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BIOGAS in DENMARK

State of the art and rapid developments
- From 2008 and onwards!

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## Energy production from biogas in Denmark

<table>
<thead>
<tr>
<th>Unit: PJ per year</th>
<th>Potential</th>
<th>Production 2001</th>
<th>Production 2002</th>
<th>Production 2003</th>
<th>Production 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal manure</td>
<td>26.0</td>
<td>0.61</td>
<td>0.70</td>
<td>0.85</td>
<td>0.91</td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>4.0</td>
<td>0.86</td>
<td>0.87</td>
<td>0.87</td>
<td>0.83</td>
</tr>
<tr>
<td>Industrial waste</td>
<td>2.5</td>
<td>0.59</td>
<td>0.67</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td>Industrial waste, imported</td>
<td>-</td>
<td>0.40</td>
<td>0.45</td>
<td>0.55</td>
<td>0.65</td>
</tr>
<tr>
<td>Meat and bone meal</td>
<td>2.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Household waste</td>
<td>2.5</td>
<td>0.03</td>
<td>0.05</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>Green waste/garden waste</td>
<td>1.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>1.0</td>
<td>0.56</td>
<td>0.62</td>
<td>0.44</td>
<td>0.46</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>3.05</td>
<td>3.58</td>
<td>3.58</td>
<td>3.74</td>
</tr>
</tbody>
</table>

Source:

Multifunctional technology

**Societal incentives**
- GHG reduction
- Aquatic environment
- Life quality (odour)
- Pathogen reduction
- Energy security
- Biomass utilisation

**Farmers incentives**
- Income and survival
- Environmental legislation

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Danish Biogas Association

Centralised • Farmscale • Projects
25 years of Danish biogas experience

Manure - from a farmers problems to an opportunity for the whole society
Development manure-based plants

Biogas production 1990 - 2006

Government
January 19 2007:
Biogas production to be tripled before 2025

Danish Biogas Association
Renewed priority to biogas
as specified in the 21st of February 2008 political agreement

- Substantially improved feed-in tariff for electricity. All biogas plants will now receive a total of **DKK 0.745 per kWh** (or an additional payment of DKK 0.405 per kWh when biogas is used together with natural gas). The tariff will be adjusted annually with 60% of the price index increase.

- As indicative objective biogas is expected to grow from presently 4 to 10 PJ or more by 2020. The increase is equal to the production from 50 centralised biogas plants or 4 new plants per year until 2020. In reality existing plants will expand in parallel with new plants being built.
How big can biogas become?

- At present biogas contributes 4 PJ or ½ % of Denmarks energy consumption.
- 10 PJ in 2020 equals 1,2 % when gross consumption is reduced by 4 %.
- The total Danish resources suitable for biogas production could produce 40 PJ per year ~ 5 % of present gross consumption.
- Time will show... if we’ll be successful ... and if additional resources such as energy crops or even sea weeds end up being financially realistic.
Costs, DDK per m³ methane

A: Natural gas price
B: Biogas send by separate pipeline to CHP
C: Biogas upgraded and injected into the grid

Natural gas approx. costs about DKK 2 per m³ methane.

Production of biogas approx. costs DKK 3 per m³ methane.

Transporting biogas by separate pipeline to a CHP station has a typical cost of DKK 0,1 per m³ methane.

Upgrading and Injecting Into the natural gas grid has a cost of approx. DKK 1,5 per m³ methane.
From Centralised to Decentralised CHP

Centralized production in the mid 80's

Decentralized production of today

Legend:
- Decentralized CHP
- Centralized CHP
- Wind mills

CHP = Combined Heat and Power generation
Agricultural and environmental advantages

- Improved fertilizer value
- Full declaration of nutrients
- Free from germs and seeds
- Reduced costs for transportation of slurry
- Reduced nitrate leaching
- Reduced odour problems
- Reduced green house gas emission
- Controlled recycling of organic waste
Actual incentives for establishment of new plants:

- New legislation and price conditions in place

- Socio-economic advantages of biogas production

- Fulfilment of environmental tasks
  - cheap tool for reduction of CO2 emissions (40 DKK/tons CO2)
  - 90 kg CO2 EQ. / t biomass treated

- Agricultural benefits
  - cheap slurry storage
  - less transport
  - less odours and flies at application and around the storage tanks
  - less CH4 emissions from treated manure - biofertilizer
  - cheap redistribution of slurry (centralised co-digestion)
  - sanitation and pathogens control
  - NPK declaration
  - high N-utilisation and less N-leaching
  - possibility of separation
Green House Gas emission, with and without biogas production

![Graph showing CH4 and N2O emission, CO2 eqv. per Livestock unit for Pig and Cattle with and without biogas production.](image)
Biogas and slurry separation

Digestate

Fibre fraction

Decanter

Liquid fraction

70 % of total P
25 % of total N, organic compounds
15 % of initial volume

75 % of total N, mainly as ammonia

Still no big market exists for fibre fraction. Costs of drying (50 eur/T) exceed nutrient value of fibres. Heavy metals content could be a problem; removal expensive!

Incineration seen like the only alternative; Documentation and approvals needed, moving market
20 centralized biogas plant in operation
Capacity: 50-600 m³ slurry per day

Thorsø Centralized Biogas Plant
55 single-farm biogas plants in operation

Capacity: 5-50 m³ slurry per day

Orø Single-farm Biogas Plant
N-application in Denmark
Future Danish development

- Biogas and separation
  - Removal of excess of nutrients
- Less reliant on waste
  - Higher manure share
  - Liquid slurry and fibre
  - Biomass from natural habitats
- Organic biogas plants
  - Self supply in nutrients
  - Self supply in energy
- Energy use
  - Co-generation and upgrading

Danish Biogas Association
Top priorities for further R&D

- Biological and process control issues within the biogas plant - focus on finding economically viable ways to gradually improve gas yield especially from recalcitrant organic matter.
- The system of optimising energy yield and minimising greenhouse gas emissions all the way from the stable through the biogas plant and slurry storage to the final field application.
- Focus on concepts and technical means by which operating costs can be minimised.
- Accurate technical standards to effectively protect neighbours from odour nuisances.
- Long-term strategy considerations: Why are we so focussed on a future hydrogen supply system when we already have a methane option?
Being or becoming credible

The history of agricultural biogas is the history of much too many mistakes being made and being repeated. It’s the same story all the way from Europe to America and to the far East. This must change if agricultural biogas is to be successful as a credible, reliable and significant part of the future renewable energy supply. Now we are getting a golden chance to adjust and to make it right.