# Biogas and Organic Farming - A Sustainable Cocktail

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# Organic agriculture may contribute with **renewable energy** and **fewer greenhouse gasses**

According to the Danish Agreement on Green Growth introduced in 2009, the Danish government plans to double the organic farming area from 2009 until 2020. Another goal is that, by 2020, 50% of all animal manure must be processed in biogas plants, and a third goal is that these initiatives must contribute significantly to reducing the emission of greenhouse gasses from agriculture. It would be ideal if some agricultural measures were able to fulfil all of these goals at the same time.

If organic farming should benefit from sale of energy, it would be profitable to change the organic operation methods into biogas production and reduce greenhouse gas emission. This solution would be close to ideal.

The project ”Energy production as a force for more organic farming” has illustrated these possibilities through an example with considerations of establishing a biogas plant at a CHP-station in Herning Municipality. This includes economic calculations for farmers as well as biogas plants. This pamphlet presents the results.

Organic Farming at Knowledge Centre for Agriculture has completed the project in co-operation with Heden & Fjorden Agricultural Advisory Centre and Herning Municipality.

The project has been subsidised by the EU and the Rural Development Programme of The Ministry of Food, Agriculture and Fisheries, and Fund for Organic Farming.

**Biogas and organic farming – a sustainable cocktail**
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# Organic Farming and Energy
# – A Healthy Cocktail

The benefits of organic farming are several. The most well-known fact is that pesticides and artificial fertilisers are not applied. This protects the environment against residues of pesticides and fertilisers, and is a safeguard to the consumer against pesticide residues in food.

From a climate aspect, this also saves energy, and with it $CO_2$ emission for production of pesticides and particularly nitrogen fertilisers, the latter being very energy consuming. The nitrogen for the organic production comes from clover plants and other nitrogen-accumulating crops grown in the organic fields. It only takes little application of fossil energy, and, at the same time, particularly clover bonds carbon to the soil. This has a positive effect in the greenhouse gas accounts.

On the other hand, the eco-friendly agricultural production is smaller per ha, which means that there is not much difference between the emission of greenhouse gases per kg product between organic and conventional products.

By growing e.g. clover and sending the harvested plant mass through a biogas plant together with slurry and other animal manure, the organic farmer will have better and more nutritious fertiliser and higher yields at the same time, and he will be able to displace fossil energy with the produced biogas.

Other values from the organic production are that no GMO plants are used, that organic forage does not contain GMO, and it focusses on comfortable and natural conditions for the animals.

Promoting renewable energy production through organic farming thus entails a number of advantages.

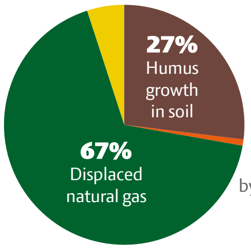
However, if the model is to become successful, it should be economically interesting for the farmers and for the people running the biogas plants. The next pages will illustrate this.

# An active contribution to the municipality's climate action plan

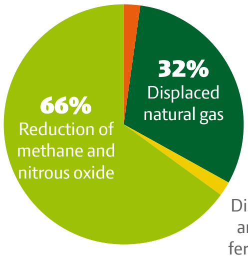
The 2009 climate plan of Herning Municipality sets a target to reduce $CO_2$ emission by 25% from 2007 to 2015 and in the same period to reduce all greenhouse gases by 15%, methane and nitrous oxide from agriculture being the most important emissions.

The agricultural sector in Herning Municipality contributes with as much as 47% of the municipality's total emission of greenhouse gases. The target of the climate plan is for agriculture to reduce the emission to 67,500 tons $CO_2$ equivalents by 2030, i.e. 22.5% lower than in 2007.

*The $CO_2$ impact of degasification of biogas crops (clover grass) includes the displaced natural gas, the saved consumption of artificial fertiliser N, and the carbon bound to the humus in the soil, with a deduction of $CO_2$ from fuel used for transport (10 km).*




*The $CO_2$ impact of bio-degasification of animal manure includes reduction of methane and nitrous oxide when treating the manure in a biogas plant, of the displaced natural gas, and of the saved consumption of artificial fertiliser N, with a deduction of $CO_2$ from fuel used for transport (10 km).*




Conversion into organic farming with associated energy production would contribute to the promotion of the municipality's climate goals. The table below shows the reduction of the climate impact if 50% of the manure was used for biogas and one third of the crop farms used 25% of the area for nitrogen-assimilating biogas crops. This would fully cover the municipality's climate goal for agriculture.

**Climate impact of degasification of manure in combination with organic energy crops. Estimate for Herning Municipality.**

| | |
|---|---|
| Total area of municipality | 132,280 ha |
| Agricultural area of municipality.<br>Of this, crop farms | 75.825 ha<br>36.000 ha |
| Number of animal units in the Municipality | 75,825 |
| Biogas production from manure (utilisation of manure is 50%) | 12.2 million $Nm^3$/year [1)] |
| Biogas production from biogas crops [2)] | 10.6 million $Nm^3$/year |
| $CO_2$ impact of degasification of 50% of manure | 48,500 tons $CO_2$ equiv./year |
| $CO_2$ effect of degasification of biogas crops | 20,100 tons $CO_2$ equiv./year |
| Total $CO_2$ effect | 68,600 tons $CO_2$ equiv./year |
| The municipality's target for reduction within agriculture (2030) | 67,500 tons $CO_2$ equiv./year |

*1) Gas is measured in "norm cubic metre" ($Nm^3$) being the gas volume at 0°C and at a pressure of 1 G.*
*2) It is assumed that one third of the crop farms will supply biogas crops from 25% of their acreage – and thus convert into organic production.*

*On the back page, you will find references to the project website with more information about the calculations.*

# **The economy** for the farmer

For the farmer, who is to supply manure and energy crops to a biogas plant, the opportunities for gains are various.

- Sale of biomass for degasification in biogas plants may provide new income.
- The farmer may be self-sufficient in nutrients, if the biomass comes from clover grass or the like. This is particularly significant for organic crop production, when in 2021 it will no longer be possible to apply conventional manure.
- The farm's $CO_2$ accounts will improve, and this will help reducing the agricultural sector's emission of greenhouse gases.

The table below shows the financial situation of four farms in current operation (two organic and two conventional), and after conversion into a production where manure and energy crops are delivered to a biogas plant. At the same time, the two conventional farms have converted into organic farming.

All of the four cases are actual farms with individual conditions and they are not meant to be compared.

For existing organic farms, there is a small gain in delivering manure and energy crops for biogas production, if they continue the purchase of conventional manure[1]. However, with the prices applied, biogas production cannot compensate for the phasing-out of conventional manure[2].

The organic crop farm is shown in two lines with[1] and without[3] conventional manure. When the organic crop production does not use fertilisers from outside, the turnover using a biogas plant is very advantageous because you get more nutrients and thus better yields. In this example, however, this is not enough to secure the same income as the organic crop farm using conventional manure[1].

The dairy farmer will derive great advantage from converting into organic farming. However, the turnover through the biogas plant represents the smallest part of the advantage.

In the example of conventional crop farming being converted into organic farming and biogas, the income is not sufficient to secure the same economy as in the conventional crop farm[4]. The result also depends on the distance to the biogas plant.

**The economy in four examples showing present production and when converted into production with biogas delivering manure and clover grass for biogas production. At the same time the two conventional farms have converted into organic farming.**

| Type of plant | Size | Fiancial result – present production (DKK) | Fiancial result – with biogas (DKK) |
|---|---|---|---|
| [2]Organic cattle (conv. fertiliser phased out by the change to biogas) | 150 cows/281 ha | 1,049,000 | 991,248 |
| [1]Organic - crop (plus conv. pig manure) | 145 ha/315 sows | 339,000 | 367,000 |
| [3]Organic - crop (excl. conv. fertiliser) | 145 ha | 136,000 | 290,000 |
| Conv. - cattle | 107 cows/111 ha | 188,000 | 397,000 |
| [4]Conv. - crop | 53 ha | 83,000 | 74,000 |

**Price assumptions**

| Grain price Conventional/organic DKK/kg | Roughage price Conventional/organic DKK/Fu | Income from biogas plant for slurry and manure (DKK/ton) | Income from biogas plant for finely-chopped energy crop (DKK/Fe) | Cost for biogas plant for growth in manurial value [1)] (DKK/kg $NH_4$ +-N) |
|---|---|---|---|---|
| 1.00/1.40 | 0.95/1.20 | 0 | 0.72 | 11.75 |

*1) During transformation of manure and plant mass in a biogas plant, the manure efficiency is increased, because most of the nitrogen will turn into effective ammonium. Upon return of the manure to the farmer, he pays for the additional ammonium ($NH_4$ +-N).*

# The necessary economy

If agriculture is to contribute actively in providing the large quantities of biogas as will be required, predicted by, among others, the Climate Commission, the economy in delivering animal manure and plant material for biogas production has to improve.

The table below illustrates the financial results for the same four farms, but in this case they have received a better price for the biomass they have delivered and they have had the manure returned at a more attractive price.

If the biogas plant is able to offer the higher prices, it would make it interesting for the nearby farmers to become suppliers and for conventional crop farms to convert into organic farming.

The conventional cattle farm will not make an extra profit from the changed prices, as there is no sale of energy crops, and as the extra manurial value equals that of the excess manure sold through the biogas plant. Whether or not to convert such farms thus solely depend upon having a contract with a dairy about buying your organic milk.

**The economy in four examples showing present production and when converted into production with biogas delivering manure and clover grass for biogas production. Higher price assumptions.**

| Type of farm | Size | Financial result - present production (DKK) | Financial result - with biogas and no conventional fertiliser (DKK) | Price changes compared to first model |
|---|---|---|---|---|
| Organic cattle | 150 cows / 281 ha | 1,049,000 | 1,100,000 | +0.5 DKK per FU energy crop |
| Organic - crop + conv. pigs) | 145 ha / 315 sows | 339.000 | 379.000 | |
| Conv. - cattle | 107 cows / 111 ha | 188,000 | 397,000 | -2.00 DKK per kg $NH_4$+-N returned |
| Conv. - crop | 53 ha | 83,000 | 161,000 | |

# **Economy** for the biogas plant

It is important to the economy as well as to the climate that the biogas plant has a ready market for all producible energy.

An effective way to solve this problem is to sell the biogas to a power and heat producing facility. Another option is to clean/upgrade the biogas to pure methane in order to facilitate injection into the natural gas grid.

Below illustrates the economy for three sizes of biogas plants, where the two are likely to deliver biogas to a power station in Herning Municipality. The plant consumes 1.7 million $Nm^3$ of natural gas annually.

A. Minor plant, where the monthly amount of biogas is equivalent to the power plant's gas consumption during the summer months (base load).
B. Larger plants that can provide the entire power plant's gas consumption (annual consumption). During the summer, the excess gas is sold to the natural gas network.
C. Large-size plants built with the intention of delivering their entire production to the natural gas network.

**Operating result for different sizes of biogas plants at different sales prices for gas. Annual result after tax in DKK 1,000.**

| **Gas price**<br>– for CHP units:<br>– for the natural gas network: | **4 DKK**<br>**2 DKK** | **4 DKK**<br>**4 DKK** | **5 DKK**<br>**5 DKK** |
|---|---|---|---|
| | (per $Nm^3$ methane) | | |
| **A. Base load** | 448 | 448 | 1,064 |
| **B. Annual consumption** | 119 | 735 | 2,105 |
| **C. Natural gas network** | -4,318 | 3,383 | 6,628 |

This calculation is based on prices from the original model of examples on page 6. These prices were not sufficiently favourable to attract suppliers. The table illustrates that particularly the large-size plants are able to generate a considerable profit, if the gas price is high enough.

This provides the financial circumstances to offer suppliers a better price. The following table illustrates the performance of the biogas plant when using the sales prices from the examples on page 7.

**Operating results for different sizes of biogas plants at different sales prices for gas. Annual result after tax in DKK 1,000. Improved prices for farmers supplying biomass.**

| **Gas price**<br>– for CHP units:<br>– for the natural gas network: | **4 DKK**<br>**2 DKK** | **4 DKK**<br>**4 DKK** | **5 DKK**<br>**5 DKK** |
|---|---|---|---|
| | (per $Nm^3$ methane) | | |
| **A. Base load** | -468 | -468 | 352 |
| **B. Annual consumption** | -2,448 | -1,592 | 311 |
| **C. Natural gas network** | -10,112 | -1,096 | 3,411 |

The table indicates that the price of the produced biogas has to be 5 DKK or more for the economy to be attractive to farmers as well as to the biogas plant. It would be particularly interesting, if it was possible to obtain this price for gas sent to upgrading and distribution in the natural gas network.

The calculations assume financing by the new 20% start up grant, and the remainder is covered by a 20-year loan at 5% interest. Costs of finance, operations, salaries, transport and maintenance have been deducted from the calculations. The gas price is for non-upgraded biogas.

The calculations also assume that half of the biomass for the plant is silage clover grass. The biogas plant pays transport of biomass to the plant, and suppliers pay for the transport from the plant. For the small plant, the average distance to grass is within a range of 5 km, for the largest plant the average distance for slurry is within a range of 20.5 km.

Experiences with biogas plants handling large amounts of clover grass are only few. This means, to a certain extent, that calculations have been based on an estimate of production and costs.

In connection with the Government's Green Growth Plan, a pool of 3 x 4 million DKK was allocated to pilot projects for development of customised systems for degassing of organic biomasses.

An opportunity to get biogas production on organic biomass started earlier would be the establishment of an organic line at an existing centralised biogas plant. Thus, it would be possible also to benefit by the expertise of existing plants.

# Biogas as a force for more organic farming

The Green Growth Plan aims to increase the organic area through market-driven growth from 170,000 hectares in 2009 to 340,000 hectares in 2020. How much of this growth would be provided by a new market for biomass for biogas?

Traditionally, mainly the livestock farms have converted into organic agriculture. However, when combining biogas production from energy crops, the options are better for conversion of crop farms as well.

It would be possible to achieve the main part of the desired growth, if e.g. 10 per cent of the Danish crop farms were converted into organic farms, and if they utilise one fourth of their land to grow nitrogen-assimilating energy crops for biogas production. This would also result in a higher production of forage, which would enable a higher number of organic livestock farms.

**The effect of converting 10% of all Danish crop farms into organic farming with biogas production.**

| | |
|---|---|
| Organic area 2009 | 170,000 ha |
| Desired growth in organic area - up to 2020 | 170,000 ha |
| Conversion of 10% of all crop farms [1] | 146,000 ha |
| Climate impact from energy crops in converted farms | 244,500 tons $CO_2$ equivalents |
| Share of agriculture's reduction target according to the Danish Commission on Climate Change Policy (6 million tons of $CO_2$ equivalents) | 4% |

*1) Farms with less than 10 tons manure per ha*

According to the Danish Commission on Climate Change Policy, such a reorganisation would also make a significant contribution to meeting targets for the reduction of agricultural greenhouse gas emissions.

The model also ensures manure from the biogas plant, which will be necessary for organic farms, when the conventional manure is phased out from 2015 to 2021.

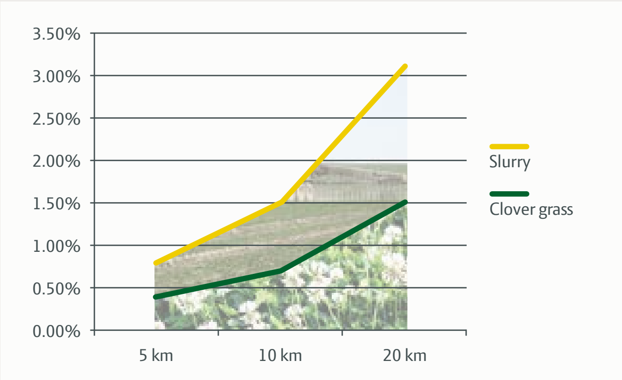
A conversion of this scale into organic crop farming would require the establishment of biogas plants in all regions of the country and that it becomes economically attractive to convert into this type of production. The calculations on the previous pages illustrate the prices required to realise this project.

On the back page, you will find references to the project website with additional information about the calculations.

# The biogas plant - our time's new 'co-operative dairy'

For reasons of both economy and environment, biogas plants should be placed within reasonable driving distances to the farmers. For the same reasons it is also a good idea to use energy crops for biogas plants as they contain far more energy per $m^3$ than slurry.

**Transport's share of the total $CO_2$ output at bio-degasification of slurry and clover.**




If you want to keep the $CO_2$ loss below 1 per cent, the average distance should not exceed 7.5 km. This means that suppliers' distance to the biogas plant must be within a radius of 15 km - or that biogas plants must be max. 30 km apart.

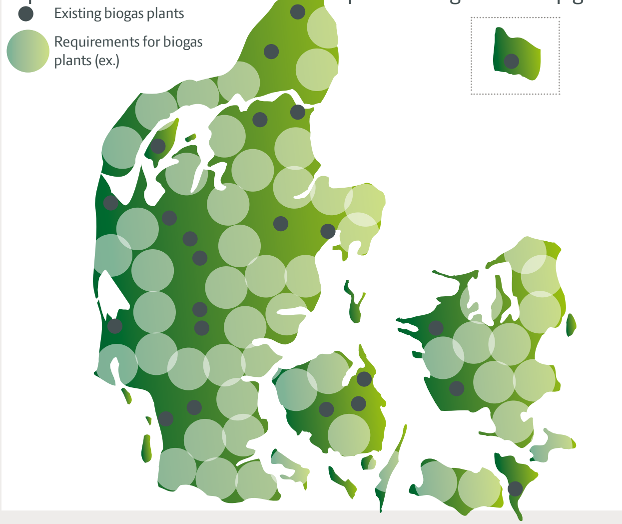
The calculations assume that approx. half of the biomass comes from clover grass grown on crop farms converted into organic farming. This also provides a positive climate effect from carbon stored in the clover grass fields and from the energy saved for production of fertilisers and pesticides.

With the possibility of supplying manure and energy crops to nearby biogas plants, it becomes easier to convert into organic farming.

The biogas plants would thus be given a similar role as the dairy co-operative, which used to be an important factor in the successful agricultural transformation into modern milk production.

**A system with biogas plants within a 15 km zone across the country would make it easier to choose organic farming with bioenergy crops for biogas.**

As part of the Green Growth Plan it is possible to get a start up grant




of 20% for the establishment of biogas plants. For more information please have a look at the website of the Ministry of Food, Agriculture and Fisheries of Denmark: www.ferv.fvm.dk.

DLBR Biogas Advisory Services willingly assist in preparing and implementing a biogas plant project. Please find additional information at www.dlbr.dk under "Produkter/Specialrådgivning" (Products/ Special Advisory Services).

# More **biogas** and more **organic farming** at the same time

Conversion to organic farming and production of more biogas may well go hand in hand, and will at the same time contribute to more Danish-produced renewably energy, a significant decrease in greenhouse gas emissions from agriculture, phasing out of fertilisers and pesticides and a larger production of organic food. All aims from the Government's Green Growth Plan.

To achieve these positive results, the individual farmers must necessarily be aware of the financial possibilities of conversion to organic farming and supply of manure and energy crops for the production of biogas. This pamphlet shows by calculations which prices to charge by the farmers for the products delivered to the biogas plant, and which prices to charge by the biogas plant in order for the production to be profitable.

This pamphlet has been produced in the project "Energy production as a force for more organic farming", implemented by Knowledge Centre for Agriculture in co-operation with Heden & Fjorden Advisory Service, and Herning Municipality.

Additional information and results from the project are available at www.landbrugsinfo.dk under "Økologi/Biogas" (Ecology/Biogas).

## Biogas and organic farming

**3 ADVANTAGES**

- Better biomass - more gas
- More carbon in the soil - better climate impact
- More ecology - better environment

**3 CONDITIONS**

- A gas price that can start investments (at least 5 DKK/Nm$^3$ methane)
- A biogas technology that works well with clover grass as a biomass
- Suppliers will be well paid for the biomass.