

Gas engine solutions for low BTU Applications

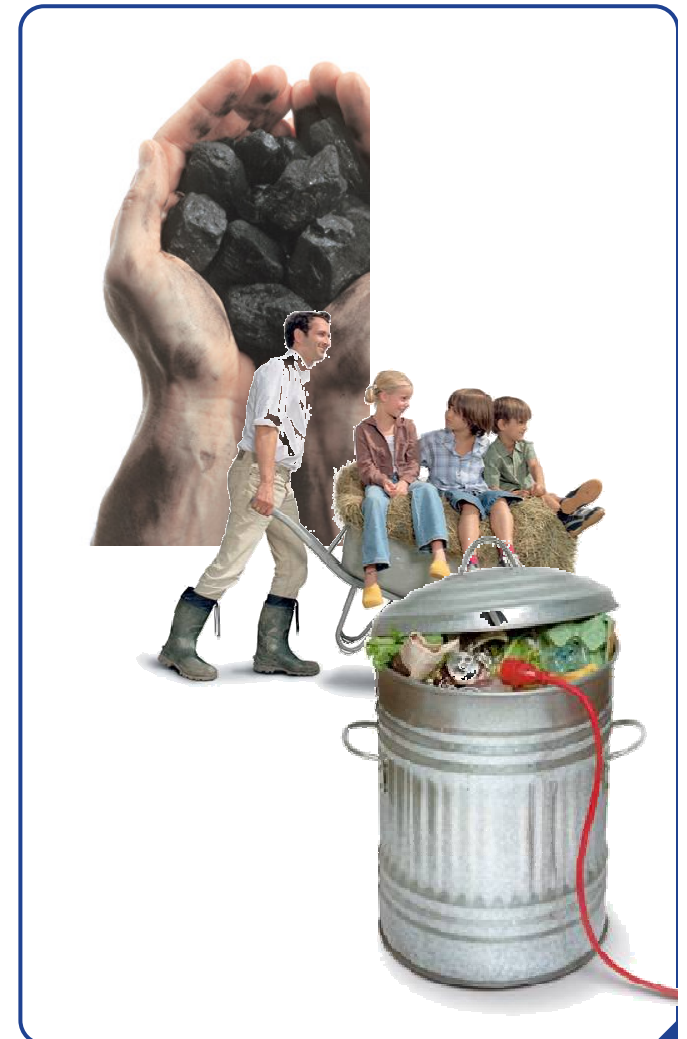
CMG-, Biogas-, Sewage Gas-,
LFG to Energy

Gerhard Pirker
Marketing Program Manager
GE Energy Jenbacher gas engines

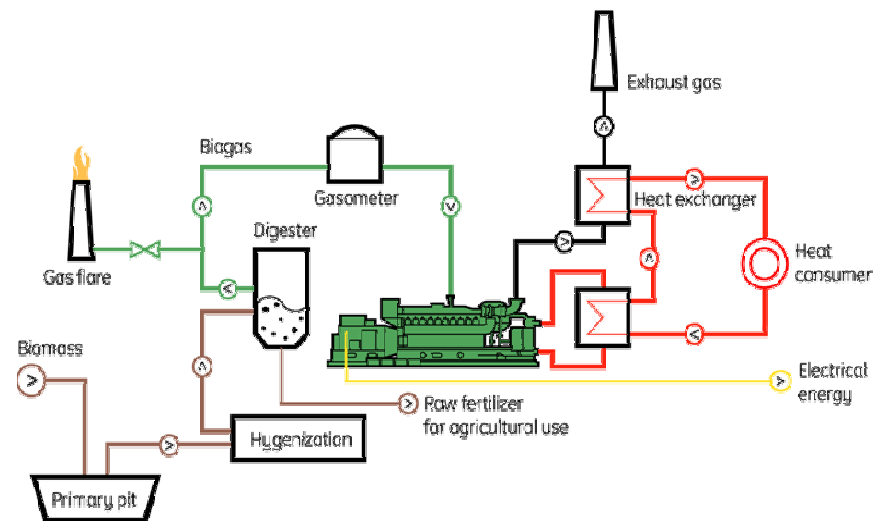
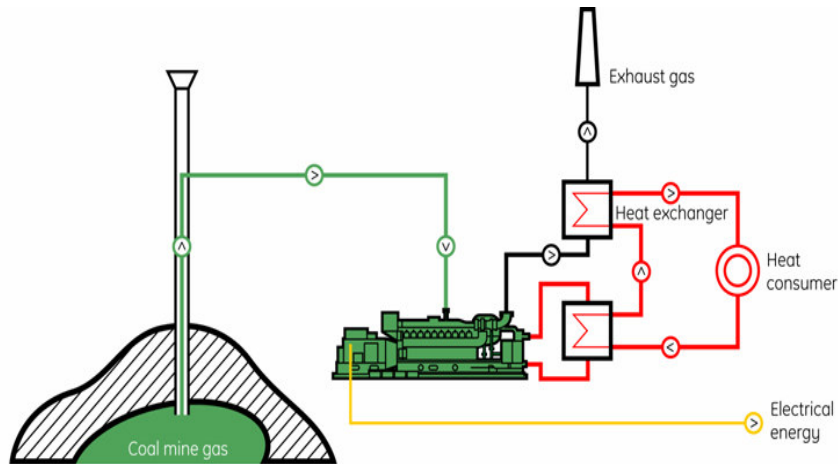
M2M Partnership Expo
New Delhi, March 2010



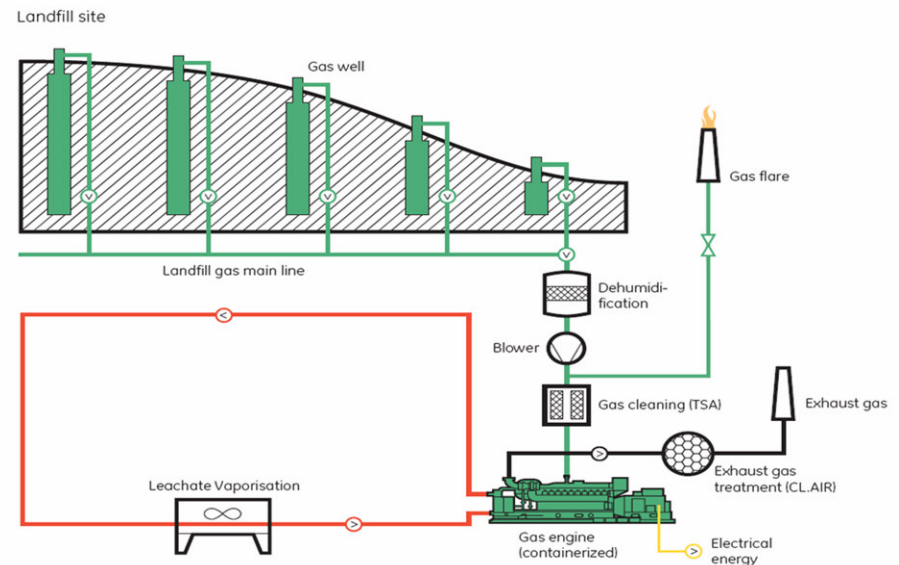
GE imagination at work



Overview of low BTU Applications

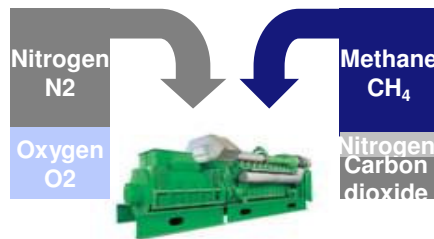


- Low BTU gases result from different processes
- Still, there are several similarities as far as gas engines are concerned
- Gas engine manufacturer provide integrated solutions
- Auxiliaries not necessarily part of supply scope, but 'turnkey thinking'



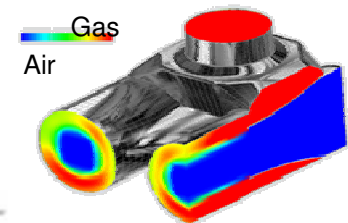
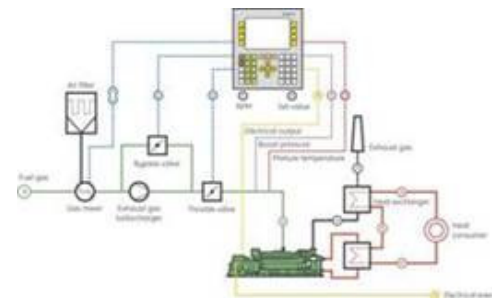
Challenges

- Low BTU, high inert fractions (CO₂/N₂)
- Gas humidity & dust
- BTU, O₂ and pressure fluctuations
- Sulfur and other Impurities
- Siloxanes (Silicon Compounds)
- Emission compliance
- CDM/JI approval, PDDs
- Capacity adaption, shift
- Less experienced O&M staff

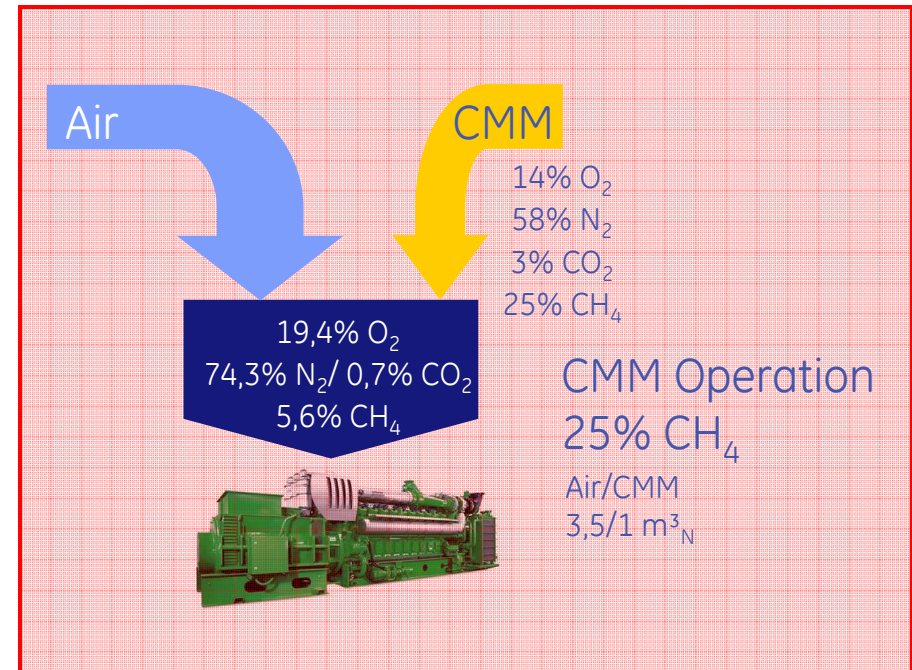
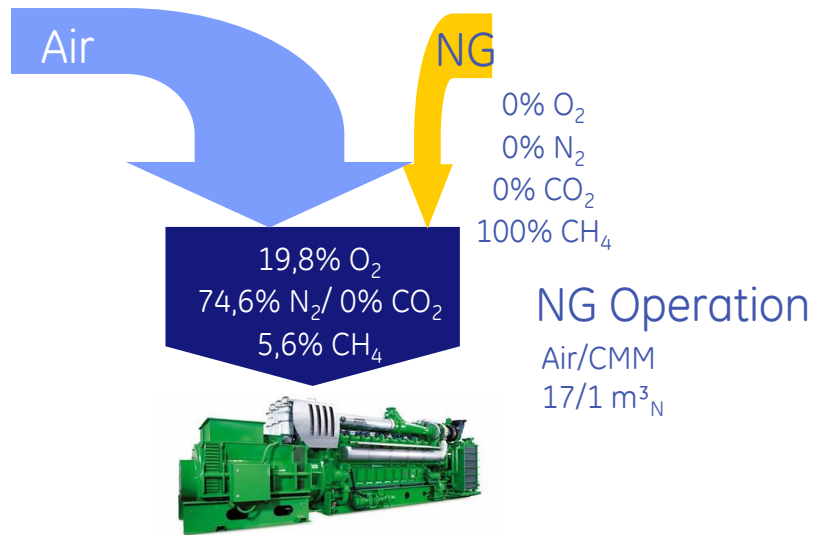


Solution

- Special design and ignition system
- Gas conditioning support
- LEANOX[®], DIA.NE[®], gas mixer, TCB
- Special materials and design
- Gas cleaning: TSA, activated carbon
- CL.AIR[®], TSA
- Methane Monitoring & other support
- Modular, compact, broad range
- Special support, flexible CSAs



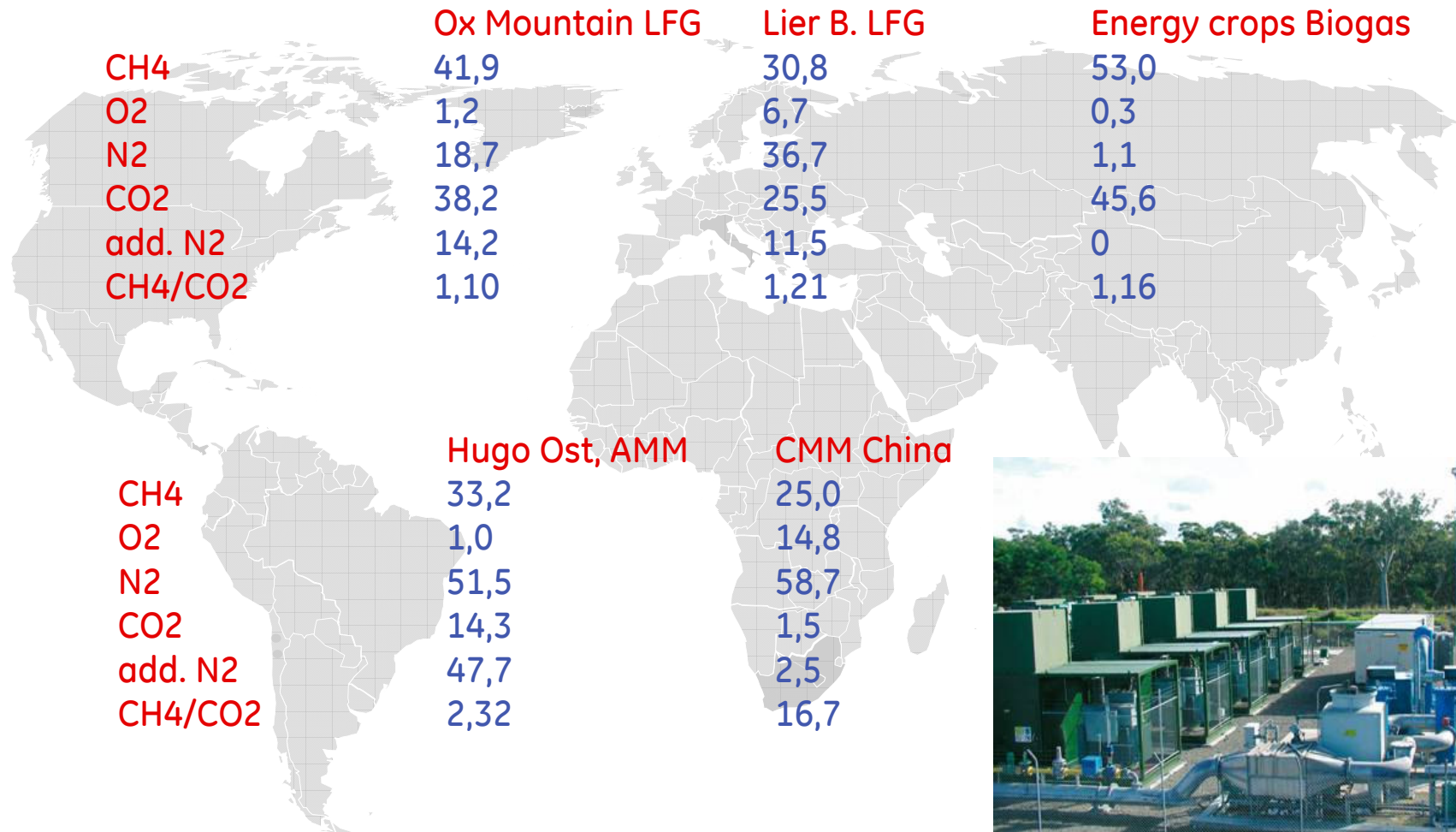
Dealing with low BTU gases



- Special gas train lay-out
- Special gas mixer
- Special turbocharger
- Special geometry of
 - combustion chamber &
 - piston head
- Special spark plugs & ignition system

- >> Gas mixture in the combustion chamber is finally about the same as in NG operation
- >> Optimal combustion despite low laminar flame-speed

Gas compositions of GE Jenbacher plants



GE Jenbacher gas conditioning support



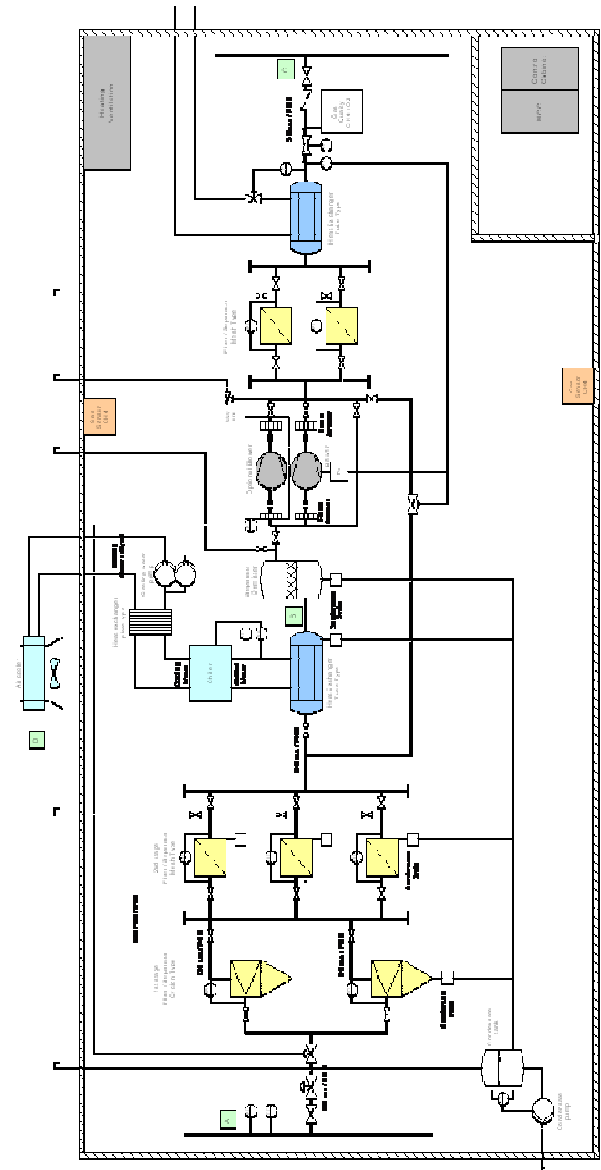
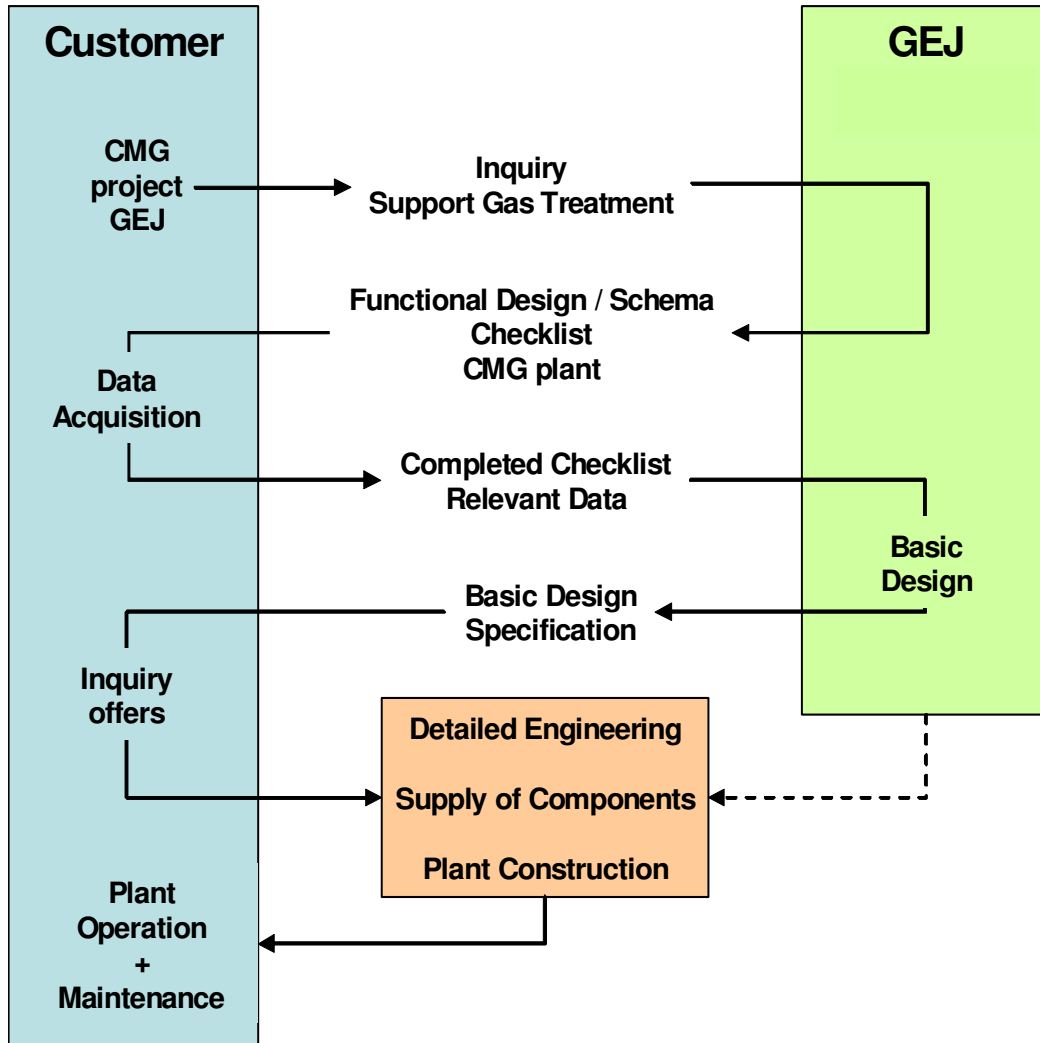
The quality of the gas conditioning has a big influence on the availability of the gas engine

GE supports with basic design, component specifications and subcontractor evaluation for effective gas conditioning

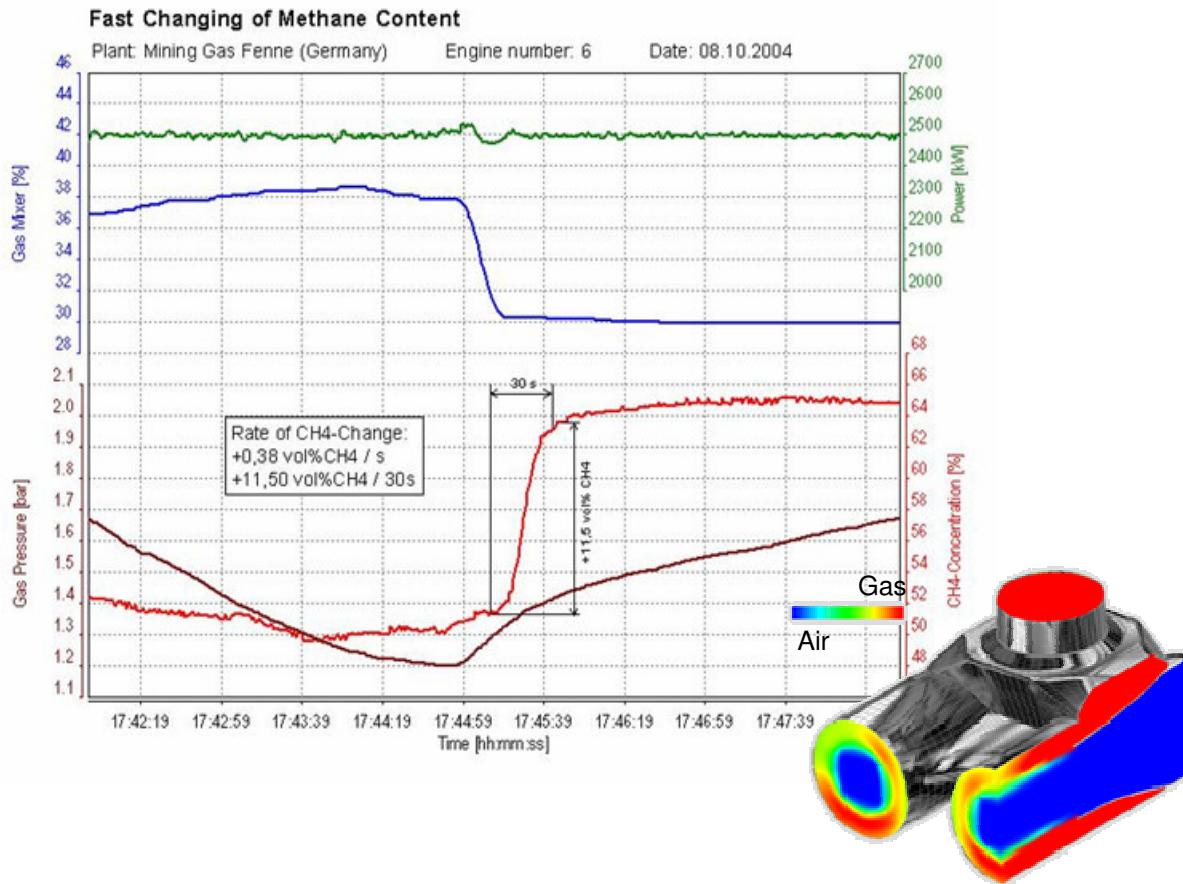


GE imagination at work

Workflow & Basic Design



Fast Changing CH₄ Content

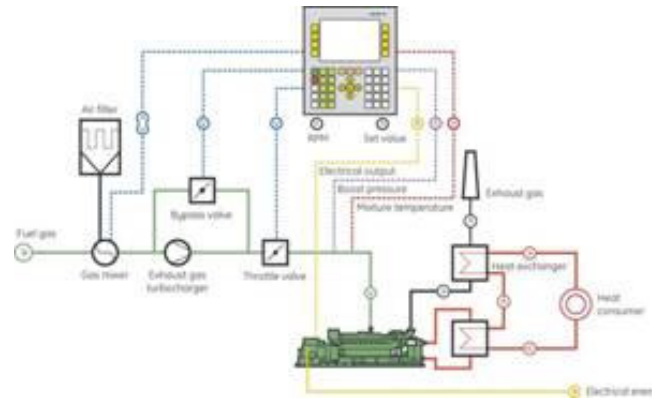
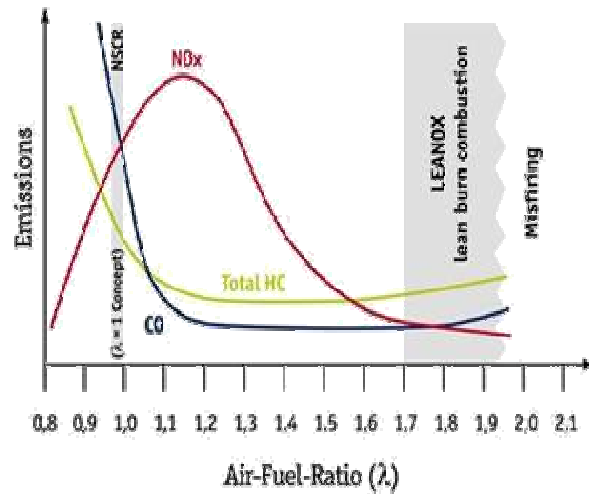


Facts

- CH₄-Concentration is changing faster than **11.5Vol%/30s**
- Only small Load Fluctuation – Engine operation is still stable
- *LEANOX* control system
- Fast Reaction of Gas Mixer
- Longest experience with turbo charger bypass system

Optimal compensation of fluctuations increases gas engine availability and components lifetime and also reduces investment in the gas supply (buffer tank e.g.)

GE Jenbacher *LEANOX*[®] + DIA.NE[®]



LEANOX[®] together with DIA.NE[®]

- enables smooth and automatic engine start and operation
- avoids thermal and mechanical stress
- extends lifetime of valves, cylinder heads and spark plugs
- keeps NOx emissions always below the limit

Performance data of existing plants

COUNTRY	PLANT	DATE	CH ₄ -RANGE	REFERENCE VALUE	Max Δ CH ₄ in 30sec
Australia	J C555 Oaky Creek JGS320	21.01.2008 - 22.02.2008	81 - 95	96	2
China	J D448 YangQuan ShentangZui JGS620	01.05.2008 - 29.05.2008	30 - 41	39	4
Germany	J B321 Grubengas Fenne JMS620	23.06.2008 - 08.07.2008	33 - 70	57	11,5
Germany	J B475 Grubengas Walsum JGC420	29.04.2008 - 29.05.2008	33 - 53	-	8
Great Britain	J A836 Stillingfleet JGC420	29.04.2008 - 29.05.2008	30 - 55	65	10
Great Britain	J D703 Stillingfleet 2006 JGS620	27.04.2008 - 29.05.2008	80,5 - 83	65	2,5
Great Britain	J A839 Maltby JGC420	01.05.2008 - 29.05.2008	26 - 48	36	8
Great Britain	J A841 Kellingley JGC420	02.05.2008 - 29.05.2208	26 - 50	-	8
Great Britain	J A843 Welbeck JGC420	27.04.2008 - 29.05.2008	25 - 44	-	8
Ukraine	B617 Sasyadko JMS620	02.09.2007 - 04.10.2007	25 - 42	36	12



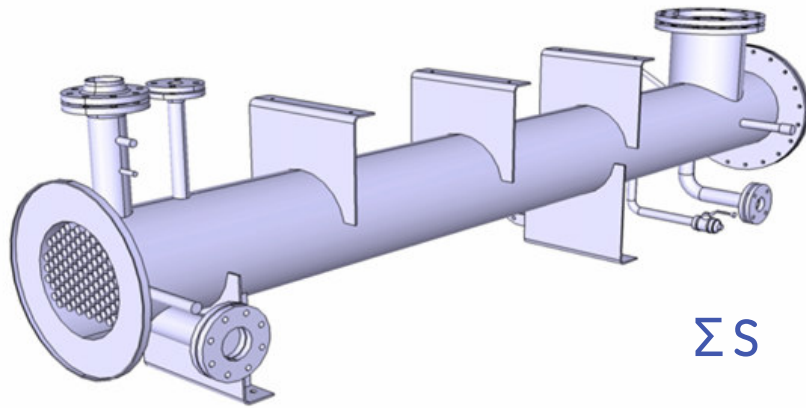
Sulfur and other impurities



Measures:

- anti-corrosive engines parts (bearings, valves)
- robust construction
- special scraper rings
- special Biogas heat exchanger

- Cooling down to 180°C or 220°C
- no pipes at the bottom > no condensate
- big condensate trap (DN50)



ΣS < 700 mg/100% CH₄ (without catalyst)
↳ Standard maintenance schedule

ΣS < 2000 mg/100% CH₄
↳ „modified“ maintenance schedule

Volatile Organic Silicon Compounds (VOSCs)



Increasing VOSC impurities in LFG and Sewage Gas

- Industrialization process >> MSW fractions increasingly contain siloxanes
- Biodegradables deposited separately
- VOSCs appears in the early phase of fermentation/ subtropical climate speeds up process

>> In all LFG to energy growth regions some VOSC load must be expected in the next 3-8 years

VOSC considerably increase O&M costs

- Deposits cause lower availability and higher maintenance costs (oil, de-coking, NNG schedule)

VOSC hamper emission compliance

- Wear is responsible for CO/NO_x drift
- Already low VOSC levels destroy catalyst

Sewage Gas: total VOCs (Volatile Organic Compounds) load lower >> fix bed activated carbon sufficient

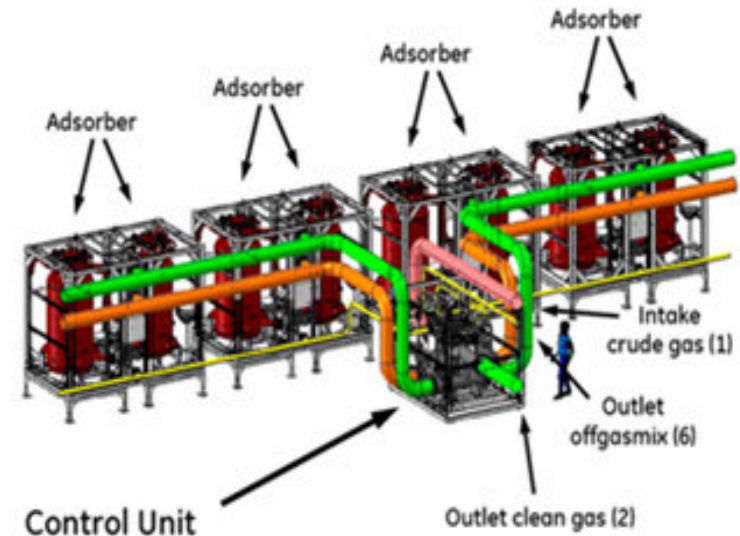


Temperature Swing Adsorber (TSA)

TSA allows automatic thermal regeneration of activated carbon filter on LFGTE site

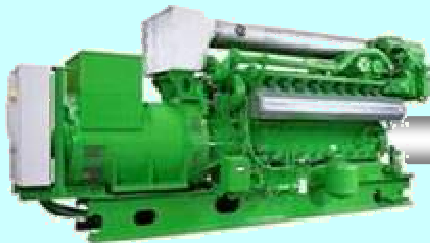
>> filter lifetime up to 8,000 Oh

- Add. availability LFG to energy plant
>> additional electricity revenues
- Increased output
- Reduced lube oil & spark plug consumption
- Less preventive maintenance (NG schedule)
- Less corrective maintenance (de-coking a.o.)
- Enables catalyst operation



CL.AIR - exhaust gas after-treatment

No fuel gas
pre-treatment
necessary



Thermal treatment



CL.AIR®

- ✓ CO < 200 mg/Nm³
- ✓ NO_x < 250 mg/Nm³
- ✓ CH₂O < 20 mg/Nm³
- ✓ THC < 200 mg/Nm³

- No VOSC removal needed
- Stable emissions/no drift
- Easy plant integration
- Low energy consumption
>> min. OPEX
- 120,000 OH lifetime
- Additional heat output
- Small footprint required
- Synchronized with engine
maintenance schedule



GE imagination at work

GE Jenbacher carbon meter support

Plant size
Engine type
Gas conditions
PDD methodology
Safety regulations
Site conditions

Jenbacher
support fully
synchronized with
gas engine

Project
Integration
DIA.NE
Implementation

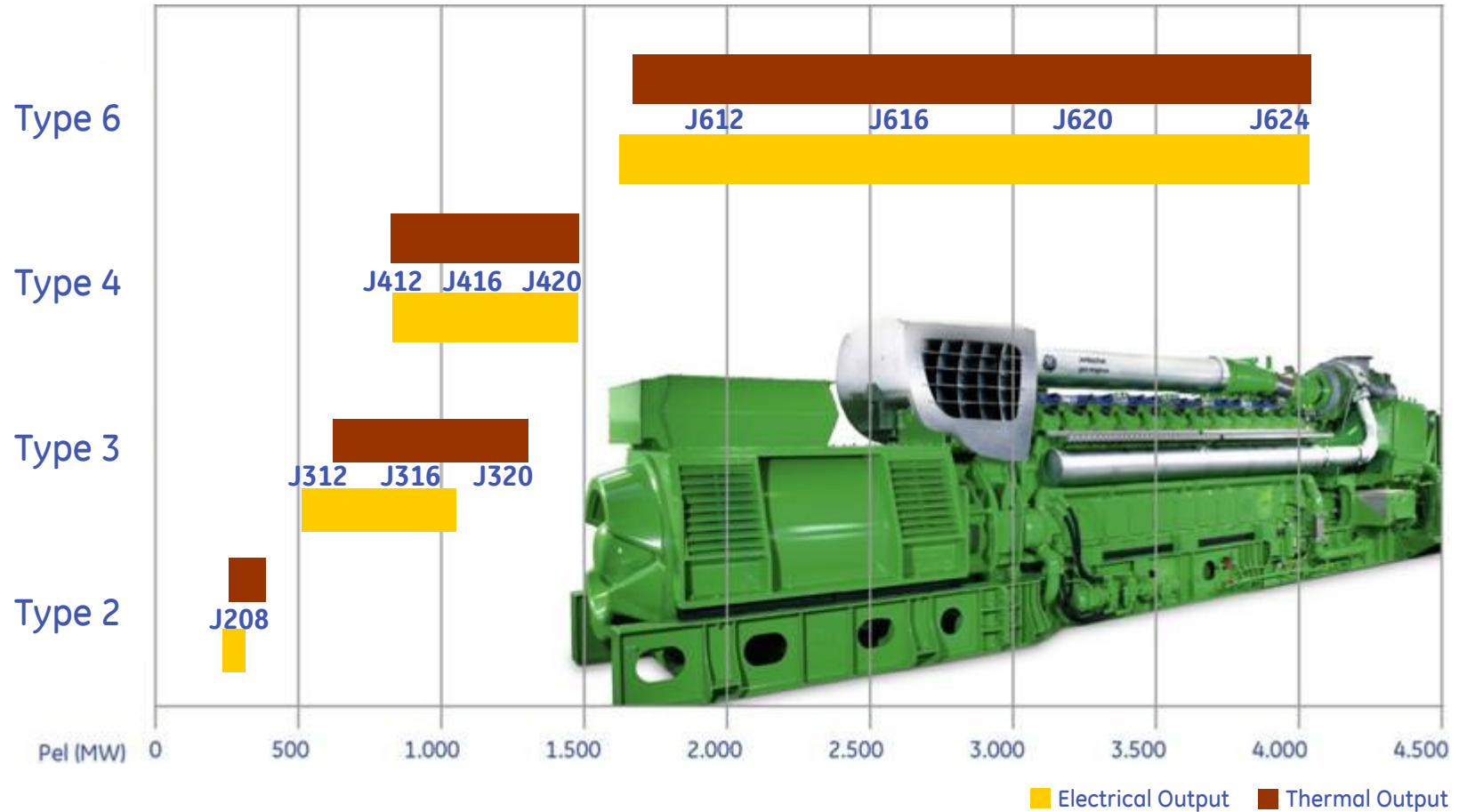


A complying, accurate and easy to maintain carbon meter for monitoring methane mitigation is key for a successful carbon trading

Broad range of mobile/ compact units

Product line 2010 (50Hz) – $\text{NO}_x \leq 500 \text{ mg/m}^3_{\text{N}}$

Electrical Efficiency up to 45% Thermal Efficiency up to 50%



Optimal service solution

- For project owner/ operator of CMG/ LFG ... plant, this is not core business
- Running and maintaining the gas collection system is often already a big challenge
- Site conditions not comparable with Natural Gas plant

>> part load operation

>> flexible, attractive service structure/ contract
(who is doing what depends on specific project landscape)

>> intensive support in commissioning phases

>> regular ASS, responsiveness,

>> regular support emission control/ gas cleaning



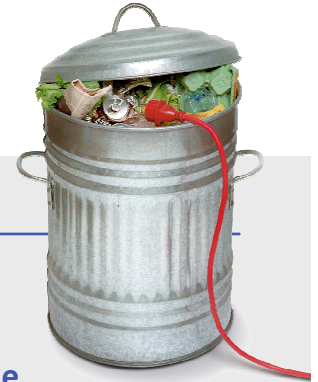
Where do you find information?

>> GE Jenbacher intranet - Webportal

The screenshot shows the GE Jenbacher intranet webportal. At the top, there is a navigation bar with links for 'NO FILTER', 'BIOGAS', 'COAL MINE GAS', 'LANDFILL GAS', 'GREENHOUSE', and 'FLAREGAS'. The GE logo is on the left, and 'Jenbacher gas engines Webportal' is on the right. Below the logo is a search bar and a dropdown menu set to 'Level 110 - Contentmanager'. A 'logout | profile | tell-a-friend | contact | sitemap | help | disclaimer | language' menu is visible. A '» Applications' section contains a search bar and a 'back' button. The main content area features a 'Change Profile' section with a 'know-how >> profile' link and an '» UPDATES' section with a message: 'Here you find a listing of all new entries in the active menu section.' Below this is a 'Categories' section with six items: '» Biogas Biogas' (with a cow image), '» Landfill Gas LFG' (with a landfill image), '» Coal Mine Gas CMG' (with a hand holding coal image), '» Associated Petroleum Gas APG' (with a green plant image), '» Greenhouse' (with a woman holding a red flower image), and '» Steelgas' (with a molecular structure image).

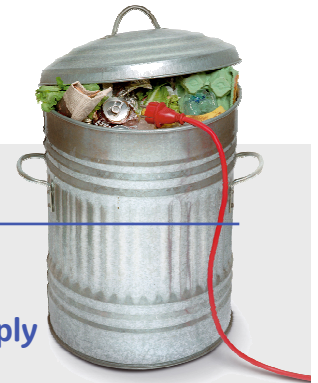
<https://information.jenbacher.com>

LFG special features and support I



Feature	Problem definition	GE's Jenbacher Solution
Solution for low LHV, inert gases	LFG typically has a high share of inert CO ₂ , that complicates an effective combustion.	Our LFG engines can run maximum load also with high CO ₂ fractions typical for this fuel and especially in the traditional European markets. To achieve this GE has developed a special geometry of the combustion chamber and piston head and applies low LHV spark plugs and ignition systems.
Specially designed engines	Many landfills contain sulfur and siloxanes, that can cause severe deposits and other harms to gas engines.	High quality, anti-corrosive engines parts (bearings, valves) robust construction and special scraper rings resist those impurities to a usual extend. Keeping the intercooler temperature above a certain level prevents the sulfur from condensation.
Siloxane Removal		If the siloxanes exceed a certain level, gas cleaning is strongly recommended. The GE in-house siloxane removal system TSA is fully synchronized with Jenbacher engines, lowers O&M costs and also avoids emission drifts in the exhaust gas.
Smooth start and broad LHV range operation	LFG pwill not only short-term fluctuate, but different qualities will appear over the years . Also frequent engine re-starts are necessary.	To ensure a constant smooth operation, up to 4 different gas types can be pre-defined in the <i>DIA.NE</i> control panel. A methane signal tells <i>DIA.NE</i> which program to apply. This controlled combustion avoids excessive thermal and mechanical stress and extends the lifetime of valves, cylinder heads and spark plugs. In addition, the methane signal is used to ease the starting procedure.
Emission control solutions	Since landfills are usually located in the surrounding of big cities, emission standards are becoming more and more rigid in many countries. This applies to limits for NO _x , CO, FMHC and formaldehydes.	To comply with those standards, not only the design and control (see <i>LEANOX</i> principle) of our engines has been optimized. Sometimes also the fuel gas needs to be cleaned to avoid drifts (see siloxane issue) or some exhaust treatment device is needed. Either the TSA in combination with a catalyst could be applied or the siloxane-resistant in-house exhaust treatment system CL.AIR. GE supplies integrated emission control solution tailored towards the specific site conditions, gas quality and emission standards of Jenbacher LFG projects.

LFG special features and support II



Feature	Problem definition	GE's Jenbacher Solution
Support LFG Conditioning	LFG is delivered from the gas suction system with a too low pressure and is also fully saturated with water.	GE specifies the single components needed for the gas conditioning also including parts in its scope of supply if required.
Methane Mitigation Monitoring Support	To acknowledge carbon credits from LFG utilization the carbon developer has to measure the methane mitigation. The suitability of the measuring method is an important part of the PDD and the accuracy of the measuring units is frequently validated. If the general approval or some regular validation fails, revenues from carbon credits can be postponed or even lost.	GE has tested several methane probes and flow meters in a pilot plant. With this knowhow, the Jenbacher team can either support the carbon developer, plant operator or general contractor on how to install the devices for accurate operation and easy maintenance. Note: Monitoring and the project-specific records will always be in the responsibility of the carbon developer.
Modular and easy movable units	Especially on a still active landfill, the amount of collectable LFG is varying a lot over the years. From time to time LFG project owners need to adapt the plant capacity to the gas flow and will also shift gas engines from one plant to some other.	Project owners can choose from a broad output range of containerized LFG engine versions to optimally adjust the installed capacity to the gas flow throughout the project lifetime. The compact design and low specific weight of the modular units makes them easy to be transported.
O&M support	In many cases, the staff at a CMG power plant has only little experience with gas engine operation. Since many plants are located in remote areas, the O&M support from the gas engine supplier becomes difficult, too.	Jenbacher gas engines are easy to maintain with minimum oil consumption and long maintenance intervals. Further, GE and its distributors offer special trainings for less experiences staff, flexible Contractual Service Agreements and various online/remote services.