GE Energy
Jenbacher gas engines

FECC - GTZ
Training for Biogas Design Institutes - Beijing

From Biogas to electricity- CHP-use in operation

Thomas Elsenbruch

ecomagination
a GE commitment

GE imagination at work

GE Energy Infrastructure

Employees: 65,000 • '08 revenue: $38.6B • Operating in 140 countries

Power & Water

- Power generation
- Renewables
- Gas Engines
- Nuclear
- Gasification
- Water treatment
- Process chemicals

Energy Services

- Contractual agreements
- Smart Grid
- Field services
- Parts & repairs
- Optimization technologies
- Plant management

Oil & Gas

- Drilling & completion
- Subsea, offshore & onshore
- LNG & Pipelines
- Pipeline integrity
- Refining
- Processing

GE's Jenbacher gas engines

over 50 years of power Jenbacher gas engines

A leading manufacturer of gas fueled reciprocating engines for power generation

1,700 employees worldwide, 1,300 in Jenbach/Austria

9,100+ delivered engines / 10,800+ MW worldwide
- Power range from 0.25 MW to 4 MW

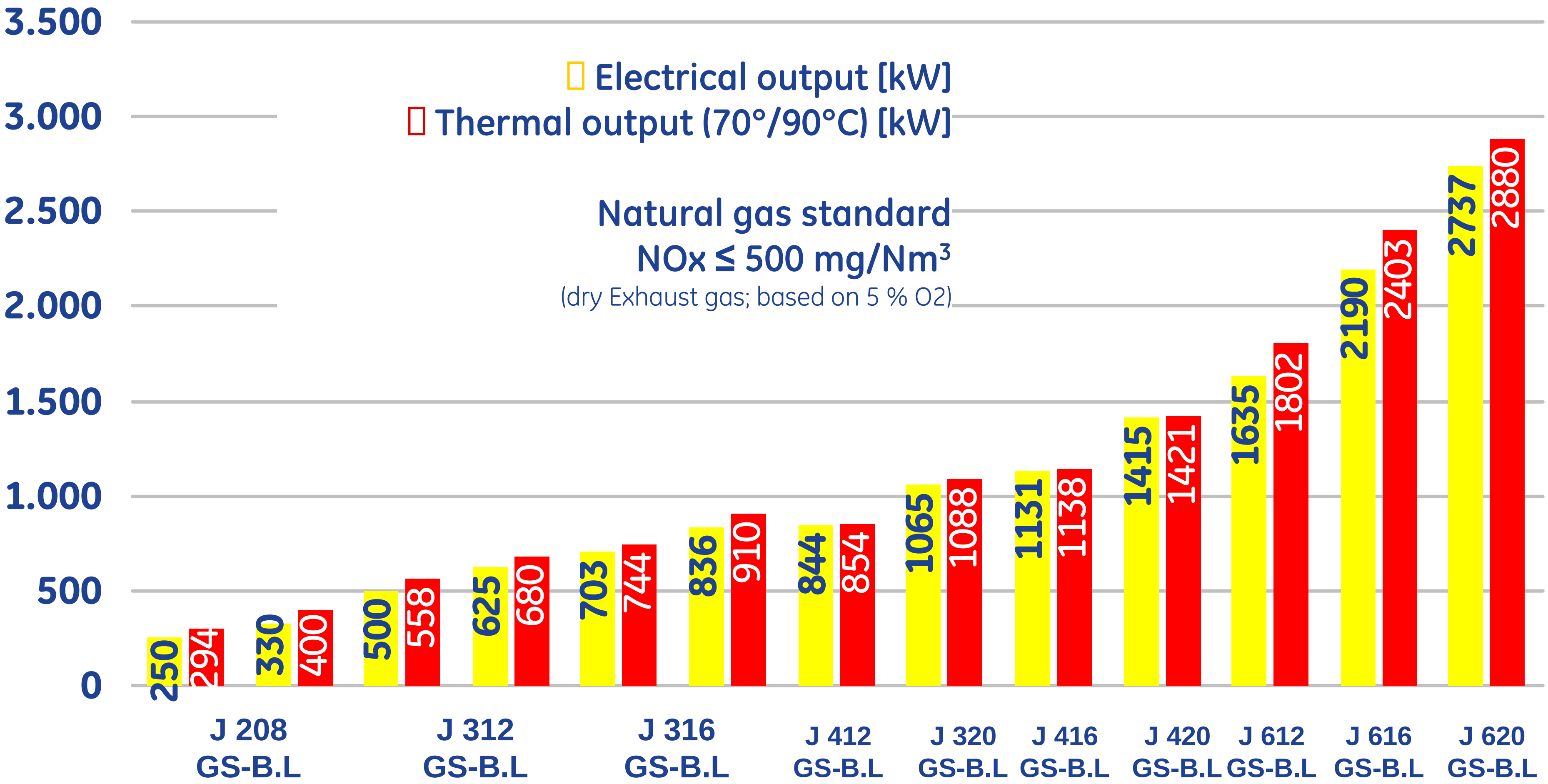
Fuel flexibility
- Natural gas, biogas, flare gas, landfill gas, steel gas, coal mine gas

Advanced system solutions
- Generator sets, container modules
- cogeneration, trigeneration, CO_2-fertilization

Environmental benefits
- Low emissions
- ecomagination solutions

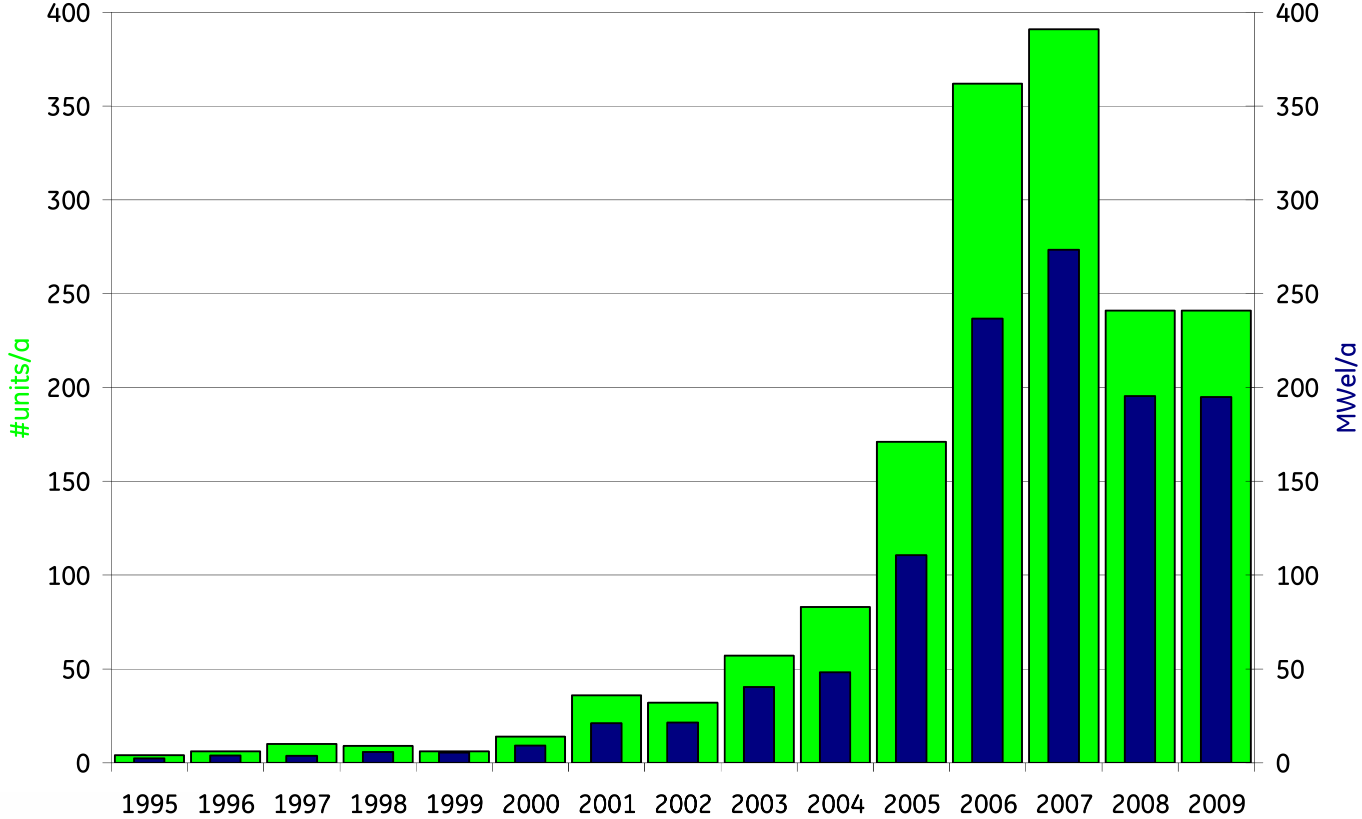
Lifetime services plus (parts, repair, CSA, upgrades)
- 2,000 units under CSA

Product Program 2010:
Biogas, Sewage Gas and Landfill Gas



The whole Jenbacher biogas fleet:

- Sewage gas: more than 450 installed engines (313 MW)
- Biogas: more than 1500 installed engines (1065 MW)
- Landfill gas: more than 1400 installed engines (1370MW)



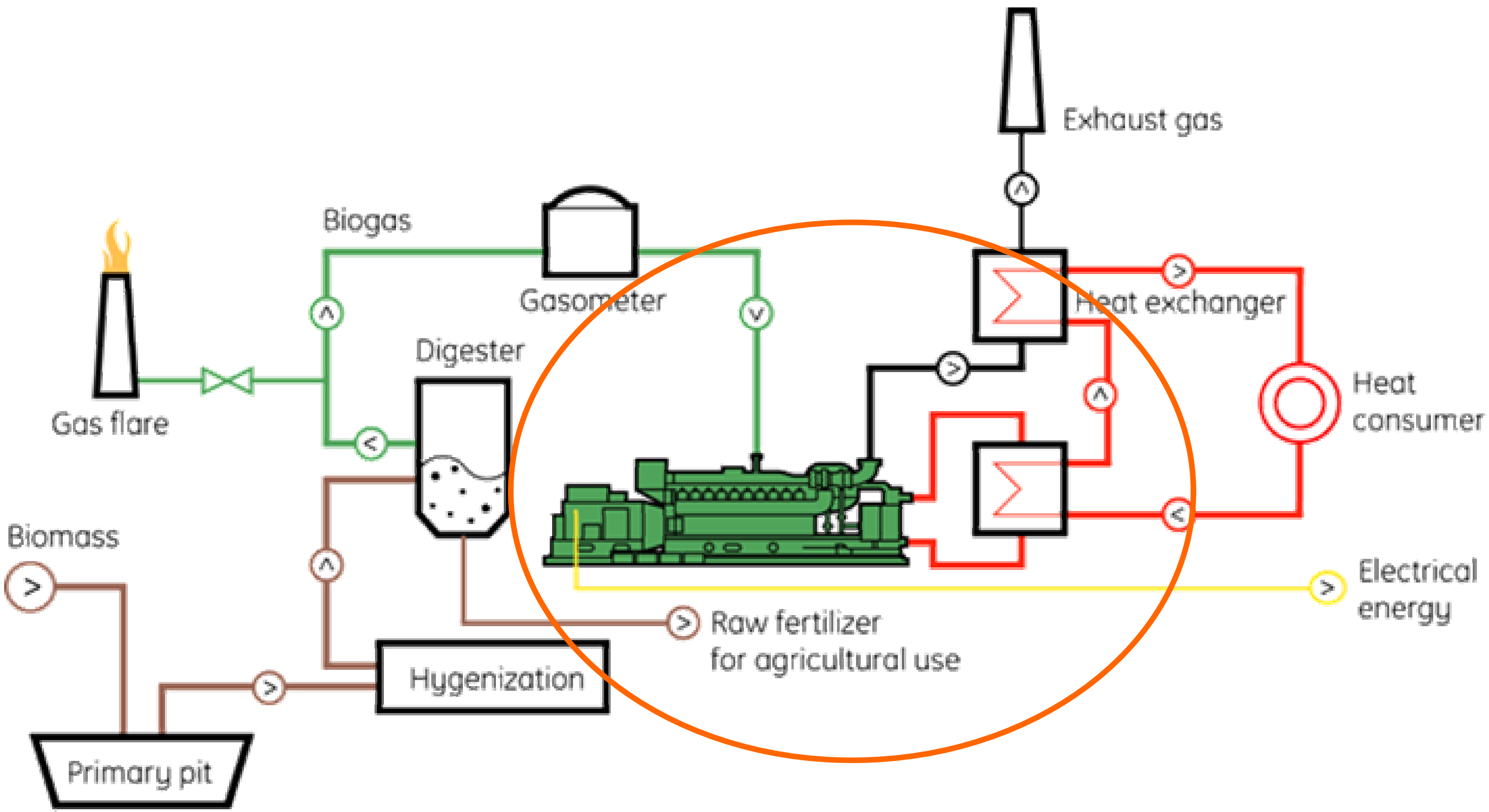
Jenbacher - Biogas engines in some EU and Asian countries

Installed in Biogas plants up to 31.12.2009:

• Germany	945 engines	527 MW
• Italy	161 engines	130 MW
• Austria	90 engines	48 MW
• Netherlands	69 engines	72 MW
• Denmark	46 engines	35 MW
• Czech Rep.	40 engines	28 MW
• Belgium	32 engines	36 MW
• Spain	32 engines	30 MW
• UK	11 engines	12 MW
• Poland	8 engines	6 MW
• Hungary	7 engines	3 MW
• Slovakia	6 engines	6 MW
• Thailand	42 engines	51 MW
• India	37 engines	32 MW
• Indonesia	28 engines	30 MW
• China	10 engines	12 MW

GE imagination at work

Gas engines play core role in biogas plants

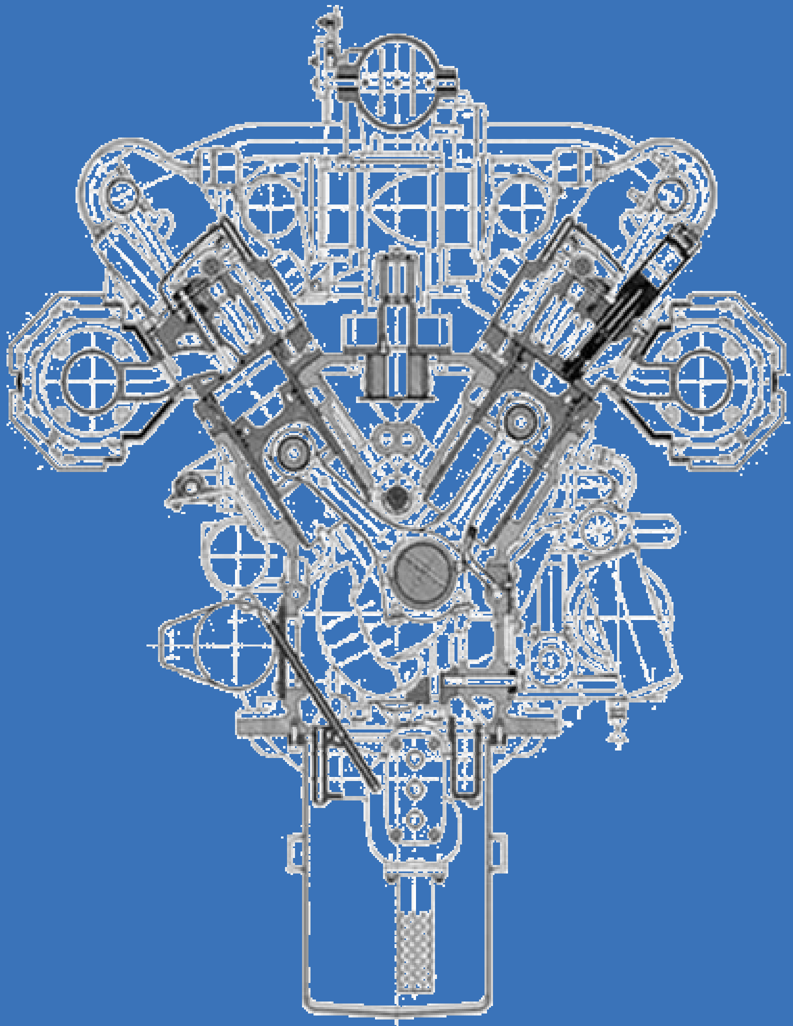


(in case of food waste)

biogas-cogeneration units are core part of biogas plant, in combination with enhanced digester-technology

GE imagination at work

Targets of development optim. Biogas engine



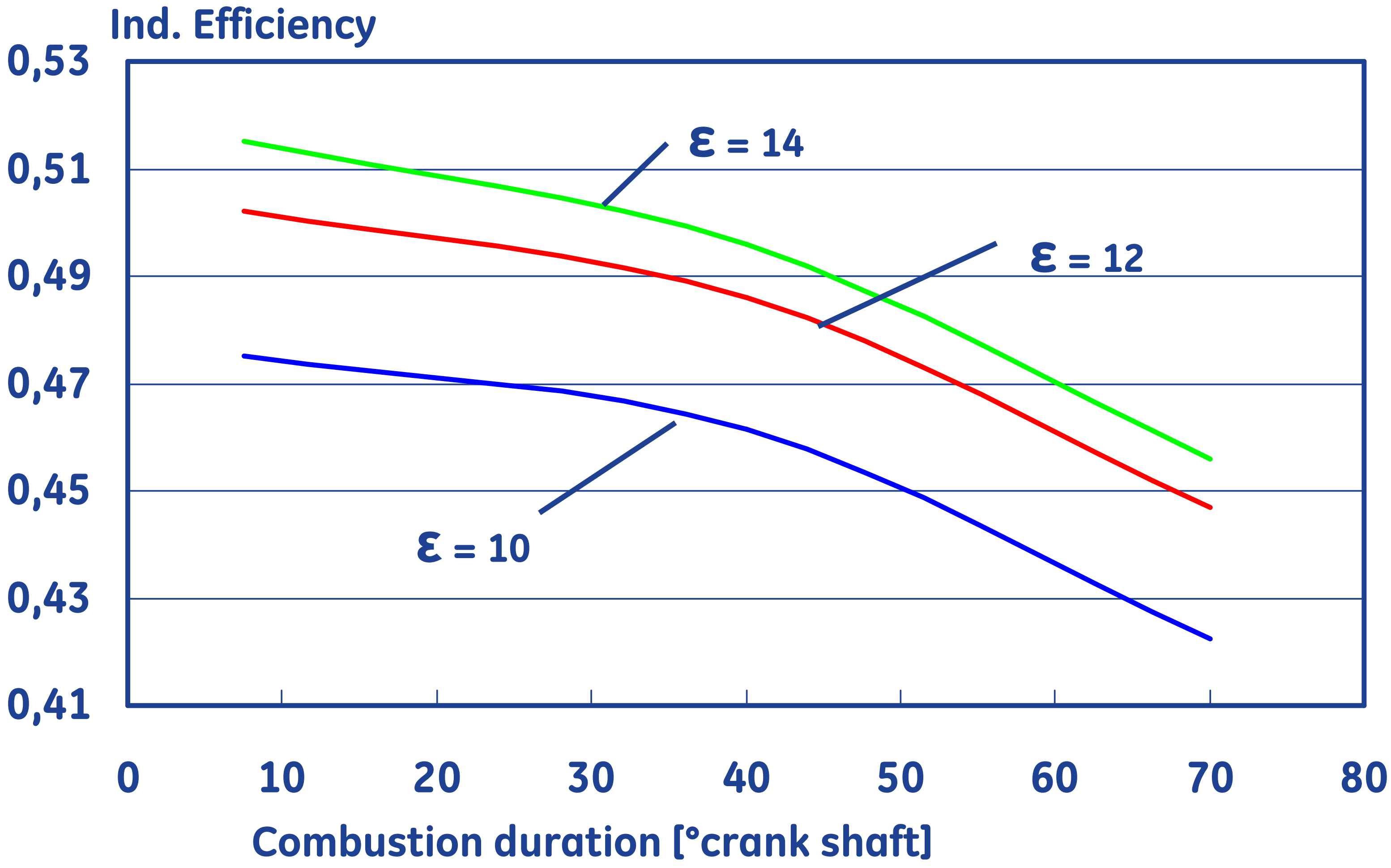
Target:
Optimized efficiency in operation with Biogas

Basic engines
Optimized specific output

Frame conditions:
- Biogas
- Exhaust emissions
- **Thermodynamic Optimum**

GE imagination at work

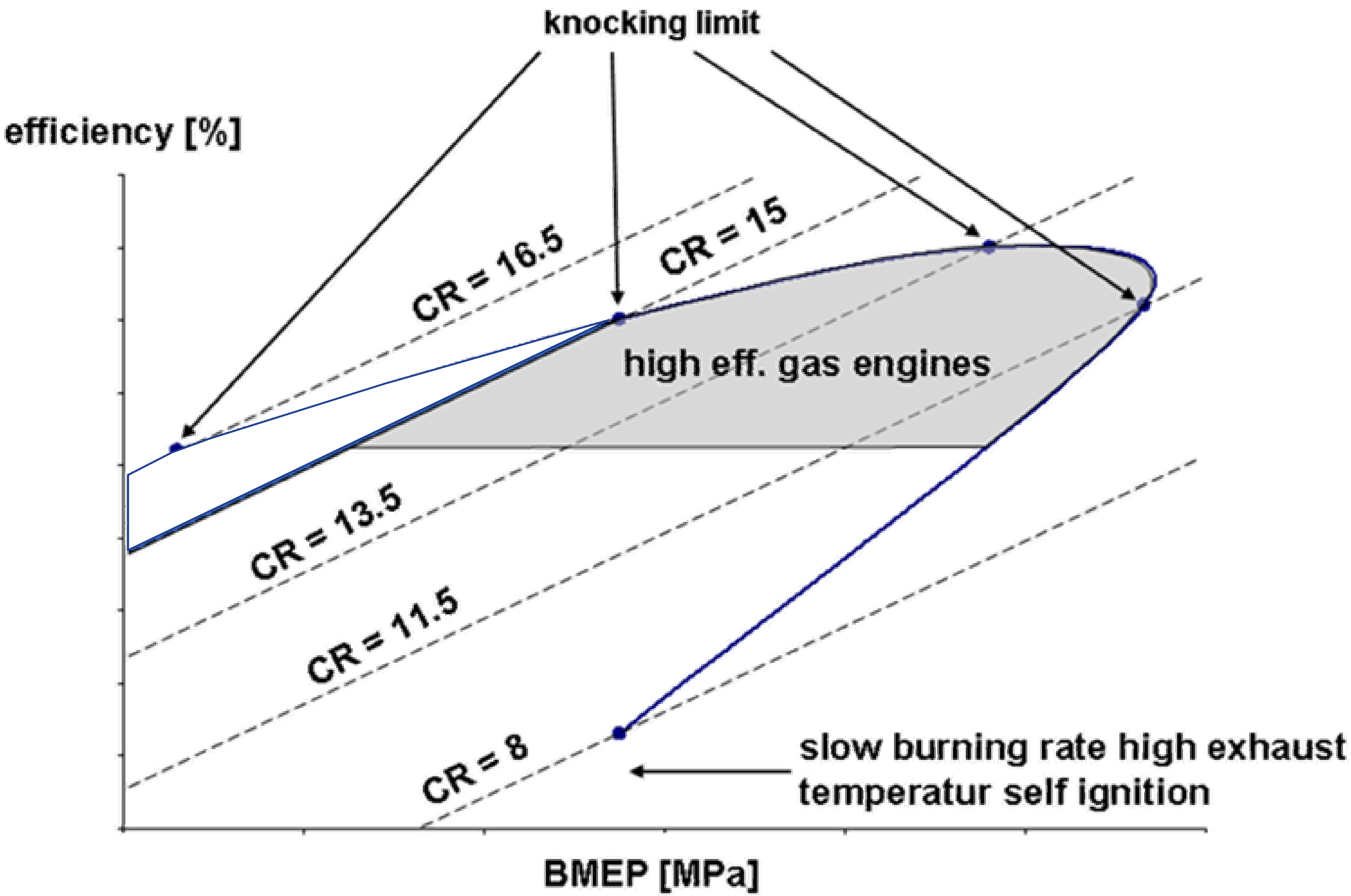
Internal efficiency – combustion duration



Higher compression-ratio helps the efficiency

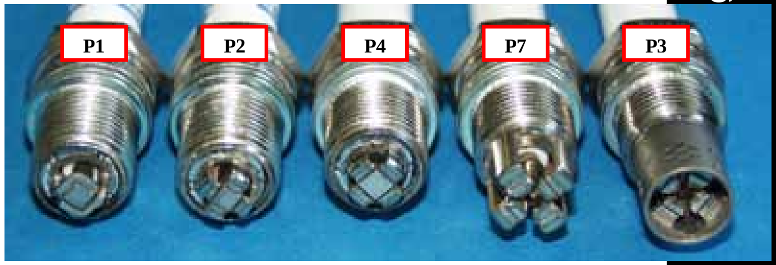
GE imagination at work

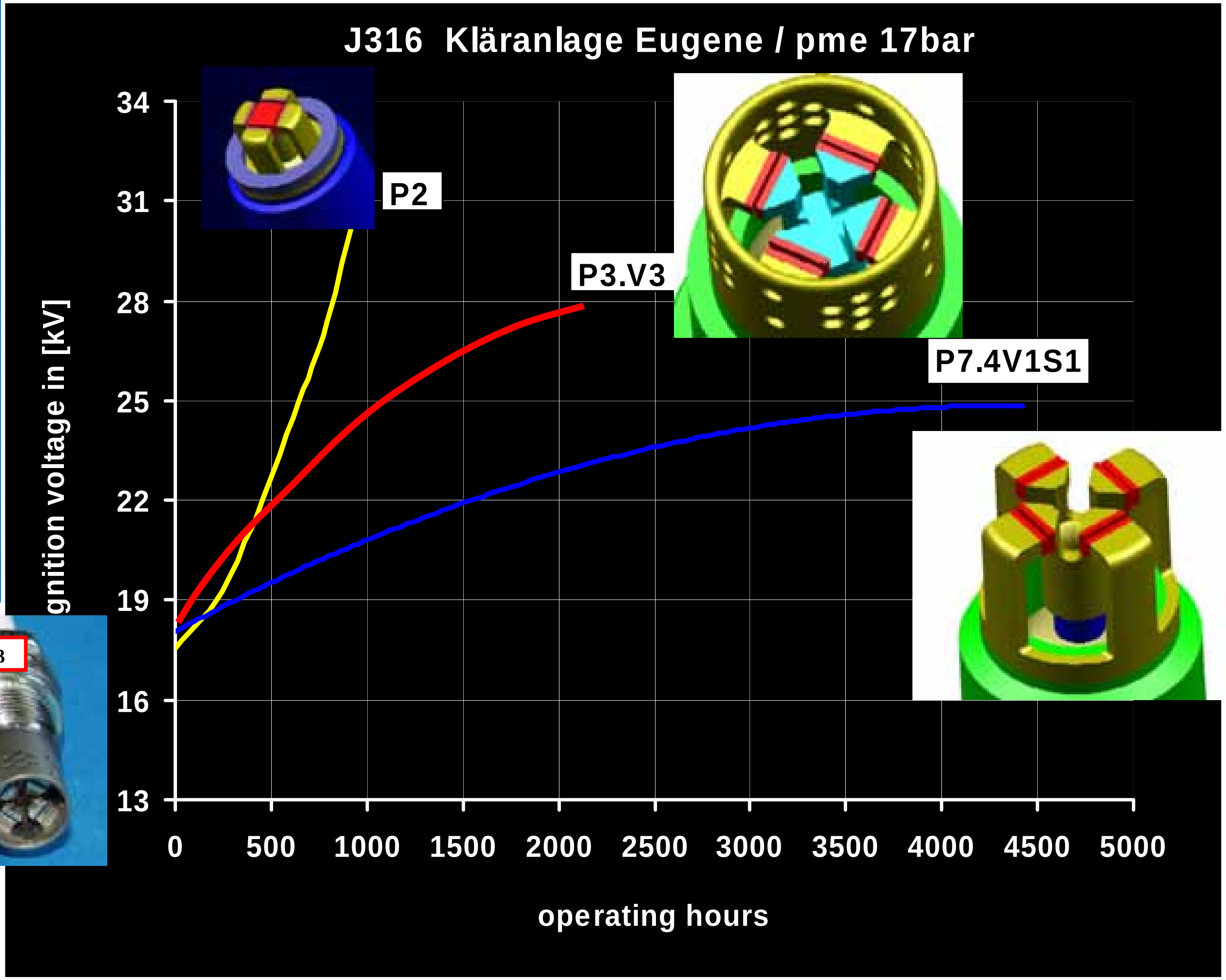
Comparison of efficiency of different concepts



The optimum of compression ratio and BMEP must be found

GEJ spark plugs/ ignition system development





GE imagination at work

WWTP Straß/A JMS 208 GS.B.LC

WWTP Strass Zillertal/A
1 x JMS 208 GS B.LC

Electrical ouput
330 kW
Thermal output
420 kW

Electr. efficiency
η_{el} = 39%
Therm. efficiency
η_{th} = 48%

Optimization of combustion Type 2/3/4

Optimized Combustion

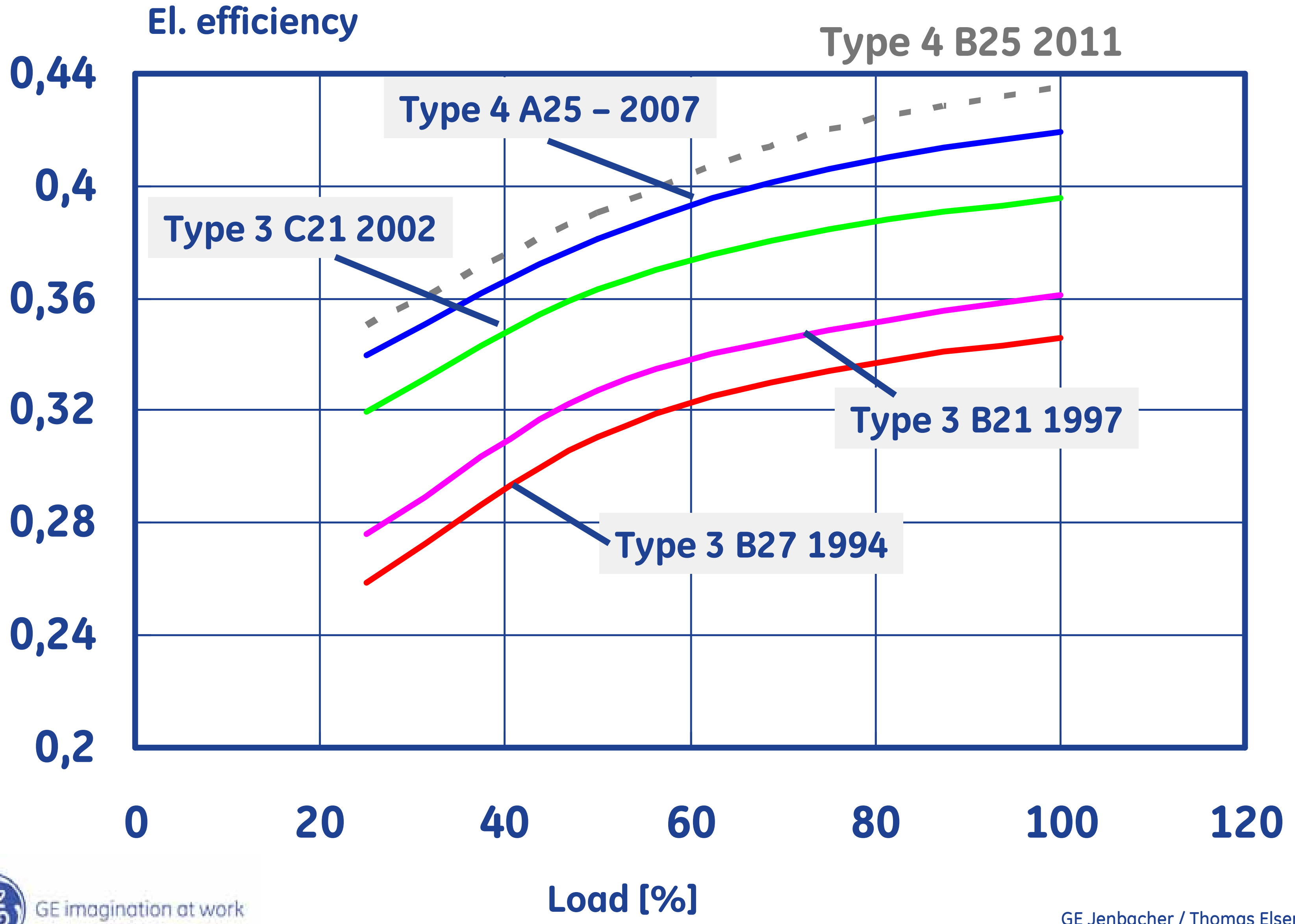
Acceleration by „heart-shaped“ piston bowl

Minimized crevice volume

- 30% lower HC
- 30% lower CO

increased compression ratio in combination mit „Miller“-timing

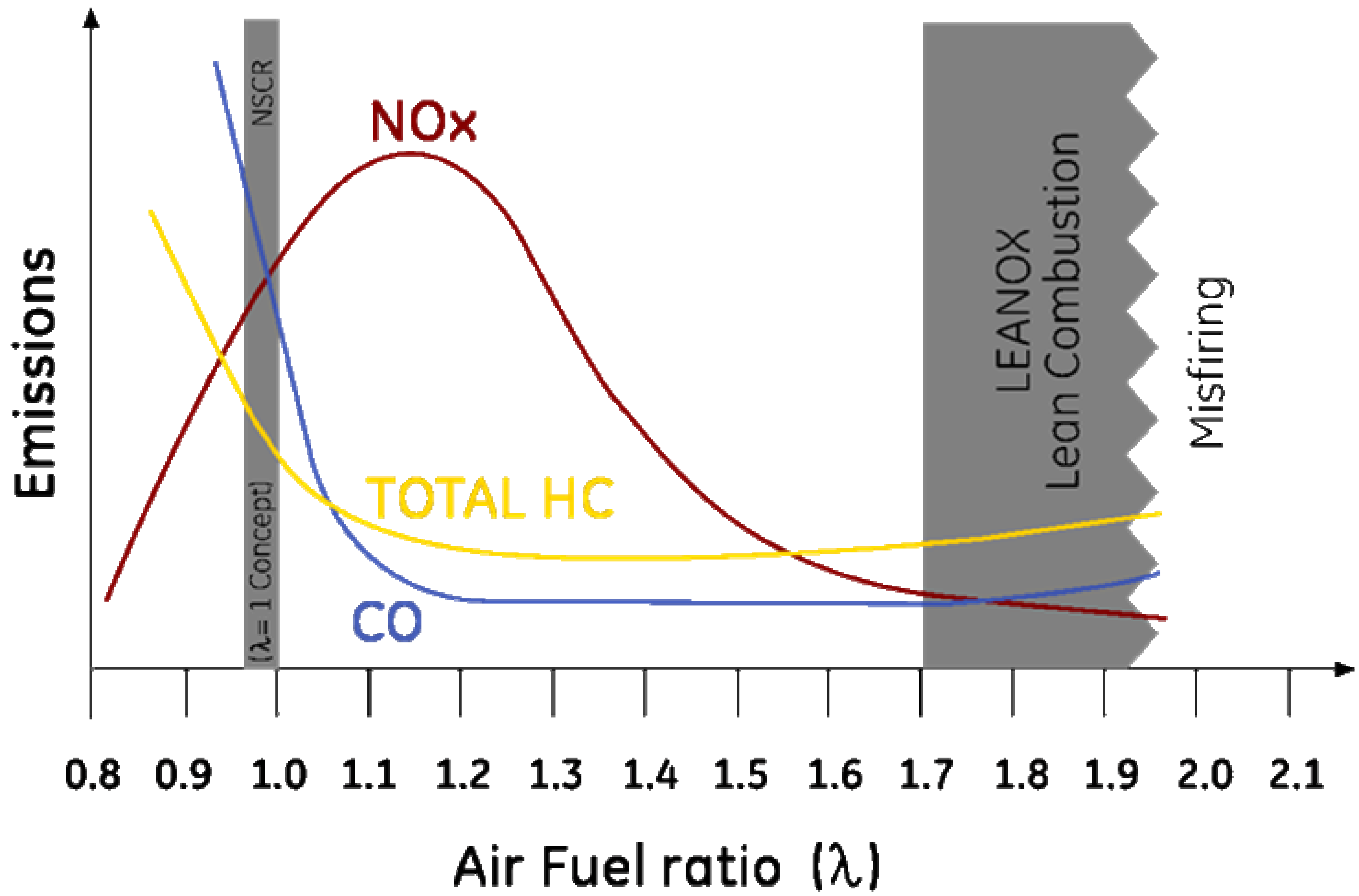
Efficiency increase in Biogas



Important criteria for gas engine selection

imagination at work

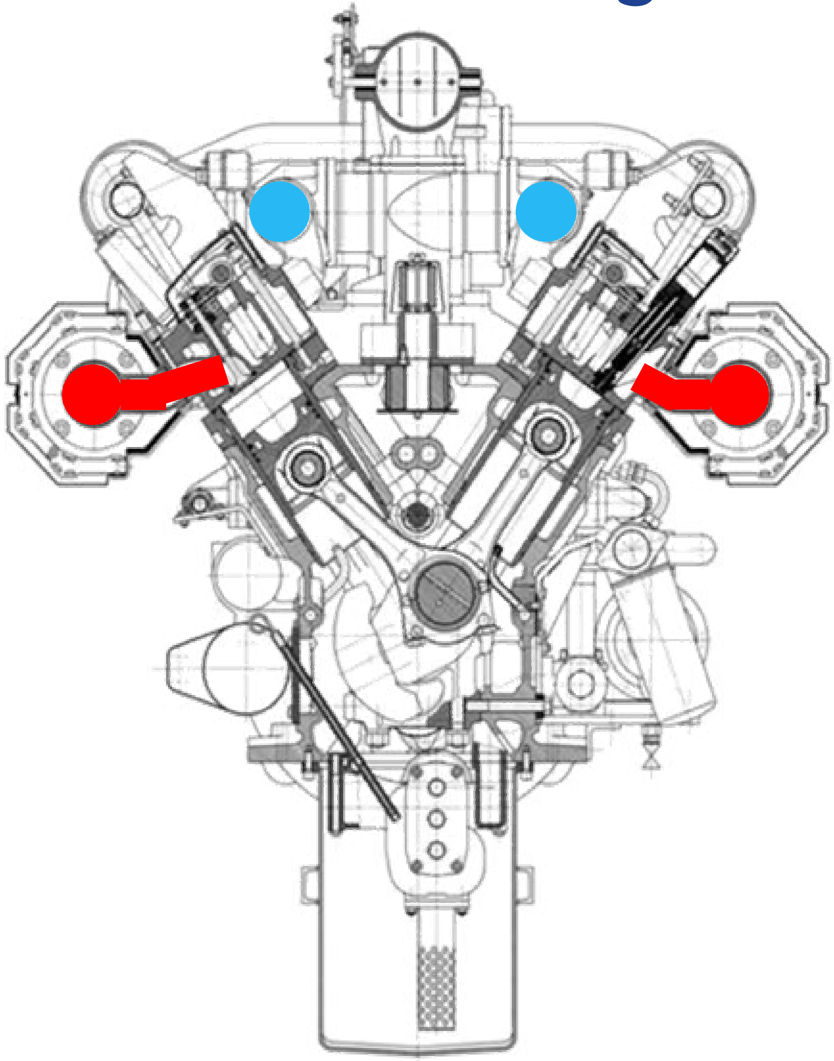
Lean-burn combustion with gas engines



- Lean combustion to ensure low NOx emission limits (500 mg/Nm³ and lower)
- Reduced combustion temperatures enable higher specific outputs and efficiency

GE imagination at work

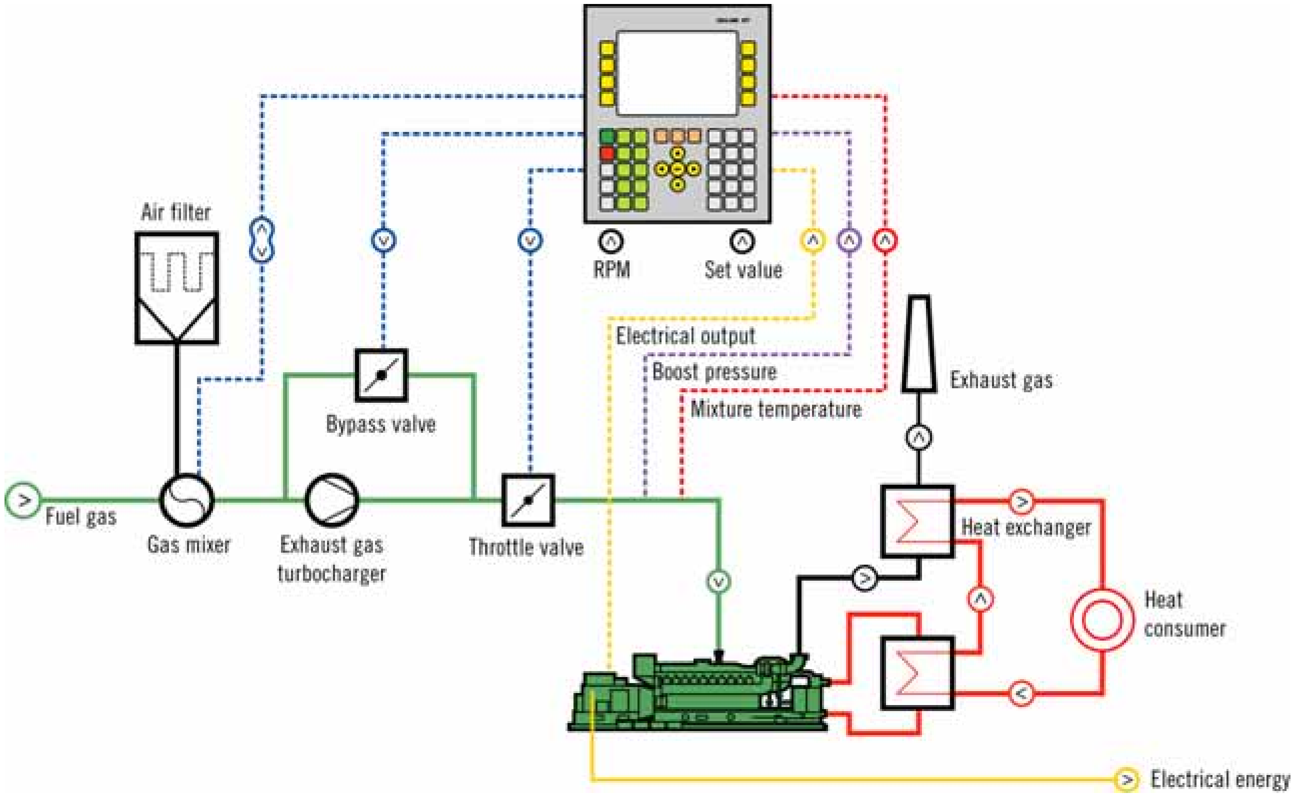
Details: „Gas engine concept“



Advantages:

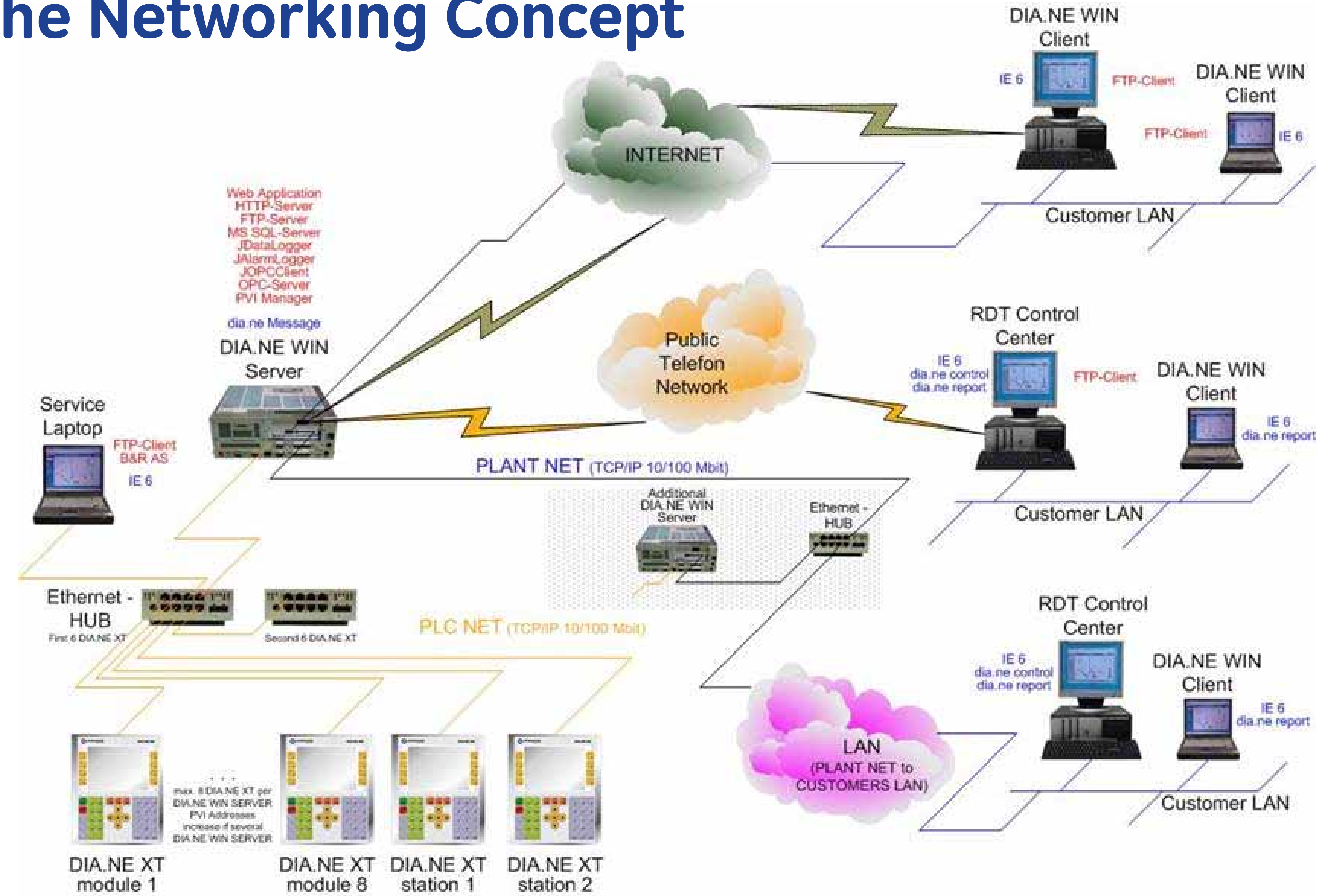
- “Cross flow” cylinder head (external exhaust gas manifolds)
- Clear separation of cold mixture inlet and hot exhaust gas
- Exactly defined thermal zones in the cylinder head
- Long cylinder head life time
- Better accessibility to the exhaust gas manifolds

LEANOX® - Lean-burn combustion 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…)

The Networking Concept



Important criteria for gas engine selection

- Select a **specifically designed biogas cogeneration unit**
- **Modern gas engine concept** ("Cross-flow" cylinder head, no derived Diesel engine)
- Turbocharged engine for high power density and efficiency
- **Electronic NOx-emission control**, preferably with sensors outside the combustion chamber and exhaust gas manifolds
- **Enhanced ignition control system** (preferably with integrated electronic ignition voltage control)
- **Knocking control** (at least 1 sensor/ cylinder-line)
- **Enhanced engine control system** with alarm management (remote monitoring, diagnosis and control recommended)
- Interfaces between engine control and system control

Typical operation and maintenance figures

- **Main maintenance intervals**:
  - Every 1,000 (2,000) ophs: spark plug and valve re-gapping, lube oil change (according oil analysis)
  - Btw 5,000 and 10,000 ophs: overhaul of turbocharger, water pump…
  - Minor or top-end overhaul btw. 15,000 and 30,000 ophs depending on manufacturer and engine condition (change of cylinder heads, pistons, liners, …)
  - Major overhaul: btw. 40,000 and 60,000 ophs depending on manufacturer: exchange of core-engine
- Specific maintenance cost:
  - 1.5 – 2 US¢/kWh for preventive and corrective maintenance
  - Major overhaul: Appr. 60% of the initial investment for the genset.

O&M costs of genset appr. same as initial genset investment

Example Biogas Gosdorf – Outstanding Reliability

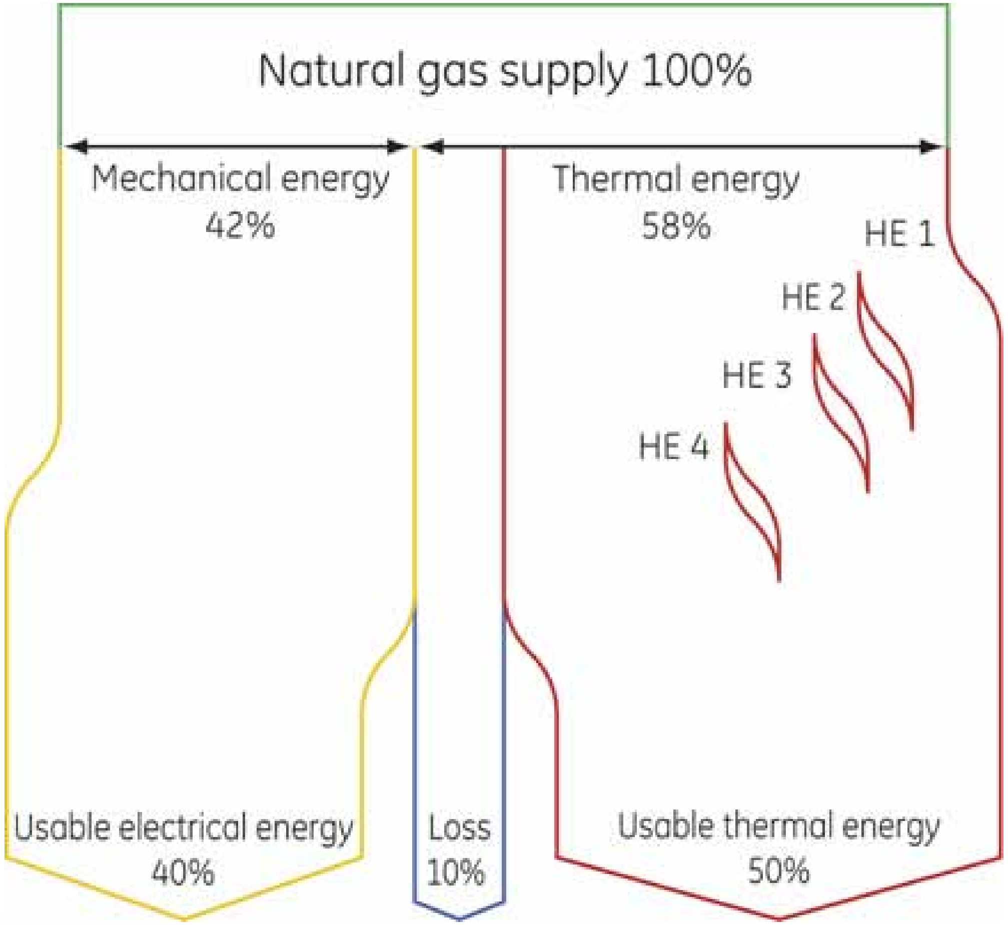
- Achieved 8,740 out of 8,760 oph/y in´05
- 99.8% Availability with Biogas
- average 98+% fleet reliability at Biogas (450+ units)

Heat recovery opportunities with gas engines

imagination at work

Cogeneration of heat and power (CHP)

CHP systems utilize the waste heat incurred during engine operation to generate overall plant efficiencies of more than 90%.



HE 1

Mixture intercooler

HE 2

Oil exchange heater

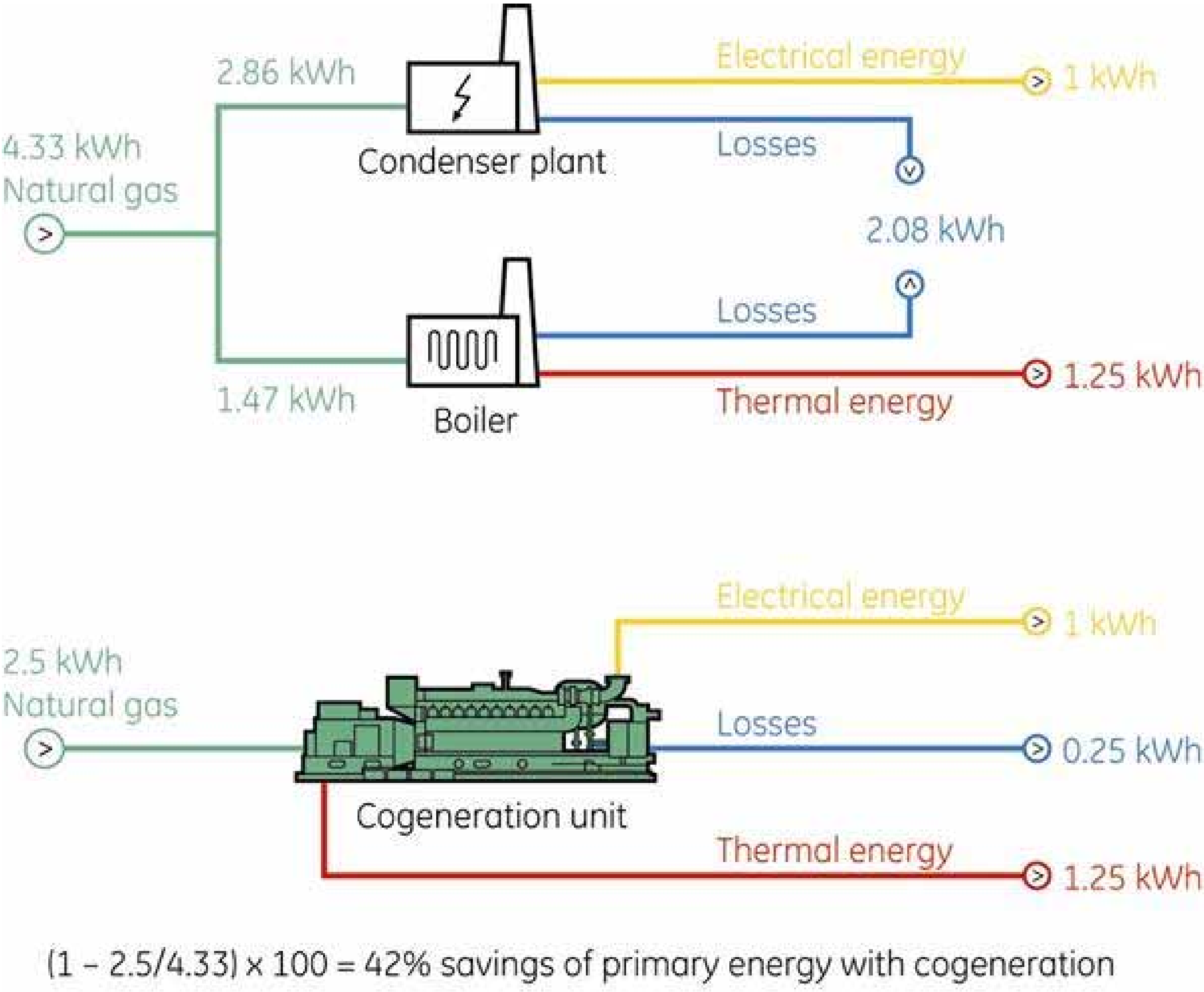
HE 3

Engine jacket water heat exchanger

HE 4

Exhaust gas heat exchanger

Energy savings through CHP technology



Primary energy savings: roughly 40%

Temperature levels of different heat sources

	Min.	Max.	Danger
Engine Jacket water	57°C	95°C	Overheating
Lube oil	70°C	90°C	Viscosity
Intercooler	55°C	80°C	Condensation
Exhaust gas	(50°C) Condensate!	220 (180)°C	Acid dewpoint

GE imagination at work

Recoverable Heat w/ Integration 70/90°C

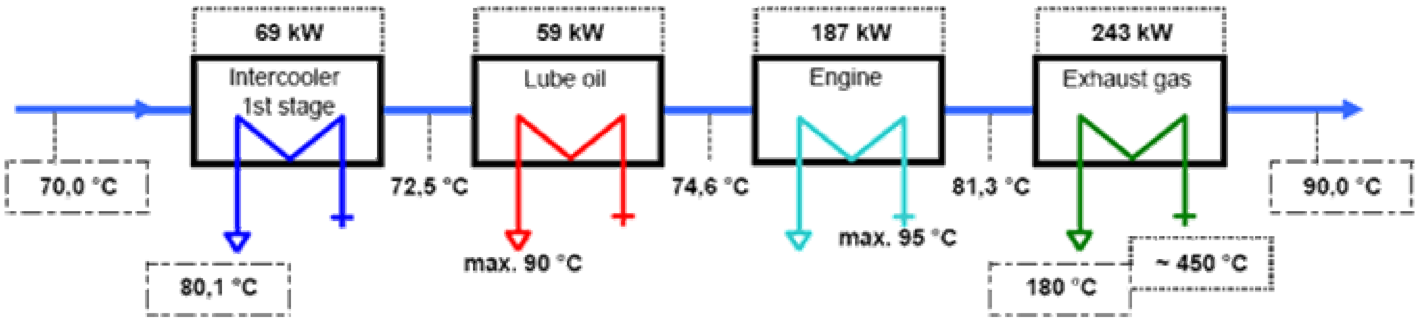
Hot water circuit

J 312 GS-C225

Recoverable thermal output = 558 kW

(±8% tolerance +10% reserve for cooling requirements)

Hot water flow rate = 24,0 m³/h

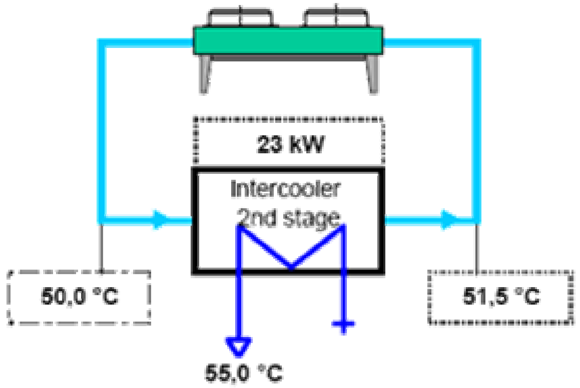


Low temperature circuit (calculated with Glykol 37%)

Heat to be dissipated = 23 kW

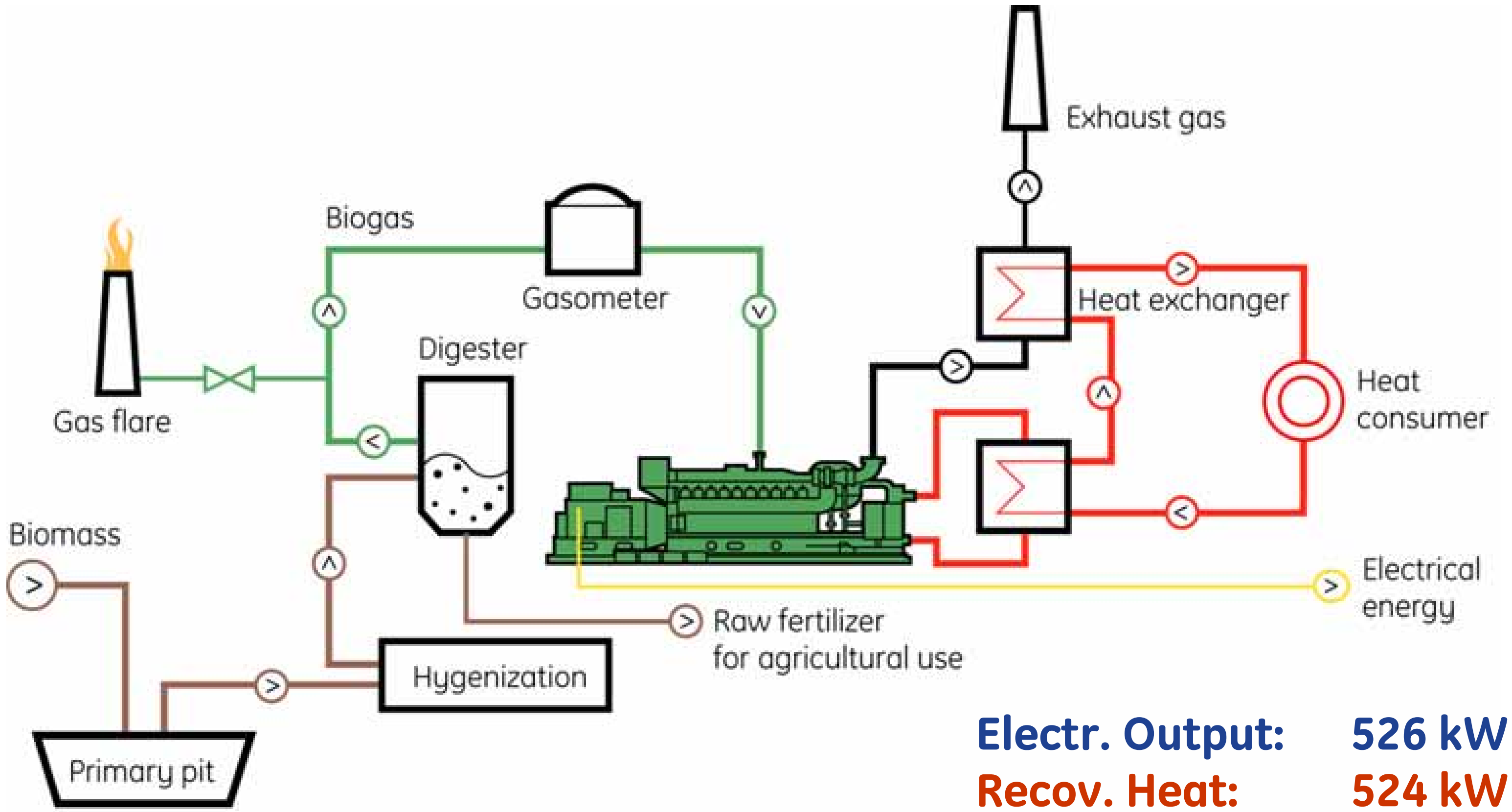
(±8% tolerance +10% reserve for cooling requirements)

Cooling water flow rate = 15,0 m³/h



GE imagination at work

Heat utiliziation in Biogas-CHP JMS 312 GS-B.L (C225)



Electr. Output: **526 kW**
Recov. Heat: **524 kW**
LT-IC heat: **23 kW**

Therm. Efficiency: **40,3%**

GE imagination at work

Steam production with Gas engines

Foto: Biogas Kogel – 1 x JMC 420 GS-B.LC

JMS 312 GS-B.L

Electr. Output: 526 kW

Therm. Output
Hot wat. 65/85°C: 325 kW
Sat. steam, 8 bar: 345 kg/h
(= 231 kW)
LT-IC heat: 19 kW

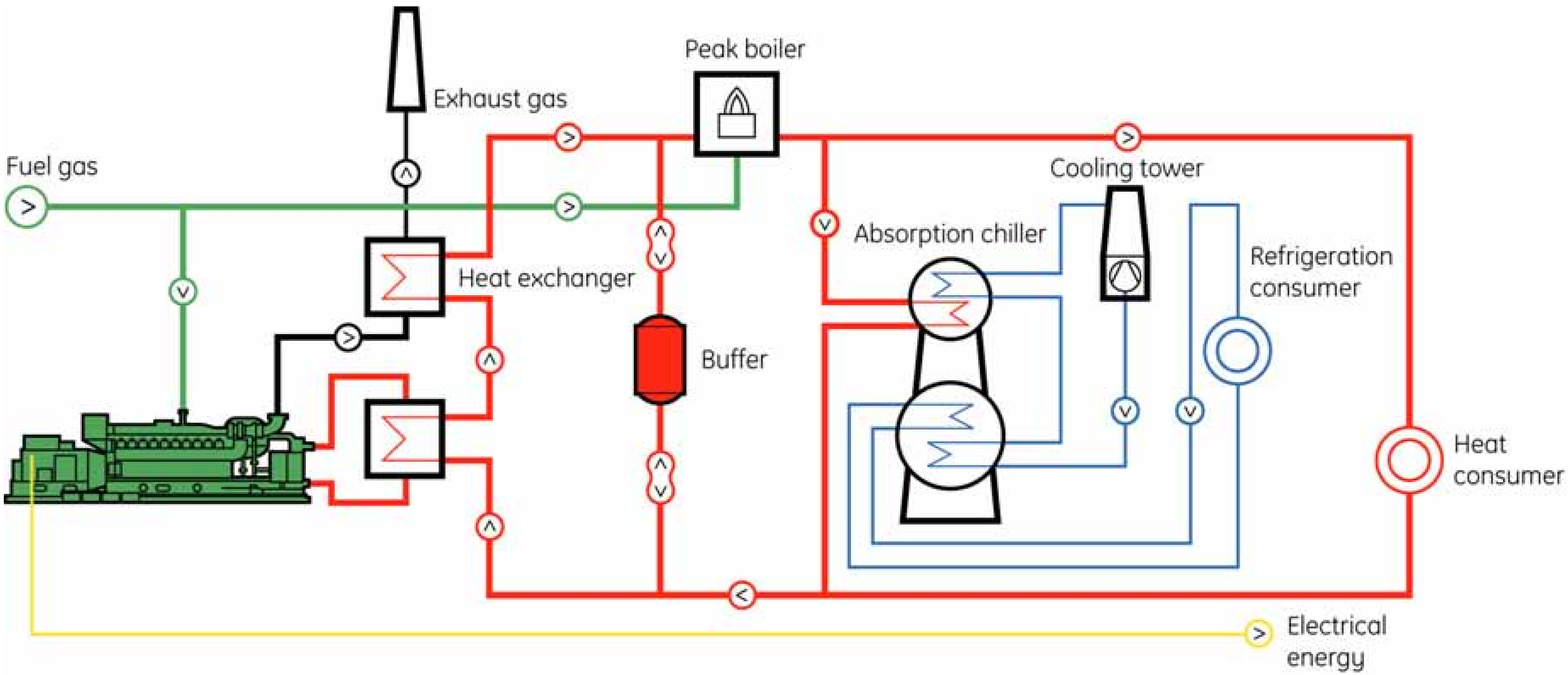
Therm. eficciency: 42,7%

Feed water must be conditioned!

Advantages of trigeneration systems over conventional refrigeration technology

- Operated with heat, utilizing inexpensive “excess energy”
- No moving parts in absorption chillers, no wear and therefore low maintenance expenses
- Noiseless operation of the absorption system
- Low operating costs and life-cycle costs
- Water as refrigerant, no use of harmful substances for the atmosphere

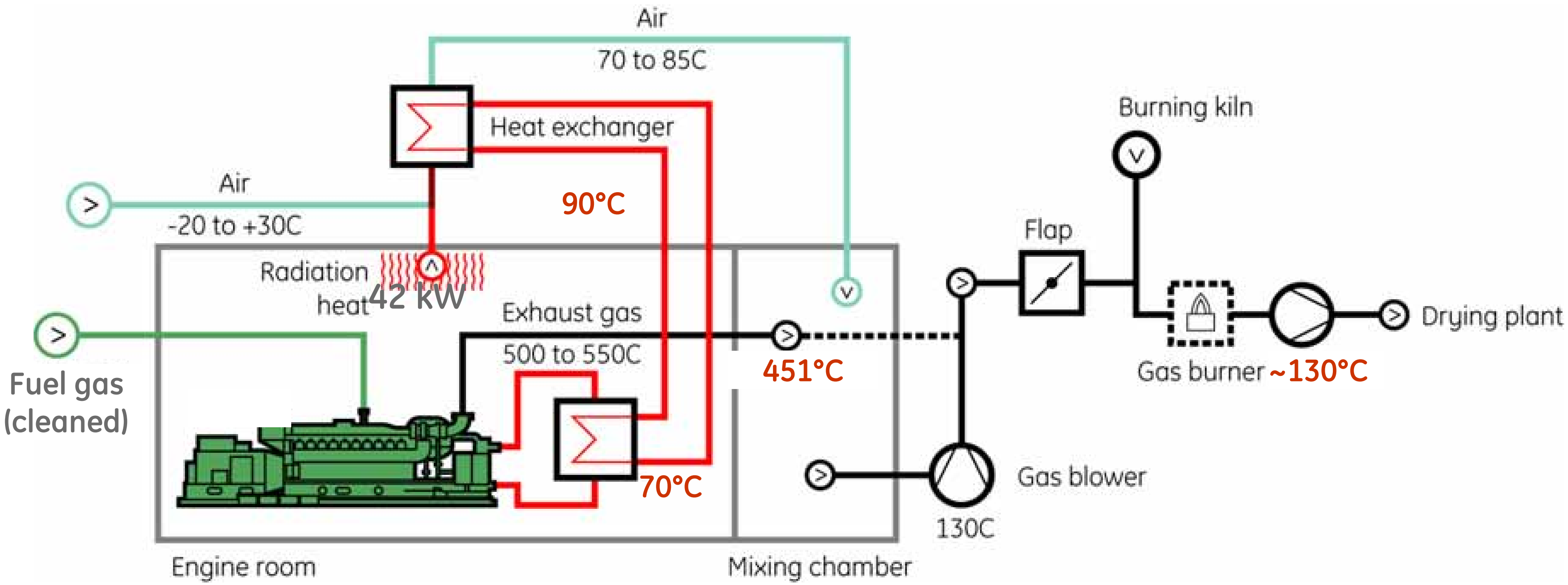
Trigeneration with gas engines



Electr. Output: **526 kW**
Recoverable Heat: **550 kW**
LT-IC heat: **40 kW**
Cold production: **~385 kW**
Therm. efficiency: **42,2%**

GE imagination at work

Drying process with Gas engines



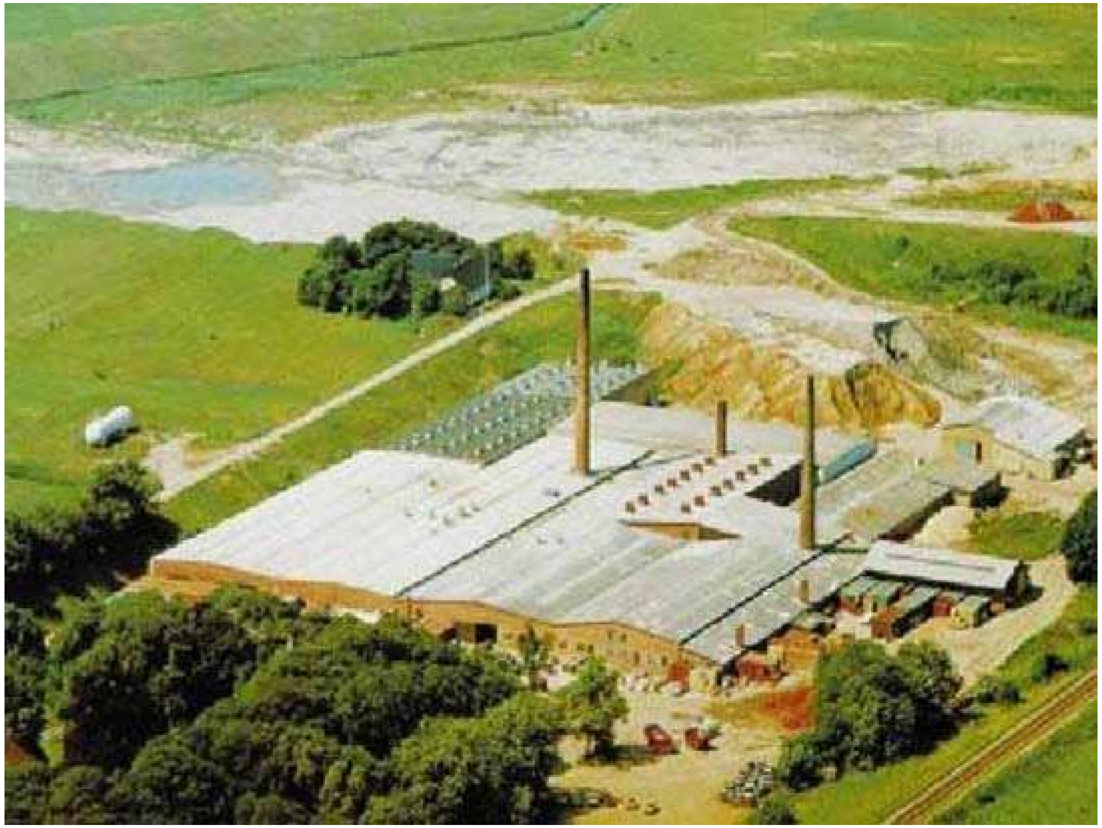
JMS 312 GS-B.L

Electr. Output:	**526 kW**
Recoverable heat:	**653 kW**
LT-IC heat:	**24 kW**
Therm. efficiency:	**50,2%**

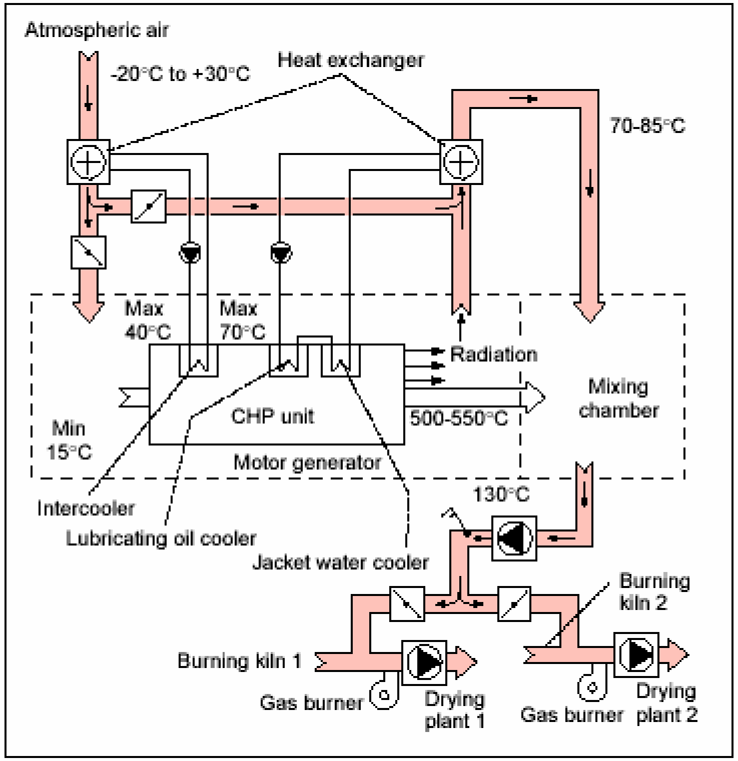
GE imagination at work

Brickyard LUNDGAARD
Stoholm - Denmark

1 x JMS 212 GS-N.LC



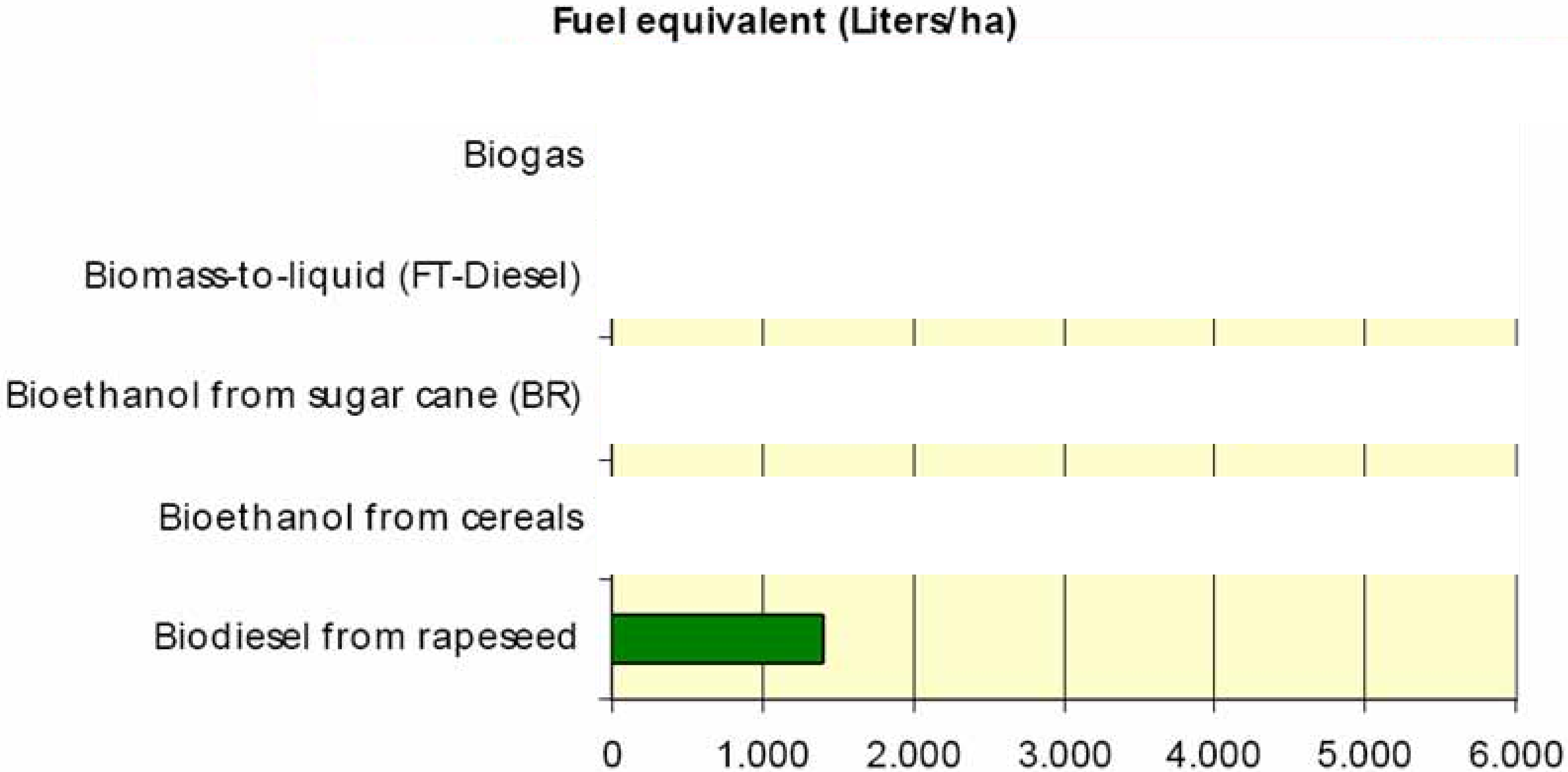
Electr. Output: 465 kW
Recoverable heat: 699 kW
Therm. efficiency: 59,0 %



GE imagination at work

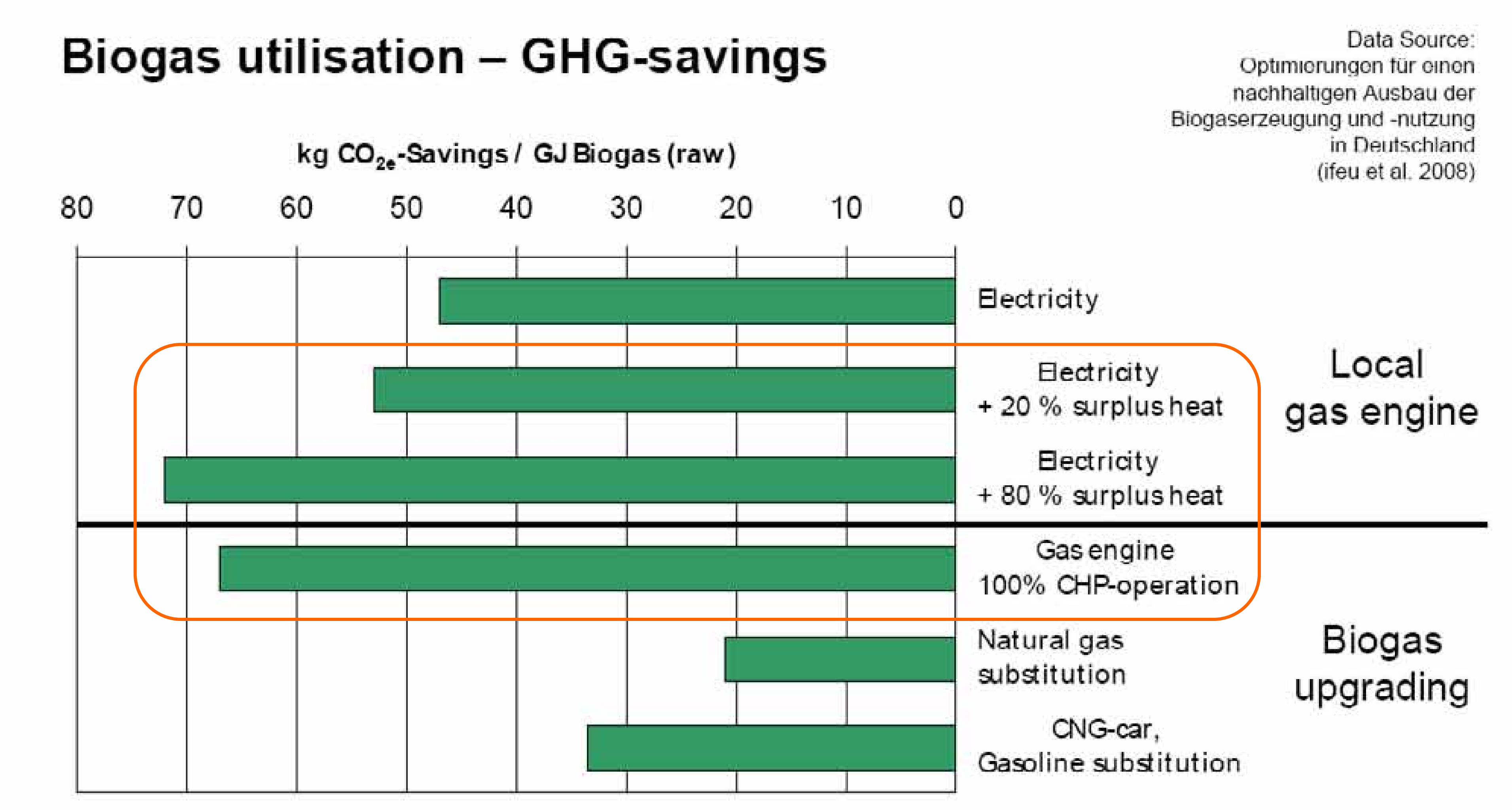
What is the right path with biogas?

Biogas utilisation – An effective biofuel



Data Source:
German Federal Agency for Renewable Resources - FNR

What is the right path with biogas?



Summary – Biogas in CHP

- **Biogas** plants are operated – weather independent – for base load supply
- **Biogas** plants can be seen as **state-of-the-art technology**
- Because of low energetic density of source materials, **biogas** should be used **decentralized**
- Using biogas in **CHP-modules** generates **highest GHG-savings**

Important design criteria

imagination at work

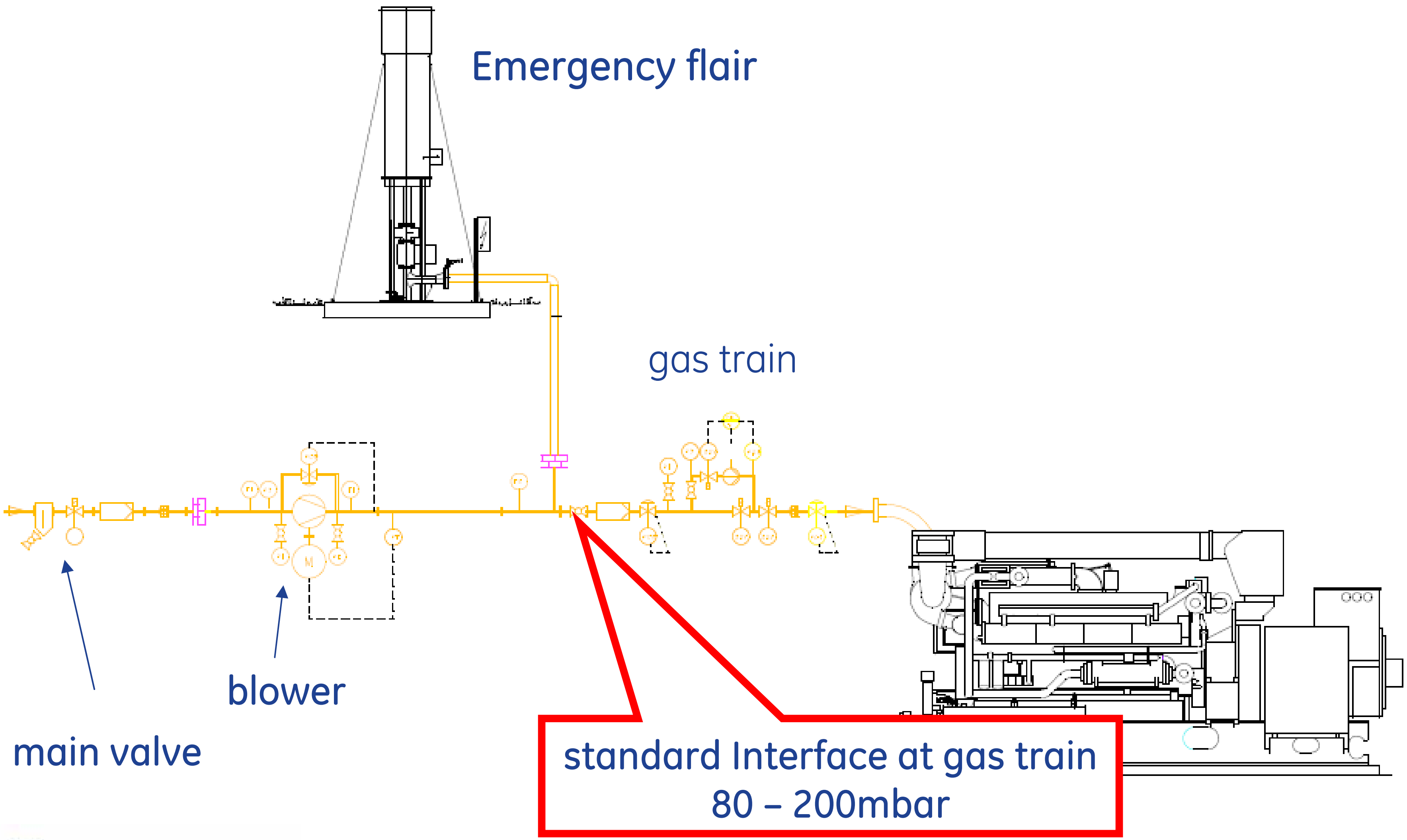
Gas Requirements :

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

In general these are important criteria for Non Natural gases

GE imagination at work

Gas – plant:



GE imagination at work

Gas Requirements :

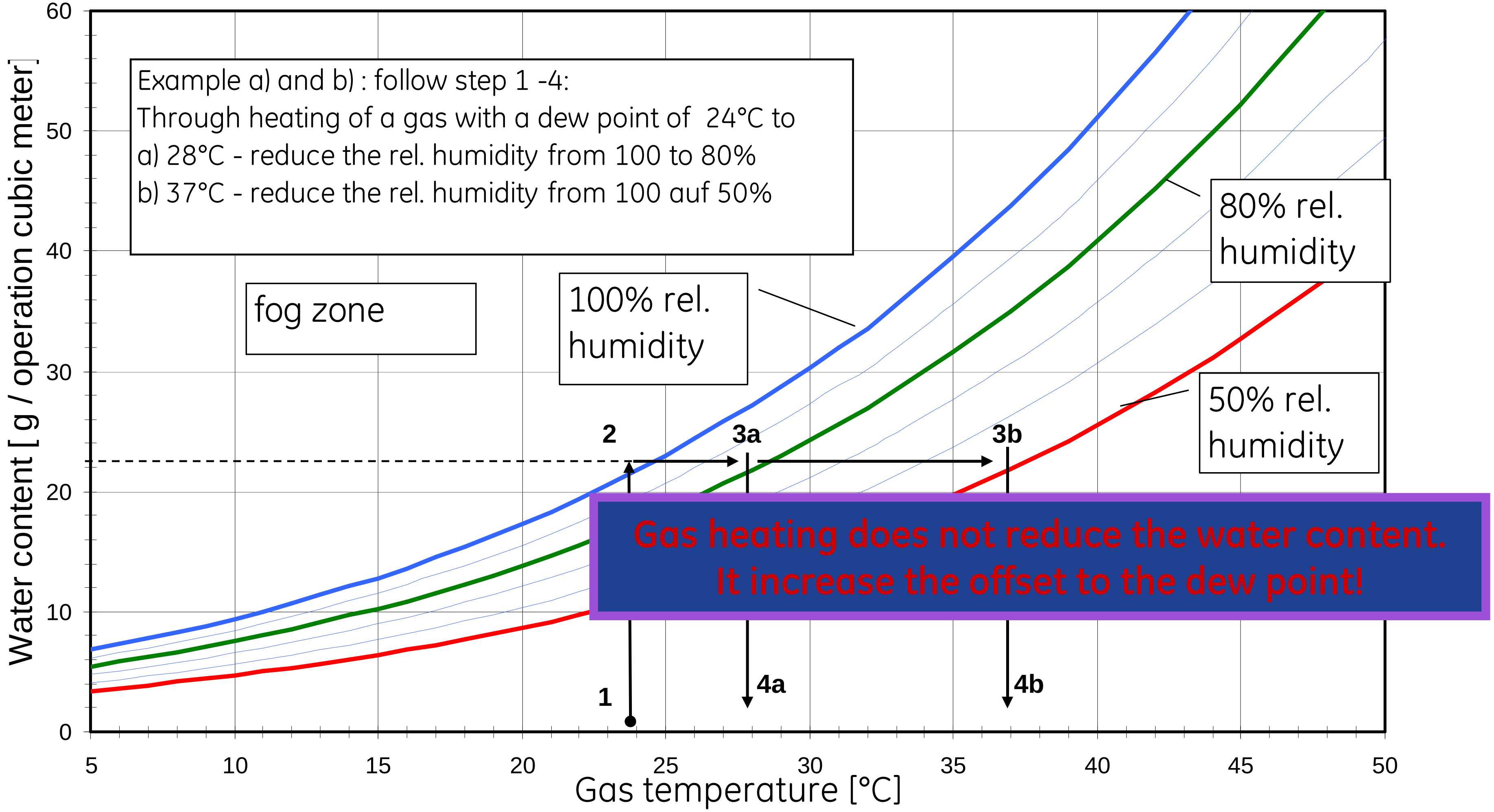
- Gas temperature < 40°C
  - mixture temperature
  - limited by rubber materials of gas train

- relative humidity < 80%

(at every gas temperature)

  - condensate in gas supply
    - filter; pressure regulator; gas train,.....
    - condensate in engine/intercooler

Relative humidity:



GE imagination at work

Gas humidity / cooling:

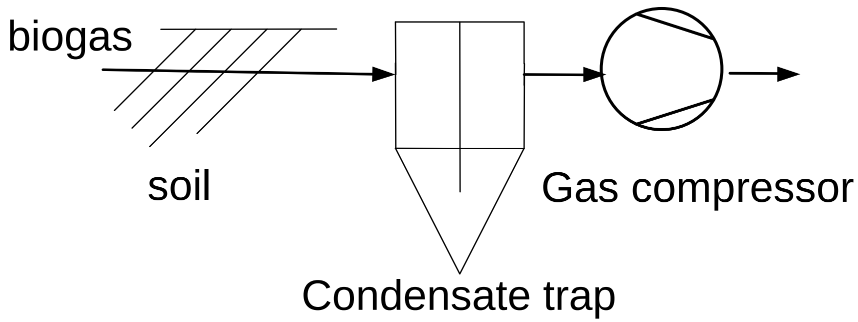
GE imagination at work

Gas Requirements TI 1000 – 0300:

Condensate in the intercooler

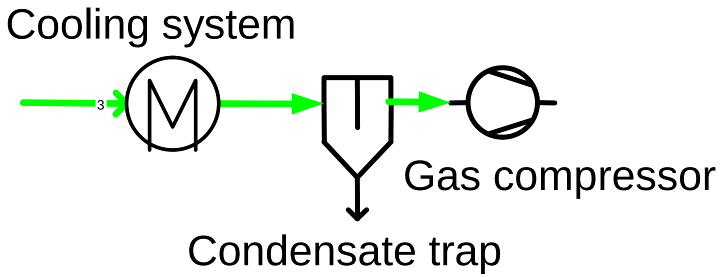
Reduce humidity:

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 because of gas pipe mounted in soil possible but not sure

Active humidity reduction → best solution



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

GE imagination at work

Active gas drying / biogas example:

Schmack 1/Deutschland

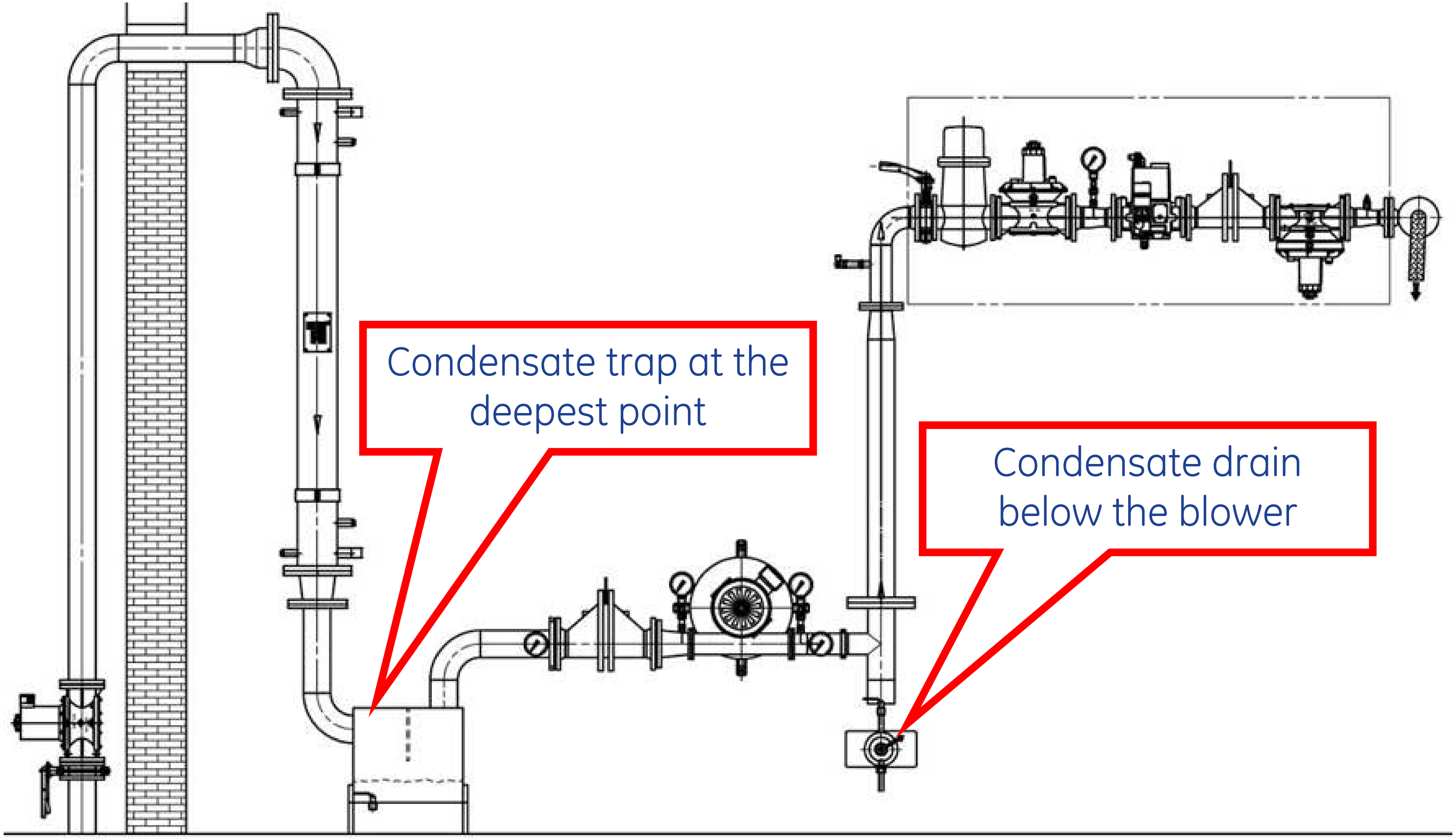
1 x JMS 312 GS-B.L

500 KWel

Gas cooling / drying / dehumidification

Electr. chiller

Layout example:



Gas Requirements TI 1000 - 0300

Sulfur:

H_2S < 700 mg/10 kWh (without catalyst)
< 200 mg/10 kWh (with catalyst)
↳ Standard maintenance schedule

$\Sigma H_2S < 1200$ mg/10 kWh
↳ „modified" 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

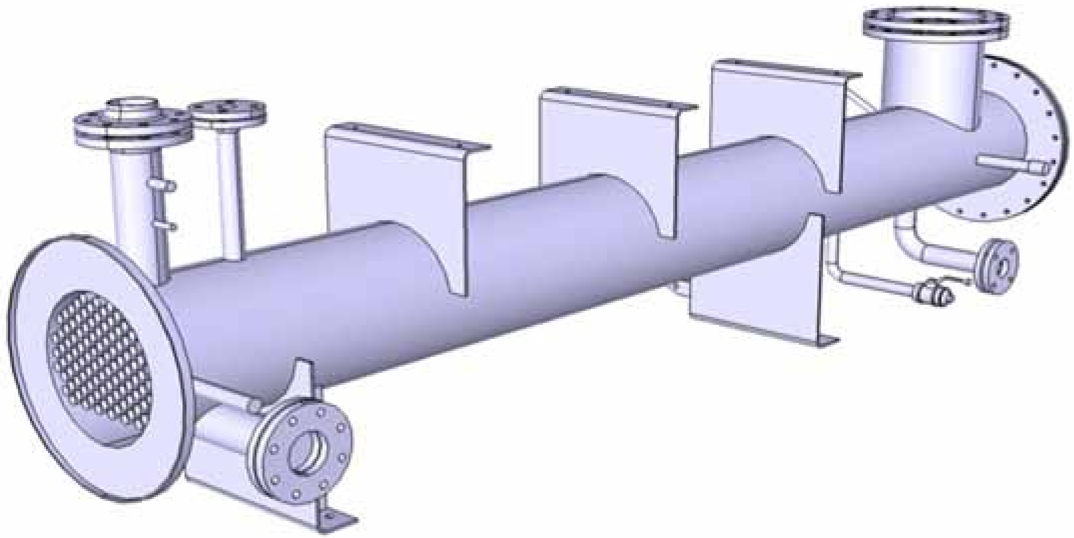
Sewage Treatment Plant
Sulfate deposits

exhaust gas temperature
below dew point

Sulfur/ash-deposits in an exhaust gas heat exchanger:

GE imagination at work

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

International references

imagination at work

Biogas plant Kogel, Germany

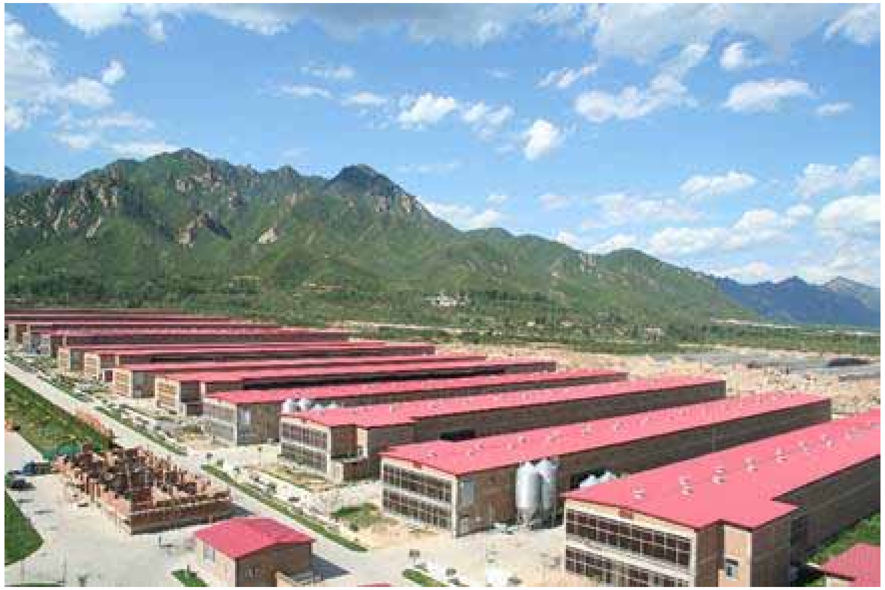
No. of units and engine type:	1 x JMC 420 GS-B.L
Fuel:	Biogas (potato peelings/pig manure)
Electrical output:	1,413 kW
Thermal output:	751 kW
Steam production:	3 bar(g) 1,037 kg or 698 kW steam production
Commissioning:	Year 2002

Biogas plant Præstø, Denmark

No. of units and engine type:	1 x JMS 312 GS-B.L
Fuel:	Biogas from pig manure
Electrical output:	625 kW
Thermal output:	726 kW
Commissioning:	June 2002

GE imagination at work

Biogas plant DeQingYuan, China



No. of units and engine type:	2 x JMS 320 GS-B.L
Fuel:	Biogas from Chicken Dung
Electrical output:	2126 kW
Thermal output:	1234 kW
Commissioning:	Sept 2008

Cow manure "methane-to-energy" plant in Ludhiana - India

Biomass Input: 235 ton/day cattle manure
Electrical output: 1 MW
Organic fertilizer: 35 ton/day

No. of units and engine type: 1 x JMC 320 GS-B.L

AD of biomass – Natural palm Oil - Thailand

Biomass:

- POME - palm oil mill effluent

Basic conditions:

- 12m3/h POME
- Temperature of POME fresh from mill 80°C -> cooling-down in open lagoon

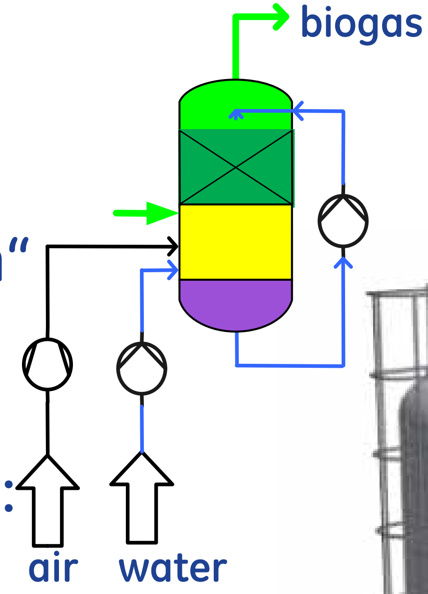
1 x JGS 320 GS-B.L.C

Power output: 1064 kWel.

Commissioning: 2005

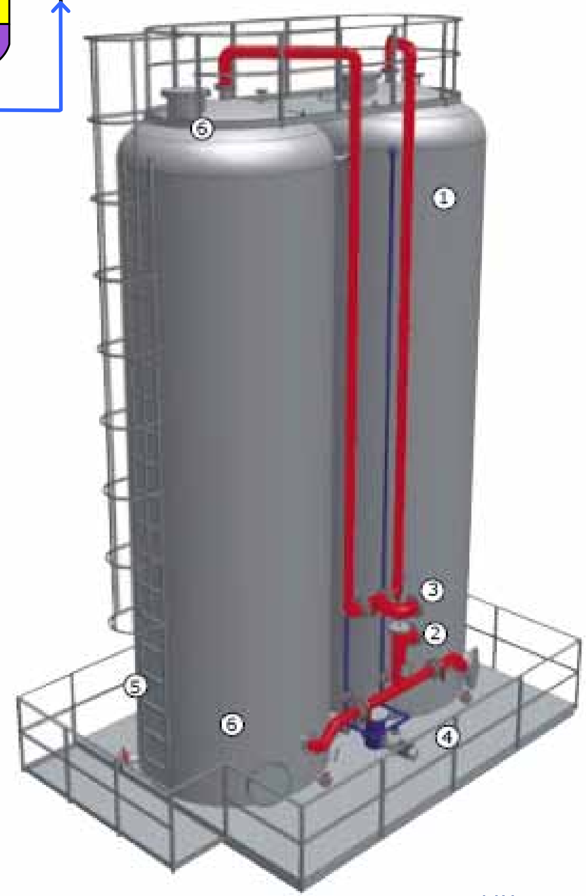
AD of biomass – Natural palm Oil - Thailand

Biogas:
H2S content up to 2000ppm
-> desulphurization is a must!
-> done with a „BioGasclean-System"



Heat demand of the "Palm Oil Plant":
-> steam 22.5 to/hr (3.5bar; 0.5to/FFB)

Steam production:
-> with "Palm Fiber"
-> in addition with exhaust gas



GE imagination at work

AD of biomass – Kanoria I + II - India:

Biomass:

- Spent wash – 675 m3/d
  -> effluent removed after fermenting sugar cane molasses (ethanol production)

1 x JMS 320 GS-B.L

1 x JMS 420 GS-N/B.L

Power output:
1034 kWel. / 1416 kWel.
Thermal output:
Water:586 kWth. / 748 kWth.
Steam: ~ 1350 kg/h; 10bar
Commissioning: 1998 / 2003

Biogas plant Highmark, Canada

No. of units and engine type:	1 x JMC 320 GS-B/N.LC
Fuel:	Biogas from cow manure
Electrical output:	1,060 kW
Thermal output:	1,240 kW
Commissioning:	March 2004

Thank you for your attention!

Further Questions?

imagination at work