INCREASE AND REGULATION OF BIOGAS PRODUCTION

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1 INTRODUCTION

Since 1984 the centralised co-digestion plant concept was developed in Denmark. Earlier attempts to develop smaller scale on-farm biogas facilities largely failed due to technical and economical problems. The idea of the centralised plant concept was that a centralised facility, to which several farmers supply livestock manure, might supply both heat and electricity to a local village or community. In 1988 an ambitious government technology development plan was launched, and before the new millennium 20 centralised plants were established.

However, in the beginning technical problems were significant, and it turned out that the biogas production potential from the manure alone was not sufficient to secure financial viability. So very soon plants started supplying organic waste from food processing industries to the plants because it represented higher production potentials. After some years of operation the centralised co digestion plant concept was considered both technically and economically viable. But as the number of plants increased, and also a large number of on-farm plants were initiated, demand for suitable organic waste accelerated, which made the co-digestion strategy increasingly difficult to persue. Consequently there is a need for alternative inputs of biomass resources.

Another challenge is the seasonal variation in heat consumption, which in many cases lead to unutilised heat surpluses during summer seasons, and heat deficits that must be covered by other energy sources, sometimes of fossil origin. Other European countries demonstrated mainly corn silage as an excellent alternative substrate to be applied when electricity sales prices are sufficiently high.

The project Increase and Regulation of Biogas Production, funded by the Danish Energy Agency, aims at the demonstration of how biogas production can be both increased and regulated by the use of storable energy crops and fibre fractions from pre-separated livestock manure.

2 IDENTIFICATION OF THE PROBLEM TO BE ADDRESSED

From experience we know (Nielsen et al. 2002) that most centralised plants need to produce approx. 30-35 m^3 biogas per ton biomass digested to make the company financially viable. So far this was not possible if based solely on liquid livestock manure, as Danish slurry holds relatively low dry matter content. On average liquid manure is anticipated to contribute to approx 20 m^3 biogas per ton manure digested. So in fact there is a 50% gap before a system based on such feedstock can be expected economic. So far both on-farm and centralised plants closed this gap by supplying organic industrial waste mainly from food processing industries. However the economic dependence on this feedstock lead to considerable increase in prices for the procurement of suitable waste. So indeed there is a need to find alternative biomass feedstock that may substitute organic industrial waste and thus close the biogas production gab. The project aims at demonstrating how organic industrial waste can be substituted by supplying storable energy crops or fibre fraction from pre-separated liquid livestock manure. In Table 1 is estimated the economic potential of doing so for the four participating plants. In the table the annual treatment capacity of each plant is listed. From this biogas production is estimated using a gas-yield of 20 m^3 biogas per ton digested, corresponding to the level if only liquid manure is digested. Then 30 m^3 biogas per ton is used, which represent the economic break even level today when organic industrial waste is supplied. But if this extra biogas production could be achieved by the application of fibre fractions from pre-separated liquid manure costs for waste procurement could be eliminated. Based on experience DKK 1-1,5 per m^3 biogas is often paid for waste procurement. The immediate economic potential in following this strategy is represented by these cost savings, which are presented in the right column of Table 1. The estimates are based on application of fibre fractions from pre-separated liquid manure or other biomass resources that can be procured costless as far as the plant is concerned.

If for example corn silage was to be used instead the economic potential would be reduced, because the company would then have to purchase corn silage.

TABLE 1 **Economic potential in substituting organic waste by fiber fraction from pre-separated liquid manure.**

Company	**Treatment capacity. Ton manure digested per year**	**Biogas production if based only on liquid manure. m^3 biogas per year**	**Biogas production if based on liquid manure and fibre fraction. m^3 biogas per year**	**Economic potential: Cost savings in waste procurement if waste is substituted by fibre fraction from manure DKK per year**
V. Hjermitslev	22.000	440.000	660.000	220.000-330.000
Vegger	14.600	300.000	440.000	140.000-210.000
Baanlev	109.500	2.200.000	3.300.000	1.100.000-1.650.000
Linkogas	200.000	4.000.000	6.000.000	2.000.000-3.000.000

It appears from Table 1 that there is a considerable economic potential in swiching from using costly organic industrial waste to costless fibre fraction from manure, as waste procurement costs are thereby eliminated. The potential will increase if biogas production could be further increased.

In Denmark biogas from centralised co-digestion plants is used for combined heat and power production. Electricity is sold to the public power grid, and heat is sold and distributed in district heating systems. There is a need for heating of houses approx 9 months every year. However the demand is not the same throughout the year which appears from the below figure 1. And in the warmest period during summer season very little heat is consumed. This in fact is a challenge to plant economy, as they would normally desire to seek full capacity utilisation all year around. In addition, today no plants are able to meet the winter peak heat demand during the winter season, which then has to be covered from other energy sources. Figure 1 illustrates the situation where a constant heat supply leads to a significant heat surplus during summer seasons and a corresponding deficit during winter seasons.

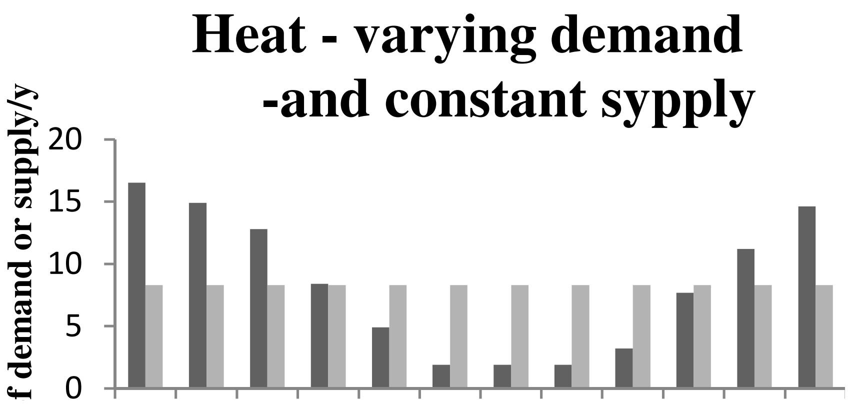

FIGURE 1 **An example of varying heat demand and constant heat supply**

This situation is very widespread among centralised plants in Denmark, and even more characteristic among on farm plants, of which some produce heat surpluses all the year round. It is evident that this situation leaves room for optimisation if biogas production can be regulated according to seasonal variation in heat demand. The figure implies that 28% of heat consumption cannot be met by heat from the biogas plant. It is evident that plant revenues may be increased significantly if production could be regulated and increased during winter seasons. The figure also implies that the heat production in question is actually produced, but at the wrong time of the year, and thus cannot be utilised. Most favourable solution would be to find ways to utilise the heat by finding new customers or other forms of heat utilisation. Another way to go is to save the extra biomass resources and thereby reduce production during summer seasons, but this is more complicated, as then also electricity production would be reduced and thus revenues decline. But if the peak heat demand could be met by increasing biogas production, the economic potential in doing this would among the four participating plants range from DKK 500.000 to 1.600.000 representing an increase in heat sales by approx one third.

Also in the project, it will be investigated to what extent biogas production can be regulated on a daily basis. This is because demand for both heat and electricity varys significantly on a 24 hour basis. If production can be regulated, some plants would be enabled to sell especially electricity production at higher prices during day hours than the general feed-in tariff allows, and thus benefit from differences in electricity sales prices. However this is only tested in lab and pilot scale, as high-load experiments of this kind may be too risky to carry out at full scale. The trials are carried out at the research and test biogas plant at Faculty of Agricultural Sciences at Aarhus University.

3 DESCRIPTION OF PARTICIPATING PLANTS AND THEIR ACUTAL SITUATIONS

The project includes four existing centralised co-digestion plants, all characterised by the need to increase biogas production and in a situation where an ability to regulate production due to seasonal variations in heat demand may improve economic results.

The first plant is Vester Hjermitslev Energiselskab, which is actually the first centralised plant established in Denmark back in 1984. It is a small plant, supplying only approx 60 ton livestock manure and industrial waste on a daily basis. The plant is obliged to supply all the heat necessary for the village all year round. Being a small plant it is highly dependant on organic waste supplies, as very high gas yields were necessary to make the company economic. This was easy when organic waste was ample, but increasingly difficult as the demand for waste was gradually increased, and now it is hardly viable for the company to follow this strategy, as they have to pay high prices to procure waste in sufficient amounts. But as it has to supply sufficient heat, extra heat has in recent years been produced from heating oil at a cost level that exceeds the revenues from selling the heat. So in this case action must be taken to meet these challenges. The management of the plant intends to do this buy supplying corn silages during winter seasons.

The next participating plant is Vegger Energiselskab, with a situation very similar to the above mentioned. The plant is even smaller, only approx. 40 ton on a daily basis. For many years this plant was actually able to procure sufficient amounts and qualities of organic waste to maintain a very high biogas production. But for the mentioned reasons this situation has changed dramatically. Furthermore, the plant needs a major renovation, and it has been decided to make a very offensive investment to enlarge the production capacity of the plant in order to enable the company to meet the winter season heat demand. They intend to do that by supplying fibre fraction from pre-separated manure.

The third participating plant is Baanlev Biogas A/S. This plant has a treatment capacity of approx 300 tons per day. This plant suffers from insufficient dry matter contents in the manure supplied to the plant, which makes it difficult to make the plant economic. The management of this plant developed its own strategy to overcome this problem. They plan to purchase in the first place one, later perhaps several mobile separators, which can be moved from farm to farm and separate the manure. The product will not be a compost like fibre fraction, but rather a more concentrated, but still liquid, manure, with a dry matter content of approx. 10 % which should allow the operation of the plant to be economic. Another significant advantage in doing this is that the concentrated liquid fraction can be transported in the same traditional slurry tankers, which are widely used for liquid manure transportation by biogas plants in Denmark. This is a special issue to be demonstration by this project.

The fourth and largest participating plant is the Linkogas plant, with a treatment capacity of 550 ton per day, which makes this it the largest plant in Denmark, as far as treatment capacity is concerned. Linkogas provides heat for the local town. There is the classic utilisation problem during summer seasons, and the peak heat consumption is met by burning wood pellets. It is the ambition to mitigate the use of pellets. A considerable enlargement of the plant is also planned, which may create a surplus situation not only during summer seasons. To meet this challence the management of this plant is open for a solution, which would involve upgrading of the biogas and distribution of it via the natural gas grid.

4 CONCLUSIONS

The project; Increase and Regulation of Biogas Production, funded by the Danish Energy Agency (EUDP Program), is a demonstration project. At four existing centralised co-digestion plants it is demonstrated how biogas production can be both increased and regulated by the use of storable energy crops and fibre fractions from livestock manure. From the program investement subsidies are granted for the feed-in equipment necessary to enable the utilisation of these concentrated biomass substrates. The plants will make this and additional investments in storage facilities. The necessary equipment is scheduled to be in place end 2010 or early 2011, and from that point the very demonstration period is started.

When experience from the operation of the systems are gained it is disseminated at seminars organised by the Danish Biogas Plant Association. In the second half of the demonstration period comprehensive economic analysis of the economic potential is carried out, not only for the participating plants but for the biogas business in general. In this paper only preliminary assessments of the economic potentials are presented, but the perspectives seem very promising

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- Vester Hjermitslev Energiselskab
- Vegger Energiselskab
- Baanlev Biogas
- Linkogas

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