 IEA Bioenergy Task 37 Energy from Biogas

Denmark Country Report -2019

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# Biogas Production in Denmark

*Source: Danish Energy Agency, 2018*

<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>51</td>
<td>281</td>
</tr>
<tr>
<td>Biowaste</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Agriculture (centralized AD + farm AD)</td>
<td>28+55=83</td>
<td>1367</td>
</tr>
<tr>
<td>Industrial</td>
<td>5</td>
<td>67</td>
</tr>
<tr>
<td>Landfills</td>
<td>27</td>
<td>48</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>166</strong></td>
<td><strong>1763</strong>*</td>
</tr>
</tbody>
</table>

About 11 PJ in 2018 = 3055 GWh/year

* The Danish Energy Statistics for 2018 will be published by end of November 2019
Biogas production is growing rapidly, and it is estimated to be more than triple by 2020, compared to 2012, when the Energy Agreement was implemented, improving economic support for biogas production and utilisation.

A new Energy Agreement was signed in 2018 and enforced in April 2019, allowing the existing biogas plants to continue receiving the present support for biogas utilisation, until 2032, and for at least 20 years for each plant. After 2020, the existing financial support will not be applicable for the construction of new plants. An upper limit is to be set for production support, and an ongoing assessment of the financial support will be done, to avoid overcompensation.

Most of the produced biogas will still be upgraded and supplied to the natural gas network. It is estimated that direct supply to electricity generation will reach the upper limit by 2020. Only limited sales of biogas are expected for industry, transport and heat.

Source: Danish Energy Agency, 2018
Utilisation of Biogas in Denmark

Source: Danish Energy Agency
## Utilization of biogas in Denmark

<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>

NB: The Danish Energy Statistics for 2018 will be published by end of November 2019
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 more than 10 % of the gas in the natural gas grid (18,6% in July 2018).
The share of biomethane is and expected to be 23% by 2023 and 100% green gas utilisation can be reached by 2035, according to “Grøn Gas Danmark”- 2019.
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 built biogas plants have gas upgrading, and most of the older ones have refurbished and added gas upgrading units.
Use of compressed upgraded biogas (CNG) for city busses and trucks is also increasing. Main drivers: pollution avoidance and economic incentives ( biogas cheaper than imported diesel )
Cost of biogas upgrading EUR 3 /GJ (Danish Energy Agency)

<table>
<thead>
<tr>
<th>Biogas upgrading plants</th>
<th>Upgrading capacity</th>
<th>Technologies / nr of plants**</th>
</tr>
</thead>
<tbody>
<tr>
<td>32*</td>
<td>38.900 Nm³/h</td>
<td>Water scrubber / 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amine scrubber / 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Membranes / 4</td>
</tr>
</tbody>
</table>

*33 upgrading plants by medio 2019 (Source Gasfakta.DK)
** The Danish Energy Statistics for 2018 will be published by end of November 2019
The transport sector needs more renewable fuels

CO2 emissions in Denmark, 1000 tons

Source: Danish Energy Agency
Biogas (CNG) for transport in Denmark

The energy content of 1 kg CNG (compressed natural gas, at 200 bar) corresponds to 1.5 l gasoline or 1.3 l diesel.

- There are 17 gas filling stations in Denmark in 2018 and 4 in construction, expected in operation by end of 2019.
- In 2017 there were 461 CNG vehicles registered in Denmark (July 2017), hereof: 223 light vehicles (<3500 kg), 123 buses, 115 trucks.
- A biogas-bus contributes to better air quality, while saving 114 tons of CO2 per year, compared to a diesel-bus.
- Estimates show that 4,500 city busses could run on biogas in Denmark by 2030, saving 51,000 tons of CO2 emissions per year.
- Only 1.2% of the busses in Denmark run on alternative fuels, hereof 0.9% on biogas.
- One of the causes is the 40% higher taxes, applied in Denmark to a biogas-powered vehicle, compared to a diesel-powered.
- Currently, the CNG production is of 179 mill. m3 gas per year, which could supply 37,000 vans, each running some 40,000 km per year.

Source: Gasbiler.info
Biogas Trends and National Policies

Large and X-Large scale plants/new built plants: advantages of scale / economic benefits
- 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, environmental benefits
- Many older plants establish gas up-grading
- 2018: Upgraded biogas = more than 10% of gas in the natural gas grid

Biogas for the transport sector: less air pollution, economic incentives
- City buses
- Trucs
- Light vehicles

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

Restriction on use of energy crops: increased sustainability
- Max 12% 2016-2020
- Lower => 0 after 2020
Biogas research topics and 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 or 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
Source: Danish Energy Agency

Performance

Methane emissions:
Biogas plants can now get support to identify, measure and control any losses of methane.

Loss of methane from biogas plants gives economic loss and diminishes the sustainability of biogas production. The Biogas Business Association has therefore set a goal of reducing methane losses from the biogas plants to under 1% of the biogas production, in 2020. This will reduce the overall greenhouse gas emissions from agriculture and thus help to achieve the government's climate targets. The program runs under the coordination of the Danish Biogas Business Association and the Danish Energy Agency, and with the collaboration of Ramboll, DTU, Force and the Danish Technological Institute.

The biogas plants can participate according to the “first come, first served” principle. The program intends to map and reduce methane losses on the plants, by providing specific information on the methane losses on each plant and tailored solutions to avoid it. Beyond economic benefits, reduction of methane loss equips the plants for future regulatory requirements on mitigation and control of GHG. Within the program, the biogas plants can sign up for various activities including implementation of self-control program, leak detection, point source measurements and assistance to remediate methane losses. A measurement of methane losses for the entire biogas plant is mandatory for the participating plants.

https://presse.ens.dk/pressreleases/energistyrelsen-igangsaetter-maalrettet-indsats-for-at-mindske-metantab-fra-biogasanlaeg-2925816

Economics:

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

Operating Costs
- The costs of producing biogas:
  - EUR 14,2-17,9 per GJ (Danish Energy Agency, 2018)
  - EUR 17,0 -20,8 per GJ in upgraded form (about 3 EUR /GJ for upgrading) (Danish Energy Agency, 2018)
Digestate utilisation

- Digestate from agricultural plants is used as crops fertiliser and applied after the same rules as animal manure and slurries.
- New Phosphorus regulation introduced in 2017, to replace earlier "harmony rules".
- Co-digestion of sewage sludge from WWTP with manure is only limited, due quality restrictions on waste material that can be applied on land.
- Restricted use of energy crops for biogas production to max. 12% of the AD feedstock until 2020, and lower limits after this date.

Photos: Dansk Landbrugsrådgivning
The main aim of the new P-regulation is to decrease P accumulation and avoid pollution of ground water on long term.

• Previously applied harmony rules lead to accumulation of 250 kg P / ha over 25 years and were thus abolished in 2017.

• New rules were adopted, giving the 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 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.
## Digestate utilisation

### 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></td>
<td>Generet</td>
<td>Skærpet</td>
<td>Generet</td>
<td>Skærpet</td>
<td>Generet</td>
</tr>
<tr>
<td>Fjerkræ/mink</td>
<td>45-55 / 43</td>
<td>45</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Slagtesvin</td>
<td>33,5</td>
<td>39</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Søer og smågrise</td>
<td>34 / 37</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Kvæg/får/geder</td>
<td>27 (kvæg)</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>35</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Overfort husdyrgødningsbiogasfællesanlæg</td>
<td>(1,4 DE)</td>
<td>Vægtet gennemsnit</td>
<td>Vægtet gennemsnit</td>
<td>Vægtet gennemsnit</td>
<td>Vægtet gennemsnit</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. nodvendig)
- Biogas fællesanlæg beregner fosforloft som vægtet gennemsnit af tilført gødnings (norm)
- Undtagelsesbrug (kvæg) rammer P loft for 230 kg N – biogas kan hjælpe med overskud
- P-loft korrigeres for lave fosfortal op til max 45 kg/ha (+1 kg/0.25 Pt v Pt<4 / + 2kg/0.25 Pt v Pt<3)
Incentives / Barriers and challenges for biogas development

Incentives / barriers

• Need of updated financial incentives to establish and operate a biogas plant
• Need of financial operation stability for the biogas plants
• Obtain competitive production costs of biogas (typically DKK 130-142 per GJ; DKK 154-166 per GJ in upgraded form)
• Have access to suitable biomass feedstock (e.g. slaughterhouse waste)
• Have access to co-substrates for manure /slurries
• To be easier to get lucrative gas selling prices; Simplify the process of selling the gas
• Planning and approval process difficult; Biogas subjected to very complex legislation /regulations

Present and future challenges

• Continuously adjust legislative frames and financial support, to 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 and promote sale through the natural gas grid
• Consider direct local sale opportunities
• Promote and increase the use of biogas for transport
• Continuous modernize 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
• Training, education and information dissemination (plant managers/operators/ farmers/public at large)
National Strategies

• 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, concerining 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. The Energy Agreement from 2012 is the main frame for the development of biogas in Denmark.

• Biogas is a key area in the agreement. The Danish Energy Authority, in its projection from 2012, predicted that it is a 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 (15 % i 2019).

• Biogas for transport (CHG) is increasing rapidly, especially for public transport in cities, heavy duty vehicles but also for light vehicles.

• A new energy agreement was signed in June 2018 and enforced in April 2019 and includes a support of a total pool of EUR 32.2 million annually. The support will go to biogas and other green gases used for upgrading, transport and industrial processes, in the period 2021-2023. At the same time, the existing biogas support schemes will be closed for plants built after 2020. The new biogas production for electricity generation will in future be supported through a comprehensive support scheme for biomass and biogas for cogeneration, while there will be no support for new biogas plants for heat production. The government estimate that the effect of these measures will be a total biogas production increase to around 23 PJ pr. year.
Financial support 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 were:

• 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 2DKK/year, up to 2019.

It is also possibly 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.

A new Energy Agreement was signed in 2018, because of growing financial expenses to biogas. The new agreement stipulates:
• From 1st of January 2020, no new built biogas plants are subsided (it was possible to get a dispensation, if you already have signed contracts for building a new plant)
• Biogas plants built before 1st of January 2020 are subsided through feed-in tariffs, until the end 2032. After this date, there will be no subsidies.
• Biogas plants build before 1st of January 2020 are assigned a production maximum, in order to control the finances.

The feed-in tariff is a combination between the gas price and a fixed price (government support). The fixed price is based on last years gas price and is fixed ultimo January, for the coming year.
Thank you