Large Biogas Plants in Denmark
-technology and operation experience

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Agenda

• NIRAS
• Large Biogas Plants in Denmark
• Large Biogas Plants concept and tour
• Input materials and gas production
• Economy
NIRAS Background

- Multi disciplinary Consultancy
- Since 1956
- 700 Employees, 2/3 hold academic degrees
Biogas Experience in NIRAS

- Biogas Consultancy for 20 years
- Total 8 joint plants built in DK
- International activities
- Danish operations, upgrading and planning consultancy
- R&D Activities
  - Digestion of Grass
  - Restaurant waste
  - Odor control
  - Process control
  - Reject water handling
  - Pre-treatment
Biogas Concept

Anaerobic treatment = Biogas production
History of Biogas in DK

- **Oil crises** (1970): Farm based
  - First combined heat and power plant
- **Groundwater protection** (1980): Co-digestion
  - First Joint Plant
- **Greenhouse gas** (1990): Commercialization
  - 20 centralised plants in Denmark
- **Sophistication** (2000):
  - Global trend
Biogas Plants in operation

m³ biomass processed at:
Large plants 2002
  Animal manure  1,105,000
  Organic waste  375,000
  Total          1,480,000
Farm Plants    300,000
New projects app. 15
Snertinge Biogas Plant

Legend
1. Reception hall
2. Hygienisation of organic waste
3. Pre-storage tanks
4. Digester tanks
5. After-storage tank
6. Separator
7. Gas storage
8. Engine
9. Office building and workshop
Waste Collection

- Tankers
  - 20 m³
  - 30 m³
- Tippers
- Pipeline
- Average distance to plant
- Emptying cycle
Pre-Treatment: Hygienisation / sterilization

- Hygienic step if recycling nutrients
- Separate unit to guarantee of retention time
- Elimination of pathogens and weeds
Digesters

• Steel or concrete tanks
• Insulated
• Processes
  – mesophilic
  – thermophilic
After Storage

- Second digester
- Buffer for return of digestate or
- Buffer before after-treatment
After treatment: e.g. separation

- Separation in solid and liquid fraction
- Different technologies
- Centrifuge
  - Solid fraction 12%
  - Liquid fraction 88%
3.4.4 Solids Fraction

- Will contain most phosphorus
- Dry matter content up to 30%
Fluid fraction - post treatment

- Various technologies can separate the liquid fraction into:
  - Concentrated nutrients
  - Reject water
3.2.9 Gas Storage

- Equalize gas production
- Max for 24 hours storage
- Size depends on utilization of gas
3.4.1 Gas Treatment

- Gas contains H₂S
- Can be removed biologically in
  - after storage
  - gas cleaning unit
3.4.2 Gas Utilization

- Boilers
- Internal Combustion Engines
- Gas turbines
- CHP applications
- Fuel Cells
Input material

- Pre-conditions
- Gas potential (CH$_4$ = methan)
- Dry matter in manure
- Example of input from 7 plants
Pre-conditions

In principal all organic wastes that are:

- Free of substances that inhibit the biogas process
- Suitable DM content
- Free of environmental toxic substances
- Sufficient biogas production
**CH₄ production and DM%**

- Pig slurry

**Graph:**

Gas production for various DM contents in pig manure

- **X-axis:** DM% (3.0% to 9.0%)
- **Y-axis:** m³ CH₄ / m³ input (3, 5, 7, 9, 11, 13, 15)

The graph shows the relationship between DM content and CH₄ production in pig manure, indicating higher CH₄ production with increased DM content.
## Operational journal

### Driftsstatus for december 2003

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasproduktion</td>
<td>638.000 Nm³</td>
</tr>
<tr>
<td>Elproduktion</td>
<td>1.450.000 kWh</td>
</tr>
<tr>
<td>Energisalg</td>
<td>1.204.864 kr.</td>
</tr>
</tbody>
</table>

### Biomasse

<table>
<thead>
<tr>
<th>Biomasse</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Kvægylle</td>
<td></td>
<td>5518 tons</td>
</tr>
<tr>
<td>Svineylle</td>
<td></td>
<td>4201 tons</td>
</tr>
<tr>
<td>Minkylle</td>
<td></td>
<td>32 tons</td>
</tr>
<tr>
<td>Fast gødning, kvæg</td>
<td></td>
<td>96 tons</td>
</tr>
<tr>
<td>Fast gødning, svin</td>
<td></td>
<td>12 tons</td>
</tr>
<tr>
<td>Fast gødning, mink/fjærkræ/hest</td>
<td></td>
<td>0 tons</td>
</tr>
<tr>
<td>Mævedamindhold fra slagteri</td>
<td></td>
<td>1103 tons</td>
</tr>
<tr>
<td>Føde- og flottationsslam fra slagteri</td>
<td></td>
<td>8 tons</td>
</tr>
<tr>
<td>Vallevallekoncentrat</td>
<td></td>
<td>2556 tons</td>
</tr>
<tr>
<td>Riskeleam</td>
<td></td>
<td>95 tons</td>
</tr>
<tr>
<td>Diverse industriaffald (fød.)</td>
<td></td>
<td>139 tons</td>
</tr>
<tr>
<td>Limløder</td>
<td></td>
<td>30 tons</td>
</tr>
<tr>
<td>Minkfoder spildevand</td>
<td></td>
<td>0 tons</td>
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<tr>
<td>Slam, minkfoderproduktion</td>
<td></td>
<td>160 tons</td>
</tr>
<tr>
<td>Protein/fiberslam</td>
<td></td>
<td>0 tons</td>
</tr>
<tr>
<td>Flottationsslam, fjærkranlagteri</td>
<td></td>
<td>630 tons</td>
</tr>
<tr>
<td>Slam, Førsingaenlæg</td>
<td></td>
<td>334 tons</td>
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### Gasudbytte

<table>
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<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>I forhold til biomassen</td>
<td>45,1 Nm³/m³ biomasse</td>
</tr>
<tr>
<td>I forhold til 7000m³ anlægsvol.</td>
<td>2,9 Nm³/(m³ x dag)</td>
</tr>
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### Varmeforbrug

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>I alt</td>
<td>139,0 MWh</td>
</tr>
<tr>
<td>Nettoproværmning af biomassen</td>
<td>8,5 °C</td>
</tr>
</tbody>
</table>

### El-forbrug

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>I alt</td>
<td>109,0 MWh</td>
</tr>
<tr>
<td>Pr. m² udrådnet biomasse</td>
<td>7,7 KW/h/m²</td>
</tr>
</tbody>
</table>

### Dieselforbrug

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>I alt</td>
<td>112,0 MWh</td>
</tr>
</tbody>
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### Supplerende oplysninger

Driften har været stabil i december måned.
Input composition 2001

Input composition in Danish biogas plants 2001

- Other industrial waste
- Conc. Fat waste (>60%)
- Medicinal ind. other
- Medicinal ind., mucosa
- Tannery waste
- Oil mill, bleach soil
- Pektin sludge
- Dairy waste
- Backery waste
- Fish waste flotation sludge
- Residues fodder production
- Fat/floataion sludge
- Stomach content - slaughter house
- Other manure
- Pig manure
- Cow manure
Economy: Income

- Gate fees
  - Gate fees for organic waste
- Biogas
  - Electricity sale
  - Heat sale
- ? Fertiliser
Economy: Capital cost

![Capital cost, plant graph](image)
Economy: Running cost

Running cost

![Graph showing running cost vs. m3/year](image)
Trends in Denmark

- Increased gas production (~25%) per unit received material
- Increased reduction of solids
- Pre-treatment: Sterilisation at 70 and 133 °C
- Reduced retention time (4-6 days termo-, 7-10 days mesophilic)
- Physical layout: 2 parallel lines, fewer pumps and moving parts
- Process monitoring and management
- Reduced capital cost
Land application/ after-treatment

- Direct application to field
- After treatment - separation
- After treatment - upgrading
Fertiliser effect

- Nitrogen uptake increased from 40 to >70%
- Phosphorous increased from ~30 to > 60 %
- Substitutes chemical fertiliser - adds organic matter to the soil
- Nutrients are recycled to land
THANK YOU!

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