



**AKADEMIA GÓRNICZO-HUTNICZA
IM. STANISŁAWA STASZICA W KRAKOWIE**

Coal Gasification

Outgasing of Coal

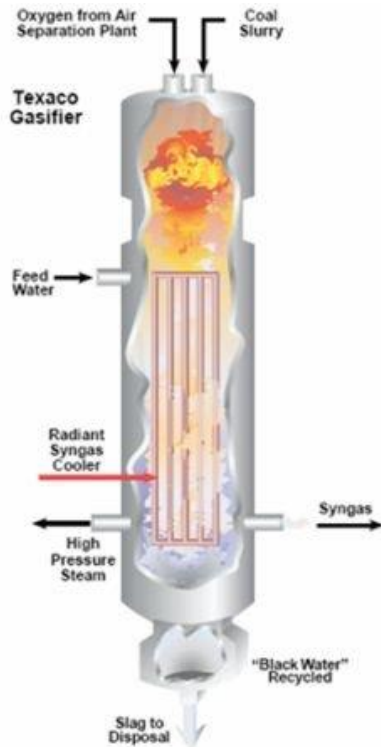
Faculty of Energy and Fuels, AGH - UST

Krakow, 2012

Coal Gasification

Coal gasification is the process of producing coal gas, a type of syngas from coal

Alternatively, the coal gas can be converted into transportation fuels such as gasoline and diesel through additional treatment, e.g. in the Fischer-Tropsch process.



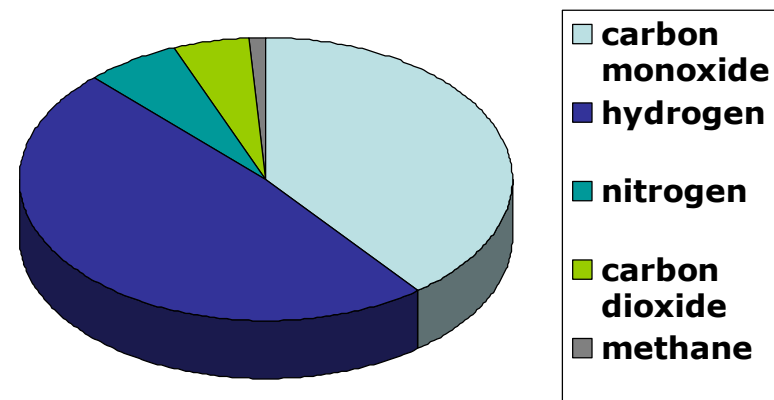
Synthesis (water) gas

Water gas is a **synthesis gas** („town gas“), containing carbon monoxide and hydrogen. It is a useful product but requires careful handling because of the risk of carbon monoxide poisoning. The gas is made by passing steam over a red-hot carbon fuel such as coke:



mixture of:

- carbon oxide (II) (ca. 39%)
- hydrogen (ca. 48%)
- nitrogen (ca. 6%)
- carbon dioxide (IV) (ca. 5%)
- methane (ca. 1%)



heating value – 10.9 MJ/m³.

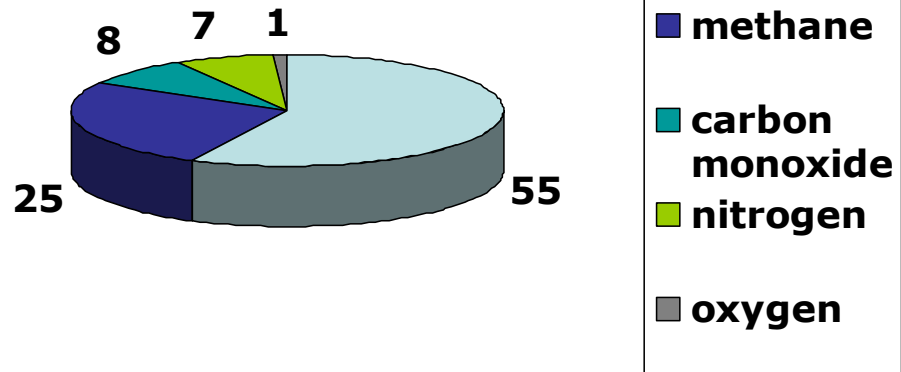
Synthesis (water) gas

Refination over iron oxides:



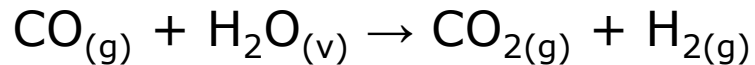
„Town Gas“

heating value $\sim 17,5 \text{ MJ/m}^3$



Water-Gas Shift Reaction

The water-gas shift reaction (WGS) is a chemical reaction in which carbon monoxide reacts with water vapor to form carbon dioxide and hydrogen:



catalyst

- Fe_3O_4 (magnetite)
- other transition metals and transition metal oxides
- Raney copper catalyst

Generator Gas

Generator gas is a gaseous fuel obtained by a specific process of solid fuel gasification (coal, tars, biomass). Composition of gas depends on construction of generator, source material and gasifying agent.

Generally contains hydrogen, carbon monoxide, methane, water vapor, carbon dioxide and nitrogen.

heating value $\sim 4\text{-}5.5 \text{ MJ/m}^3$



Wood Gas (Holzgas)

Wood gas is a syngas fuel which can be used as a fuel for furnaces, stoves and vehicles in place of petrol, diesel or other fuels.

During the production process biomass or other carbon-containing materials are gasified within the oxygen-limited environment of a wood gas generator to produce hydrogen and carbon monoxide.

Composition:

- Nitrogen N_2 : 50.9%
- Carbon monoxide CO : 27.0%
- Hydrogen H_2 : 14.0%
- Carbon dioxide CO_2 : 4.5%
- Methane CH_4 : 3.0%
- Oxygen O_2 : 0.6%

heating value 15-18 MJ/kg



Generator Gas (coal and coke)

Generator gas is a syngas fuel which can be used as a fuel for furnaces, stoves. Was used in the public gas network for heating and cooking purpose.

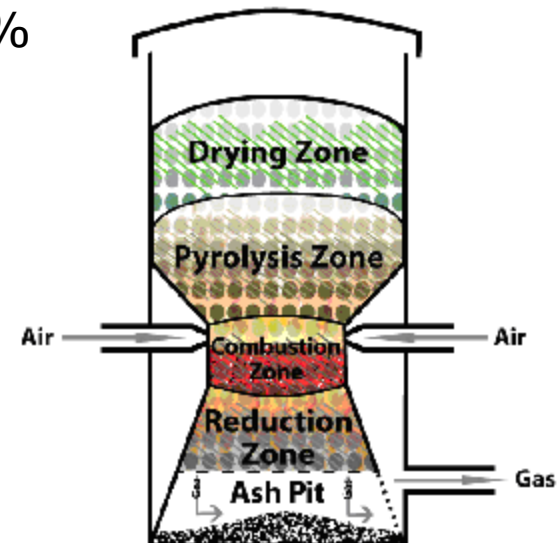
Generator gas was produced in the gas producers in cooprocess of low temperature carbonization and gasification in the mixture of air and steam.

Composition from coke (coal):

- Nitrogen N₂: 55.3 (52.0)%
- Carbon monoxide CO: 29.0 (26.5)%
- Hydrogen H₂: 11.0 (13.5)%
- Carbon dioxide CO₂: 3.8 (5.0)%
- Methane CH₄: 0.7 (2.5)%
- Oxygen O₂: 0.2 (0.2)%

heating value 5.1 (5.9) MJ/m³

Downdraft Gasifier
Nozzle and constriction (Imbert)



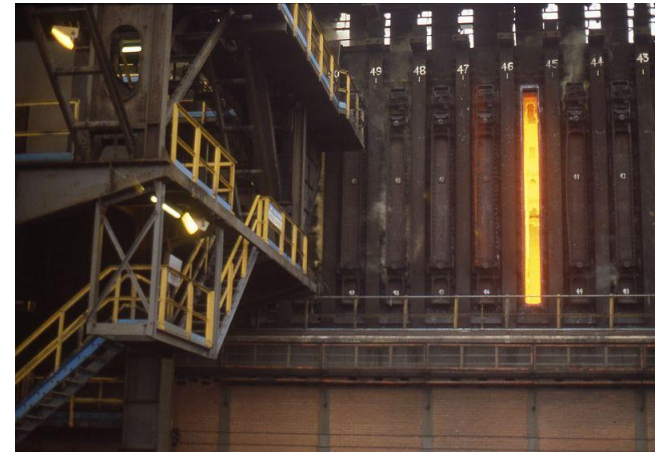
Coke Gas

Coke gas is a fuel which can be used as a fuel for blast furnaces (metal production) or heating of coking cells.

Raw coke gas contains many admixtures. After purification its composition is:

- hydrogen H_2 : 53–60
- methane CH_4 : 23–28
- heavy hydrocarbons C_nH_m : 2–4
- carbon monoxide CO : 6–10
- nitrogen N_2 : 3–8
- oxygen O_2 : <1

heating value $\sim 17 \text{ MJ/m}^3$



Blast Furnace Gas

Blast furnace gas is a waste gas from metallurgy process which can be used as a fuel for energy purpose: heat and wet steam production.

Raw coke gas contains many admixtures. After purification its composition is:

- hydrogen H_2 : 2%
- methane CH_4 : 0.3%
- carbon monoxide CO : 28.5–32.0%
- carbon dioxide CO_2 : 7.5-11.0%
- nitrogen N_2 : 58.0%
- oxygen O_2 : 0.2 %

heating value $\sim 4.3 \text{ MJ/m}^3$

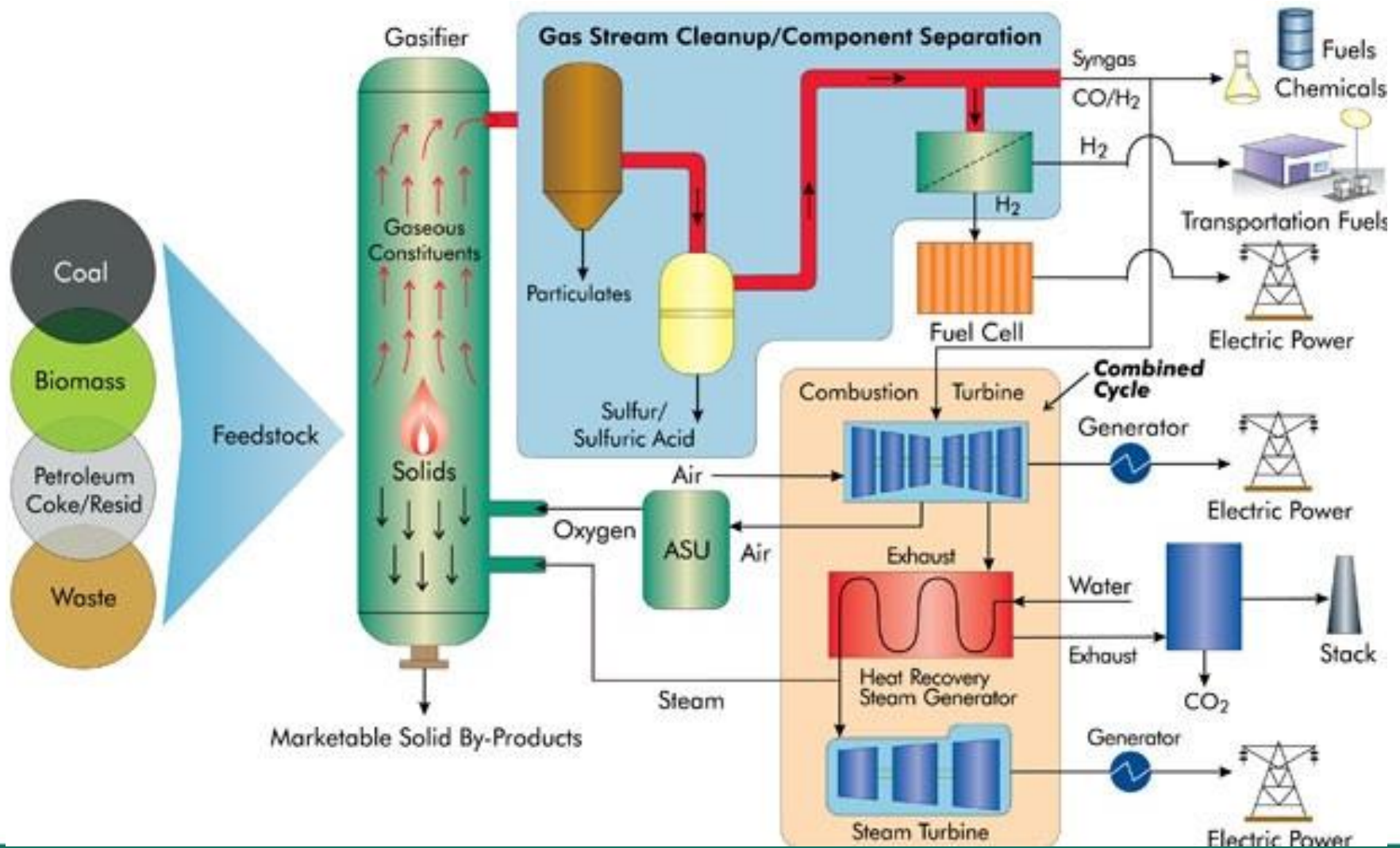


Syngas production

Process comparison

Source→	Coal		Oil remains		Natural gas
Process	gasification		gasification		water vapor conversion
	Koppers-Totzek	Lurgi	Shell	Texaco	
Pressure	0.105	2-3	5.4	8.5	2-35
Content:					
H ₂	28.7	40.2	45.9	63.0	76.0
CO	57.0	20.6	48.6	1.8	13.0
CH ₄	0.1	10.7	0.5	0.3	2.0
C ₂ +	-	1.0	-	-	-
N ₂	1.4	0.3	0.2	0.1	-
CO ₂	12.6	26.9	4.0	34.2	9.0
H ₂ S	0.2	0.3	0.8	0.6	-
H ₂ /CO	0.5	1.95	0.94	--	5.85

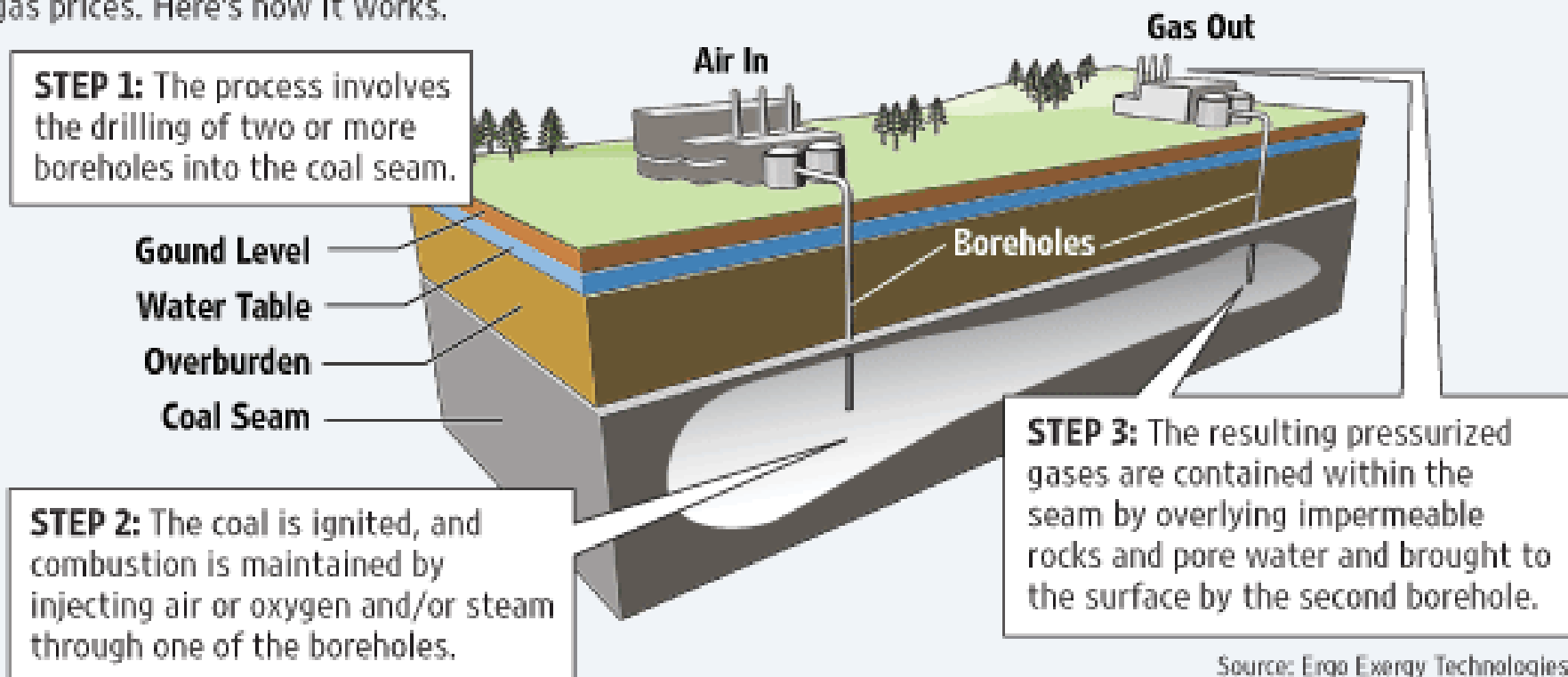
Concept of gasification



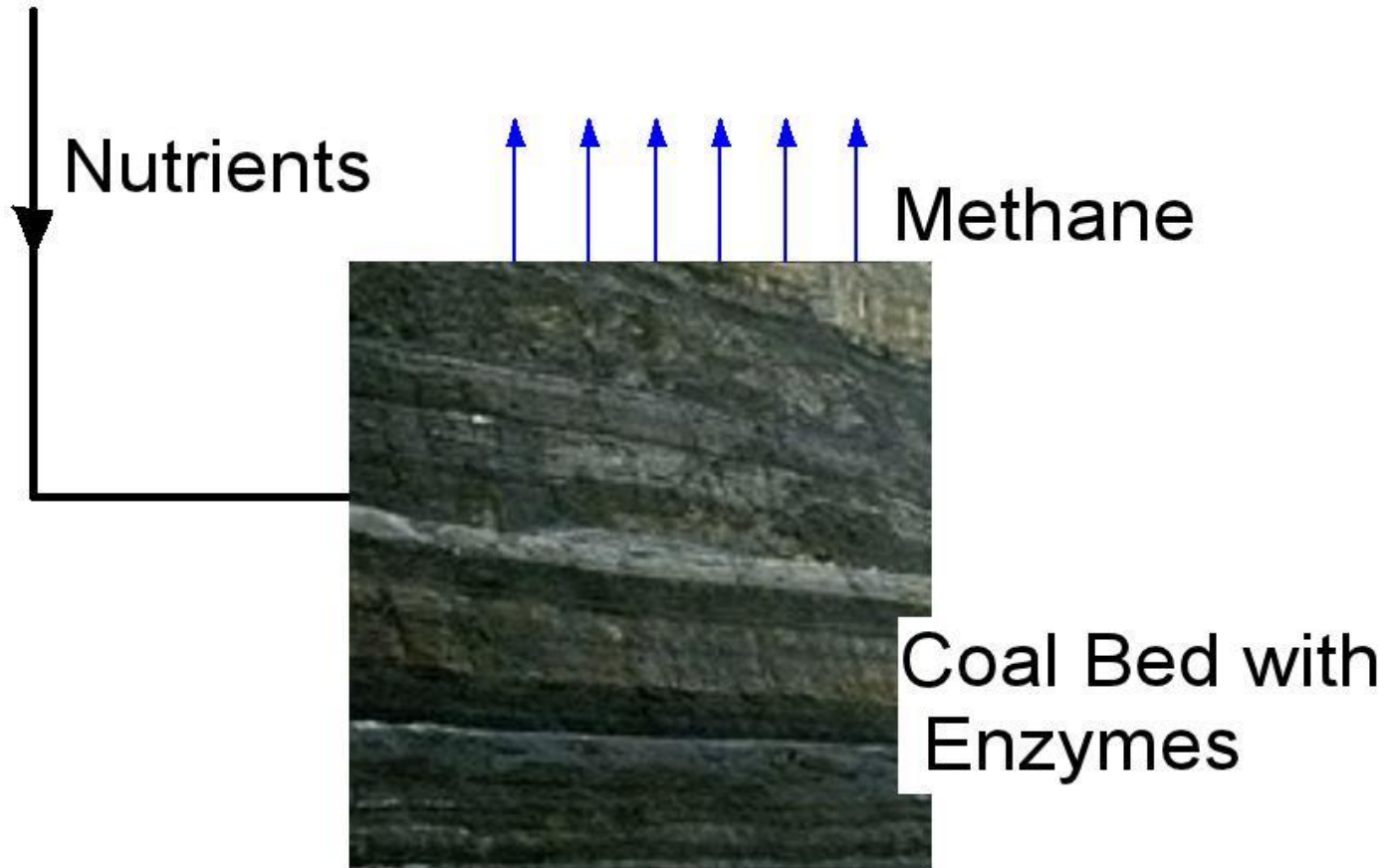
Underground coal gasification

Below the Surface

Underground coal gasification had been largely abandoned in recent decades because increasing reserves of oil and natural gas provided cheaper alternatives. Now, though, it's making a comeback because of higher oil and gas prices. Here's how it works.

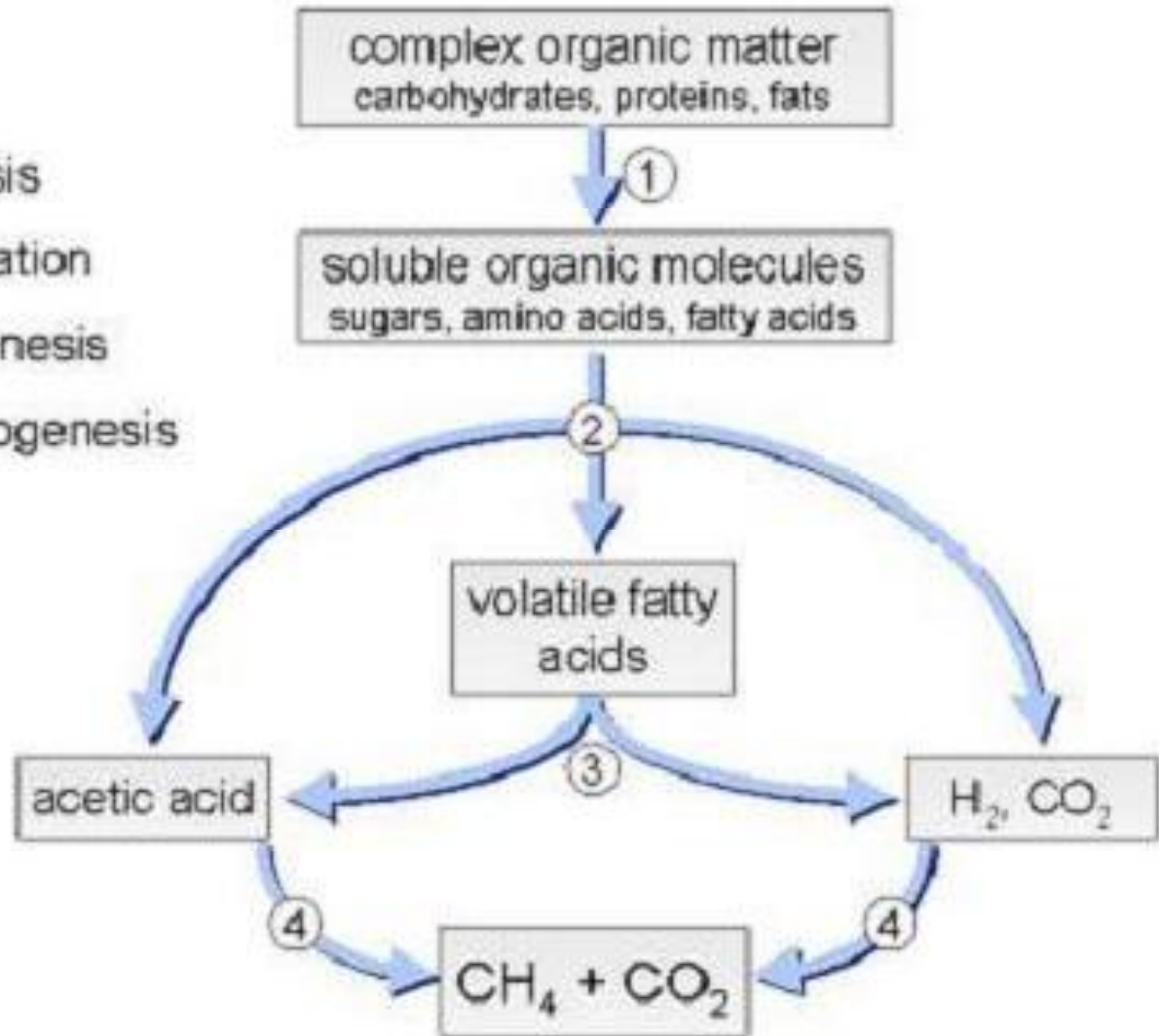


Underground coal sludge utilisation

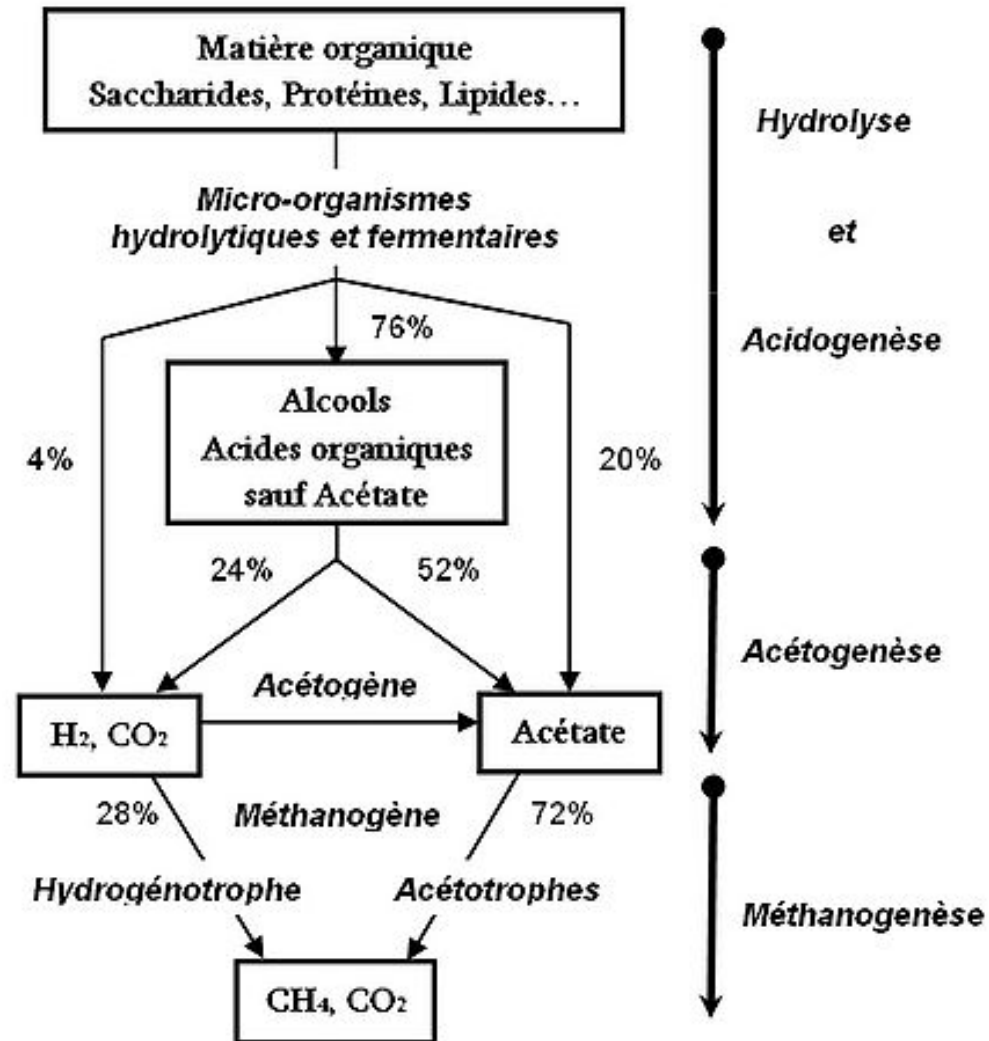


Biogas production

- ① hydrolysis
- ② fermentation
- ③ acetogenesis
- ④ methanogenesis



Different pathways of methane production



Biogas composition

Biogas is a mixture of gases that is composed of:

methane (CH₄): 40 - 70 vol.%

carbon dioxide (CO₂): 30 - 60 vol.%

other gases: 1 - 5 vol.%

including:

hydrogen (H₂): 0 - 1 vol.%

hydrogen sulfide (H₂S): 0 - 3 vol.%

heating value: 17-27 MJ/m³



Gaseous fuels

Gases

