Utilization of special gases in gas engines -

- Requirements and Experiences

Martin Schneider

GE - Jenbacher gas engines / Austria

GE imagination at work

Jenbacher gas engines core product portfolio

Type 2

- Electrical output: 248 - 330 kW (50 Hz), 335 kW (60 Hz)
- V8 cylinder
- 1,500 rpm (50Hz) 1,800 rpm (60Hz)
- Delivered engines: ~1,100
- Since 1976 in the product program

Type 3

- Electrical output: 526 - 1,063 kW (50 Hz), 633 - 1,059 kW (60 Hz)
- V12, V16 and V20 1,500 rpm (50 Hz) 1,800 rpm (60 Hz)
- Delivered engines: ~8,500
- Since 1988 in the product program

Type 4

- Electrical output: 844 - 1,562 kW (50 Hz), 852 - 1,421 kW (60 Hz)
- V12, V16 and V20 1,500 rpm (50 Hz) 1,800 rpm (60 Hz)
- Delivered engines: ~3,500
- Since 2002 in the product program

Type 6

- Electrical output: 1,639 - 4,491 kW (50 Hz) 1,622 - 4,335 kW (60 Hz)
- V12, V16, V20, V24 1,500 rpm (50 Hz, 60 Hz with gear-box)
- Delivered engines: ~4,000
- Since 1989 in the product program

Type 9

- Electrical output: 9,500 kW (50 Hz), 8,550 kW (60 Hz)
- V20 cylinder
- Electrical efficiency: 48.7%
- Total efficiency: 90%
- 1,000 rpm (50 Hz), 900 rpm (60 Hz)

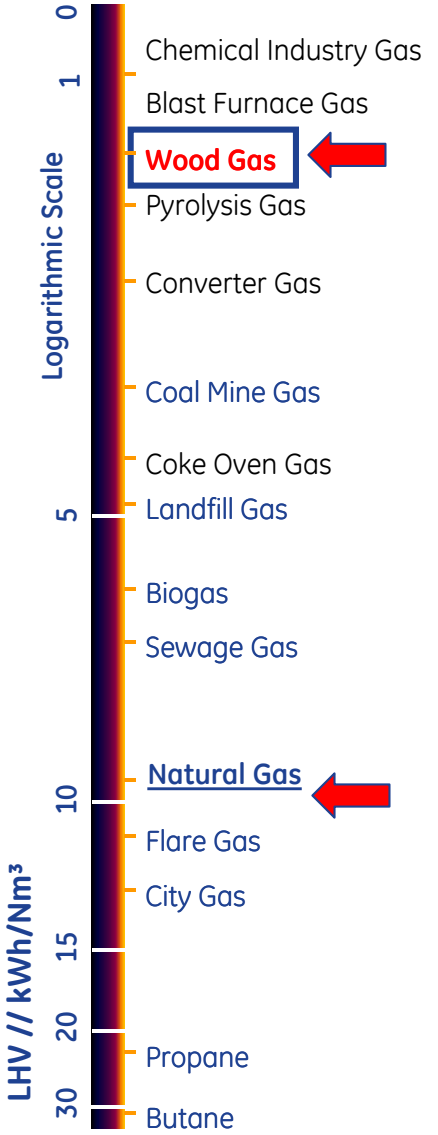
... 10 products for special gases
~200kWe - ~2MWe

Fuel Flexibility with Jenbacher Engines

Natural Gas,
Propane,
LNG, ...

Landfill Gas
Biogas
Coal Mine Methane

Special Gases
(COG, BFG, LDG, Wood gas, ...)



Important fuel properties to consider

- ✓Heating Value
- ✓Methane Number
- ✓Laminar Flame Speed

GEJ Steel Mill- and Ferro Alloy Gas References

53 units

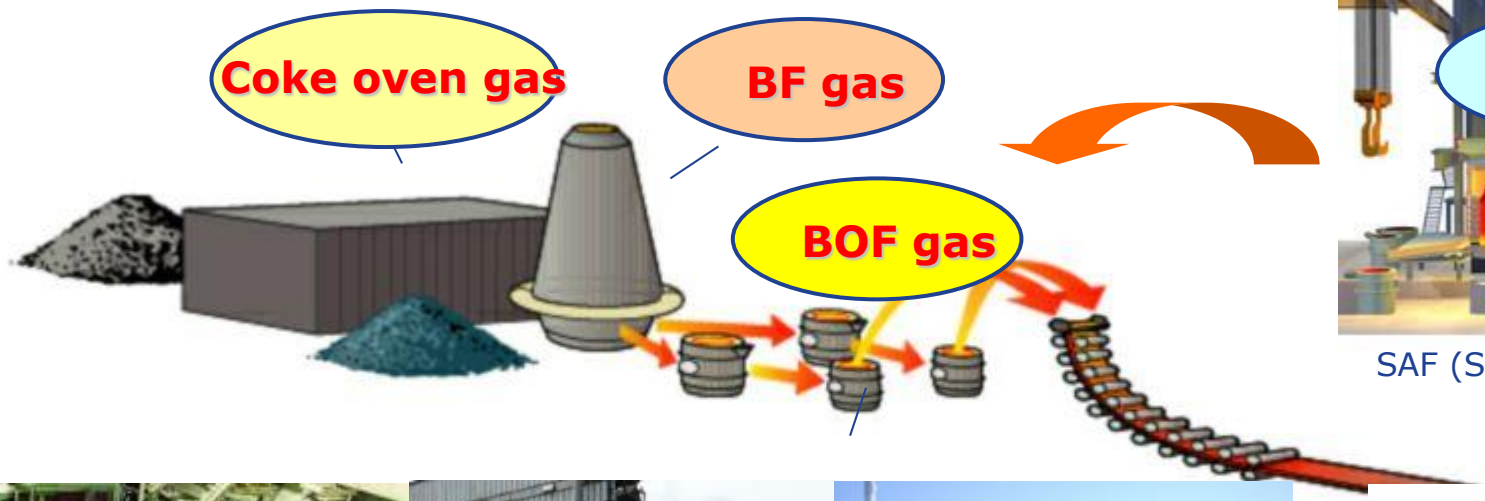
and more than

76 MWel

GE imagination at work

Integrated steel plant

Fe-Alloy Industry



SAF (Sub Merged Arc Furnaces)

Coke gas(COG)

H_2: ~50-70Vol%
CH_4: ~20-25Vol%
LHV: ~5 kWh/m³

Blast furnace (BFG)

H_2: ~1-3Vol%
CO: ~20-25Vol%
LHV: ~0.8-1 kWh/m³

Converter gas (BOF)

H_2: ~1Vol%
CO: ~60Vol%
LHV: ~3 kWh/m³

Furnace off gas (FOF)

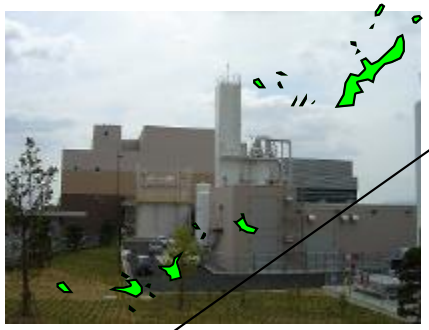
H_2: 25-35Vol%
CO: 50-75Vol%
LHV: ~3.2 kWh/m³

W2E - Waste gasification references

...approx. 32 MWe installed, ...majority in Japan

more than 500k oph experience

„Thermoselect“ plants Japan



AX Green (Mutsu)
2 x JMS 616
Installed: Feb/2003
Electrical Output: 2.4 MW

Chuo Kooiki Env. Center (Yoshino)
2 x JMS 612
Installed: May/2005
Electrical Output: 1.8 MW

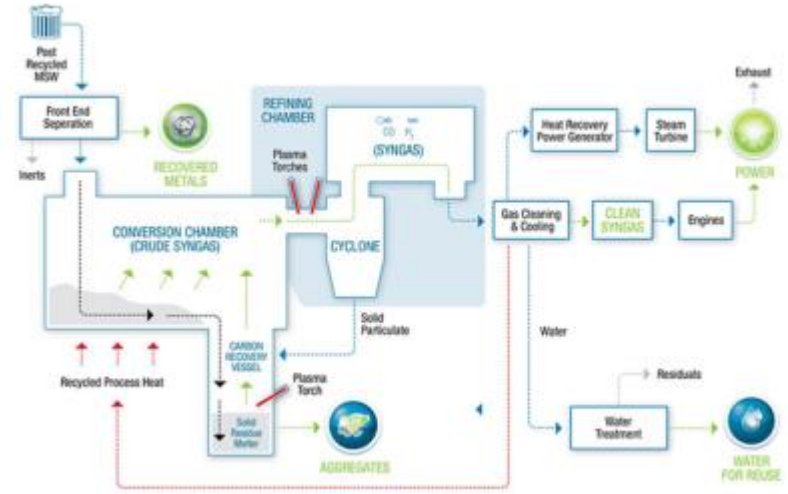
Sainokuni Thermal Recycle Facility (Sainokuni)
2 x JMS 620
Installed: est. March/2006
Electrical Output: 3,0 MW
Thermal Output: 0.9 MW

Japan Recycle Center (Chiba) 1 x JMS 620
Installed: Oct/2001
Electrical Output: 1.9 MW

Kenou Kennan Clean Center (Isahaya)
5 x JMS 620
Installed: March/2005
Electrical Output: 7.5 MW

GE imagination at work

Plasco “Trial Road” Ottawa 5xJ320



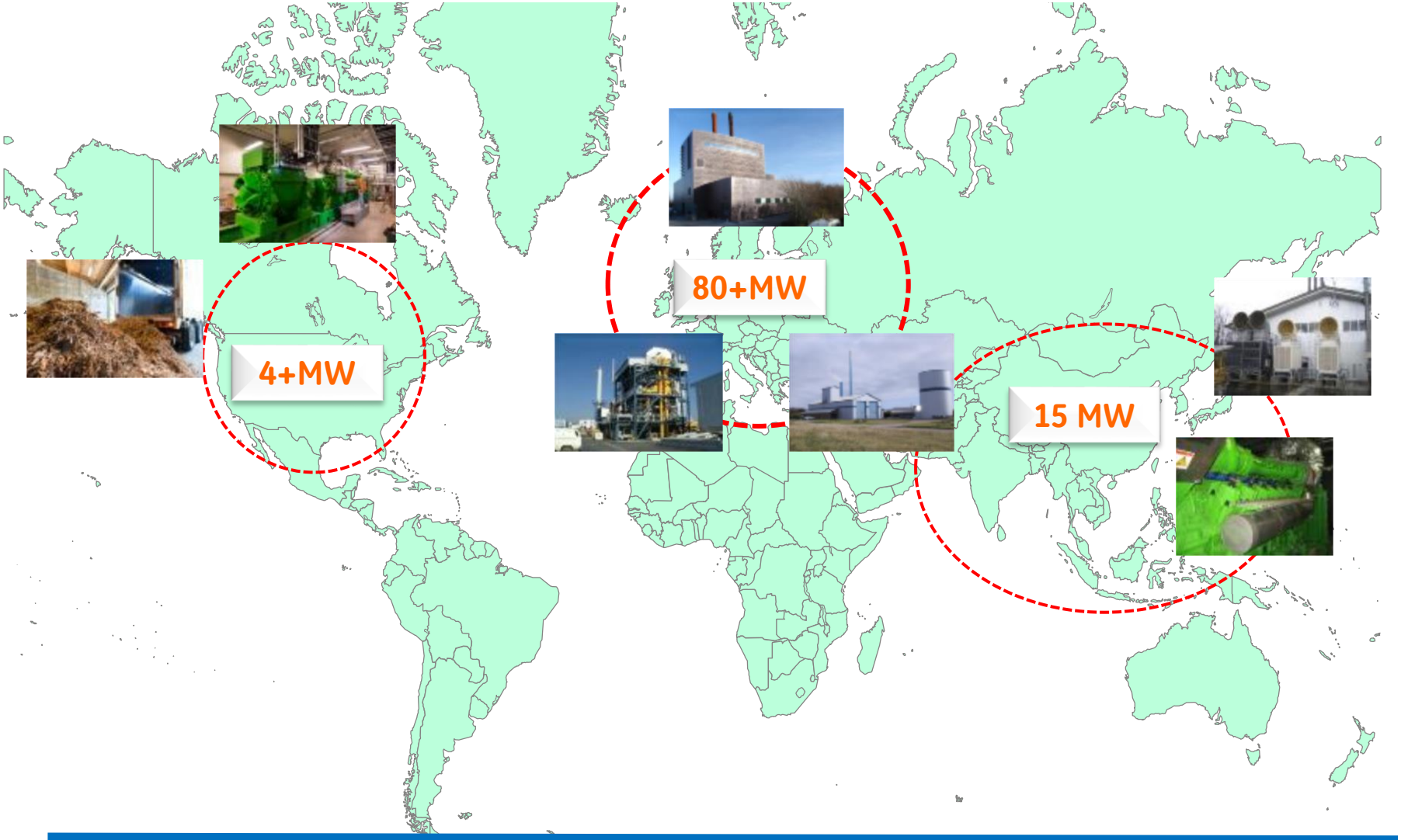
Ottawa/Ca

Plasma Waste gasification

5x J320 ~ 3.5MWe

H_2	12 - 17%
CH_4	2 - 3%
CO	11 - 15%
CO_2	10 - 12%
N_2	50 - 55%
Hu	1.5-1.8 kW/Nm³

B2E - Biomass gasification references



...almost 100 MWe installed, ...majority in Europe

Experiences with Wood gasification (extract)

- Harboore / Denmark;

  Woodgas; H_2: 15 - 18%; CO: 25-28%; LHV = 6.8 MJ/Nm³

- Güssing / Austria

  Woodgas; H_2: 35 - 40%; CO: 20-25%; LHV = 10.5 MJ/Nm³

- Stans / Switzerland

  Woodgas; H_2: 12 - 15 %; CO: 18-20%; LHV = 5.4 MJ/Nm³

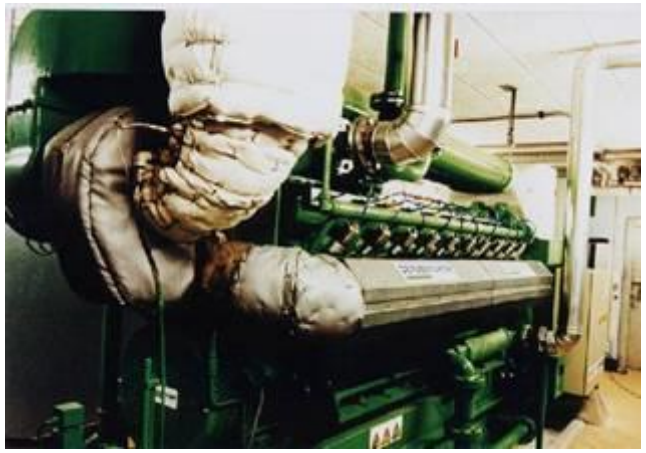
- Skive / Denmark

  Woodgas; H_2: 15 - 18%; CO: 18 - 20%; LHV = 6.1 MJ/Nm³

Biomass Gasification Harboøre/Dk

Harboøre/Denmark
2 x JMS 320 GS S.L

Concept:
Fixed bed updraft
from B&W Vølund



wood gas:

H_2	15 - 18%
CH_4	3 - 5%
CO	25 - 28%
CO_2	7 - 10%
N_2	50 - 55%
LHV	6.8 MJ/Nm³

2 x J320
2 x 760 kWe

...more than 105,000 ophs (09/2012), ...increased output (bmep = 13bar) in 04/2001

Biomass gasification Tohoku-Yamagata/Jp

Yamagata/Jp

Fixed bed updraft
JFE/Babcock-Vølund

Wood gas:

H_2	15 - 18%
CH_4	3 - 5%
CO	25 - 28%
CO_2	7 - 10%
N_2	50 - 55%
Hu	6.84 MJ/Nm³

1 x J612 / 1 x J616
900kWe / 1200kWe

...~15,000 ophs (2010); ...JFE/Backcock Vølund® ...commissioning 2007

Nidwalden/CH Pyroforce®

Biomass power plant Nidwalden/CH

2 x J320
2 x ~600 kWe

PYROFORCE® Concept:
Fixed bed downdraft

Wood gas:

H2	15 %
CH4	2 %
CO	18 %
CO2	12 %
N2	47 %
H2O	rest
LHV	5.4 MJ/Nm³

Nidwalden ~100k ophs accumulated (04/'17) ... commissioning 2007

Biomass Gasification Güssing/A

repotec
renewable power technologies

Concept:
fluidized bed steam gasification

Wood chips:	8 MWth input	
Wood gas:	N_2	3 %
	CH_4	10 %
	CO_2	23 %
	H_2	40 %
	CO	24 %
LHV	10.5 MJ/Nm^3	

1 x J620
1 x 1.97(2.3) MWe

...more than 70,000 ophs (05/2015), ...commissioning 04/2002

Güssing/Austria

1 x J620 1 x 2.3 MWe

Villach/Austria

2 x J620 2 x 1.97 MWe

Ulm/Germany

2 x J620 2 x 2.1 MWe + 0.8MWe ORC

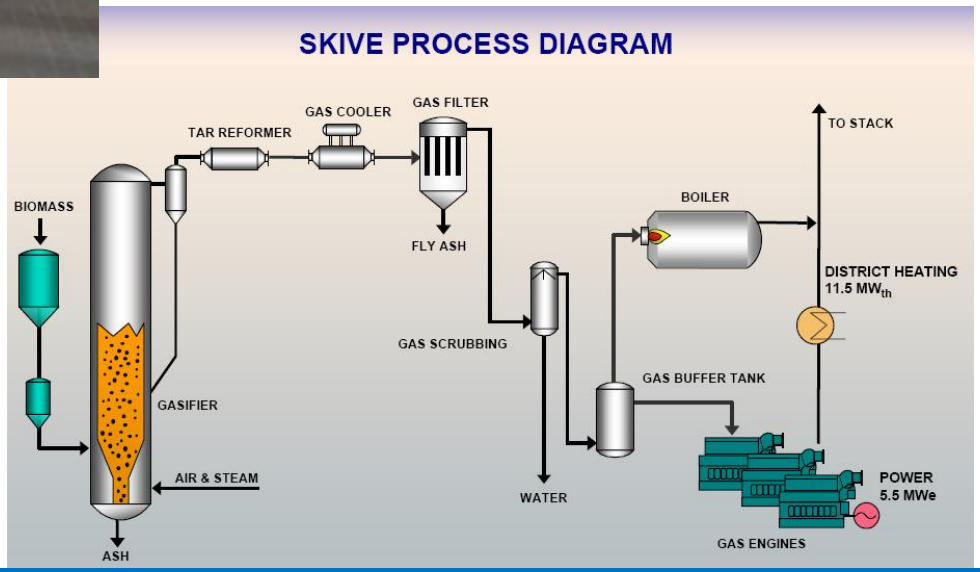
Oberwart/Austria

2 x J612 2 x 1.2 MWe + 0.4 MWe ORC

..... 3 follow up projects from Güssing....

Woodgas plant Skive/Denmark

3 x J620
3 x 2 MWe



... cumulated ~100,000 ophs (05/´17), ...commissioning 2008

Biomass gasification Molla/Spain

2 x J320 Pel 2 x 765 kWe

Wood chips:	N_2	48 %
	CH_4	6 %
	CO_2	16 %
	H_2	12 %
	CO	15 %
LHV	5 MJ/Nm^3	

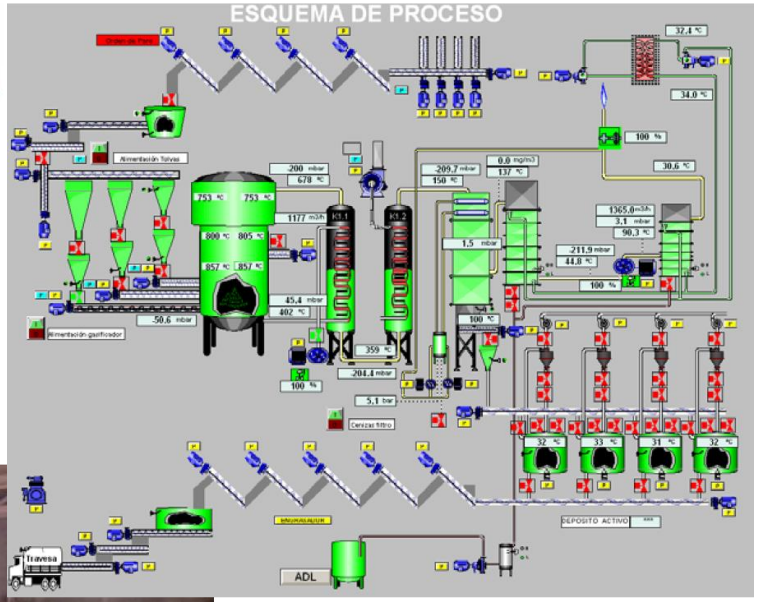
2 x J320

2 x ~825 kWe

… ~10,000 ophs (09/2012), …commissioning 2010

Biomass Gasification Movialsa/Spain

EQTEC Iberia



Biomass from olive production

3 x J620
3 x 1.97 MWe

~10,000 ophs (09/2013).....commissioning 2010

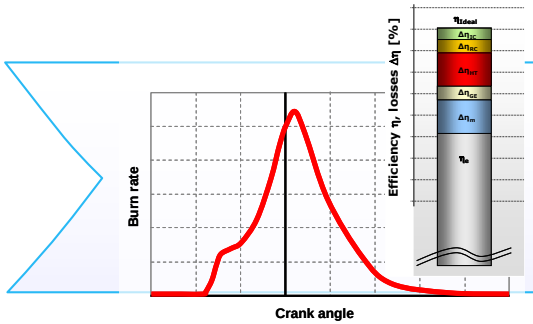
Special gas development

Jenbacher gas engines

Special gas development

50+ years experience

comprehensive data base & analytical methods



conceptual studies

component Test

Single cylinder test

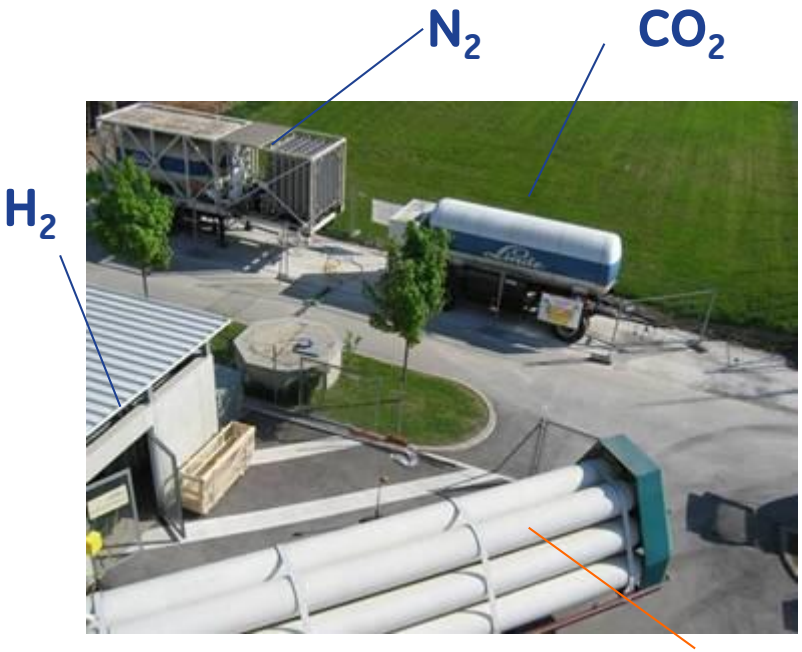
Full engine test

Pilot plant

Special gas product development

Combustion development at single cylinder engine test bench with artificial special gases

- Various test runs with different combustion concepts
- Gas type specific concept selection



Synthetic gas mixing plant

Single cylinder test bench

Biomass Gasification Güssing/A

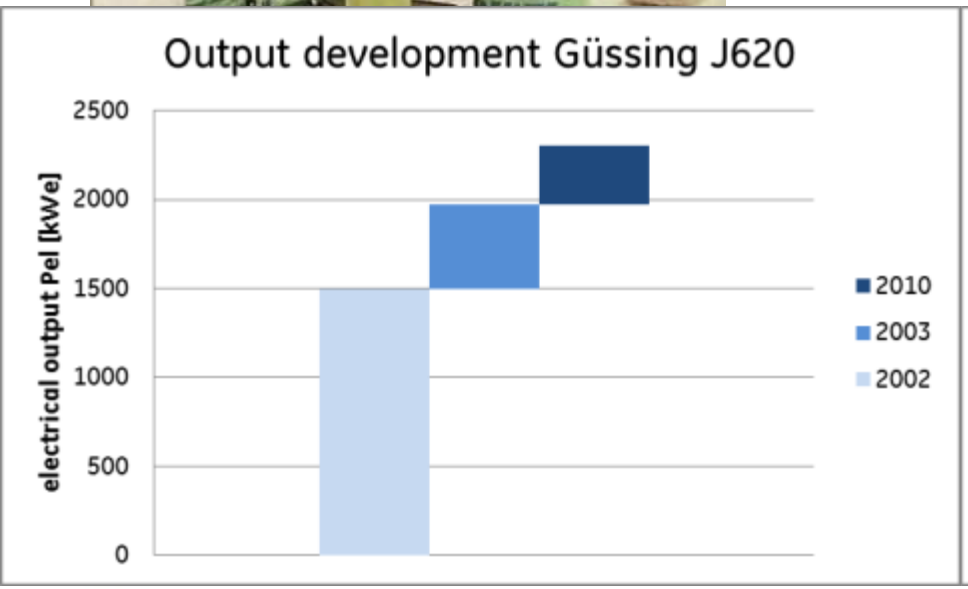
1 x J620E 1.9 MWe

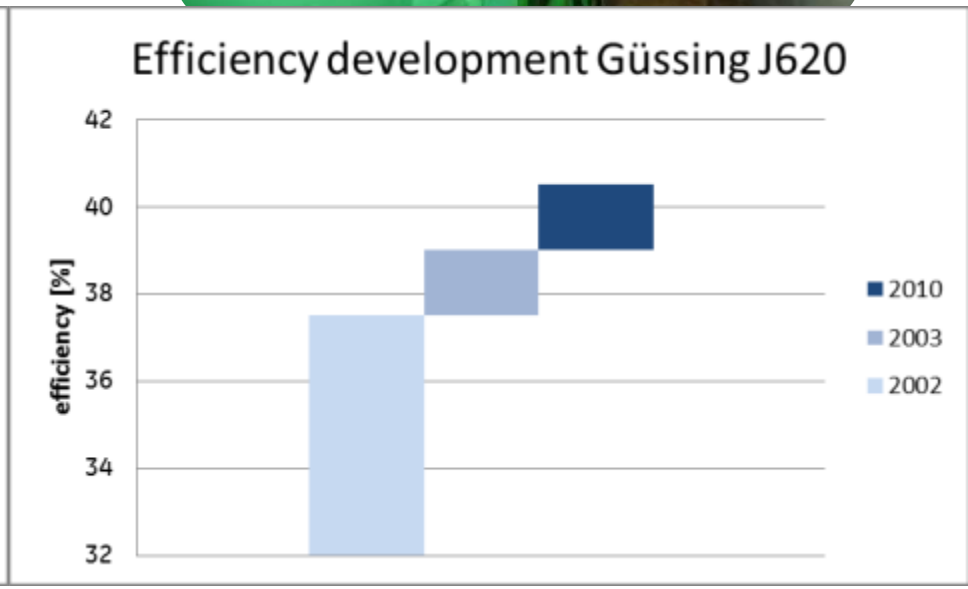
Engine

Upgrade

10/2010

J620F 2.3 MWe





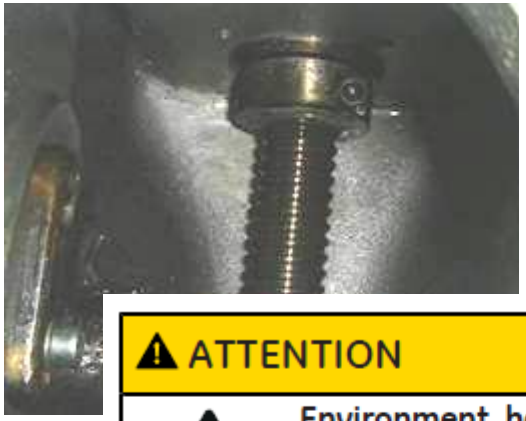
Crucial points in the utilization of wood gas

- Gas cleaning technology

- Fulfillment of emissions requirements

Condensate, deposits (water, tar, naphtalenes.....)

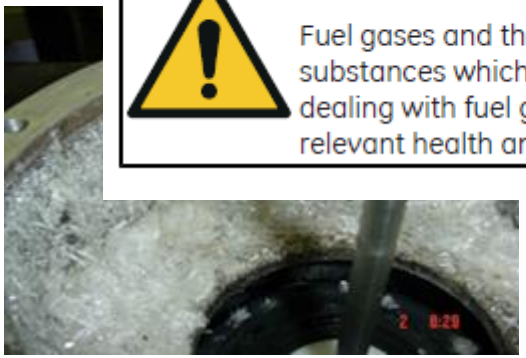
Fuel gas
TI 1000 – 0300

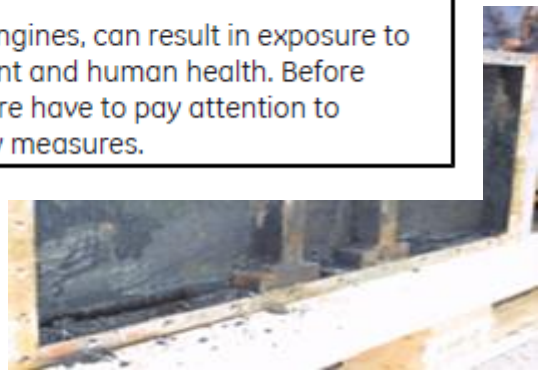


⚠ ATTENTION

Environment, health & safety

Fuel gases and their production, and the use of fuel gases in engines, can result in exposure to substances which are dangerous or harmful to the environment and human health. Before dealing with fuel gases, deposits and condensates, we therefore have to pay attention to relevant health and safety instructions and take precautionary measures.

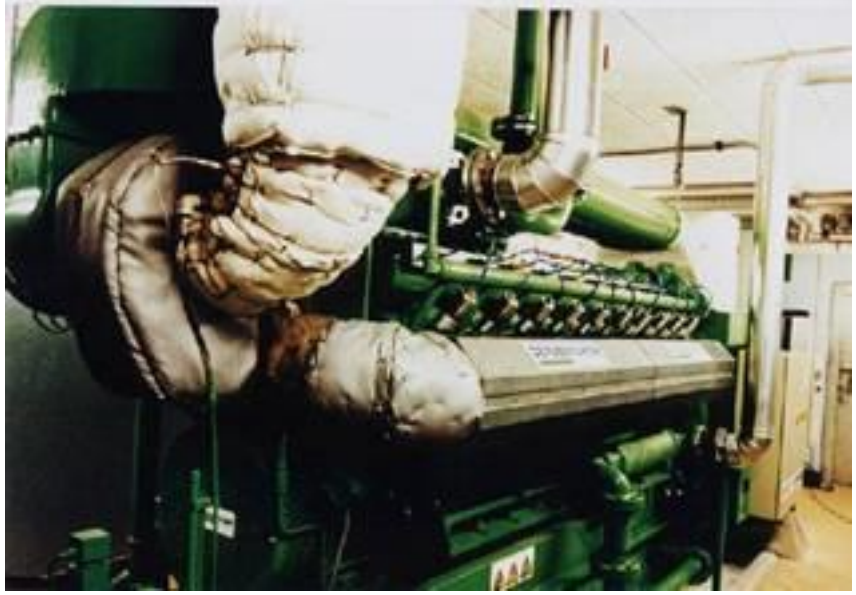




Gas cleaning is the key technology

Example: Gas cleaning Harboøre

Wet scrubber & wet electrostatic precipitator



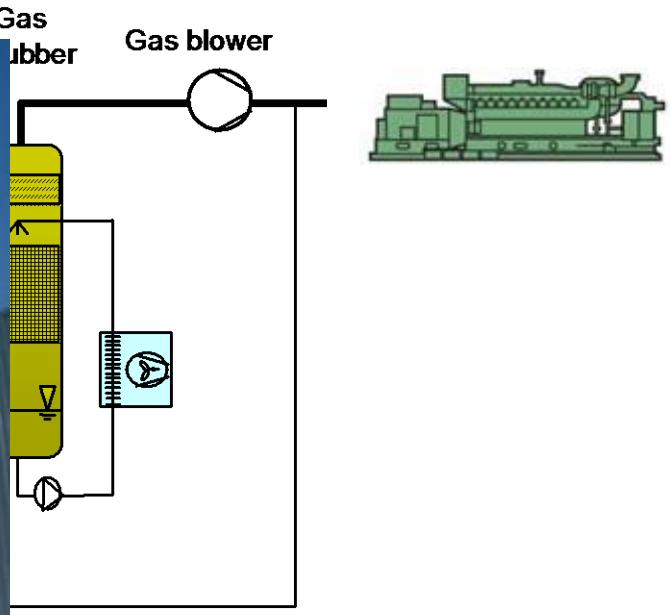
2 x J320
2 x 760 kWe

...more than 105,000 ophs (09/2012), ...increased output (bmep = 13bar) in 04/2001

Example: Gas cleaning Pyroforce®/CTU

...Nidwalden~50,000 ophs (04/'17); ...PYROFORCE® ...commissioning 2007

Example: Gas cleaning Güssing / Austria Scrubber with RME & precoat filter



...more than 70,000 ophs (05/2015), ...commissioning 2002

Crucial Points/Technical Barriers

Emissions limits according e.g. “TA Luft”

NOx ≤ 500 mg/Nm³

CO ≤ 650 mg/Nm³

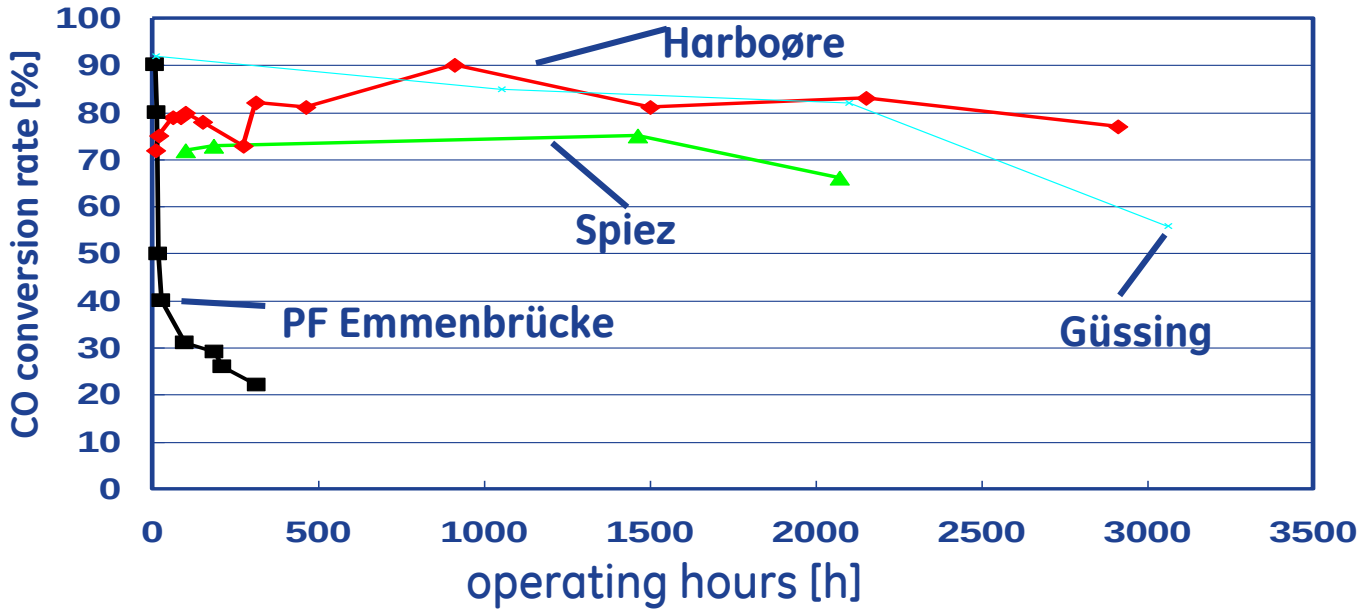
		Gas		Exhaust gas [mg/Nm³]	
Plant	Engine	H2 [%]	CO [%]	NOx	CO
WUT Wamsler	J 208 GS	9 - 12	20 - 26	50 -150	2500 - 3500
Boizenburg	J 612 GS	13 - 15	16 - 20	200 - 250	3000 - 3500
Harboore	J 320 GS	18 - 20	20 - 30	200 - 400	2000 - 3500
Güssing	J 620 GS	30 - 45	20 - 30	450 - 500	3000 - 4500

unburned CO- content of syngas

Emissions

unburned CO- content of wood gas requires exhaust gas after-treatment

=> Catalytic reduction possible, but.....



Gas cleaning is the key technology

Summary

- wide range of H_2 gases can be used in gas engines
- key factor is laminar flame speed
- main challenges:
  gas contamination (tar, humidity....)
  VOC/CO- emissions
  Health & Safety requirements

Thank You!

Martin Schneider

GE - Jenbacher gas engines / Austria

GE imagination at work