WEST POMERANIAN UNIVERSITY OF TECHNOLOGY, SZCZECIN,POLAND

WIMiM

THE FACULTY OF MECHANICAL ENGINEERING AND MECHATRONICS

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BIOFUELS AND BIOTECHNOLOGY II



PELLETS & BRIQUETTES

Briquettes cylinders

Briquettes c

Fireplace briquettes

Grill briquettes

http://www.paliwadrzewne.pl

Sawdust drier

Worm briquetting machine

http://www.paliwadrzewne.pl

http://www.paliwadrzewne.pl

Dimensions od pellets and briquettes enable very efficient burning and automation of the small boilers fires with that biofuels.

Parameters of wood pellets i briquette,

Physical parameters	
Bulk density	630 - 750 kg/m^3
Length	pel. 5 - 40 mm, bryk. 10 - 30 cm
Mass density	1,2 - 1,4 t/m^3
Gross net value	21 000 kJ/kg
Diameter	6 - 30 mm
Moisture	8 - 10 %
Ash	0,5 - 1 %
Chemical constitution (%)	
Nitrogen	0,1
Oxygen	40,1
Coal	53,6
Water	6,2
Chlorine	< 0,1
Sulphur	< 0,1

BC (Biomass+Coal) briquettes Q_i = 19 – 26 MJ/kg

Emission from BC i hard oal

Parameter	Haed caol Cal size-pea	Briquette BC
Efficiency of the boiler [%]	80,9	85,5
Emission indicator CO [mg/m^3]	2347	2361
Emission indicator SO_2 [mg/m^3]	315	308
Emission indicator NO_x [mg/m^3]	311	144

STRAW

- Moisture content in straw depend upon logging proces
- Straw used for burning contain 14-20% of moisture,
- Remainded dry mass contains 50% of coal, H_2 = 6%

  O_2 = 42% , small amount of N_2 ,S, Si.

Straw ballots

Flax straw briquettes

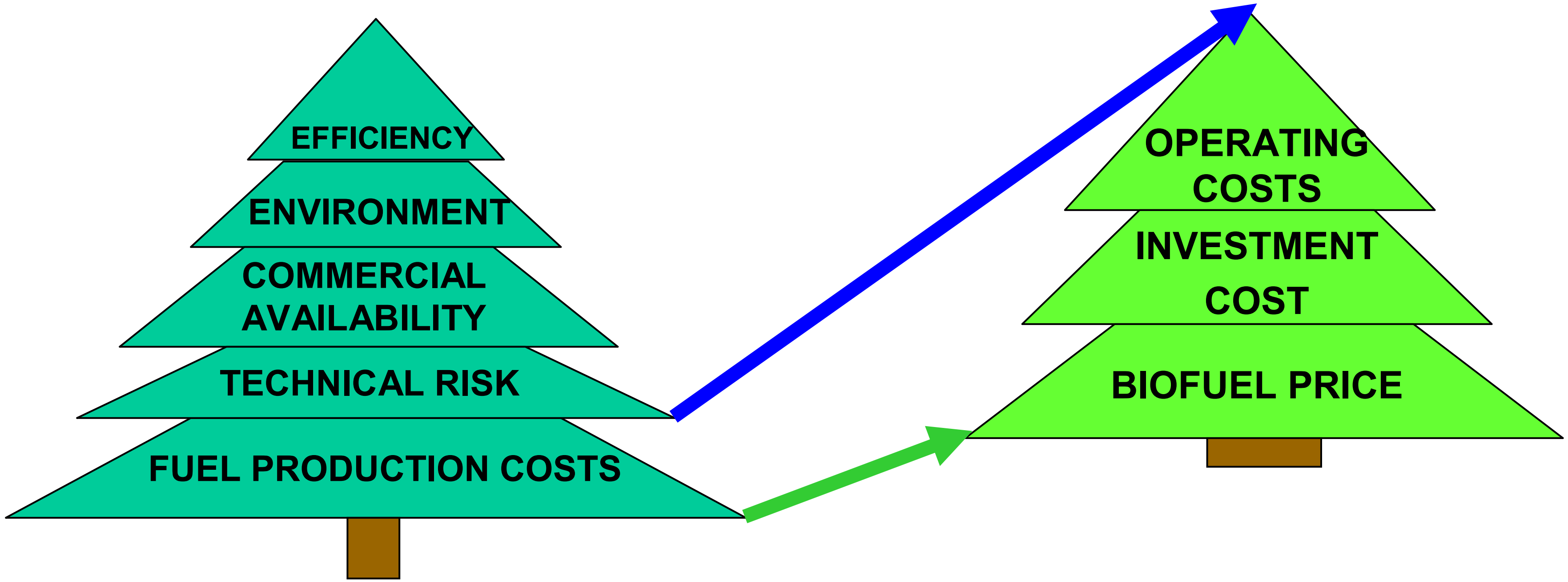
Peat briquettess

http://www.paliwadrzewne.pl

- Yellow straw is not recommended for burning as it contains a large contents of S, Cl and alkaline compounds
- Because of removal S,Cl and alkaline compoundsgray (wilted straw) straw is recommended for burning.

Biomass usability in the power plants of the different scale.

Biofuel/ application	Small power plants	Large power plants
Wood	Recommended	Not recommended
Wooden chips	Recommended	Specially recommended
Wooden dust	Not recommended	Recommended
Pellets	Specially recommended	Recommended
Briquettes	Specially recommended	Not recommended
Straw and crop grasses	Not recommended	Specially recommended
Straw briquetts	Not recommended	Specially recommended



,,Trees" for evaluation of solid biofuel quality

THERMOCHEMICAL CONVERSION OF BIOMASS

THERMOCHEMICAL CONVERSION OF BIOMASS

- PYROLYSIS
- GASIFICATION
- COMBUSTION

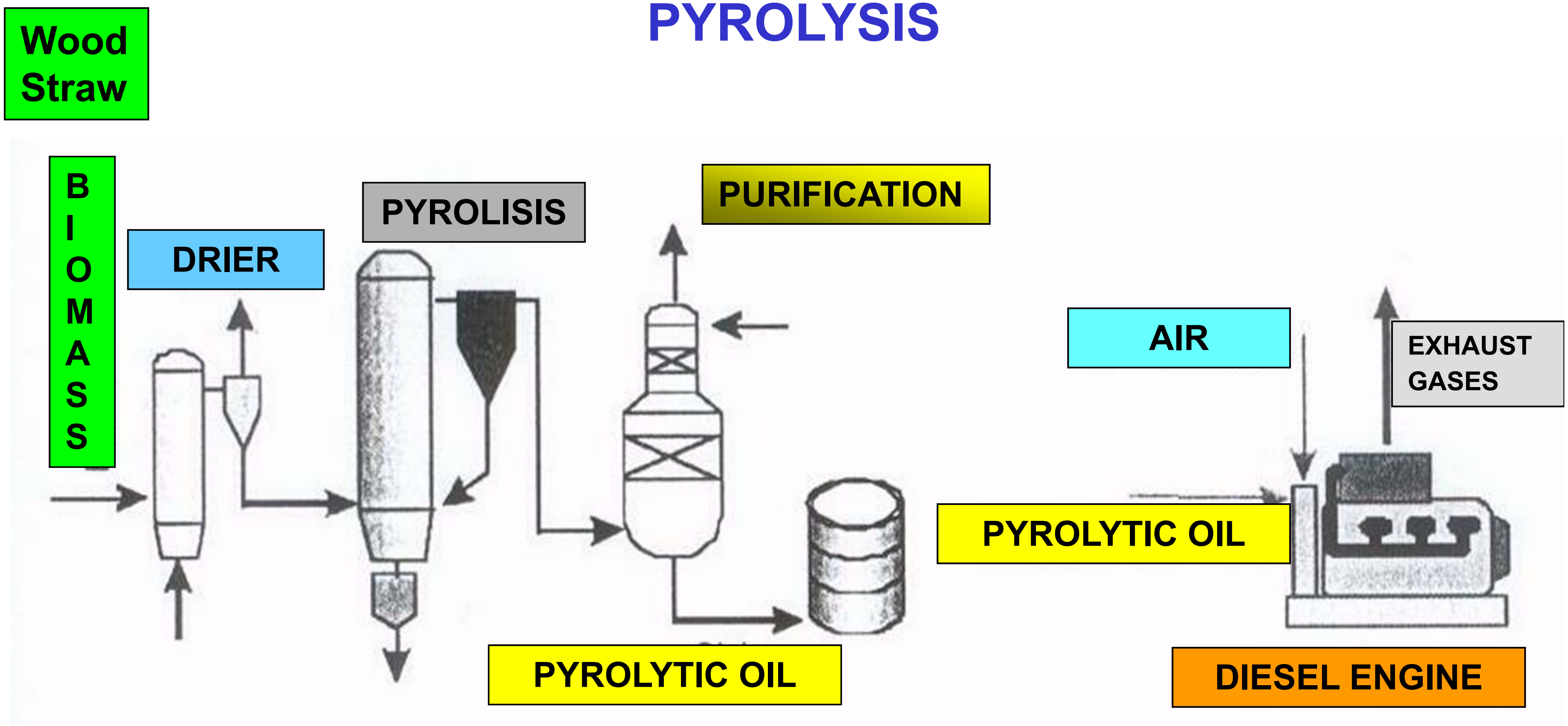
Two processes:

- pyrolysis
- gasification

are applied for the conversion of biomass into biofuels that are more easily:

- handled,
- stored
- combusted

PYROLYSIS



Based on: W.Rybak:Spalanie i wspólspalanie biomasy, OW PW, Wrocław ,2006

PYROLYSIS

high-temperature process, where the biomass is heated in the oxygen - free atmosphere, generating vapours and some charcoal.

The vapours are cooled and condensed, forming pyrolytic oil ,

WOOD PYROLYSIS

- I period t > 170°C – release of water
- II period t = 170 – 270°C release of CO_2 i CO;
- III period t = 270 – 290°C exotermic reactions, release of: methanol, acetic acid, hydrocarbons, hydrogen
- IV period t = 280 – 400°C intensive release of hydrocarbons, hydrogen.

In case of charcoal, contents of carbon in the final product depends upon of the process temperature.

PYROLYSIS

Table 4 Typical analysis of wood-derived crude pyrolysis oil[5]

Physical property	*Typical value*
Moisture content	15–30%
pH	2.5
s.g.	1.2
C	56.4%
H	6.2%
O	37.3%
N	0.1%
Ash	0.1%
Heating value	16–19 MJ/kg
Viscosity	40–100 cP
Solids (char)	1%

Source ADRIAN LOENING:Landfill Gas and Related Energy Anaerobic Biomass Energy Systems

GASIFICATION

GASIFICATION

Gasification is a partial oxidation process whereby a carbon source such as coal, natural gas or biomass, is broken down into CO , H_2 and CO_2 and possibly hydrocarbon molecules such as CH_4.

GASIFICATION OF BIOMASS

Gasification involves the heating biomass in atmosphere of a controlled quantity of oxygen and water:

Endothermic reaction :

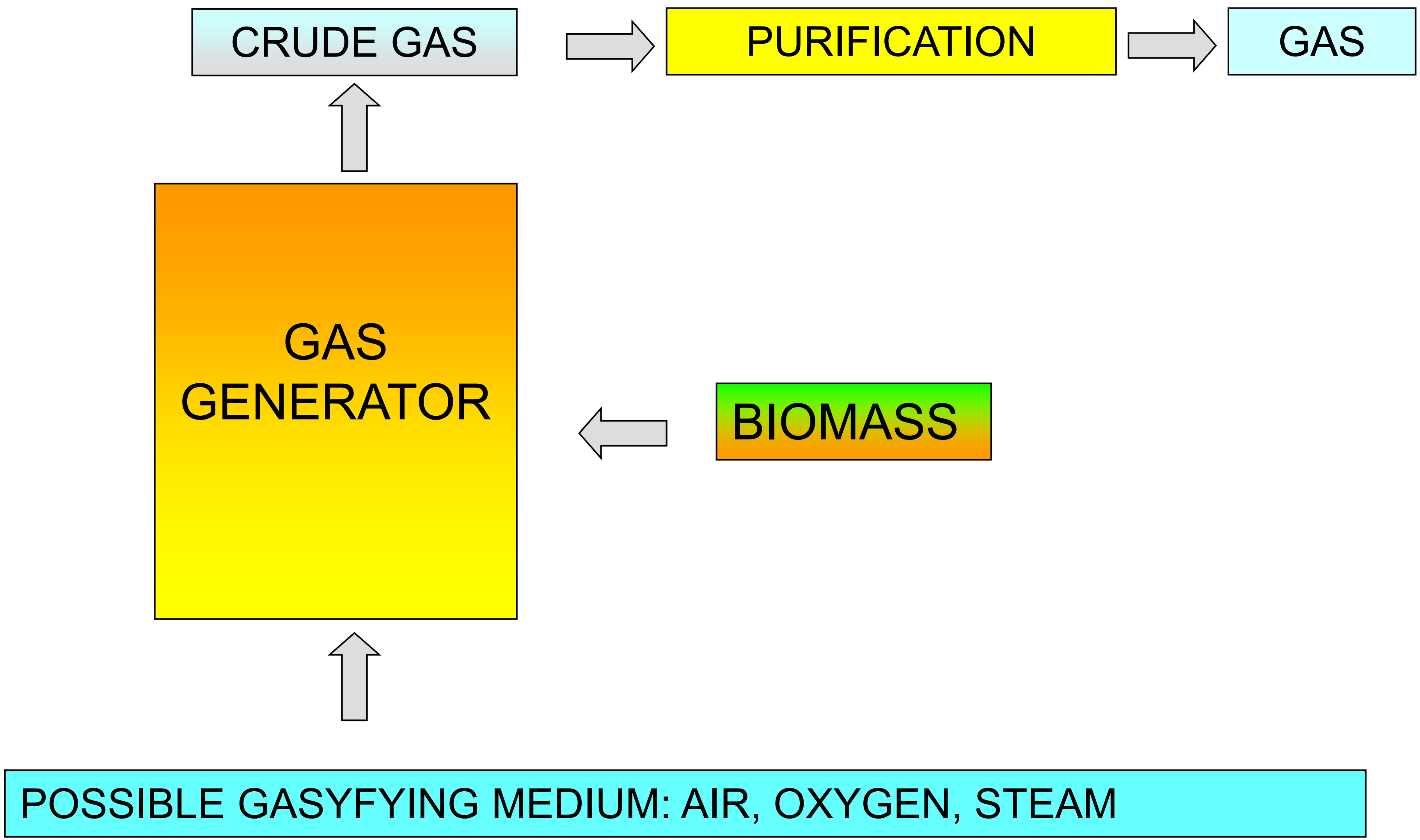
$C + H_2O = CO + H_2$

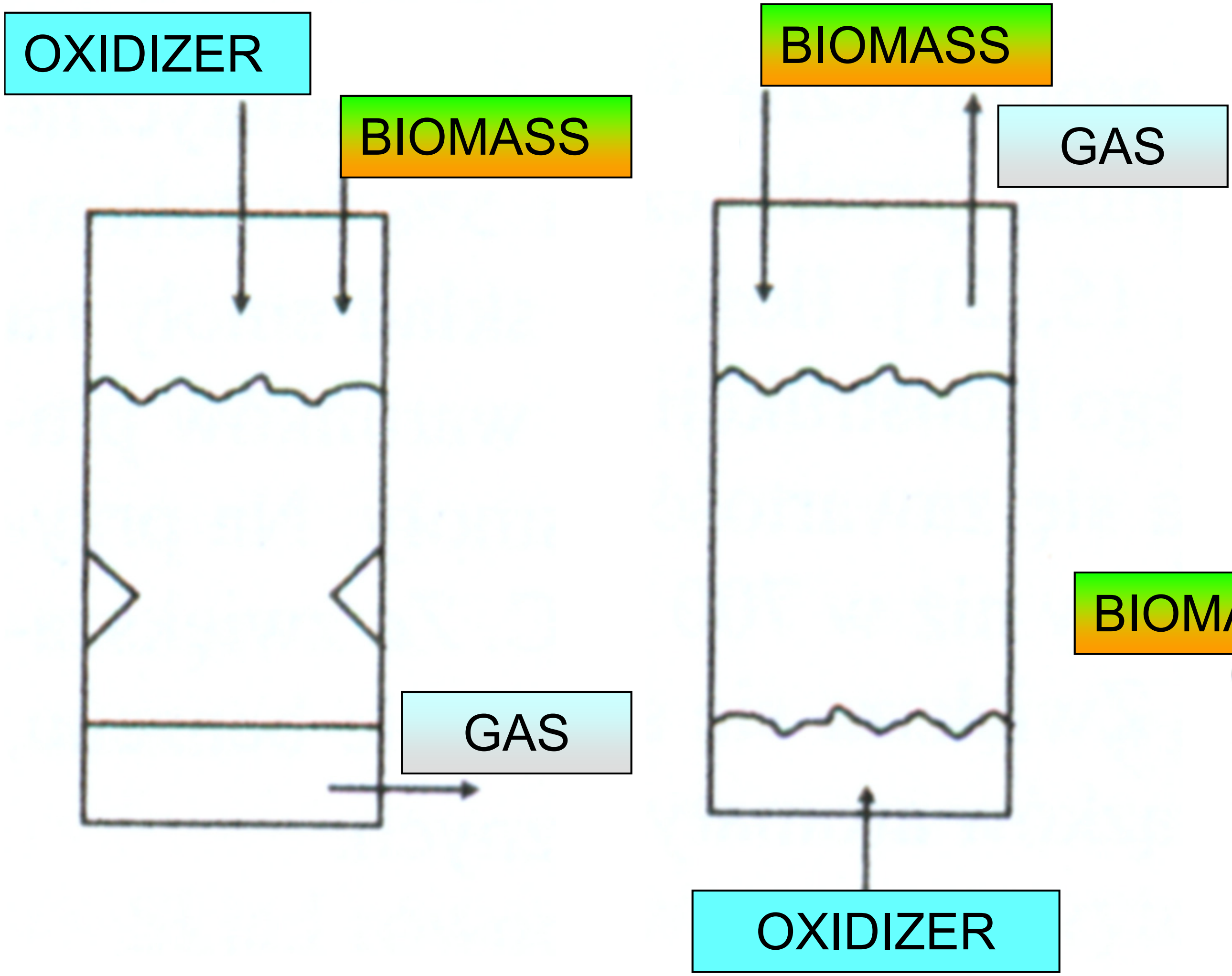
Exothermic reactions:

$C + 1/2\ O_2 = CO + \Delta H_1$

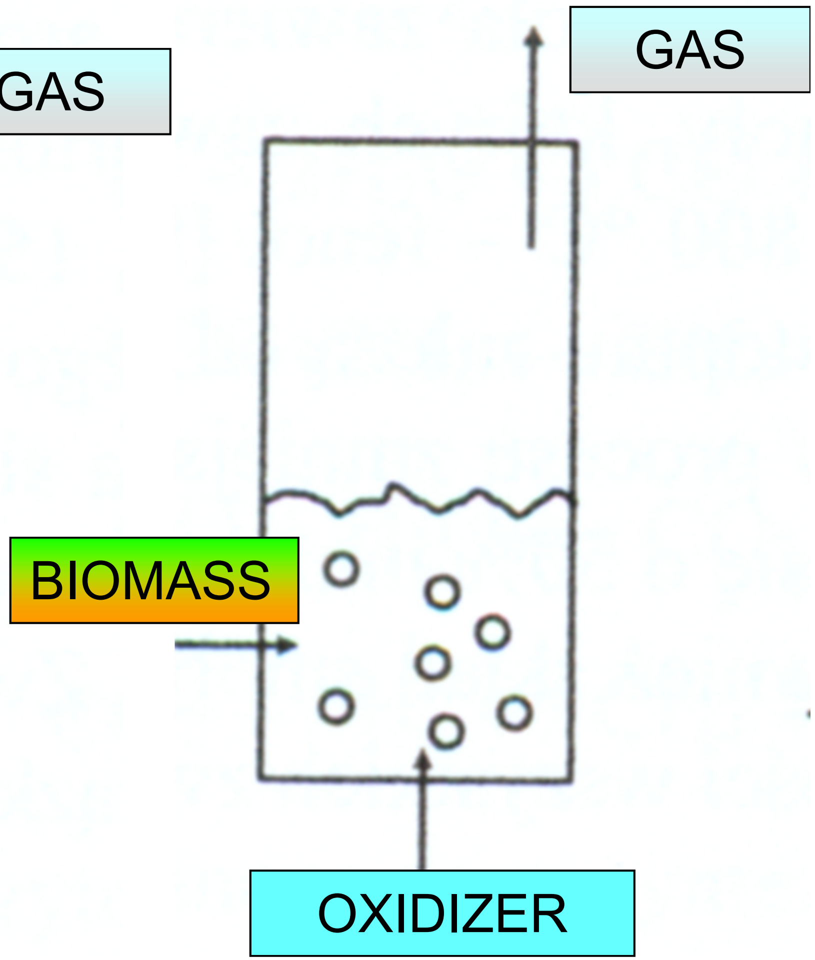
$C + O_2 = CO_2 + \Delta H_2$

GASIFICATION PROCESS



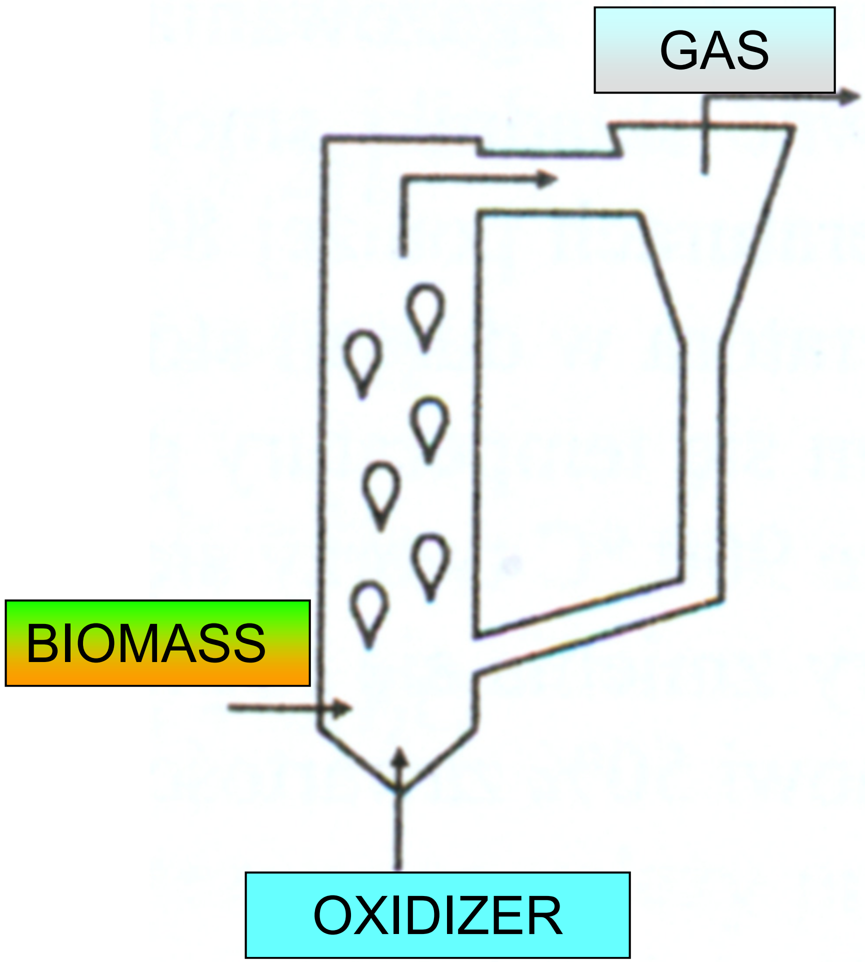


1. Gas generators with a stable bed

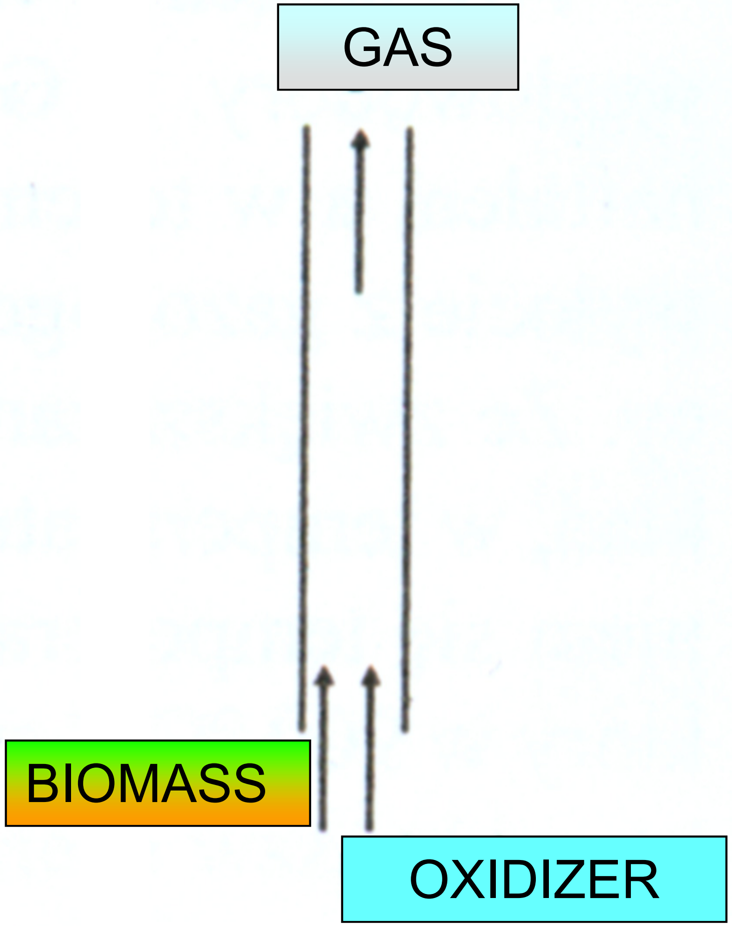


2. Gas generator with bubble fluidized bed

Based on: W.Rybak:Spalanie i współspalanie biomasy, OW PW, Wrocław ,2006



3. Gas generator withcirculating fluidised bed



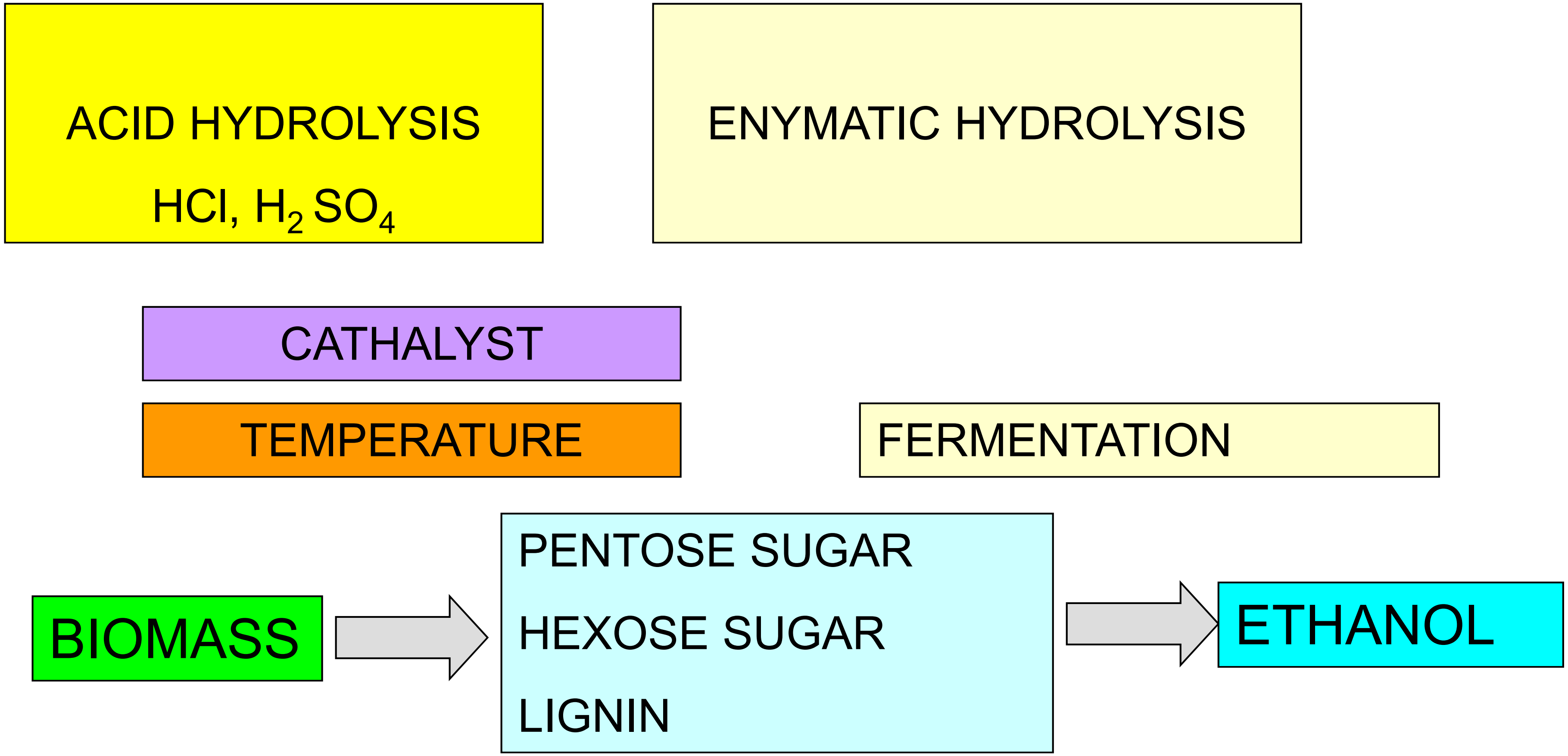
4. Stream gas generator

Based on: W.Rybak:Spalanie i wspólspalanie biomasy, OW PW, Wrocław ,2006

Gasifier	Inlet Gas	Product Gas Type	Product Gas HHV MJ/Nm^3
Partial Oxidation	Air	Producer Gas	7
Partial Oxidation	Oxygen	Synthesis Gas	10
Indirect	Steam	Synthesis Gas	15
		Natural Gas	38
		Methane	41

m=1500kg/h, t=600-800^{O}C

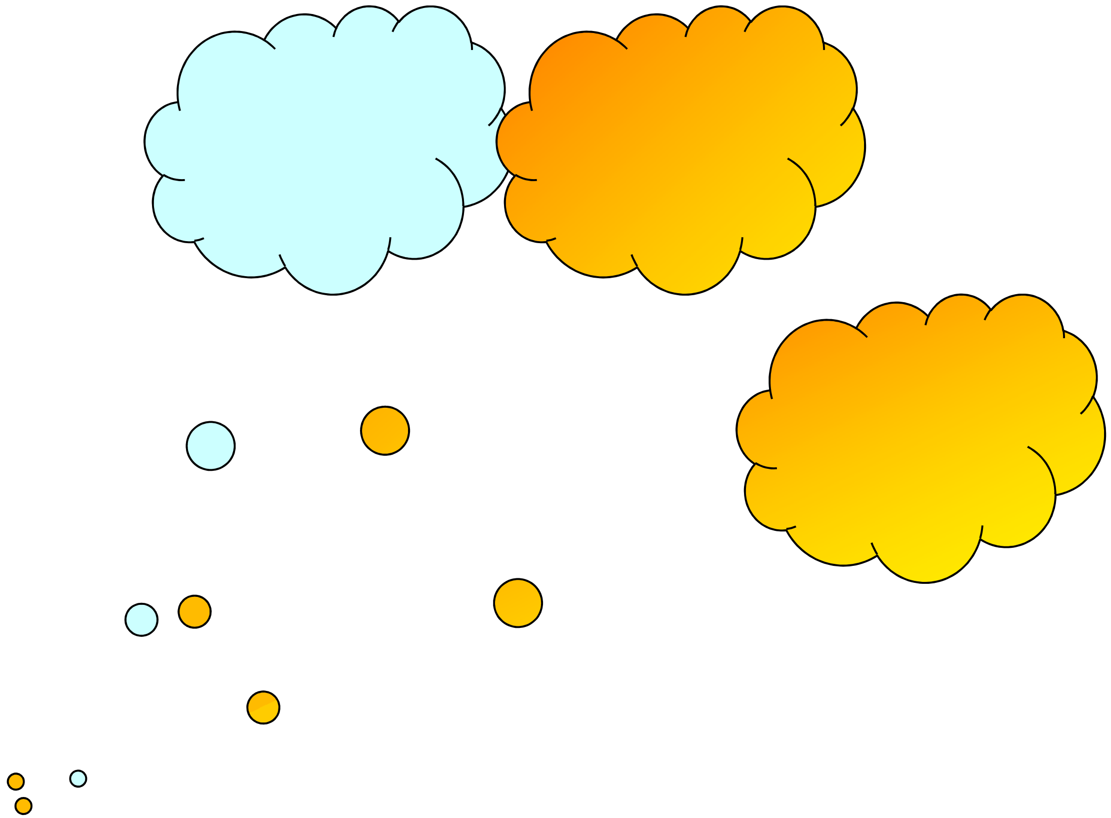

CHEMICAL CONVERSION OF BIOMASS



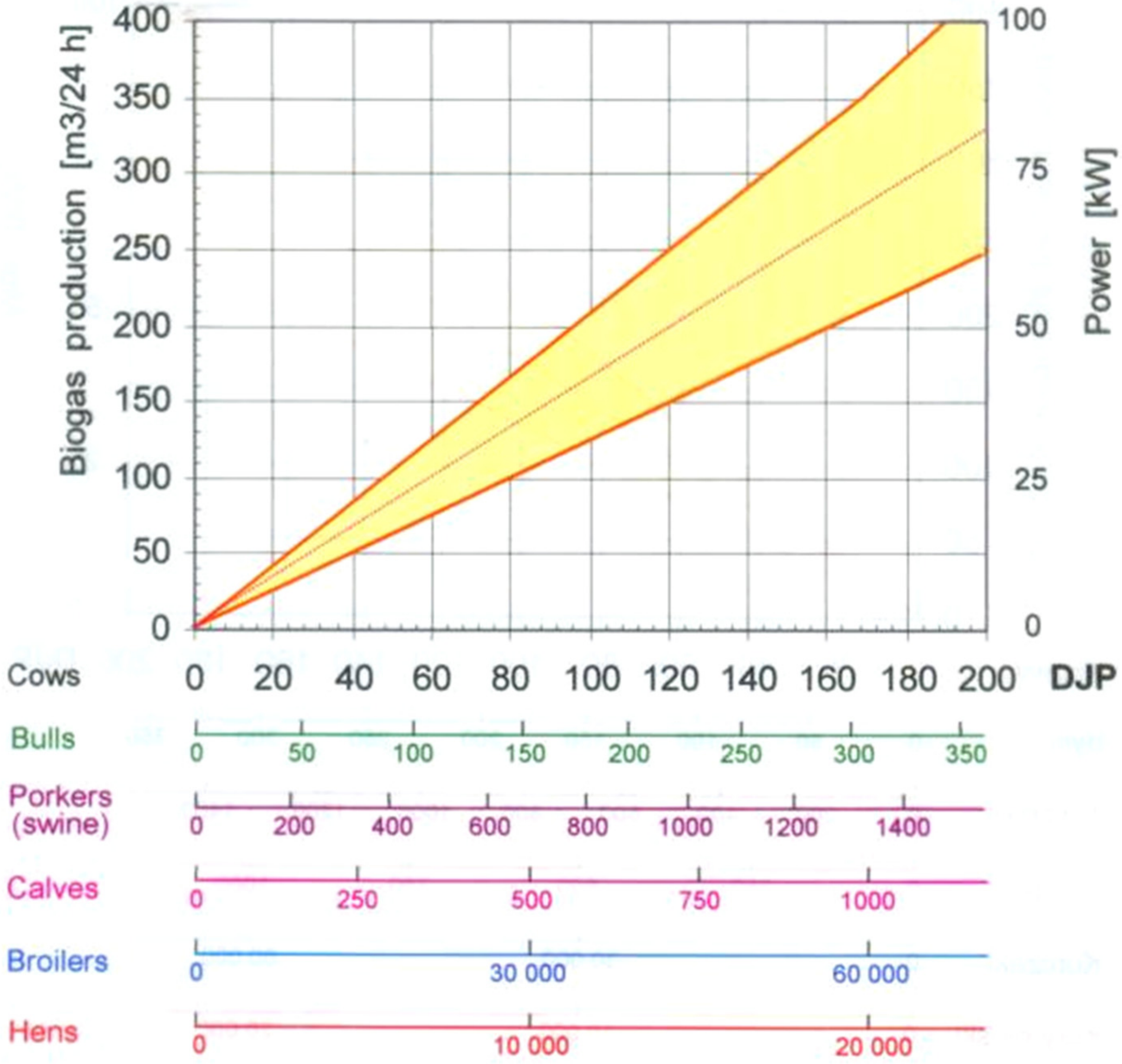
HYDROLYSIS OF BIOMASS:

- CORROSION
- RECOVERY OF ACIDS USED IN PROCESS IS COSTLY

BIOCHEMICAL CONVERSION OF BIOMASS

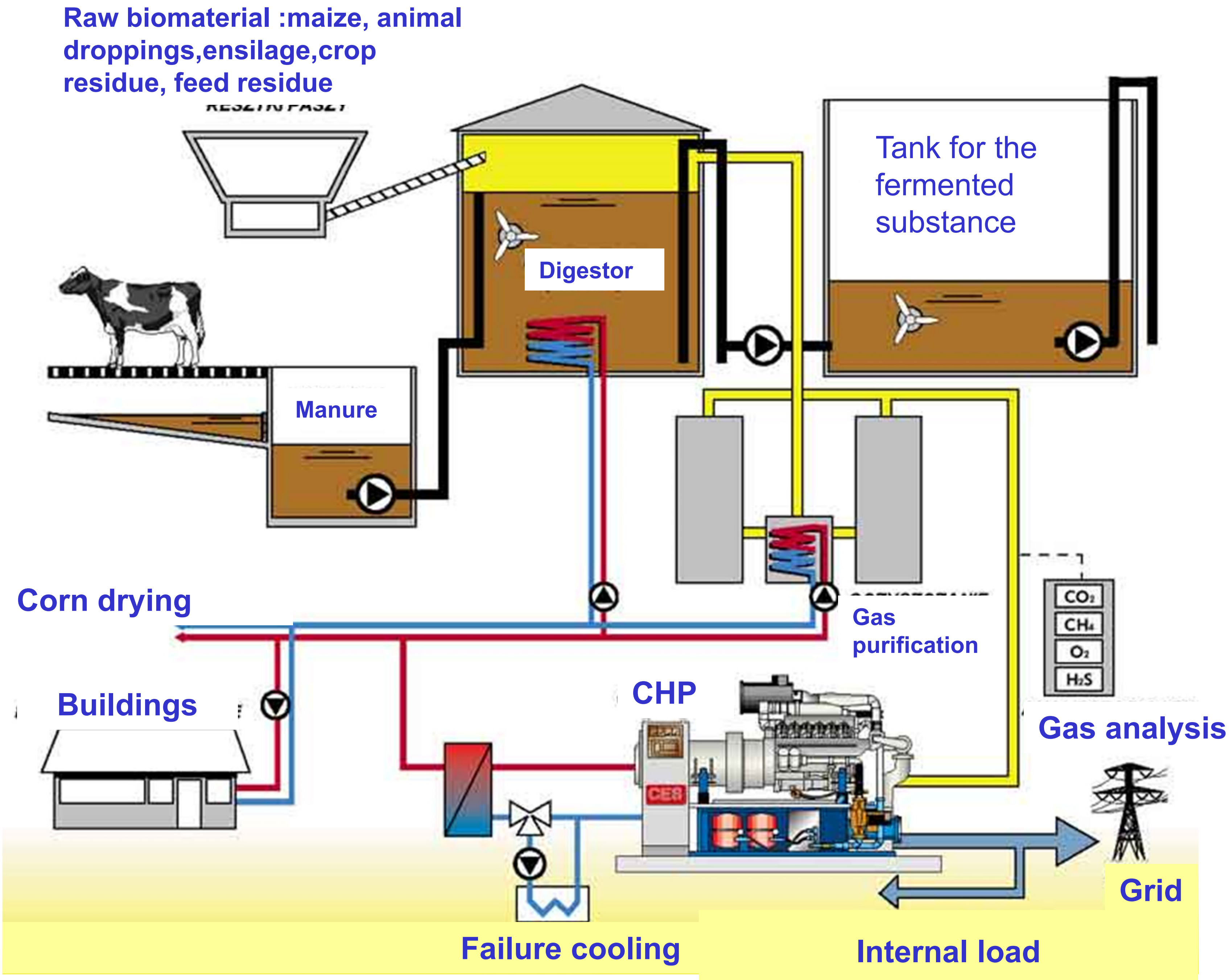


BIOGAS



Estimation of biogas potential from animal's manure and poultry's droppings

(1 DJP = 500 kg weight)



file:///G:/images/Schemat_biogazowni1.jpg

ANAERobic DIGESTION

is the process whereby bacteria break down organic material in the absence of air, yielding a biogas.

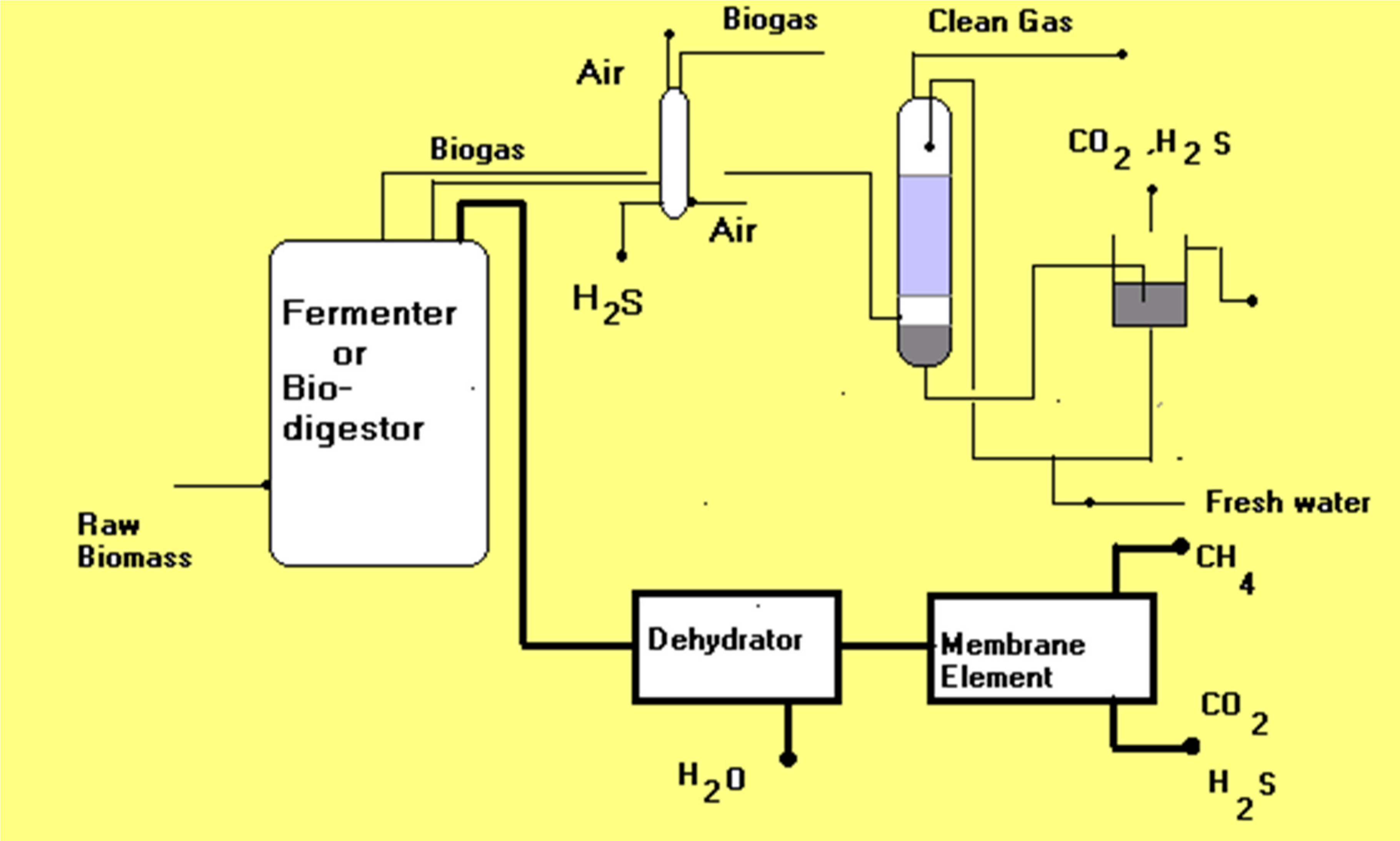
PRODUCTS

- Biogas: CH_4 and CO_2.
- A solid residue - digestate that is similar, but not identical, to compost,
- A liquid liquor that can be used as a fertilizer.

Mesophilic digestion

takes place between t=20ºC - 40ºC and can take a month or two to complete.

Thermophilic digestion takes place t=50-65ºC and is faster, but the bacteria are more sensitive.



Biogas Generation Via A Digestor With Stripping or Membrane Purification

SOURCE http://www.esru.strath.ac.uk/

TYPICAL COMPOSITION OF BIOGAS

Matter	**%**
Methane, CH_4	55-75
Carbon dioxide, CO_2	25-45
Carbon monoxide, CO	0-0,3
Nitrogen, N_2	1-5
Hydrogen, H2	0-3
Hydrogen sulfide, H_2S	0,1-0,5
Oxygen, O_2	traces;

http://www.kolumbus.fi/suomen.biokaasukeskus/en/enperus.html

AVERAGE COMPOSITION LANDFILL GAS

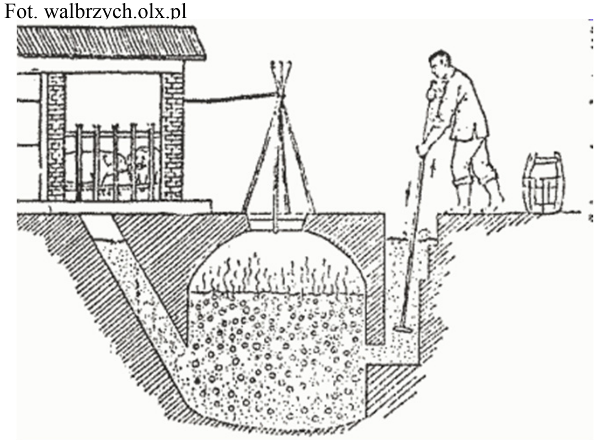
Matter	Content
Methane, CH_4	54 %
Carbon dioxide, CO_2	42 %
Oxygen, O_2	0,8 %
Nitrogen, N_2	3,1 %
Chlorine (total $_2$)	22 mg/ mł
Fluor (total F_2)	5 mg/ mł
Hydrogen sulfide, H_2S	88 mg/mł

http://www.kolumbus.fi/suomen.biokaasukeskus/en/enperus.html

Mikro biogasplants

Autogenous microbiogas plants, where boigas is produced by bacteries of proliferation at t=15 – 20^{o}C.

Fot. walbrzych.olx.pl



Fot. www.flickr.com

Lanfill gas

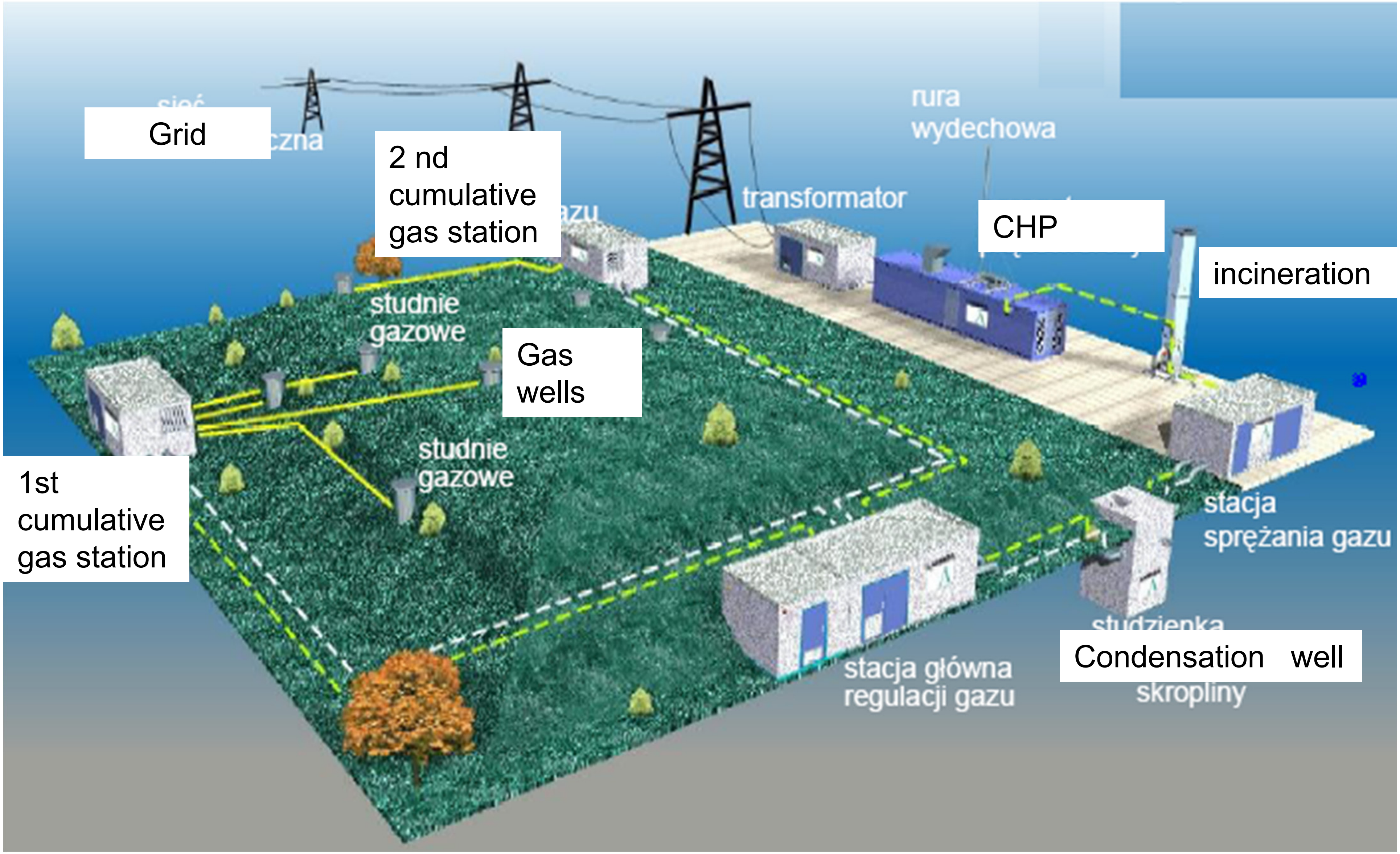
1 t of garbage gives approximately 200 m^3 of landfill gas

http://www.energiaidom.pl/prad-i-cieplo-z-odpadow

Composition of lanfill gas according to EPA (Environmental Protection Agency)

Gas	Chemical formula	Concentration, EPA, ppm
Methane	CH_4	500000
Carbon dioxide	CO_2	500000
Carbon monoxide	CO	309,72
Ammonia	NH_3	
Ethylene	C_2H_4	
Ethane	C_2H_6	1105
Propane	C_3H_8	11,1
Acetone	C_2H_6CO	7,1
Hydrogen sulfide	H_2S	35,5
Ethyl mercaptane	C_2H_2SH	2,28
Methyl mercaptane	CH_3SH	4,34

Scheme of degassing instalation at the waste dump



Swedish –Polish project ,, Biogas from algae”

http://ekogroup.info/wp-content/uploads/2010/06/biogaz_algi_glony_energia-300x201.jpg

- Trelleborg (Sweden) spent yearly 0,5 mln crowns (50 000€/year) for removing algaes(see-weeds)
- Trelleborg i Sopot (Poland) run a project of a biogas plant supplied with algaes
- 1,2 mln € financed from UE, Project ,, Southern Baltic”
- Now machines for collectin algaes are tested
- Fermentation residues contains a lot of Cd ,
- Now the test of the special biofilters for Cd capture are being performed

http://ekogroup.info/szwedzko-polski-biogaz-z-glonow/

COMBUSTION

PRIMARY ENERGY

Chemical energy contained in the fuel

↓

EFFECTIVE ENERGY

Effective energy that comes from combustion of fuel.

↓

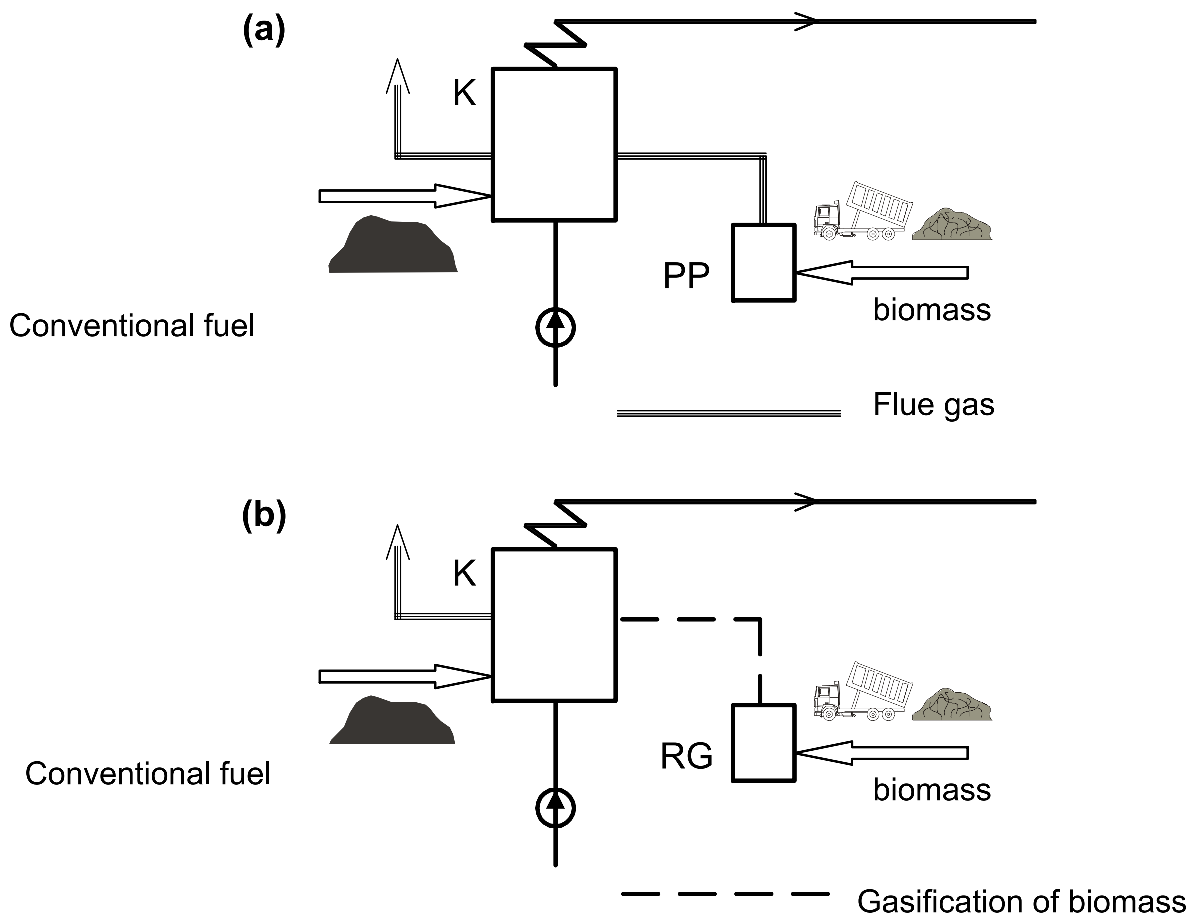
FINAL ENERGY

Effective energy obtained from the fuel ,considering conversion and transportation losses.

SOLID AND LIQUID FUELS				
Combustible			BALAST	
C	S	H_2	ASH	MOISTURE

GAS			
Combustible			BALAST
C	S	H_2	CO_2, N_2, H_2O

ADVANCED TECHNOLOGIES OF BIOMASS COFIRING



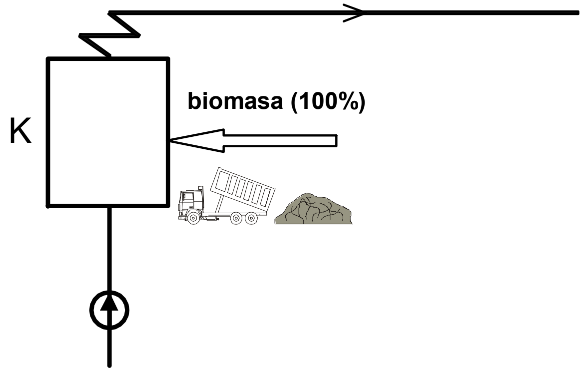
Co-firing of biomass witht e use of Dutch –oven PP (a)
and the gas generaator RG (b)

b) (Lahden Lampovoima Oy, Lahti, Finland)

*SOURCE: H.Kruczek-Prezentacja ,, **Biomasa dla celów energetycznych",Politechnika Wrocławska.,** h_kruczek - biomasa[1]ppt.*

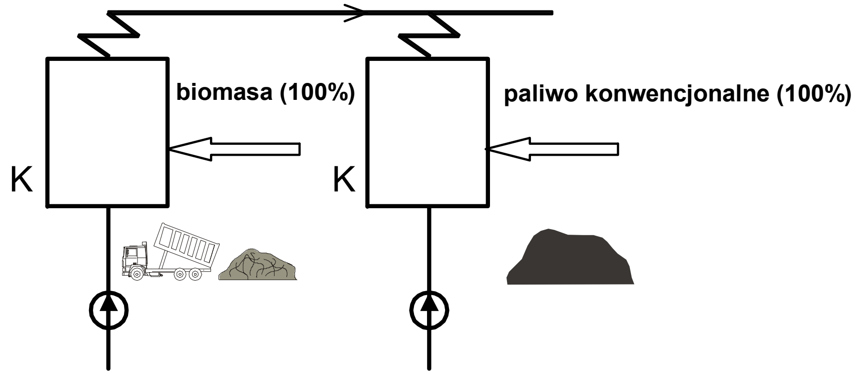
Direct combustion of biomass

(Kokkolan Voima Oy, Finland)



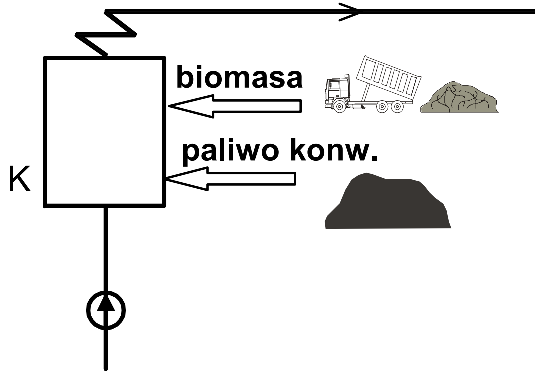
Direct combustion of biomass in The hybrid installations

(Denmark SK Power - Avedore II, Dania)



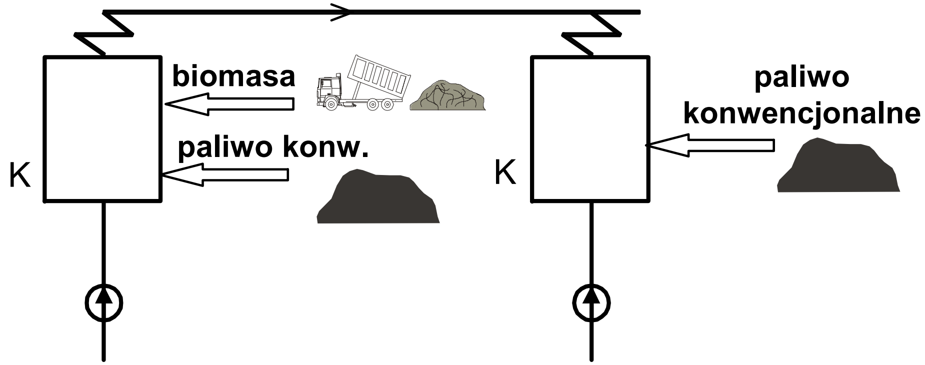
Co-firing of biomass

(Elektrownia Dolna Odra, Szczecin, Poland)

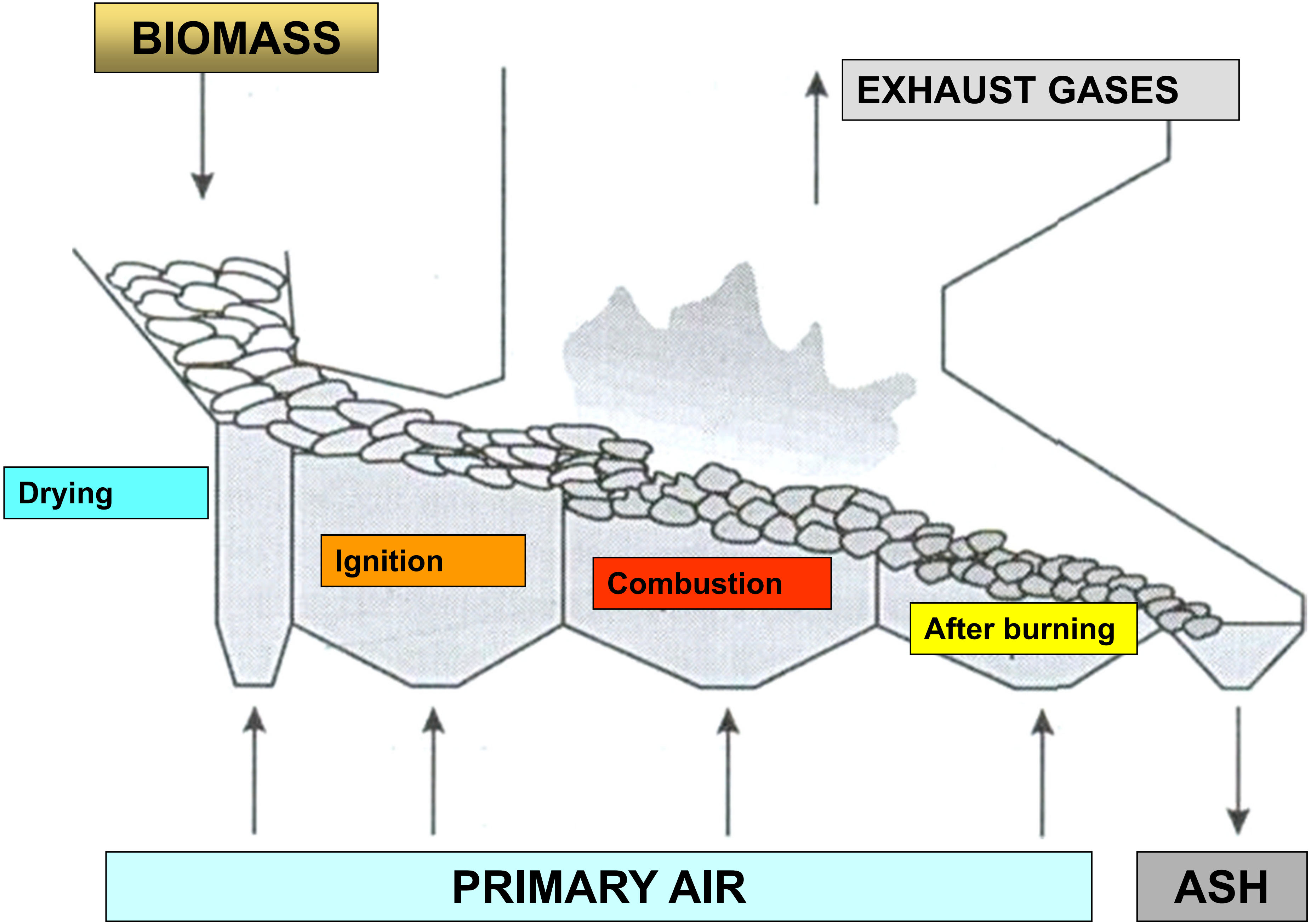


Mixed technology of biomass cofiring

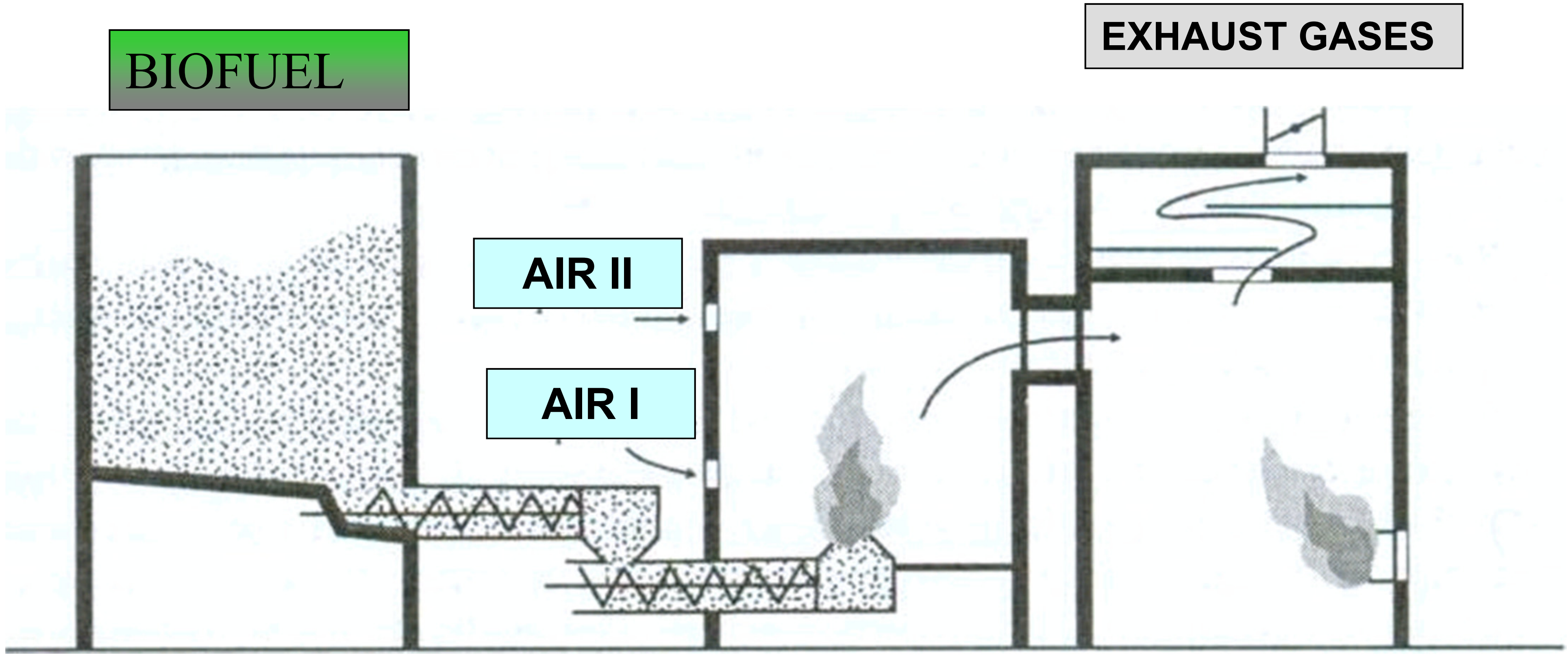
(Zespół Elektrowni Pątnów-Adamów-Konin S.A., Poland)



*SOURCE: H.Kruczek-Prezentacja ,, **Biomasa dla celów energetycznych",Politechnika Wrocławska.,** h_kruczek - biomasa[1]ppt.*

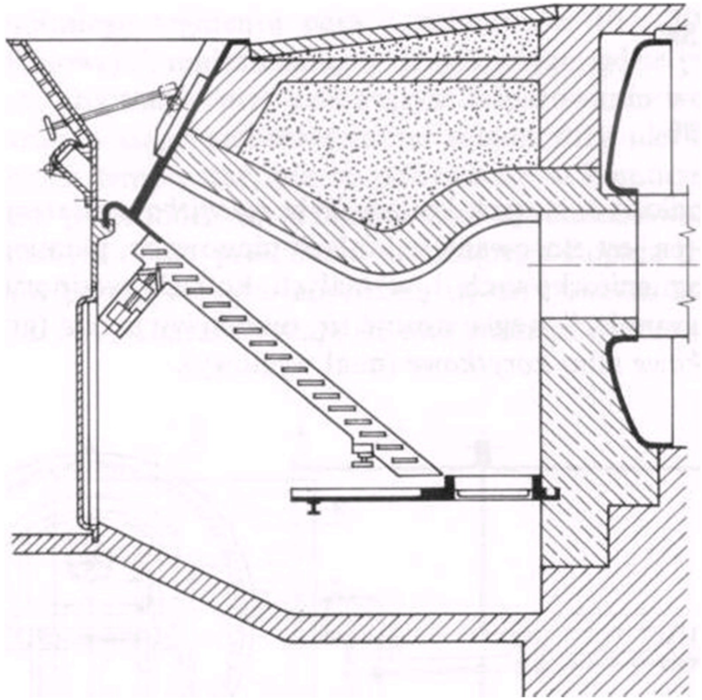


W.Rybak: Spalanie i współspalania biomasy,WO PW, 2006



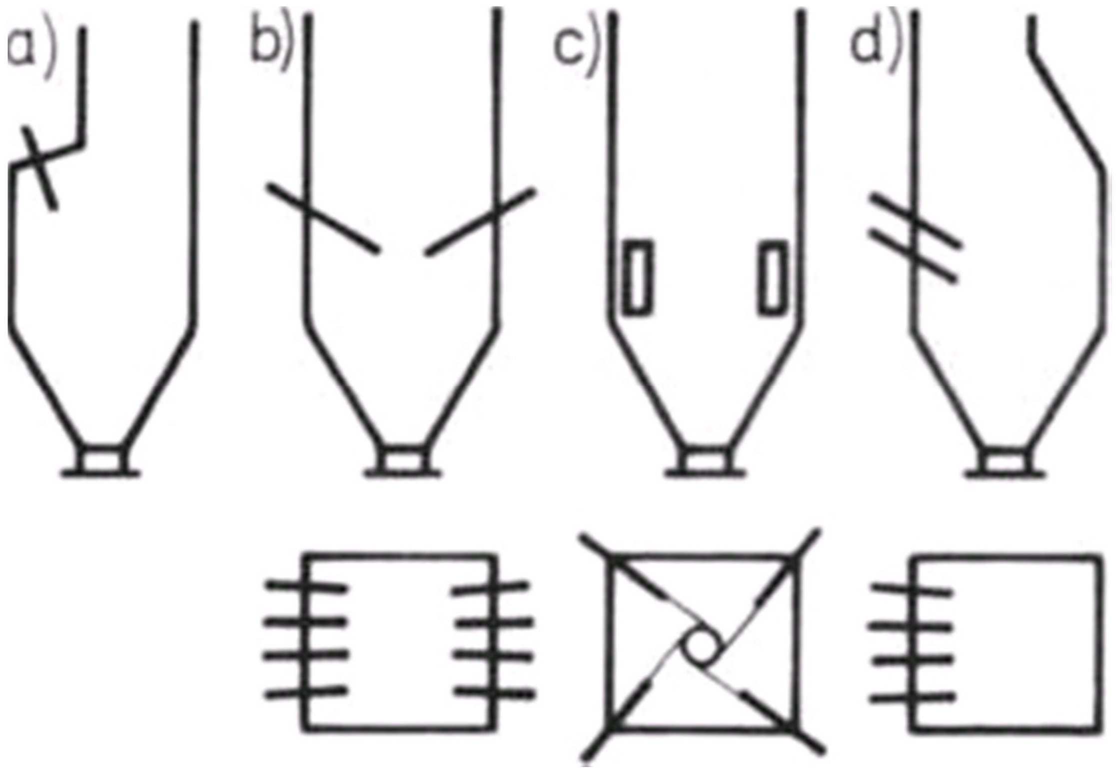
COMBUSTION OF BIOMASS IN THE BOILER EQUIPPED WITH THE DUTCH OVEN

W.Rybak: Spalanie i współspalania biomasy,WO PW, 2006



BOILER FURNACE

SYSTEM OF POWDERED-FUEL BURNERS

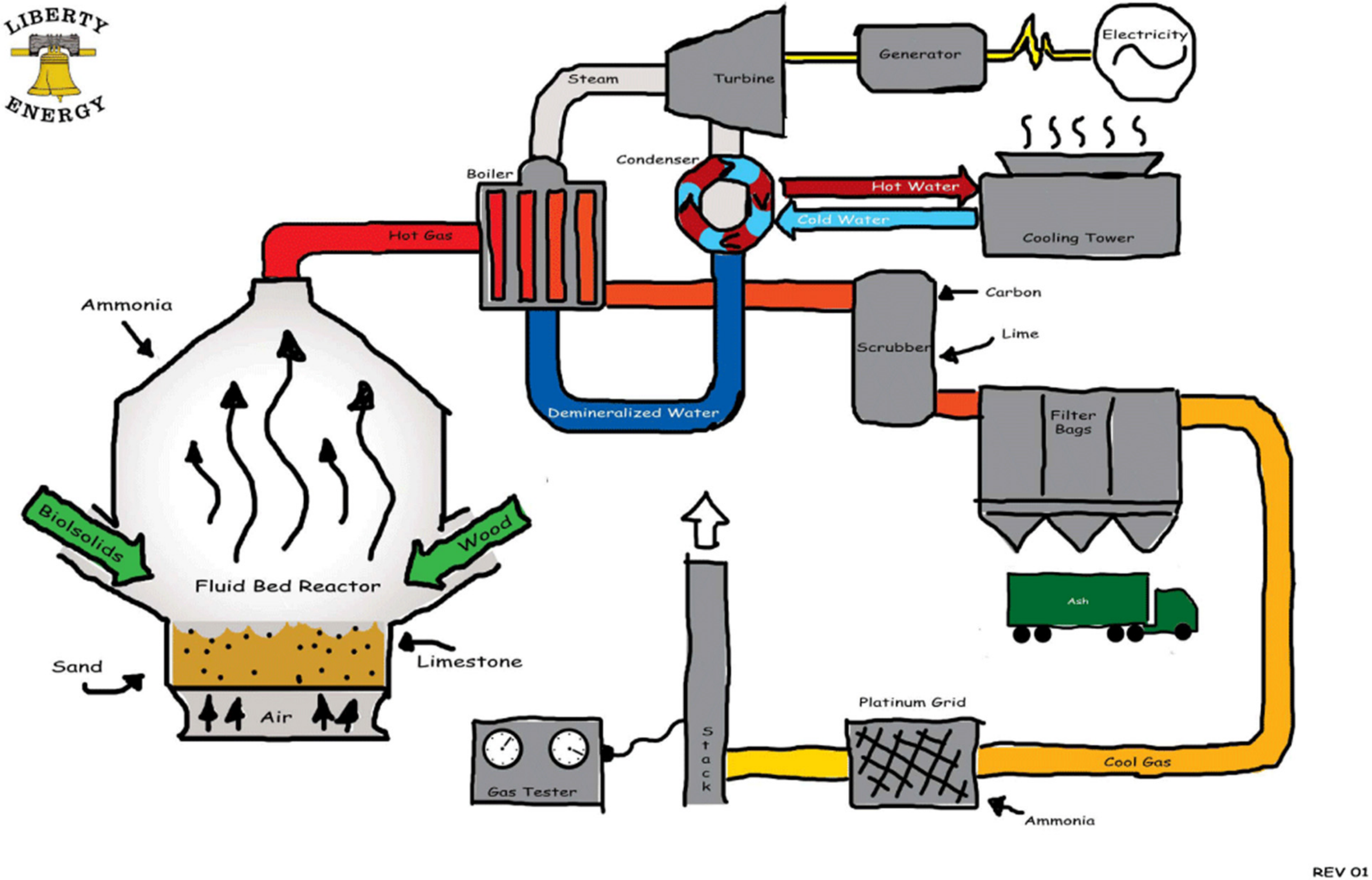


BIOMASS CO-FIRING

IN THE POWER PLANT DOLNA ODRA STARE CZARNOWO

Photos: A.Majchrzycka

FLUIDISED BED BOILERS



Heat boiler fuelled with:

- wood
- wooden briquettes,
- sawdust,
- peat,
- straw.

- coke,
- hard coal, brown coal,
- hard coal dust
- oil fuel

Heat boiler "WARMET-SDS Ceramik"

Parameters of heat boiler:

- maximal heat power 13,5 kW,
- efficiency ,when feeded with the solid fuel 80 %
- efficiency when feeded with the fuel oil >92 %

Heat boilr fuelled with:

pellets

– eko-pea,

– wood .

Heat boiler parameters:

– maximal heat power 13,5 kW,

– nominal effciency 87 %

Heat boiler -Ling Combi

Heat boiler fuelled with:

– straw

– wood

Heat boiler parameters:

– nominal heat power 15 kW,

– nominal effciency 80 %

– single load of combustion chamber:

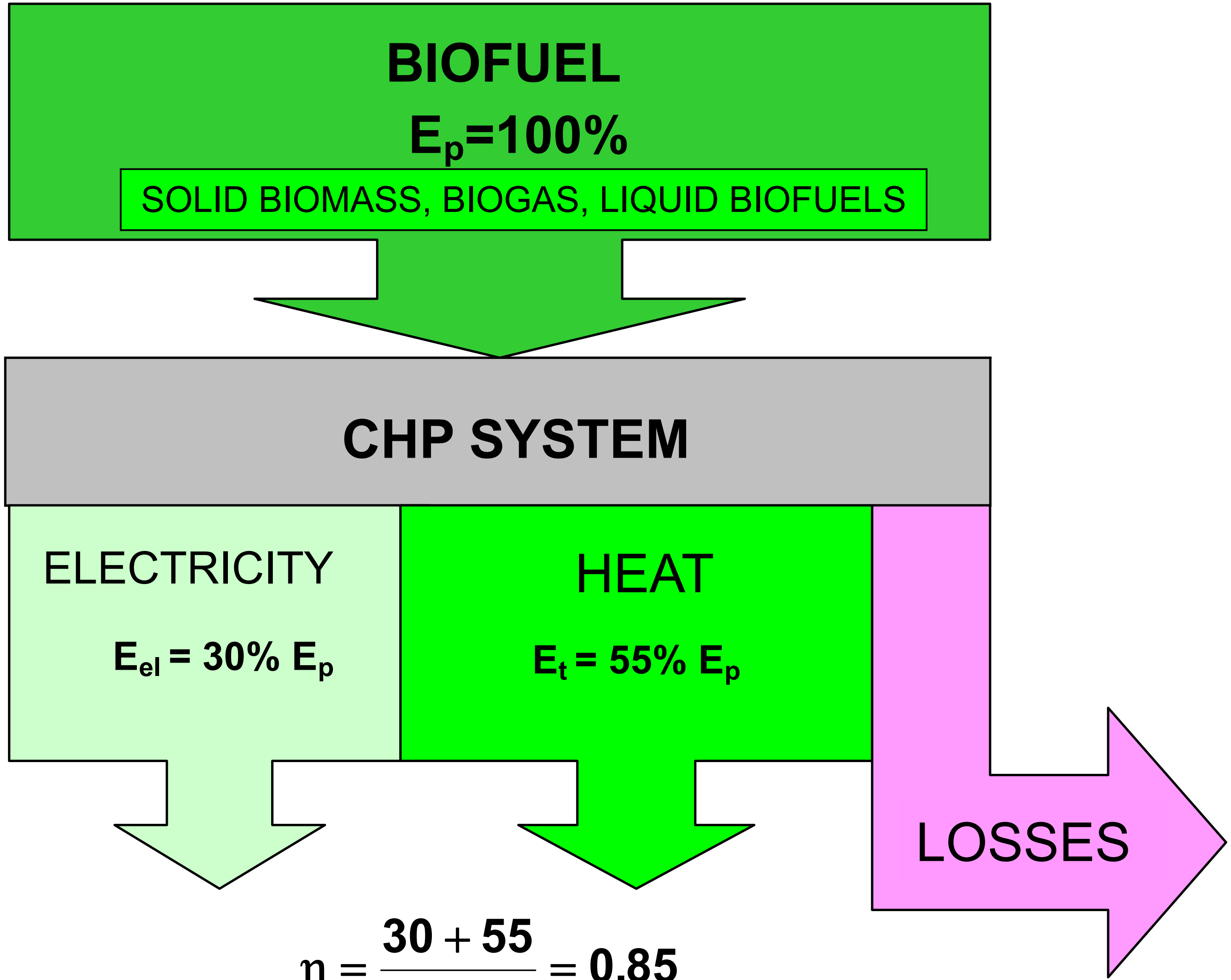
2 straw bricks of 45x40x80 cm

STRAW FIRED BOILER IN THE SMALL RURAL HEAT GENERATING PLANT

CHP

COMBINED HEAT AND POWER

COMBINED HEAT AND POWER PRODUCTION



$$\eta = \frac{30 + 55}{100} = 0{,}85$$

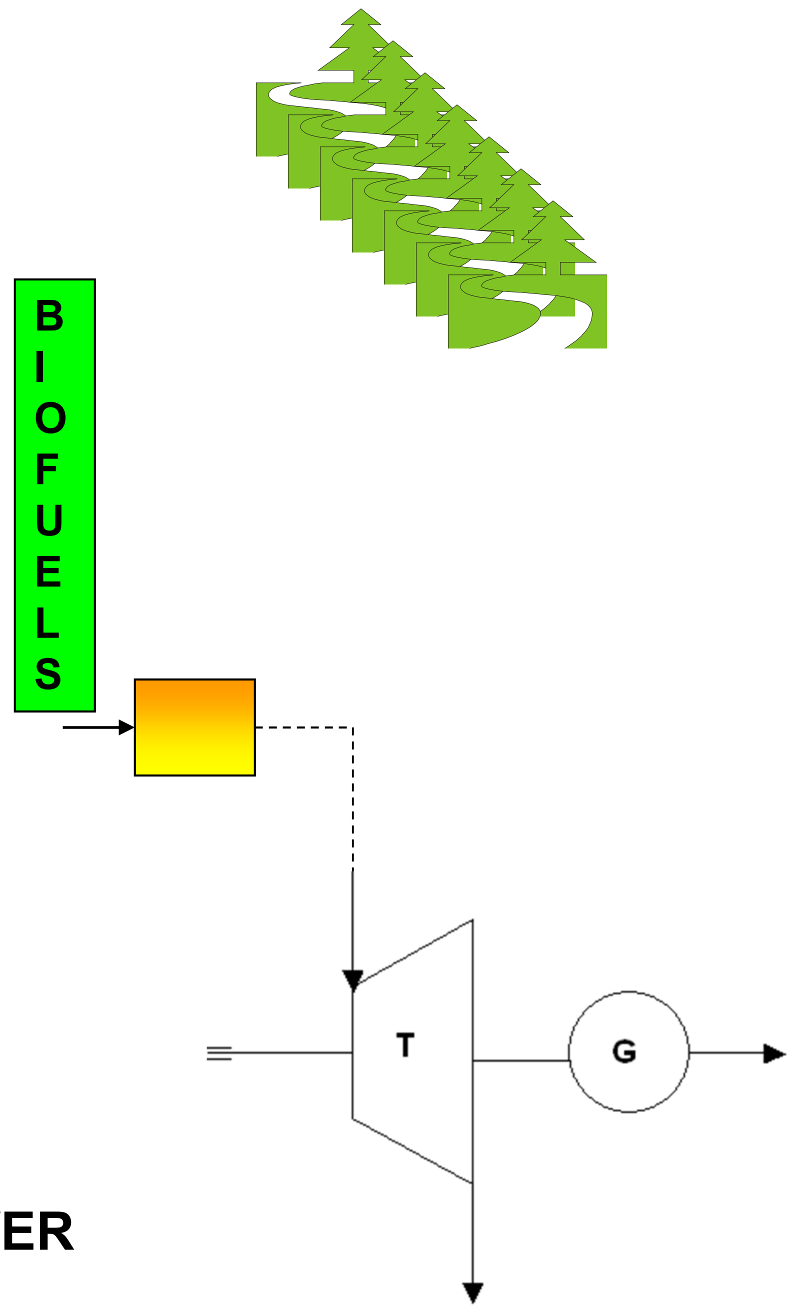
PLANNING

↓

REALISATION OF THE PROJECT

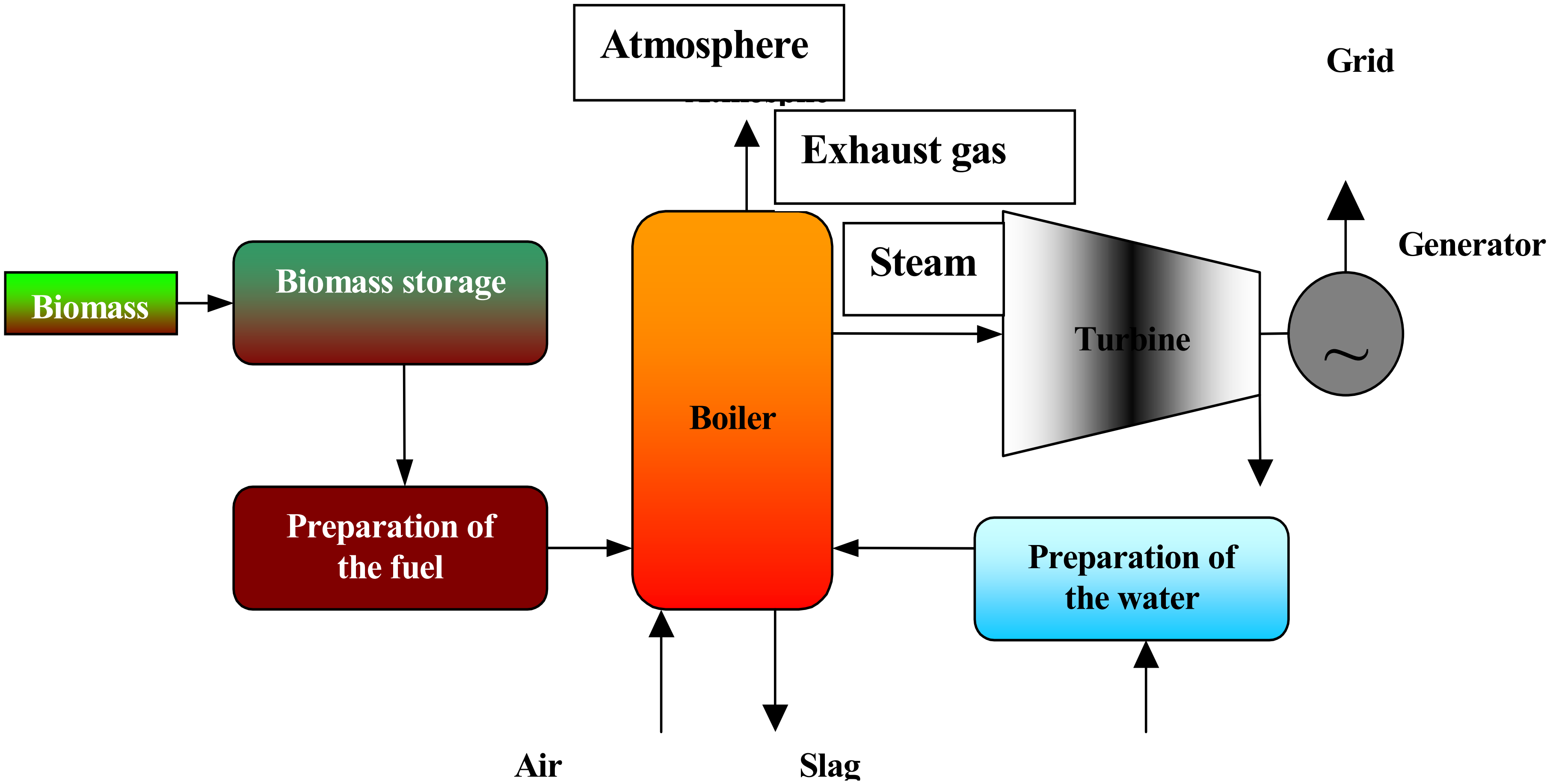
↓

EXPLOITATION



COMBINED HEAT AND POWER

CHP



COMBINED HEAT AND POWER PRODUCTION

ADVANTAGES OF CHP :

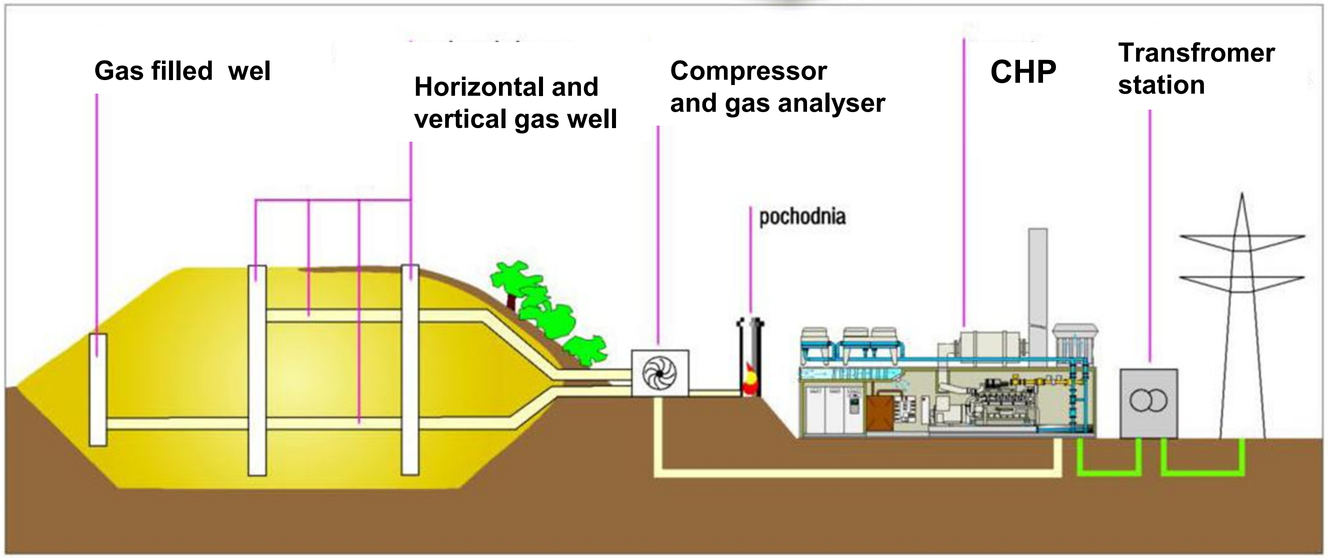
- Energetic efficiency about 40% higher than separated production of electricity and power,
- About 30% less fuel consumption than that in the conventional boilers,
- Reduced emissions,
- Lower production costs .

CHP SYSTEMS BASED ON COMBUSTION OF :

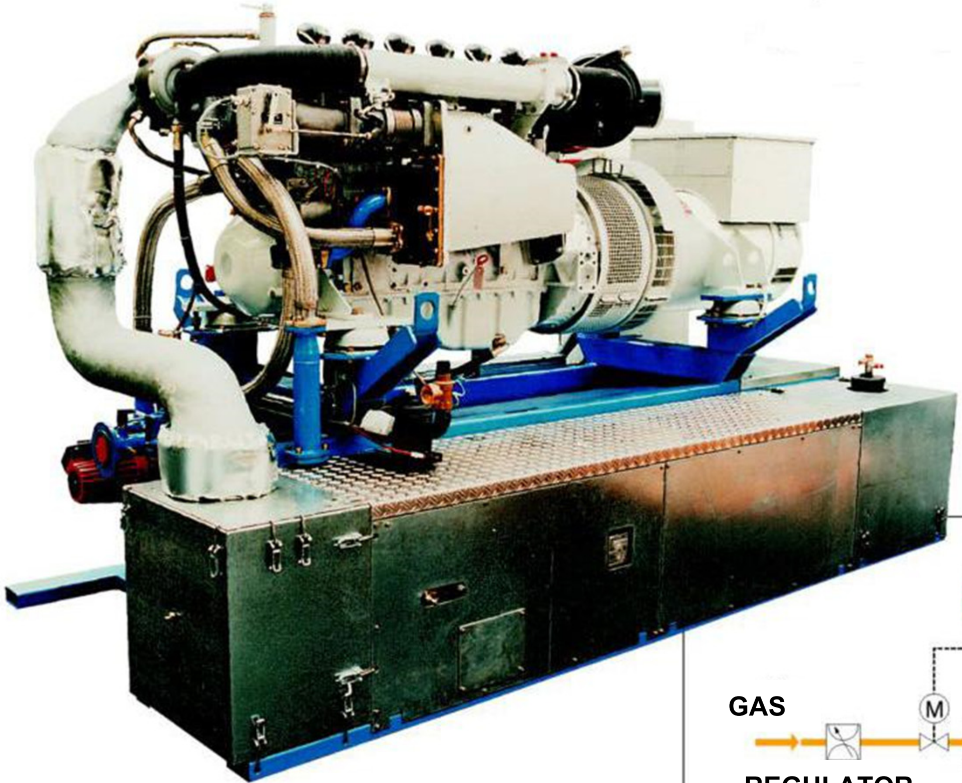
- BIOMASS,
- BIOGAS,
- LANDFILL GAS,
- SLUDGE,
- **RDF** (**R**esidue **D**elivered **F**uel),
- **MDF** (**M**unicipal **D**elivered **F**uel).

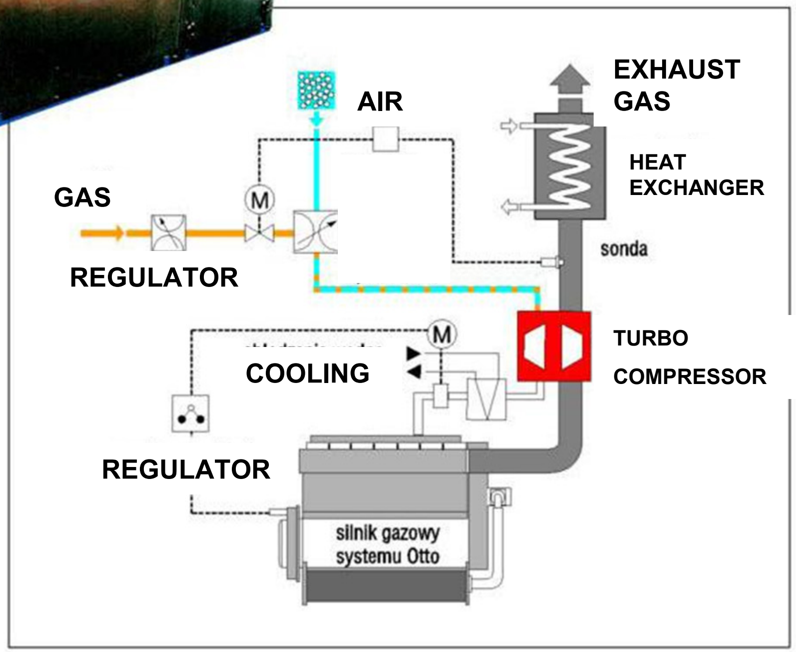
η_{th} = 90% η_{el} = 32-37%

LANDFILL FIRED CHP SYSTEM

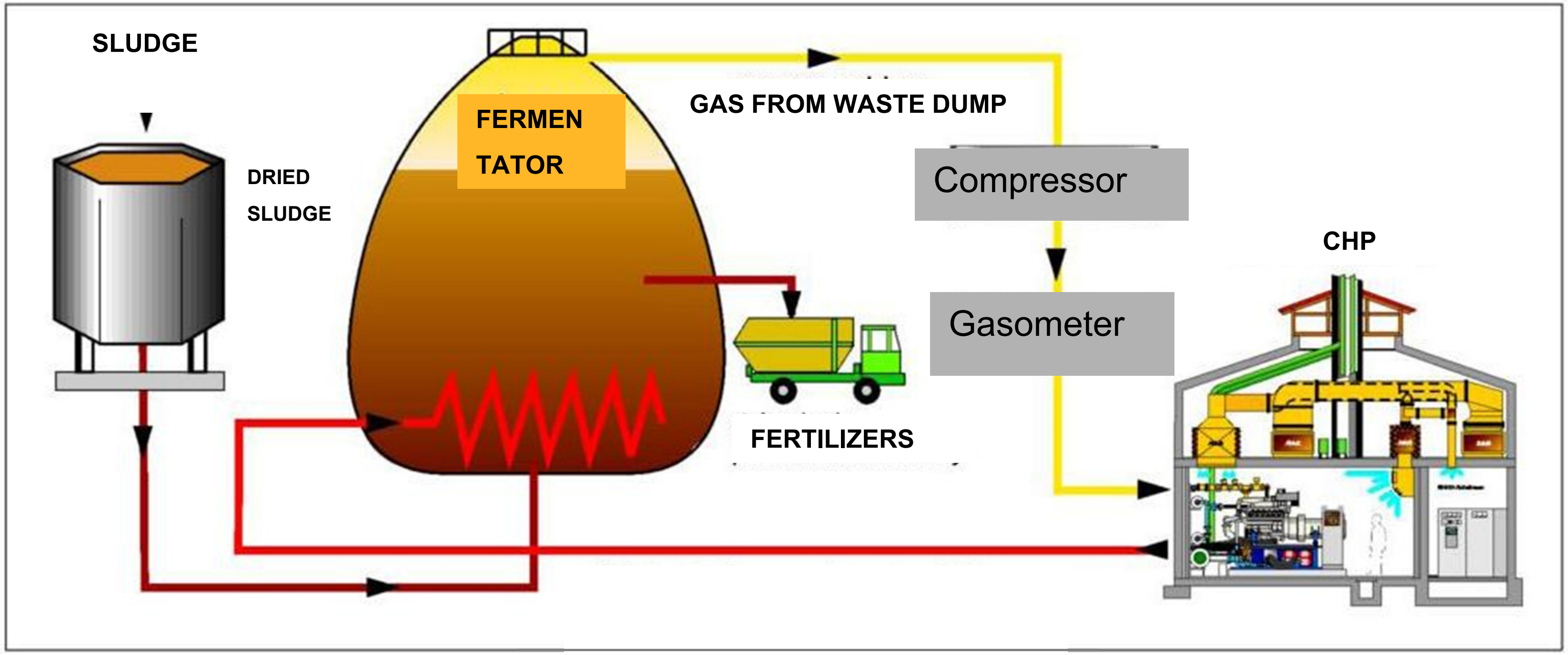


GAS FUELLED CHP SYSTEM





SLUDGE CHP SYSTEMS



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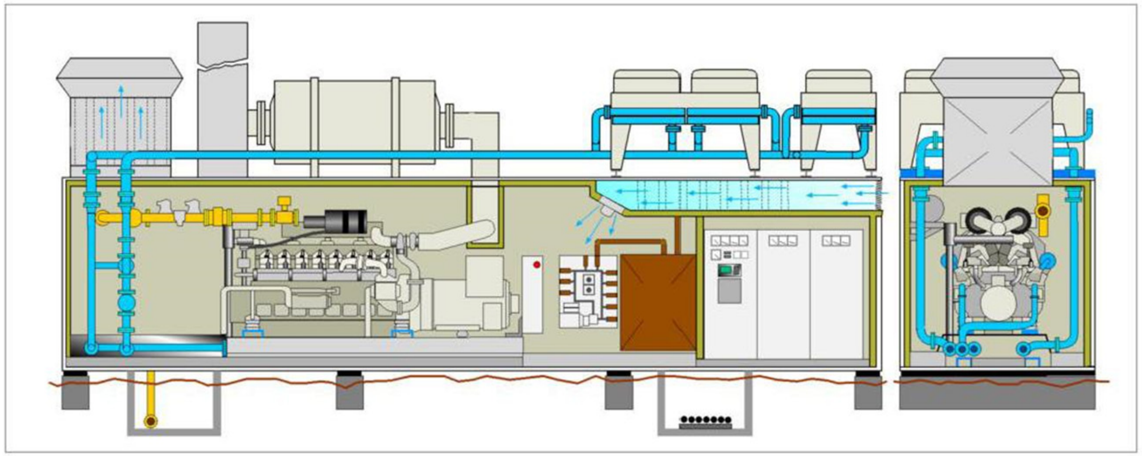
GHP MODULES



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World energy scenarios – Future goals

No.			Source
1.	Non collected straw (50%)	75 000 PJ/year	Sanders J.: *Biorefinery, the bridge between Agriculture and Chemistry.* Wageningen University and Researchcenter. Workshop: Energy crops & Bioenergy.
2.	Collected waste processing (50%)	45 000 PJ/year	
3.	Forest/pastures (50%)	150 000 PJ/year	
4.	10% of arable land – World Wide (20tTS/ha)	51 000 PJ	Holm-Nielsen J.B., Madsen M., Popiel P.O.: *Predicted energy crop potentials for biogas/bioenergy. Worldwide – regions – EU25.* AAUE/SDU. Workshop: Energy crops & Bioenergy.
5.	20% of arable land – World Wide (20tTS/ha)	101 000 PJ	
6.	30% of arable land – World Wide (20tTS/ha)	152 000 PJ	
Sum: 1+2+3+5		371 000 PJ	

	Predicted value	Source
Total energy required year 2050	1 000 000 PJ/year	Sanders J.: *Biorefinery, the bridge between Agriculture and Chemistry.* Workshop: Energy crops & Bioenergy.
Total energy demand year 2050	1 300 000 PJ/year	Shell's World Energy Scenario

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