENDER OR SUBSTITUTE .

ALCOHOLS ARE FEEDSTOCKS TO MAKE GASOLINE ADDITIVES:

- ETHANOL FOR ETHYL TERTIARY BUTYL ETHER (ETBE),
- METHANOL IS FEEDSTOCK TO MAKE METHYL TERTIARY BUTYL ETHER (MTBE),

- CROP PRODUCTION, TRANSPORT , RECEPTION AND STORAGE,

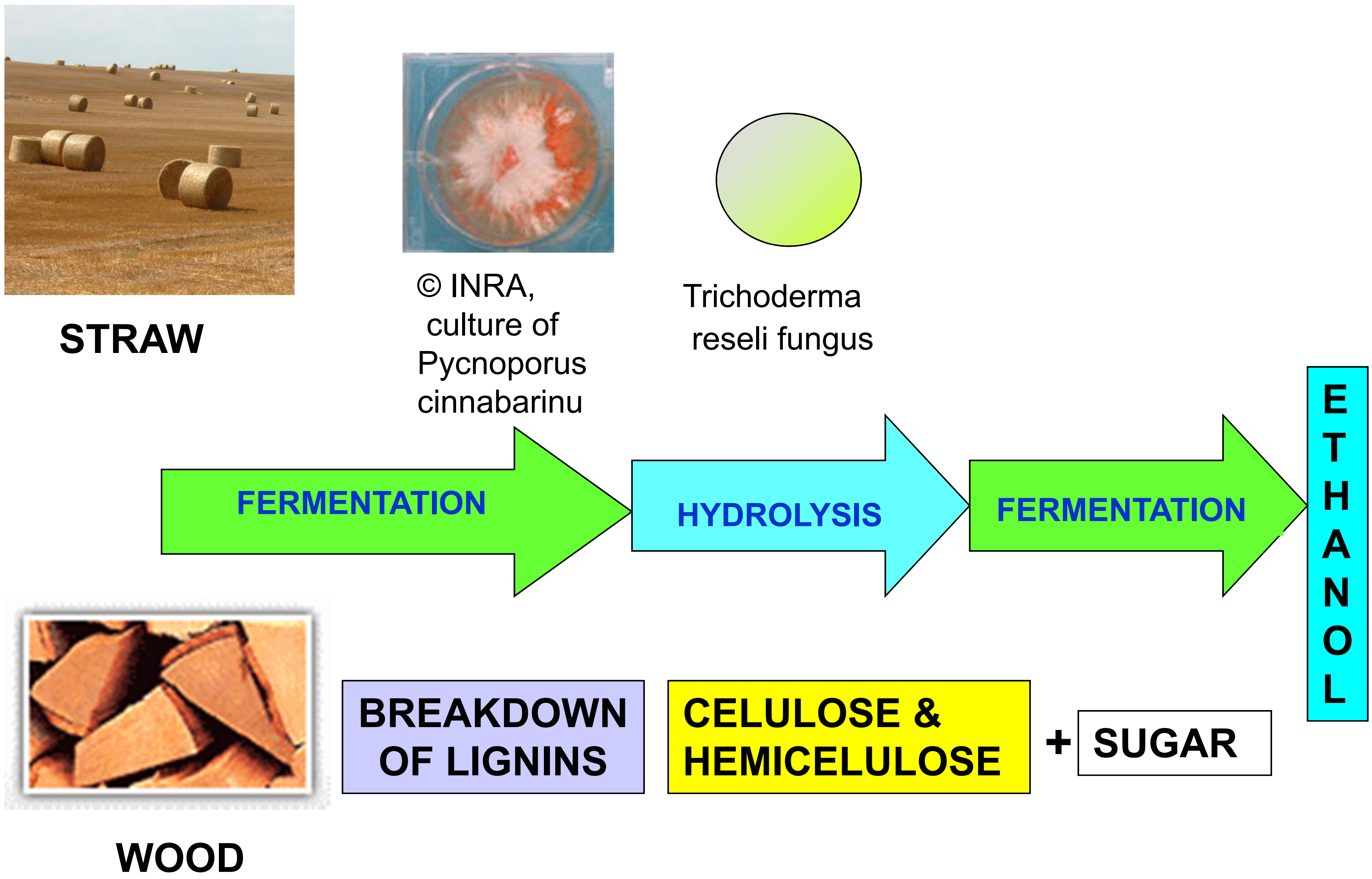
- PREPEARATION TO PRODUCE FERMENTABLE SUGAR (PHYSICAL PRETREATMENT: MILLING, CHEMICAL TREATMENT –HYDROLYSIS OF STRACH AND CELLULOSE,

- DILUTION OF THE SUGARS WITH WATER AND ADDITION OF YEAST OR OTHER ORGANISMS,

- FERMENTATION TO PRODUCE ETHANOL IN SOLUTION ,

- DISTILLATION AND DEHYDRATION TO SEPARATE THE EHTANOL ,

- WASTE DISPOSAL / BY-PRODUCT PREPARATION


STRAW
© INRA,
culture of
Pycnoporus
cinnabarinu
Trichoderma
reseli fungus
FERMENTATION
HYDROLYSIS
FERMENTATION
ETHANOL
BREAKDOWN OF LIGNINS
CELULOSE & HEMICELULOSE
+ SUGAR
WOOD

PROPERTIES OF THE OXYGEN COMPOUNDS

Oxygen compound	FORMULA	Density t=15°C kg/m^3	RON	MON	V.P (Reid's method), kPa	T boiling poimt, °C	T freezing point, °C	Q_i MJ/kg	O_2 % m	Solubitiy in water, % m	C/H	Heat of evaporation, kJ/kg
Methyl alcohol	CH,OH	795,6	107	91	32	64,7	-97,7	19,9	49,93	∞	1/4	1100
Ethyl alcohol	C_2H_5OH	793,2	108	92	16	78,3	-114,1	26,8	34,73	∞	1/3	910
Isoproyl alcohol (IPA)	C_3H_7OH	788,5	118,0	102	14	82,3	-87,8	29,9	26,63	∞	1/2,76	700
Butyl alcohol II	$C_2H_5CH(OH)CH_3$	811,9			6	100,0	-114,0	33,8	21,59	∞	1/2,5	
Butyl alcohol (IBA)	$(CH_3),CHCH_2OH$	809,6	110	90	4	108,7	-88,5	32,4	21,59	10,0	1/2,5	680
Tertbutyl alcohol (TBA)	$(CH_3)_3COH$	792,6	109	93	7	82,8	+25,6	33,8	21,59	∞	1/2,5	544
Methylotert-butyl ether (MTBE)	$(CH,)OC(CH_3),$	743,0	116	101	54	55,0	-109,8	35,1	18,15	4,8	1/2,4	337
Ethylotert-butyl ether (ETBE)	$C,H_5OC(CH_3),$	750,0	118	102	28	72,0		36,7	15,66	1,2	1/2,33	321
Disopropyl ether (DIPE)	$(CH_3)_2CHOC(CH_3)_3$	733,0	110	100	24	68,0		36,4	15,66	2,0	1/2,33	410
Tertamylobutyl (TAME)	$CH_3OC(C_2H_5)(CH,)_2$	770,0	111	98	16	85,0		37,9	15,66	2,0	1/2,33	410
Eter izopropylo-tertbutylowy (PTBE)	$(CH_3),CHOC(CH_3)_3$	757,0			20	88,5		37,5	13,77	0	1/2,28	410
Dimethyl carbonate (DMC)	$CO(OCH_3),$	1082,0	(LOB + LOM)/2 = = 104		11	90,2	4,0		53,30		1/2	410
Gasoline Super EN228	C4 - C12	720...775	min. 95	min. 85	45...105	25...215	<-40	<-41,0	O...2/7	0		350...380

ENERGY USE IN PROCESSING FROM BELOW 10

TO ABOVE 20 MJ / LITRE ETHANOL PRODUCED

PURE CO_2 IS PRODUCED AT A RATE OF ROUGHLY

1 KG CO_2/ LITRE ETHANOL PRODUCED

BIOFUELS FROM OILSEEDS

1900 - the first known use of vegetable oil as fuel

1912 - Rudolf Diesel investigated using vegetable oil to fuel engines of his design.

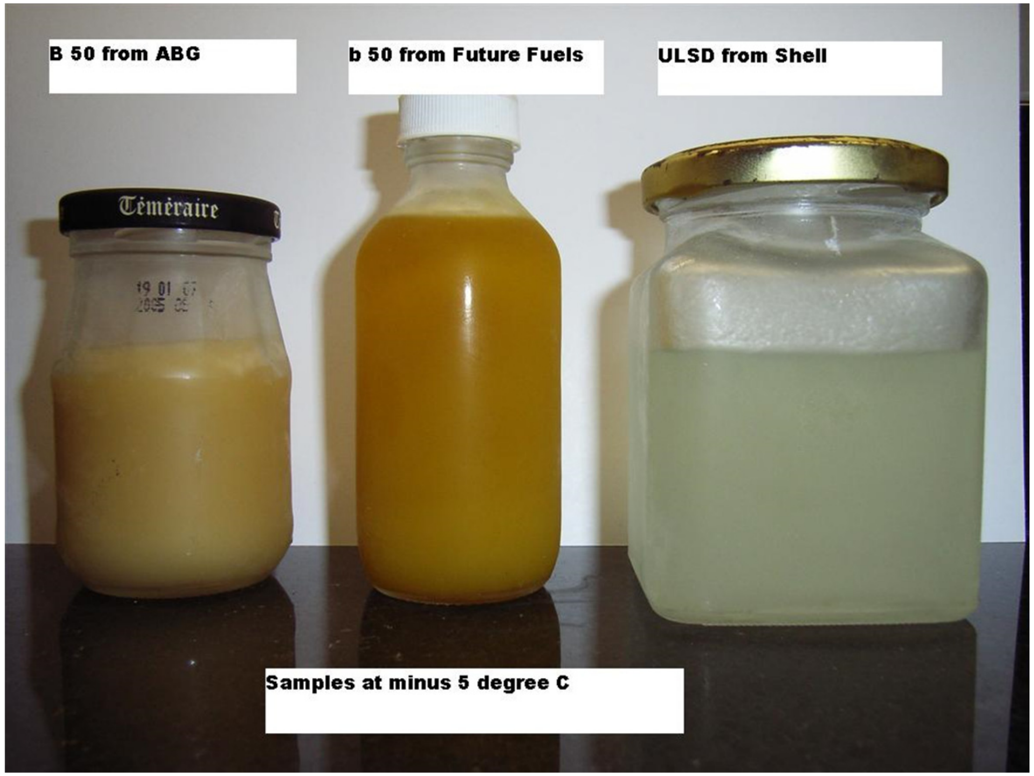
R.Diesel

"The fact that fat oils from vegetable sources can be used may seem insignificant today, but such oils may perhaps become in course of time of the same importance as some natural mineral oils and the tar products are now."

SEVERAL TRIALS HAVE BEEN UNDERTAKEN TO USING PURE VEGETABLE OILS, BLEDNS OF DIESEL FUEL, AND VEGETABLE OIL AND DEGUMMED VEGETABLE OILS.

MOST OF THESE WERE UNSUCCESFULL: DIESEL OPERATING ON THE FUELS HAD **HIGH PARTICULATE EMISSIONS , REUCED EFFICIENCY AND HIGHER MAINTENANCE REQUIREMENTS.**


B 50 from Future Fuels
B 50 from ABG
ULSD from Shell
Téméraire
Samples in Frigde for 3 Hours at 5 degree C


B 50 from ABG
b 50 from Future Fuels
ULSD from Shell
Téméraire
Samples at minus 5 degree C

Tablica 6.2. Porównanie parametrów olejów napędowych i wybranych olejów roślinnych (wartości średnie)

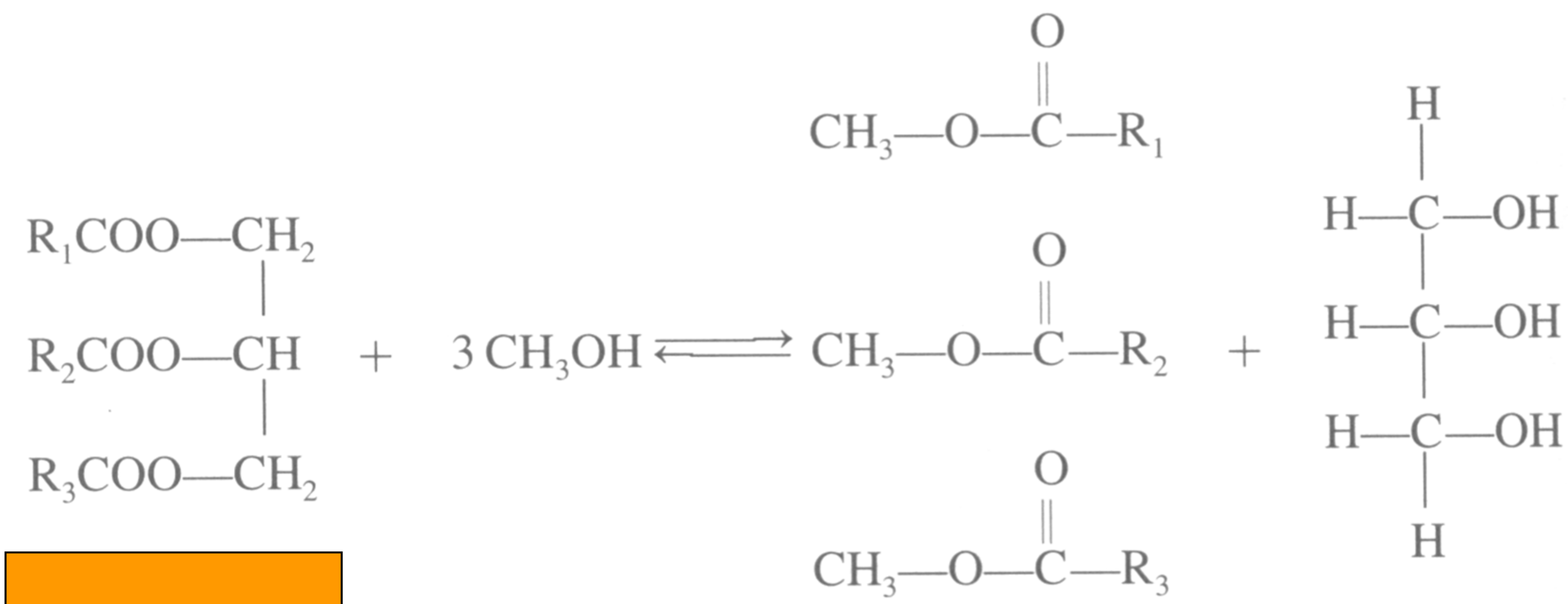
Parametr	Unit	Oil	Vegetable oil		
			Rape	Palm	Coconuts
Density 15°C	kg/m³	820...860	920	899	908 (w 40°C)
Lepkość kinematyczna Kinematic viscosity – 40°C – 100°C	mm²/s	1,5...4,5 0,75	30,0...43,0 8,0...8,4	39,3 8,4	26,9 6,0
LC		45...55	~51	~51	~59
Net calorific value	MJ/kg	42...45	37,1...37,5	37,3	35,4
Temperatura płynięcia	°C	< –15	–6	38	24
C/H/O	% masy	86/14/0	77/12/11	77/12/11	74/12/14
Sulphur	mg/kg	< 350	1	< 1	4

TRANSESTERIFICATION PROCESS

VEGETABLE OIL
FATTY ACID GLYCEROL + **ALCOHOL (C_1-C_5)** —**CATALYST**→ **GLYCEROL** + **FAME FAEE**

$$\begin{array}{l} CH_2OOCR_T \\ | \\ CHOOCR_T \\ | \\ CH_2OOCR_T \end{array} + 3\,R_aOH \underset{\text{temperatura}}{\overset{\text{katalizator}}{\rightleftharpoons}} \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + 3\,R_TCOOR_a$$

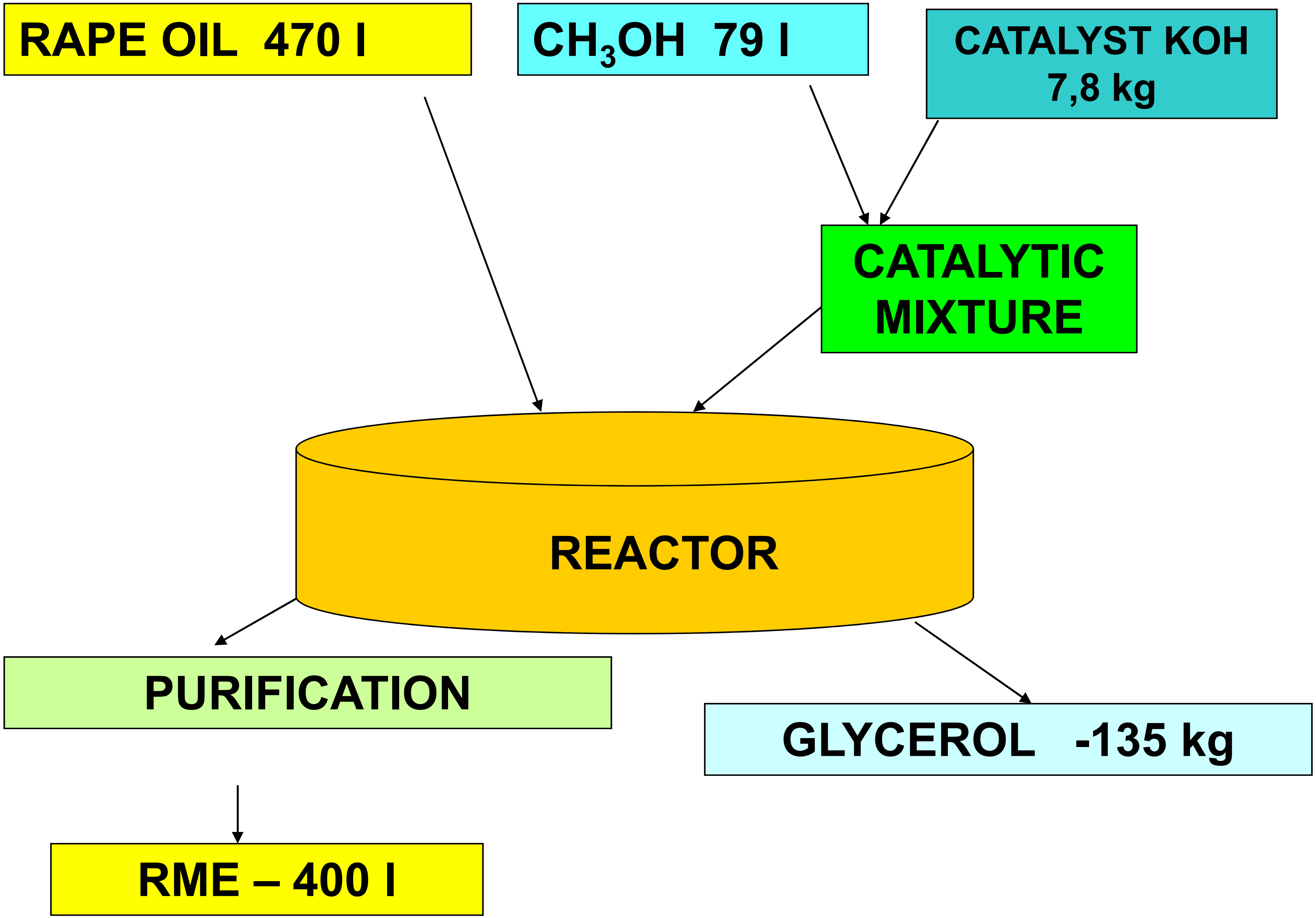
PRODUCTION OF RAPE-SEED OIL METHYL ESTER (RME)



RAPE OIL + **CH_3OH** ⇌ **RME** + **GLYCEROL**

R_1, R_2, R_2 – ALKYL GROUPS

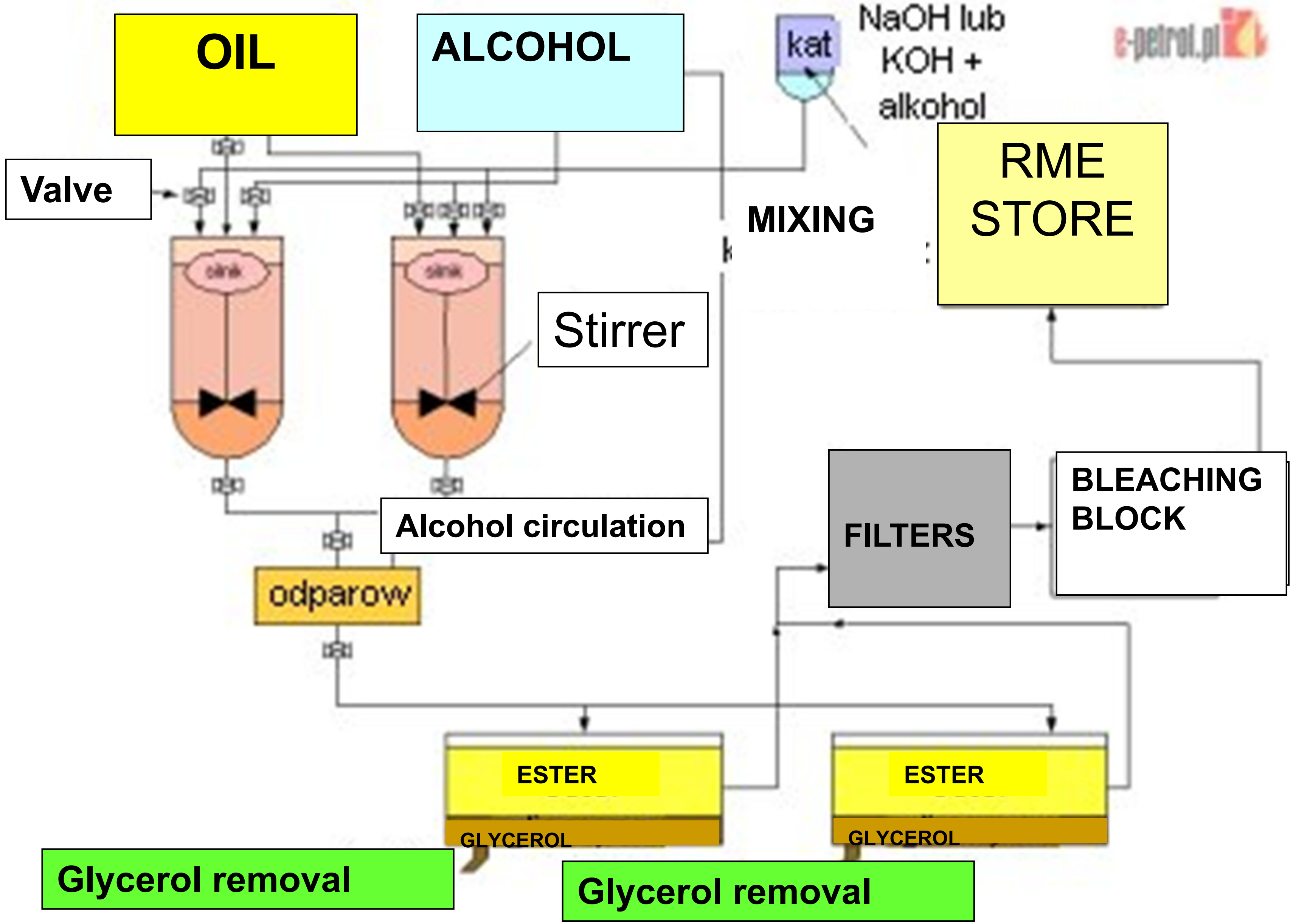
Bio-diesel is defined as monoalkyl esters of vegetable oils or animal fats.


RAPE OIL 470 l
CH3OH 79 l
CATALYST KOH 7,8 kg
CATALYTIC MIXTURE
REACTOR
PURIFICATION
GLYCEROL -135 kg
RME – 400 l

PARAMETERS OF TRANSESTERIFICATION PROCESS

- Moderate temperature - alcaline catalyst (KOH,NaOH)
- t =100^{o}C – acid catalyst
- t >250^{o}C – without catalyst , pressure p=10MPa,

  significant excess of CH_3OH.



OIL
ALCOHOL
kat
NaOH lub KOH + alkohol
e-petrol.pl
Valve
MIXING
RME STORE
Stirrer
Alcohol circulation
odparow
FILTERS
BLEACHING BLOCK
ESTER
GLYCEROL
ESTER
GLYCEROL
Glycerol removal
Glycerol removal

SMALL BIODIESEL PLANTS TRANSESTERIFICATION PROCESSING

Estryfikator PEM 300

Productivity:
300 litres of the bio-diesel from one production cycle

http://www.alvanblanch.co.uk/vegetablioil.htm

PRESSES FOR SQUEEZING OIL (OIL PRESS)

Press A – 40

http://protechnika.com/eng/prasy.php?id_s=0

Productivity: 0.8 - 1 ton/day)

Speed of the turnover of the screw:40 - 50obr/min.,

Engine:5,5 kW 1400 rpm;

Dimensions: 675 x 880 x 880 mm;

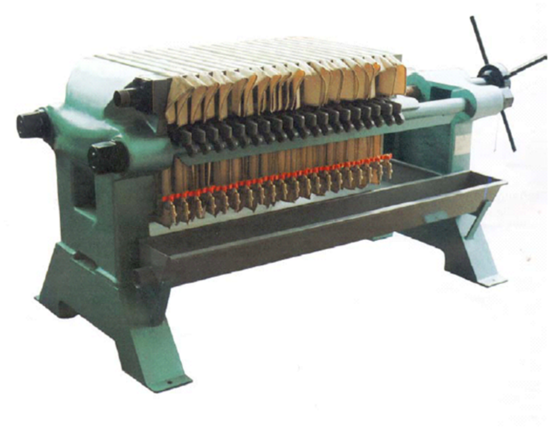
Weight:140 kg

Small 150 Kg/h oil expeller press processing rapeseed

http://www.alvanblanch.co.uk/vegetablioil.htm

FRAME FILTERS

Plate Filter Press S500



http://www.alvanblanch.co.uk/vegetablioil.htm

PRESS PF-60

Efficiency: 40-60 kg/h;
Engine: 0,75 kW;
Weight: 190 kg

http://protechnika.com/eng/prasy.php?id_s=0

PLASTIC CONTAINERS WITH THE PETROL PUMP

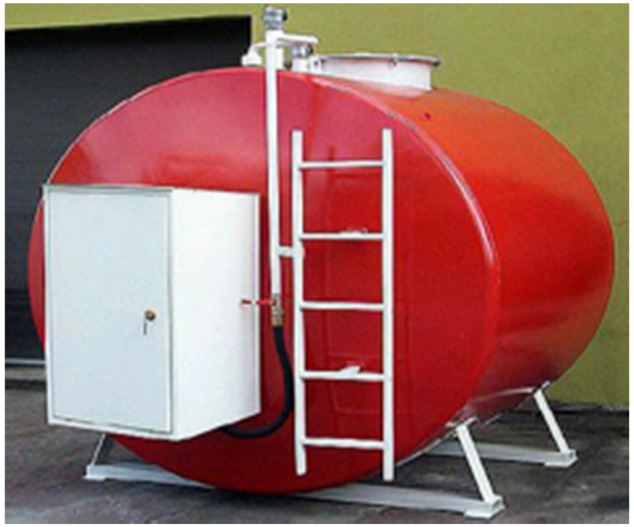
Containers are made from the polyethylene of medium density,

Fuel tank capacity of:

- 1 200 litres with analogue gauge
- 5 000 litres with the code protection for up to 50 users

http://protechnika.com/eng/prasy.php?id_s=0

METAL CONTAINERS, DOUBLE WALL (JACKET):



Ground container, double wall are designed to store liquid, inflammable materials (petrols, oils).

Capacity 5 000 –30 000 l

http://protechnika.com/eng/prasy.php?id_s=0

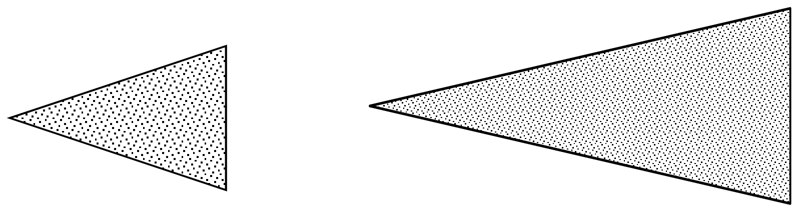
PROPERTIES OF RME

DENSITY

at t=15 °C ρ = 860...900 kg/m^3

Density influences :

- the fuel dosage,
- behaving fuels in the fuel injector,
- fuel storage,
- fuel distribution,



- settlements of accounts

NET CALORIFIC VALUE

Q_i = 37...39 MJ/kg, (33..34 MJ/dm^3)

Rape fuel is characterized by a lower calorific value than the diesel oil, therefore specific fuel consumption increases about 8 - 14%.

CETANE NUMBER

Bio-diesel is characterized with cetane number comparable to LC of the diesel oils LC≈55).

FLASH POINT

On account of the high flashpoint (166-186°C) and low vapour pressure (v.p $<$ 1 Hg mm), bio-diesel isn't regarded as substances explosive.

VISCOSITY

Bio-diesel is characteristic much higher viscosity than the diesel oil.

Kinematic viscosity

- 20 ^oC – γ = 6,9...8,2 mm^2/s
- 40 ^oC – γ = 4... 6,3 mm^2/s
- 100 ^oC – γ = 1,8 mm^2/s

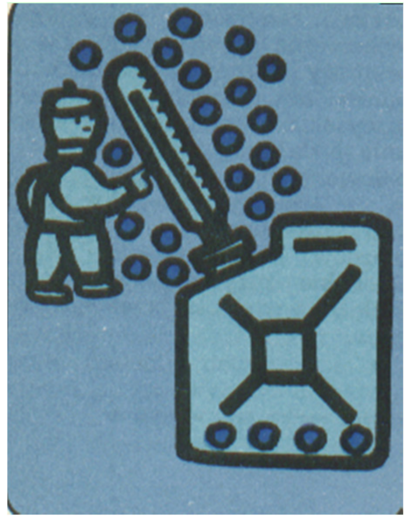
LOW-TEMPERATURE PROPERTIES

Flow temperature - – 5...- 8 ^{o}C

Cold Filter Plugging Point – 5 -13 ^{o}C

Low-temperature parameters of the bio-diesel are an essential criterion governing of the bio-diesel use in winter conditions.

FRACTIONAL COMPOSITION.



Temperature of boiling point - 320...350 °C

distillation

t = 250°C – 0%

t = 340°C – 95%

t ≈ 350°C – 100%

- The temperature of the beginning of the distillation is much higher than that of diesel –oil because of the small volatility of the bio-diesel,
- Therefore very accurate spraying fuel by the injector is required to facilitate evaporating,
- The high boiling point causes that bio-diesel is burnt best at great burdens for the engine when the temperature of a combustion chamber is high.

SULPHUR

Ester fuel practically doesn't contain sulphur (< 0.001%), according to Polish standards sulphur contents in the diesel oil should be maintained at the level less than 0,05%).

Bio-diesel is considered as the environmental friendly fuel that can be applied in modern engines.

CONTENT OF WATER

Comparative research on the ability to absorb water through bio-diesel and diesel show, that the ones first can take more water up for c 40 times than diesel.

On account of the ones feature, the production, the transport and distribution of the bio-diesel requires keeping proper parameters in order to protect water against getting to fuel.

RESISTANCE TO OXIDIZING.

Bio-diesel is characterized by a reduced resistance to oxidizing compared to diesel-oil, what is of special importance at the longer shelf life.

POSSIBILITY OF MIXING UP WITH DIESEL

Bio-diesel can be mixed in any proportion with diesel-oil. It is one of the most essential characteristic which decided about universal applying esters, as fuel for powering diesel engines, mainly as the addition a few percentage to diesel.

MIXTURE RME + DIESEL OIL

- improvement of cold filter plugging point
- good lubricating ability
- increase of LC,
- increase of fuel consumption
- worse engine performance ,
- corrosion ,
- elastomers negative reaction,
- hygroscopic propertles,

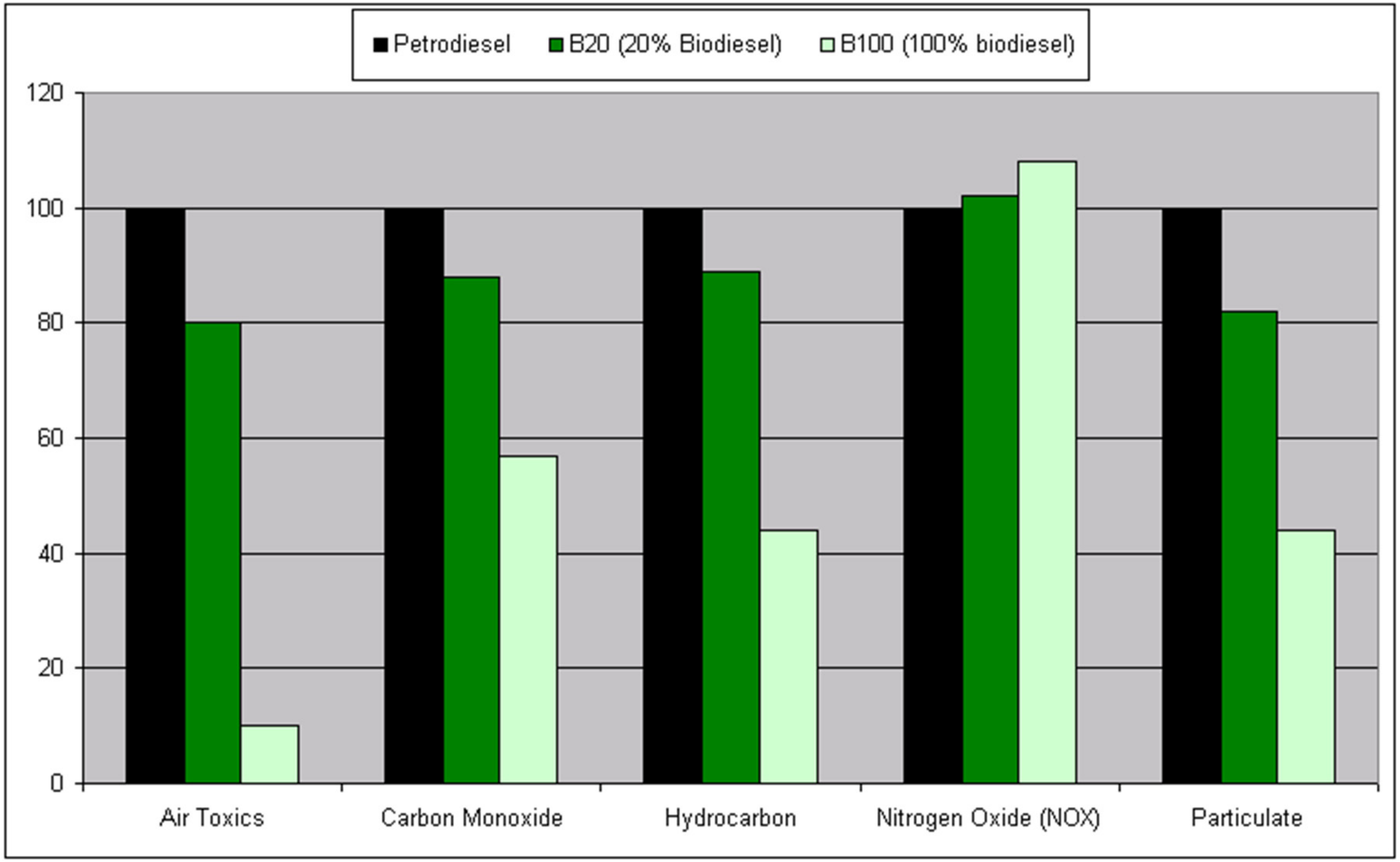
MIXTURE RME + ALCOHOLS

- improvement of the bio-oil dispersion,
- addition of 20%$_m$ C_2H_5OH deteritoriates self ignition properties (LC) of the bio-oil ,
- ignition lag of the fuel decreases, therefore burning period is shortened that leads to better quality of exhaust gas (PM , NO_x lower contents),
- improvement of engine efficiency,
- decrease of deposits ,

BIODIESEL- 100% BIODIESEL FUEL

BIODIESEL BLEND - BIODIESEL BLENDED WITH PETRODIESEL.

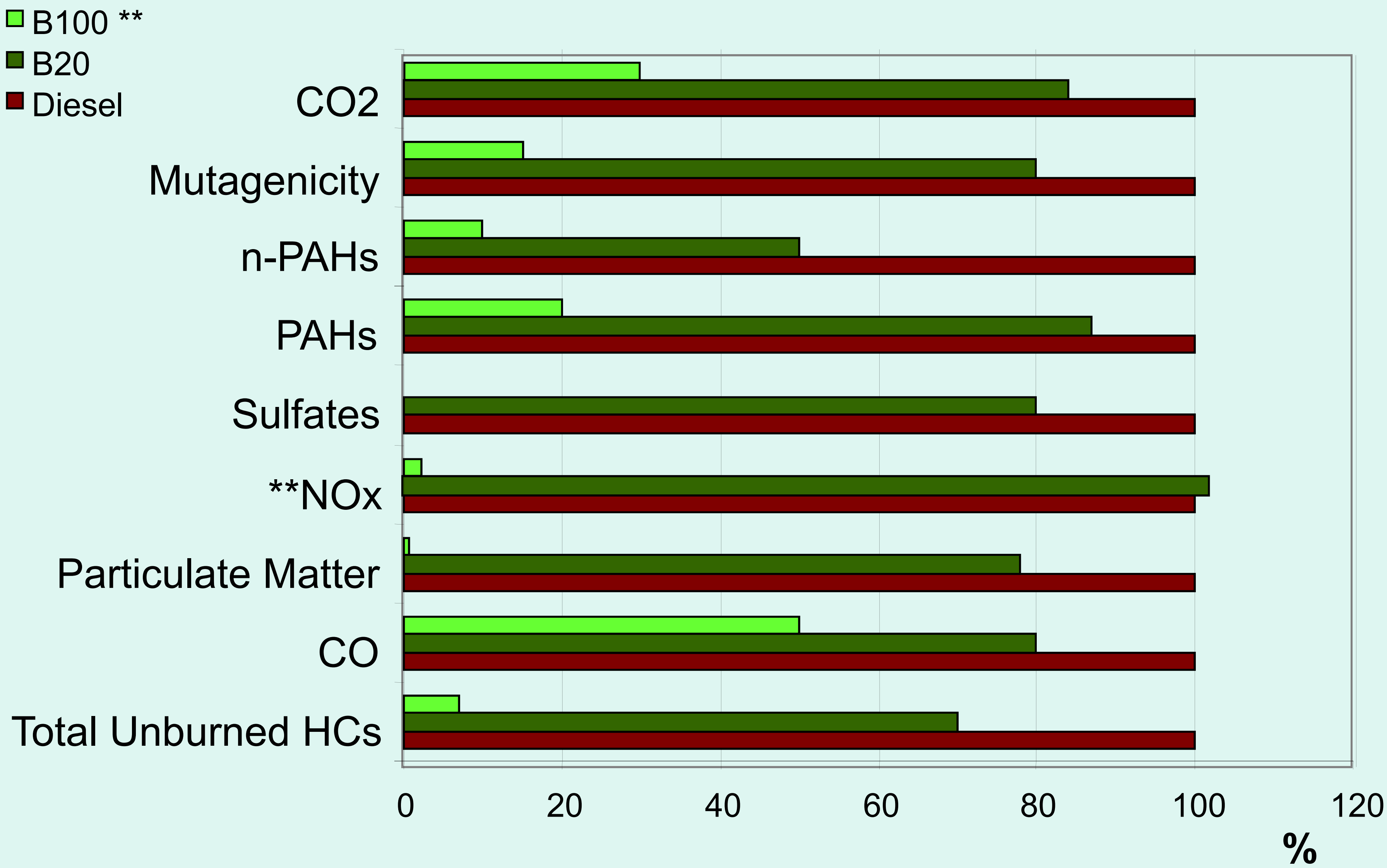
B20 BLEND CONSISTS OF 20% BIODIESEL AND 80% PETRODIESEL.



Emission of B20 and B100 compared with Petrodiesel

http://www.biofuel.be/whatisbiodiesel.html

Relative emissions: Diesel and Biodiesel



** B100 (100% biodiesel) with NOx adsorbing catalyst on vehicle

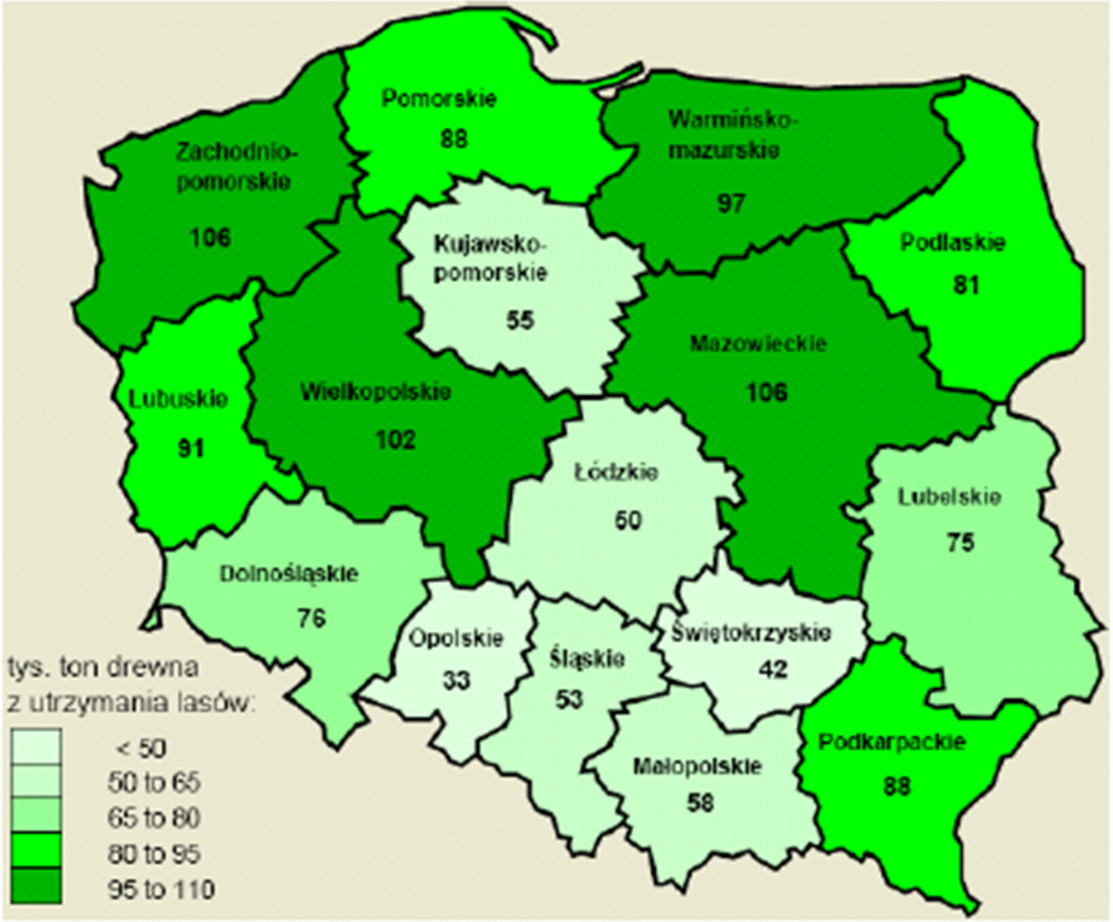
SOLID BIOFUELS

TYPES OF BIOMASS

- wood,
- waste wood products,
- energy crops (Miscanthus, Switch Grass, Reed Canary Grass,grasses oilseed, willow, poplar ,etc.)
- organic industrial byproducts (cellulose,lignine,fruits, meat,etc)
- agriculture wastes (straw, hay, flax, tobacco, leafy tops, haulms, manure, dunghill, etc.)
- wastes (cardboard,cotton, selected garbage etc.)

1ha - 10 ton biomass - 5 ton hard coal

[www.energetyka.most.org.pl]

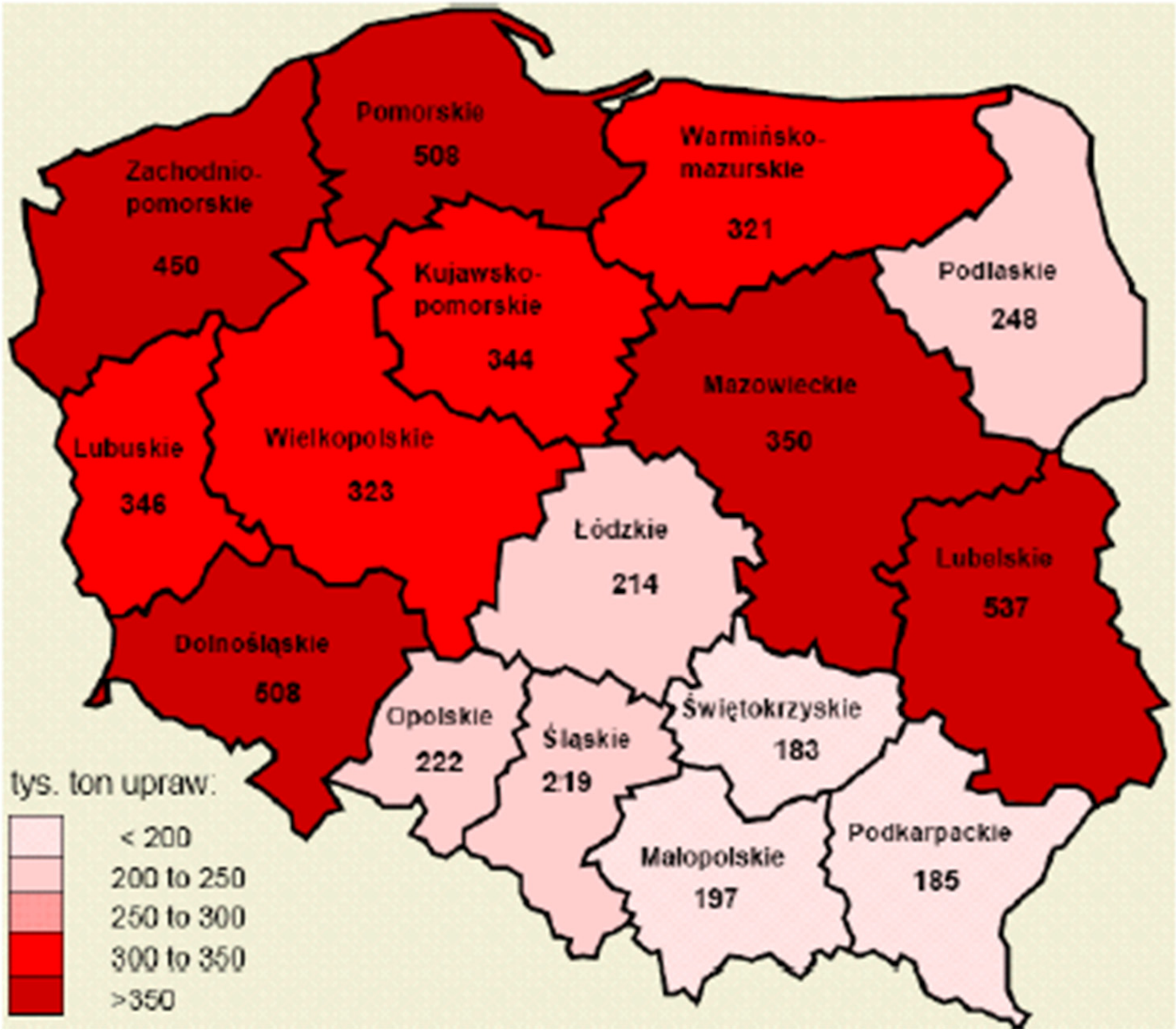


Wood resources in Poland

Gaj H.: 2004 „Potencjały i koszty redukcji emisji CO_2 w technologiach produkcyjnych”, Konferencja „Handel emisjami od strony prawnej, organizacyjnej i technicznej”

Straw resources in Poland

Gaj H.: 2004 „Potencjały i koszty redukcji emisji CO_2 w technologiach produkcyjnych", Konferencja „Handel emisjami od strony prawnej, organizacyjnej i technicznej"



Short rotation biomass plantation.

Gaj H.: 2004 „Potencjały i koszty redukcji emisji CO_2 w technologiach produkcyjnych", Konferencja „Handel emisjami od strony prawnej, organizacyjnej i technicznej"

Table 2 Gross energy potential of crops[4]

Fuel	*Heating value* (MJ/kg)	*Approximate crop yield* (T/ha)[a]
Lignin	28.0	
Wheat straw	14.5	6.0
Energy cereals	15.0	12.0
Miscanthus	17.0	30.0
Wood	17.0	10.0
Eucalyptus	19.53	10.0
Bamboo	15.85	
Rape straw	17.0	8.0
Heating oil	41.0	

[a]Approximate figures as individual locations vary widely.

Landfill Gas and Related Energy Sources: Anaerobic Digestion; Biomass Energy Systems

ADRIAN LOENING

PROPERTIES OF BIOMASS

COMPONENT	UNIT	YELLOW STRAW	GRAY STRAW	WOOD WITHOUT BARK	WOODEN CHIPS	WOODEN BARK	PELLETS BRIQUETTES	WILLOW	PEAT	COAL	NATURAL GAS
MOISTURE	%	10–20	10–25	5- 60	20–50	45–65	7–12	50–60	40–55	5–10	0
VOLATILE MATTER	%	70–80	70–80	>70	76–86	69–77	>70	>70	n.o.	25–40	100
ASH	%	5	3	0,4-0,5	0,8–1,4	3,5–8	0,4–1,5	1,1–4,0	4–7	8,5–11	0
C*)	%	45–48	43–48	48–52	47–52	48–52	48–52	47–51	52–56	76–87	74
H	%	5–6	5–6	6,2–6,4	6,1–6,3	4,6–6,8	6–6,4	5,8–6,7	5–6,5	3,5–5	24
O	%	36–48	36–48	38–42	38–45	24,3–42,4	40	40–46	30–40	2,8–11,3	0,9
Cl	%	0,97	0,14	0,01–0,03	0,02	0,01–0,03	0,02–0,04	0,02–0,05	0,02–0,06	<0,1	0
N	%	0,3–0,6	0,3–06	0,1–0,5	<0,3	0,3–0,8	0,3–0,9	0,2–0,8	1–3	0,8–1,5	0,9
S	%	0,05–0,2	0,05–0,2	<0,05	<0,05	<0,05	0,04–0,08	0,02–0,1	0,05–0,3	0,5–3,1	0
K	%	1.3	0,7	0,02–0,05	0,02	0,1–0,4	n.o.	0,2–0,5	0,8–5,6	0,003	0
Ca	%	0,6	0,1	0,1–1,5	0,04	0,02–0,08	n.o.	0,2–0,7	0,05–0,1	4–12	0
GROSS CALORIFIC VALUE	MJ/kg	17,4	17,4	18,5–20	19,2–19,4	18–23	16,2–19	18,4–19,2	20,9–21,3	26–28,3	48
DENSITY	kg/m^3	100–170	100–170	390–640	250–350	320	500–780	120	n.o.	1100–1500	n.o.
ASH MELTING POINT	°C	800–1000	800–1000	1300–1700	1000–1400	1400–1700	>1120	n.o.	n.o.	1100–1400	0

*DRY BIOMASS

Based on : W.Rybak -Spalanie i wspólspalanie biopaliw stałych, Wrocław, OW PW2006

Combustibles	Ash	Water	Specific weight	Effective heat value	Effective heat value
	% of dry weight	% of total weight	(kg/lm³)	(MWh/ton)	(MWh/lm³)
Wood, birch	0,8	20	430	4,1	1,76
Wood, spruce	1,3	20	345	4,1	1,41
Wood chips, pine	1,5	55	390	1,9	0,73
Wood chips, spruce	2	55	355	1,9	0,69
Industrial chips, raw	1,8	55	300	1,9	0,55
Industrial chips, dry	0,3	20	200	4,1	0,82
Planer chips	0,5	15	100	4,6	0,46
Sawdust	0,5	44	230	2,7	0,63
Bark, coniferous wood	3	50	280	2,3	0,65
Return logs	15-20	20	265	3,8	1
Pellets	1	8-12	650	4,8	3,1
Briquettes	0,7	10-12	600	4,3	2,6
Wood powder	0,5	5	280	4,9	1,4
Bark	2,5-3,0	55	280	2,1	0,6

http://www.renewableenergy.no/sitepageview.aspx?articleID=177#anker_1

GROSS CALORIFIC VALUE & NET CALORIFIC VALUE

- Composition of the fuel (contents of C,H,S, ash, moisture) determinate gross and net calorific value.
- Different fuels burn differently, and also give off different amounts of heat per amount of the biofuel .
- Gross calorific value of biomass $Q_i^{daf} \cong 15 - 20 MJ/kg$
- This should be considered when choosing a biomass fuel.

VOLATILE MATTER

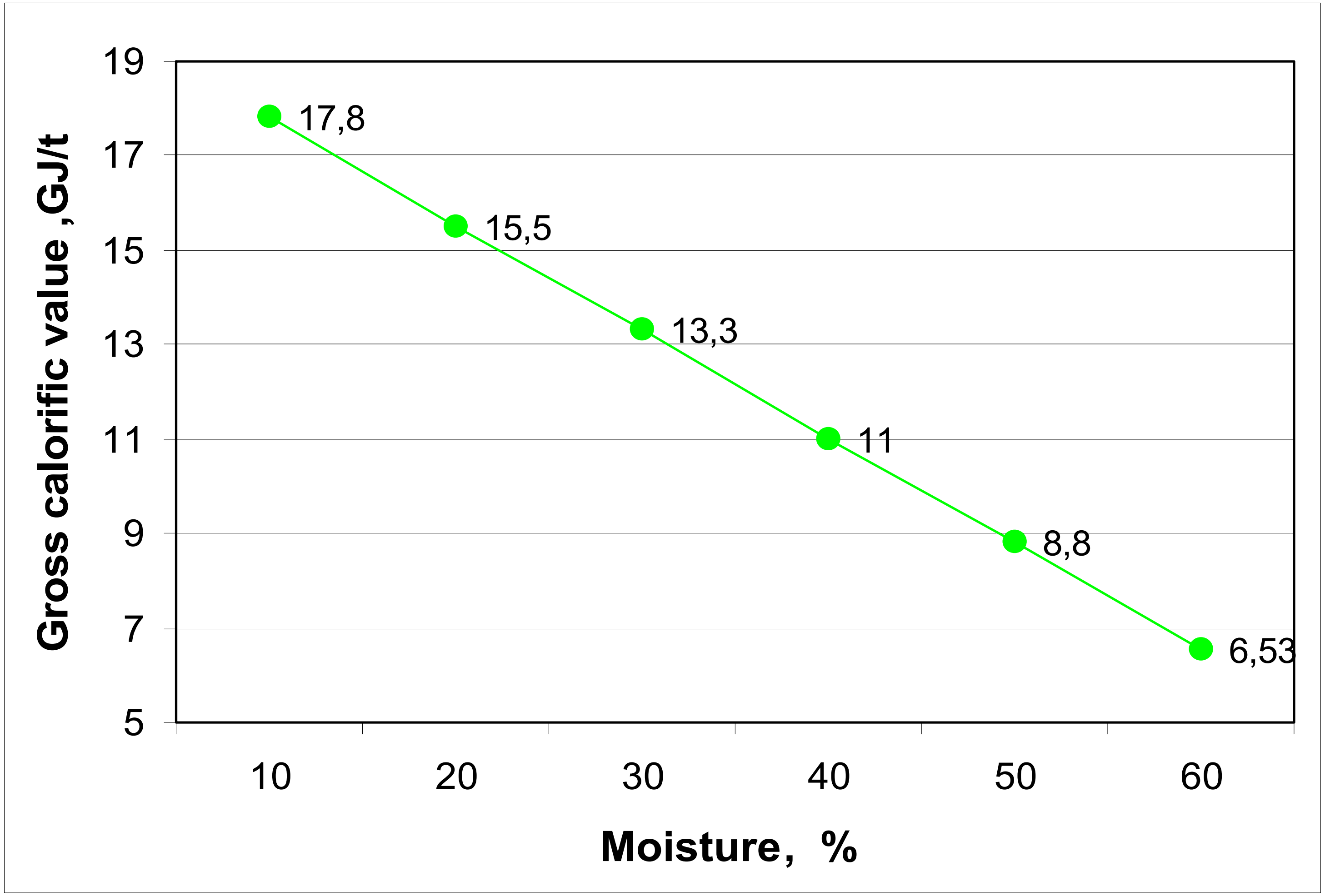
- Compared to coal biomass has more volatile matters that are released at t >100 ^{o}C during biomass carbonisation,
- Approximately 80% of biomassis is carbonisated , while 20% is transformed into coke
- High contents (70-80%) of volatile matters improves biomass ignition .

ASH

- Different biomass fuels contain different quantities of ash.
- Wood, depending on the species and bark content A< 3%.
- Energy crops produce more ash A= 2 - 6%
- Straw has similar ash contents as coal
- Some boilers cannot handle high ash content fuels, more ash means more maintenance (more contaminated heating surfaces) .

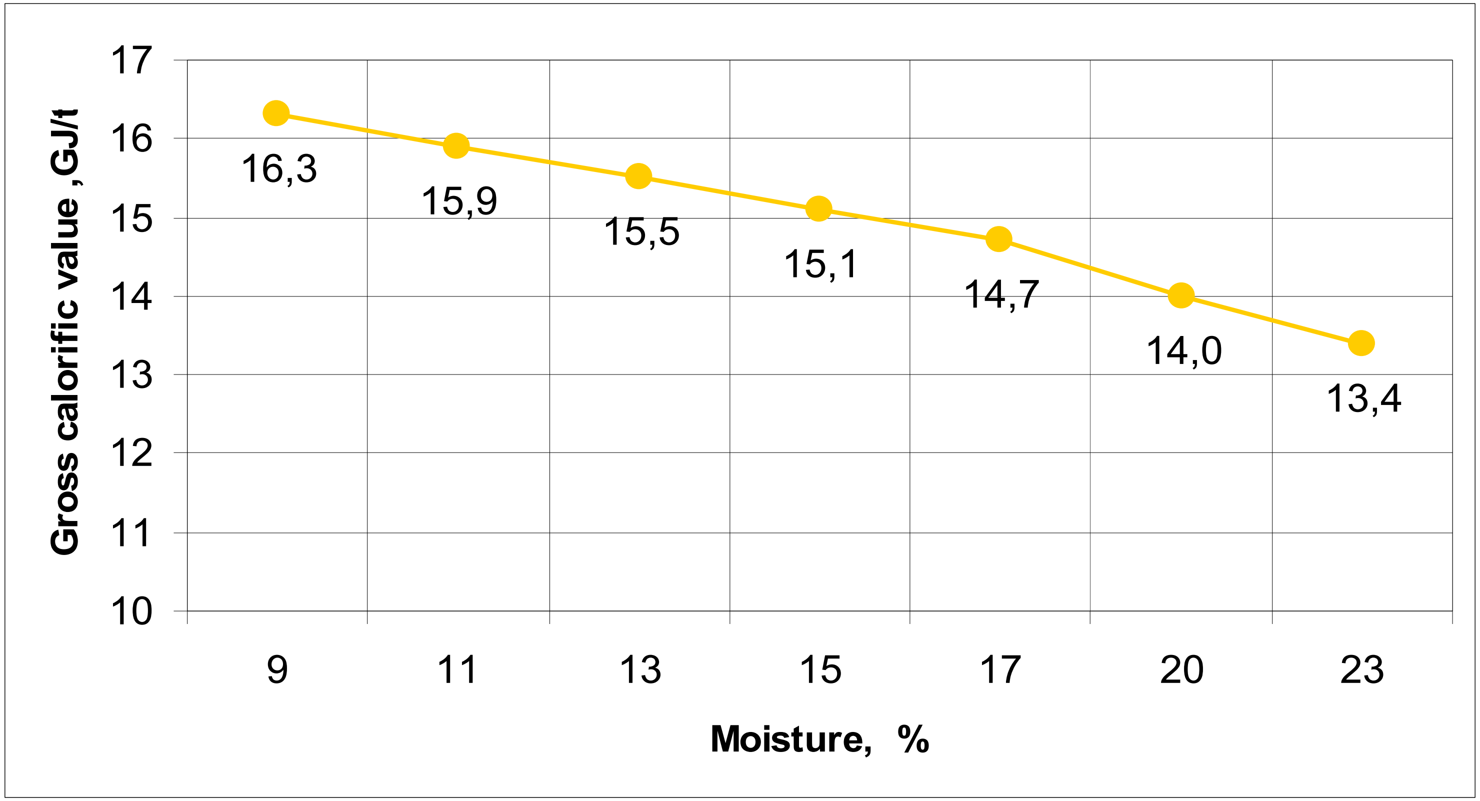
MOISTURE

- Moisture contents in biomass depends upon the character of biomass and ambient parameters,
- Thre is a great variation in moisture contens in biomass,
- High contents of moisture contributes to decrease of biomass gross and net calorific values,
- By convention, it can be assumed that mean moisture contents in biomass is W_t=15%



Relationship between gross calorific value and moisture contents in willow tree.

Source : Kościk B. Rośliny energetyczne, Wydawnictwo Akademii Rolniczej w Lublinie 2003



Relationship between gross calorific value and moisture contents in the straw .

Source http://www.bape.com.pl/index_pl.html

SULPHUR

- Is a low temperature corrosive,
- Contents of sulphur in biomass is low.
- Biofuels which contain S >0.1% will effect corrosion within the boiler at low temperatures.

CHLORIDE

- Chloride is a high temperature corrosive,
- Biofuels which contain Cl > 0.1% will cause corrosion (yellow straw contains significant chloride contents) within the boiler at low temperatures.

DENSITY

- Small density of biomass ρ = 250 -360 kg/m^3 contributes to some problems in transporation and storage.
- Profitable distance of biomass transporation should be < 150 km.

WOOD CHIPS FOR ENERGY PRODUCTION

consist of wood mechanically reduced to small pieces for the generation of energy

- dimensions: length at edge max. 60 mm
- free from paint, varnish, coating, impregnation
- free from chipboard
- free from plastics and metals of any kind
- no contamination of any kind