European & Danish Biogas Experience

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Summary

Anaerobic digestion of manure, energy crops and organic industrial and municipal waste in biogas plants gives numerous advantages to farmers and society in general. For farmers as a tool to minimise obnoxious odours after spreading of manure, to maximise nutrient utilisation and as a platform for separation and removal of surplus of nutrients from farms and local areas and hence to develop the livestock production under still more strict environmental legislation. For society through production of renewable energy, protection of ground water and aquatic environments from pollution with nutrients and as an effective and cheap reduction of emissions of green house gases. Favourable framework conditions are needed. This includes incentives for farmers to invest in environmental technology and public support such as premium prices for renewable energy.

The History of Biogas in Denmark

Biogas plants are established for environmental, energy, and agricultural reasons. Following the first oil crisis in the 1970s Denmark began to develop alternative energy sources in general. The first farm scale biogas plant was built in 1975 and the first joint plant in 1984.

From the outset the plants had to be commercially viable. Their economy was based on energy sales. Through the 1980s and 1990s the development was promoted through a close public-private co-operation. This included public funding for research, development and up to 40 per cent investment grant in full-scale demonstration plants. The subsidy for investment in biogas plants was gradually reduced from 40 to 20 per cent and has been reduced to zero by the government.

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The participation of the private sector – farmers and industry – in the development has had tremendous importance for the success. In the first years it was based on trial and error and all mistakes were probably experienced. All the positive experiences was recorded through a co-ordinated biogas programme with the participation of the ministries for Environment, Energy and Agriculture, the universities, the agricultural research institute, the agricultural advisory system, industry, plant owners and other private stakeholders. During the 1990s efforts continued to standardise and modulise biogas plants, resulting in cheaper, simpler and technically stable units.

The energy production from biogas plants is subsidised through premium prices for electricity and tax exemption for the heat production. The electricity is sold to the grid and the heat from joint biogas plants is used for district heating. Heat from farm scale biogas plants is used on the farm for heating the household, the stables and drying of grain.

It is the experience in Denmark that co-digestion of manure and organic waste, from industry and households, is the best way to achieve a stable and viable economy. The addition of organic waste increases the gas production per cubic meter digester volume and hence per invested capital. In addition the biogas plants receive a gate fee for receiving the organic waste. It is a win-win situation as the biogas plants earns money and alternative waste handling options are more expensive for the industry and municipality.

From 1984 to 1998, 20 joint biogas plants were established each handling manure from up to 100 farmers within a distance of 10-15 kilometres. From 1999 to 2002 the number of farm-scale biogas plants – primarily on larger pig farms – were doubled from 30 to 60, promoted by a special government programme. Most manure based joint biogas plants are owned by the farmers involved through co-operatives.

The development in the Danish manure based biogas plants is illustrated in **Figure 1**. The increased gas production from joint biogas plants in the period up to 1998 is primarily due to the steady installation of new plants. After 1999 the increase is due to improved management and reconstruction and enlargement of existing plants. Several plants shifted from mesophillic (33-38 degrees centigrade) to thermophillic (52-55 degrees centigrade) process temperatures.

The installation of new biogas plants ceased in the beginning of this century. The primary reason is the energy policy by the current government, which has reduced the premium price for electricity from biogas and other renewable sources.

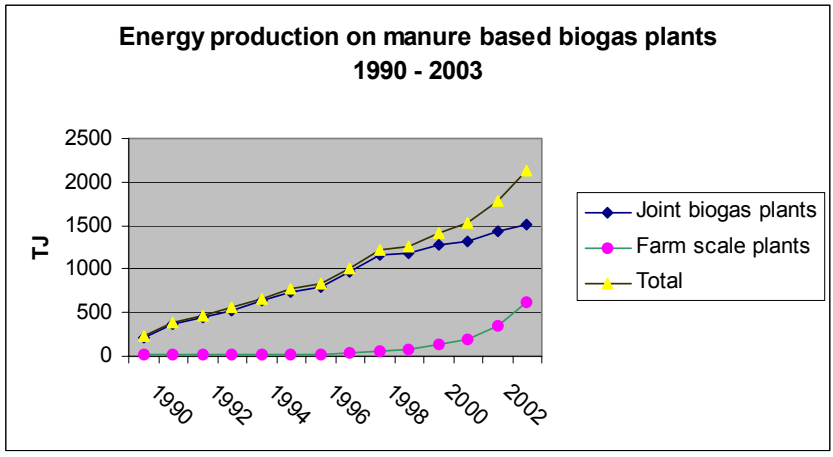

Figure 1: Energy production in Danish joint and farm scale biogas plants 1990 to 2003.

The farmers on the other hand are more than ever interested in establishing biogas plants as an environmental technology that enables them to development the livestock production despite the environmental legislation is being stricter and stricter. Either as a stand alone biogas plant or combined with separation technology. At least 10-15 large joint biogas plants are currently being planned. The farmers are only waiting for the Parliament to pass an act that increases the payment for electricity. Currently a power plant is constructing a biogas and separation plant on the island Bornholm. The Ministry of Food, Agriculture and Fisheries is constructing a biogas and separation plant at the Danish Institute of Agricultural Science.

■ Farmers Incentives

Environmental impact of agricultural production has been a hot political issue in Denmark since the mid 1980s. The farmers were facing:

- obligation to ensure storage capacity for liquid manure, initially for 6 months, which was later increased to 9 months;
- restrictions on the livestock production in terms of maximum stock density per acreage where the manure is being spread: originally 1.7 livestock units (LU) for pigs and 2.3 LU for cattle (1 LU equals 100 kg of nitrogen in the manure), now further strengthened to 1.4 and 1.7 respectively;
- obligatory minimum utilisation percentages for the nitrogen in the manure and fixed maximum total application of nitrogen in manure and fertilisers for each crop.

For the farmers there were advantages in using biogas plants to fulfil these obligations as the joint biogas plants

- efficiently redistributes manure from livestock producers to plant producers and from stables to decentralised storage tanks near the fields where the digested manure is used as fertiliser
- improves the nutrient value of the manure due to mineralisation of the nitrogen and hence optimises the application of manure to the crops compared to raw manure.

In the coming years the Danish farmers will be facing further challenges such as reduction of bad smells from application of manure and reductions in leaching of phosphorous. Digestion of the manure in a biogas plant reduces the content of organic matter and the manure becomes thinner. Therefore the digested biomass disperses much quicker into the soil which effectively reduces the bad odours.

The digestion makes it technically easier to separate the liquid manure. By simple mechanical separation technology such as a decanter centrifuge the digested manure can be split up into two fractions:

- a liquid fraction comprising 80-85 per cent of the volume containing 80 per cent of the nitrogen of which almost all is ammonium which can be utilised right away by the crops
- a fibre fraction comprising 15-20 per cent of the volume but containing more than 75 per cent of the phosphorous content and almost all the organic bound nitrogen.

The combined biogas and separation plant produces – as illustrated in **Figure 2** - an environmentally friendly liquid manure which can be utilised by the local farmers as a high value fertiliser with low impact on the environment through minimum risk of leaching and highly reduced smell. The fibre fraction contains all the environmental and societal problems (leaching of nutrients and smell). It can, due to the reduced volume, be transported to more distant places, which need organic soil improvers. The Danish Parliament has in 2006 passed a new act which makes it legal to use the fibre fraction as a biofuel to produce electricity and heat and hence totally eliminate the environmental impact. The phosphorous can be recovered from the ash.

By investing in biogas plants with separation technology the Danish livestock farmers have the option to keep up or even further increase the production. In many parts of Denmark the alternative to use this kind of proven environmental technology is to reduce the livestock production up to 40 per cent. This would have very serious impact on not only the farmers' economy but also the socio-economy of the rural areas and the Danish society at large.

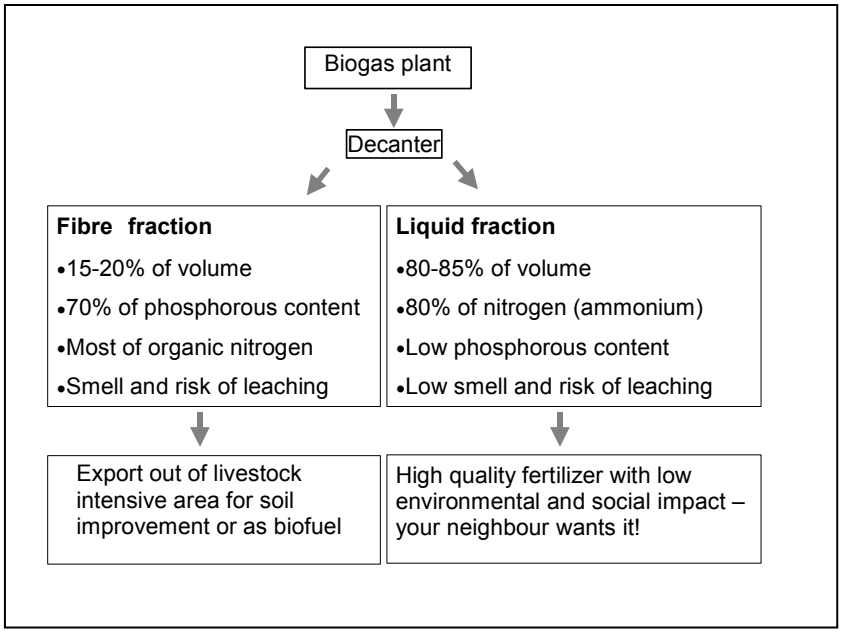

Figure 2: Combined biogas and mechanical separation plant.

■ Societal Incentives

An anaerobic digester is not only environmental equipment treating the manure in the interest of the farmer. It is indeed also a technology that gives many advantages for society in general:

- Reduces emission of greenhouse gases by substituting fossil fuel and by reducing emission of methane from manure storage facilities and N_2O from the fields, which are respectively 21 and 320 times as serious greenhouse gases as CO_2.
- Protects ground water and aquatic environment against leaching through increased utilisation of the nutrients by the crops.
- Increases life quality in rural areas by reducing obnoxious smells
- Reduces zoonoses and other pathogens in manure.
- Renewable energy and nutrient recovery from waste.
- Continued and perhaps increased agricultural and food production.
- Utilises biomass from energy crops and natural habitats that need thinning to prevent overgrowth.

Due to these – and other – societal benefits there is a willingness in many countries to support the installation of biogas plants. In Denmark a socioeconomic analyses was done in 2002 stating that Danish society earns money by establishment of new joint biogas plants. This is primarily due to the simultaneous solution of many problems, which reduces investment of public and private money in solving the problems one by one, which will be much more expensive.

Unfortunately the current Danish government that came into office in 2001 for many years didn't want to promote biogas. There are, however, indications that the policy is shifting as the government has realised that environmental issues and especially climate change has a very high priority in the Danish public. The political interest is also promoted by the fact that climate change and protection of water and environment is a priority issue all over the world, which might promote markets for industry within these key technologies. Therefore the Danish farmers – and the biogas industry – are looking forward to a change in the Danish policy which might not only open up for the national market but also internationally.

▪ Development in other European Countries

Biogas is also being promoted in other European countries. The traditional frontrunners in addition to Denmark are Austria and Germany. But also in Sweden, Netherlands, France, Spain, United Kingdom etc. there is a growing acknowledgement of the multifunctional advantages in biogas. Especially in Germany the government has been promoting the development of biogas through very favourable framework conditions. To compare the situation the Danish biogas plants are being paid $122 CAD per MWh electricity (which will be reduced to $81 CAD after 10 years in new plants). German plants are paid $145 CAD per MWh on large joint biogas plants and up to $300 CAD in small farm-scale biogas plants using energy crops. Further development for biogas in Denmark and most other countries is as a tool to solve the problems related to livestock production whereas the future in Germany is also in biogas plants with energy crops as main raw material.

▪ Framework Conditions

All over the world the development in the biogas sector – and the extent to which biogas is an option for the farmers - depends on the framework conditions. This is seen in the past and current situation in Denmark. Here the basis for development was laid through the co-ordinated public-private co-operation in the 1980s and 1990s. At the same time there was a pressure on farmers to invest in environmental technology and the payment for electricity

gave an acceptable economy in the biogas plants. For some years the farmers' incentives were low – they had fulfilled their obligations. Now they face new threats and they seek new technological solutions. The framework conditions for biogas is, however, currently very poor. Therefore, there is a risk that farmers will have to reduce livestock production with loss in private and social comfort. Or they may invest in other kinds of technology that solves their current problems – leaving a bill for the rest of the society for isolated solutions for other problems.

■ Conclusion

Biogas is a proven and technologically mature technology. It may therefore be an interesting option for farmers to handle the environmental challenges. Combined with commercial available separation technology it may furthermore be an efficient tool to enable farmers to expand production despite stricter environmental legislation. Biogas plants offer in addition many advantages to the public, which therefore should be willing to ensure a viable corporate economy.