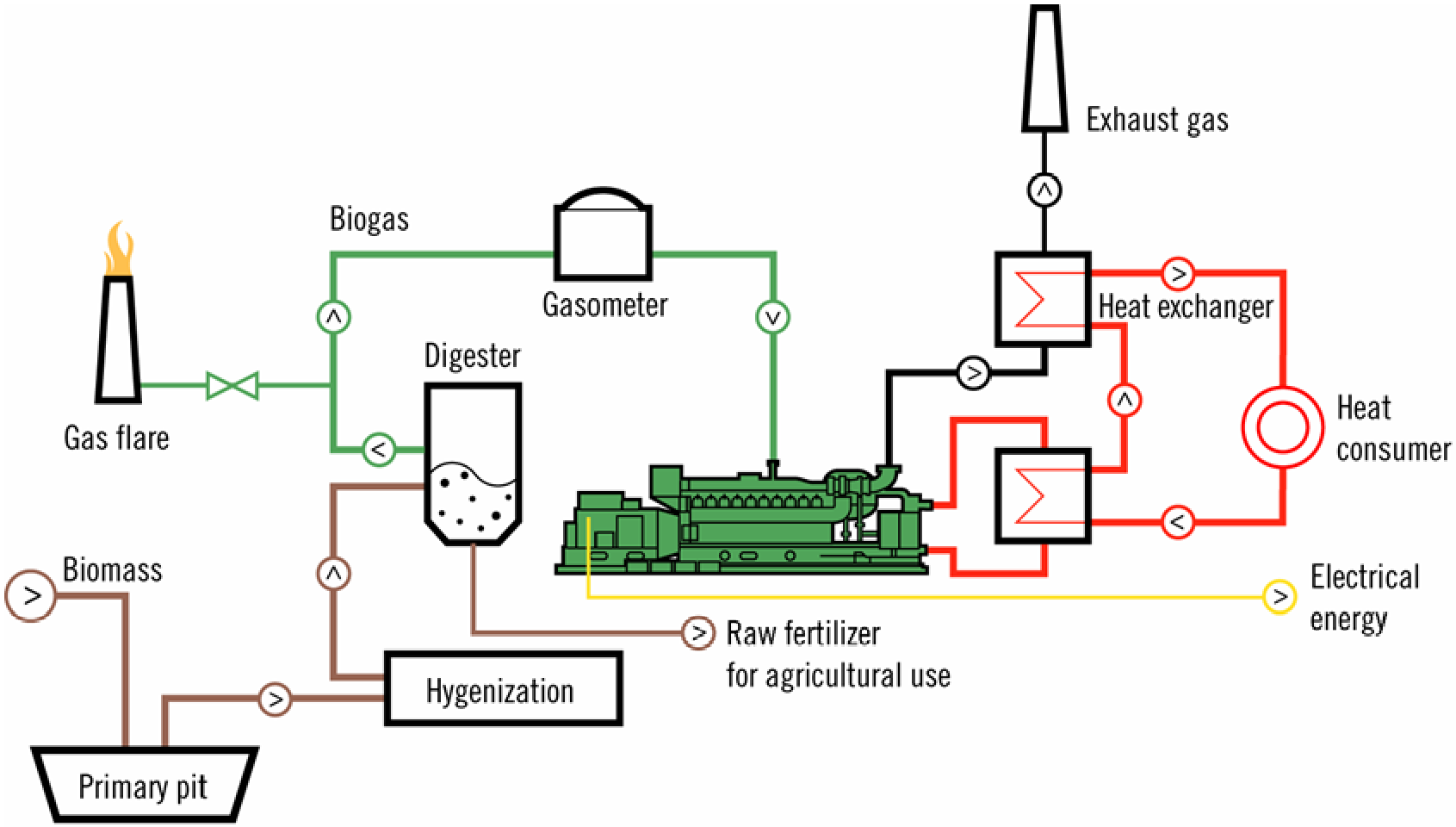
Biogas – a renewable energy sourc

Cows Give Both – Milk and Power:
Using Biogas in Gas Engines

GE imagination at work

Biomass Digestion



Advantages of Anaerobic Digestion

For farmers, the agricultural & food industry:

- improvement of **manure properties**: odor reduction, elimination of acid components, viscosity decrease, mineralization of organic nitrogen, reduction of pathogenic germs and weed seeds
- additional incomings from **heat and power production**
- **waste water treatment** without costly sewer connection

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

Biogas Yields

		Gas amount m³ / t dry matter	m³ / t wet matter	Power generation kWh / t wet matter
Manure	Cattle manure	210	25	50
	Chicken manure	340	10	140
Fresh plant parts	Grass	500	110	220
	Clover	420	90	180
	Corn plant	650	250	500
	Sugar beet leaves	390	90	180
	Potato leaves	500	110	220
Silages	Grass silage	450	190	380
	Corn silage	590	200	400
Hay	Barley hay	240	220	440
	Oat hay	280	250	500
	Wheat hay (raw)	155	135	270
	Wheat hay (fine)	300	260	520
Wastes	Bio waste	250	130	260
	Food waste	480	110	220

Biomass Digestion

Siggerwiesen/Austria

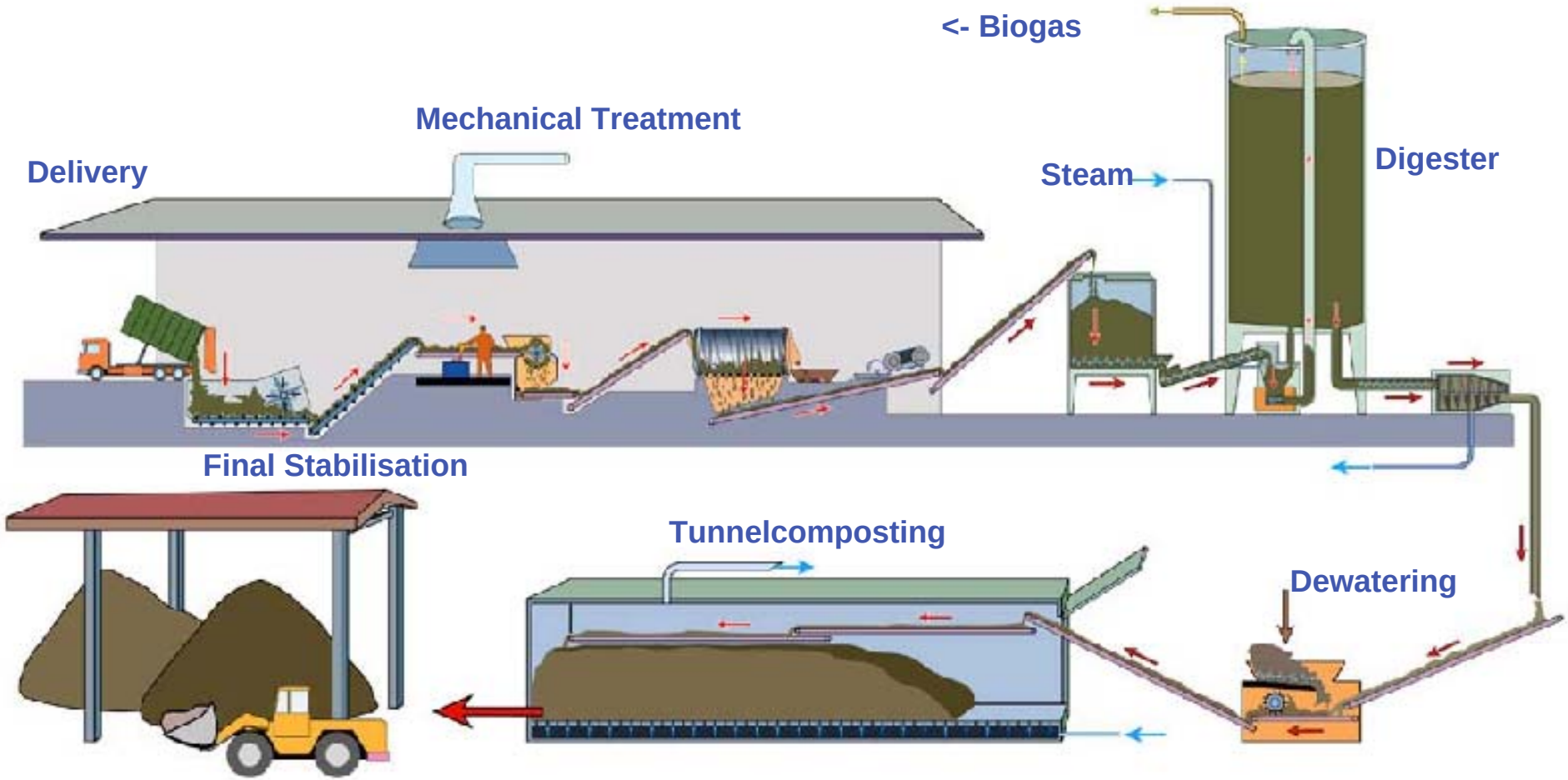
3 x JMS 316 GS B/L.L

Plant Output
1,629 kW_{el}
Thermal Output
2,373 kW

Biomass	**19,900 to/year**
Biogas production	**3,036,000 m³/year**
Compost production m³/year	**4,950**
Landfill gas	**2,371,000m³/year**
Electricity production	**6,510 MWh/year**
Heat production	**3,260 MWh/year**

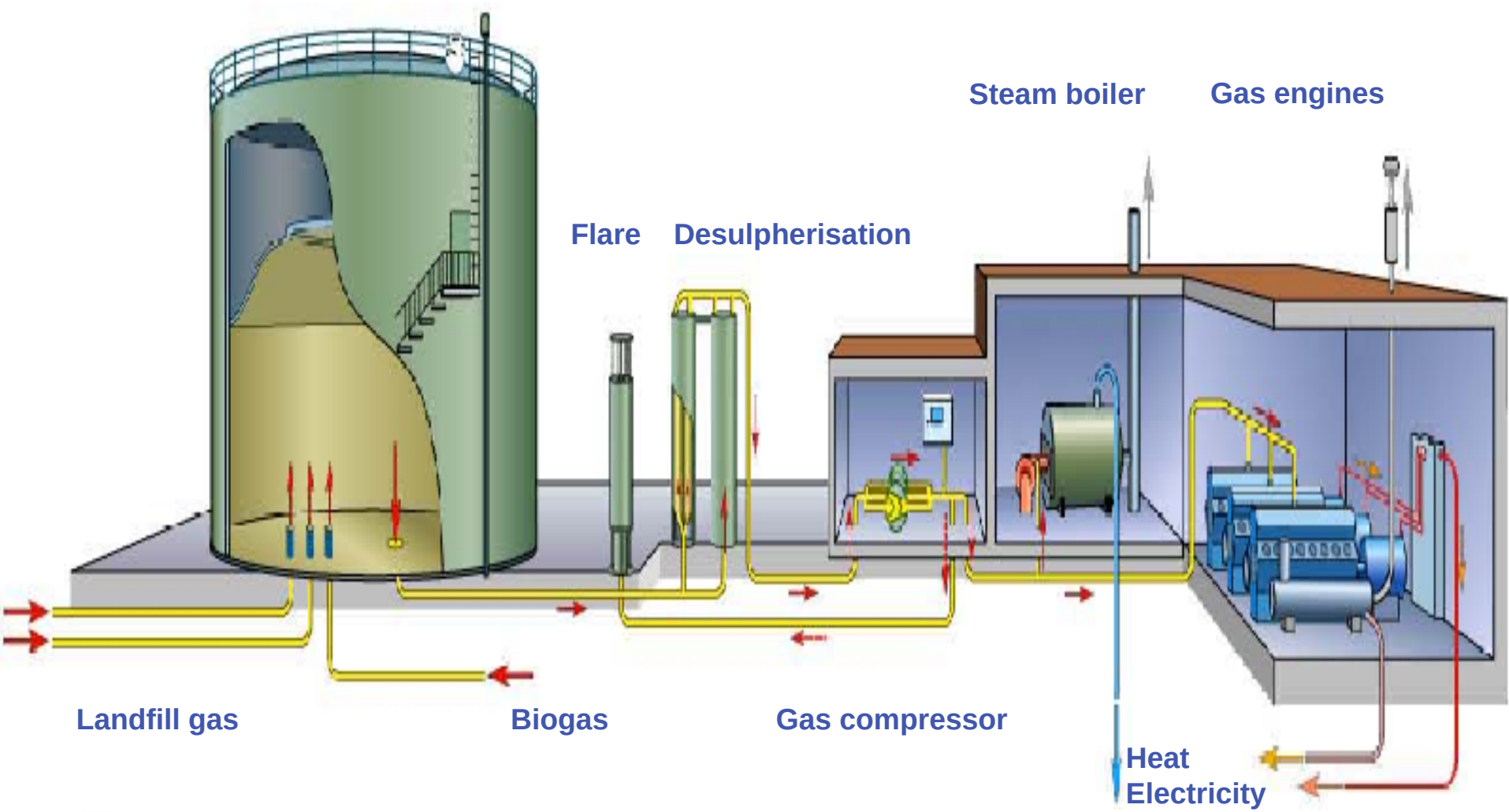
GE imagination at work

Biomass Digestion Siggerwiesen



GE imagination at work

Biomass Digestion Siggerwiesen



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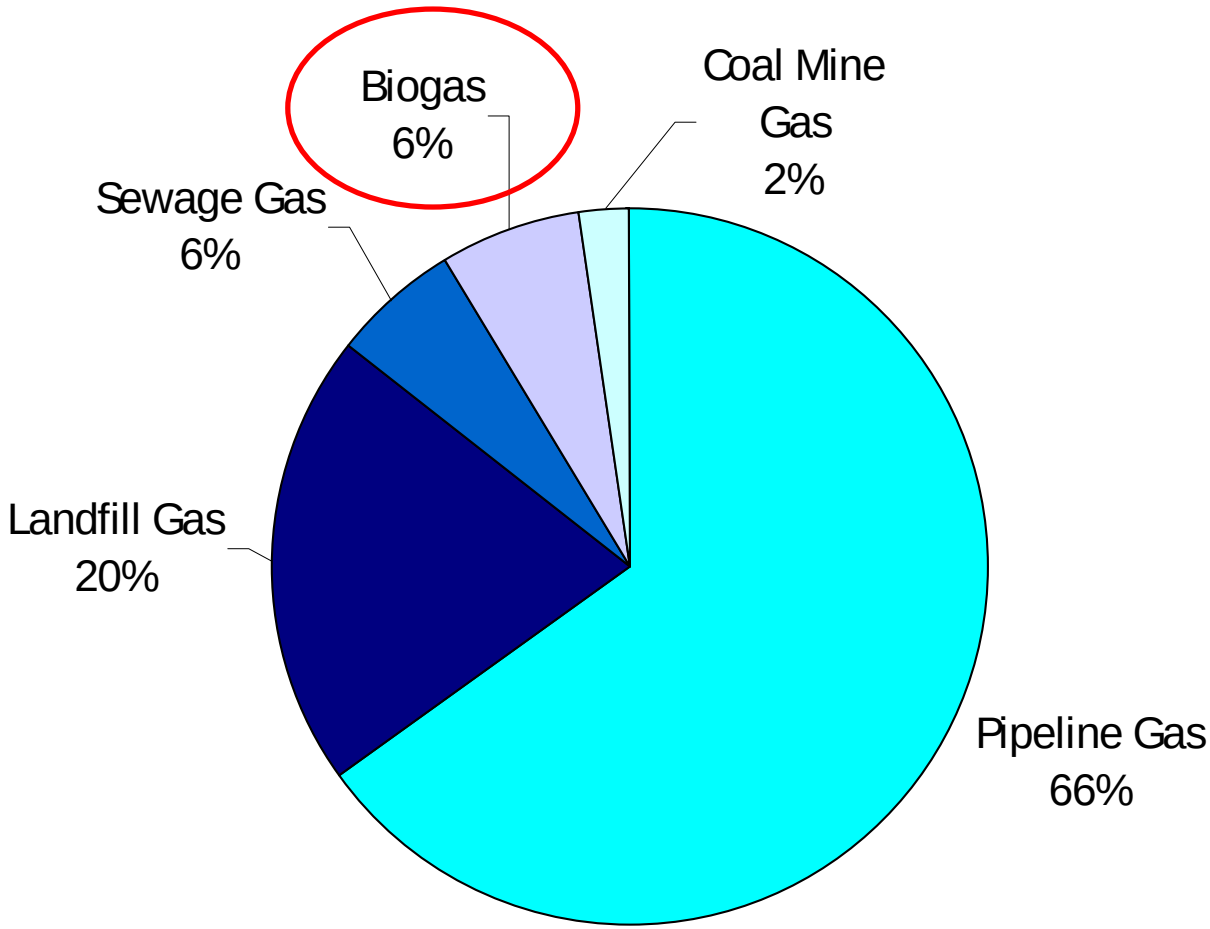
Delivered Engines – NG / NNG Application

1988 – 2004



AD of biomass - Germany

Gut Wolfring / Germany

1 x JMC 208 GS-B.L

Electrical Output:
330 kW

Thermal Output:
421 kW

AD of biomass St. Veit/Glan / Austria

St. Veit /Austria

1 x JMC 320 GS-B.LC

Electrical Output:
1,065 kW

Thermal Output:
1,052 kW

Biogas Plant

Japan/Food industry

JMS 316 GS-B/N.L

Biogas/Natural gas

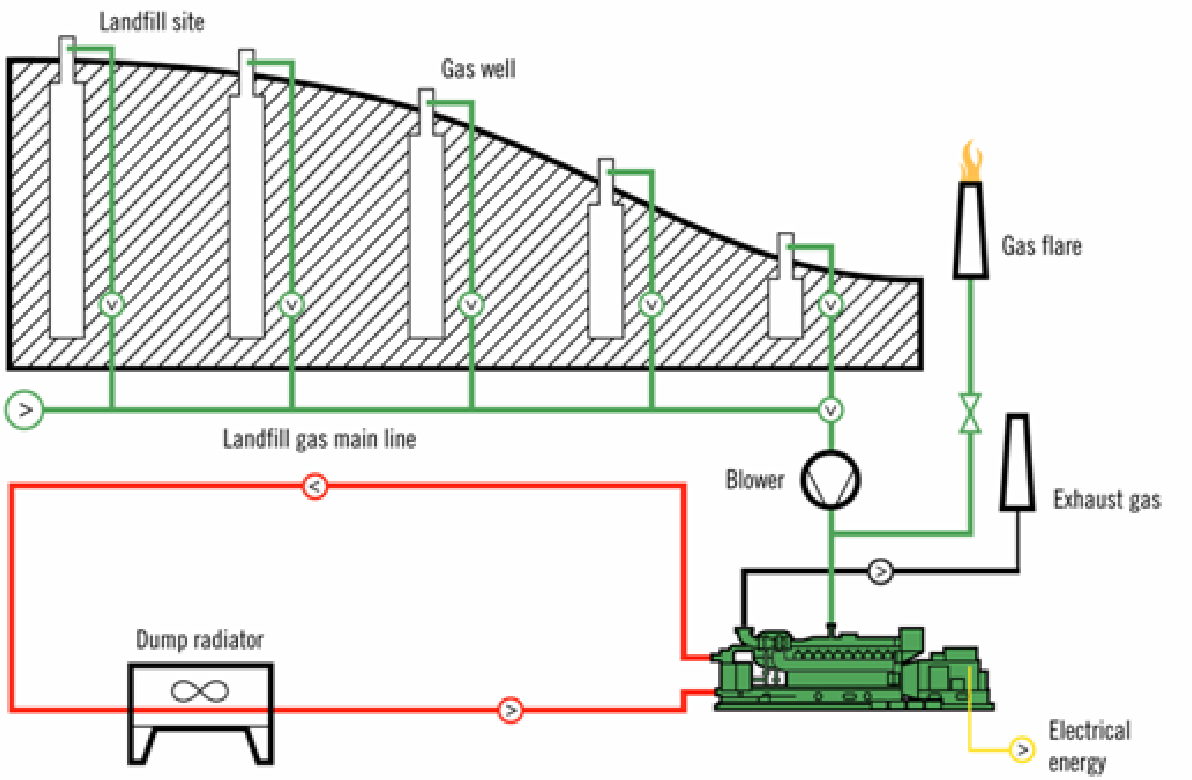
Electrical Output:
522 kW

Utilization of landfill gas

background and
experience

GE imagination at work

Landfill gas production

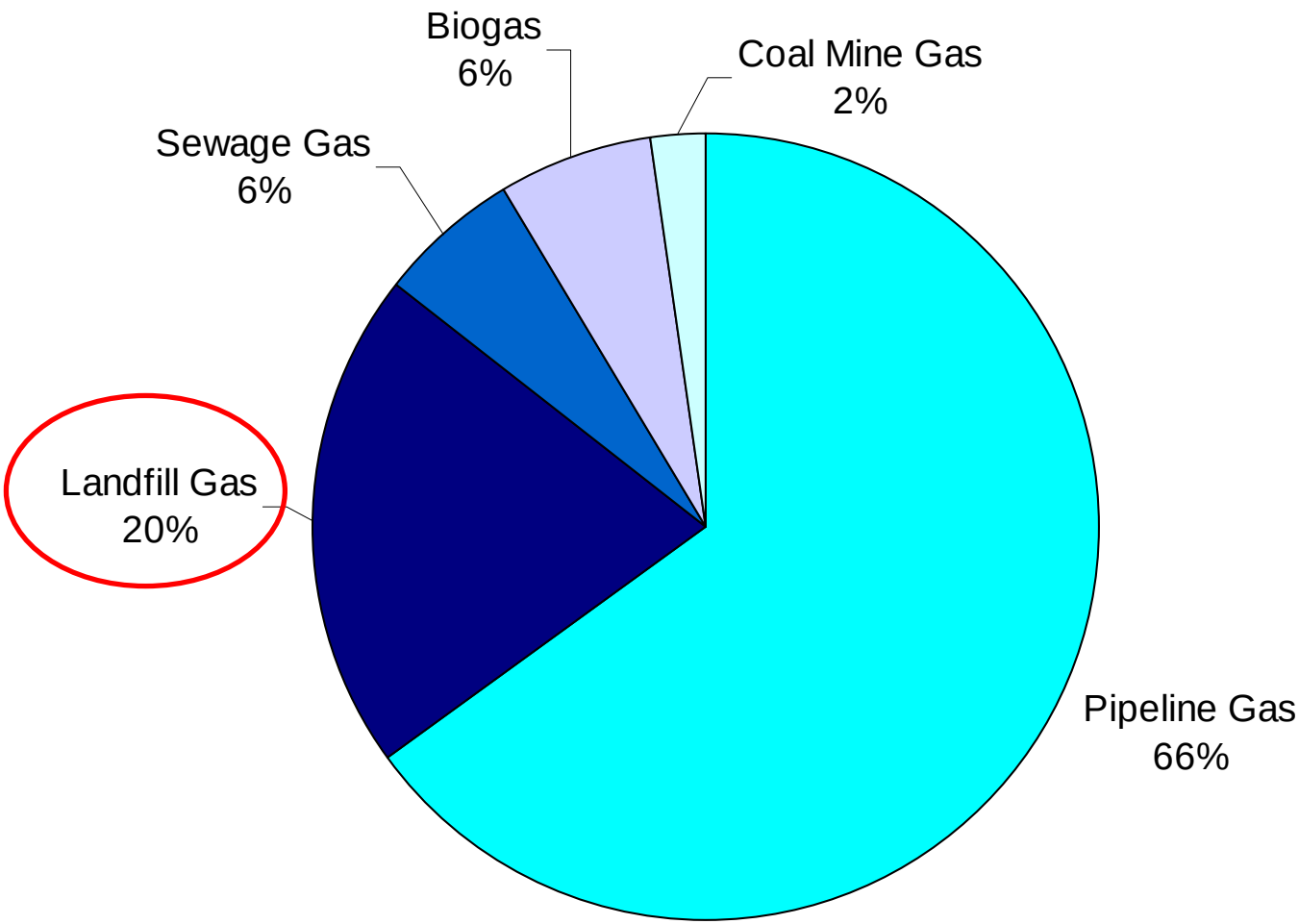


- 1 ton domestic waste => 150 - 250 Nm³ Landfill gas over a period of 15 - 25 years
- LHV = appox. 4.5 - 5 kWh/Nm³
- 40 - 50% collectable from a covered landfill

Source: Biogasvolume and Properties; U. Loll, ATV Seminar 2/99 Essen; Germany

Delivered Engines – NG / NNG Application

1988 – 2004



Utilization of Landfill Gas

NENT/Hong Kong

2 x JGC 320 GS-L.L

Electrical Output:
2 x 922 kW

Utilization of Landfill Gas

Simeprodeso /MEX

7 x JGC 320 GS-L.L

Electrical Output:
7,042 kWel

Utilization of Landfill Gas

Arpley/UK

18 x JGC 320 GS-L.L

Electrical Output:
18,612 kWel

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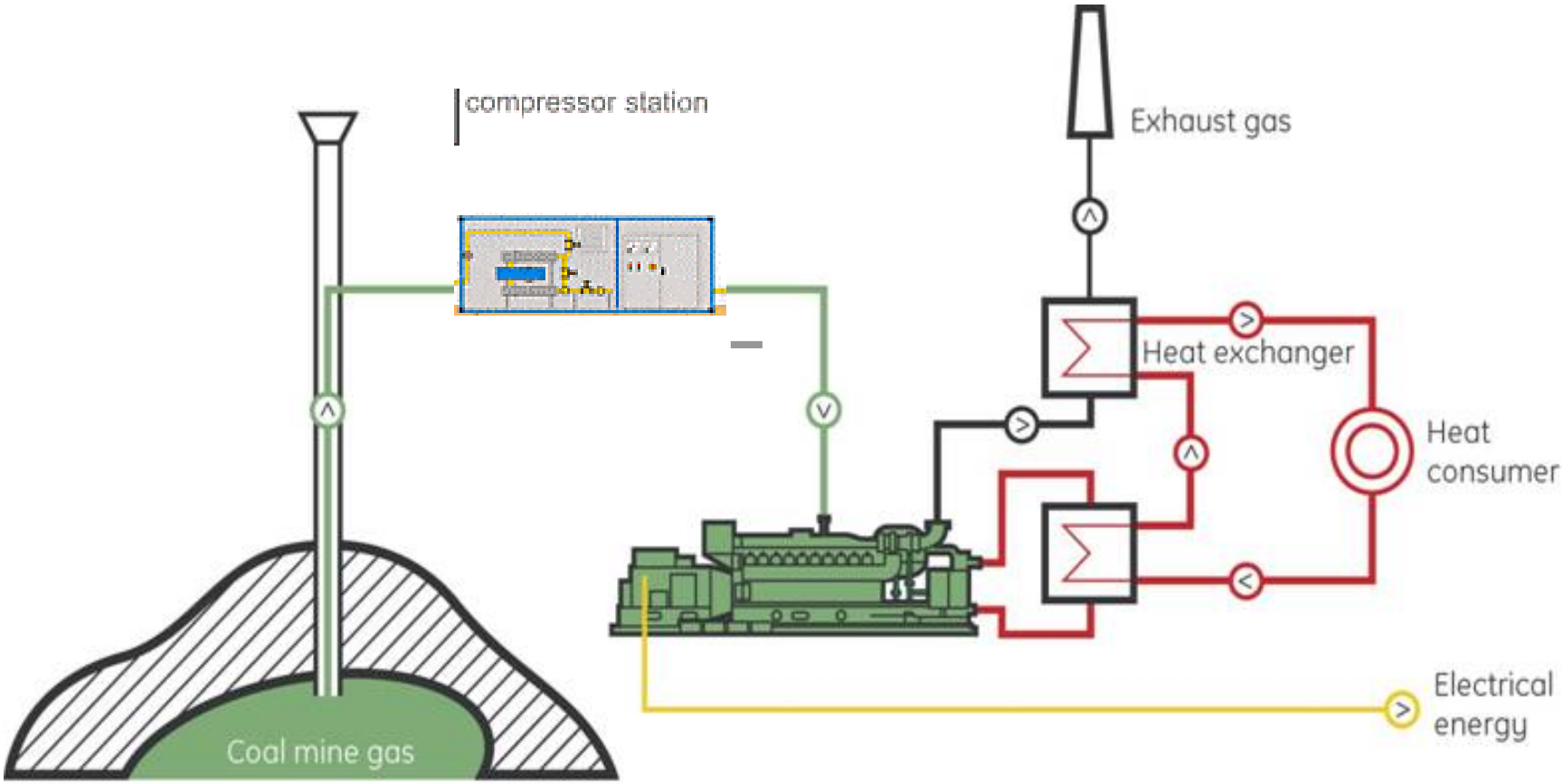
Utilization of Coal Mine Methane

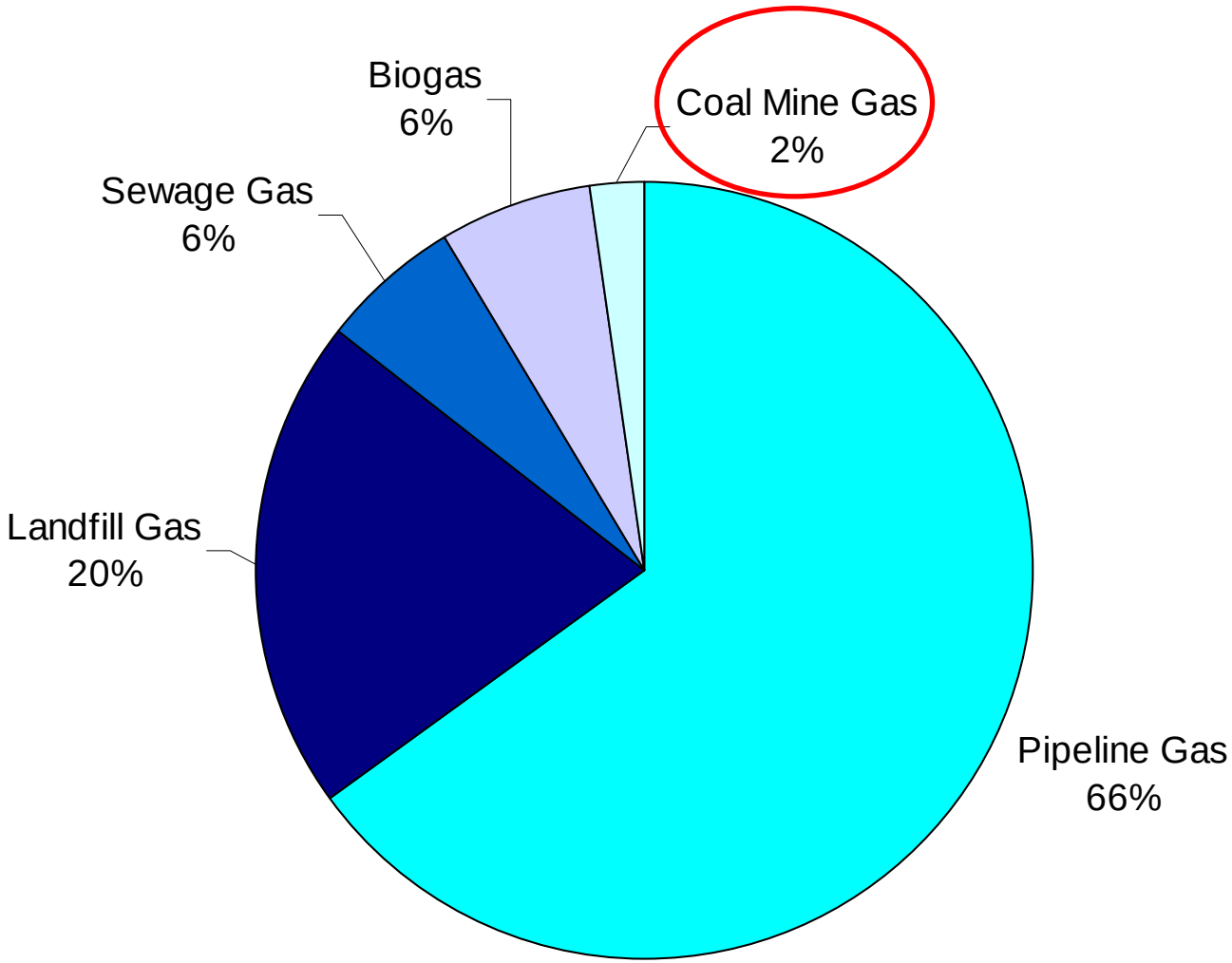
GE imagination at work

Coal mine methane utilization



Delivered Engines – NG / NNG Application

1988 – 2004



Active Mine Fenne/Germany

Fenne/Germany

14 x JMS 620 GS S.LC

Electrical Output:
40 MWel

Total Operating Hours:
175 000
GWh: 474

Closed Mine Shirebrook/ UK

Shirebrook Colliery/UK

5 x JMS 616 GS-S.L

Electrical Output: 10 MW

Total Operating Hours: 178 000

GWh: 310

CDM possibilities with Jenbacher gas engines

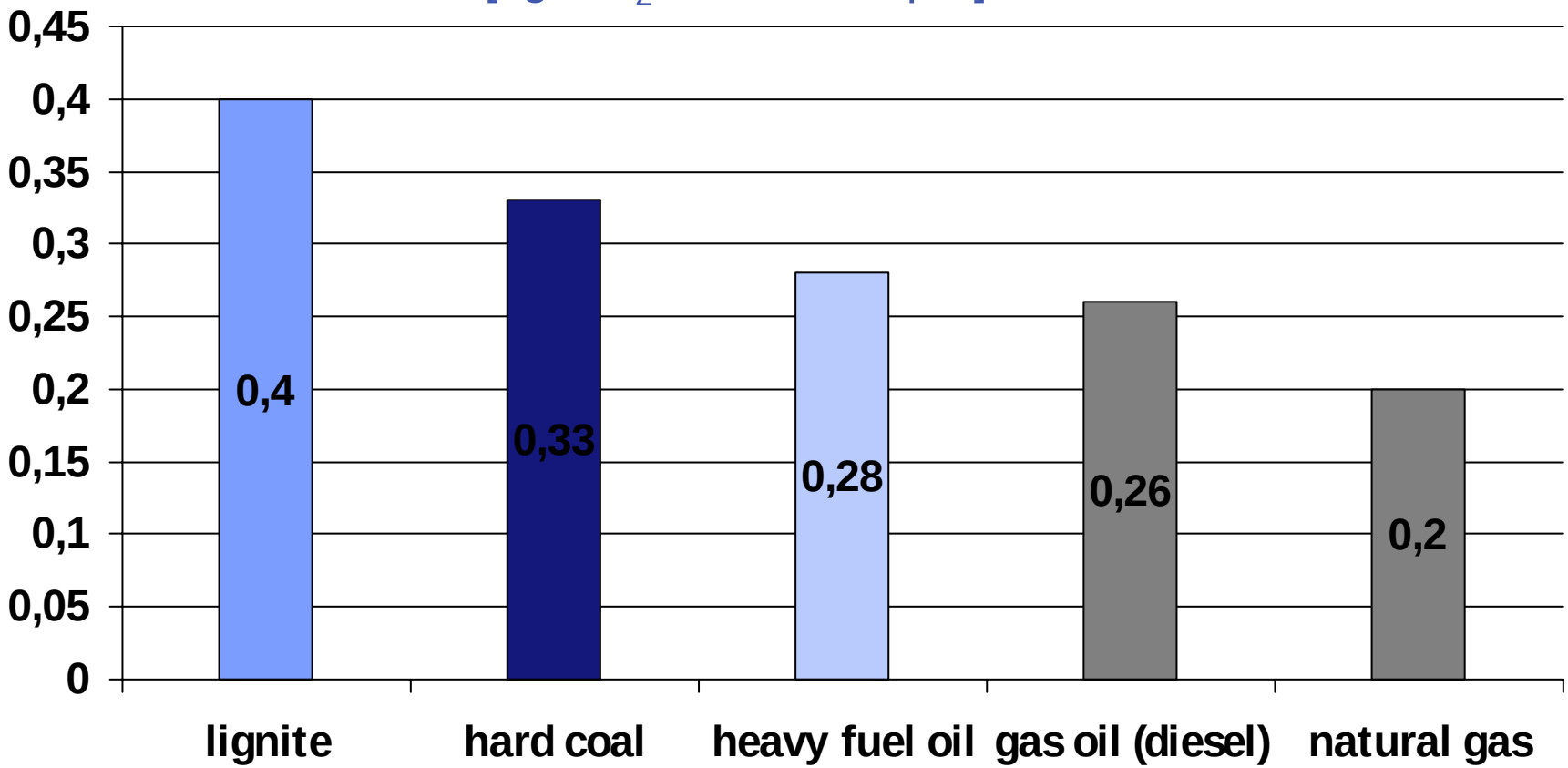
ecomagination
a GE commitment

GE imagination at work

Natural Gas - The Cleanest Fossil Fuel

CO_2 formed by the combustion of fossil fuels

[kg CO_2/kWh fuel input]



Source: Third Report of the Parliamentary Commission on „Preventive Measures to Protect the Earth`s Atmosphere“ published in October 1990

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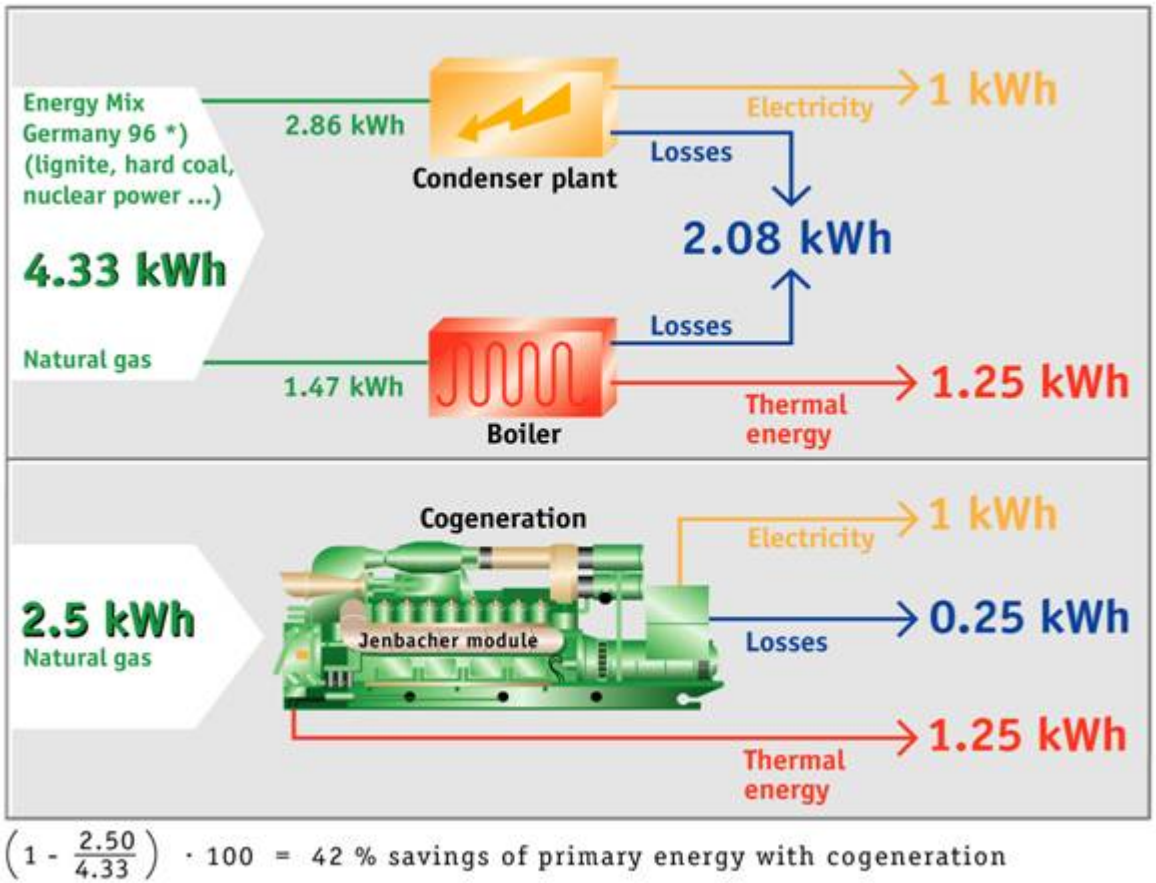
Example for specific CO2 – production of different technologies



=> 0 .669 kg CO_2

Total 0.963 kg CO_2

=> 0.294 kg CO_2

Total 0.5 kg CO_2

=> 48% CO_2-reduction with Cogeneration

*) Source: „Ganzheitliche Bilanzierung der Energiebereitstellung“ FfE-Studie; Energy Mix Germany 1996: 0.669 kg CO_2/kWh_{el}

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Natural Gas - CHP

Theoretical Emission Reduction Potential:

0.5t / MWh * 8000hr / year
⇨appr. 4,000t CO_2 / MWel / year
⇨appr. € 20,000 / MWel / year

Assumption: Energy Mix Germany; 40% el. Efficiency; 8,000 OH/y; 1ton CO2: 5€

Biogas

Emission Reduction Potential:

0.963 t / MWh * 8000 hr / year

⇨**appr. 7,700t CO_2 / MWel / year**
⇨**appr. € 38,500/year**

Theoretical example for:
St. Veit, Austria
Engine type: 1 x JMC 320 GS-B.L.

Electrical output: 1.065kW
Emission Reduction Potential:
8200t CO_2 / year
(eq. 40,000 €)

Assumption: Energy Mix Germany; 40% el. Efficiency; 8,000 OH/y; 1ton CO2: 5€

GE imagination at work

Coal Mine Gas

Theoretical example for:
Tahmoor Colliery/ Australia
Engine Type: 7 x JGS 320 GS-S.L

Electrical Output: 7 MW
Emission Reduction Potential:
240,000t CO_2/ year
(eq. 1.2 Mio. €)

Emission Reduction Potential:

2.5 kWh coal mine gas => 1 kWhel
2.5 kWh coal mine gas = 0,18 kg CH_4 (GWP CH_4 = 21)
=> 3.76 kg CO_2- equivalent
=> 4.22 kg /kWhel CO_2 reduction by CHP with CMM

4.22t / MWh * 8000hr / year
⇨ **appr. 34,000t CO_2 / MWel / year**
⇨ **appr. € 170,000 / MWel / year**

Assumption: Energy Mix Germany; 40% el. Efficiency; 8,000 OH/y; 1ton CO2: 5€

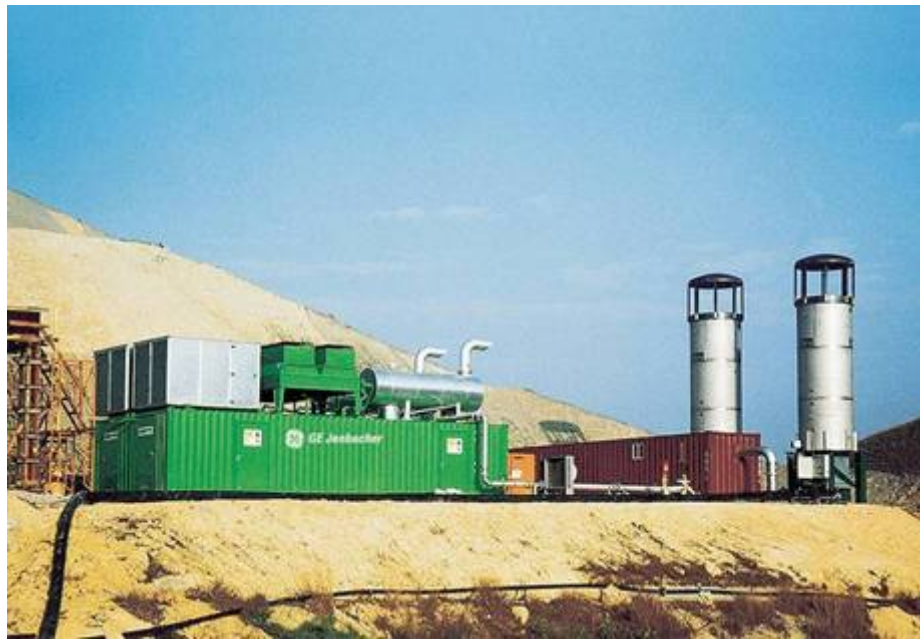
Landfill Gas

Emission Reduction Potential

Landfill Gas has to be flared:

0.669 t / MWh * 8000 hr / year

⇨**appr. 5,350t CO_2 / MWel / year**
⇨**appr. € 27,000/year**



Landfill Gas doesn‘t have to be flared:

4.43 t / MWh * 8000 hr / year

⇨**appr. 35,000t CO_2 / MWel / year**
⇨**appr. € 175,000/year**

Theoretical example for:
Landfill site Nent, Hongkong
Engine type: 2 x JGC 320 GS-L.L

Electrical output: 1,844 kW
Emission Reduction potential: 9 865t CO_2/year
(eq. 50.000 €)

Assumption: Energy Mix Germany; 40% el. Efficiency; 8,000 OH/y; 1ton CO2: 5

GE imagination at work

CDM – a key component

- Biogas power generation projects in several cases viable because of CDM
- Costs of project development should be lowered and bureaucratic barriers simplified
- 2012 window is closing fast ⇨ opportunities could be lost if immediate action is not taken
- Jenbacher gas engines offer the benefit of both : useful utilization of renewable energy sources for power generation & creating carbon credits

Potential is enormous

GE imagination at work

GE imagination at work