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
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

<table>
<thead>
<tr>
<th></th>
<th>Ox Mountain LFG</th>
<th>Lier B. LFG</th>
<th>Energy crops Biogas</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH4</td>
<td>41,9</td>
<td>30,8</td>
<td>53,0</td>
</tr>
<tr>
<td>O2</td>
<td>1,2</td>
<td>6,7</td>
<td>0,3</td>
</tr>
<tr>
<td>N2</td>
<td>18,7</td>
<td>36,7</td>
<td>1,1</td>
</tr>
<tr>
<td>CO2</td>
<td>38,2</td>
<td>25,5</td>
<td>45,6</td>
</tr>
<tr>
<td>add. N2</td>
<td>14,2</td>
<td>11,5</td>
<td>0</td>
</tr>
<tr>
<td>CH4/CO2</td>
<td>1,10</td>
<td>1,21</td>
<td>1,16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Hugo Ost, AMM</th>
<th>CMM China</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH4</td>
<td>33,2</td>
<td>25,0</td>
</tr>
<tr>
<td>O2</td>
<td>1,0</td>
<td>14,8</td>
</tr>
<tr>
<td>N2</td>
<td>51,5</td>
<td>58,7</td>
</tr>
<tr>
<td>CO2</td>
<td>14,3</td>
<td>1,5</td>
</tr>
<tr>
<td>add. N2</td>
<td>47,7</td>
<td>2,5</td>
</tr>
<tr>
<td>CH4/CO2</td>
<td>2,32</td>
<td>16,7</td>
</tr>
</tbody>
</table>
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.
Workflow & Basic Design

Customer
- CMG project GEJ
- Data Acquisition
- Inquiry offers
- Plant Operation + Maintenance

GEJ
- Inquiry Support Gas Treatment
- Functional Design / Schema Checklist CMG plant
- Completed Checklist Relevant Data
- Basic Design Specification

Detailed Engineering
- Supply of Components
- Plant Construction

Customer GEJ ComOps
Data Acquisition
Detailed Engineering
Supply of Components
Plant Construction
Fast Changing CH₄ Content

Facts

- CH₄-Concentration is changing faster than 11.5 Vol% / 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

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>PLANT</th>
<th>DATE</th>
<th>CH₄-RANGE</th>
<th>REFERENCE VALUE</th>
<th>Max Δ CH₄ in 30sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>J C555 Oaky Creek JGS320</td>
<td>21.01.2008 - 22.02.2008</td>
<td>81 - 95</td>
<td>96</td>
<td>2</td>
</tr>
<tr>
<td>China</td>
<td>J D448 YangQuan ShentangZui JGS620</td>
<td>01.05.2008 - 29.05.2008</td>
<td>30 - 41</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>Germany</td>
<td>J B321 Grubengas Fenne JMS620</td>
<td>23.06.2008 - 08.07.2008</td>
<td>33 - 70</td>
<td>57</td>
<td>11,5</td>
</tr>
<tr>
<td>Germany</td>
<td>J B475 Grubengas Walsum JGC420</td>
<td>29.04.2008 - 29.05.2008</td>
<td>33 - 53</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Great Britain</td>
<td>J A836 Stillingfleet JGC420</td>
<td>29.04.2008 - 29.05.2008</td>
<td>30 – 55</td>
<td>65</td>
<td>10</td>
</tr>
<tr>
<td>Great Britain</td>
<td>J D703 Stillingfleet 2006 JGS620</td>
<td>27.04.2008 - 29.05.2008</td>
<td>80,5 – 83</td>
<td>65</td>
<td>2,5</td>
</tr>
<tr>
<td>Great Britain</td>
<td>J A839 Maltby JGC420</td>
<td>01.05.2008 - 29.05.2008</td>
<td>26 - 48</td>
<td>36</td>
<td>8</td>
</tr>
<tr>
<td>Great Britain</td>
<td>J A841 Kellingley JGC420</td>
<td>02.05.2008 - 29.05.2208</td>
<td>26 – 50</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Great Britain</td>
<td>J A843 Welbeck JGC420</td>
<td>27.04.2008 - 29.05.2008</td>
<td>25 - 44</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Ukraine</td>
<td>B617 Sasyadko JMS620</td>
<td>02.09.2007 - 04.10.2007</td>
<td>25 - 42</td>
<td>36</td>
<td>12</td>
</tr>
</tbody>
</table>
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)

$\Sigma S < 700 \text{ mg/100% CH}_4$ (without catalyst)
$\Rightarrow$ Standard maintenance schedule

$\Sigma S < 2000 \text{ mg/100% CH}_4$
$\Rightarrow$ „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/NOx 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

- CO < 200 mg/Nm3
- NOx < 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
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) – NO\textsubscript{x} ≤ 500 mg/m\textsuperscript{3} N

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

- **Type 6**
  - J312
  - J316
  - J320

- **Type 4**
  - J412
  - J416
  - J420

- **Type 3**
  - J312
  - J316
  - J320

- **Type 2**
  - J208

Pel (MW) 0 500 1,000 1,500 2,000 2,500 3,000 3,500 4,000 4,500

- Electrical Output
- Thermal Output
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

https://information.jenbacher.com
### LFG special features and support I

<table>
<thead>
<tr>
<th>Feature</th>
<th>Problem definition</th>
<th>GE's Jenbacher Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution for low LHV, inert gases</td>
<td>LFG typically has a high share of inert CO2, that complicates an effective combustion.</td>
<td>Our LFG engines can run maximum load also with high CO2 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.</td>
</tr>
<tr>
<td>Specially designed engines</td>
<td>Many landfills contain sulfur and siloxanes, that can cause severe deposits and other harms to gas engines.</td>
<td>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.</td>
</tr>
<tr>
<td>Siloxane Removal</td>
<td></td>
<td>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&amp;M costs and also avoids emission drifts in the exhaust gas.</td>
</tr>
<tr>
<td>Smooth start and broad LHV range operation</td>
<td>LFG will not only short-term fluctuate, but different qualities will appear over the years. Also frequent engine re-starts are necessary.</td>
<td>To ensure a constant smooth operation, up to 4 different gas types can be pre-defined in the DIA.NE control panel. A methane signal tells DIA.NE 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.</td>
</tr>
<tr>
<td>Emission control solutions</td>
<td>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 NOx, CO, FMHC and formaldehydes.</td>
<td>To comply with those standards, not only the design and control (see LEANOX 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.</td>
</tr>
</tbody>
</table>
### LFG special features and support II

<table>
<thead>
<tr>
<th>Feature</th>
<th>Problem definition</th>
<th>GE’s Jenbacher Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Support LFG Conditioning</strong></td>
<td>LFG is delivered from the gas suction system with a too low pressure and is also fully saturated with water.</td>
<td>GE specifies the single components needed for the gas conditioning also including parts in its scope of supply if required.</td>
</tr>
<tr>
<td><strong>Methane Mitigation Monitoring Support</strong></td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Modular and easy movable units</strong></td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td><strong>O&amp;M support</strong></td>
<td>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&amp;M support from the gas engine supplier becomes difficult, too.</td>
<td>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.</td>
</tr>
</tbody>
</table>