Jenbacher gas engines

“Economic utilization of Biomass and Municipal Waste for power generation.”

Some energy lasts for generations

ecomagination™
a GE commitment

George Ehrenstein at work
GE – facts

• Founded in 1892 by Thomas Edison
• Operations in more than 100 countries
• More than 300,000 employees worldwide; 85,000 in Europe
GE’s portfolio

Energy Infrastructure

Technology Infrastructure

GE Capital

NBC Universal
GE Energy ... power gen platforms

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**Thermal**
- **Gas turbines**
  - Heavy duty (40–500MW)
  - Aeroderivatives (18-100MW)
  - Combined cycle systems
- **Coal**
  - IGCC
  - Steam turbines

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**Nuclear**
- **New Reactors**
- **Nuclear Fuel**
- **Reactor Services**
- **Performance Services**

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**Renewables**
- **Wind**
  - Land based
  - Offshore
- **Solar**
  - Grid connected
  - Stand alone
- **Biomass**
  - Gas engines 0.3-4MW
  - Non natural gas
The Type 6 Gas engine more than 2200 engines since 1989
Jenbacher gas engines

A leading manufacturer of gas-fueled reciprocating engines for power generation

- **Power range:** 0.25MW to 4MW, 4 platforms / 11 products
- **Fuel flexibility:** Natural gas or a variety of renewable or alternative gases
- **Plant configurations:** Generator sets, cogeneration systems, container solutions
- **Delivered engines:** about 8,500 units / 9,800 MW
- **Business:** World wide operations
Headquarters

- Jenbach premises... 1300 employees
  - Production facilities
  - Global Customer support center
  - Repair shop
  - Training center
- Engine assembly in China
- Container assembly in Hungary

- 1,700 world wide employees
- Business in >60 countries
- 8 Subs + Hubs
- >60 ITPs (independent 3rd parties)
5 decades of experience

1957 1st gas engine
1979 1st cogeneration module
1985 1st LEANOX® gas engine
1994 1st 20 cylinder gas engine JW 320
1997 World’s smallest 20 cylinder gas engine in the 3 MW power range
2000 Presentation of “High Efficiency Concept” J420 GS
2003 May: GE acquires Jenbacher
2004 December: 1st Mechanical Drive unit in field operation, Louisiana (US)
2006 Opening of assembly hall 2
2007 World’s 1st 24-cylinder 4 MW engine on test bench (J624)
...but world is changing

Emerging markets
add ~1500 engines ´08-´11

Distributor:
Clarke Orient Orient Clarke misc Power Solutions Navigat

(# of units installed)
Product range

**Gen-Sets**
- On-site generation of electricity
- Base load or peaking
- Island / grid mode

**Container modules**
- Container solutions for type 2, 3, 4 engine
- Gas supply and electricity connectivity needed
- Also as CHP solution

**Cogeneration plant**
(or combined heat & power (CHP) plant)
- produces electricity and heat
- > 90% degree of (total) efficiency
- transform heat from combustion, internal water/oil-circuitry
Jenbacher gas engines core applications

- Landfill gas
- Sewage gas
- Flare gas
- Special gas
- Biogas application
- Greenhouse application
- Coal mine gas
- Natural gas for CHP applications
Advantages of on-site energy supply

Energy supply directly at the load source allows to reduce or avoid transport and distribution losses.

Key features of Jenbacher plants

- High electrical efficiencies of up to 44%
- Overall efficiencies (electrical and thermal) of over 90%
- Minimum NOx-emissions through the patented LEANOX® lean mixture combustion
- Specially designed engines for use of alternative, renewable energy sources and special gases
- Maximum operational safety and availability
- High power density
Biogas

Landfill gas

Sewage gas

Agricultural waste

Organic waste
Biodegradable waste components turn into landfill gas (LFG)

- Landfill gas is created during the decomposition of organic substances under anaerobic conditions

- Landfill gas consists of methane, carbon dioxide, nitrogen and oxygen

- With a calorific value of $4.5 \text{ kWh/m}^3_N$, landfill gas is a high-value fuel for gas engines
Customer-oriented solutions

Landfill gas is captured by wells and turned into energy with Jenbacher gas engines
One J320 gas engine (1 MW) running with LFG reduces annually emissions equivalent to:

- 46,500 tons of CO$_2$
- Emissions of 1,000 cars
- Planting 9,000 acres of forest
- Averting the use of 60,000 light bulbs

=> while producing sufficient energy to provide 2,700 EU homes with electricity
GE is a competent partner for your landfill gas solution

• 25 years of experience in the combustion of landfill gas
• More than 1,300 Jenbacher landfill gas systems worldwide
• About 1,300 MW total electrical output

The Jenbacher product team offers an unparalleled breadth of expertise, references and solution variants.
Biogas – renewable fuel able to substitute fossil fuels

For a wide range of organic substances from agriculture, food waste or food industry anaerobic fermentation is a superior alternative to composting.

Biogas ...

• results from anaerobic digestion of organic materials
• is a mixture of methane and carbon dioxide
• serves as a high-energy, CO2-neutral fuel
Operational conditions of the fermentation process

- **Temperature**
  - mesophile process: 35 - 40°C
  - thermophile process: 50 - 55°C

- **Retention time**
  - minimum 15 days
  - range: 20 - 50 days
  - typical: 25 - 30 days

**Dry matter concentration**
- dry fermentation: 20 - 30%
- wet fermentation: 10 - 15%

- Absence of oxygen
- pH value from 6.5 to 7.5

**Gas composition:**
- 50 – 70% methane (CH4)
- 30 – 50% carbon dioxide (CO2)
Biogas yields of 1t suitable organic materials

<table>
<thead>
<tr>
<th>Kind of material</th>
<th>%DM</th>
<th>Biogas [Nm³/t]</th>
<th>El. Energy [kWh/t]</th>
<th>El. Output [kW*/1000t]</th>
<th>Residue after fermentation [t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat &amp; Bone meal</td>
<td>90</td>
<td>860</td>
<td>2200</td>
<td>268,3</td>
<td>0,3</td>
</tr>
<tr>
<td>Oil-seeds residues</td>
<td>90</td>
<td>600</td>
<td>1443</td>
<td>176,0</td>
<td>0,4</td>
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<tr>
<td>Corn (grain)</td>
<td>73</td>
<td>525</td>
<td>1030</td>
<td>125,6</td>
<td>0,48</td>
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<tr>
<td>Waste bread</td>
<td>70</td>
<td>500</td>
<td>925</td>
<td>112,8</td>
<td>0,5</td>
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<tr>
<td>Slaughterhouse waste (innards)</td>
<td>30</td>
<td>320</td>
<td>770</td>
<td>93,9</td>
<td>0,77</td>
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<tr>
<td>Grease trap residues</td>
<td>25</td>
<td>250</td>
<td>640</td>
<td>78,0</td>
<td>0,82</td>
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<tr>
<td>Corn silage</td>
<td>40</td>
<td>260</td>
<td>510</td>
<td>62,2</td>
<td>0,74</td>
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<tr>
<td>Food waste</td>
<td>18</td>
<td>180</td>
<td>450</td>
<td>54,9</td>
<td>0,87</td>
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<tr>
<td>Pomace (vine)</td>
<td>40</td>
<td>180</td>
<td>430</td>
<td>52,4</td>
<td>0,8</td>
</tr>
<tr>
<td>Grass silage</td>
<td>33</td>
<td>200</td>
<td>384</td>
<td>46,8</td>
<td>0,8</td>
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<tr>
<td>Flotate (slaughter house)</td>
<td>15</td>
<td>145</td>
<td>375</td>
<td>45,7</td>
<td>0,87</td>
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<tr>
<td>Blood</td>
<td>20</td>
<td>140</td>
<td>336</td>
<td>41,0</td>
<td>0,86</td>
</tr>
<tr>
<td>Organic waste</td>
<td>30</td>
<td>120</td>
<td>290</td>
<td>35,4</td>
<td>0,85</td>
</tr>
<tr>
<td>Chicken Manure</td>
<td>25</td>
<td>100</td>
<td>240</td>
<td>30,0</td>
<td>0,95</td>
</tr>
<tr>
<td>Draff (beer)</td>
<td>20</td>
<td>75</td>
<td>185</td>
<td>22,6</td>
<td>0,93</td>
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<tr>
<td>Vegetable residues</td>
<td>12</td>
<td>70</td>
<td>174</td>
<td>21,2</td>
<td>0,91</td>
</tr>
<tr>
<td>Vinasses (sugar)</td>
<td>65</td>
<td>150</td>
<td>120</td>
<td>14,6</td>
<td>0,85</td>
</tr>
<tr>
<td>Whey (dairy)</td>
<td>2</td>
<td>25</td>
<td>60</td>
<td>7,3</td>
<td>0,98</td>
</tr>
<tr>
<td>Cow manure</td>
<td>8</td>
<td>40</td>
<td>80</td>
<td>6,6</td>
<td>0,98</td>
</tr>
<tr>
<td>Pig manure</td>
<td>6</td>
<td>21</td>
<td>50</td>
<td>6,1</td>
<td>0,98</td>
</tr>
<tr>
<td>Distiller's wash</td>
<td>4</td>
<td>19</td>
<td>47</td>
<td>5,7</td>
<td>0,98</td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>4,4</td>
<td>14</td>
<td>32</td>
<td>3,9</td>
<td>0,98</td>
</tr>
</tbody>
</table>

* Based on 8, 200 op.hrs/a ; Source: AAT
Energy potential of biomass

1 JMS 312 GS-B.L with **500 kWel**
can be fueled by manure of:

- **3,600** dairy cows
- **14,000** feeding pigs
- **700,000** laying hens or chickens

Or biogas generated from:
- **250 ha** cultivated corn
- **20,000 tons/a** of organic household waste
GE’s Jenbacher gas engine business offers customized biogas solutions

Jenbacher biogas-cogeneration units are core part of biogas plant, but enhanced digester-technology

(in case of food waste)
GE is a competent partner for your biogas solutions

- more than 1,450 Jenbacher biogas systems worldwide
- over 985 MW total electrical output

Jenbacher cogeneration technology fueled with biogas enables maximum economic and ecological benefits.
Biogas

Market dynamics
Comparison of investment costs by type of power plants in Austria

Specific investment costs in 1,000 € / kWel

- Photovoltaic: ~ € 20,000.-
- Hydropower: ~ € 20,000.-
- Windpower: ~ € 500.-
- Gas/Steam turbine: ~ € 500.-
- Condenser plant: ~ € 500.-
- Jenbacher CHP: ~ € 500.-
Development of Biogas in Germany

EEG in Germany

- Long-time tariff-guarantee (currently 0.19 €/kWh) for operators of Eco-power-plants (20 years)
- Fair tariffs including index-adaptation
- Obligation to buy eco-power
- Criteria for Energy Efficiency and Innovation bonus

EEG as Job engine in Germany

- **134,000 Jobs** are directly related to the EEG
- German Suppliers play key role internationally

Germany’s biogas plants deliver decentralized energy at the volume of large thermal power plant
Biomass Digestion:

Investment costs – based on European figures:

European spec. investment for biogas plant
- 500 kWel. plant – approx. 3,000 – 3,500 € per kW
- 1000 kWel. Plant - approx. 2,300 – 2,800 € per kW

Cost of Asian biogas plants are significantly lower (~-40%)
Biomass Digestion:

Initial cost of electricity – € Cent/kWhel:
- assumption – University Leipzig 2003 - for Germany:
  - 8000 operation hours per year
  - 12 years

<table>
<thead>
<tr>
<th>Biomass</th>
<th>330KW</th>
<th>1000KW</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% manure</td>
<td>~ 10</td>
<td>~ 8</td>
</tr>
<tr>
<td>2/3 energy crops</td>
<td>~ 16</td>
<td>~ 13</td>
</tr>
<tr>
<td>(Corn silage cost: 30 €/t)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Calculation – for Asia:
- 8000 operation hours per year
- 10 years

<table>
<thead>
<tr>
<th>Biomass</th>
<th>500KW</th>
</tr>
</thead>
<tbody>
<tr>
<td>palm oil mill effluent</td>
<td>~ 4-6</td>
</tr>
</tbody>
</table>

Summary – Biogas in CHP

- **Biogas** plants are operated – weather independent – for base load supply
- **Biogas** plants can be seen as **state-of-the-art technology**
- Because of low energetic density of source materials, **biogas** should be used **decentralized**
- Using biogas in **CHP-modules** generates **highest GHG-savings**
Reference Sites
Biogas plant – Bösch Herisau - Switzerland:

Biomass: up to 40,000 to/a:
- manure from pigs
- waste from slaughter houses
- food waste

Used biomass will be dehydrated – reduce amount to 25% - sold as fertilizer

1 x JGS 320 GS-B.L.C

Power output: 1064 kWel.
Landfill gas plant Busan, Korea

No. of units and engine type: 6 x JGC 320 GS-L.L
Fuel: Landfill gas
Electrical output: 6,348 kW
Commissioning: May 2003
Puchong Landfill, Malaysia

Fuel: Landfill gas
Engine type: 2 x JGC 320 GS-L.L with Electrical output: 1,064 kW
Commissioning: 2004
Foodwaste plant Busan, Korea

No. of units and engine type: 2 x JGS 320 GS-B.L
Fuel: Bio gas from Foodwaste
Electrical output: 1,116 kW
Commissioning: January 2005
Biogas plant DeQingYuan, China

No. of units and engine type: 2 x JMS 320 GS-B.L
Fuel: Biogas from Chicken Dung (3 Mio chicken)
Electrical output: 2126 kW
Thermal output: 1234 kW
Commissioning: Sept 2008
Cow manure biogas plant in Ludhiana/India

Biomass Input: 235 ton/day cattle manure
Electrical output: 1 MW
Organic fertilizer: 35 ton/day

No. of units and engine type: 1 x JMC 320 GS-B.L
AD of biomass – Kanoria I + II - India:

Biomass:
Spent wash – 675 m³/d
-> effluent removed after fermenting sugar cane molasses (ethanol production)

1 x JMS 320 GS-B.L
1 x JMS 420 GS-N/B.L

Power output:
1034 kWel. / 1416 kWel.

Thermal output:
Water: 586 kWth. / 748 kWth.
Steam: ~ 1350 kg/h; 10bar
Commissioning: 1998 / 2003
AD of biomass – Natural palm Oil - Thailand

Biomass:
- POME - palm oil mill effluent

Basic conditions:
- 12m3/h PMOE
- Temperature of PMOE fresh from mill 80°C -> cooling-down in open lagoon

1 x JGS 320 GS-B.L.C

Power output: 1064 kWel.
Commissioning: 2005
Lets put hands together for GROWTH!

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