Commercializing Landfill Gas to Energy Opportunities in (South) Eastern Europe

GE's Jenbacher integrated LFG to Energy solution

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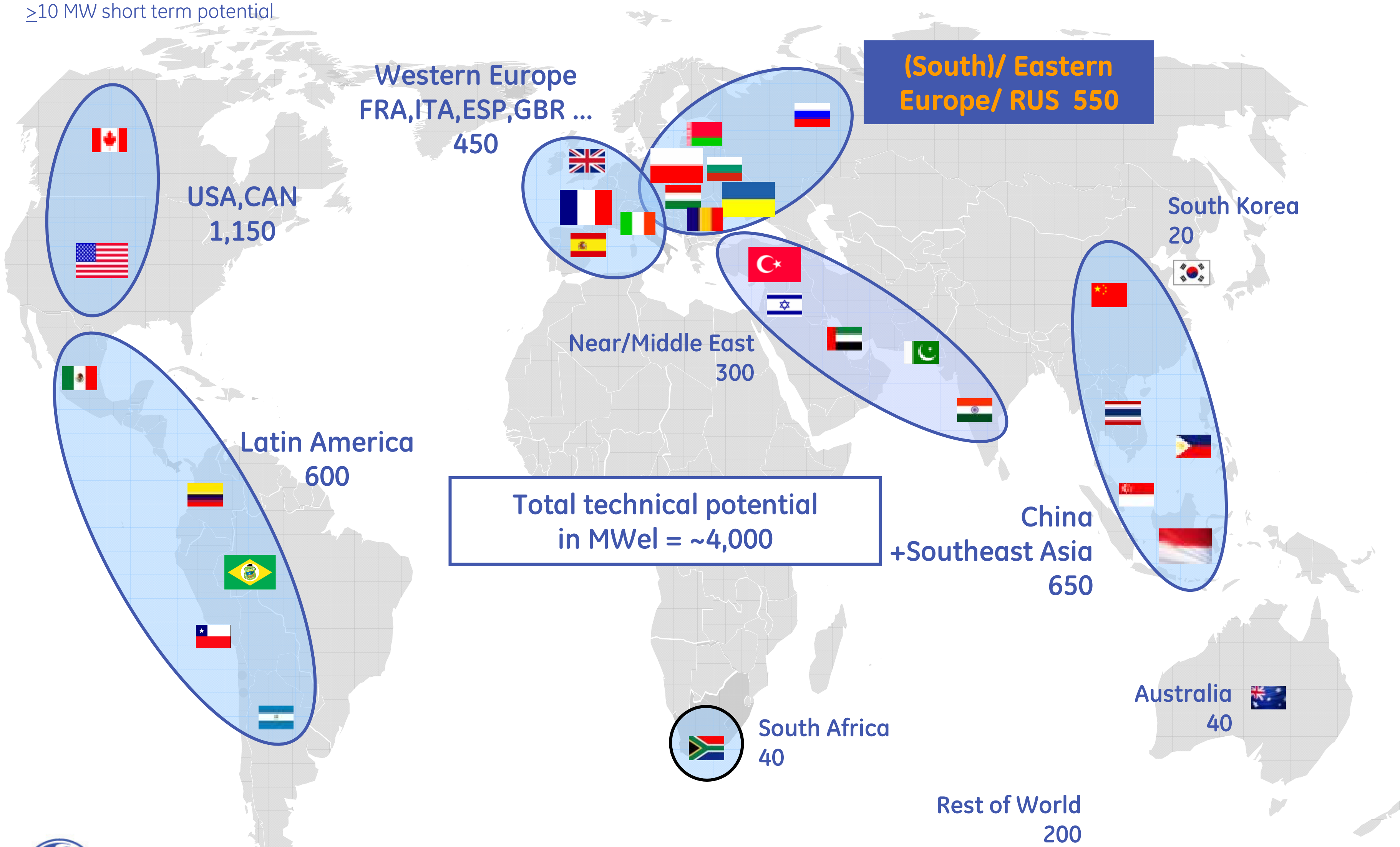
Novi Sad, 2010

GE imagination at work

LFG to Energy - Future regions

30 countries with
≥10 MW short term potential

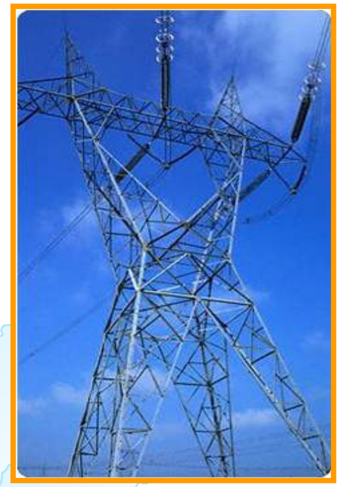


GE imagination at work

Drivers & Barriers in new countries

Drivers

- Some professionally managed landfills (mostly in the capital/ bigger cities)
- High share of biodegradables in the MSW
- First reference plant in the country
- Incentives
  - Government electricity buying guarantee
  - Attractive/ supported feed in tariff
- Kyoto Protocol, Carbon Trading (CDM/JI)
- Technology co-operations and financing schemes available



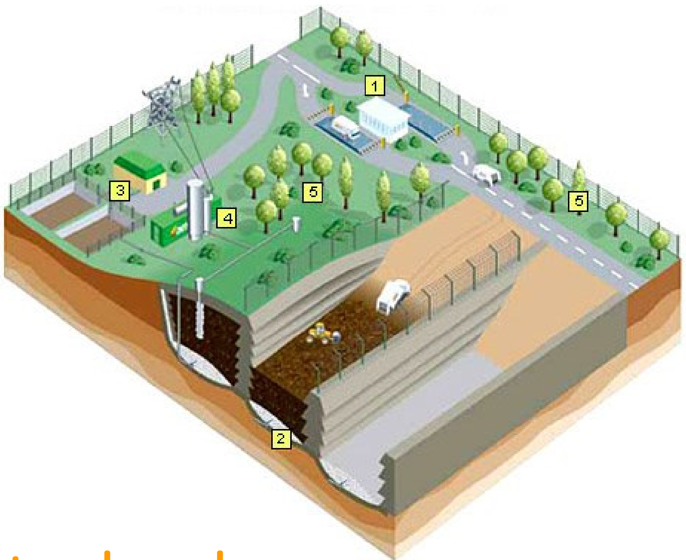
Barriers

- **Landfill design and waste management not suitable for LFGTE**
- **Low feed-in tariffs** (in case of coal-based energy supply)
- Changing political situation, municipalities own gas rights
- No regulations on environmental protection imposed
- Lengthy process of project preparation
  - Gas suction system not optimized
  - CDM/JI Bureaucracy
- Pilot projects relatively risky in terms of economics

The amount and chemical composition of the produced gas depends on a variety of factors

- **Landfill size**
  total size of the landfill
- **Waste composition**
  organic portion in MSW, VOSCs
- **Time**
  opening and closure of landfill

Non-hazardous waste landfill



- **Water level**
  amount of leachate in the landfill body
- **Climate**
  temperature, wind, air pressure etc.
- **Emplacement**
  landfill structure, design, compression

Landfill fact-finding questionnaire

Landfill Questionnaire

Landfill name and location ……………………………………

Landfill Owner/ Operator ……………………………………

Address, City, State ……………………………………

Contact Details (Phone, Email) ……………………………………

Project Developer ……………………………………

Address, City, State ……………………………………

Contact Details (Phone, Email) ……………………………………

Drop- Out- Criteria *(If two or more drop out criteria apply >> landfill is inappropriate for LFG to Energy)*

	Yes	No	N/A
Landfill has been closed for 10 years or greater?	☐	☐	☐
Are there any points on the landfill, that are catching on fire/ smoldering?	☐	☐	☐
The landfill accepts less than 30% of its waste from organic sources (e.g. food waste, paper, yard trimmings, wood, sewage sludge)	☐	☐	☐
Is the landfill steeply inclined and/ or is the waste density loose?	☐	☐	☐
Landfill's waste collection is unorganized (wasted deposit height is less than 6m/ 20 ft high and was never compressed)	☐	☐	☐

Landfill status *(please give MM/YYYY)*	landfill opened in: …………………	☐ landfill active until: …………………	☐ landfill was closed i in …………………

Current and future landfill dimension *(please indicate measuring unit)*

	min. required
Number of inhabitants in the collection area of the landfill: ………………	min. 200.000
Current body of waste length and width: diameter: ………………	2 ha/ 5 acres 160m/ 530ft
Average, (minimum, maximum) waste deposit height resp. landfill depth today: ………………	min. 6m 20 ft
Landfill was ☐ constructed as a quarry (gravel pit) ☐ filled into a natural pit/ cavity ☐ constructed alongside a slope	
Current body of waste volume: ………………	min. 500,000 m³ min. 18MM cbf
Landfill is divided up into … ☐ ……… (#) different cells/ areas ☐ is one body	
Maximum total site capacity in final stage: *(length & width & height or volume)* ………………	

Landfill Questionnaire

Waste Amount and Composition *(please underline or indicate relevant measuring unit)*

Current amount of waste brought to landfill per day	in tons ……………	in m³/ cft …………	specific weight in kg/ ton …………	Landfill receives waste (#) ……… days a week	☐ no daily data available

Annual waste disposal in tons/ m³/ cft in the past/ future

2000 ………	2007 ………	2014 ………	2021 ………
2001 ………	2008 ………	2015 ………	2022 ………
2002 ………	2009 ………	2016 ………	2023 ………
2003 ………	2010 ………	2017 ………	2024 ………
2004 ………	2011 ………	2018 ………	2025 ………
2005 ………	2012 ………	2019 ………	2026 ………
2006 ………	2013 ………	2020 ………	2027 ………

Cumulated waste disposal before year 2000 in t/ m³/ cft: ………………

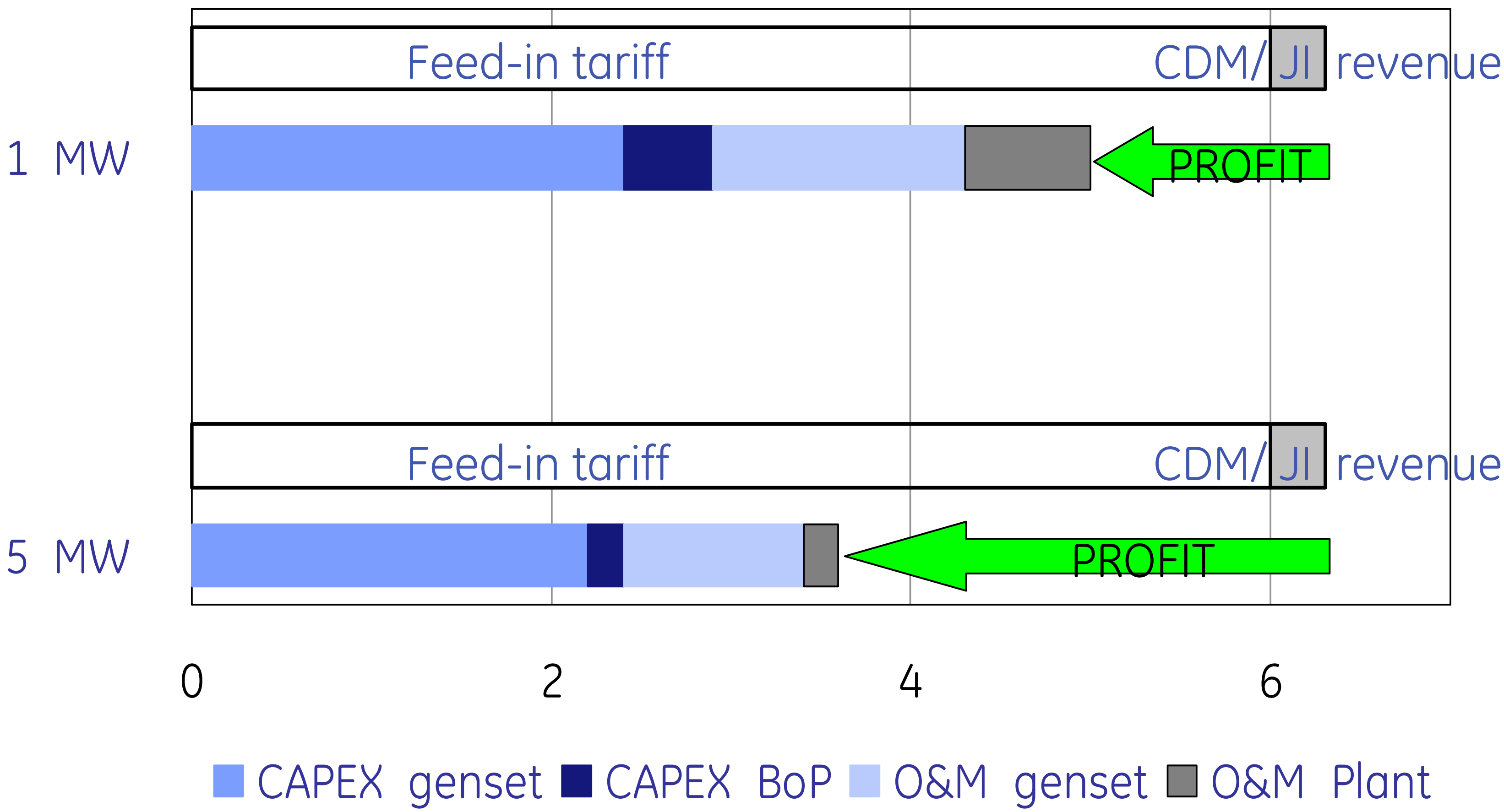
Type of waste deposited	☐ houshold refuse only	☐ medical/ toxic waste, pretreated? Yes ☐ No ☐	☐ rubble/ construc-tion waste	☐ other industrial refuse, namely: ………………

Average waste composi tion in %	food scrap ………	wood/ yard trimmings ………	paper/ cardboard ………	plastics rubber ………	glass/ metals ………	leather/ textiles ………	ash/ minerals ………	other, namely: ……… ………

Landfill design and operation *(please underline or indicate relevant measuring unit)*

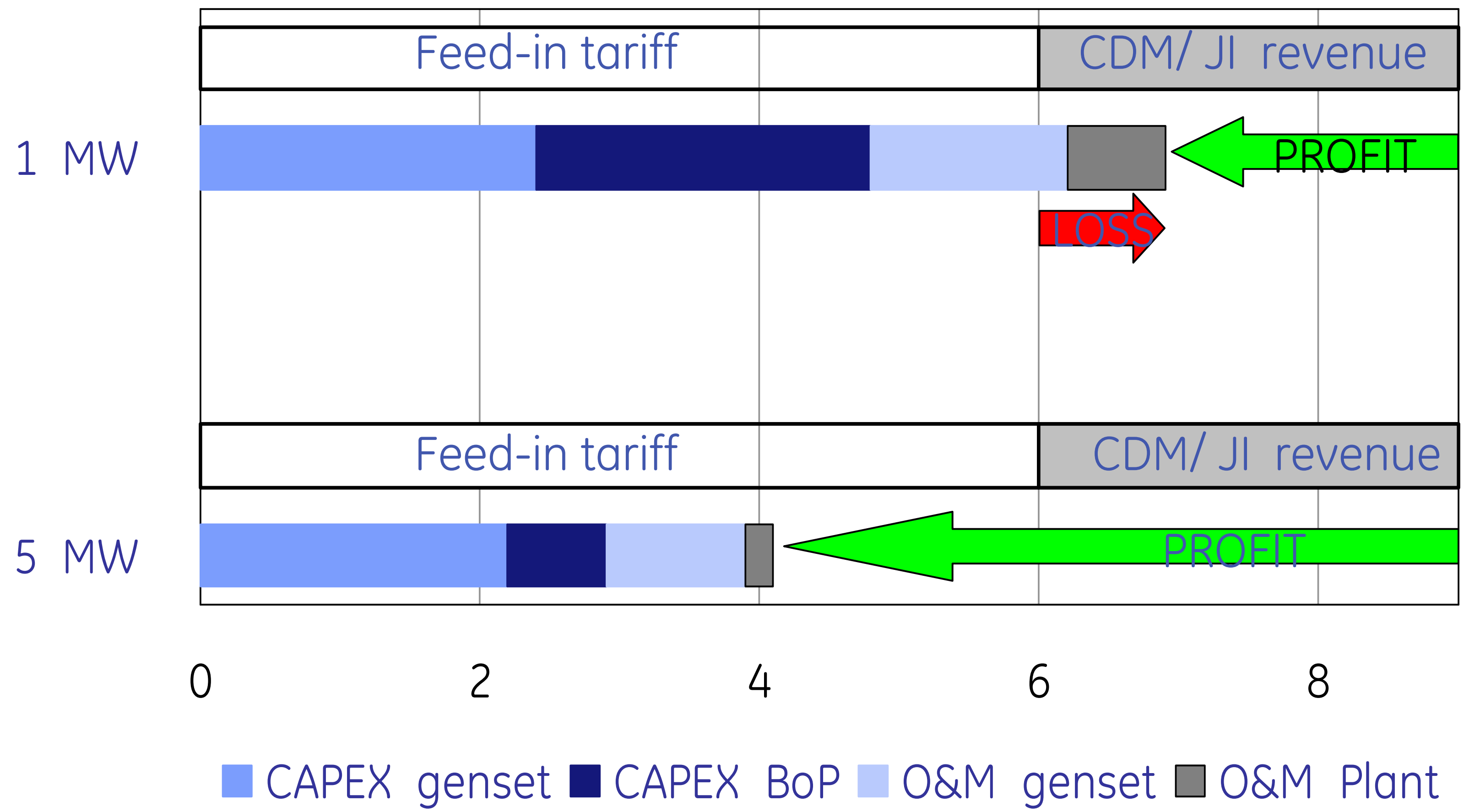
The landfill has a …	☐ basic sealing made of: ………………		☐ no basic sealing
New refuse is/ was stored …	☐ over a ramp piled up at one spot	☐ spread all over the surface	
New refuse is/ was compacted with …	☐ a caterpillar	☐ a special compactor	☐ is not compacted
New refuse is/ was covered with ..	☐ soil ☐ other material:	at a layer thickness of ……… meters/ft	☐ is not covered
Landfill consists of sectors …	☐ with different waste age	☐ with different waste fractions	☐ is homogenous
The landfill is equipped with a …	☐ leachate outfall	☐ leachate recirculation	☐ none of those
Landfill is/ will be covered …	☐ temporarily with: V	☐ permanently with: V	☐ no cover
If covered, please indicate material and method	………………………………		

Project margin LFGTE - Case 1:
Gas collection & flaring/utilization mandatory



*all figures stated in US$ cent per kWh$_{el}$ and calculated for 60,000 operating hours (=7,5 years) of J320

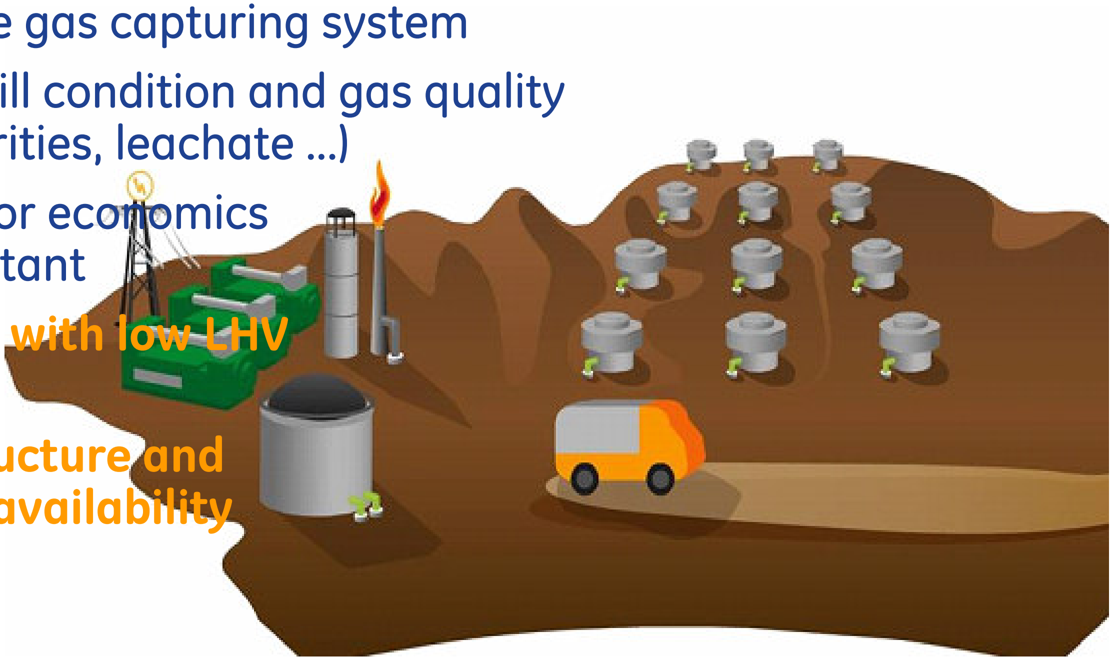
Project margin LFGTE - Case 2:
Gas collection & flaring/utilization **NOT** mandatory



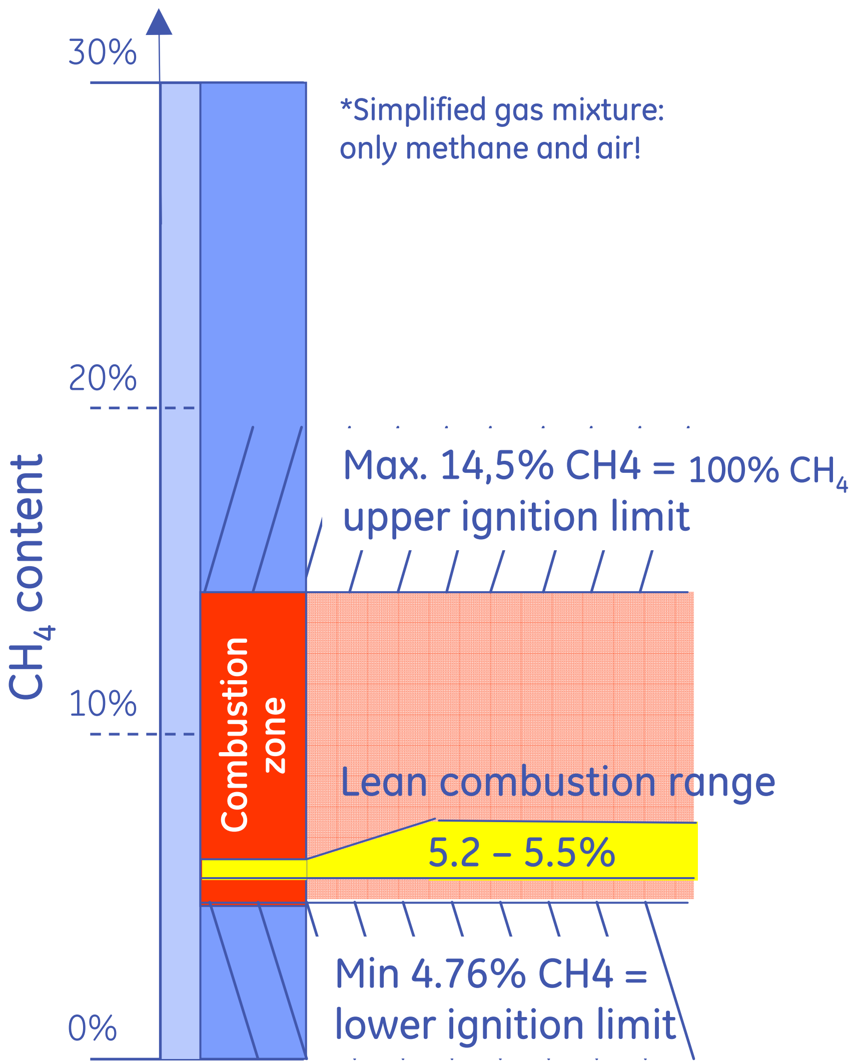
*all figures stated in US$ cent per kWh$_{el}$ and calculated for 60,000 operating hours (=7,5 years) of J320

Success factors for profitable LFGTE projects

- **Long-term planning of entire project**
- **Try to reach project size >> 1MWel**
- Strive for long-term Power Purchase Agreement
- Try to obtain further revenues with heating (CHP) or other
- Select robust, light-weight engines with high power density in containerized configurations
- Install professional and flexible gas capturing system
- Thorough assessment of landfill condition and gas quality (gas curve, VOSCs, other impurities, leachate ...)
- Gas engine availability is key for economics electrical efficiency also important
- **Apply engine, which can deal with low LHV and varying gas qualities**
- **Ensure long-term service structure and contracts to maximize plant availability**



CH_4 concentrations in combustion chamber*



Combustion limit LHV:		LFG example	
CH_4:CO_2 <u>min. 1:1</u>	<	33/27	✓
CH_4/N_2 <u>min. 28/72</u>	<	33/39	✓

Jenbacher type 3 and type 4 engines can run full load with each possible composition of landfill gas due to special …

- ignition system
- spark plugs
- piston heads
- combustion chamber geometry

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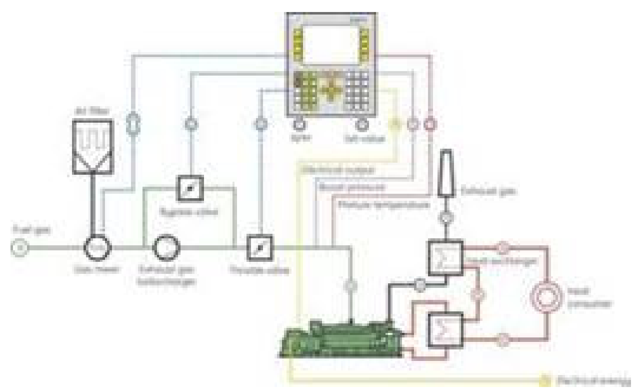
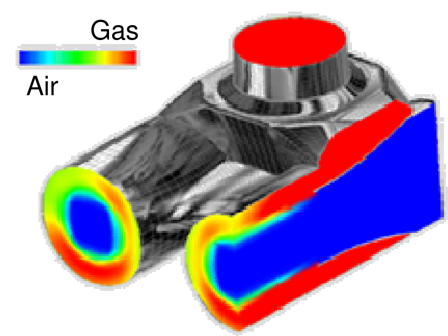
LFGTE challenges

- Low LHV, high inert portions (CO2/N2)
- Leachate, Sulfur
- Siloxanes = VOSCs
- LHV fluctuations, Oxygen Content
- Emission compliance
- Capacity adaption, shift
- Less experienced O&M staff

GE Jenbacher solution

- Special design and ignition system
- Gas conditioning & special design
- Temperature Swing Adsorber (TSA)
- LEANOX®, DIA.NE®, gas mixer, TCB
- LEANOX®, CL.AIR®, TSA
- Modular, compact, broad range
- Remote services, flexible CSA





Landfill gas project Ana Liossia/ GRE

No. of units and engine type:	4 x JMS 620 GS-L.L
Fuel:	Landfill gas
Electrical output:	9,700 kW (extension)
Thermal output:	5,500 kW
Commissioning:	September 2006

Landfill gas project Maribor/ SLO

No. of units and engine type:	1 x JGC 312 GS-L.L
Fuel:	Landfill gas
Electrical output:	625 kW
Commissioning:	1998

Landfill gas plant Pohang, Korea

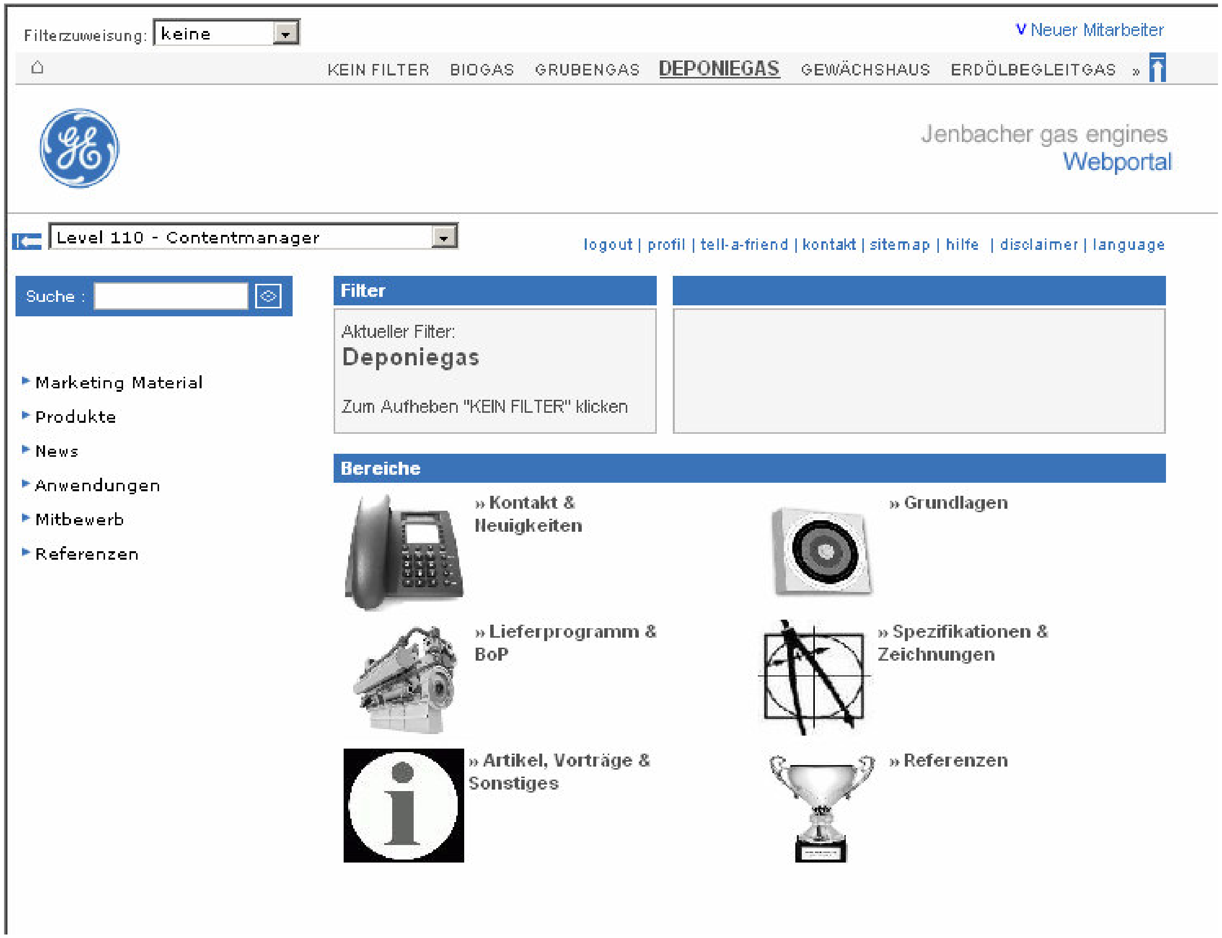
No. of units and engine type:	2 x JGC 320 GS-L.L
Fuel:	Landfill gas
Electrical output:	2,116 kW
Commissioning:	May 2002

Landfill gas plant Pinto, Spain

No. of units and engine type:	11 x JMS 420 GS-L.L
Fuel:	Landfill gas
Electrical output:	15,543 kW
Thermal output:	8,327 kW
Commissioning:	June 2000

Where do you find information?

>> GE Jenbacher intranet - Webportal



https://information.jenbacher.com