Raw materials for biogas plants

Seminar about optimisation of raw materials for biogas plants at the research centre Forskningscenter Foulum 29th of January 2009 at 10 AM to 4 PM

Schedule:

- Welcome and introduction. Michael Støckler, CBMI.
- How large are the potential biomass resources in Denmark for biogas? Uffe Jørgensen, Faculty of Agricultural Sciences, Aarhus University.
- Which financial possibilities does the latest energy settlement provide for biogas production and for payment of new raw materials? Kurt Hjort-Gregersen, Institute of Food and Resource Economics, University of Copenhagen.
- Comparison of dry matter output, biogas convertibility and net energy surplus of various crops for biogas. Poul Erik Lærke, Faculty of Agricultural Sciences, Aarhus University.
- Dry matter output and biogas convertibility of maize and festulolium at various localities and harvest times. Søren Ugilt Larsen, AgroTech.
- Possibilities of optimising the energy content of livestock manure. Henrik B. Møller & Alastair James Ward, Faculty of Agricultural Sciences, Aarhus University.
- Energy utilisation of grass from extensive areas. Lisbeth Nielsen Natur & Landbrug and Henrik B. Møller, Faculty of Agricultural Sciences, Aarhus University.
- How can the convertibility of biomass to biogas or ethanol be increased through pre-treatment, and what will it cost? Hinrich Uellendahl, Centre of Biotechnology & Bioenergi, University of Aalborg Copenhagen
- Is there future potential in decentralised production of ethanol, biogas and feed from beets? Karl Martin Schelde, CBMI.

Price: DKK 100 for students and DKK 300 for others, including lunch.

Registration: No later than the 22nd of January to Mette Toft Christensen, e-mail mtc@cbmi.dk, ✆ +45 8999 2503

CBMI AgroTech

COPENHAGEN INSTITUTE OF TECHNOLOGY
AALBORG UNIVERSITET KØBENHAVN

Gasification plant for waste

Title:	4781 - High-temperature slagging waste gasifier, Phase 1
Responsible:	TK Energi, Thomas Koch, ✆ 4618 9000
Grant:	PSO – DKK 4,194,000

The purpose of the project has been to evaluate a concept for a gasification plant for waste as well as to plan select components for a pilot plant.

The first analysis showed that a so-called entrained flow gasifier would be a sensible choice. The technology has been used commercially for coal, and it appears that the heavy metals from the waste will be encapsulated in the slag, which means that the risk of leaching will be minimal.

The preliminary tests were carried out in a vertical cyclone reactor with dried waste water sludge as fuel. It was possible to get a bit of slag out of the test, but it was not possible to achieve satisfactory control of the gasifier. Therefore, it was decided to construct a new horizontal plant where fuel and oxygen is blown in through one end, while gasification gas and slag comes out the other end. The advantage of that design is that a slag bath is formed at the bottom of the reactor, where large particles are caught. Thus, they get a longer retention time than the gas, which sets lower demands for trituration of the fuel.

Tests with the new plant showed that it is possible to gasify waste water sludge, but that the outlet of the reactor has to be changed. Analyses of the slag showed that the risk of leaching of heavy metals is lower than for slag from Danish waste incineration plants, and that the slag meets the requirements for use as construction material.

In preparation for the construction of the next gasifier, a design study has been made of a number of relevant components, where the focus has for example been on:

– A new technology for pre-treatment of waste at low temperatures.
– A new gasifier design that ensures that the outlet cannot be blocked by slag.
– A new system for purification of the gas.
– A financial study that reviews the finances of a commercial plant

photo: tk energi

Tests with gasification of waste water sludge in a horizontal test reactor at TK Energi.

Optimisation of staged gasification plant

photo: biosynergi proces

A peek into the reactor at the gasification plant in Græsted.

Title:	5729 - Upgrading and optimisation of the plant operation of staged gasification plant (the castor plant in Grædsted)
Responsible:	BioSynergi Proces ApS, Henrik Houmann Jakobsen, ✆ +45 4586 1430
Grant:	PSO – DKK 2,942,000

With aid from the Danish Energy Agency's development programme for renewable energy, BioSynergi Proces ApS finished the establishment of a so-called open core plant for gasification of wood chips in 2003-2004. The gas is used for the production of electricity and heat through a gas engine that is connected to an electric power generator.

The current project has been about further development of the plant, with particular focus on reducing the daily tending tasks and on ensuring stable and unmanned operation of the plant. Furthermore, there has been as special sub-assignment that has consisted of gaining increased insight and achieving practical experience with optimisation of the engine operation. At the start of the project, the plant was only able to supply electricity for the network for about 200 hours, but at the end of the project, 2,500 hours of engine operation on gasification gas had been achieved.

A more detailed description of the project's results is available in the two reports from September 2008, which can be obtained by contacting BioSynergi Proces ApS.

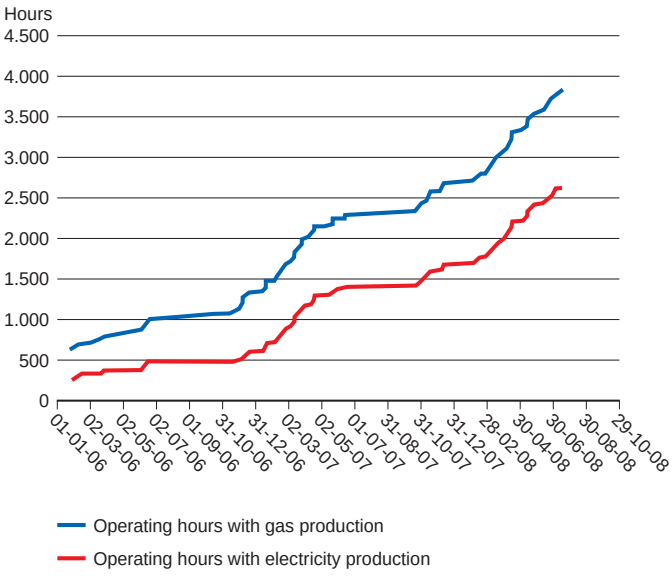

Figure 1. The accumulated number of operating hours with the gasification plant from the 1st of January 2006 until the end of the project in the autumn of 2008.

Optimisation of gas output from biogas plants

Title:	33030-0017 - Methods for optimisation of biogas output of liquid manure-based biogas plants
Responsible:	The Technical University of Denmark, Rena Angelidaki, ✆ +45 45251429
Grant:	EFP – DKK 7,000,000

The purpose of the project has been to investigate the possibilities of increasing the biogas production from liquid manure through serial operation of reactors, change of stirring procedures and post-treatment of fibres.

The results show that when two reactors are series-connected, the gas production can be increased by 11 - 17.8 percent compared to parallel operation. The increase in gas production mainly comes from the second reactor in the series, and it is vital that both reactors operate at the same temperature in order to ensure a stable process. The tests with change of stirring procedures show that the gas production can be increased by 12.5 percent by changing from continuous stirring to only ten minutes of stirring in the reactors each day.

Through post-treatment of degasified fibres, it is possible to achieve improved gas output through aerobe treatment and trituration, while chemical treatment does not result in any significant improvement.

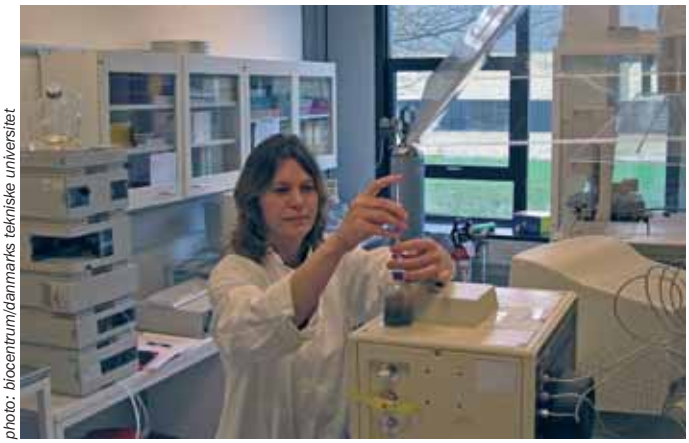

photo: biocentrum/danmarks tekniske universitet

Test at the Technical University of Denmark show that the biogas production can be increased to series operation of reactors, change of stirring procedures as well as post-treatment of fibres.

The market for biofuels

Title:	33032-0146 – REFUEL – Renewable fuels for Europe
Responsible:	COWI, Henrik Duer, ✆ +45 4597 2211
Grant:	EFP – DKK 693,000

Refuel, which stands for "Renewable Fuels for Europe", is a large EU-financed project, where a so-called "road map" describing how the market for biofuels can develop in the EU up to the year 2030 has been developed.

In this project, market opportunities and potentials for biomass resources have been analysed for countries in the EU 27 and Ukraine, and scenarios have been set up for the development up to the year 2030. Furthermore, specific suggestions have been made for framework conditions, and the political means of control have been assessed.

The project has shown that there is enough biomass potential to ensure significant supply of biofuels, but it is vital to accelerate the development of new 2nd generation technologies in order to ensure sustainable development.

X-ray analysis of biofuels

Title:	5773 - X-ray analysis of CO_2-neutral fuels
Responsible:	Danish Technological Institute, Lars Nikolaisen, ✆ 7220 1302
Grant:	PSO – DKK 617,000

The traditional chemical analyses of biofuels and ash from burning of biomass are expensive as well as slow. An obvious alternative could be x-ray analyses, which are less expensive as well as quicker, but experience from this project shows that the results can in some cases deviate from the traditional chemical analyses.

The most conspicuous is a consistently large deviation with regard to the element silicon, but also with regard to the lighter elements, there are large or small variations. For the other substances, there is pretty good consistency between the reference method and the x-ray analyses.

For most fuels, the mass balance of chlorine is very precise with deviation down to 0 percent. This may be connected to the fact that chlorine is mainly in the flue gas and not so much in the ash.

The opposite is the case with sulphur. There, the main part of the element is in the ash and only a minor part is in the flue gas. In several cases, more sulphur was found through the x-ray analysis than through the reference method, while there was good consistency between the two methods in other cases. The reason for the deviating mass balances of sulphur is unknown.

Gasification of biomass for fuel cells

Title:	33030-0113 and 33031-0093 – GreenFuelCell – Integreret forgasnings-brændselscelleanlæg (SOFC)
Responsible:	TK Energi A/S, Thomas Koch ✆ +45 4618 9000
Grant:	ENS – DKK 1,729,000

The purpose of the project has been to develop a scalable staged gasification concept where the gas is so pure that it can be used in a fuel cell.

In this project, two parallel tracks were developed - one at ECN in the Netherlands and one at TK Energi in Køge. At the same time, researchers at the Technical University of Denmark and RISØ worked on removing the tar content of the gas. ICT in the Czech Republic and CEA in France worked on removing inorganic components from the gas. In France, CEA worked together with Dutch ECN on developing the fuel cells, while Force Technology in Denmark handled the system study.

ECN's gasification concept failed, as the system for gas purification generated large amounts of soot. At first, TK Energi succeeded in demonstrating the concept, but in the final version, there were problems with the part of the reactor where the pyrolysis takes place. At the Technical University of Denmark and RISO, the researchers gained new knowledge about how to remove tar from a staged gasification plant, while ICT and CEA did not manage to find new methods for purification of the gas. At ECN and CEA found new limits for how sensitive the fuel cells are to typical pollutants in the gas.

Apart from support from the energy research programme, the project has been given support from the EU's 6th framework programme.

Co-firing of biomass and natural gas

Title:	6526 - Co-firing of biomass with natural gas and NOx formation through biodust firing
Responsible:	DONG Energy, Peter Simonsen, ✆ +45 9955 1111
Grant:	PSO – DKK 4,500,000

The purpose of the project has been to achieve new knowledge about co-firing of biomass and natural gas at power plants using dust firing. In that connection, measurements have been carried out at the plant Avedøre II as well as a minor test plant at the Technical University of Denmark, and a number of valuable experiences have been gained about emission of nitrogen oxide (NO), burnup of wood particles and formation of deposits in power plant boilers.

Among other things, the results show that no matter which combination of fuel you use, the emission of NO can be reduced by dividing the burning into two stages, and at Avedøre II, it is possible to minimise the emission through proper selection of operating parameters. The highest emission was measured at firing with oil. When using wood combined with natural gas, the emission did not depend of the percentage of wood.

The project group has made a detailed description of combustion of wood particles at dust firing. At the Technical University of Denmark, the wood particles were exposed to powerful heating, which resulted in a significant release of pyrolysis products and a low coke fraction of 2-7 percent. In most tests with powerful heating, spherical, very porous coke particle were formed. The tests at the Avedøre plant showed that up to 99.8 percent of the wood burned out at a content of O_2 as low as 1.5 percent.

As we all know, the use of biomass in power plants can cause problems with deposits and corrosion, but at the Avedøre plant, only moderate deposits were found. When wood is burned together with oil or natural gas, alkali metal usually occurs as sulphate in the deposits, while there is hardly any chlorine. When adding fly ash from coal firing, there is an increased content of alkali-Al-silicate in the deposits.

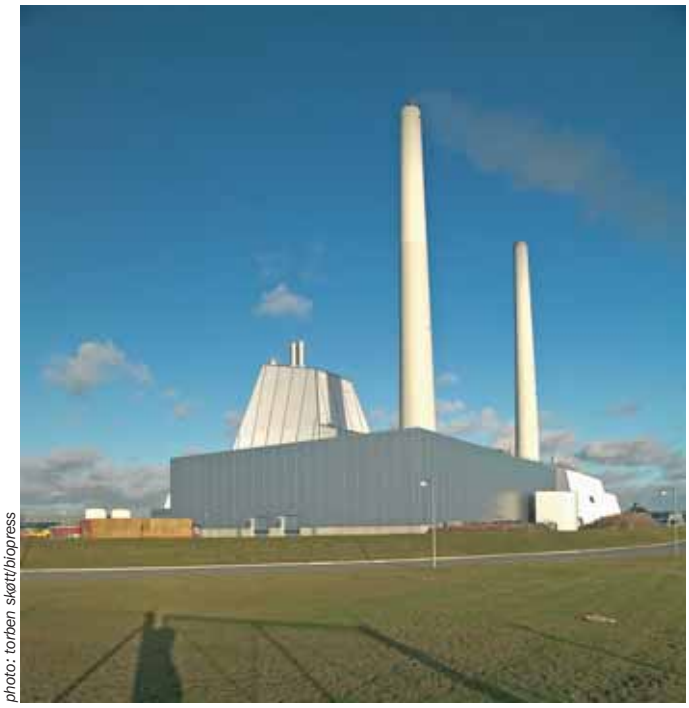

photo: torben skøtt/biopress

At the Avedøre plant in Copenhagen, only moderate deposits were found in the boiler for biomass.