Nordic Biogas Conference

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7th NORDIC BIOGAS CONFERENCE – The next wave

April 9th–10th 2019, in Oslo

Hyperthermics transforms biomass and raw material into sustainable products using nature's own organisms living under extreme temperatures. Being among the first inhabitants on the planet, they are extracted from places deep in the earth or hydrothermal vents on the seafloor, heated by volcanic activity.

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Hyperthermics create a sustainable environment for future generations.
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Welcome from the Mayor of Oslo

(Foto: Oslo kommune/Sturlason)

Oslo is growing fast. By 2030, an additional 100,000 people will call Oslo home. The trend is world-wide. Today, roughly half of the world's population live in cities. In a few decades, that number will be two thirds.

Cities account for the majority of emissions and pose one of the biggest threats to resources and the environment. Therefore, cities need to grow smart and climate friendly.

As European Green Capital 2019, Oslo will take on the task to try out new solutions and share our experiences with others. An important area of interest is the biogas industry. Oslo has taken many steps in the past to develop a fully integrated value chain for biowaste. We look forward to share our experiences at the Nordic Biogas Conference 2019.

Marianne Borgen
Mayor

Welcome to the 7th Nordic Biogas Conference

I am very happy to wish you all welcome to the 7th Nordic Biogas Conference (NBC) on behalf of all the organisers. We have put together a program that will showcase the rapid development in the biogas sector in the Nordics and elsewhere. This week three exiting bio-waste events are taking place in Oslo the European Green Capital. Included the ISWA Beacon conference Apr 8, we are 300 participants from 19 countries and more than 30 speakers. I am sure we will all learn, inspire and be inspired these days.

Thank you to the City of Oslo for co-hosting the event, to all the speakers, poster presenters, sponsors and exhibitors supporting NBC. And lastly thank you for coming!

I hope NBC will enhance cooperation, establish new business relationships and broaden our perspectives. Enjoy the conference and your stay in green Oslo!

Jens Måge, Chairman of the organising committee

Avfall Norge
Suomen Finnish Finlands Biokaasuyhdistys Biogas Association Biogasförening
Avfall Sverige
Foreningen Biogasbranchen
SORPA
Oslo kommune Energigjenvinningsetaten

PROGRAM FOR NBC 2019

• Tuesday, April 9 •

08.30–09.00: Regsitration and coffee/tea.

09.00–10.30: Opening session – The big picture. The carbon neutral society and the "green shift"

09.03– 09.08: Welcome to the Environmental Capital of Europe. Marianne Borgen, The Mayor of Oslo.

09.12– 09.35: Biogas, more than "just" energy – Why Oslo has invested in biogas for a cleaner city, contributing to a circular economy and sustainable food production. Daniel Rees, Secretary of Environment and Transport, City of Oslo.

09.35–10.05: Global economics and market outlook. The shift from fossil to renewable energy. Thina Margrethe Saltvedt, Senior Advisor Sustainable Finance Nordea Bank (former Chief Analyst oil and gas).

10.05– 10.15: Sum up/ Questions.

10.15– 10.45: Break, coffee/tea and mingling in the exhibition area.

10.45– 12.00:

Parallell 1; **Biogas utilisation Market update and technology status.**

Parallell 2; **Biogas utilisation New trends and emerging technologies.**

12.00– 13.30: Lunch, mingling and visits to the exhibition and poster area.

13.30– 14.45:

Parallell 3; **Biofertilizer / digestate. Securing the whole value chain. How to turn digestate from a cost to an asset?**

Parallell 4; **An outlook on policy, regulations and frameworks in the Nordics and EU.**

14.45– 15.15: Break, coffee / tea, cake and mingling in the exhibition area.

15.15–16.15: Status and potential for biogas production in the Nordics

15.15: The future of biogas – Biogas production and potential in the Nordics.

15.35–16.00: Developing a Nordic Gas Ecosystem – the role of Biogas. Jukka Metsälä – Vice President for Traffic, Gasum Group.

16.10–16.20: Sum up / Questions.

16.20–17.00. Closing session day 1 – The circular economy of biogas

16.20–16.50: Why go circular? The circular economy of biogas - tackling scarce resources and climate change. Henrik Wenzel, Professor University of Southern Denmark.

16.50–17.00: Sum up and close day 1.

19.00–21.00: Conference dinner at the hotel.

• Wednesday, April 10 •

08.30 –09.00: Registration and coffee/tea.

09.00–10.30: Opening session – Happy customers and a sustainable world with biogas

09.05 –09.25: From the "big picture" to Happy Customers! What says the customer? What are the benefits, why do we choose biogas? Fast developments in the European markets! Xavier Pontone, Vice President Europe Air Liquide Advanced Businesses and Technologies.

09.25 –09.50: How can biogas contribute to a more sustainable world? – What will be the "next wave" for biogas? David Newman, president World Biogas Assocation.

09.55 –10.45: Poster session – 8 chosen abstracts are presented orally

10.45 –11.20: Break, coffee/tea and mingling in the exhibition area.

11.20 –12.30

Parallell 5; **R&D in production technology for biogas. Gasification and the potential to use forrest residues.**

Parallell 6; **Raw materials for biogas – potential, new trends, technologies and value chains Manure and waste from agri, fish sludge, human sludge etc.**

12.30–13.45: Lunch, mingling and visit to the exhibition and poster area.

13.45–14.30: Benefits of biogas in a sustainable energy system. How to grow the market using certificates and guarantees

13.50–14.10: Biogas production, infrastructure and storage systems. Benefits of biogas in the energy system. Jean-Marc Leroy, Executive Vice President External Relations, ENGIE.

14.10–14.30: How to grow the market for biogas - perspective on mass-rollout and certificates. Philip Fjeld, Chief Executive of CNG Fuels Ltd.

14.30–15.00: Nordic success stories

14.35–14.50: The green shift revolution: Hyperthermics is pioneering a fermentation technology that uses ancient living organisms to produce biogas at 80 degrees Celsius with high output. Erlend Haugsbø, COO Hyperthermics.

14.50–15.00: Production of vehicle fuel from landfill gas in Iceland – carrying the Nordic Swan environmental label, as the only fuel in Iceland. What have been the success crierias?

15.00–15.30: Break, tea/coffee mingling in the exhibition area.

15.30–16.35: Closing session – The way forward – "the next wave"

15.30–16.00: Biogas and the Sustainable Development Goals - how are they connected? What will be the "next wave"? Mats Eklund, Professor in Environmental Technology and Management, Linköping University, Sweden.

16.00–16.10: Success stories from the Nordics: Biogas operations further enhanced by Valmet, the most progressive innovation advocate.

16.10–16.20: Success stories from the Nordics. Biokraft.

16.20–16.30: Poster Presentation – award.

16.30–16.35. Closing remarks.

• Thursday, April 11 •

Choose one of the following excursions – limited number of seats. The tours will include a lunch-pack, bus transportation and guiding.

Excursion 1 (short):
Oslo biogas plant and LBG filling station. The bus leaves from the hotel 08:45. Returns to Oslo airport Gardermoen 13:00 and to the hotel 14:00.

Excursion 2 (long):
The Magic Factory, Hyperthermics and Air Liquid. The bus leaves from the hotel 08:15. Returns to the hotel 16:00.

POSTER PRESENTATION AWARD

The best abstract posters will be rewarded at NBC

There will be 2 Poster Presentation Awards

- PEOPLE'S CHOICE
- ORGANISERS CHOICE

Voting will take place in the poster exhibition area during both days, ending after lunch April 10 at 13:30. The winners will be presented at the end of NBC, April 10.

Who will win the Award for best abstract poster?

The Poster Presentation Award will be presented at the end of NBC.

How to vote: Write down the number of your favorite abstract incl your name and leave the ballet in the voting box.

1

LBG as a catalyst for the development of the biogas industry – A case study of Sweden´s largest biogas plant

Mr. Erik Nordell[1], Dr. Mr. Jan Moestedt[1], Mr. Sören Nilsson Påledal[1]

1: Tekniska Verken I Linköping Ab, Linköping, Sweden

Biogas production in Linköping started 22 year ago. The start up was a consequence of the need to reduce soot particles and effectively treat of organic waste from the large local slaughterhouse in Linköping.

Today, TV supply more than 180 busses in the county of Östergötland and Kalmar with biogas. Moreover, the subsidiary Svensk Biogas i Linköping AB (SB) has established 12 filling stations for CBG around the region. In addition to slaughterhouse waste, source-separated food waste is used as the main substrate at the biogas plant. The annual bio-methane production at the facility is 120 GWh.

In 2019 TV will build a liquefaction plant to produce liquefied biogas (LBG) in addition to compressed bio-methane (CBG). LBG makes transportation to off-grid CBG-filling stations more effective. Moreover, SB has signed a long-term contract with Toyota Material Handling (Mjölby, Sweden) to replace their propane used in the production process of their trucks, corresponding to up to 25 GWh/year. By locating the LBG-storage tank nearby the Toyota facility, the LBG tank can simultaneously supply biogas to an industry, a CBG filling station and a LBG filling station for heavy vehicles; a 3 in 1 solution with biogas to three different market segments. Furthermore, in Linköping only one single day production can be stored as CBG in the high pressure storage, requiring just in time-production. With LBG, biogas can instead be efficiently stored adding flexibility to the operation of the plant.

2

Technologies for production of liquefied biogas for heavy transports – Energy, environmental, and economic analysis

Dr Marcus Gustafsson[1], MSc Igor Cruz[1], Dr Niclas Svensson[1], Dr Magnus Karlsson[1]

1: Linköping University, Linköping, Sweden

The heavy transport sector is facing a growth within technology and infrastructure for use of natural gas. This opens an opportunity for the biogas market to grow as well, especially in the form of liquefied biogas (LBG). This study presents an investigation of the energy balance, environmental impact and economic aspects of current technologies for production of LBG: mixed refrigerant cycle, nitrogen cycle, pressure reduction and cryogenic liquefaction. Calculations are based on a review of recent literature and data from the biogas industry. The results show that mixed refrigerant cycle is the most economic and energy efficient technology for liquefaction of upgraded biogas, followed by nitrogen cycle. The lowest electricity use and environmental impact is achieved if the liquefaction process is preceded by amine scrubber upgrading. Pressure reduction liquefaction is inexpensive and can be an alternative in areas connected to a high-pressure gas grid, but as a method for liquefaction it is not very efficient as only about 10% of the incoming gas is liquefied and the rest remains in its gaseous form. Moreover, addition of propane for distribution in the natural gas grid increases the environmental impact compared to other distribution pathways. The cryogenic technology has a higher energy use than other liquefaction technologies but compensates by also including CO_2 separation, which could make it suitable if there is no existing upgrading facility in place. However, there are technical difficulties to overcome and it is not widely implemented.

3

Strengthening the market position of the products and services in the biogas value chain through environmental product declarations (EPDs)

Forsker Kari-Anne Lyng[1]

1: Østfoldforskning, Kråkerøy, Norway

The environmental performance of products and services is becoming more and more important, especially within public procurement. According to the European commission's communication on Public procurement for a better environment (COM 2008 400), green public procurement is defined as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life-cycle". The Norwegian regulations regarding public procurement states that environmental consequences relating to the procurement shall be taken into account, and that environmental aspects shall be weighted 30%.

The products and services of the biogas value chain are competing with other products and services on the market: anaerobic digestion with incineration, biogas with other fuels and energy carriers and digestate with fertilisers and soil improvement products. Environmental product declarations (EPDs) can strengthen the market position of those products and services by providing information to the purchasers about their environmental performance, enabling them to including environmental criterions in the procurement process.

The product category rules for developing EPDs of the products and services of the biogas value chain is presented: anaerobic treatment of biowaste, upgraded biogas (biomethane) from anaerobic digestion (CBG and LBG), biofertiliser from anaerobic digestion, compost and soil improvement products from anaerobic digestion and CO_2 from upgrading of biogas. In addition, example EPDs for products and services from one biogas plant will be presented.

4

Biogas-based fuels as renewable energy in the transport secto

Sofia Dahlgren[1]

1: Linköping University, Linköping, Sweden

An energy system based on more renewable energy can help reduce greenhouse gas emissions. The energy used in the transport sector seems to be especially complicated to substitute. One way to increase such a substitution is to use biogas-based fuels, since there is a potential to increase the production of biogas. Apart from a recent development in the use of biogas-based compressed and liquefied methane for transports, biogas can also be a raw material for other fuels by gasifying the biogas: Fischer-Tropsch fuels, methanol, dimethylether and hydrogen. This study gives an overview of biogas-based vehicle fuels and their respective potentials as substitutes for fossil fuels in the transport system.

A common factor for all the studied fuels is that currently they are primarily produced from fossil fuels. Compressed and liquefied methane, which have come furthest in their technical development, are the only ones being commercially produced using biogas. The other fuels, Fischer-Tropsch fuels, methanol, dimethylether and hydrogen, all have strengths that both compressed and liquefied methane lack. One example is the possibility of using hydrogen in emission-free vehicles. These gasification-based fuels might, however, require larger production sites than biogas can offer, and they are all less developed and used than compressed and liquefied methane. In conclusion, although the gasification-based fuels have certain strengths that make them interesting, the greatest short term potential is for an expanded use of biogas in compressed and liquefied methane.

5

Local potential production, use and conditions for implementation of biogas solutions in Norrköping, Sweden

Dr Marcus Gustafsson[1], MSc Axel Lindfors[1], Professor Stefan Anderberg[1], Assistant professor Jonas Ammenberg[1], Professor Mats Eklund[1]

1: Linköping University, Linköping, Sweden

Biogas is expected to make an important contribution to the vision of fossil-free transports in Sweden. However, estimates of the national production potential have taken a top-down perspective, without detailing where the potential exists and how to realise it. This study is made with a bottom-up perspective, investigating the potential for production and use of biogas within different sectors and individual industries in the municipality of Norrköping. Moreover, critical factors and driving actors for realising these potentials are raised and analysed. The study was conducted with a participatory approach involving 22 representatives from the municipality, biogas producers, interest organisations and companies dealing with potential biogas substrates. The results indicate a potential biogas production of 500 GWh/year by 2030, out of which 60% would come from the agricultural sector and 30% from local pulp and paper industries. A more modest estimate indicate that the production would cover 10–15% of the local energy demand for road transport and shipping as well as industrial energy gas. Substrates are distributed over a large geographical area and between several actors, requiring cooperation between substrate owners to reach an economically feasible scale. In addition, collaboration with biogas companies could provide the substrate owners with necessary specialist knowledge. In order to realise the biogas potential, Norrköping municipality has a central role to play as coordinator and knowledge hub, as well as by directing procurements towards biogas and plan for biogas fuelling stations.

6

Critical analysis of the life-cycle performance of digestate management pathways

Dr. Roozbeh Feiz[1], Dr. Jörgen Ejlertsson[2], Dr. Niclas Svensson[1], Dr. Karin Tonderski[1]

1: Linköping University, Linköping, Sweden, 2: Scandinavian Biogas Fuel AB, Sweden

Large amounts of digestate are produced in co-digestion biogas plants. Digestate is nutrient-bearing and can serve as the substitute of mineral fertilizers. But it also contains low levels of dry matter and its transportation to remote farms can become expensive. So, sometimes it makes economic sense to perform dewatering, or further treatments, in order to reduce the volume and weight that must be transported. This may lead to a reduction in costs but can lead to a net increase in greenhouse gas emissions and energy use from digestate treatment.

In this study, we perform a quantitative life-cycle based modelling of several digestate management alternatives considering climate impact, primary energy use, nutrient recycling potential, and cost. We will define a few scenarios, but also perform uncertainty and sensitivity analysis in order to identify the conditions under which it is suitable to perform additional treatment steps. The outcome of this research is relevant and practically beneficial to many existing biogas plants.

This research is related to Biogas Research Center, a Swedish center of excellence funded by Swedish Energy Agency and several industrial, municipal, and academic partners. Many biogas and biofertilizers producers and users are presented in the network of BRC and provide expertise and empirical input into the research.

Optimizing temperature in dry anaerobic digestion of municipal solid waste

Environmental Engineer Emelie Persson[1], PhD Maria Westerholm[2], Professor Anna Schnürer[2], Environmental Engineer Daniel Tamm[3], Environmental Engineer Ulf Nordberg[3]

1: IVL Svenska Miljöinstitutet, Sweden, 2: SLU Sveriges Lantbruks Universitet, Sweden, 3: RISE Research Institutes of Sweden, Sweden

Purpose:
This project studied how the operating temperature affects microbial community composition, sanitation, process and energy efficiency at existing dry-digestion plants using food waste as main substrate. Dry-digestion allows digestion of material with high solid content without need for dilution with water or other process fluid. Some facilities have been established in Sweden during the last years, and more plants are prospected. Many of these plants wish to operate the process under thermophilic conditions to avoid external hygienisation which is costly. However, this has proved to be problematic because thermophilic digestion of food waste as a sole substrate poses a risk of ammonia inhibition, which leads to process disturbances. To reduce the problem, the substrate is diluted with water or other materials such as park and garden waste, which means increased costs while reducing the nutrient content of the digestate. This project investigated the possibility of using an intermediate operating temperature (42–44 °C) to achieve process efficiency while reducing ammonia inhibition problems and still have good hygienisation effects.

Methods:
Process data and digestate samples from four different dry-digestion plants operated at 38–40, 42 and 52 °C have been collected and analysed to investigate the link between microbial composition, process efficiency and energy efficiency. Material from one plant has also been used to investigate the survival of indicator organisms at different temperatures and ammonia concentrations.

Results and Conclusions:
he project report will be ready by the end of January 2019.

An example of the circular economy of biogas: combining aquaculture waste resources with green energy production and resource recovery

PhD Environmental Technology Maria Estevez[1], PhD Chemical Enigneering Renata Tomczak-Wandzel[1], Engineer Kristine Akervold[2], Engineer Oddvar Tornes[3]

1: Aquateam COWI, Oslo, Norway, 2: Bergen Municipality, Water and Wastewater Department, Bergen, Norway, 3: IVAR IKS, Stavanger, Norway

Purpose:
Circular economy is the baseline for a regionally R&D funded project involving the municipal sewage agencies of Hordaland and Rogaland counties, in Western Norway. With the establishment in 2016 of new biogas plants at both counties, the project studies:

i) the possibility and effects of co-digesting aquaculture waste with the sewage sludge input of the new biogas plants;
ii) the production of bio-resources during the anaerobic digestion process, as organic acids and plant available nutrients.

The applied research project aims to increase the valorization of organic waste fractions in Western Norway by improving renewable energy production and resource recovery.

Methods:
Fish sludge originated from different aquaculture systems was tested as co-digestion substrate together with sewage sludge. Different mixture ratios of fish sludge (% vol.) at mesophilic and thermophilic temperatures were evaluated in BMP assays. For selected co-digestion mixtures, pilot research in semi-continuous reactors was performed. Digestates were analyzed for heavy metals and nutrients content, as well as plant-available phosphorous fraction.

Results and Conclusions:
An improved methane production was in general achieved for the sludge from both plants when combined with fish sludge, but under thermophilic conditions the process did not run stable. Fish sludge samples coming from different aquaculture systems gave different ranges of improvement. The importance of conducting specific co-digestion evaluations before accepting a new waste fraction into an established biogas plant is emphasized here. Phosphorus availability in the digestates was proven to be primarily dependent of the sewage sludge quality, and not on the fish sludge presence.

9

Decarbonising pulp and paper industries by adopting biogas solutions

Dr Francesco Ometto[1], Dr. Anna Karlsson[1], Prof Jörgen Ejlertsson[1,2]

1: Scandinavian Biogas, Stockholm, Sweden, 2: Linköping University, Linköping, Swede

Pulp and paper industries are committed to reduce carbon emissions targeting 80% reduction comparted to the level of 1990, by 2050. In this context, including biogas solutions within their wastewater treatments (WWTs) provides the opportunity to reduce energy demand, chemical nutrients dosing and related carbon emissions. Overall, while wastewater streams post primary sedimentation could be treated by Upflow Anaerobic Sludge Blanket (UASB) modules, waste sludges are valuable feedstock for Continuously-Stirred Anaerobic Digester (CSTR) applications. Applied to a pulp and paper mill in Scandinavia (treating 20,000 m3 wastewater per day), the EffiSludge-for-LIFE project demonstrates the synergy between UASB and CSTR alternatives to improved WWT efficiency while reducing carbon emissions. In particular, the adoption of both anaerobic digestion technologies, providing an annual capacity of 125 GWh, supports innovative operation within the activated sludge treatment. Reduction of the sludge age from 12–14 days to 4–5 days shows significant energy saving within the aerobic step and increases WAS' digestibility and availability. Co-digestion of WAS with nutrient enriched organic waste (e.g. fish waste) offers the opportunity for nutrient recovery/reuse. Post digestion rejected water is returned into the WWT being a source of nitrogen and phosphorus. Hence, based on a life cycle assessment (LCA) approach, thanks to energy savings and nutrient recovery, the WWT's carbon emissions reduction is expected to contribute for 3.5 million kg CO_2-eq per year. Additional 40 million kg CO_2-eq are saved as avoided emissions due to replacing petrol fuels with upgraded biogas delivered as compressed biogas (CBG) or liquid biogas (LBG).

10

Bark as a bedding material in dairy barn – an effect to biogas production

Senior Scientist Saija Ras[1], Markku Vainio, Lilli Frondelius, Heidi Leskinen

1: Natural Resources Institute Finland, Jyväskylä, Finland

Sawmills and pulp mills have a need for new possibilities to utilise tree bark. Tree bark contains valuable bioactive compounds, like polyphenols, tannins and lignans. The overall aim of the project was to study the suitability of bark as a bedding material in a freestall dairy barn. In this paper, we compared the effect of tree bark and peat bedding on biogas production.

The grinded bark was a mix of pine and spruce. BMP assays were performed for mix of manure/bark and mix of manure/peat. The ratio of bedding material and manure was calculated by estimating the amount of manure per day and compared the amount of manure to the fact that about 20 L of the bedding material per cow was added to stalls three times a week.

The use of bark had minor effect on biogas production compared to peat. BMP value for the peat/manure mix and bark/manure mix were 181±9.7 and 168±6.5 mLCH4/gVSadded, respectively. The results considering the animal welfare are still incomplete, but as a preliminary result it was noted that the use of grinded bark increased a dusting in barn.

The use of bark did not decrease the methane production substantially. In this experiment the main portion of the bark was spruce, which has different BMP as pine (results not shown). In practice the suitability of the bark on biogas technology has to be taken into account so that there will be no clogging. More research is also needed on the effect to animal health.

11

Anaerobic digestion of softwood bark – cascading use of material

Senior Scientist Saija Rasi[1], Markku Vainio, Elina Tampio, Petri Kilpeläinen, Risto Korpinen, Jan-Erik Rantanen, Kimmo Rasa, Tuula Jyske

1: Natural Resources Institute Finland, Jyväskylä, Finland

Softwood bark is a side-stream produced in sawmills and pulp mills. Currently bark is used as energy source. The aim of this study was to develop a process concept combining hot water flow-through extraction (HWE), slow pyrolysis and anaerobic digestion (AD) to create value-added products from bark.

HWE for barks were performed at 75 °C using flow-through extraction system to extract tannins from bark. Biochemical methane potential (BMP) assays was conducted for untreated and extracted barks as well as for the liquid fraction derived from slow pyrolysis (443 °C) of extracted bark.

BMP value for untreated pine and spruce bark were 40–62 and 30–45 mLCH4/gVSadded, respectively. BMP values for HWE-treated pine and spruce bark were 80–113 and 43–65 mLCH4/gVSadded, respectively. BMP value for liquid fraction from extracted pine and spruce bark pyrolysis were 108–131 and 86–138 mLCH4/gWW, respectively. HW extracted 8.2–8.8 % of spruce and 6.2–6.5 % of pine bark. Extracted compounds were mainly tannins, sugars and wood extractives such as stilbene glucosides. Slow pyrolysis produced 37–38 % char, 40–42 % of pyrolysis oil and 20–21 % gas.

Results showed that HWE, slow pyrolysis and AD can be combined in meaningful way. Spruce and pine bark can be valorized as valuable products like extractives and biochar in addition to production of energy. Optimization of process parameters and further development of end products will be fascinating topic for further research.

12

Resource efficient anaerobic digestion of fur animal manure in a centralized biogas plant

Elina Tampio[1], Suvi Lehtoranta[2], Johanna Laakso[1], Sari Luostarinen[1]

1: Natural Resources Institute Finland (Luke), Jokioinen, Finland, 2: Finnish Environment Institute, Helsinki, Finland

In Finland, approximately 150 000 tons of fur animal manure is produced annually. Fur production is concentrated in a region which also hosts other intensive animal production. The regional supply of manure nutrients is too high and new solutions for processing and transporting manure elsewhere is needed. This study assessed the treatment of fur animal manures in a centralized anaerobic digestion (AD) plant with mass, nutrient and energy balances and LCA methodology.

The assessed theoretical concept consisted of AD plant treating 40+10 kt/a of fox and mink manure and 40+10 kt/a of cattle and pig slurry. To enable the transportation of the digested nutrients outside the area of intensive animal production, digestate was processed into fertiliser products. A centrifuge was used to separate solid and liquid fractions and the latter was filtrated with membranes to produce a nutrient concentrate. Biogas was either upgraded to vehicle use or converted to heat and electricity.

After digestate processing 90% of phosphorus was in the solid fraction and 73% nitrogen in the concentrate. Depending on the selected biogas utilization, AD and digestate processing consumed 55–58% of the total energy potential of AD. Overall, the centralized digestion concept had a lower climate impact compared to composting of the manure. If biogas is utilized as vehicle fuel instead of combined heat and power production, climate benefits are greater.

Replacing inorganic fertilisers with digestate-based organic fertilisers is a step towards reducing agricultural dependence on inorganic fertilisers and reducing the associated environmental impacts, and energy and costs.

13

Sustainability assessment of public transport – a multi-criteria approach to compare different bus technologies

Sofia Dahlgren[1], Jonas Ammenberg[1]

1: Linköping University, Linköping, Sweden

Diesel dominates as fuel for bus transports in the world, but there exist renewable alternatives such as biodiesel, biogas, ethanol and electricity. These fuels can all have a part in substituting from fossil fuels to renewables, as well as reaching other sustainable development goals. However, many are still wondering what alternative is best for them. Swedish public transport companies are some of those who are wondering, and in many cases, they have been forerunners for renewable fuels. Procurement of public transport is a substantial application, where the actors calls for methodological support for assessment as well as for information about the advantages and disadvantages of the potential alternatives.

The aim of this study has been to develop a multi-criteria method to contribute to broader evaluations of different bus technologies, as well as applying the method to obtain information about the advantages and disadvantages of biogas, biodiesel, diesel, ethanol and electric buses. The study was performed through literature studies and workshops with actors within public transport, bus manufacturing and renewable fuel production.

The results of this study include the developed method, which covers essential areas regarding sustainability as well as technical aspects important for operation of buses. The method is adapted to its context as a facilitator for informed decision making through overview, data collection and weighting of relevant information. The application of the method, which is also part of the results, provides further insights on the strengths and weaknesses of the studied fuels.

14

Methodology for Analysing Energy Demand in Biogas Production Plants – A Comparative Study of Two Biogas Plants

Phd Student Emma Lindkvist[1,2], Senior lecturer Maria Johansson[1,2], Jakob Rosenqvist[3]

1: Linköping University, Linköping, Sweden, 2: Biogas research center, Linköping, Sweden, 3: Tranås Energi, Tranås, Sweden

Biogas production through anaerobic digestion may play an important role in a circular economy because of the opportunity to produce a renewable fuel from organic waste. However, the production of biogas may require energy in the form of heat and electricity. Therefore, resource-effective biogas production must consider both biological and energy performance. For the individual biogas plant to improve its energy performance, a robust methodology to analyse and evaluate the energy demand on a detailed level is needed. Moreover, to compare the energy performance of different biogas plants, a methodology with a consistent terminology, system boundary and procedure is vital. The aim of this study was to develop a methodology for analysing the energy demand in biogas plants on a detailed level. In the methodology, the energy carriers are allocated to: (1) sub-processes (e.g., pre-treatment, anaerobic digestion, gas cleaning), (2) unit processes (e.g., heating, mixing, pumping, lighting) and (3) a combination of these. For a thorough energy analysis, a combination of allocations is recommended. The methodology was validated by applying it to two different biogas plants. The results show that the methodology is applicable to biogas plants with different configurations of their production system.

15

Utilization of biogas CO_2 adds another level to the circular economy

Mr. Henrik Lyhne[1], Mr. Rasmus Find[1], Mr. Niels Grave[1], Mrs. Bettina Barsøe[1]

1: Pentair Union Engineering, Snaremosevej 27, Denmark

After yet another summer with scarce resources of CO_2 for mainly food & beverage applications, the CO_2 from biogas is a low-hanging fruit. Pentair Union Engineering is now installing the first plant in Denmark. Not all upgrading technologies are suitable for adding a CO_2 liquefaction unit – however both amine and membrane plants are. Pentair has both upgrading technologies in the product portfolio. The content of CO_2 in the raw biogas is approx. 40–45% and without CO_2 liquefaction unit installed, the CO_2 is vented to the atmosphere.

The working principle of the CO_2 plant is compression of the CO_2 gas to 15–18 bar. After compression of the CO_2 gas, all non-condensable gases are removed by distillation. Accordingly, the plant is supplied with a combined purification and a CO_2 gas condensation system. A refrigeration unit supplies the required refrigeration capacity.

The proprietary CO_2Scrub technology will effectively remove impurities with a high boiling point, including aromatic components, all alcohols and oxygenates and some sulfur components. Other sulfur components such as H_2S and COS are removed in separate process steps by special carbon filters. As the Pentair Union Engineering CO_2 liquefaction plant need to purify the liquid CO_2 to fulfill the ISBT quality requirements, a large number of our proprietary technologies are implemented. The overall process design of the plant is considered the most innovative and robust technology the market has seen and will set the benchmark for the future biogas plant segment.

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Biogas as a part of regional development in Central Finland

Project Manager Outi Pakarinen[1], Hannu Koponen[1], Suvi Bayr[1], Hanna Kunttu[1]

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Biogas potential in Central Finland is approximately 460 GWh in year, corresponding to 18 % of energy used in traffic sector. Currently ca. 10 % of the potential is in use. However, in recent years the interest to invest in biogas production has risen.

Biogas is currently mainly used in heat and power production, but upgrading to vehicle fuel is getting more space. In Central Finland there is no natural gas grid. There is already some good examples how to use public procurements to increase the biomethane use in transport.

Central Finland is participating in Circwaste project, which is aiming to inrease recycling and improve circular economy. Circular economy roadmap made in the project is focusing on four themes, one of which being biodegradable waste, biogas and nutrient recycling.

Regional transport system plan is going to be revised in 2019. Effects on climate change is going to be involved in the plan. In addition to that, regional transport system plan is taking into account the need to develop alternative fuel network in Central Finland.

There has been good co-operation in Central Finland what comes to biogas production and use. Main stakeholders have been involved. Communication has a key role in developing the biogas ecosystem in the regional level. We have still a lot of work to do to increase the biogas production close to the production potential in the area in sustainable way.

Green CO_2 from biogas to greenhouse

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CO_2 is a by-product from the upgrading of biogas to biomethane. We call it «Green CO_2» since it has biological origin. For the first time in Norway green CO_2 will be used in a greenhouse. A greenhouse using the soap bubble technology has been built at the Greve biogas plant, also called The Magical Factory(TMF).

Water scrubbing technology is used for upgrading the biogas at TMF. The CO_2 is stripped from the water with air, giving approximately 13% CO_2 in air. The water temp in the scrubber is approximately 14 C. Certain chemical compounds that may be present in the CO_2 will be detrimental to the plants in the greenhouse. We have based the quality requirements for the gas on experience from The Netherlands. Based on an evaluation we have decided that H2S (toxic to plants) and ethylene (plant hormone) are the critical. Note that the plants are less tolerant for H2S than the requirement for the working atmosphere. Our target for the atmosphere in the greenhouse is 10 ppb H2S and 11 ppb ethylene.

The CO_2 /air mixture is first passed through an activated carbon filter to remove odour. This filter has been installed to prevent odour spreading in the neighbourhood. All offgas passes through this filter independent of use. After this filter a side-stream is taken to the greenhouse, approximately 10% of the total. There is a fan and then a second activated carbon filter. This carbon in this filter has been selected by the supplier to maximise adsorption of H2S and ethylene. After the filter the pipe goes underground down to the greenhouse. There is a condensate trap at the lowest point.

The CO_2 /air mixture is added to the air in the greenhouse in the manifold distributing air to below the rows of plants. There is a three-way valve that is controlled to give the correct CO_2 concentration in the greenhouse (1000–1200 ppm). Excess CO_2 is vented directly to the atmosphere.

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Sustainable transportation of natural gas via Mobile Pipeline

Filippo Munna[1]

1: Hexagon xperion GmbH, Kassel, Germany

Mobile Pipeline® is a method for transporting natural gas with high methane content to locations that are not located near traditional natural gas pipelines and distribution systems. It is a safe, cost effective, and efficient way to transport natural gas to customers that do not have access to pipeline natural gas. With over 1200 Type 4 transport modules in operation worldwide, Hexagon is the market in this field. Our X-STORE® and TITAN® Type 4 transportation modules offer the highest transport capacities worldwide.

The use of Mobile Pipeline® will allow remote RNG (Renewable Natural Gas) production facilities the ability to reach either a pipeline injection point or an end use facility where RNG may be consumed or distributed further to vehicles. Furthermore, the need for expensive pipeline taps or construction of long laterals to reach a production site is avoided.
Mobile Pipeline® can be used either as a permanent method to transport RNG to an injection point or as a temporary method to transport RNG while a pipeline interconnection is built.

The focus of the presentation would be as follows:

- Compression of Renewable Natural Gas at production sites. What is required for equipment and space required to implement a Mobile Pipeline solution.
- Transportation of RNG from production sites to either a pipeline injection point or a vehicle fueling location.
- Recompression of RNG for pipeline injection or for direct to vehicle fueling. Why is recompression necessary?

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The Turbo Brayton, a disruptive technology for biogas liquefaction

Industrial Cryogenics Sales and Market Manager
Yannick Rouaud[1]

1: Air Liquide Advanced Technologies, Sassenage, France

The Air Liquide Turbo-Brayton cooling system is an optimal solution for natural gas liquefaction. Combining performance, reliability and compactness, it can be used for liquefying biogas, natural gas or flare gas as well.

Key benefits of the Turbo-Brayton liquefaction system:

- Integrated solution with feed gas pretreatment
- No feed gas losses,
- Low installation cost and time: plug and play, compact (low footprint and weight)
- Maintenance-free for 5 years
- Unmanned operation, fully automatic
- Cold power available instantaneously (less than 5 min) from stand-by mode
- Multi-sources liquefaction: biogas, natural gas, flare gas
- Flash and boil off are avoided thanks to methane sub cooling,
- No water cooling
- Utility-free: no compressor, no oil, no nitrogen
- Safe technology: inert process gas, no refill of process gas required
- Low electrical consumption and high efficiency on all operate range from 0 to 100% turn down.

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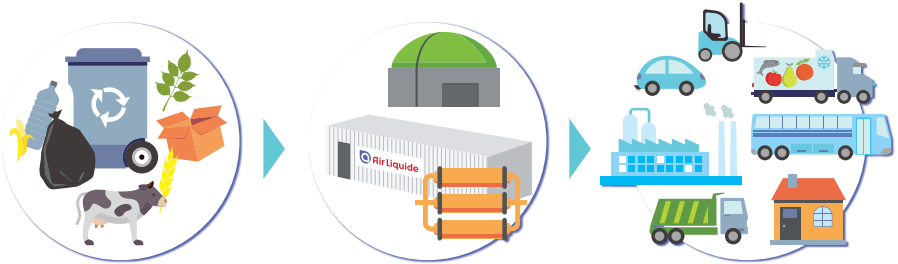

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