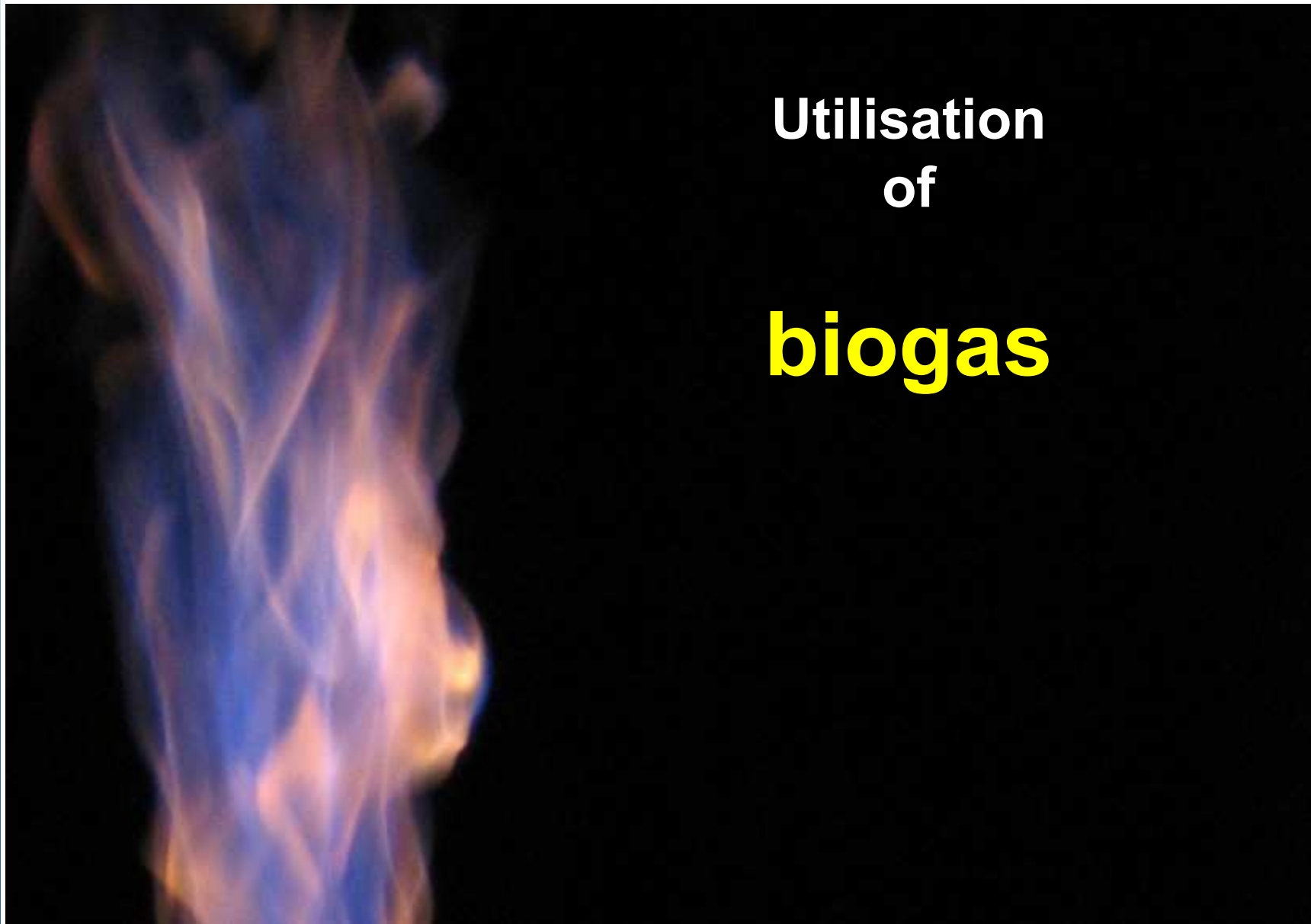
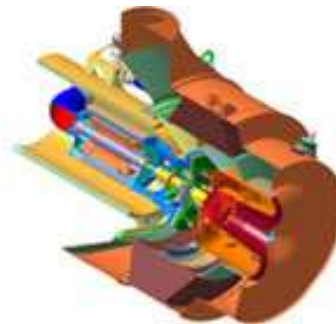


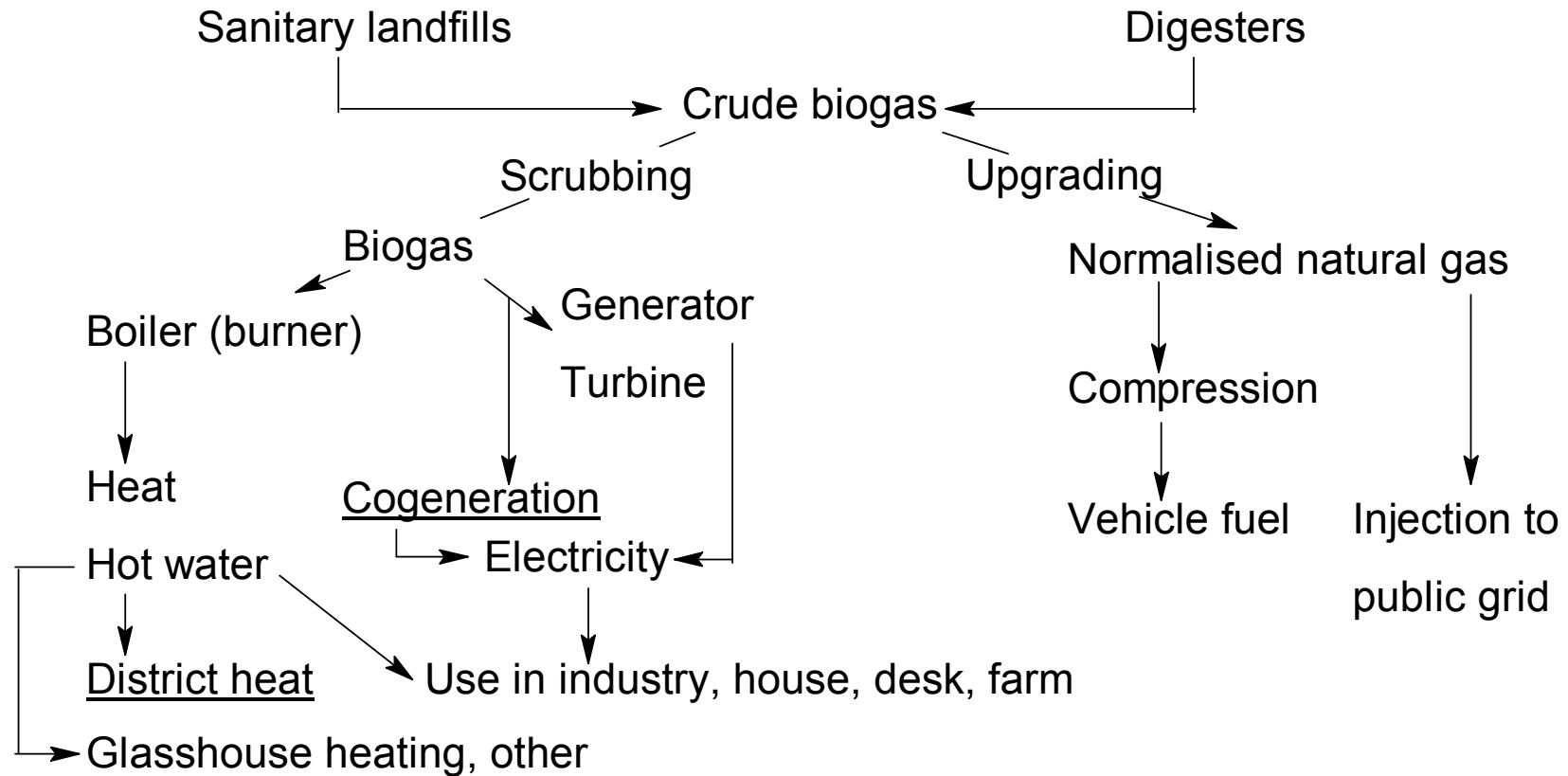
# Utilisation of **biogas**



# Biogas has many utilisations

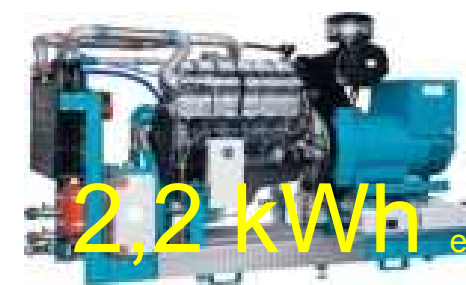
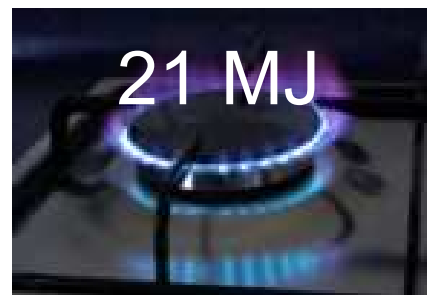
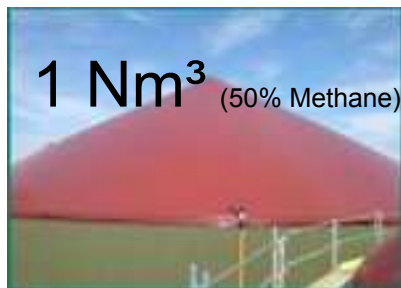


## Biogas end-uses



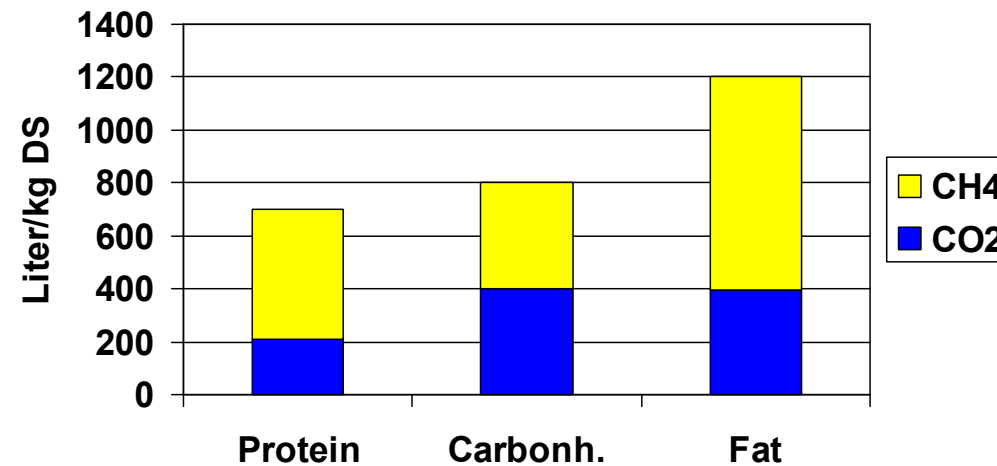
## Composition of biogas

Compound	Chemical symbol	Content (Vol.-%)
Methane	CH <sub>4</sub>	50-75
Carbon dioxide	CO <sub>2</sub>	25-45
Water vapour	H <sub>2</sub> O	2 (20°C) -7 (40°C)
Oxygen	O <sub>2</sub>	<2
Nitrogen	N <sub>2</sub>	<2
Ammonia	NH <sub>3</sub>	<1
Hydrogen	H <sub>2</sub>	<1
Hydrogen sulphide	H <sub>2</sub> S	<1



## Theoretical gas yields

Substrate	Liter Gas / kg DS	CH <sub>4</sub> [%]	CO <sub>2</sub> [%]
Raw protein	700	70 to 71	29 to 30
Raw fat	1.200 to 1.250	67 to 68	32 to 33
Carbohydrates	790 to 800	50	50



DS = Dry Substance

## Methane yields of different feedstock material

Feedstock	Methane yield [%]	Biogas yield [m <sup>3</sup> /tFF]
Liquid cattle manure	60	25
Liquid pig manure	65	28
Distillers grains with solubles	61	40
Cattle manure	60	45
Pig manure	60	60
Poultry manure	60	80
Beet	53	88
Organic waste	61	100
Sweet sorghum	54	108
Forage beet	51	111
Grass silage	54	172
Corn silage	52	202

FF = fresh feedstock

## Direct combustion and heat utilisation



## Direct combustion and heat utilisation



Digester with Stirrer

Biogas storage



Biogas heating



- 37 cattle
- 2,5 m<sup>3</sup> slurry / d
- 60 m<sup>3</sup> biogas / d
- 360 kWh heat / d

## Direct combustion and heat utilisation

- Biogas burner is almost free of maintenance
- Efficiency almost 100%
- Quiet
- Gas contamination ( $H_2S$ ) is no problem
- Installation Costs < 150 €/kW



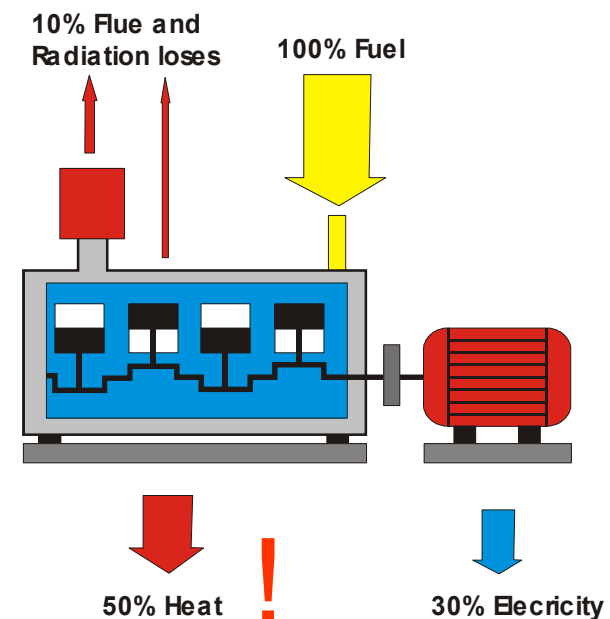
## Combined heat and power generation (CHP)

- Prime mover and generator
- Standard utilisation for biogas
- Most common is the combustion engine
- Efficiency up to 90%
- 35% Electricity 65% Heat
- Block Type Thermal Power Plant (BTTP)
- Installation costs > 700 €/kW
  
- Alternatives: Stirling-Motors, micro gas turbines and fuel cells



## Combined heat and power generation (CHP)

- Produced electricity for equipment or grid
- Important for energy and economic efficiency is to use the heat!
- 1/3 of the heat is used for the plant
- 2/3 can be used for external needs
- Heat utilisation:
  - Building and household heating
  - Drying crops, wood chips etc.
  - Power-heat-cooling-coupling



## Gas-Otto engines

- Gas-Otto or Gas-Diesel engines
- Exhaust turbo charger for high performance
- Biogas with min. 45% methane
- Biogas or natural gas can be used
- Gas contamination (H<sub>2</sub>S) is a problem



## Pilot-injection gas motor

- Based on the diesel engine principle
- Modified heavy duty engines
- Can operate without biogas
- Ignition oil can be diesel, heating oil, biodiesel, vegetable oil
- 10% of ignition oil are necessary for biogas operation



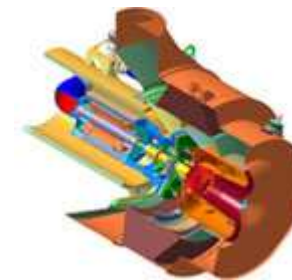
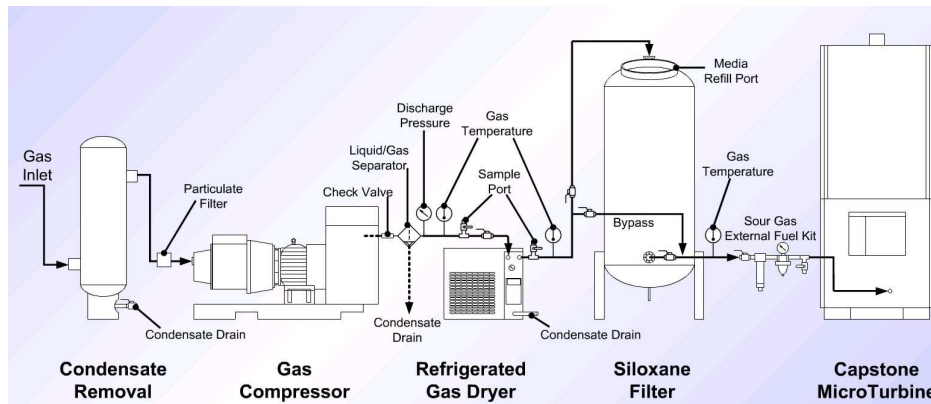
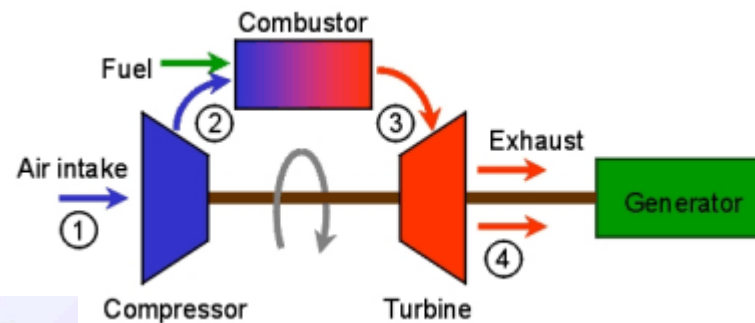
## Stirling motor

- External combustion
- Biogas with low methane content can be used
- Gas contamination (H<sub>2</sub>S) is no problem
- Low maintenance costs
- Electrical efficiency 24 to 28%
- Usually below 50 kW



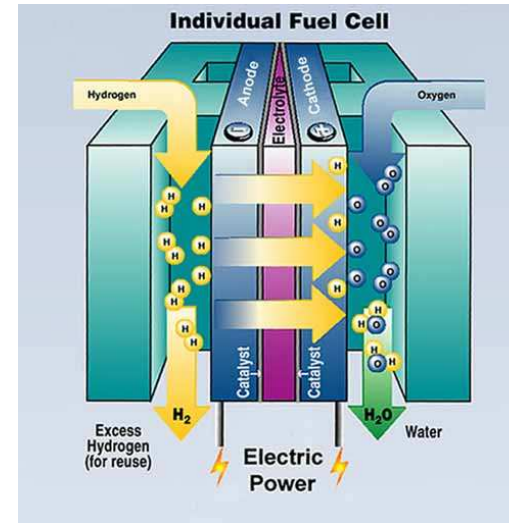
## Biogas micro-turbines

- Air is taken into a compressor
- Pressed into a combustor, mixed with biogas and fired
- The hot, burned gas is released through a turbine
- The rotating turbine shaft is driving a generator and the compressor
- Air bearing, no lubricant is needed
- Typically below 200 kW el.
- High cost



## Fuel cell

- Electrochemical devices that turn chemical energy direct into electrical energy
- Various fuel cell types suitable for biogas
- High efficiency, high performance
- High cost, over 10000€/kW



## Biogas upgrading

- Biogas can be used for the same purposes as natural gas
- Therefore it has to be upgraded to biomethane
- Methane content > 95%
- Common methods use the absorption with solvent. Water solvent scrubbing, organic solvent scrubbing, pressure swing absorption
- Costs are not linear to the plant size
- Biogas input > 500 m<sup>3</sup>/h



## Biogas as vehicle fuel

- Utilisation of biomethane in the transport sector is a technology with great potential
- Biomethane is used in the same way like natural gas
- There are specially built biogas vehicles
  
- Biomethane has the highest potential as vehicle fuel of all biofuels



## Biomethane for grid injection

- Upgraded biogas (biomethane) can be injected and distributed through the natural gas grid
- Connect rural production areas with high populated areas
- The gas can be used on a higher efficiency level
- The Biomethane has to fit the national standards for natural gas
- The costs are the same as for upgrading plus the grid connection





**Thank you  
for your attention.**

**Bernhard Natterer  
Dipl.-Ing.(FH)**