AgroTech A/S
+45 8743 8400
www.agrotech.dk

AgroTech Skejby
Agro Food Park 15
DK-8200 Aarhus N

AgroTech Taastrup
Højbakkegård Allé 21
DK-2630 Taastrup

AgroTech Holeby
Maribovej 9
DK-4960 Holeby

Methane emission from Danish biogas plants

Economic Impact of Identified Methane Leakages

Project: ForskEl 2013-1-12093

Report

By Kurt Hjort-Gregersen
AGROTECH
March 2014

Methane emission from Danish biogas plants

Economic Impact of Identified Methane Leakages

By Kurt Hjort-Gregersen, AgroTech

AgroTech

AgroTech transforms science into business
through knowledge-based consultancy, technological services and innovation within the fields of:
Environment / Plants / Food

1. BACKGROUND

Considerable efforts have been taken to develop biogas technology in Denmark over the recent 25 years. Especially successive R&D, demonstration and monitoring programs conducted by the Danish Energy Agency has been successful. In addition, a favorable environment of frame-work conditions has been created, which has allowed the technology to develop and the number of plants to increase. Part of the success has been the general recognition that biogas plants serve not only as energy producers, but also as an attractive tool in Green House Gas mitigation. In addition biogas plants can also be considered as facilitators of improved fertilizer efficiency in livestock farming.

So far this development has resulted in the construction of 25 centralized biogas plants and 60 farm scale biogas plants.

Biogas production has during the last decades taken a prominent position in government energy planning, and in 2009 the Green Growth plan stated the ambition of using 50 % of livestock manure for biogas production.

2. METHANE LEAKS AND THE ENVIRONMENT

In Denmark liquid livestock manure must be stored for six to nine months to reduce leaching of the manure nutrients in periods without plant growth. During storage, part of the volatile organic carbon content of the manure can be converted and emitted as methane. Methane is a potential Green House Gas with a Global Warming Potential value of 25, which means that 1 ton of Methane has a warming potential equal to 25 ton carbon dioxide. When manure is treated in a biogas plant, this methane production is increased, captured and used for energy production. Consequently biogas production not only prevents methane to emit from conventional manure storage tanks, it also substitutes the use of fossil fuels in energy production. Indeed a win-win situation.

3. METHANE LEAKAGES AT BIOGAS PLANTS

Historically the focus on methane leakages at biogas plants has been concentrated on the small amount of un-burned methane emitting from the exhaust system of the engines of the Combined Heat and Power units, in which methane is usually converted into heat and power. Engine manufacturers have therefore tried to optimize their equipment. Meanwhile the Danish Government made methane emissions subject to environmental taxation.

Until recently only little attention has been paid to methane leaks from the biogas production facility itself. There are safety standards that must be met, but no one has so far focused on the detection of methane leaking from the biogas facilities.

Many key actors in the biogas business were taken by surprise by the findings in the project “Methane Emissions from Danish Biogas Plants”, in which AgroTech A/S and Dansk Gasteknisk Center identified numerous leaks at Danish biogas plants.

It is not that methane or biogas emissions are never heard of. Most likely leaked biogas has been part of odour problems that haunted a number of plants in the early stages of the technology development. Also corroded digester roofs turned out to leak biogas and both untight membrane and concrete covers of manure storage tanks and gas storage tanks has been known to have caused leakages of biogas and thereby methane.

4. ECONOMIC IMPACT OF METHANE EMISSIONS

The detection of methane leakages was carried out by using an optical gas imaging camera. 66 biogas plants were invited to participate in the project, of these 14 plants wanted to be involved in the project. The identification of leakages at biogas plants were successfully performed at nine plants where 52 leakages were identified in total.

One thing is the detection of methane leakages; another thing is the quantification of the amount of methane leaking from the identified leaks. Both issues were addressed in the project.

Table 1 displays the number of leaks detected by the camera, and the measured annual emission loss of methane from each biogas plant.

Quite considerable variation was found in both the number of leaks among the plants as well as the emitted quantities of methane. Centralized plants are often larger in size and have in general a higher production potential than farm scale plants, and as it seems, also a high potential for methane leaks.

Environmental impacts of methane emissions have previously been addressed. But there is also an economical aspect, as lost methane represents a value that could otherwise be capitalized as a profit to the farmer or the biogas company. Especially because the costs of the biogas production has been paid already. Also the need for process energy is already covered. So if the emissions through leakages could be avoided the full value of the methane can be achieved.

Most new biogas engines have an efficiency of close to 40 % for electricity and 50 % for heat, which means that 1 Nm^3 methane is able to produce about 4 kWh electricity and 5 kW heat.

Most farm scale plants are only able to utilize a small amount of the heat production. Most likely they would not be able to capitalize the heat value from reduced methane leaks. Contrary most centralized plants sell their heat to district heating systems; however, in many situations the demand for heat is lower than the heat production during the summer periods, which mean that only a part of the heat production normally are utilized. So centralized plants are likely to be able to put value to 50 % of the increased heat production as a consequence of the reduced methane leaks

At an electricity price of 1.15 DKK/kWh the sale of the electricity that can be produced by 1 Nm^3 methane will amount to 4.60 DKK/Nm^3 methane.

Heat is often sold to district heating companies for approx. 600 DKK/mWh. Therefore, if 50% of the heat production is utilized, the extra heat production from 1 Nm^3 methane will amount to 1.50 DKK/Nm^3 methane.

In other words, if the estimated methane leaks could be avoided, farm scale plants are likely to profit from additional electricity sales, and centralized plants from additional electricity sales and half of the amount of extra heat sales.

Farm scale plants are therefore likely to realize 4.6 DKK/Nm^3 reduced methane emission, while centralized plants are likely to realize 6.1 DKK/Nm^3 reduced methane emission

In Table 1 these preconditions are used to calculate the lost annual profits as a consequence of methane leaks, which at the same time, represent a potential for increased profits.

Table 1. Number of leaks and the measured emission loss at different biogas plants, and the calculated lost annual profits/potentially improved profits at each plant.

Biogas plant	Type of biogas plant	Number of leaks identified	Annual methane-production Nm^3 CH_4	Measured annual loss of methane Nm^3 CH_4	Rate of lost methane %	Lost annual profits DKK
1	Farm scale	10	300,000	1,600	0.6	7,360
2	Farm scale	4	500,000	4,400	1.0	20,240
3	Farm scale	0	100,000	0	0.0	0
4	Farm scale	5	500,000	3,900	0.8	17,940
5	Farm scale	2	900,000	10,100	1.1	46,460
6	Centralized	3	1,300,000	28,000	2.1	170,800
7	Centralized	14	4,900,000	276,000	5.7	1,683,600
8	Centralized	3	1,200,000	123,000	10.0	750,000
9	Centralized	11	3,900,000	131,000	3.4	799,100

Lost annual profits due to methane leakages were found to vary between 0 to almost 1.7 mio. DKK per biogas plant.

5. CONCLUSIONS

Loss of methane is loss of money. Therefore, if the methane leakages at biogas plants could be totally avoided, most of the plants would achieve considerable profits.

Both centralized and farm scale biogas plant would profit from increased sale of electricity. As farm scale plants most often are unable to place value on an increased heat production, they may only profit from increased electricity sales. Contrary many centralized plants may be able to place value on half the extra heat production and thus profit from both increased electricity and heat sales.

Farm scale plants are likely to realize 4.6 DKK/Nm^3 reduced methane emission

Centralized plants are likely to realize 6.1 DKK/Nm^3 reduced methane emission

Based on the findings in this project, regular detection of methane leaks at biogas plants are highly recommendable.