ECONOMIZER SE – patented solution for hydrolysing woody cellulose-rich biomass
1. Biogas Systems GmbH
   motivation, people, history, references

2. How the technology works
   video, process flow diagram, mass balance

3. Advantages for the customer
   commercial, technical
Our technology solves fundamental challenges facing the biogas industry

**Problem**
- Feedstock costs
- Gas yield and feedstock flexibility
- CAPEX for new build and/or repowering

**Solution**
- The ECONOMIZER SE allows the use of all waste products and residues (e.g. straw, manure) with a gas yield of up to 350 Nl CH4/kg oDS and significantly reduces costs by >50%
- Different feedstocks are broken up via technical hydrolysis into homogenous constituent components.
- Significant CAPEX savings due to halving the fermenter retention time as well as the size of feedstock storage capacity

80% of biogas in Germany is produced from maize silage (food or fuel) and feedstock is the biggest cost factor.

Fermentation of feedstock is incomplete and changing feedstock leads to problems with fermentation.

Fermenter volume and silage clamp capacity are major CAPEX factors for new build or repowering.
Company History

2010-2011
- Company founded by Leinich (investor), Dauser and Nussbaumer
- Setting up an experienced interdisciplinary core team
- Initial patents, trademarks
- Completion of first down-scaled prototype (1:10 scale)
- Acquisition of Parndorf biogas plant as demonstration site

2012-2015
- Patents awarded
- Construction of full-scale ECONOMIZER SE
- Live operations, proof of concept since 2014
- Continuous operations with ongoing optimization

Since Q2 2015
- Start of sales activities (expanding team, trade fairs)
- Signed sales partnership for the UK with Future Biogas (Q1/2016)
### Biogas Systems GmbH

#### Reference clients

<table>
<thead>
<tr>
<th>Waste Water</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesco (Polen)</td>
<td>RWE</td>
</tr>
<tr>
<td>Beiersdorf Chemie</td>
<td>Torrent Power (India)</td>
</tr>
<tr>
<td>Unilever</td>
<td>Shell</td>
</tr>
<tr>
<td>Lonza AG</td>
<td>Electrabel</td>
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<tr>
<td>Rauch Fruchtsäfte</td>
<td>Al Ain Municipality (Abu Dhabi)</td>
</tr>
<tr>
<td>11er Nahrungsmittel</td>
<td>ADNOC (Abu Dhabi nat. oil company)</td>
</tr>
<tr>
<td>Brigl &amp; Bergmeister</td>
<td></td>
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<tr>
<td>ADSSC (Abu Dhabi state service company)</td>
<td></td>
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<tr>
<td>Makro C&amp;C (Polen)</td>
<td></td>
</tr>
</tbody>
</table>
1. Biogas Systems GmbH
   motivation, people, history, references

2. How the technology works
   video, process flow diagram, mass balance

3. Advantages for the customer
   commercial, technical
Process flow diagram
Main components

- Receiving tank
- Hydrolyser
- Feed tank
- Expander
- Pipe for steam recycling
- Feed from feeder box
- Pre-conditioning
- Feed into fermenter
Process flow diagram
Process steps

1. Wetting & feeding
2. Flash steam recycling
3. Filling feed tank
4. Thermal Pressure hydrolysis
5. Steam Explosion
6. Cooling
1. Biogas Systems GmbH
motivation, people, history, references

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video, process flow diagram, mass balance

3. Advantages for the customer
commercial, technical
## Advantages for the customer (1)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefits and advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Technology was developed through pilot- to current full-scale</td>
<td>Delivers optimum operational results with a real biogas plant.</td>
</tr>
<tr>
<td>Economizer SE over 5 years.</td>
<td>Fit for purpose practical solution.</td>
</tr>
<tr>
<td>Optimization and operation with own 500 kW biogas plant.</td>
<td></td>
</tr>
<tr>
<td>2 Technology development was supported by an internationally</td>
<td>Scientific understanding of process development/optimization.</td>
</tr>
<tr>
<td>acclaimed research institute.</td>
<td>Improved biogas production as a result.</td>
</tr>
<tr>
<td></td>
<td>Results scientifically verified over many years.</td>
</tr>
<tr>
<td></td>
<td>Bankable solution.</td>
</tr>
<tr>
<td>3 High quality industrial components, little wear and tear.</td>
<td>The technology is built to last. Low OPEX technology.</td>
</tr>
<tr>
<td>4 No chemicals, enzymes, additives</td>
<td>Low OPEX technology.</td>
</tr>
</tbody>
</table>
## Advantages for the customer (2)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefits and advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>5  Single technological solution for all input materials.</td>
<td>Works with varying quantities, quality and feedstock.</td>
</tr>
<tr>
<td>Easy to operate, adjust.</td>
<td>Flexible solution.</td>
</tr>
<tr>
<td>6  Core technology is standardized, containerized.</td>
<td>Quick design and planning phase. Quick installation and commissioning phase.</td>
</tr>
<tr>
<td>Quick design and planning phase. Quick installation and commissioning phase.</td>
<td>Reduces CAPEX, quicker payback.</td>
</tr>
<tr>
<td>7  Fully automated technology.</td>
<td>Simple management and remote diagnosis of operational status. Low OPEX technology.</td>
</tr>
<tr>
<td>8  No narrow feed piping or sensitive pumps etc.</td>
<td>Particles &lt; 60mm are no problem.</td>
</tr>
<tr>
<td>Particles &gt; 60mm can easily be removed.</td>
<td>Robust technology.</td>
</tr>
<tr>
<td>9  Heat recovery. Heat from previous batch is used to pre-heat the feedstock for the next batch.</td>
<td>Lower heat requirement, heat demand peaks are flattened. Low OPEX technology.</td>
</tr>
<tr>
<td>10 Main process energy is exhaust heat.</td>
<td>Low OPEX technology.</td>
</tr>
</tbody>
</table>
### Improved methane yield

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Methane yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nm³ CH₄/ tonne organic dry solids</td>
</tr>
<tr>
<td>Untreated maize silage</td>
<td>338</td>
</tr>
<tr>
<td>Reed</td>
<td>Up to 400</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>Up to 350</td>
</tr>
<tr>
<td>Maize straw</td>
<td>325</td>
</tr>
<tr>
<td>Poultry manure with straw</td>
<td>325</td>
</tr>
<tr>
<td>Horse manure</td>
<td>325</td>
</tr>
<tr>
<td>Cattle/pig manure</td>
<td>325</td>
</tr>
<tr>
<td>Biogas seprated digestate</td>
<td>250</td>
</tr>
</tbody>
</table>
Substrates processed
Wheat straw

350 Nm³ methane per tonne organic dry solids
335 Nm³ methane per tonne organic dry solids
Substrates processed
Pig manure

296 Nm³ methane per tonne organic dry solids
Substrates processed
Digestate solid fraction

245 Nm³ methane per tonne organic dry solids
Electron microscope picture of straw before steam explosion

Width of whole picture = 1 mm
Electron microscope picture of straw after steam explosion

Width of whole picture = 1 mm
Example business case (CAPEX)
1 MW Biogas plant using mainly straw

General observations
• Biogas Systems is supplier of Economizer SE technology.
• Optional supply: System for automatically shredding and feeding straw.
• Biogas Systems do NOT build biogas plants.
• Economizer SE Technology allows you to reduce costs in the biogas plant.
• Overall complete system investment costs are not significantly higher.

Biogas plant CAPEX cost savings
• Max 2,700 m³ fermenter volume required (30% of usual volume)
• No silage clamp/covering/drainage costs since no silage.
• No digestate separation required.
• Less digestate storage required since no manure/slurry.
• Less or no biogas plant heating required. Mixing is easier.
• Feeder box can be replaced by automatic crane and shredder.
Example business case (OPEX)
1 MW Biogas plant using mainly straw

Example business case with largest ECONOMIZER SE module (2,5)
Size of biogas plant / kW electric: 1,000 kW gross electricity export

Substrate related operational costs
- 7,000 tonnes p.a. straw (assuming 90% dry solids), chopped to < 50 mm
- 14,000 m³ „water“ (should be dirty water, not clean, low dry solids)
- Ca. 1,000 to 2,000 tonnes p.a. chicken manure: Amount depends on:
  - 1: % dry matter of chicken manure and 2: quality of straw

Other operational costs
- Minimal quantity of spare parts, few wear and tear components.
- Minimal labour requirement
- No chemicals, no enzymes
- CHP high temperature heat (heat produced >> heat required)
- Electricity (36 kWel)
Additional slides
Mass and energy balance
Why invest in an Economizer SE?
The future of biogas

1. 12.5 Mio. t.p.a. unused straw in Germany
   • Pre-treatment with Economizer SE: additional + 1,500 MWel

2. 32 Mio. t.p.a. of manure
   • 80% not used for biogas generation
   • Pre-treatment with Economizer SE: additional + 950 MWel

3. 900,000 ha used to grow maize silage in Germany
   • Used to grow grain instead of silage
   • Pre-treatment of straw with Economizer SE: -1,250 MWel less

Summary of all scenarios:
• No maize silage needed for biogas plants (3)
• 1,200 MWel additional capacity from biogas generation
• Lowered costs for feedstock (1+2+3)
• 6.3 Mio. t.p.a of grain grown (market value € 0.9 Bio p.a.) (3)
One product, many value generation paths

**Lignocellulosic waste materials**
- Cereal straw (from maize, wheat, rice)
- Manure (from poultry, pig, cattle, horse)
- Wood waste (chips, brash, twigs)
- Food production residues (mushroom compost, chaff, peel)
- Grasses (reed, miscanthus, hay)
- Food processing waste (bagasse, spent grains, pomace)
- Green/brown waste (clippings, cuttings, compostables)
- Biogas plant solid digestate

**Waste treatment**
- Avoidance/reduction of smell
- Avoidance of pollution due to straw burning.
- Sterilization/pathogen kill

**Energy generation**
- High energy feedstock for biogas plants
- Biogas
- Biomethane, Bio-CNG, Bio-LNG
- Bio LCO₂

**After further post-treatment processes**
- Extraction of lignin
- Extraction of cellulose/hemi-cellulose
Low operating costs

Data apply for the ECONOMIZER SE 2.5 model

Electricity requirement
- Installed power: $32 \text{ kW}_{el}$
- Electricity requirement: $26 \text{ kWh}_{el}/\text{hour}$
  $617 \text{ kWh}_{el}/\text{day}$
- Equal to 2.6% of 1,000 kW

Heat requirement
- Heat requirement: between $260 \text{ kWh}_{th}$ and $280 \text{ kWh}_{th}/\text{hour}$
- Heat supplied from exhaust gas heat exchanger

Water requirement
- Feedstock mix should be max. 30% dry solids

Labour requirement
- ca. 1,000 hours p.a.

Service package
- € 25,000 p.a.

Chemicals/Enzymes
- € 0 p.a.

Footprint
- for the container: 3m x 14m (plus feeder box)
- Thermo oil plant: 3m x 7m
Sustainability

1. Investing in the Economizer SE technology means that Maize Silage is no longer required as a biogas feedstock

2. Straw no longer needs to be
   - ploughed in to the ground after the grain harvest
   - composted in the soil (soil nitrogen)
   - burned (reduced air pollution)

3. Straw or other lignocellulosic waste inputs are pathogen-free after treatment.

4. Digestate is practically fibre-free, containing lignin and macro-nutrients (N-P-K).
Other benefits

1. Higher feed in tariffs due to
   • alternative feedstocks
   • Additional heat use
2. Allows arable land to be used for growing wheat for grain instead of energy crops
3. Sustainability criteria concerning limiting energy crops are fulfilled.
4. Since energy crops are not used
   • No silage clamps need to be built
   • No leachate or odours produced
5. Lower requirement for water/recirculation and feedstock
   • \( \rightarrow \) lower retention time
   • \( \rightarrow \) smaller fermenters
6. Biogas plant can become multi-feedstock: dependency on one kind of feedstock is reduced.