
POWERING
EVERYONE
GE's Distributed Power Customer Event 2016
MADEITAAS

Electricity & heat from Biogas and Landfill gas applications

- Challenges and proven solutions
- Trends from Europe and other regions

Imagination at work

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Biomass sources

Landfill

Waste Water Treatment Plant

Agricultural Waste

Kitchen waste (Food, Oil, cooking fat ..)

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Landfill gas

- More than 1,800 of GE's landfill gas engines* with an electrical output of about 1,900 MW worldwide
- Organic decomposition produces fuel gas
- Waste from U.S. city of one million can power 8 MW plant

*as of June 2011

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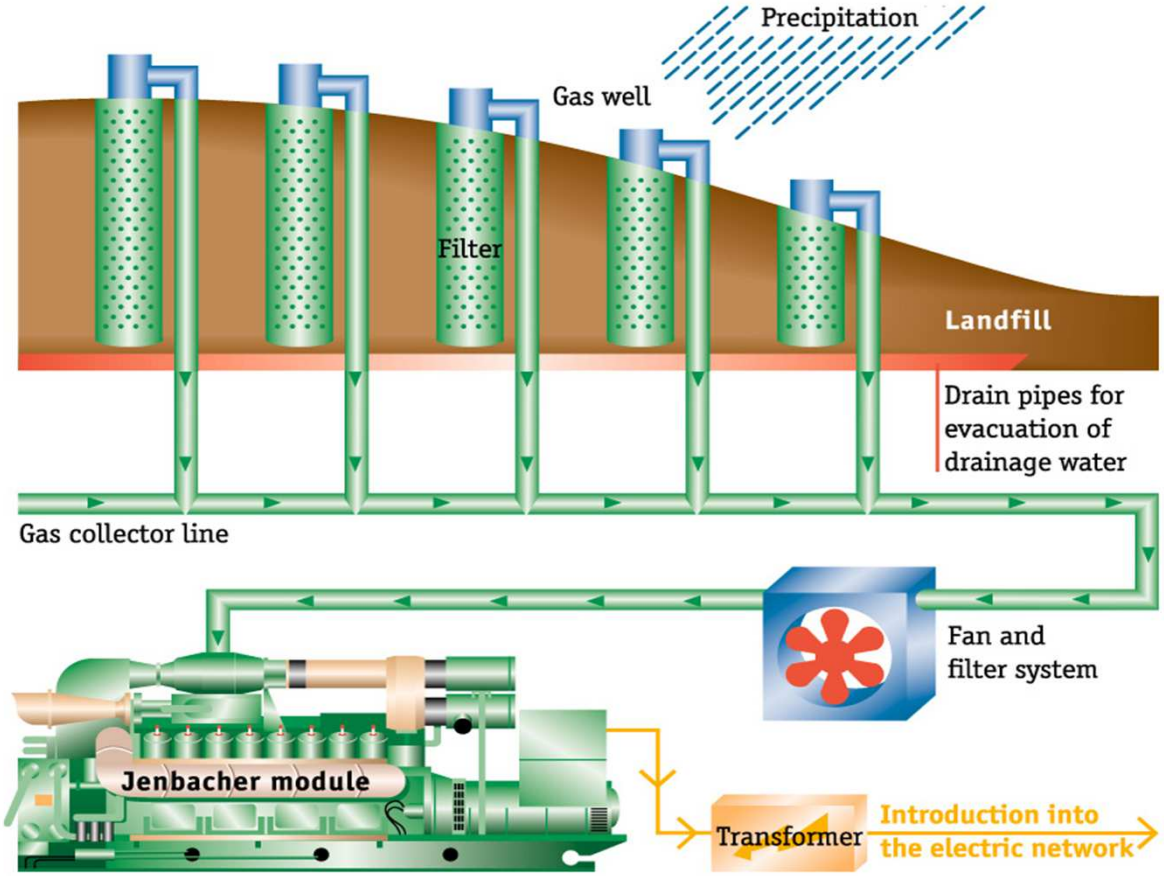
Utilization of Landfill Gas



Nent/Hongkong
2 x J320 Electrical Output 2 x 922 kW

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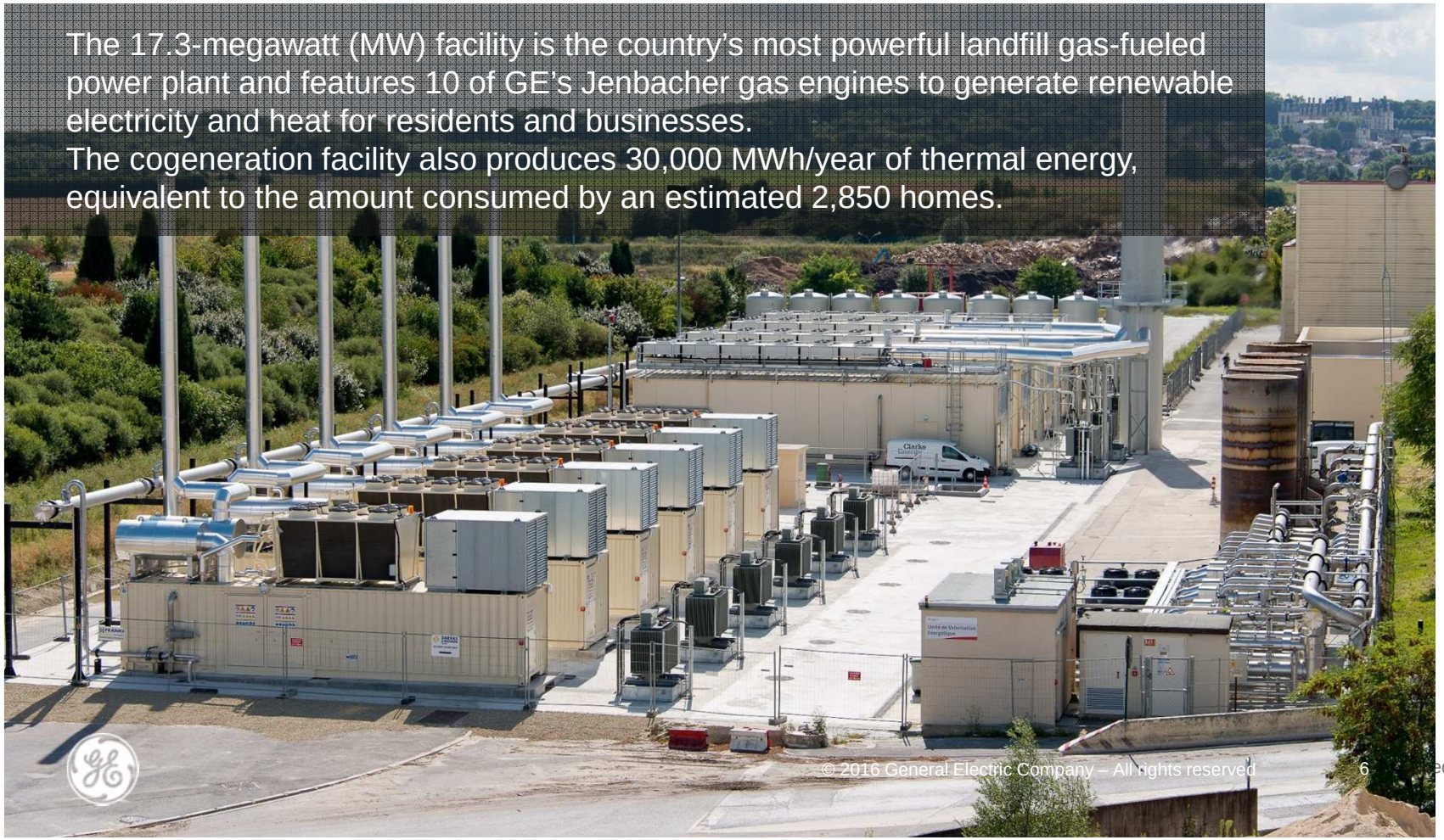
Largest Landfill Gas Power Plant in France

The 17.3-megawatt (MW) facility is the country's most powerful landfill gas-fueled power plant and features 10 of GE's Jenbacher gas engines to generate renewable electricity and heat for residents and businesses.
The cogeneration facility also produces 30,000 MWh/year of thermal energy, equivalent to the amount consumed by an estimated 2,850 homes.



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Biogas

ecomagination
a GE commitment

> 4,300 Jenbacher biogas engines >3,000 MW worldwide

- Anaerobic digestion produces fuel gas
- Renewable – from organic and animal waste
- 7,000 cows can power 1 MW plant

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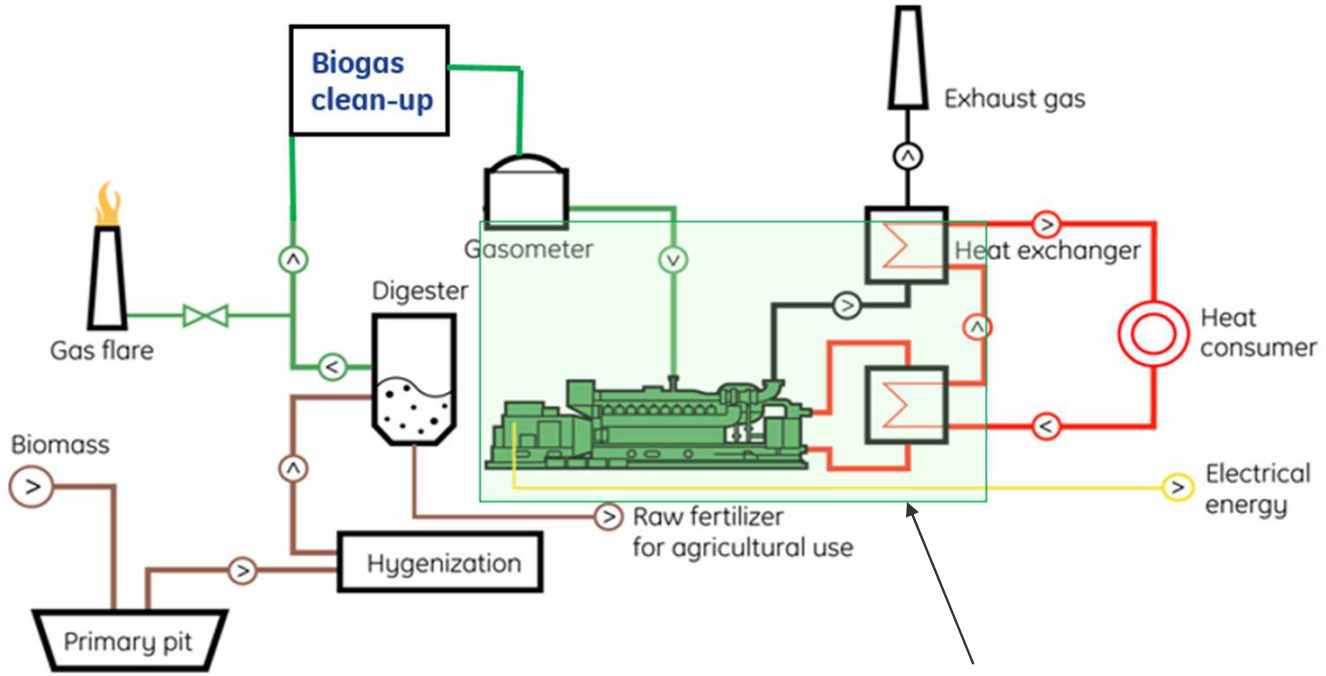
Biogas Plant – typical solution



GE scope ~35% of total biogas plant capex:
Jenbacher engine, heat exchangers, generator

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Source: GE Jenbacher/KWE

Model solution for ecological and economical energy 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.

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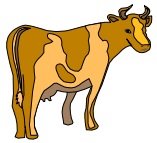
Animal waste

Energy potencial

1 Live Stock Unit (LSU) = 500 kg live weight respectively

1 LSU = 0.6 - 1.2 milking cow
approx. 1.3 m³ Biogas/LSU, day
LHV = approx. 6.0 kWh/Nm³
~7,000 cows = 1 MWel



1 LSU = 2 - 6 hogs
approx. 1.5 m³ Biogas/LSU, day
LHV = approx. 6.0 kWh/Nm³
~70,000 hogs = 1 MWel

1 LSU = 250 - 320 layers
approx. 2 m³ Biogas/LSU, day
LHV = approx. 6.5 kWh/Nm³
~1.4 million layers = 1 MWel

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

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Palm oil … promising electricity supplier for the future

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Palm Oil Biogas (POME) Technologies

Covered Lagoon type

Hybrid in-ground type

Tank Type CSTR

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Reliable

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Outstanding reliability enables high availability

Examples

- Bio-Energie Gosdorf, Austria, 1 x J312 biogas - 99.8%
- NV Groeikracht Lierbaan, Belgium, 1 x J312 CHP NG – 99.9%
- Perin SRL, Italy, 1 x J320 biogas – 99.8%

Availability

- The outstanding **Reliability** of Type 3 results in very low unscheduled downtime.
- The **Easy to maintain** concept enables very low scheduled downtime.
- This results in outstanding **Availability** and short customer return of investment.

Average of remotely connected engines have shown an availability of >98%

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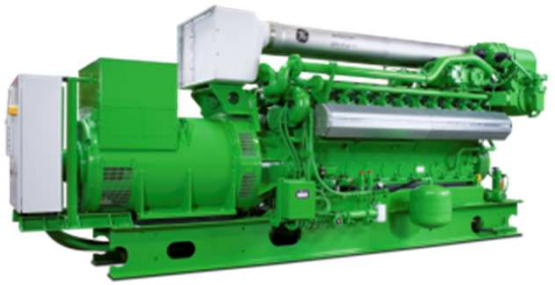
Proven very high availability…



2013 Plant #	Site	Engine	Oph @ 31.12.2013	Oph/year [hrs]	Downtime [hrs]	Availability [%]
1	###	J320	58.500	8.702	58	99,34%
2	###	J312	21.643	8.671	89	98,98%
3	###	J320	19.719	8.639	121	98,62%
4	###	J312	45.490	8.620	140	98,40%
5	###	J312	40.109	8.620	140	98,40%

2012 Plant #	Site	engine	Oph @ 31.12.2012	Oph/year [hrs]	Downtime [hrs]	Availability [%]
1	###	J320	55.546	8.749	11	99,87%
2	###	J312	30.902	8.723	37	99,58%
3	###	J320	40.469	8.703	57	99,35%
4	###	J312	26.558	8.689	71	99,19%
5	###	J320	11.080	8.687	73	99,17%

Extract: Annual availability of Top 5 Type 3 biogas plants in Switzerland

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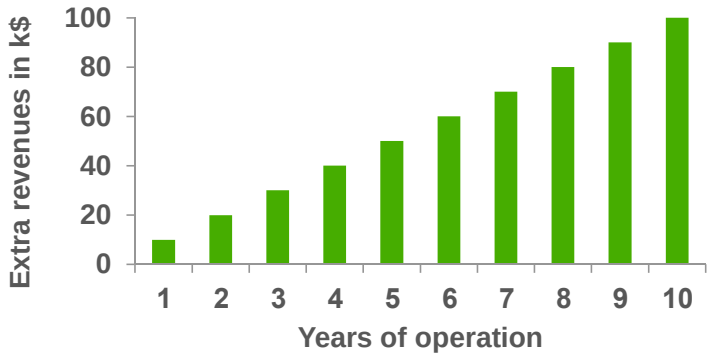
* Source: Internal statistics, Jenbacher remotely connected engines in 2011

Type 3 offers attractive savings

10,000$ savings with 1%pt extra availability



A J312 biogas unit delivers extra revenue per %pt availability of

10,000$ …	1 year
50,000$ …	5 years
100,000$ …	10 years

500 kWe in Germany EEG @ 21US$ct/kWhel with

Average >98% fleet availability
1% pt availability = ~ 1%pt efficiency

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Section header layout uses 54 pt lorem ipsum

Critical interfaces
for a reliable plant operation

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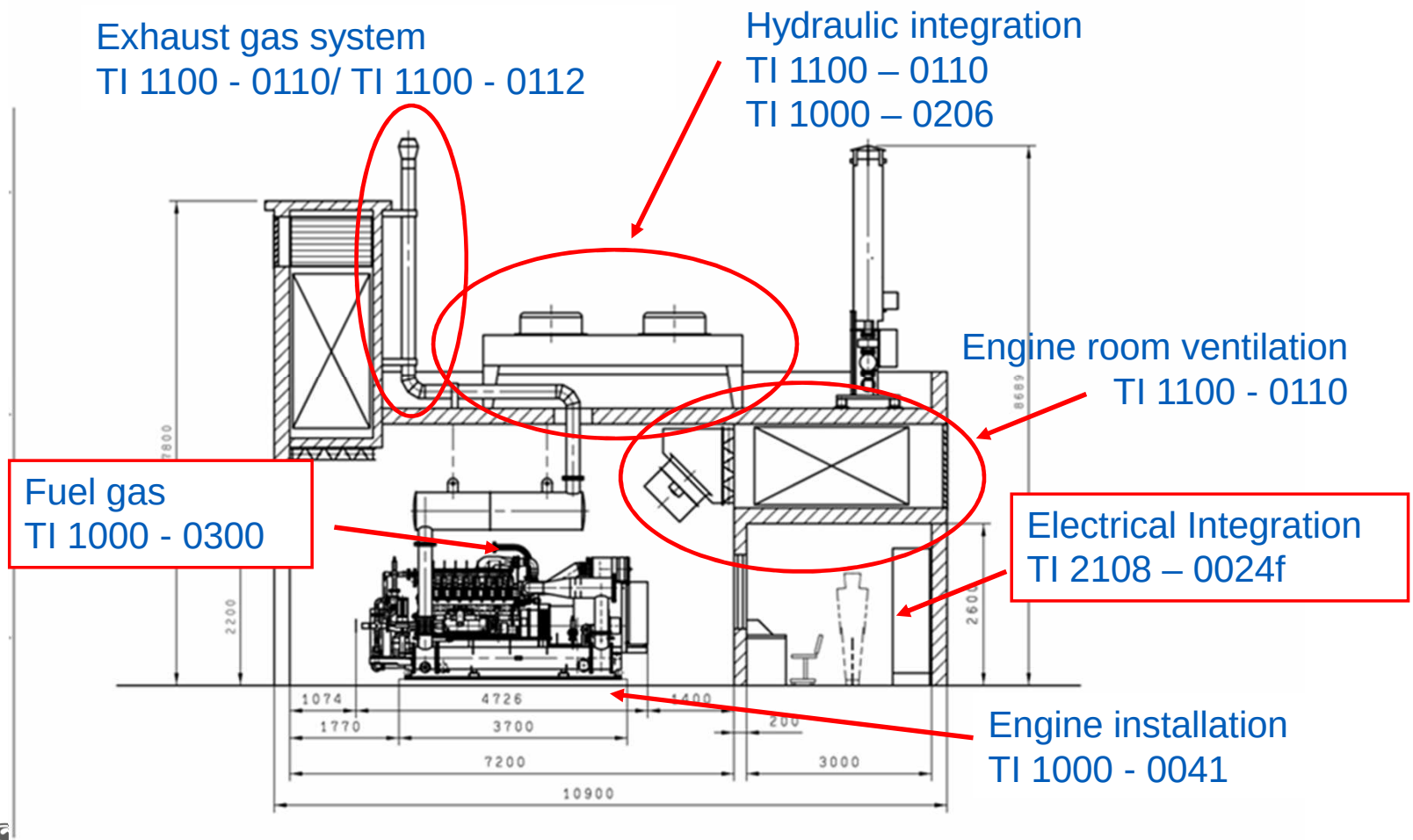
Interfaces / Plant integration



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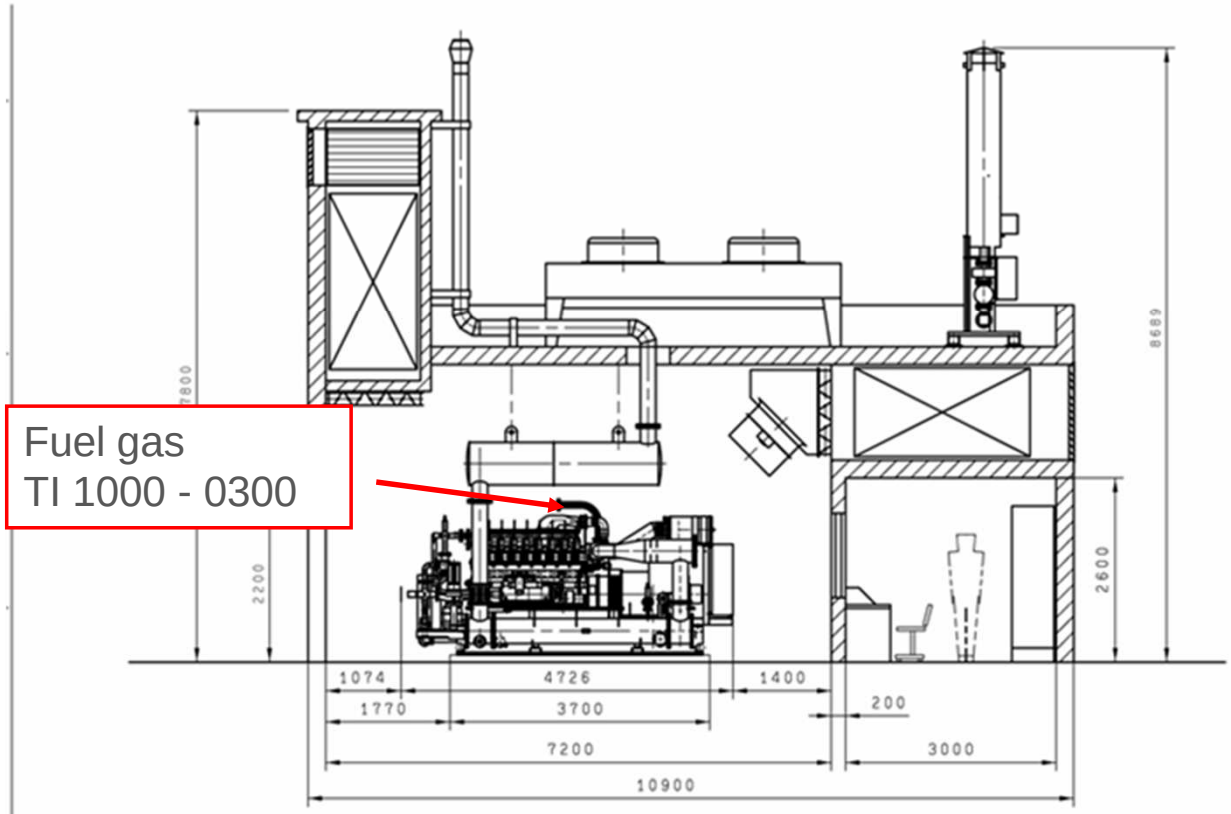
Interfaces / Plant integration



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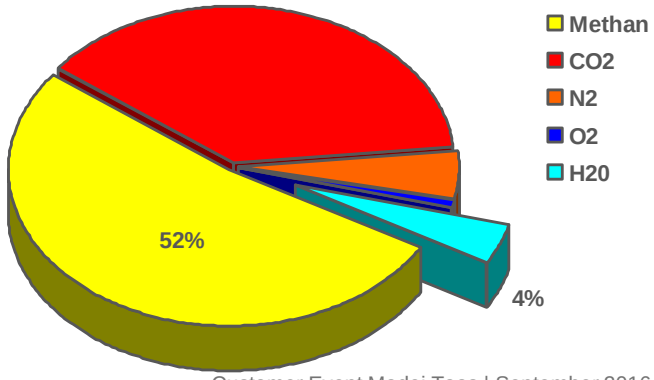
typical Biogas composition

Main components	
Gas component	**Volume %**
CH_4 [Vol. %]	**45 – 75**
CO_2 [Vol. %]	**25 – 50**
O_2 [Vol. %]	**0 – 2**
N_2 [Vol. %]	**0 – 5**

contaminations	
Gas component	**concentration**
Water [Vol.%]	1 – 7
NH_3 [ppm]	0 – 500
H_2S [ppm]	0 – 6,000
Siloxane [ppm]	0 - 10



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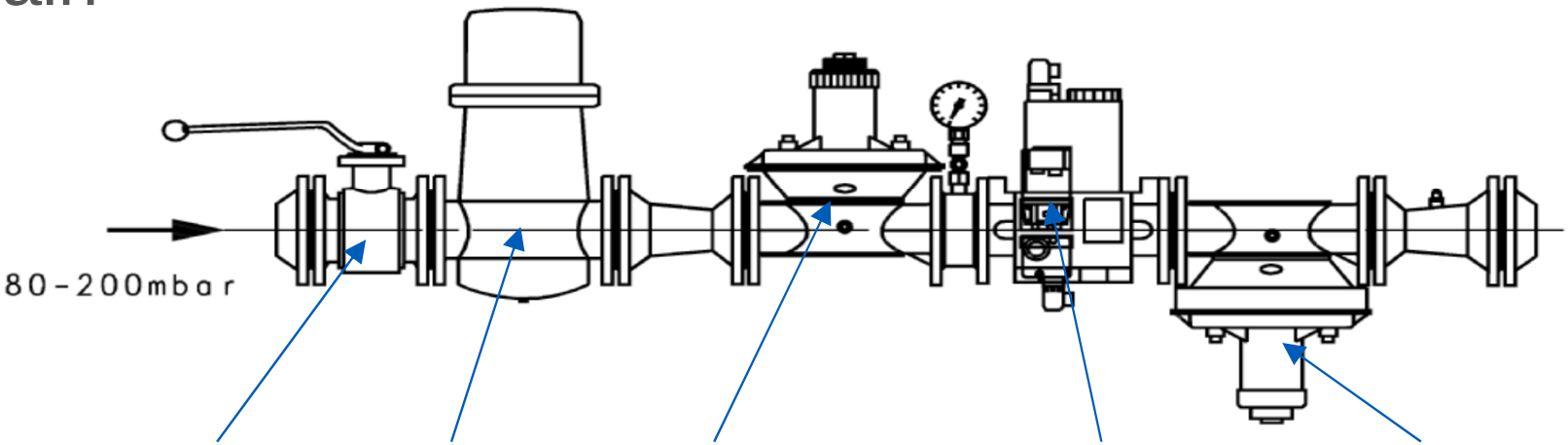
Gas train



3µm safety filter = standard scope

- Polypropylene filter (3µm) for wet gases

Pre-pressure regulator = standard scope

- smoothens pressure fluctuations

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Gas pressure

Important for dimensioning of gas train

- Standard:
  - 80 - 200 mbar (prechamber gas pressure Type 6: 4-5.5 barg)

    higher/lower gas pressure on request

max. gas pressure fluctuation <10 mbar/sec.

↳ condensate in gas train => pressure drops 💥

↳ condensate trap, continuously upward/downward pipes

↳ blower with bypass pressure control valve

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Fuel gas requirements TI 1000–0300

- **Gas temperature < 40°C**
  - ↳ **Mixture temperature**
  - ↳ **Limits of gas train materials**
- **relative humidity < 80%**

(at every gas temperature)

↳ **risk of condensation in gas supply**

Filter; pressure regulator; gas trains,.....

Condensate in engine/intercooler

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Gas humidity / Cooling

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Fuel gas requirements TI 1000-0300
Humid ambient

Condensate in throttle /

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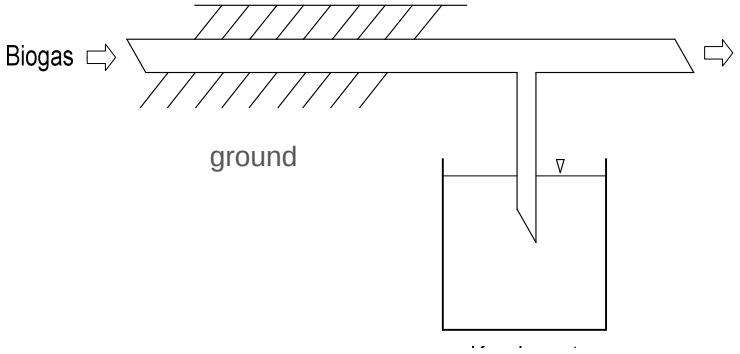
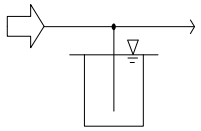
Condensate

Water column → not the preferred solution

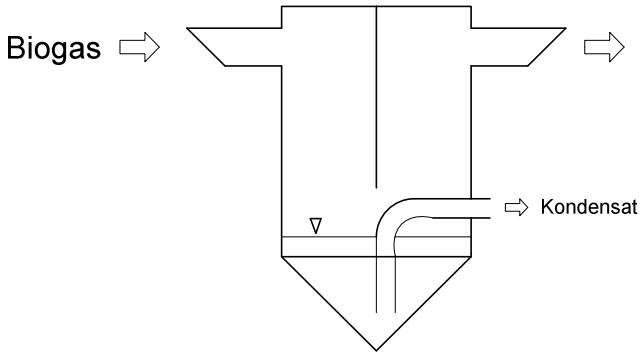


Symbol



- **Not really a condendsate trap**
- **Water column**
- **Condensate can flow down pipe surface**
- **Rel. humidity in gas not reduced!!!**

Condensate trap → preferred solution



Symbol

- **Condensate trap via Entspannung**
- **Water column**
- **Rel. humidity in gas not reduced!!!**

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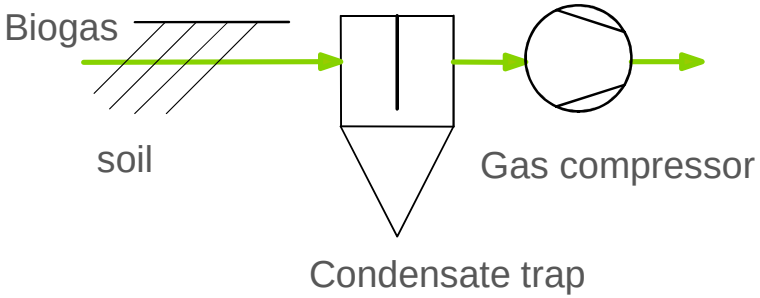
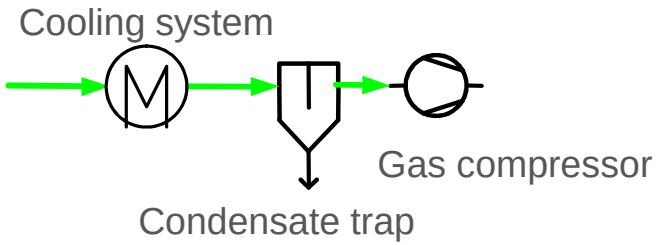
Humidity reduction

Cooling via gas pipe



- **Affects relative humidty; only at low gas temperatures**
- **Actual water content not changed**
- **Avoid cooling in down stream**
- **Cooling effect of soil not guaranteed → depends on soil condition**

Active humidty reduction → better solution



Example		
Gas volumen flow	400	Nm^3/h
Gas Temperature ON/OFF	40/10	° C
Elec output for cooling system ca.	8	kW
Investment costs ca.		30.000,--€

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

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Fuel gas requirements TI 1000–0300

Sulfur

Σ H_2S <700 mg/10 kWh

- Standard maintenance schedule Biogas/NG

Σ H_2S < 1200 mg/10 kWh

- Reduced warranty
- Acidification of oil
- Reduced oil lubrication capacity
- $H_2S + H_2O$ ➔ corrosion

$$S = \frac{\text{Measured concentration [mg / Nm}^3\text{]}}{\text{Calorific value [kWh/Nm}^3\text{]}} \times 10$$

<700mg/10kWh re-calculated to PPM -> means …

LHV 6.0kWh/Nm³ (**CH4 60%)** the H2S should not exceed <293ppm
LHV 5.0kWh/Nm³ (**CH4 50%)** the H2S should not exceed <244ppm
LHV 4.0kWh/Nm³ (**CH4 40%)** the H2S should not exceed <195ppm

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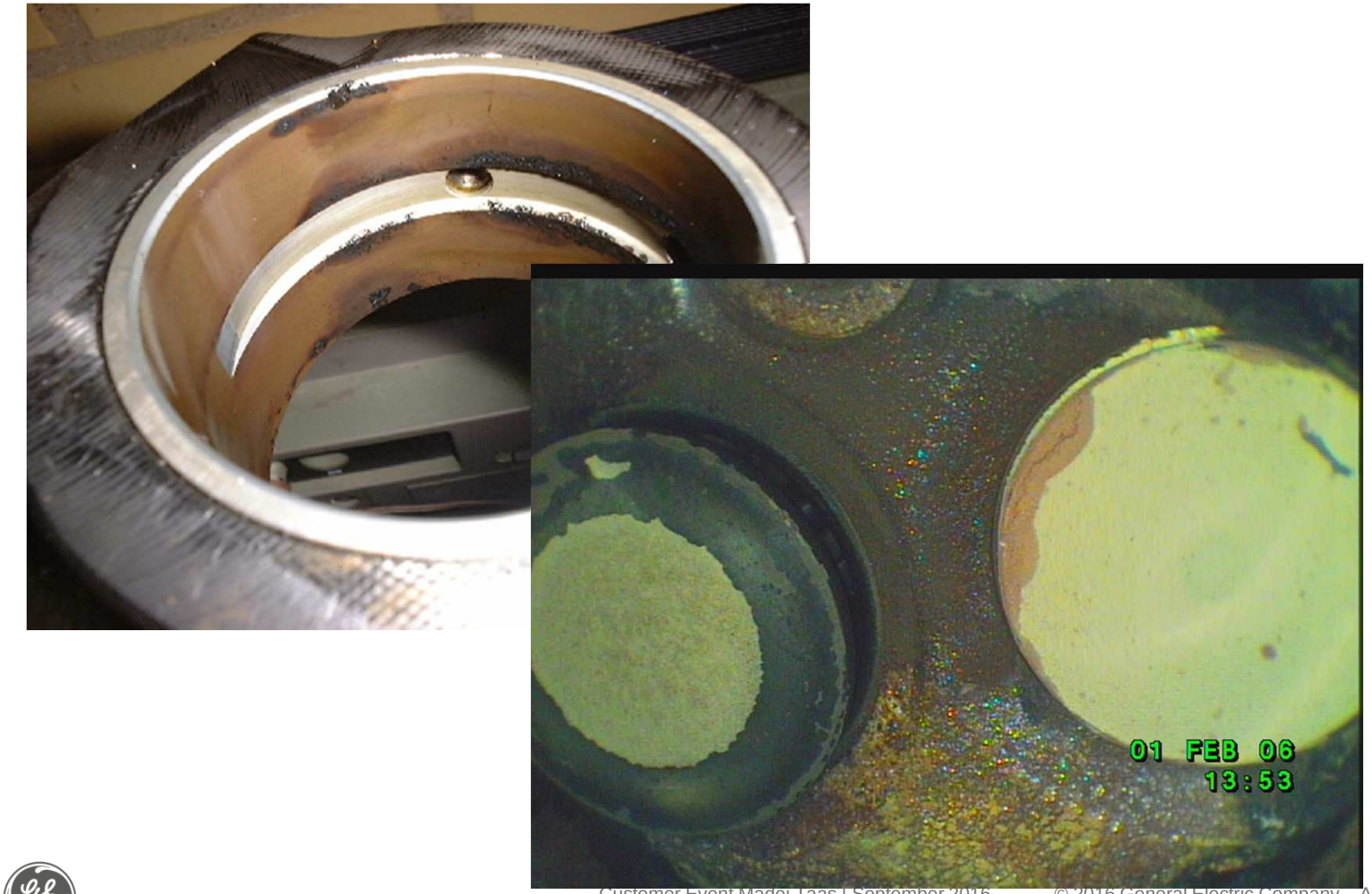
Sulfur



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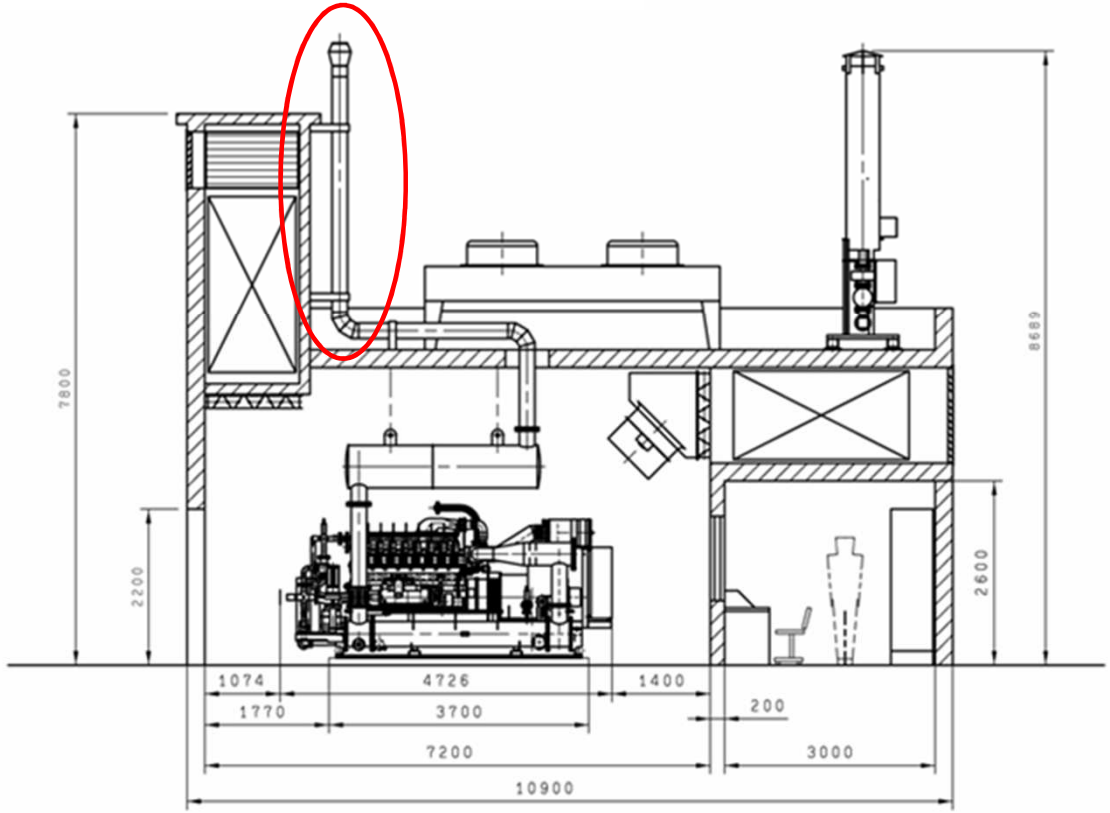
Interfaces / Plant integration

Exhaust gas system
TI 1100 - 0110/ TI 1100 - 0112



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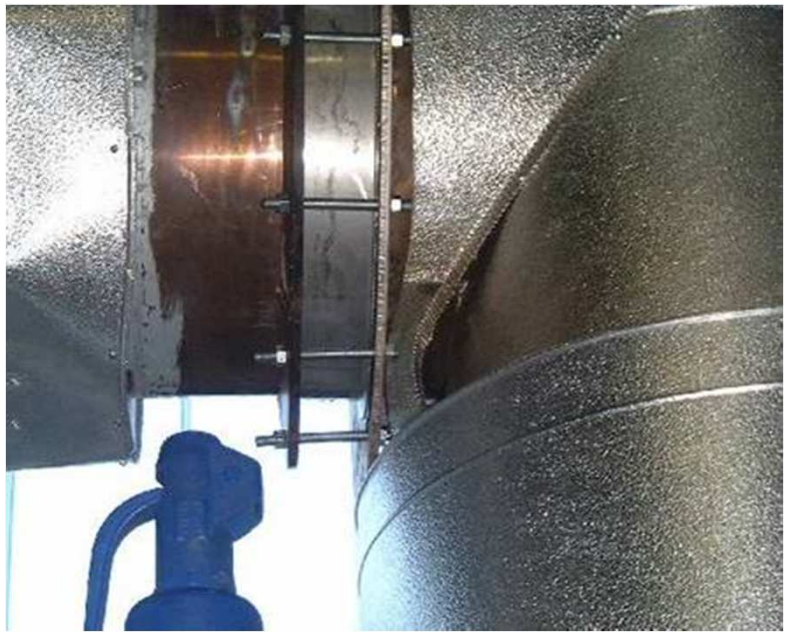
Exhaust gas piping

Design for short term pressure peaks (6bar) !

Exhaust gas Temperatures

320 – 490˚ C **420** – 460˚ C

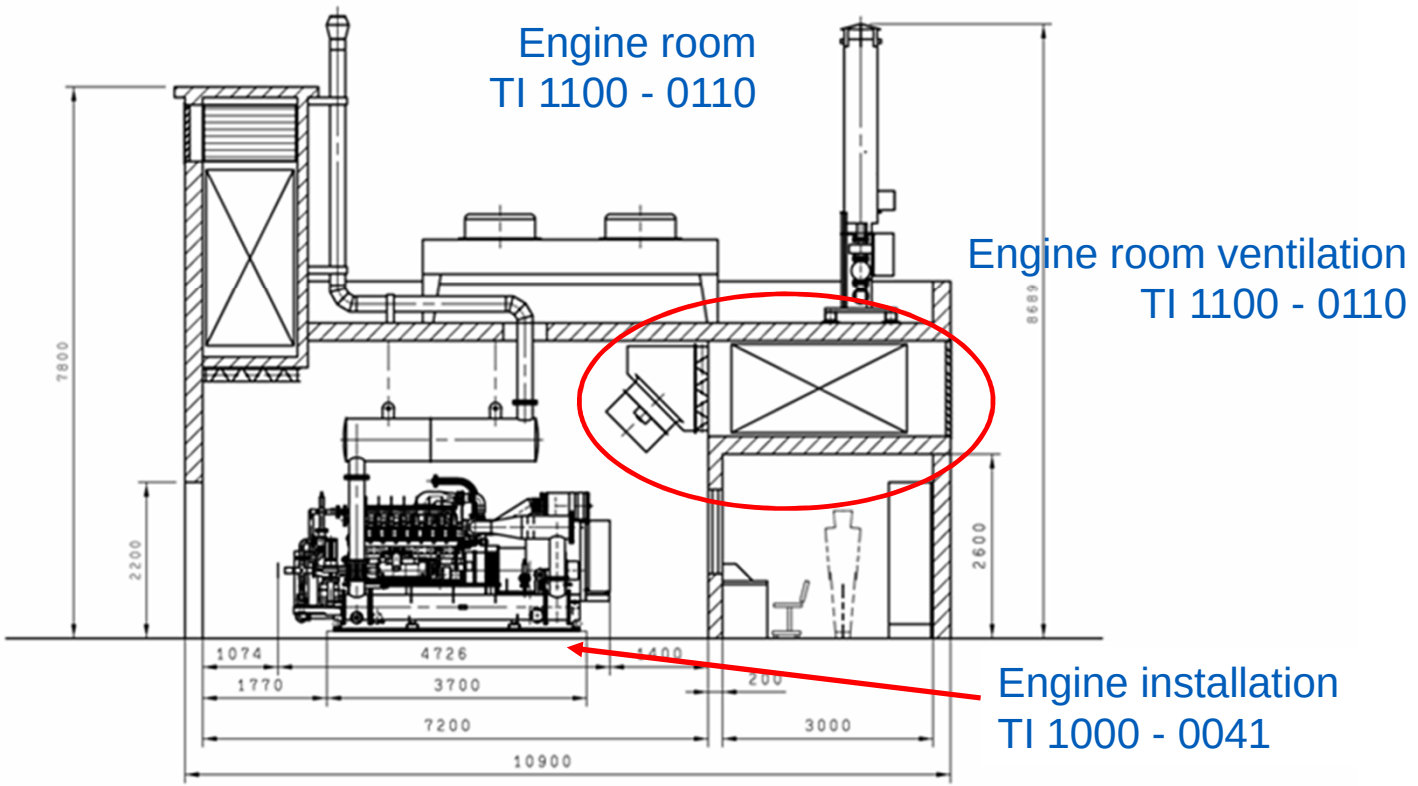


Flange connection

compensator

reserved

Interfaces/Plant integration



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Installation of GEJ units

Fresh air supply / Ventilation system

TECHNICAL INSTRUCTION no:
1100-0110 (Boundary conditions for GE Jenbacher gas engines)

Example Installation Type 620 Brazil

FRONT VIEW:

SIDE VIEW:

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Radiator types

Hot water cooling

Table cooler

- Cost effective & simple

V-Type cooler

- Footprint
- Low noise

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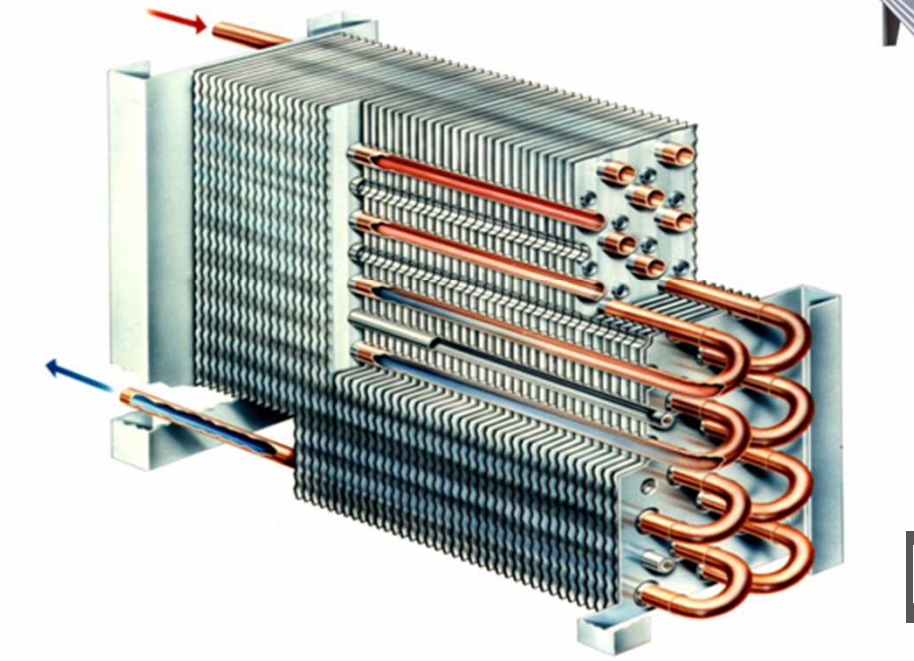
Standard radiator specification

- Standard with 2.2 – 3(4)mm fin spacing
- Standard with flat fins



Easy to clean!

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Radiator installation

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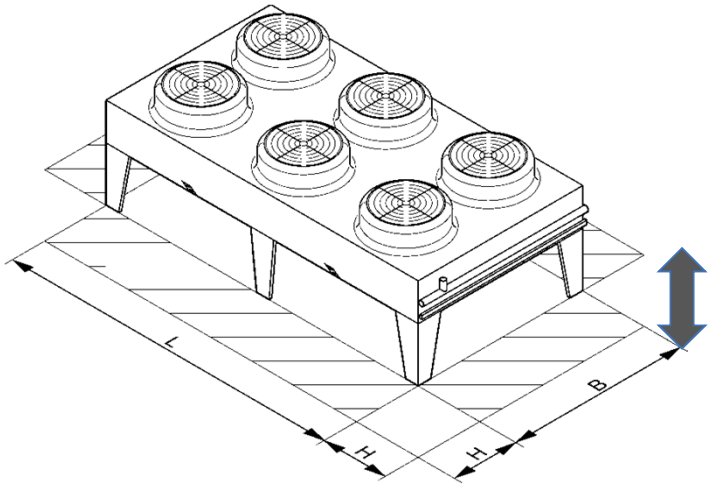
Radiator Layout single unit table cooler

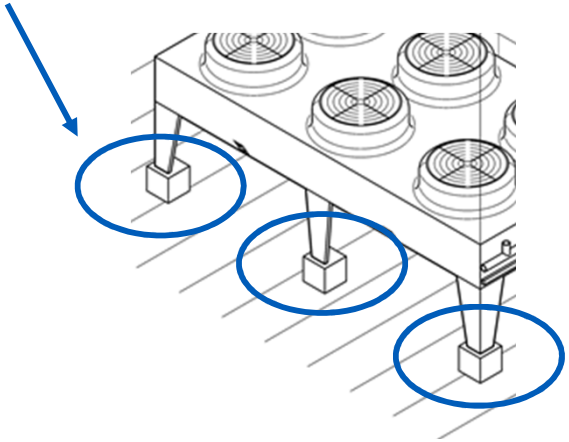


$A_Z = A_A * 0,7$

$A_A = L * B$

$H = A_z/(2*(L+B))$

FOR TROPICAL COUNTRIES:
Especially for tropical countries a additional Pedestal at each Radiator foot is required to increase the air volume. Pedestal should be 400mm



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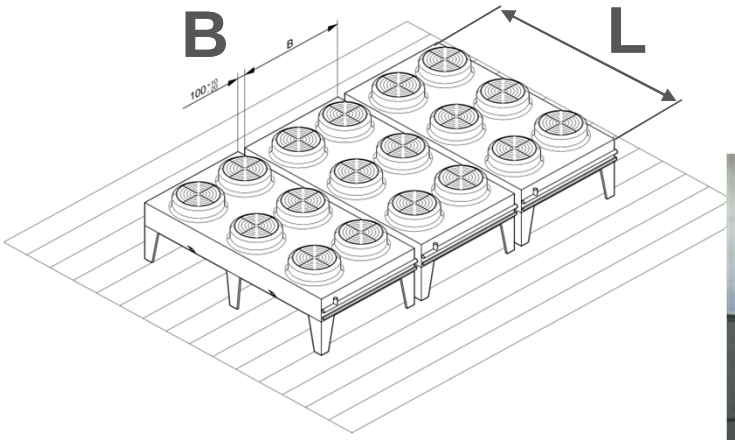
Radiator Layout multiple unit table cooler



Space in between radiator:

Max. 80 mm to avoid short circuit ventilation

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