IEA Bioenergy Task 37 Energy from Biogas

Denmark Country Report
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Teodorita AL SEADI

BIOSANTECH | Lerhøjs Allé 14 | DK – 6715 Esbjerg N | Denmark

tedorita.alseadi@biosantech.com | +45 30511553
# Biogas Production in Denmark
## 2015 statistic data

<table>
<thead>
<tr>
<th>Substrate/Plant type</th>
<th>Number of plants</th>
<th>Production (GWh/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage sludge</td>
<td>52</td>
<td>281</td>
</tr>
<tr>
<td>Biowaste</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Agriculture</td>
<td>68*</td>
<td>1367*</td>
</tr>
<tr>
<td>Industrial</td>
<td>5</td>
<td>67</td>
</tr>
<tr>
<td>Landfills</td>
<td>25</td>
<td>48</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>153</strong></td>
<td><strong>1763</strong></td>
</tr>
</tbody>
</table>

*Source: 2015 Energi Statistik; ENS/Søren Tafdrup - personal communication*

- The Danish Biogas production has increased by 40-45% during 2016-2017, compared to 2015. Gas up-grading is common for the majority of the plants (both new and old), with amin wash as the dominating technology. The official statistics for 2016 will be available by the end of 2017.
Biogas production in Denmark

The Energy Agreement from November 2013 is working!

- The last two years shown that the increased support, given to biogas by the Energy Agreement in November 2013, for the use of biogas for electricity production and for gas-upgrading, is working!
- Biogas production has doubled in 2017, compared to 2015
- Many new biogas plants; majority with biogas up-grading unit
- Many ny plant building projects in the pipeline
- Existing framework conditions must be revised and adjusted/improved, to ensure the continuous biogas expansion.

Source: Danish Biogas and Association
Danish Energy Agency, 2017
Nu leverer biogassen:

2012: 4,1 PJ  
2013: 4,6 PJ  
2014: 5,5 PJ  
2015: 6,4 PJ  
2016:  

+ 12%  
+ 34%  
+ 56%  
+ 100% ?

Ingeniøren

Biogas-støtte runder 1,6 milliarder  
- nu griber ministeren ind

Branchezoreningen for Biogas
Production and utilisation of Biogas in Denmark

Source: HMN Naturgas I/S
# Utilization of biogas in Denmark

## 2015 statistical data

Source: Danish Energy Agency and Søren Tafdrup - personal communication

<table>
<thead>
<tr>
<th>Utilisation type</th>
<th>GWh</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>1150</td>
<td>66</td>
</tr>
<tr>
<td>Heat</td>
<td>288</td>
<td>16</td>
</tr>
<tr>
<td>Up-grading</td>
<td>308</td>
<td>17</td>
</tr>
<tr>
<td>Flaring</td>
<td>&lt;17</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

### Up-grading technologies and nr of plants anno 2015

<table>
<thead>
<tr>
<th>Technology</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSC</td>
<td>8 plants</td>
</tr>
<tr>
<td>AMIN</td>
<td>3 plants</td>
</tr>
<tr>
<td>Other</td>
<td>1 plant</td>
</tr>
</tbody>
</table>

Source: Tafdrup, S., Danish Energy Agency, 2017
Biogas Upgrading 2017

<table>
<thead>
<tr>
<th>Biogas upgrading plants (fed in)</th>
<th>Upgrading capacity</th>
<th>Technologies / nr of plants</th>
<th>Gas filling stations CNG</th>
<th>Gas driven cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 + 8 under construction</td>
<td>158. Mill Nm3</td>
<td>Water scrubber / 10</td>
<td>16 + 1 under construction</td>
<td>150 in 2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amine Scrubber /5</td>
<td></td>
<td>461 in 2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Membranes /4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Economic incentives, thus great interest for the up-grading/grid injection.
- The first Danish biogas upgrading plant was established in Fredericia, in 2011.
- Biomethane represents today 10% of the gas in the natural gas grid, and its share is increasing every year.
- Biomethane prove to be a major contributor to reach the national climate goals and the goals in the Paris Agreement.
- Biomethane can be stored in existing gas facilities, balancing other green energies (wind and sun) at no extra cost.
- Suppliers of biomethane and of city gas receive subsidies for the gas delivered, depending on the energy content in the gas.
- A green gas certificate system (1MWh=1certificate) adds marked value of bio methane, especially as transport fuel.
- New biogas plants have gas upgrading, while many older biogas plants have subsequently established gas upgrading.
- Use of upgraded biogas (CNG) for city busses and trucks is increasing. Main drivers: pollution avoidance and economic incentives / biogas cheaper than imported diesel (NIRAS A/S).
- 7 DKK / GJ support for upgrading.
Bio methane upgrading plants

Source: HMN Naturgas I/S


Biogas (CNG) for transport in Denmark

**Utilisation of gas for transport in Denmark 2011-2017**

<table>
<thead>
<tr>
<th>Year</th>
<th>Bioturb</th>
<th>Naturb</th>
<th>FREMSYN estimator</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2016</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2017</td>
<td>9</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

Source: K. Boesgaard, FREMSYN

**16 Gas filling stations**

+ 1 under construction

**The energy content of 1 kg of CNG corresponds to:**
- approx. 1.5 l of gasoline
- approx. 1.3 l of diesel.

Source: Gas2Move

- 461 CNG vehicles registered in Denmark (July 2017), *hereof*:
  - 223 light vehicles (<3500 kg)
  - 123 buses
  - 115 trucks

Source: Gas2Move
Biogas for transport around the world

- Focus on RNG (renewable natural gas) for city transport
- Focus on air quality in cities around the world => biogas chosen as vehicle fuel for the heavy transport

Source: K. Boesgaard, FREMSYN

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Biogas Trends / National Policies

Large and X-Large scale plants / new built plants (advantages of scale)
- Treatment capacity of 200 000 - 900 000 t biomass/year/plant
- Biogas production of 6 – 64 mill. Nm3 biogas/year/plant

Gas up-grading / grid injection: (economic incentives)
- 75% of the new biogas production upgraded / grid injected
- 20% used for CHP (at the AD plant, or sold)
- 5% used for production process (own process, or sold)
- Many older plants establish gas up-grading
- 2017: Upgraded biogas = 10% of gas in the natural gas grid

New AD co-substrates (independence from ind. waste and sustainability)
- Deep litter
- Straw
- Source separated household waste
- Beetroot silage

Restriction on use of energy crops (increased sustainability)
- Max. 27% until 2016
- Max 12% 2016-2020
- Expected lower after 2020

Biogas for the transport sector (less air pollution, economic incentive)
- City buses
- Trucs
- Light vehicles
Main focus areas

Higher share of straw as feedstock
Focus: Pre-treatment technology/ Enhancing digestibility of recalcitrant (lignocellulosic) biomass

Higher share of biogas supply to the gas grid
Focus: Upgrading technology

Using biogas as energy storage buffer for excess electricity from fluctuating renewable energy resources
Focus: Conversion of electricity into valuable feedstock, flexible biogas production

Biogas as part of the biorefinery for full valorization of biomass feedstock
Focus: Biomass conversion technology to lower cost/benefit ratio for valorization of biomass

Biogas externalities / socio-economic analysis
Focus: Biogas sustainability
Performance and Economic Data

Performance Data
Methane emissions:
Project: Methane emission from Danish biogas plants /AgroTech
Aim: Identification of methane leaks from 9 Danish biogas plants, and quantification of methane losses.
The project report, published in June 2015, shows:

- Measured methane emissions represented an average of 4.2% of total methane production.
- Originate from big and small leakage sources.
- Plant owners were informed of the extent and presence of identified leaks.
- Repair of identified leaks reduced the average methane emissions from 4.2 to 0.8% of total methane production.
- Reduction of methane emissions subsequently reduced the GHG effect of the biogas production, from 40 to 31 kg CO₂ equivalents per tonne of digested biomass

https://www.teknologisk.dk/_/media/66055_metanemission_fra_danske_biogasanlaeg_klimaeffekt_af_metanaekager_op_biogasanlaeg.pdf

Economic Data:
Investment costs
- AD plant 170-190 EUR / m3 digester
- Up-grading: n.a.

Operating Costs
- The costs of producing biogas:
  - EUR 17,5-19,5 per GJ
  - EUR 20,7-22,3 per GJ in upgraded form
Digestate utilisation

- Digestate from agricultural plants is used as crops fertiliser and applied after the same rules as animal manure and slurries.
- No Harmony rules from 2017

- Co-digestion of sewage sludge from WWTP with manure is only limited, due quality restrictions on waste material that can be applied on land.

- For sustainability reasons, the use of energy crops for biogas production is restricted between 2016-2012 to max. 12% of the AD feedstock.

Photos: Dansk Landbrugsrådgivning
It was noticed, that the current harmony rules lead to accumulation of 250 kg P/ha over 25 years.

The rules were abolished from August 2017.

The new rules give possibility of using a maximum of 170 kg N/ha from Livestock Manure (Nitrate Directive); Exemption for cattle farms, with eco-friendly land use (230 kg N/ha from Livestock Manure).

The new N-rules will worsen P-accumulation.

The need to set up phosphorus limits for the supply of phosphorus by all kind of phosphorus fertilizers (commercial fertilizers, manure and other fertilizer types, such as sewage sludge) occurred.

The new phosphorus limits vary between farms, depending on the type of farm, the crop rotation, the soil, the P-reserve on soils, the animal feeding practices etc.

- This means, that some farms will have higher limits than earlier, others will have lower.
- The exemption for the cattle farms means, that a specific farm can increase its harmonic demand from the normal 170 kg nitrogen per hectare to 230 kg nitrogen per hectare, against the fact that the cattle breeder grows its fields more environmentally-friendly under certain strictly prescribed conditions.
- These conditions mean e.g. a crop rotation with a particularly high nitrogen uptake and a long growing season, for at least 70% of the farm's area.
- In addition, the farm must meet requirements of plowing down the nitrogen rich crops (leguminous) and of making laboratory tests of nitrogen and phosphorus content of the soil, every 4 years.

The main aim of the new P-regulation is to achieve an average decreasing P accumulation in soil (protection level) on long term.
New P-regulation

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2017</th>
<th>2020</th>
<th>2022</th>
<th>2027</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fjerkræ / mink</td>
<td>45-55 / 43</td>
<td>43</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Slagtesvin</td>
<td>33,5</td>
<td>40 (circled)</td>
<td>39</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Søer og smågrise</td>
<td>34 / 37</td>
<td>35</td>
<td>30</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Kvæg/får/geder</td>
<td>27 (circled)</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Undtagelsesbrug</td>
<td>36</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Organisk affald</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Overført husdyrgodning</td>
<td>1,4 DE</td>
<td>Vægtet gennemsnit</td>
<td>30</td>
<td>Vægtet gennemsnit</td>
<td>30</td>
</tr>
<tr>
<td>Gennemsnit</td>
<td>32,3</td>
<td>[36,3]</td>
<td>[30,7]</td>
<td>[34,8]</td>
<td>[30,7]</td>
</tr>
<tr>
<td>Beskyttelses niveau</td>
<td>31,9</td>
<td>35,6 kg P/ha</td>
<td>34,3 kg P/ha</td>
<td>32 - 33 kg P/ha</td>
<td>30-31 kg P/ha</td>
</tr>
</tbody>
</table>

- Generelle krav (forventet 76 pct.) skærpede krav ved søer og evt. andre vandmiljøer
- Initielt højere fosforloft – men de reduceres over årene (fodertilpasning m.v. nødvendig)
- Biogas fællesanlæg beregner fosforloft som vægtet gennemsnit af tilført godning (norm)
- Undtagelsesbrug (kvæg) rammer P loft for 230 kg N – biogas kan hjælpe med overskud
- P-loft korrigeres for lave fosforal op til max 45 kg/ha (+1 kg/0,25 Pt v Pr<4 / +2kg/0,25 Pt v Pr<3)
Barriers and Challenges for the Biogas Development

Main barriers

• Need for new and improved financial incentives to establish and operate a biogas plant
• High cost of producing biogas (typically DKK 130-142 per GJ; DKK 154-166 per GJ in upgraded form)
• The financial situation of biogas plants is still uncertain, despite the current price supplements; some price supplements are to be phased out and will disappear after 2020, if the price of natural gas evolves as expected.
• Difficult for biogas plants to access suitable biomass feedstock (e.g. slaughterhouse waste)
• Complex process of selling the gas, and obtaining a lucrative price
• Biogas subjected to complex legislation/regulation, making the planning and approval process difficult

Overall present and future challenges

• Improve the legislative frames and the financial support frames, to better fit present and future biogas deployment objectives
• Find and test new AD co-substrates for animal manure and slurries (e.g. deep litter, straw, household waste, beetroot silage)
• Integrate the biogas in the national energy supply
• Enhance the biogas up-grading / promote sale through the natural gas grid
• Consider direct local sale opportunities as well
• Increase and encourage the use of biogas for transport
• Training, education and information dissemination (plant managers/operators/ farmers/public at large)
• Continuous modernise the national biogas association; create local platforms for project generation.
• Enhance commitment/involvement of policy/decision makers
• Encourage the establishment of local biogas infrastructures
• Simplify project approval procedure
The legislative framework impacting the Danish biogas sector

EU
- The Waste Framework Directive
- By-product Regulation
- RES Directive
- EIA Directive
- The Habitats Directive
- Nitrate Directive
- Water Framework Directive

Climate, Energy and Building Ministry
- The Renewable Energy Law
- Heat supply and project Ordinance
- Electricity Supply
- Natural gas law
- Climate Plan
- Strategic energy planning
- RE in the process

Ministry of the Environment
- Planning Act
- EIA Decree
- Habitat Ordinance
- Environmental Protection Law
- Sludge Ordinance
- Waste Ordinance
- Resource Strategy

Ministry of Food
- Support /ha agriculture
- Rural development
- Statutory order for fertilizer and plant cover

Ministry of Taxation
- Tax Laws
- Nature Agency biogas mobile team

Economy-94 and Ministry of Internal Affairs
- Local Proxy Rules
National Strategies

The main frame for the present and future development of biogas in Denmark is represented by the Energy Agreement from 2012.

- The "Green Growth" initiative formed the basis for a political agreement made in 2009, which includes the objective that **50% of the livestock manure is to be treated in biogas plants by 2020**. This requires a significant deployment of biogas technologies all over the country.

- In March 2012, the Danish Government entered a broad **ENERGY AGREEMENT**, concerning the period 2012–2020. The agreement includes multiple elements and calls for a significant enhancement of the share of renewables in the Danish energy supply. **The aim is to have 35% of energy supply from renewables by 2020, and to make Denmark complete free of fossil fuels by 2050.**

- **Biogas is a key area** in the agreement. The Danish Energy Authority, in its projection from 2012, predicted that it is possible to have **a 4-fold increase (to 16.8 PJ) of the total biogas production by 2020**. Danish politicians have indicated that the biogas in Denmark should not be developed based on energy crops, and have therefore introduced **restrictions for the share of energy crops** used for biogas production. In exchange, there is now growing interest in co-digesting animal slurry, deep litter, straw and other lignocellulosic biomass, along with source separated household waste in the production of biogas in Denmark.

- A large part of the biogas will be **up-graded and injected into the natural gas grid**. 10% of the gas in the national grid was in 2017 upgraded biogas.

- **Biogas for transport (CHG)** is increasing rapidly, especially for public transport in cities, heavy duty vehicles but also for light vehicles.
Financial Support Systems for Biogas

An improved financial support of the biogas sector was adopted and approved by the EC at the end of 2013. The support cannot be overlapped (e.g. cannot be received by the same plant for both investment costs and for operation costs).

The main elements are:

- 0.056 EUR/kWh for biogas used in a CHP unit or injected into the grid (115 DKK/GJ).
- 0.037 EUR/kWh for direct usage for transport or industrial purposes (75 DKK/GJ)

These tariffs include natural gas price compensation of maximum 0.012 EUR/GJ (26 DKK/GJ) and temporary support of 0.005 EUR/GJ (10 DKK/GJ) up to 2016: after this, the support will decrease by 2 DKK/year, up to 2019.

It is also possible to apply for investment grants for plants digesting mainly manure. 19 new biogas projects received governmental grants 2013 with a total value of 268 MDKK (36 MEUR).

Support for upgraded biogas supplied to the natural gas network in the calendar year 2013 is of 111.6 DKK per GJ. The support is payable to both upgraded biogas supplied to the natural gas grid and to purified biogas entering a town gas grid. This support is provided with effect from 1 December 2013.

In the energy agreement, new support frames for biogas to transport, process and other applications were also proposed.

Support for biogas after 2020:

Some of the surcharges are tapered off, and the support indexed only partially. There is no expiration date on the surcharges in Danish law, but according to the EC, the aid approval is only valid for 10 years. For subsidies for electricity and upgrading until 2023. Thereafter, the aid will be renotified to the EC, which could involve changes. The given subsidies for electricity can not be granted also to the heat generation, accompanying power generation.
Thank you