JENBACHER

INNIO

Creating Energy for Profit with Biogas - Efficient installations with biogas

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Four strong types for biogas

Type 2

- Electrical output from 250 to 330KW
- 8 cylinder inline
- 1,500 rpm (50Hz) / 1,800 rpm (60Hz)
- Delivered engines: more than 1,100
- Since 1976 in the product program

Type 3

- Electrical output from 500 to 1,100KW
- V12, V16 and V20 cylinder
- 1,500 rpm (50Hz) / 1,800 rpm (60Hz)
- Delivered engines: more than 9,700
- Since 1988 in the product program

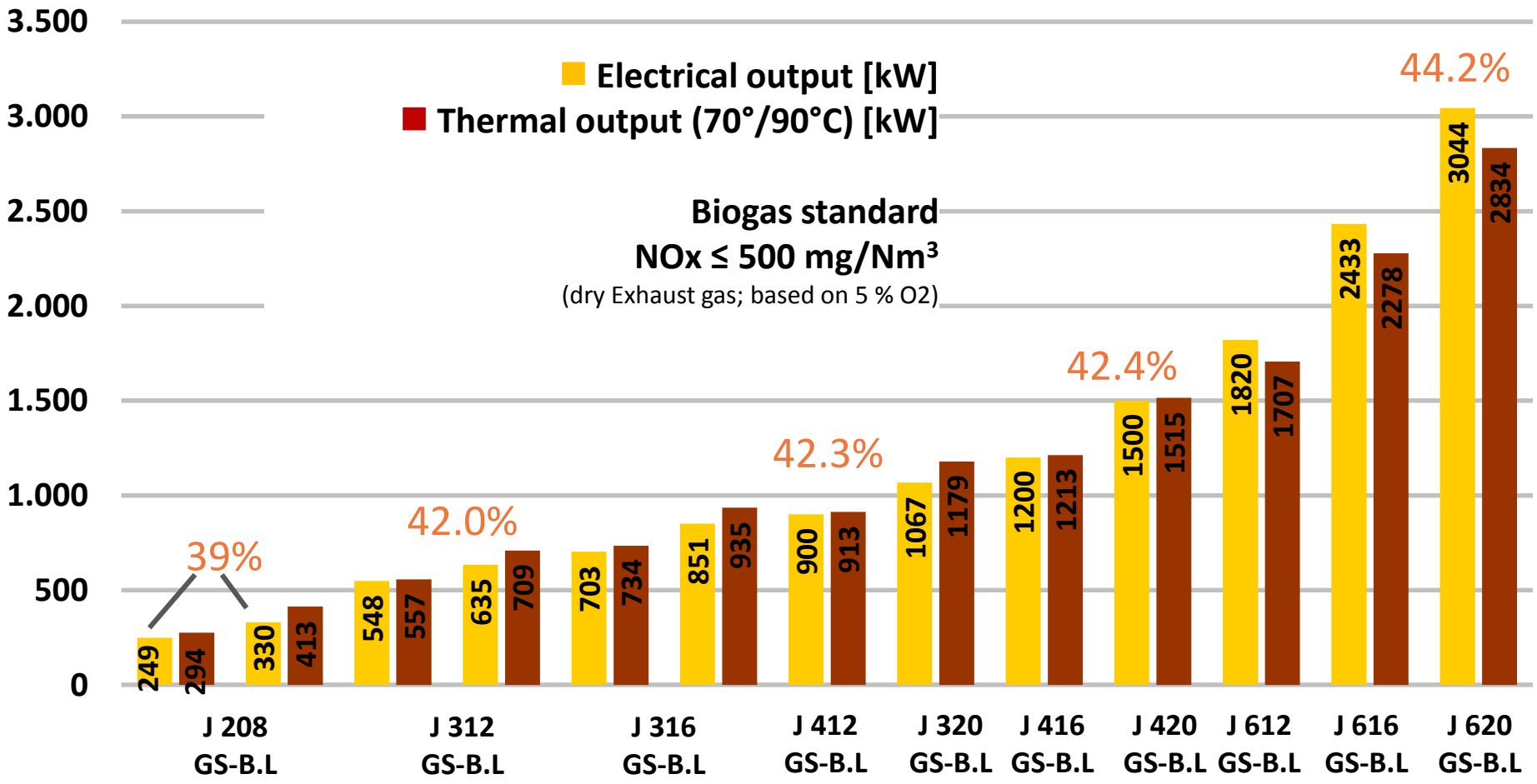
Type 4

- Electrical output from 800 to 1,560KW
- V12, V16 and V20 cylinder
- 1,500 rpm (50Hz) / 1,800 rpm (60Hz)
- Delivered engines: more than 4,300
- Since 2002 in the product program

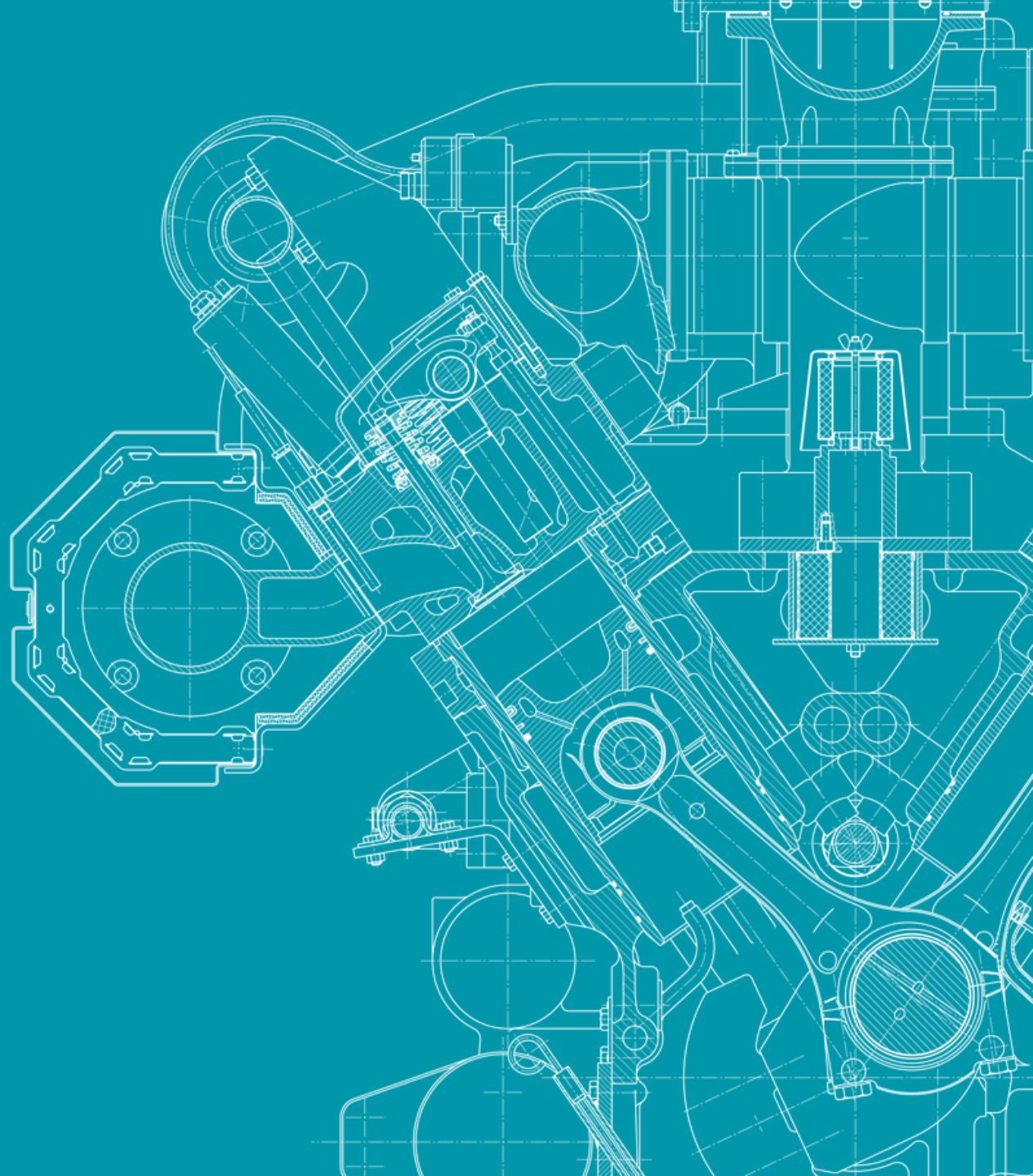
Type 6

- Electrical output from 1.5 to 4.5 MW
- V12, V16, V20 and V24 cylinder
- 1,500 rpm (50Hz, 60Hz with gear-box)
- Delivered engines: more than 5,100
- Since 1989 in the product program

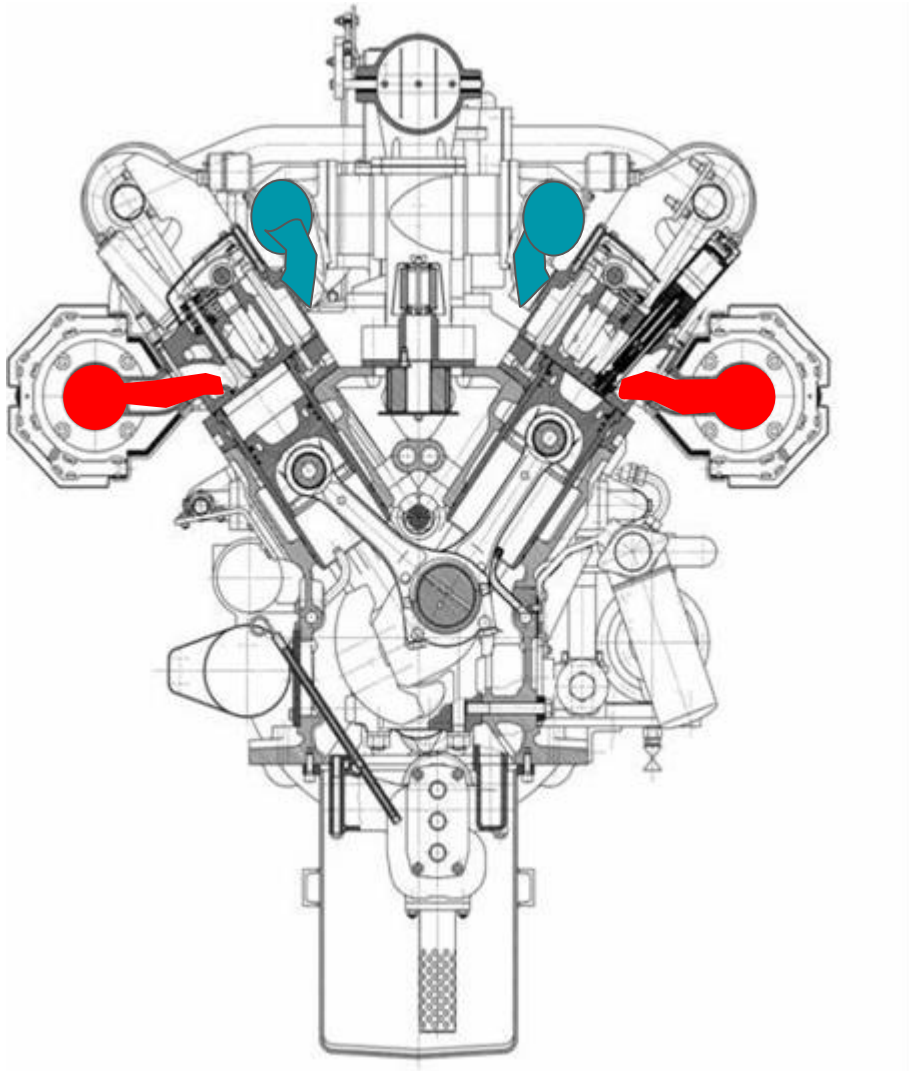
Product Program 2019:
Biogas, Sewage Gas and Landfill Gas



Jenbacher gas engines
What makes the difference?



Details: „Gas engine concept“



Advantages:

“Cross flow” cylinder head
(external exhaust gas manifolds)

Clear separation of cold mixture inlet and hot exhaust gas

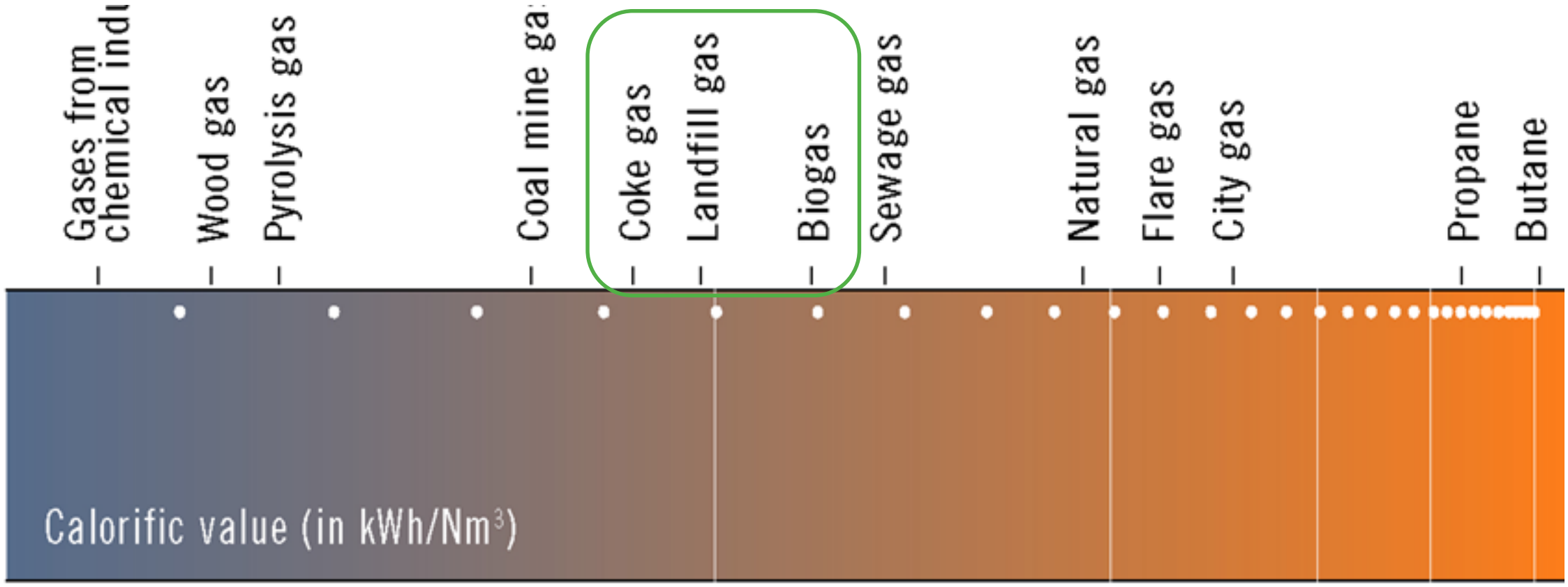
Exactly defined thermal zones in the cylinder head

Long cylinder head life time

Better accessibility to the exhaust gas manifolds

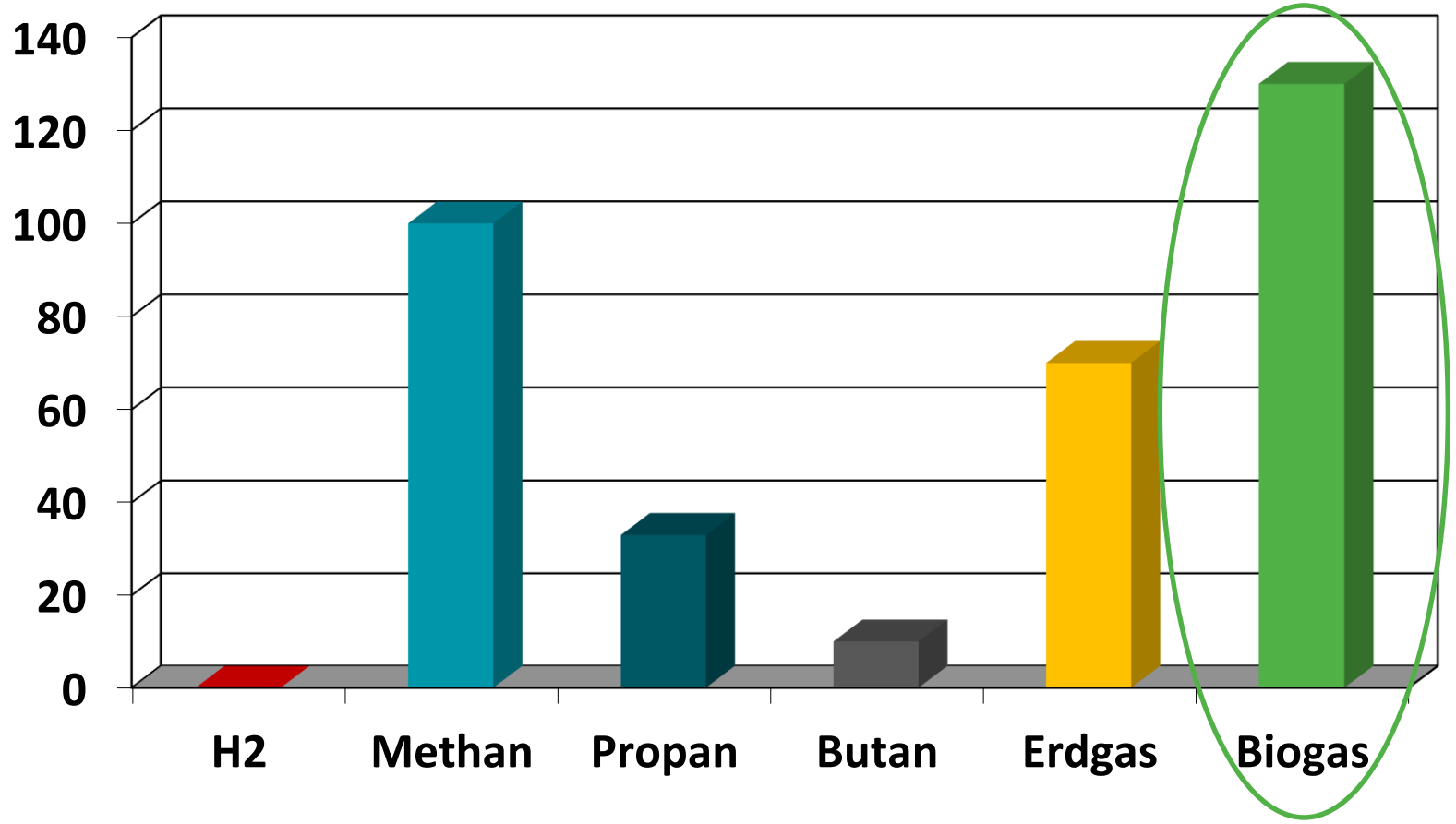
High fuel flexibility

Range of gases used in Jenbacher gas engines



Low heating values are not critical for suitability in our gas engines.

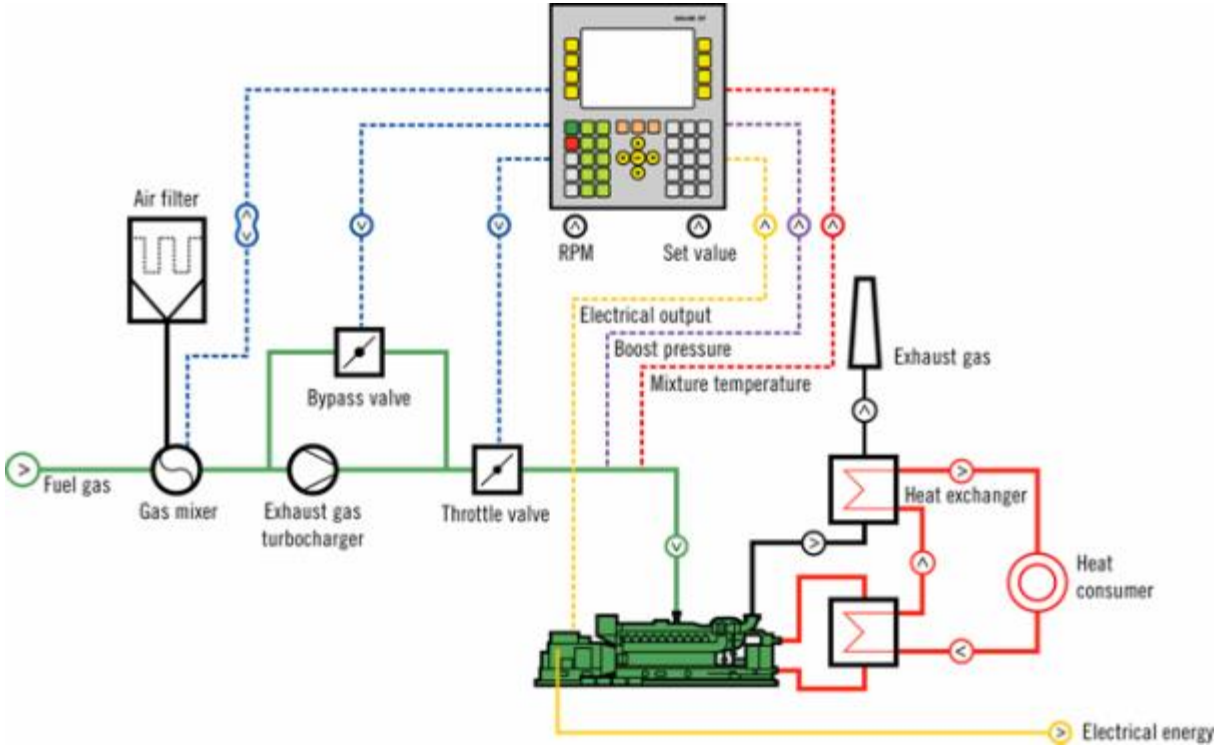
Methane Number



Biogas is characterised by very high knocking stability

LEANOX® - Lean-burn combustion control

Gas fluctuations under control



- Sensors in non critical measurement ranges (pressure, temperature, deposits...)
- Reliable and durable compliance with exhaust emission limit at changing operational conditions (fuel gas compositions...)
- Controlled combustion and subsequently controlled stress of various components (valves, cylinder heads, spark plugs...)

INNIO‘s SPARK PLUG Technology

Longest life times for every gas

- Efficient & reliable combustion
- Low emission (NOx)
- Enables high specific output
  - Low specific product cost
  - Low specific service cost

- Low specific spark plug cost
- Long regapping interval
- Low emissions
- High reliability

Jenbacher gas engines - reliable operation on biogas

Examples of availability:

- Bio-Energie Gosdorf/AT, 1 x J312 Biogas – 99,8%
- NV Groeikracht Lierbaan/BE, 1 x J312 Erdgas– 99,9%
- Perin SRL/IT, 1 x J320 Biogas – 99,8%

Average fleet reliability at Biogas: 98+% (2,000+ units)

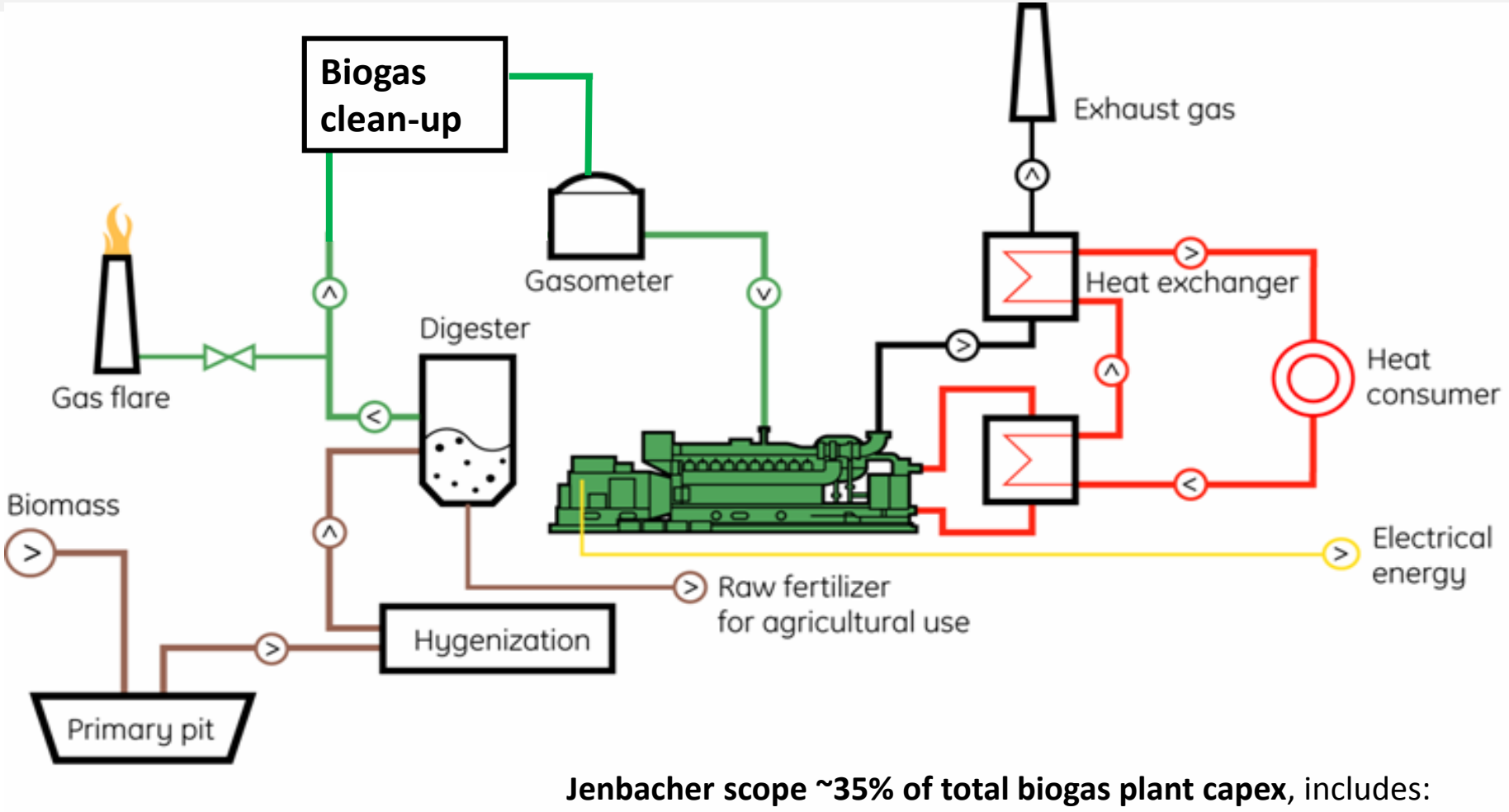
- High **Reliability of type 2, 3 and 4** results in low number of unplanned stops
- High level of **Serviceability** minimises planned down-time
- Both factors together result in high **Plant Availability**

Biogas

- More than 5,800 Jenbacher biogas engines with an electrical output of over 4,900 MW worldwide
- Fuel gas from waste products through anaerobic digestion
- Renewable – from organic and animal waste

Biogas Plant

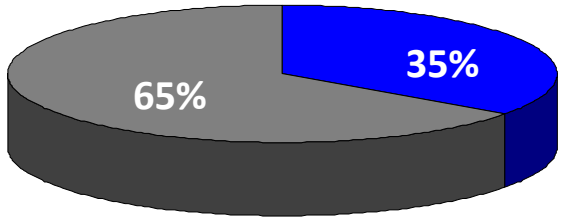
Typical solution



Jenbacher scope ~35% of total biogas plant capex, includes:
Jenbacher cogeneration solution, heat exchangers, generator

Investment and Cost of electricity basis

Biomass preparation, digester, Gas storage, …



Containerized Cogeneration plant

1000 kWel. Plant - approx. 3,000 – 4,000 € per kW

Initial cost of electricity – **€cent/kWhel**:

- 8,000+ operating hours per year
- Financing based on 10 years

Biomass input	500 kW	1.000 kW
95% manure	**~ 10**	**~ 8**
2/3 energy crops (Corn cost: 30 €/t)	**~ 15**	**~ 13**
palm oil mill effluent (Asia)	**~ 6**	**~4**

Operational conditions of the fermentation process

- **Temperature**
  - mesophile process: 35 - 40°C
  - thermophile process: 50 - 55°C
- **Retention time**
  - minimum 15 days
  - range: 20 - 50 days
  - common: 25 - 30 days

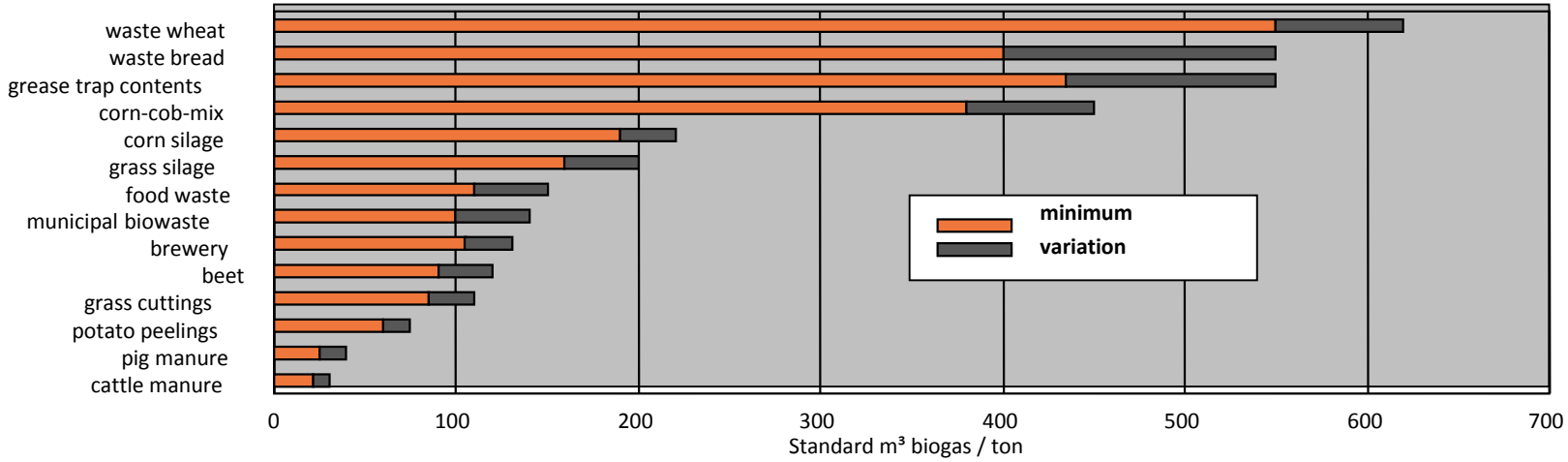
Dry matter concentration
- dry fermentation: 20 - 30%
- wet fermentation: 10 - 15%

- Absence of oxygen
- pH value from 6.5 to 7.5

Gas mixture composition:

50 – 70% methane (CH4)

30 – 50% carbon dioxide (CO2)



Advantages of Anaerobic Digestion

For the Farmer:

- **Improvement** of **manure properties**: odor reduction, elimination of acid components, viscosity decrease, mineralization of organic nitrogen, reduction of pathogenic germs and weed seeds
- **Additional** income from **heat and power production**

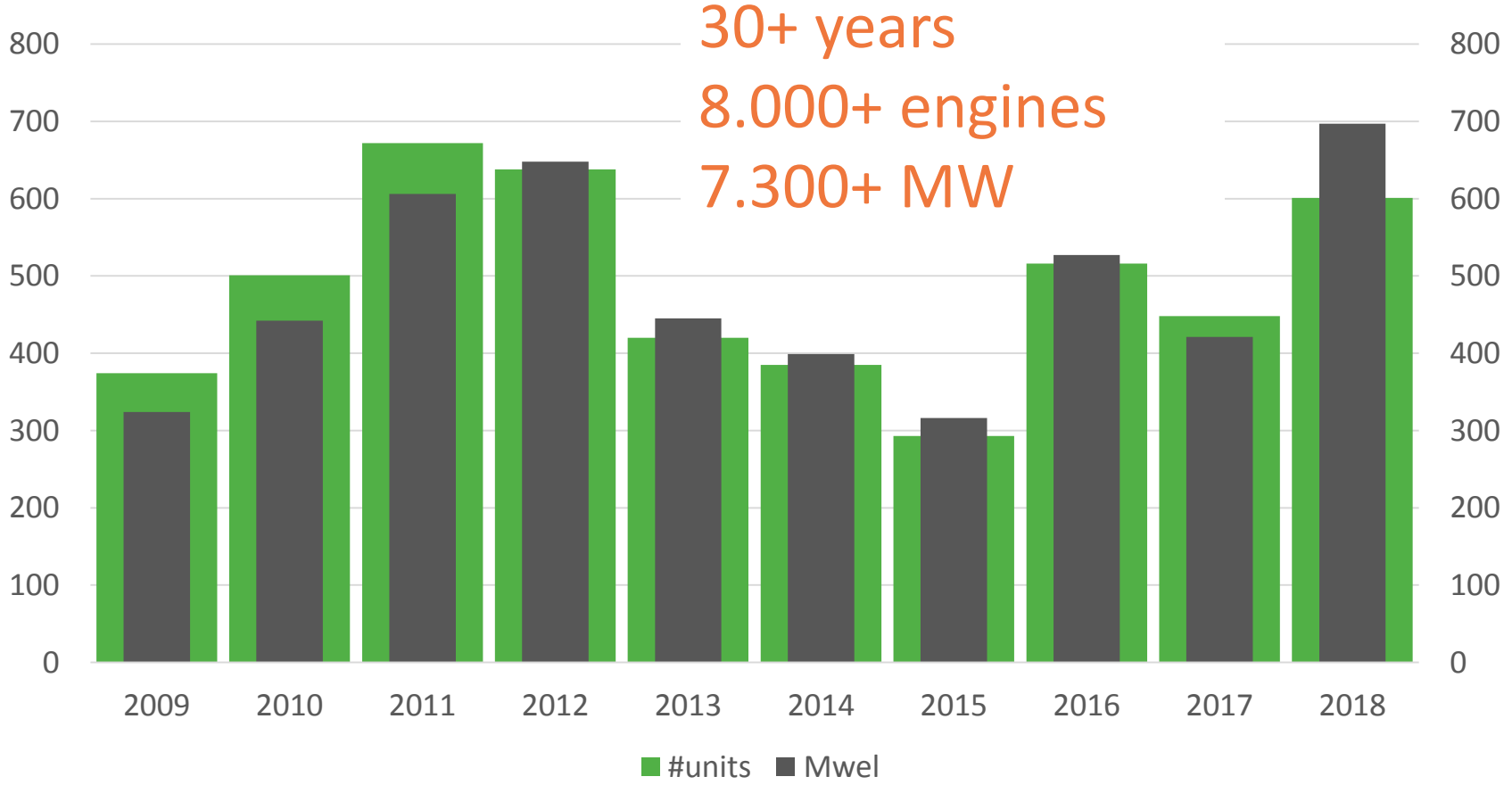
For the Environment:

- **Reduction** of **methane and ammonia emissions** from manure
- **Reduction** of **nitrate wash-out** into groundwater
- **Recycling** of **fertilizer compounds** from organic wastes
- **Reduction** of **carbon dioxide emissions** by substitution of fossil resources

The whole Jenbacher biogas fleet

A huge basis of expertise

- Sewage gas: more than **650** installed engines (540 MW)
- Biogas: more than **5,100** installed engines (4,400 MW)
- Landfill gas: more than **2,250** installed engines (2,400 MW)



Around the globe …

Jenbacher biogas fleet

Installed in biogas plants until 31.12.2018	
Germany	1475 MW
Italy	845 MW
UK	290 MW
Belgium	140 MW
Czech Rep.	125 MW
Denmark	115 MW
Netherlands	97 MW
Austria	78 MW
Spain	70 MW
France	57 MW
Poland	**41 MW**
Thailand	225 MW
Indonesia	155 MW
China	141 MW
USA	138 MW
India	88 MW

Jenbacher Biogas installations in 70+ countries

Model solution for ecological and economical power generation

The biogas plant in Soltau, Germany, uses corn and rye as biomass to power three of GE's Jenbacher J420 cogeneration systems. The facility generates 4.2 MW of electricity, which is fed into the regional grid. In addition, the Jenbacher engines produce 4.3 MW of thermal energy, which is used to support an integrated yeast-production process.

POME … an effluent converted to power

The palm oil production process generates huge quantities of organic waste material that, if not processed, has a negative impact on the ecological balance. In Thailand, two type 3 of GE's Jenbacher gas engines are supplying 33,000 Thai households with a reliable electrical output of 2.1 MW.

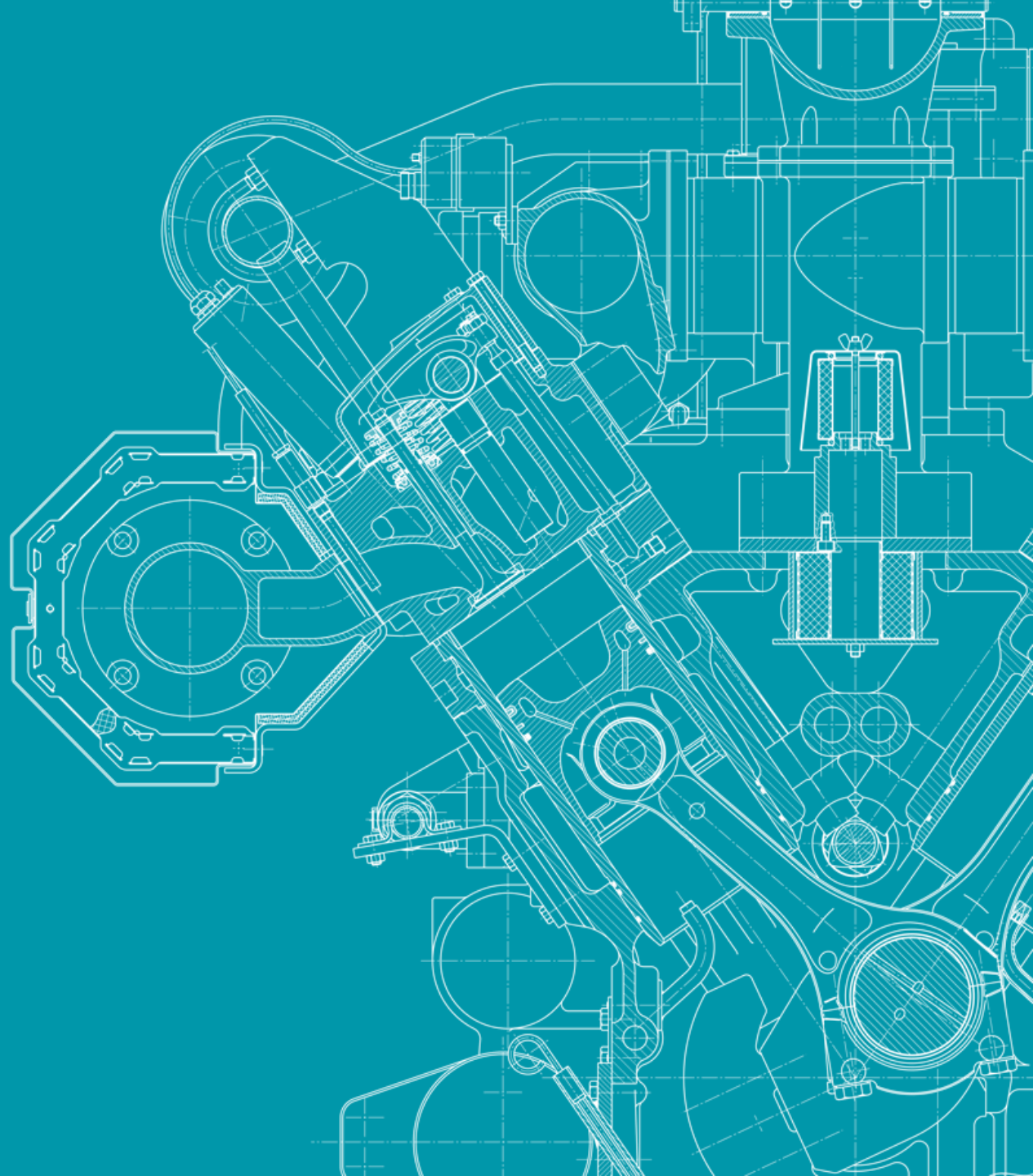
Cow power: biogas from 250 tons of waste daily powers 1 MW plant

In India a J320 Jenbacher biogas engine is powering a successful demonstration cattle manure-methane cogeneration plant at a large dairy complex, helping to address the region’s increasing energy and environmental needs.

China’s first chicken manure-biogas plant

Two type 3 Jenbacher biogas engines generate an output of 2 MW while helping to solve the farm’s waste problems. The farm north of Beijing, China, owns three million chickens, producing 220 tons of manure and 170 tons of wastewater each day.

Optimized plant concepts for biogas installations



Gas Requirements:

- gas pressure
- methane number
- **gas temperature/relative Humidity**
- heating value fluctuation
- **contaminations**
  - **Sulphur**,
  - **Ammonia**,
  - Halogens,
  - Silica …

Gas Requirements:

- Gas temperature < 40°C
  - ↳ mixture temperature 💥
  - ↳ limited by rubber materials of gas train 💥

- relative humidity < 80%
  (at every gas temperature)
  - ↳ condensate in gas supply 💥
    - filter; pressure regulator; gas train,.....
    - condensate in engine/intercooler 💥

Gas humidity / cooling:

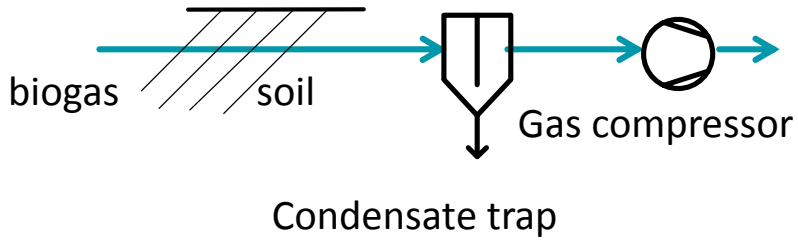
- Gas filter filled with condensate water
- Distance to dew-point to small

- Amounts of water condensate are significant
- Taking measures upfront is important

Humidity reduction

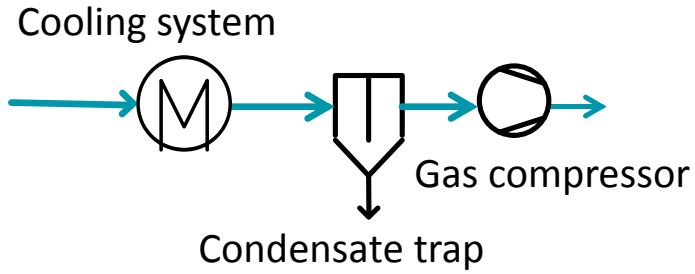
Controlled cooling conditions

Gas pipe + pre heating → second best solution



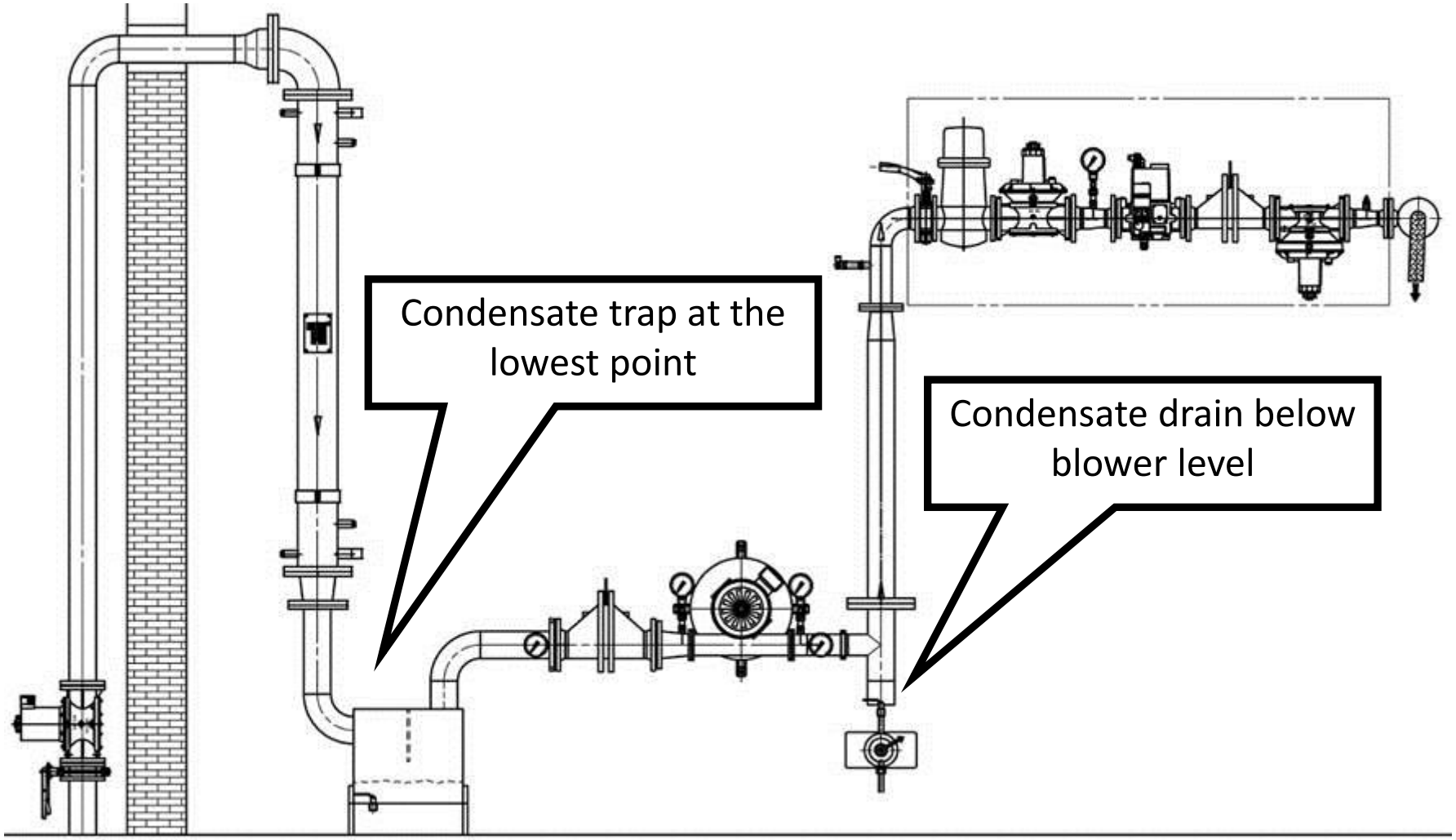
- Only reduction of rel. humidity; works only at a low gas temperature level
- Water content is not changed
- Avoid condensate drain off in subsequent parts
- Gas cooling by gas pipe in soil helpful, but no controlled condensate removal

Active humidity reduction → best solution



- Effective reduction of water content
- Reduce danger of having condensate in the gas system
- Reduce risk of corrosion!

Optimum Layout of gas supply:



Gas Requirements

Sulfur:

H_2S < 700 mg/100% CH4

↳ Standard maintenance schedule

Σ H_2S < 1200 mg/100% CH4

↳ adapted maintenance schedule

↳acidification of oil

↳reduced Oil lubricity

↳$SO_x + H_2O$ ➔ corrosion

↳deposits in exhaust gas heat exchanger, when temperature is below dew point

Gas Requirements TI 1000-0300

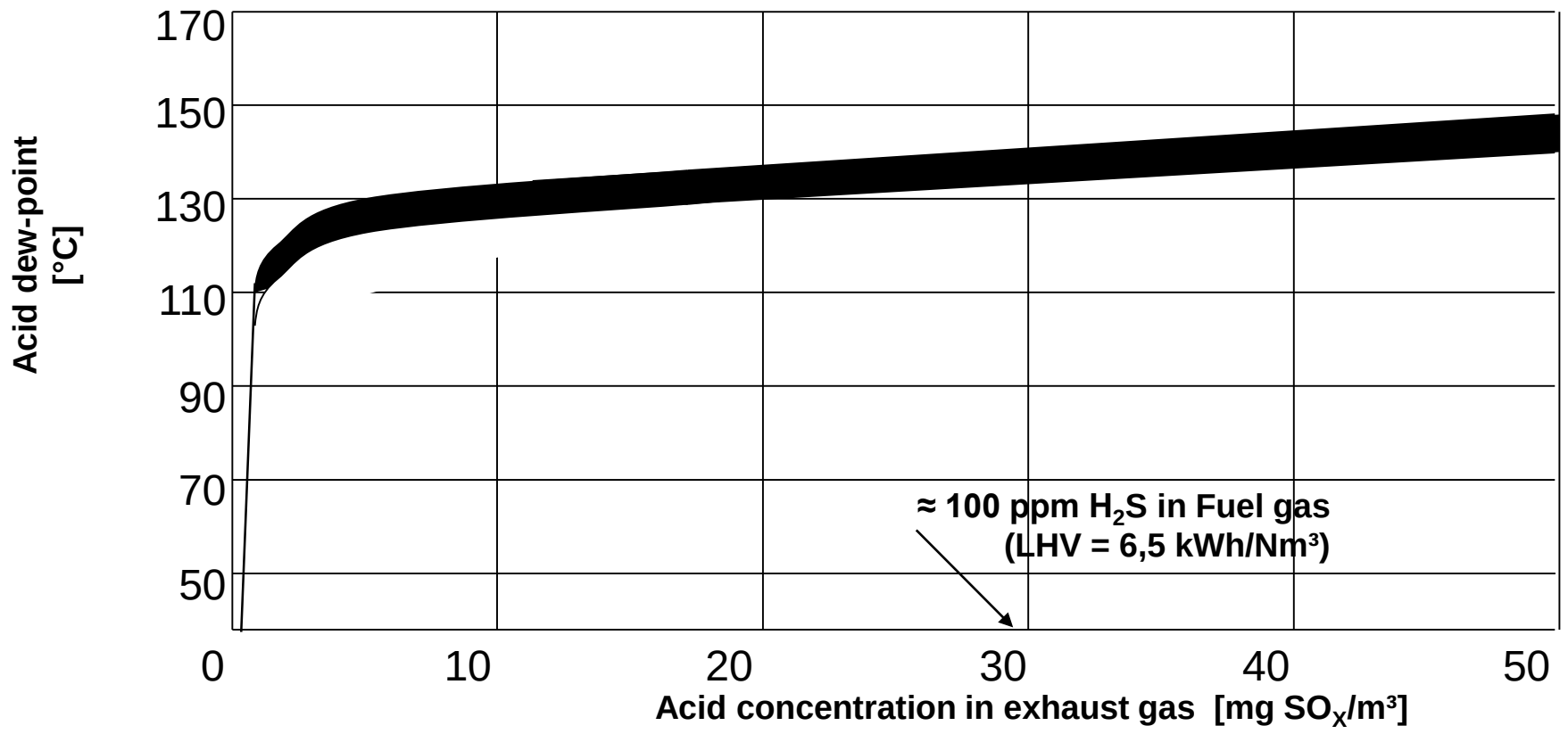
Waste Water Treatment Plant

Sulfate deposits

exhaust gas temperature

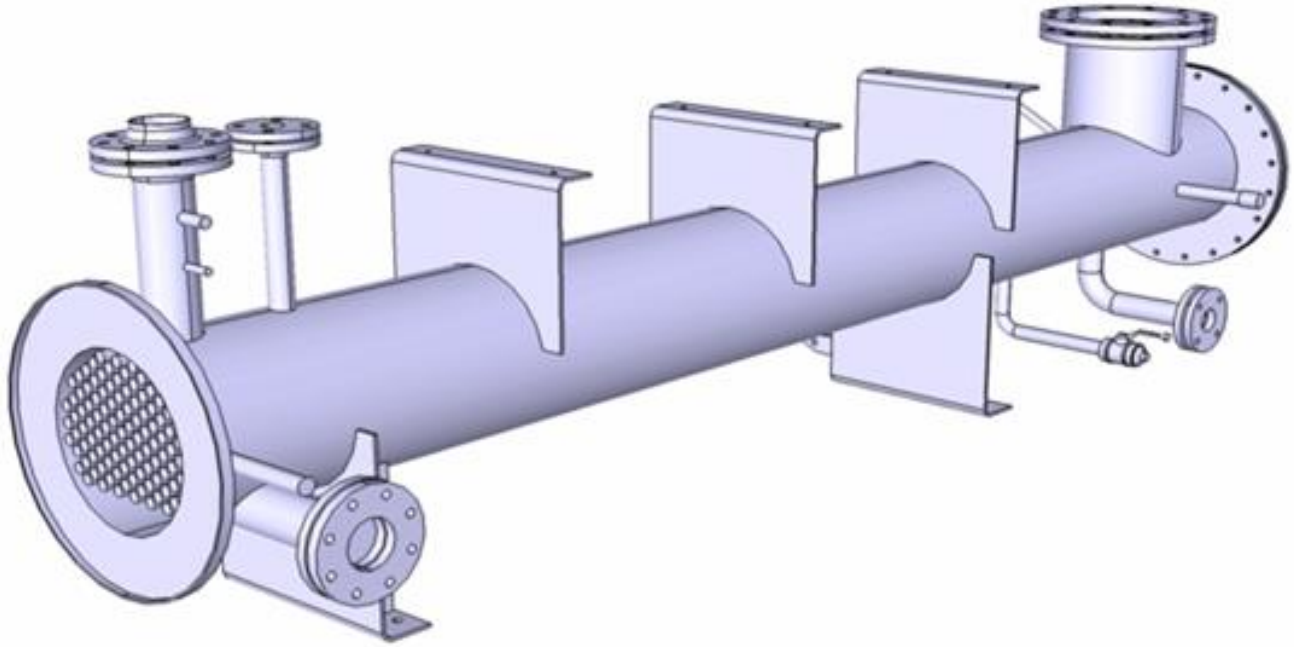
below dew point

Dew-point-line for SO_x



Cooling of exhaust gas **not below 180°C** recommended!

Solution → special Biogas heat exchanger:



- Cooling down to 180°C or 220°C
- Exhaust gas heat exchanger without pipes at the bottom → no condensate around the pipes
- Big condensate trap (DN50) + falling condensate pipes

Oil Requirements

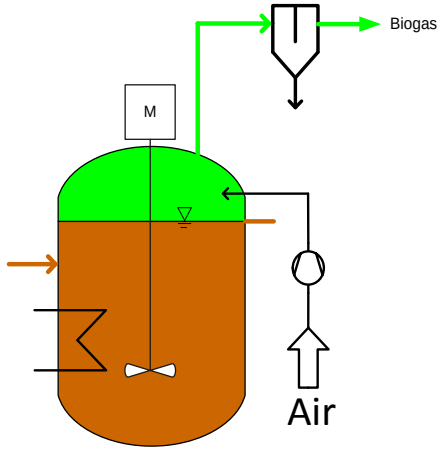
Sulfur

Biogas plant DK
Polymerization of oil

H2S approx. 3400 mg/100% CH4
oil change interval
exceeded by 100%

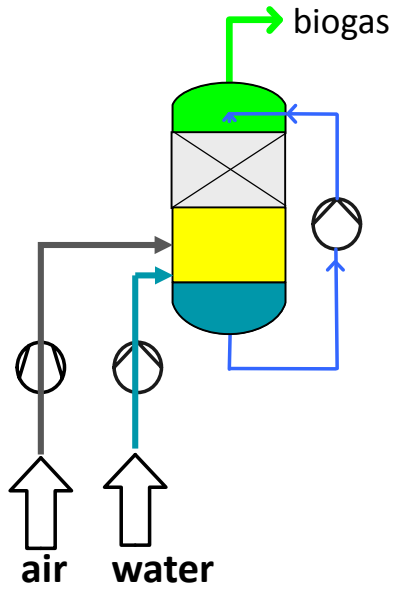
H_2S reduction:

Air dosing



- allocation of air is important
- Consider max. air volume
- H_2S reduction is not constant
- The additional air increases corrosion activity

Biological H_2S reduction



- Saturate the water content of the gas
- The additional air increases corrosion activity
- H_2S reduction is stable!
- Higher investment costs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