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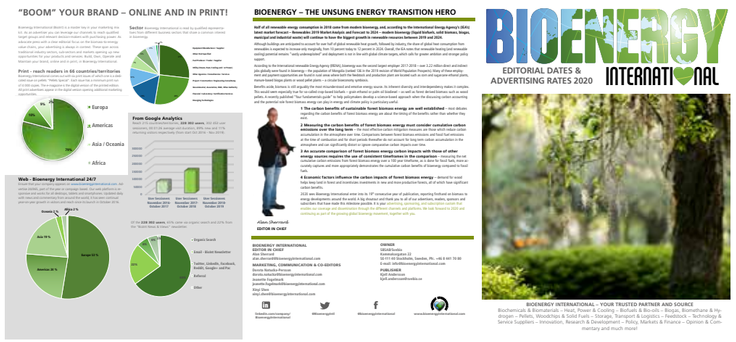

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COVER PHOTO

Giannis Petrakakis, Plant Manager of Sychem Biogas says that his company is able to provide integrated solutions for the management of organic waste and the production of biogas by designing plants incorporating novel technologies (photo Markku Björkman).

ANAEROBIC DIGESTION IS BOOMING, GREEN GAS IS GOING GLOBAL

As governments around the world recognise the scale of the climate crisis and acknowledge the need for action to counter and mitigate the effects of rising temperatures, anaerobic digestion (AD) is one bioenergy technology that has enormous untapped potential and is seeing remarkable growth.

A recent report by the World Biogas Association (WBA) illustrates the contribution that the AD can make to meeting the Paris Agreement commitments, and its potential to become a key player in the development of a sustainable circular economy. A key finding of the WBA report, *'Global Potential of Biogas'* is that anaerobic digestion (AD) technology, which produces biogas from the treatment of wastes, can help reduce global greenhouse gas (GHG) emissions by 3 290 to 4 360 million tonnes CO_2 eq or approximately 10-13 percent of the world's current GHG emissions.

Furthermore, the report finds that only 2 percent of the feedstocks available are treated through AD. These include food waste, sewage waste, farm waste and crops, which can all be used to make biogas in every country. Indeed, an estimated 80 percent of all global wastewater discharged is currently not being recycled through an AD process suggesting that there is still a huge potential for governments, city- and urban administrations to address wastewater treatment and curb methane emissions while improving air- and water quality, nutrient recovery and produce biogas as an energy source, displacing fossil fuels. The use of untreated wastewater from cities to irrigate crops downstream is 50 percent more widespread than previously thought, 65 percent of all irrigated areas within 40 km downstream of urban centers – amounting to about 35.9 million hectares (about the size of Germany) – are affected by wastewater flows to a large degree. Of the total area of 35.9 million hectares, 29.3 million hectares are in countries with very limited wastewater treatment, exposing 885 million urban consumers as well as farmers and food vendors to serious health risks according to the study *'A global, spatially-explicit assessment of irrigated croplands influenced by urban wastewater flows'*.

Another recent report, *'Global Food Waste Management: An Implementation Guide for Cities'*, also by the WBA in partnership with the C40 Cities Climate Leadership Group Food, Water and Waste Programme puts particular emphasis on the importance of separately collecting and treating inedible food waste. A "how to do" guide for cities, the report highlights the role of biogas technologies, which through AD recycle inedible food waste into renewable heat and power, clean transport fuel, and nutrient-rich biofertiliser. AD technologies, which are mature, ready-to-implement, and cost-effective, allow maximum recovery of resources for both green energy generation and soil restoration.

Most cities around the world currently do not collect food waste separately, leaving it to be disposed of in landfills or, at best, in waste-to-energy facilities. As a result, food waste is not treated and loses its potential to resolve a series of environmental issues faced by all cities. A timely guide given that the *'Global Gas Report 2018'*, jointly published by Snam, International Gas Union (IGU) and The Boston Consulting Group (BSG estimates that more than 90 percent of global gas' consumption growth to 2040 will come from cities.

On biomethane (aka green gas or renewable natural gas – RNG), the joint report suggests that it is still at "an early stage of development", although biogas plants have seen strong growth in Europe, driven by favourable policy environments in certain countries. Renewable gas used in existing gas infrastructure could play an important role in reducing Europe's greenhouse gas (GHG) emissions to net-zero by mid-century, according to a study conducted Ecofys and commissioned by the Gas for Climate initiative. Such a reduction is needed to comply with the Paris Agreement to keep global warming well below 2°C and could save Europe EUR 138 billion annually the study suggests.

Initiated mid-2017, the Gas for Climate group consists of seven leading European gas transmission companies; Enagás, Fluxys Belgium, Gasunie, GRTgaz, Open Grid Europe, Snam and TIGF and two renewable gas industry associations, the European Biogas Association (EBA) and Consorzio Italiano Biogas (CIB).

The study, *'Gas for Climate: How gas can help to achieve the Paris Agreement target in an affordable way'* shows that it is possible to scale up renewable gas production between now and 2050 to more than 120 billion m^3 (bcm) >>

"Biogas can be used as a fuel for transport and as energy for electricity and heat, whilst the residue left over from biogas generation, digestate or natural fertiliser, can replace 5-7 percent of inorganic fertiliser currently in use. This means it could fertilise 82 million hectares (ha) of land, equivalent to the combined arable land in Brazil and Indonesia"

DR SARIKA JAIN, the lead author of the Global Potential of Biogas report

>> annually, including both renewable hydrogen (H_2) and biomethane. This, the study suggests, is possible through the large-scale implementation of sustainable biomethane production produced from a range of agricultural and woody biomass types. A "prudent estimation of a truly sustainable" production potential of biomethane within the EU shows that it is possible to produce at least 98 billion m^3, or 1 072 TWh of energy, annually by 2050.

The study highlights an additional potential to produce 24 billion m^3 of renewable hydrogen by converting low-cost wind and solar electricity into hydrogen. Using this renewable gas in existing gas infrastructure for the heating of buildings, to produce dispatchable electricity as a complement to wind and solar, and to fuel heavy transport, could save about EUR 138 billion annually by 2050 compared to a future energy system without any gas.

Long centred in Europe, the green gas sector is indisputably going global according to a report from France-headed international natural gas association CEDIGAZ. There will soon be more than 1 000 biomethane production plants operating in thirty-four countries, up from 720 at year-end 2017 and 173 in 2010. Since 2010, world biomethane production has increased exponentially, reaching three billion cubic meters (bcm) in 2017.

In Europe, biomethane use is spreading across the continent. There are now nineteen European producing countries, whose output totalled nearly 2 bcm in 2017. Across the Atlantic, the United States (US) is now world leader for the use of biomethane as vehicle fuel, further to its production surge of 2014-2017 and driven by federal and state regulations. The fact that China and India have recently adopted biogas upgrading technology promises to be a game changer. Both countries have set ambitious biomethane production targets and figure as huge emerging markets. In Central and South America, Brazil is taking regulatory steps to exploit its huge potential.

It should also be emphasized that biogas and AD technologies can play an important role on a household level for instance as a self-produced source of a renewable clean cooking fuel. In many developing countries, biogas cooking can also improve the livelihoods of rural households, as by-products of biogas production such as slurry and fertiliser boost agricultural productivity. Modern biogas use, meanwhile, reduces the amount of time spent by women and children collecting fuelwood or saves money by not having to buy fuel such as charcoal, kerosene or LPG. Biogas is also one potential solution to combat household air pollution – according to the World Bioenergy Association (WBA) ociation (WBA), over 3 billion people worldwide currently use traditional cookstoves (TCS) fuelled by solid fuels such as fuelwood, charcoal or dried manure. These generate considerable indoor air pollution causing serious health and environmental problems.

Despite these clear advantages, the potential of domestic biogas has not been fully exploited.

A technology brief, *'Biogas for Domestic Cooking'* from the International Renewable Energy Agency (IRENA) provides technical background information, analyses market potential and barriers, and offers insights for policymakers on biogas for domestic cooking. Recent research by the US Stockholm Environment Institute (SEI) and Hivos evaluating the performance of the Africa Biogas Partnership Programme (ABPP) of its biodigester market creation efforts in East Africa finds that biogas is a feasible and scalable means of promoting clean cooking and household air pollution reduction in rural Sub-Saharan Africa, though not without adoption challenges especially related to financing.

Thus in summary, the potential for growth for anaerobic digestion (AD) technologies – from rural household biodigesters to large integrated urban wastewater and food waste treatment facilities – is huge, and with it, the development of a major economic force that provides renewable energy and food security manages waste, protects water bodies, restores soil health, improves air quality, promotes health and sanitation, and creates mass employment.

This the inaugural edition of Bioenergy International's Digital Biogas Special is a dedicated compilation of articles featuring some of the feedstocks, anaerobic digestion technologies (biomass gasification and power-to-gas (PtG) are excluded in this edition) and biogas plants that have previously appeared in regular issues of Bioenergy International in recent years. The choice is subjective and based on what has captured the imagination of the editor in terms of good practise, novelty and potential.

Text & photo: Alan Sherrard
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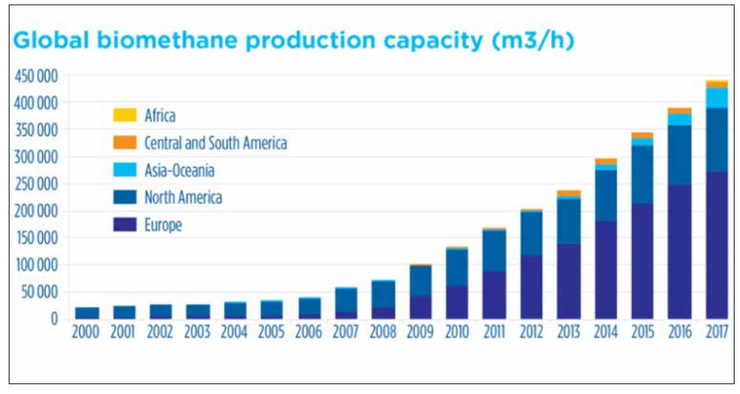

Long centred in Europe, the green gas sector is indisputably going global. According to a report from France-headed international natural gas association CEDIGAZ, there will soon be more than 1 000 biomethane facilities operating in 34 countries, up from 720 plants at year-end 2017 and 173 in 2010 (graphic courtesy CEDIGAZ).

PRE-TREATMENT WITH PULP FRICTION

A key pre-treatment process for papermills using recycled paper is the high consistency pulper that converts this feedstock into a homogenous contaminant-free substrate. An application that, on paper, lends itself to the biogas sector.

IN THE PAPER INDUSTRY, pulpers are an important piece of kit that transform the bale of pulp into a pumpable homogenous substrate free from contaminants but without damaging the fibre. A Swedish company, Cellwood Machinery AB, which develops, manufactures and supplies machinery and systems for the pulp and paper industry has taken note of this.

Although the company may be the new kid on the biogas block, it is not a new company. It has roots that date back to 1913. In 1954 Cellwood Machinery started to produce its first equipment, a woodchip grinder, for the pulp, paper and wallboard industry. In 1972 it launched dispersing systems for waste paper. In 1976 it acquired Grubbens Fractionator, which focused on pulpers and ancillary equipment for the paper industry.

It has adapted its pulper experience and know-how to develop a turnkey pre-treatment unit for biowastes which, it claims, can handle sorted and unsorted household waste. And with about 2 500 pulpers installed at papermills around the world it would be fair to say there is ample experience and know-how to draw from.

Yet is there not an issue of scale that separates the pulp and paper industry from say the biogas sector in terms of feedstock processing capacity?

– No scale is not an issue, capacity is customised in the level of 2-20 tonnes per hour per unit, commented Olof Lekander, Business Development Manager with Cellwood Machinery.

Installation to Norway

Up to now it seems that this pre-treatment unit has been a pretty well-kept secret. Not any more. The Norwegian company, Greve Biogass AS, announced in June that it had begun construction of its biogas plant in Tönsberg, southern Norway, which includes a turnkey 12 tonne-per-hour capacity pre-treatment unit.

According to the planning specification, the biogas plant will use about 60 000 tonnes per annum of a feedstock mix comprising mainly of solid and liquid manure but also biowaste from the food and meat industries, sewage sludge and the organic fraction of sorted household waste. Start-up with first waste in is scheduled for September 2015.

Not the first

As it turns out Greve Biogass is not the first plant to have such a pre-treatment installation.

– Actually we have already supplied several pre-treatment units to household waste treatment plants in China, Denmark, South Korea and Sweden since we launched the unit in 2008/2009. These have capacities ranging from about 3-12 tonnes per hour, said Lekander. He also revealed that the first high consistency (HC) pulper for non-paper industry use was installed at a waste treatment plant in Denmark in 1995, at the request of the client. It is still operational.

– I suppose that's when you can say things started for the non-paper applications. We sold a number of stand alone HC-pulpers all ad-hoc and at the back-end of an existing biogas or waste pre-treatment plants so to speak, he said.

Leveraging pulp know-how

In short, dispersers, pulpers and dewaterers with ancillaries for the pulp and paper are the core technologies and know-how base. In 2000 Cellwood Machinery established a full-scale Research Technology Center (RTC) with its equipment and laboratory, at its headquarters in Nässjö, Sweden.

– The RTC is one of the smartest investments we have made. It allows existing and presumptive clients to test their material using our equipment and verify results together with our sales and engineering staff who are in the same building. The HC-pulper with reject separator is a complete system for dissolving and separation of household waste and other organic materials and is a direct result of development work using the RTC, explained Olof Lekander.

Internal friction – pulper 101

What makes this pre-treatment unit different is that despite appearances to the contrary, a HC pulper is not a mechanical fragmentation process typically used at biogas plants, whereby all the material is size-reduced, including any contaminates that may end up in the digestate.

– The purpose of a pulping system is to dissolve or "slush" the fibre material as completely as possible without damaging fibres and without breaking down non-paper components or contaminants such as plastics, metals and glass often found in recycled paper bales, explained Lekander.

Instead, high consistency (HC), 18-22 percent dry solids (DS) pulpers make use of a phenomen known as "internal friction". The pulper enables intensive but gentle fibre-to-fibre friction while maintaining the original fibre properties and minimising fragmentation of contaminants.

Pre-treatment process

That is what makes the concept very attractive, provided of course it can be applied to separating and dissolving organic content from household waste. A typical pre-treatment unit consists of three basic components; a receiving and feeding unit, a HC-pulper and a reject separator with accept material buffer.

Working batchwise the HC pulper vat is filled from the receiving bin with the material to be treated such as sorted or unsorted household waste or solid manure. Water is added to reach an operating consistency of up to 22 percent DS. The helix shaped screw stirer at the bottom of the vat creates a certain turbulence in the liquid mass subjecting the solid organic components to internal friction and dissolve whereas the non-organics like plastic remain unfragmented.

– In effect the HC pulper opens the plastic bag and dissolves the contents without chewing up the bag which instead is collected for material or energy recovery, remarked Johan Göth, Sales and Marketing Director, Cellwood Machinery.

Once the batch is fully dissolved the pulper is emptied by the reject separator. Here the accept material, substrate, passes through a sieve screen of a pre-determined size, usually 4-6 mm, and is pumped to a buffer tank. The system washes the reject before it is removed to minimise losses of organic material with recirculation of the water to the next batch to be processed.

–The entire cycle sequence of filling, dissolving and emptying is done automatically by intregrating it with computer setup control. The power consumption is low, 15 kW for the pulper and about 20 kW for the whole pre-treatment unit, commented Johan.

While this all sounds straight-forward enough it is not just a matter of fill up the vat and press start. The entire principle hinges on getting the right combination of percent DS, stirer rpm and time, which in turn depend on the material coming in and the degree of dissolving required, up to 99 percent particle fraction under 4 mm.

– This is why the RTC one-tonne-per-hour unit is so valuable. It is here we, together with the client, test run the feedstock mixes to determine the "receipe" that achieves the desired degree of dissolving. Once this receipe is determined then we can start discussing the size of the unit needed. And it forms part of the operational output guarantee, highlighted Johan Göth.

Household waste may not look pretty or smell nice but it has an energy and material recovery value. Seperating the two is the challenge even if it arrives at a plant source seperated. Here the RTC 1-tonne-per-hour pre-treatment unit testing a batch of client feedstock with (1) infeed from the receiving bin to the (2) HC-pulper. (3) the reject separator (photo courtesy Cellwood Machinery).

Sedimentation - a ticking bomb?

Three optional components are also available; a cyclone sand remover, a dewatering screw press for DS optimisation and a disperser. These are stand-alone components that can be retrofitted to most existing biogas plants.

– Digester sedimentation is perhaps not a problem that many biogas plant operators have come across. High density particles will accummulate over time and, if not removed, cause gradual loss of effective volume and eventually agitator failure due to high density loading. Not to mention abrasive wear on pumps and pipes all of which lead to extensive downtime, costly repairs and loss of income through missed production. A heavy density particle remover is a very worthwhile investment for any biogas plant, concluded Olof Lekander.

Text & photo: Alan Sherrard
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(Above left) Cellwood has already begun installing its pulper food waste pre-treatment and its Grubbens High Density Cleaners (HDC) systems adapted for biogas plants such as this one installed at the dedicated food waste processing line at the Tuvan wastewater treatment plant (WWTP) in Skellefteå, Sweden.

CELLWOOD

Cellwood Machinery is part of the Cellwood Group, a privately-owned Swedish industrial group. The other companies are Söderhamn Eriksson (machinery and systems for the sawmill industry), Bruzaholms Bruk (iron foundry) and Simson Power Tools (hydraulic power jacks). Cellwood Group has approximately 350 employees and annual turnover is around SEK 700 million of which 75 percent is generated from export markets.

Boosting manure-based biogas with straw

Agricultural residues in the form of animal manure and straw represent a significant yet under-utilised source of renewable energy and fertiliser. Increasing livestock densities and tougher environmental demands on manure management are compounded by low methane yield from manure-based biogas plants and the lignocellulosic nature of straw that makes it elusive to co-digest. Until now that is. Danish company Kinetic Biofuel A/S has demonstrated a patented straw pre-treatment technology that enables manure-based biogas plants to use straw as co-substrate and over double biogas output.

THE BALTIC SEA REGION (BSR) is an area of intensive arable and animal husbandry production, though not without its environmental issues. Methane and ammonia emissions to the air, groundwater nitrate pollution, run-off leading to freshwater eutrophication and algae blooms in the Baltic Sea, which is one of the world's largest brackish inland seas and a particularly sensitive marine environment regulated under the 1992 Convention on the Protection of the Marine Environment of the Baltic Sea Area.

According to Baltic Manure, a recently concluded European Union (EU) funded flagship project to address manure management practices around the BSR, some 187 million tonnes of cattle, pig and poultry manure are produced annually in the BSR, excluding Russia, most of which is generated in Poland, Denmark and the northern German states.

EU legislation regulates application rates of animal manure according to its nitrogen content. Especially for pig manure this can result in over-fertilisation of phosphorous since pig manure is characterised by a high content of phosphorous relative to nitrogen. Denmark is one of the world's leading exporters of pork and, according to Statistics Denmark, the stock of pigs in 2013 numbered almost 12 million. The Danish government is keen to both increase biogas production capacity while mitigating the environmental impact of its livestock industry and has set a target of digesting 50 percent of the total annual volume of animal manure by 2020.

Yield hampers economics

Whilst anaerobic digestion (AD) is a suitable technology to treat manure, produce biogas and use the digestate as organic fertiliser, manure-based biogas remains largely untapped compared to its potential.

– For the farmer the economics of manure-based biogas production is often the most serious bottle-neck for increasing capacity, even with generous feed-in tariffs for heat and/or electricity, simply because the biogas yield per tonne of manure feedstock is very low compared to a crop-based feedstock, said Dr Torben A. Bonde, during a visit to Foulum biogas plant in Denmark where the straw pre-treatment technology has been installed and demonstrated.

A specialist in microbial ecology, Dr Torben A. Bonde is a distinguished Danish entrepreneur with a long scientific R&D career. He is a founder and CTO of Biofuels Technology ApS, a company specialised in developing biofuel processes and technologies, as well as a Director and Partner of Kinetic Biofuel A/S, a newly formed company for the patented straw pre-treatment technology.

Straw as substrate

Cattle and pig manure at 8–10 percent dry matter content typically have a methane yield of 15–25 Nm^3 per tonne whereas poultry litter does better, at 30 percent dry matter content and 30–100 Nm^3 per tonne. Manure pales compared to crop-based feedstock such as maize or grass silage at 33 percent dry matter content and 160–220 Nm^3 per tonne not to mention substrates such as fats and crude glycerine which can reach 1000 Nm^3 methane per tonne.

– Mixing livestock manure types and energy crops as co-substrate in manure-based biogas plants can improve profitability by increasing the methane yield, but results in additional organic nitrogen applied to the fields and potentially increased leaching. Furthermore additional land is needed to grow these crops or additional costs are incurred to purchase them and this eats into profitability, said Bonde.

However profitability can now be considerably improved by using other residues from agricultural production such as cereal straw as co-substrate.

And Danish farmers produce a lot of straw. On an annual basis 5.5–6 million tonnes of which roughly one third is used as fuel for heating, one third is used for animal bedding and feeding and the remainder is essentially unused.

– The Danish government's 50 percent manure-based biogas target can only be achieved by using large amounts of straw to increase methane yield and secure plant economies. All other high yield residues such as from the food processing industry are already taken, said Bonde.

In theory cereal straw has a potential methane yield of 240–320 Nm^3 per tonne but up until now has had limited use in biogas plants.

– Under the microscope a strand of cereal straw is a fantastic ligno-cellulosic structure. It is light, strong, hydrophobic and decay resistant with the cellulose and hemi-cellulose locked behind the lignin coated cell walls. The challenge is to make these components readily available for microbial conversion, he said.

Quite a challenge as even shredded or macerated straw that absorbs some degree of water is difficult to mix in with cattle or pig slurry. It is voluminous and will inevitably float causing surface crust or dead-zones in a reactor, and blockages in pumps and pipes. Furthermore electrical consumption of pumps, stirrers and mixers goes up in addition to the energy needed for shredding or maceration.

Mechanical industrial pre-treatment

Given the above mentioned, the technology solution offered by Kinetic Biofuel comes somewhat as a surprise at first as it is too is entirely mechanical, a briquetting press line consisting of a bale conveyor, shredder, stone trap, hammermill, cyclone and filter, feed silo and briquette press. Furthermore the press itself is a seemingly standard BP 6510 HD 1.5 tonne per hour briquetting press from Danish manufacturers C.F. Nielsen A/S.

As straw briquettes have a much higher bulk density than a big bale, about 550 kg per m^3 compared to 150 kg per m^3, the immediately obvious benefit is a radical reduction in transport and storage costs.

– This is of course an important benefit as it enables cost-effective volume aggregation. Briquetting also preserves straw quality over time with minimum degradation that would otherwise have a negative effect on biogas yield when used, said Torben.

There is though more to it than that. The briquetting process itself also has, as Bonde reveals, a remarkable effect on the straw and its properties.

– In short it can be described as mechanically induced steam explosion, said Torben adding that the C.F. Nielsen briquette press has been adapted and modified to optimise this internal process, and patented.

The shredded and milled particles are compressed under high pressure. The kinetic energy on the moment of impact by the piston and sudden pressure drop on its retraction together with the high temperature caused by dissipation of kinetic energy into the straw causes steam explosions rupturing the fibres, cell walls and pores.

– This as you know changes everything. The dry straw particles are able to absorb water at high capacity and the cell structures are opened allowing enzymatic and microbial conversion of the contents, said Torben.

The straw briquettes can preferably be fed directly from the briquetting line via a screw conveyor into a biogas reactor or fed into a mixing tank and stirred in liquid manure before pumping the mixture into a reactor.

Full-scale research plant

The entire briquetting line including both reactor feed-in systems have been installed and tested at Aarhus University's biogas research plant in Foulum. Built in 2007 the Foulum plant is one of the world's largest of its kind and the University has its own livestock and crop research and production in the surroundings. Research at the full-scale biogas plant is focused on advanced technologies for improving the biogas production including optimisation of the biogas potential and improvement of methods such as pre-treatment, high technology separation of nutrients, thermal conversion of the residual fibres after digestion, high solid digester technology and upgrading of biogas to vehicle fuel or natural gas quality.

The research part of the facility consists of four 15 litre reactors, four 200 litre reactors, two 10 m^3 continuously stirred tank reactors (CSTR) and two 30 m^3 CSTRs all of which are used for test and piloting research. In addition there is a section that can accommodate up to six independent set-ups for testing equipment and pro- >>

(Top) Mogen Møller Hansen, Plant Manager Foulum Biogas sharing research results and experiences with visitors from a 70 strong delegation of the European Forage Association.

(Above) The complete set-up of a 1.5 tonne per straw briquetting line at the Foulum biogas reserach plant. A Linka straw bale feed conveyor and shredder (red) stone trap, hammer mill, cyclone, press feed silo, briquetting press and combined briquette cooling and feed conveyor to the biogas receiving and feedstock mixer bin (photo courtesy Kinetic Biofuel).

"Under the microscope a strand of cereal straw is a fantastic ligno-cellulosic structure. The challenge is to make these components available for enzymatic and microbial conversion"

DR TORBEN A. BONDE Kinetic Biofuel.

If the results at Foulum biogas plant are anything to go by then Kinetic Biofuel duo, Dr Torben A. Bonde (top) and Mogens Slot Knutsen have good reason to be pleased.

>> cesses along with a fully-equipped laboratory and conference facilities. Furthermore there is also a separate unit for testing biomass combustion up to 1 MW thermal.

The main biogas plant, supplied by Danish biogas technology designers and builders Xergi A/S, consists of a 1200 m³ primary digester, a 1500 m³ secondary and two 1500 m³ gas storage tanks. The daily gas production is around 4800 m³ with a 15-day average retention time in the main digester. A biological gas scrubber is used to reduce hydrogen sulfide (H_2S) to below 100 ppm and the biogas is cooled to condense water vapour before pressurisation to around 200 mbar. The high-pressure is needed to ensure 150 mbar entry pressure for the 625 kWe 12-cylinder Jenbacher 312 gas engine which is located around 1.5 km from the biogas plant. The normal daily output for the engine is around 1 MWh power and 1.4 MWh heat.

The plant also has several feedstock reception and pre-treatment options. This includes two 75 m³ tanks for fatty residues, one of which is heated and a 600 m³ slurry tank. A decanter centrifuge enables slurry separation into a solid fraction with a high dry matter content of 25–30 percent and a liquid fraction. For solid feedstock a 50 m³ stationary feeder is installed and, since 2011, a Kinetic Biofuels straw pre-treatment line. There is also a mixer/dosage module installed where fats, raw slurry and solids are mixed and pre-heated to around 52°C before being pumped into the reactor. The plant facilitates testing at all temperature levels and this makes it possible to test for instance process efficiencies related to changes in temperature.

The results

It is reasonable to assume that there have been ample testing and demonstration opportunities. Results show that briquetted straw has up to 19 percent higher gas yield than shredded or macerated straw. The addition of 1 percent lye to briquetted straw gives another 10 to 20 percent higher gas yield. The resulting digestate is also a better fertilizer with soil improvement properties.

– Briquetting allows for the addition of large quantities of straw and, at the same time increases the biogas yield. This means that production can be doubled in biogas plants that currently use manure as the key feedstock, said Mogens Møller Hansen, Plant Manager at Foulum.

The overall increased yield depends of course on the technology used and retention time in the biogas plant. Achieving a biogas yield of around 250 Nm³ methane per tonne of briquetted straw is possible provided it is good quality straw, uses a thermophyilic digestion of 30-40 days ideally in serial reactors, and not least has a well-adapted micro-flora for ligno-cellulosic biomass.

– Another important result is that the addition of straw briquettes to manure reduces H_2S in the raw biogas significantly, as much as 75 percent compared to manure only, said Møller Hansen.

Very encouraging technical and biological results, but do the numbers stack up? They do according to a presentation on the subject comparing different pre-treatment options by Henrik B. Möller, Senior Scientist, Aarhus University at the 5th Nordic Biogas Conference in Rekavijk, Iceland last August. A benchmark dimensioning figure is a 100 000 tonne per annum slurry-based biogas plant can increase its biogas production by up to 160 percent, from around 2.5 million Nm³ to up to 6.5 million Nm³, by adding 10 000 tonnes straw briquettes, 10 percent, as co-substrate.

According to Mogen Slot Knudsen, CEO for C.F. Nielsen and also CEO for Kinetic Biofuel, the investment cost for a complete 1.5 tonne per hour straw pre-treatment briquetting line is in the region of EUR 400 000. Factoring in operating costs such as power consumption of about 75 kW per tonne, spares and maintenance of about EUR 3-4 per tonne, and labour at 25-50 percent of full-time per shift, the total pre-treatment cost is around EUR 30-40 per tonne, the cost being further reduced for larger plants treating for instance up to 50 000 tonnes per annum.

– Such a 1.5 tonne per hour unit is built semi-mobile meaning it can be dismantled, and moved to another location within one or two days which makes it attractive from a financing perspective, remarked Slot Knudsen adding that Kinetic Biofuel is offering capacities of up to 10 tonnes per hour.

If the technology, biology and numbers add up for a manure-based biogas plant, as they seem to do, one cannot help but wonder how it could work for say a straw based cellulosic biofuels plant. Or with other agricultural residues for that matter. With that in mind it's not a stretch to suggest that we may learn more from Messrs Bonde and Slot Knudsen in the not too distant future.

Text & photos: Alan Sherrard
BI80/4853/AS

Background Kinetic Biofuel

In late 2011 a consortium consisting of C.F. Nielsen, Biofuels Technologies and Aarhus University were granted project co-funding by the Danish Energy Agency, EUDP to build, demonstrate and further develop a full-scale mechanical straw pre-treatment technology at Aarhus University's biogas research plant in Foulum. Up to 10 000 tonnes of straw was to be pre-treated and co-digested with 50 000 tonnes of manure and other biomass over the two-year project. In addition a partial stream of the pre-treated material was to undergo enzymatic liquefaction to demonstrate the viability of the concept for cellulosic ethanol. Aarhus University has conducted and documented a wide range of pilot and full-scale measurements of biogas yield under various conditions as well as experiments with the addition of chemical additives such as sodium or potassium hydroxide, lye. The results of the development project have been patented and transferred to Kinetic Biofuels A/S, a company formed in 2014 by C.F. Nielsen and Biofuels Technology to market the technology.

Foulum Biogas

Gas production:	2.08 million m³/yr
Power production:	4.4 million kWh/yr, 625 kWe gas engine
Digesters:	1 200 m³ primary & 1 500 m³ secondary
Final storage:	2 × 1 500 m³
Process temperature:	52°C
Biomass boiler:	895 kWh
Biomass feedstock used	**25 890 t/yr**
Cattle manure:	16 000 t/yr
Pig manure:	6 200 t/yr
Mink manure:	1 000 t/yr
Chicken litter:	135 t/yr
Sheep manure:	80 t/yr
Fodder residuals:	1 000 t/yr
Non-food crops:	360 t/yr
Cover crops:	15 t/yr
Fats:	500 t/yr

BREAKING THE STRAW TO BIOGAS CONUNDRUM

With around 13 percent of the global cereals production 2013, the European Union (EU) is also one of the largest straw producers. Most of this is unused something that Netherlands-based biogas technology developers HoSt seeks to address. Recently it commissioned a 1.5 MWe manure-based biogas plant in Bulgaria with a novel dedicated straw input line.

ACCORDING TO 2013 FIGURES from Eurostat, some 305.7 million tonnes of cereals including rice was harvested in the EU-28. This represents about 13 percent of global cereal production based on estimates by the United Nations' Food and Agriculture Organisation (UN FAO). Of the EU-28 total land area, about 40 percent or 175 million ha is utilised agricultural area of which around 105 million ha was used for to grow cereals 2013.

Unused potential

– This annual cereal production results in enormous amounts of straw as each ha of cereal generates between 2 and 3 tonnes of straw yet maybe 5 percent is currently used for energy purposes. In fact most of the straw has no direct application but is directly ploughed under, said Herman Klein Teeselink, Director for HoSt.

According to Klein Teeselink, one tonne of digested straw can yield 300 – 400 Nm³ of biogas which, if upgraded is about 180 – 250 Nm³ biomethane or fossil gas equivalent.

– Based on a EUR 40 per tonne cost for straw, the feedstock cost works out at EUR 0.16 - 0.22 per m3 biomethane whereas the fossil gas price fluctuates EUR 0.16 – 0.30 per m³, said Klein Teeselink.

Straw co-digestion

Essentially there are four energy conversion pathways for straw; fermentation for liquid biofuels, anaerobic digestion for biogas, combustion for heat and/or power and gasification for syngas.

– We provide technologies for the three latter straw conversion pathways, each have their complexities, advantages and disadvantages, remarked Klein Teeselink.

Why is straw not more widely used in biogas plants and how can this be addressed? According to Klein Teeselink the early feed-in tariff (FIT) regimes put the focus on electricity production resulting in ever-larger fuel, energy and cost inefficient power only plants.

In countries where biogas production is stimulated, digesting manure with an energy crop such as maize is the most common as an input combination.

– It is not widely known that you can build anaerobic digestion plants using only agricultural residues as input streams, without the need for dedicated energy crops, said Klein Teeselink.

Part of the problem is that straw is a "difficult" material. As a light, dry material, using straw will also increase the solid content in the digester, which calls for special mixers that can handle this.

– If you want to digest large amounts of straw, you need special feeding systems, because of the large volumes. You need special pre-treatment and the conversion process is relatively slow, especially in the beginning, he remarked.

Novel pre-treatment

HoSt has conducted an extensive research programme in association with the Technical University of Münster in Germany on the preparation of straw to increase conversion. Some of the research topics included making powder, hammering, thermal treatment at medium temperatures together with acid or high temperature treatment and enzymes.

The high thermal treatment gave the highest gas production per tonne of straw, but needs a large amount of steam, more than a gas engine can supply. It is also an expensive system which is difficult to make economical feasible.

– In nearly all the biogas projects we're currently involved in the biogas is converted in biomethane for grid injection or compressed. This means that there is no heat available for the high thermal treatment option, explained Klein Teeselink.

First straw to biogas

Therefore HoSt is focusing on low temperature pre-treatment, where hammering is one of the best options. In Chernozemen, Bulgaria the company has commissioned its first biogas plant in which large amounts of straw are fed. The 1.5 MWe capacity plant will use around 50 000 tonnes per annum of cow slurry co-digested with maize silage and straw. The Chernozemen facility consists of a dedicated solid feeding system, a liquid input system consisting of a pump and cutter, two 2 174 m³ digester tanks, a single 2 174 m³ post-digester tank, a separator system, after-storage tanks and a building with a control and heating room, a 1.5 MWe gen-set and a room for the operator.

One of the striking features is the dedicated straw input system. Straw bales are placed on a large straw conveyer that can handle straw bales and feeds the bales to a bale breaker. Here the first initial size reduction takes place before a hammer mill. The hammer mill is sufficient to mill the straw enough to break its tubular structure to prevent floatation. Tests were conducted with different sieve sizes to find the optimal particle size for the digestion process.

– Apart from the feeding system, the digester tanks are optimized for the digestion of straw. A special paddle mixing technology combined with propeller mixers ensures that no floating layers are formed. Furthermore, recirculation ensures that enzymes and bacteria are retained, which improves the degradability, explained Klein Teeselink.

Nutrient capture

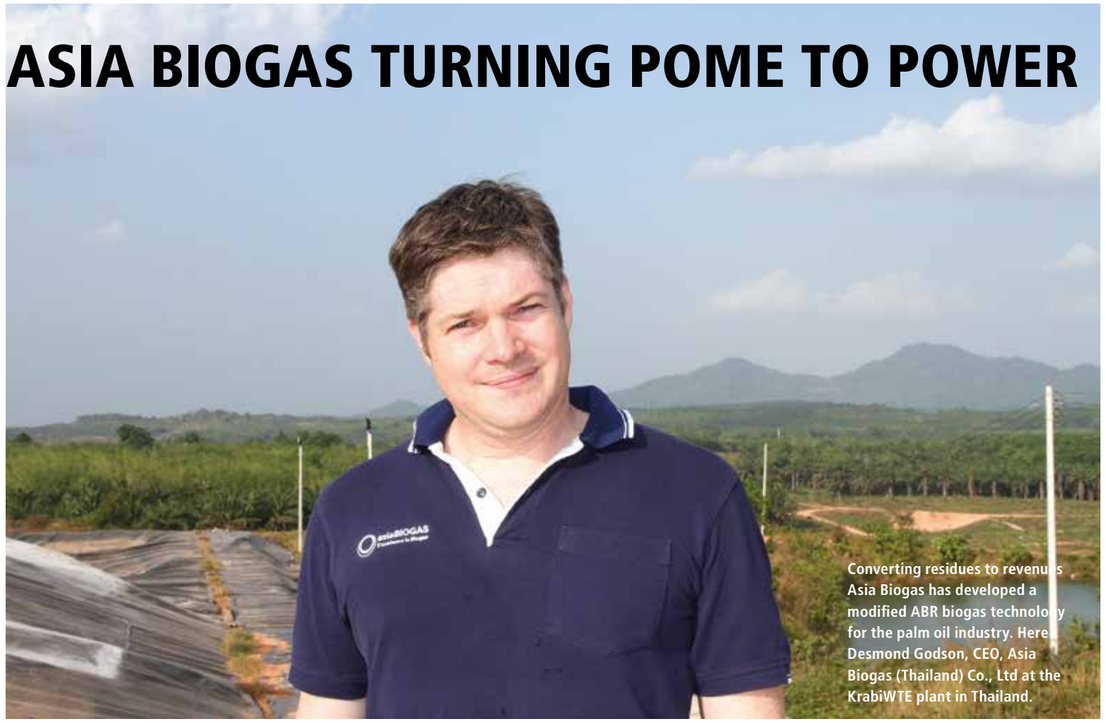
According to him another advantage is that nutrients, such as nitrogen (N), potassium (K) and phosphorus (P) are made available for use as fertiliser along with the organic matter in the digestate.

– In many countries with a cool climate, a second commercial grain harvest is not possible, though a fast growing cover crop such as grass, winter rye or tubers is. These can be used for the biogas plant to increase the overall production while the same amount of cereal can be produced, he suggested.

The additional biomass not only leads to an increased biogas production, also the available organics on the land increases. Moreover, the winter cover crop reduces the risk of mineral and nutrient leaching. The concept of using straw seems to be catching on. No sooner than Chernozemen came on line, HoSt revealed it has started building a second plant, this time in France. More are likely to follow.

Text: Alan Sherrard
Photo: courtesy HoSt
BI87/5354/AS

ASIA BIOGAS TURNING POME TO POWER



Converting residues to revenues Asia Biogas has developed a modified ABR biogas technology for the palm oil industry. Here Desmond Godson, CEO, Asia Biogas (Thailand) Co., Ltd at the KrabiWTE plant in Thailand.

Palm oil mill effluent (POME) represents a major untapped source of energy and greenhouse gas emissions in the form of methane. Capturing and converting POME to biogas not only significantly reduces the environmental and climate impacts of palm oil production, it can also provide a revenue stream.

THAILAND IS THE WORLD'S THIRD LARGEST palm oil producer. According to the US Department of Agriculture (USDA) June 2016 forecast the 2016/2017 production is estimated at 2.3 million tonnes. Though its production is a factor ten less than compared to that of Indonesia and Malaysia, the world's largest two producers, all three share a major untapped source of energy and greenhouse gas (GHG) emissions reduction.

Major GHG source

– It is estimated that methane slippage from conventional treatment systems for palm oil mill effluent (POME), the organic liquid waste generated during palm oil production, can account for up to 70 percent of the total GHG emissions in crude palm oil (CPO) production, said Desmond Godson, CEO, Asia Biogas (Thailand) Co., Ltd.

Fresh POME is hot (temperature 60–80°C), acidic (pH of 3.3–4.6), thick, brownish liquid with high fats, oil and grease (FOG), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) values.

– Typically in Thailand and Indonesia palm oil mills use open lagoon systems for anaerobic and aerobic treatment of POME before discharge to a recipient due to their low costs and operational simplicity, explained Godson.

A conventional open lagoon system consists of four types of ponds: a fat pit, cooling pond, anaerobic pond, and aerobic pond. The fat pit recovers any remaining FOG in the POME and is generally recovered by the mill operator. The cooling pond decreases the temperature of POME, creating optimal conditions for the decomposition of organic material in the anaerobic and aerobic ponds. After treatment in these four ponds, the effluent is safe to discharge to waterways or apply on land as a fertiliser. Although open lagoon system is economical, it is land and time intensive, and releases large volumes of methane to the atmosphere primarily from the organic decomposition that occurs in the anaerobic pond.

Adapted ABR

This is a major market opportunity that Asia Biogas is addressing with its modified Anaerobic Baffle Reactor (ABR) biogas technology designed to be able to handle the high FOG content in POME. In principle an Anaerobic Baffle Reactor (ABR) is a tank with alternating hanging and standing baffles that create reactor sections within the tank. The baffles forces the liquid to flow up and down from one section to the next, enabling an enhanced contact between the incoming wastewater entering the reactor and the residual sludge with the microorganisms that digest the organic pollutants and generate the methane. This sectional design separates the hydraulic retention time from the solids retention time making it possible to maximise digestion of suspended solids in the wastewater. Solids high treatment rates are high, while the overall sludge production is low.

– We have researched numerous types of digester technologies, before deciding upon a system that would be efficient at both methane production, wastewater treatment while being extremely cost-effective and easy to operate. Traditional tank digester systems are quite the opposite, with lower methane recovery, higher capital and operating cost structures, said Godson.

– We never retrofit lagoons with cover. That approach fails due to sludge build up inside the reactor reducing retention time. The upflow in ABR system prevents sludge build up, he said. Asia Biogas Palm Oil Mill ABR System has been installed at palm oil mills in Indonesia and Thailand with the latest, Krabi Waste to Energy Co Ltd, (KrabiWTE) entering into commercial operation in January 2016. Located in Krabi province in southwest Thailand, KrabiWTE processes 500 m³ POME per day supplying biogas for a 2.2 MWe power plant at a palm oil mill operated by Krabi Oil-Palm Farmers Cooperatives Federation Ltd.

– ABR's have the advantage that they are very robust to hydraulic and organic shock loading, which is an important consideration given the variable seasonality of palm oil production. However our design is highly engineered, that involves careful design of the ABR and feeding system to ensure correct vertical and horizontal >>

(Left) The palm oil mill operated by Krabi Oil-Palm Farmers Cooperatives Federation Ltd generates about 500 m³ of palm oil mill effluent (POME) per day during its processing. This is piped online from the production to the KrabiWTE biogas plant built next door. The POME is received in the fat pit and cooling pond (centre) where fats, oil and grease (FOG) is removed and the temperature cooled before it is pumped into the modified Anaerobic Baffle Reactor (ABR). The raw biogas from the ABR is then passed through a cleaning unit (right) to remove impurities before it goes to the gas gen-set.

>> flows in the digester. We can design in tank systems but in tank systems are inherently more expensive and less robust than in ground systems, therefore we recommend and prefer in-ground systems, explained Godson.

Powerful partner

KrabiWTE has a Power Purchase Agreement (PPA) for the electricity with the Provincial Electricity Authority (PEA) under the Very Small Power Producers (VSPP) scheme and entered commercial operation in January 2016. As grid-fed electricity is a major component of the cost structure of industrial plants and farms in the region the biogas plant has a suitable gen-set unit. Here the choice fell on two Cat CG170-12 engines supplied by Metro Machinery Co. Ltd, the exclusive Caterpillar dealer for Thailand, Laos and Cambodia. Metro also runs a Power System Division for the sale and service of Cat gas engines in Thailand.

Commercial non-recourse loan

On the subject of financing, in May 2014 the company via its subsidiary for the KrabiWTE project struck a deal with Caterpillar Financial Services whereby Caterpillar Leasing (Thailand) Ltd provided debt finance on a non-recourse basis. According to Godson the loan is most likely one of the first commercial non-recourse loans provided to a biogas project in Southeast Asia. The project has been funded to date by shareholders Asia Biogas Singapore Pte Ltd, parent of the Asia Biogas Group and Metro Machinery Co Ltd.

– Closing a non-recourse deal is always a difficult process but even more so in this case as it is certainly one of the first of its kind in Southeast Asia. Transaction costs usually make non-recourse project finance impractical for small-scale projects, but we have received great support from the Caterpillar team and the advisors which has ensured that this transaction not only gets over the line, but also we now have a set of documents available for a number of follow on projects in our pipeline, remarked Godson.

Cash-flow to BOOT

There seems to be no shortage of projects and to date the company has completed some 80 or so biogas projects in Thailand, Philippines and Indonesia with another two under construction and a further two in the design phase. Projects are on either an Engineer, Design and Construct (EPC) basis, or on a Build Own Operate Transfer (BOOT) basis, such as KrabiWTE.

– KrabiWTE is our forty fifth project on a BOOT basis and we have another under construction in Indonesia and a strong pipline of projects in development. The BOOT projects provide cash flow that help to balance the financial tops and troughs that one can experience with EPC contracts, commented Godson.

Cassava roots

The company is open to taking a position in other projects such as in 2014 when it acquired TEPCO's stake in a cassava waste to energy project in Kalasin, Thailand.

– Actually we're well established in the cassava starch industry as it was in 2002 when we commissioned the Korat Waste to Energy (KWTE) project. It was our first, indeed Thailand's first, commercial cassava wastewater biogas plant and a great success. It was a BOOT project and was followed by five more such cassava wastewater biogas projects all on a BOOT basis. Incidentally KWTE was handed over to the host Sanguan Wongse Industries (SWI) in 2013 and is still operating today, said Godson.

We also deliverd a second project to SWI in 2012 which was the solid waste - cassava - pulp from the factory. Collectively both projects now generate over 11 MW of electricity and over 40 MW of thermal energy.

EFB to biogas next?

– Here at this site in Krabi we've also looked at utilising the empty fruit bunches (EFB) from the oil mill for biogas and compost production. Phase two here involves setting up a 3 MW high solid digester, said Godson without revealing much detail on how feedstock pre-treatment and preparation would be solved.

The original plan was that construction of phase two would begin during 2015.

– We've had to push back and put it on hold, not because of technology or finance issues but for local power politics. The regional grid has feed-in capacity restrictions and there are plans for a coal fired plant despite significant local opposite and the huge abandance of biogas and biomass feedstocks from the palm industry, ended Desmond Godson.

Text & photos: Alan Sherrard
BI87/5334/AS

FACTS POME

Processing fresh fruit bunches (FFBs) from palm trees for palm oil production generates several types of waste. Oil extraction, washing, and cleaning processes generate liquid waste called palm oil mill effluent (POME). In the oil extraction process, three major operations generate the bulk of POME; sterilisation of the FFBs, pressing station where extraction, separation and clarification of the crude palm oil (CPO) takes place and finally empty fruit bunch (EFB) pressing. An average palm oil mill generates from 0.7 to 1 m³ of POME for every tonne of fresh fruit bunches (FFBs) processed. The oil extraction process does not use chemicals in its process and POME contains a considerable amount of nitrogen, phosphate, potassium, magnesium and calcium making it a desirable fertilizer for palm oil plantations. However fresh POME is a hot (temperature 60–80°C), acidic (pH of 3.3–4.6), thick, brownish liquid with high fats, oil and grease (FOG), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) values and must be pre-treated before field application or discharge to recipient.

THAI BIOGAS SECTOR NEEDS LOW-COST SYSTEMS

Agriculture is one of Thailand's most prominent industries, and as a consequence there is an abundance of biomass resources. These include residues from the oil palm industry, bagasse from sugar and ethanol production, and wastewater treatment from the food processing industry to mention a few.

Dr Stephen P Etheridge, CEO, Biotrix inspecting the digester complex at General Starch Ltd (GSL) Digester System which now comprises 1 x 120 000 m³ (rear) and 1 x 60 000 m³ (left) Biotrix Flexible Liner Reactors (FLRs), capable of producing up to 20 MWe of biogas if all the starch effluent and wet cakes are used.

NATURAL GAS VEHICLES (NGV'S) are also becoming increasingly prevalent in Thailand whereas local authorities in the Gulf of Thailand wants to turn a whole island chain into a green tourism paradise. The third largest Thai island of Koh Chang and it's 51 neighbouring islands around 240 km southeast of the capital Bangkok want to reduce greenhouse gases (GHG) emissions.

Growth in biogas

The development of biogas plants and the corresponding installed capacity has steadily increased in Thailand in recent years. As of October 2016, the total capacity of these facilities, both on- and off-grid, was 412 MW. In 2013-2015 alone, a total of 179 MW of new additional capacity was installed.

On-grid plants refers to facilities that export power to the grid and most of these facilities are found in the livestock sector. Off-grid facilities are typically found in industrial applications such as the production of palm oil, tapioca starch or sugar where the power is used for internal self-consumption.

The number of pigs bred in Thailand amounts to about 10 million animals, with almost half of them in provinces in central Thailand. Most pig farms in the region are located in the provinces of Ratchaburi and Nakorn Phatom. At Kacha Resort on Koh Chang, nine unusual guests moved in recently: a gang of wild boars.

– The hotel produces 150 kilograms of organic waste, and every pig can eat 10 to 15 kilos a day, said HR Director Nopparat Chomchoei adding the boar manure is turned into biogas.

Enter Biotrix

During a recent visit to Thailand, Bioenergy International met two experienced biogas professionals, active in the Thai biogas sector – German microbiologist Dr Ulrike Leroff and English chemical engineer Dr Stephen Etheridg.

Both Dr's have been developing novel biogas systems in several countries since 1981 and have been active in Thailand since the turn of the century, working on a number of early biogas projects across the region. In 2010, the duo jointly established Biotrix Asia Company Ltd and the company has already become a key a player in the biogas sector in Thailand and South East Asia.

Acting as CEO, Dr Etheridge is a biogas entrepreneur having designed, developed or operated nearly 100 plants worldwide, starting in the UK in the early 1980s. In Thailand, he developed major biogas projects in the starch, ethanol and oil palm industry sectors.

His colleague and company chair, Dr Leroff has more than 30 years experience in the biogas and renewable energy sectors having . commissioned and operated biogas plants in the cassava, ethanol and oil palm industry sectors in SE Asia.

– Biotrix Asia is an environmental technology company based in Bangkok Thailand that provides complete bioenergy, biogas and renewable energy solutions, Dr Etheridge said adding that the team also installed and operated some of the first commercial H2S scrubbers in Thailand.

– Coupled with the microbiological expertise available within the Biotrix team, it was a logical step for Biotrix to develop its own bioscrubbers as well as its anaerobic digestion (AD) systems, Leroff commented.

The Biotrix team also provides consultancy services and has undertaken a range of projects from advising on the development of China's National Biogas Action Plan, as part of a UN GEF funded programme, which included a number of pilot biogas plants across the country.

– Our other projects have included promoting the uptake of industrial-scale biogas systems China, Philippines and Indonesia as well as developing the first CDM methodology for industrial biogas systems explained Etheridge.

Incidently, the founders´ early work in the 1980s, sponsored by the European Union (EU), was to determine the baseline parameters and subsequent optimaisation for the digestion of range of crop materials and animal wastes. This work has contributed to the vibrant plants which we see in Europe today.

– Over the earlier years, our team has undertaken projects in Europe, USA, Nigeria, Central America, Southeast Asia, working on a wide range of substrates using many different reactor designs said Leroff.

Large and small

After a number of milestone plants in the UK, later work focused on China and SE Asia. From its base in Bangkok, Biotrix has a been awarded a number contracts to design, construct and commission biogas plants to treat wastes and effluents from the agro-industrial sector including tapioca starch, cassava, wet cake, ethanol, and palm oil, including what the company says is the largest biogas plant in the world (222 000 Nm³) without revealing any further details.

According to Dr Etheridge, the company has also designed one of the smallest commercial scale biogas systems used to treat food waste, which is a growing global issue.

– We have also developed small-scale projects with design, optimisation and plant operation at the Thai Yamaha canteen digester in Bangna, Bangkok. Food waste from the 4 000 staff is treated each day to produce biogas for cooking on the site, he said.

Cassava pulp, ethanol and POME

Although Biotrix offers a range of AD treatment systems, the use of a Biotrix FLR lagoon system is preferred for industrial plants as it is based >> technology to treat starch residues that contain fibrous solids in the effluent stream. Biotrix systems can now treat effluent and wet cake almost doubling biogas production output.

(Above left) An aerial view of the General Starch plant at Chonburi, Thailand. Light Blue Bioscrubbers are shown in the foreground before the gas is used in MTU CHP sets. Four large flares located the back of the site as well as the SCADA PLC control system, Laboratory and Control Building. (Above right) Dr Ulrike Leroff advising on granule formation at an Upflow Anaerobic Sludge Blanket Reactor at Chok Yuen Yong Plant in Nakorn Ratchasima (photos courtesy Biotrix).

The tapioca starch market in Thailand is mature and probably 80 percent saturated, with over 120 biogas plants already installed to treat the effluent.

– The production of ethanol from cassava is becoming increasingly popular but is dependent on the political implementation of biofuel blending policies, underlined Etheridge.

According to him, Palm Oil Mill Effluent (POME) and Empty Fruit Bunches (EFB's) are another major opportunity for biogas production, although there are relatively few palm oil mills in Thailand compared to Malaysia and Indonesia.

– We actively market ourselves to the animal waste and food industry sectors and in the past the team has operated 60 pig manue biogas plants on the day to day basis, but most could only generate 100-200 kW. There are opportunities, but the scale is small and very low-cost systems are needed, Etheridge stressed.

Ulrike Leroff stated that the key strength of the Biotrix team is its experience and knowledge of the anaerobic digestion process and system design. This enables the company to tailor processes to new substrates and microbial requirements leading to innovative systems.

According to Etheridge, Biotrix is actively developing this approach internationally with agents, and also with partners in Thailand.

Unfortunately, renewable energy companies have been inundated by some cold policy showers in normally hot and humid hot Thailand.

The Bangkok Post recently commented on the Thai Minister of Energy announcement that the government plans to stop purchasing electricity from renewable power projects over the next five years. The reasoning is that such projects have caused retail tariffs to jump by 20-25 satangs per unit and that the electricity system has enough installed capacity.

– This policy, if implemented, will undo a decade of success that Thailand has achieved on the path toward sustainable energy.

At the same time, the latest national Alternative Energy Development Plan (AEDP) calls for more than 900 MW of new biogas installations by 2036, cautioned the national daily.

Text & photos: Markku Björkman
BI99/6028/AS

Bathing the elephants is not a hobby for these Thai guys. Its normal procedure after a hard working day.

NOVEL BIOGAS PLANT FEASTS ON CULINARY CULTIVAR

While Belgian endives may have been discovered by accident, the biogas plant at endive grower Joluwa N.V. is purpose built. Commissioned in September 2010 the fully automated plant uses spent chicory roots as feedstock. It is the first commercial installation of a novel high yield digester technology developed by another Belgian firm GreenWatt SA.

IN THE CULINARY WORLD the term "Endive" denotes a lettuce like leaf vegetable, Cichorium endivia, from the chicory genus. Often used in salads they are especially popular in France, Belgium and the Netherlands. Somewhat confusing Belgian endives or Witloof is a cultivated variety of the common chicory, Cichorium intybus, whereby the blanched, tight heads known as Chicons are produced by forcing mature chicory roots to grow in darkness. Once the chicon is harvested the root is discarded.

Located in countryside just outside the town of Nivelles is the Witloof grower and producer Joluwa N.V. The company currently produces around 4 000 tonnes of forced chicory roots per year at its growing, harvesting and packing facility. According to Joost Depaepe from Joluwa the company needed an environmentally suitable, cost effective and long-term solution for the growing volume of residue from spent chicory roots. The expanding business was having issues with odour and leaching from storage piles of rotting roots. Disposal costs at external processing facilities were increasing and the company had heat and power needs but had no particular desire to run a biogas plant.

– It is important for us to be independent and cost efficient in our waste and energy management but biogas in itself is not our business or interest. We wanted to address these issues with a turnkey solution that was easy to manage and not time consuming, said Joost Depaepe from Joluwa.

FEEDSTOCK

Start-up: September 2010
Technical: Two-stage anaerobic digestion plant: hydrolysis tank, High Yield Flushing Digester (HYFAD) reactor & postdigester. CHP with 104 kWe rating
Feedstock: 4 000 tonnes/year of forced chicory roots and vegetable waste
CH_4 potential: 38 m³ per tonne (chicory roots)

PEAK INPUT
Hydrolysis tank: 30 tonnes/day, 165 tonnes/week, 500 tonnes/month
HYFAB: Up to 35 kg COD/m³ per day

ANNUAL PRODUCTION
Biogas: 280 000 m³ at 54% methane content
Electricity: 500 MWh
Heat: 760 MWh

Novel technology

A project to utilise the energy potential of the chicory roots was set-up in 2009 with GreenWatt SA, a Belgian company specialised in the design and installation of on-site biogas plants for farms and agribusinesses. A research spin-off from the Catholic University of Louvain, GreenWatt developed a novel high yield flushing anaerobic digestion (HYFAD) reactor and the Joluwa project is the first commercial installation of this patented technology.

– We specialise in designing biogas plants based on fruit and vegetable waste as substrate. Each project is tailored to fit the residue generated, said Baptiste Genin, R&D engineer at GreenWatt. The different stages of the anaerobic digestion process have conflicting operating parameters which need strict regulation management. A change in the composition or volume of the feedstock input in a conventional biogas plant risks destabilising the process through acidification damaging the methane producing bacteria.

– We have removed this risk entirely. The methane production is stable and consistent regardless of feedstock quantity variations. Our multi-stage technology process is based on the separation and specialisation of these phases into two or three stages to control the operating parameters of these different reactions independently of one another, Genin said.

Two-stage AD plant

The Joluwa facility is a two-stage anaerobic digestion (AD) biogas plant with three main process steps: a hydrolysis tank, the HYFAD reactor and a post-digester. On average the plant produces 850 m³ biogas a day 75 percent of which is produced in the reactor and the rest in the post-digester. The solid digestate is used as fertiliser and the fluid is discharged to the public wastewater system after decantation. The biogas has an average methane content of 54 percent and is used to fuel an on-site a combined heat and power genset with 104 kW power rating. All the electricity and around 65 percent of the heat is used by Joluwa for the chicory processing plant and self-consumption of the biogas plant. An additional 30 percent of the heat is supplied via a small network to a printing company located about 1 km from the biogas plant.

– The overall heat loss is only 5 percent which is very low for a biogas plant, Genin pointed out.

In the first step, hydrolysis and acidogenesis, the chicory roots along with other vegetable matter are loaded into the receiving hopper using a front loader. An X-ripper grinder pump is used to get the material into the hydrolysis tank where it is converted into a liquid loaded with volatile fatty acids. In the second step, methanogenesis, this acid liquor is fed into the HYFAD fixed bed reactor to produce biogas. The HYFAD reactor consists of two 25 m³ vessels that are side by side and connected to each other. The vessels are packed with vertical honeycomb columns which function as the fixed bed media. The honeycomb structure provides a very large surface area in relation to the reactor volume. This leads to a high concentration of bacteria attached to the bed as biofilm enabling a high methane yield. Organic loading rates (chemical oxygen demand) of up to 35 kg COD/m³ per day have been achieved with this reactor. The reactor has an anti-clogging system that cleans the columns and recovers the biofilm.

The temperature in the HYFAD phase is kept at 38°C and the pH is always kept neutral and remains stable even if the liquefier is overfed. The post-digester in the final step allows the digestion of organic material that had not been fully processed in the hydrolysis tank. The global hydraulic retention time (HRT) for the plant is 45 days.

The plant uses on average 11 tonnes of chicory roots per day but can handle up to a 30 tonnes per day peak. According to Genin, chicory roots yield about 38 m³ methane per tonne.

– This is quite low compared to other feedstocks and is due to the high water content, around 85 percent, said Baptiste Genin.

Text & photos: Alan Sherrard
BI70/3992/AS

View of the Joluwa biogas plant. To the left the red receiving bin with the hydrolysis tank, the HYFAD unit is inside the shed. In the foreground the feedstock chicory roots and endive leaves alongside the solid digestate discharge. Further to the right, out of view, is the CHP unit and the post digester.

The HYFAD reactor consists of two well insulated 25m³ vessels keeping a temperature of 38°C and neutral pH. It produces 75 percent of the biogas.

Baptiste Genin R&D engineer at GreenWatt spoke on the benefits of converting fruit and vegetable residue to energy with examples of other projects.

"This project was about 1 million EUR including the 1 km heating circuit to the printers. Payback is within four years"

BAPTISTE GENIN GreenWatt.

BEANS, BABOONS AND BIOGAS

In March 2015 Tropical Power commissioned Gorge Farm, the largest biogas plant in sub-Saharan Africa. Located in Naivasha, Kenya, it is reputed to be the first biogas to grid-connect project on the Continent. By all accounts it is a pioneering showcase of how such a project is possible and anything but a monkey's business. Except when it comes to risk assessment.

– I SUPPOSE BABOONS ARE NOT TOP OF MIND for European biogas plants, but they are certainly a risk assessment factor to be reckoned with here in Kenya, commented Christopher Macharia, Project Engineer, Tropical Power Energy Group during a visit to the plant. His work brief includes setting up operational health and safety procedures, which in Kenya includes dealing baboons and big stray cats. With subsidaries in Ghana and Kenya, Tropical Power is a UK-headed engineering, procurement and construction (EPC) company specialised in developing and building utility scale renewable energy projects from biomass and solar. The recently commissioned 2.6 MWe Gorge Farm biogas facility is reputed to be the first biogas power to grid plant in Africa and the largest biogas plant in sub-Saharan Africa.

"I suppose baboons are not top of mind for European biogas plants, but they are certainly a risk assessment factor to be reckoned with here in Kenya"

CHRISTOPHER MACHARIA
Project Engineer, Tropical Power Energy Group

Horticultural major

The biogas plant is owned and managed by Biojoule Kenya, an Independent Power Producer (IPP) which in turn is jointly owned by Tropical Power and Kenya-headed VP Group, the largest fresh-produce exporter in East Africa. Gorge Farm is nestled on the slopes of the Rift Valley between Hells Gap National Park and the southern shore of Lake Naivasha. The farm is an 800 ha horticultural estate owned and operated by VP Group. Complete with its own on-site packing facilities, Gorge Farm is one of several large "flower, fruit 'n' veg" farms in the Lake Naivasha region. Situated around 2 000 m above sea level the region has a warm, dry climate which together with fertile soils and access to water makes it suitable to grow flowers and vegetables. Lake Naivasha's relative proximity to Nairobi's airports, about 90 km, gives producers direct daily access to major export markets in Europe and the Middle East especially for roses and French beans.

Feedstock availability

Gorge Farm alone generates around 50 000 tonnes per annum of organic material in the form of harvest residues, pack-house rejects as well as tops and tailings.

– Through our partnership with VP Group, we are able to access abundant high-quality feedstock: around 150 tonnes of fresh organic matter every day. We only use farm residues as feedstock not purpose grown energy crops such as maize silage, stressed Macharia emphatically rebutting a rumour that the contrary could also be the case.

– However, we also carry out experimental biogas trials here on other feedstock that could be grown or used to produce biogas for power projects elsewhere in Kenya. For instance cacti that could be grown in the non-used semi-arid regions or invasive species like the Giant Water Hyacinth which is a problem here in Lake Naivasha, explained Macharia, adding that plenty of residues from neighbouring farms were available should the need arise.

(Above) The biogas plant is a two-stage process type with a hydrolysis stage followwed by the methanogenic stage.
(Left) The coast is clear - a troop of baboons from neighbouring Hells Gap National Park take the opportunity to rumage around recently delivered vegetable waste for an afternoon meal. Whilst they tend to avoid getting close to humans they are risk factor to take into account as is the odd big stray cat.

Two-stage process

The biogas plant is of a two-stage process type, with the hydrolysis stage separated from the methanogenic stage enabling optimum temperature and pH conditions for the various microorganisms to work in. The plant is of German origin, from Snow Leopard Projects GmbH (SLP) in Bavaria. SLP have been involved in over 40 biogas installations in Europe and elsewhere though this is one of the largest.

An advantage with a two-stage plant, of particular importance to Gorge Farms, is feedstock flexibility in terms of time and type.

– The farm grows a variety of seasonal products over the year. As you can see at the moment we're getting in residues from baby sweetcorn, beans and cauliflower, said Macharia.

Mixing the feedstock and gradual progression from one substrate to another over a season avoids shocking the micro-organisms while keeping retention time and biogas yields on an even keel. The retention time is around 20 days, significantly shorter and with better biogas yields than what might have been achievable with a typical single stage plant.

– Plant start-up was a challenge though and took quite a long time, revealed Macharia.

Normally for a new plant startup one takes samples from a selection of biogas digesters using the same type of feedstock to get the microorganism base needed to start the biological process.

– Being the first such plant we had to feed cows and other herbivores with the different substrates and take samples from their digestive system to find the right mix of micro-organisms, he explained.

Displacing artificial fertiliser

A key product for VP Group is the digestate that when dewatered is reminiscent of horse-manure in colour and texture. The plant gives rise to roughly 35 000 tonnes annually of nitrogen-rich digestate. Both the liquid and dewatered material are used as fertiliser on the farm and it is expected that this will help reduce the overall use of artificial fertiliser over time. How much remains to be seen.

– While fertile the soil lacks humus so the digestate is a very important product for the farm as it acts both as a fertiliser and a soil conditioner, Macharia explained.

Water is also a constraint and irrigation is monitored, all commercial farms around the lake need permits that regulate water usage.

– We don't need to add water to the process other than the initial start-up. The feedstock is fresh plant material that contains a lot of water and the facility recirculates its process water with the excess used as a nutrient rich liquid fertiliser, Macharia pointed out.

First biogas power to grid

The two containerised genets, each with a GE Jenbacher 420 biogas engine and supplied by UK-headed Clarke Energy, also mark a first for GE Jenbacher in so far as they are the first biogas engines from the company in East Africa. They are configured for cogeneration with engine heat recovery supplying heat to the biogas process as well as heat to nearby plant propagation houses.

– This is also the first biogas plant in Kenya to be granted a Power Purchase Agreement (PPA) to supply to the grid, said Macharia.

The PPA with Kenya Power Lighting Co (KPLC), the sole power distributor in the country, is for the excess power after supplying Gorge Farm. In theory this means that there is no minimum or maximum supply obligation. The current (2012) feed-in tariff (FiT) for a grid connected biogas plant in the 200 kW - 10 MW band is US$0.10 kWh. The value is fixed, except for the annually indexed operations and maintenance (O&M) component which in this case is 15 percent, from the signing the PPA and valid for 20 years.

– Obviously it is in our best interest to supply as much power as possible to the grid as it is our main source of revenue, said Macharia.

In essence the feedstock supplied by VP Group is free subject to receiving the digestate in return for free. The electricity supplied to VP Group is estimated to displace 6 million litres of diesel fuel previously used to run gensets.

Tech-transfer

The Gorge Farm biogas project investment was around KES 591 million (≈US$6.5 million) and includes the biogas plant and grid connection together with onsite workshop, office and laboratory.

– The plant has work. As you can see we have

cont. on page 20

Receiving and mixer bin. (Far right) A key product is the horse-manure like digestate.

cont. from page 19

a fully equipped workshop with a comprehensive spares stock along with a proper laboratory. Just getting OEM spares takes a long time in this part of the world so we need to be as proficient and self-sufficient as possible on-site, remarked Christopher Macharia.

The plant took less than 12 months to build, quite a remarkable achievement and a testament to the commitment of the project partners and the knowledge-transfer capabilities of the technology providers. Unlike countries with a well developed industrial biogas sector, there were no experienced engineers in Kenya at the start of the project to build or operate a facility of this scale.

Renewable hybrid ahead

With the PPA the biogas plant has, according to Tropical Power, an estimated payback of just under six years and a technical lifespan of 20 years. Furthermore the company can begin to leverage on its experience and expertise in developing other biogas projects in Africa as part of its overall target to build 130 MW of renewable power assets by 2018. For instance it has already announced plans for a 5 MW biogas project in Ghana where VP Group also have operations. The proposed setup is similar: Tropical Power the EPC, Biojoule the IPP owner operator and feedstock supplied by VP Group.

– Actually we're renewable technology agnostic. We have a biomass boiler installation that uses residues from a VP Group rose farm to heat the farm at another location in Kenya, said Mike Nolan, Operations Director, Tropical Power. Apart from serving as a demonstrator and shop-front for other African biogas project developers, Tropical Power have additional development plans for Gorge Farm, a 10 MW grid-connected solar photovoltaic (PV) plant.

– We've secured the PPA and the PV plant will be set-up adjacent to the biogas facility. The idea is to integrate the two facilities to provide baseload and dispatchable peak load power to the grid. VP Group has a very clear agenda to reduce its climate impact and environmental footprint. Our job is to provide the best suited renewable energy solution adapted for the site and situation in question, ended Mike Nolan.

Text & photos: Alan Sherrard
BI88/5395/AS

(Above) The biogas is used to fuel two self-contained GE Jenbacher 420 gensets. The engine and exhaust heat is recovered to support the biogas process and to heat nearby plant propagation houses. Nighttime temperatures can be quite cool at 2 km above sea level and roses love a steady 22 degrees.

FACTS

Lake Naivasha is one of several flori- and horticulture regions in Kenya that make up an export industry that has mushroomed since 2000 and continues to bloom. According to figures from the Kenyan Export Council the sector generated just over 17 percent of the country's total KES 581 billion (≈EUR 5.2 billion) in commodity exports 2015, second only to tea which had 21 percent share.

Herzberg double bottom-line benefits

The biogas plant (left) is located next door to the Deutsche Tiernahrung Cremer animal feed facility in Herzberg, Germany. Cremer provided the site and leased it to EnviTec who financed and built the biogas plant. The plant supplies heat in the form of hot water and saturated water vapour to Cremer.

Like many other processing industries, heating oil has been used for fuel by one of Germany's leading animal feed producers for its process heat needs. Since the end of 2009 a neighbouring biogas plant has been supplying a major share of the heat demand for its Herzberg production facility. This has cut fossil carbon dioxide emissions and improved the bottom-lines of both operations.

PRODUCING AROUND 2.8 million tonnes of product per annum, Deutsche Tiernahrung Cremer GmbH & Co. KG is one of Germany's oldest and leading animal feed and pet food producers. Located on the border between Saxony-Anhalt and Saxony, some 90 kilometres south of Berlin, Herzberg is one of 14 production sites operated by the company. Previously the entire heat needs of the Herzberg plant were met using heating oil. Since the end of 2009 the neighbouring biogas plant has supplied a significant share of the heat requirements.

Bottom-line benefits

– We originally intended to build our own biogas plant. But then we thought that we know how to produce animal feed best and that EnviTec knows very well how to build biogas plants. So we very quickly reached an agreement, explained Thomas Schulze, Plant Manager of Deutsche Tiernahrung Cremer GmbH & Co. KG ('Cremer') in Herzberg.

The biogas plant and heat supply is the result of cooperation between Cremer and EnviTec Biogas Beteiligungsgesellschaft, a subsidiary of the German biogas technology supplier EnviTec Biogas AG. Cremer provided the site and leased it to EnviTec, who financed and built the biogas plant. The plant consists of two 500 kW electric output modules and the heat generated in the electricity production process is sold to Cremer.

– Thanks to this cooperation, we need fewer fossil fuels, which greatly improves our bottom line and carbon footprint here at Herzberg, said Schulze.

Heat and saturated vapour

The biogas plant uses poultry manure, liquid manure and other non-food organics, so called "NawaRos" (Nachwachsende Rohstoffe) as feedstock material. A heat pipe carries water heated to around 90 °C from the biogas plant to the Cremer facility. Apart from heating the administrative building and the production halls the heat is also used in the production process to ensure that the liquid state of ingredients such as oil, fat or molasses is maintained at temperatures in the storage tanks between 40-60 °C.

Another pipeline from the biogas plant supplies saturated water vapour that is used in the pelletising process.

– We need about one tonne of saturated vapour per hour. About two thirds of this volume is supplied by the biogas plant, said Thomas Schulze.

The saturated vapour comes from a steam plant that utilises the high exhaust gas temperatures from biogas combustion in the co-generation units thereby increasing the overall efficiency of the plant. This saturated vapour is supplied to Cremer at 180 °C and a pressure of 10 bar.

– We are of course pleased that we are able to make a contribution to climate protection. However entering into the partnership with EnviTec Biogas was fundamentally a very sensible business decision especially in light of increasing fossil fuel prices, ended Thomas Schulze.

Text: Alan Sherrard
Photo: courtesy EnviTec Biogas
BI79/4842/AS

For Wyke Farms '100% Green' is anything but cheesy

At Wyke Farms they know a good thing when they're on to it. When your award winning cheddar proves so popular, it's best to guard and stay loyal to that 150-year-old recipe. Yet this third-generation family-run business realises that presenting yourselves with new challenges is also key to continued success – in this case, motivated by its genuine love for its Somerset home and sustainable practices that will protect it.

SET IN SOMERSET, WYKE FARMS LTD is one of the UK's largest independent cheese makers and milk producers. With a herd of 1 100 cows, the integrated dairy farm and cheese factory selling over 15 000 tonnes annually to over 160 countries around the world. With the help of some pumping equipment from another traditional yet forward-thinking company, Wyke Farms is harnessing its resources in style.

Going for '100% Green'

In 2013, the company commissioned phase one of its biogas plant supplied by German company Biogas Nord. Consisting of three 4 600 m³ digesters it also introduced its first biogas-powered 500kW generator to produce green heat and power to run its dairy. Part a £10 million long-term sustainability plan, the launch of its own on-site biogas plant saw Wyke Farms become the UK's first national cheddar brand to be 100 percent self-sufficient in green energy.

In 2014, phase two of the biogas plant was commissioned. This saw additional 4 600 m³ digester and another 499 kWe generator unit along with an upgrading unit and biomethane-to-grid injection supplied by CNG Services Ltd, an independent UK biomethane consultancy and project management services provider. The company also struck a green gas supply deal with Sainsbury's, one of its supermarket clients. The same year also saw a wastewater treatment and recovery plant brought on-line enabling the company to recover up to 95 percent of its factory wastewater.

Pump up it up and around

Today, the four anaerobic digesters at Wyke Farms convert 75 000 tonnes per annum of biodegradable waste such as manure into heat, electricity, biomethane and biofertiliser. Pumps become a key component in keeping movement in the various flows throughout the AD process.

Andrew Langley from Laminar Pumps Ltd works in close conjunction with Wyke Farms' Engineering Director, Jason Fewell to diligently keep the 10MW '100% Green' operation running as smoothly and as efficiently as possible. Two 18.5kW Landia mixers and an 18.5kW Landia AirJet serve a 0.5 million litre part-underground tank that receives the milky and fatty wastewater from the cheese making process. After treatment to remove fats, these effluent solids are then sent to a sludge holding tank before being pumped to the AD plant – with excess water cleaned and polished for use as wash-water.

One mile away at the totally self-contained AD plant, a 75m3 slurry pit is a firm reminder that managing an AD plant is no walk in the park. Here, a 30kW long shaft Landia chopper pump, assisted by an 18.5kW Landia propeller mixer acts as the main slurry feed to the AD plant, chopping and mixing a demanding blend of slurry, maize and straw.

"This is a very hard duty for any pump or mixer. Straw especially, is a nightmare for most pumps - but not here. As long as we maintain a consistent feed and flow rate, the Landia equipment just keeps on working, said Andrew Langley.

"Also, we were able to provide a simple upgrade too of the long shaft pump to allows for the increased duty required for the new plant extension. We only run this Landia pump and mixer for 20 minutes per hour - 5 minutes, every 15 minutes so the power consumption is low and improves the longevity and the equipment. We feed the digesters gradually, one by one. As the solids get broken down, this keeps everything nice and consistent," said Langley.

Innovative 'big box design'

As if that early part of the process wasn't tough enough, it has taken Andy's own innovative 'big box design' to conquer the second part. At this stage of the process, maize and straw (that often contain grit), are injected in to the slurry feed line, this process involves the compression of the straw to form a sealing plug between the 'dry' and 'wet' sides of the products. This causes a highly viscose substrate to be released, this is collected and then pumped back into the feed line.

"Straw especially, is a nightmare for most pumps – but not here. As long as we manitain a consistent feed and flow rate, the Landia equipment just keeps on working"

ANDREW LANGLEY, Laminar Pumps Ltd

Regular maintenance is of course key to equipment performance, this maintenance however leads to the escape of product which is collected in a local reception tank, then with the use of a Landia DG chopper pump the digestate is returned to the feed stock, this duty can be very aggressive with the high grit content, but the pumps just keeps on going, they are very tough".

Andy has first-hand, day-in, day-out experience of which kit works best at Wyke Farms – and together with Jason Fewell, has sourced quality equipment for the AD plant and beyond – for the long-term.

"As always, it's a learning process – with a switch to Landia's mixers for Wyke Farms' first two digesters we have seen a noticeable improvement in performance.

"Pumping the feedstock for AD plant can be such a heavy duty", Andy continued, "and there has to be scope for variables, no matter how hard we try to control it. We always want to get to the very heart of the process to understand what's going on, so we work closely with a number of pump manufacturers to find the most suitable equipment for each application. Some, for example are very good with Landia being excellent for high volume and hard to handle solids. The Landia mixers, together with their pumps, there have been addition to the biogas plant, which are sized specifically for our process, so they are trouble free and easy to service".

Very efficient operation

Wyke Farms has continued to make significant impact on further reducing its carbon emissions by fitting solar panelling across its family owned farms and cheese dairy, using electric vehicles for delivery and reducing its packaging waste. With its attention to detail and firm belief in sturdy, efficient equipment, it is no surprise that Wyke Farms' long-term commitment to being '100% Green' has seen it become the UK's first dairy company to become 100 percent self-sufficient in green energy. One result of its efforts is that Wyke Farms has been awarded triple Carbon Trust certification to become the first UK dairy to achieve the Carbon Trust Standards for carbon, water and waste at the same time.

"This is a very efficient operation", continued Andrew Langley. "Nothing is left to chance. Resources are precious. Any excess heat from the CHP (now 2 x 500kW engines) is recovered for the lining of the four digesters to help keep them at their optimum temperature."

As a result the AD plant is self-sufficient and the gas-to-grid unit is achieving over 20 000 Nm³ of biomethane per day. Following on from the digesters, the biosolids in the final settlement tank make excellent fertiliser for the lush pastures of the Mendip Hills where Wyke Farms' 1100 cows graze, where the whole process begins again.

"Wyke Farms has been at the forefront of sustainability in farming and dairy for many years because they work very hard to strike the right balance – and it's fair to say that the now 22 different pumps and mixers from Landia that we've invested in are continuing to play their part in the phenomenal success of us being 100 percent green", concluded Andrew Langley.

Text: Alan Sherrard
Photos courtesy Wyke Farms & Chris French/Landia
BI107/6418/AS

(Top left) A view of the digesters at Wyke Farms. (Above) Andrew Langley (left), Director, Laminar Pumps discussing plant operations with Landia's Paul Davies.

PASSIONATE DAIRY AND BIOGAS PIONEERS

Whilst the benefits of co-locating pellet production with a wood processing plant seem pretty obvious, setting up a 15 000 tonne-per annum capacity plant on a dairy farm are less self-evident. Yet that is exactly what an entrepreneurial dairy farming family in Italy has done.

– The Pasini's are pioneers and great ambassadors for us at BTS. Their farm is in one sense a showcase of our technical developments over the last decade, said Björn Blankespoor, International Sales Manager for BTS.

LOCATED IN MARMORTA DI MOLINELLA in the province of Bologna, the Agricola Antonio Farm is a dairy cattle farm owned and run by passionate dairy farmers, the Pasini family. The 500 ha farm has around 400 head of cattle of which 200 are milk cows. Apart from milk production the farm grows its own feed and fodder. Furthermore, it owns and operates two manure and silage-based BTS Biogas biogas power plants, each at 1 MWe capacity supplying into the power grid under the feed-in tariff (FIT) scheme.

– The Pasini's are pioneers and great ambassadors for us at BTS. Their farm is in one sense a showcase of our technical developments over the last decade, said Björn Blankespoor, International Sales Manager for BTS Biogas Srl/GmbH.

Both biogas plants are of conventional Continuously Stirred Tank Reactor (CSTR) types that operate under mesophyll process conditions, around 40 °C and both produce biogas from manure and silage feedstock that is used directly for onsite power-to-grid production in two Jenbacher JGS 320 biogas gensets, one for each plant respectively. Though located next-door to each other on the farm, each biogas power plant including feedstock storage, substrate feed-in and genset is its own separate administrative unit, in compliance with Italian feed-in tariff (FIT) regulations.

Most of the feedstock is produced on the farm with silage as a part of crop rotation whereas an amount of chicken manure and vegetable waste is sourced locally from neighbouring farms.

– The CSTR concept has several advantages such as uncomplicated construction and low operating costs in terms of labour. However, the most important advantage in this context is that it runs at a steady state with continuous operation as opposed to a batch process, commented Blankespoor.

It is a fair point. The substrate composition for both of the plants is well defined and relatively homogenous in its composition throughout the year as is the output, biogas for power production.

Same but different

The first plant commenced operations in 2009 and consists of two 1 900 m^3 digesters, a 4 700 m^3 post-digester. In 2012 the plant was retrofitted with a "BIOaccelerator" pre-treatment unit to accommodate a higher share of ligno-cellulosic material. A screw-type extruder, it assists with input substrate breakdown with a thermo-mechanical treatment process by means of two juxtaposed, interlocked screws. As a result the substrate for this plant currently consists of cattle slurry, maize- and ryegrass silage and chicken manure. The hydraulic retention time (HRT) is around 80 days and the biogas has around 55 percent methane content.

The second plant commenced operations in 2012 and is quite different. Like the first plant it too has mechanical pre-treatment unit, a "BIO-accelerator" though this is a different type of pre-treatment unit – a mechanical size-reduction macerating unit. Furthermore, the plant differs in that it has a hydrolysis step with a 470 m^3 tank and a single 3 000 m^3 digester. The substrate for the second plant consists of cattle manure, maize silage, straw and stalks. The hydraulic retention time (HRT) is shorter, around 70 days and the biogas has around 55 percent methane content.

Heat utilisation

Apart from heating the digesters, the excess heat from the gensets of both plants is used onsite. From the first plant excess heat is used to dry around 5 000 tonnes per annum of forage and hay for the cattle as well as provide space heating for the 250 m^2 farm house. In energy terms around 1 200 MWh per annum of heat is used in this way.

The residual heat from the second biogas power plant is used to dry sawdust and wood shavings for a 15 000 tonne per annum pellet plant, the most recent project venture for the Pasini family.

The residual heat from the first biogas power plant is used to dry around 5 000 tonnes per annum of fodder and hay for the 400 head of cattle as well as space heating for the farm-house.

All the digestate from the two biogas power plants is press-screwed to remove excess water, which is recirculated and the solid digestate used as fertiliser on the 500 ha farm.

(Top) View of the first biogas power plant with two digesters seen from the feed-in side. (Above left) A close-up of the Bioaccelator'" installed at the second biogas power plant. (Above right) The Pasini family are passionate about dairy farming with cow no. 7652 enjoying a well deserved "scratch'n'scrub" moment.

The heat from the second plant was originally used to in a manure management and valorisation project to dry and pelletise digestate using another technology from BTS, its BIOdry. With a grant from the Rural Development Programme of the Emilia-Romagna region, a digestate drying and pelleting line was setup in 2013 to produce digestate fertilizer pellets as well as liquid fertilizer.

– The concept is to use the residual heat from the genset to produce two fertiliser products from the digestate, a solid that can then be pelletised and a liquid ammonium sulphate fertilizer. The advantage is a reduction of the volume of digestate and a pastorised final product, said Blankespoor.

The system uses the residual heat of cogeneration and is able to also exploit the residual heat potential of the drying air to thicken a part of the liquid fraction of the digestate resulting from the solid-liquid separation. The air, rich in water vapour, ammonia, and malodorous compounds, resulting from drying of the digestate, is treated in a sulphuric acid scrubber that gives rise to an with production of an aqueous ammonium sulphate solution that can be used to increase the nitrogen content in the organic fertilizer or can be marketed as liquid nitrogenous fertilizer.

From digestate to wood to...

Although successfully demonstrated, the market for organic fertilizer was lacking and the farm has sufficient acreage to utilize all the digestate from both of the biogas plants without having to upgrade it. Instead it was decided to repurpose the digestate pellet plant to produce wood pellets for the local market and so now the heat from the second biogas plant is used to dry sawdust and woodshavings for the 15 000 tonne per annum Greenergy Società Agricola S.r.l. pellet plant.

What is next for the pioneering Pasini's remains to be seen, however, the FIT is for a 20-year period which means 2019 is the expiry for the first biogas power plant. Perhaps biogas upgrading to biomethane though the farm is not located within a reasonable distance of a gas pipeline for grid injection.

– There is no shortage of ideas though I am not at liberty to disclose anything at this moment in time, ended Björn Blankespoor.

Text & photos Alan Sherrard
BI94/5794/AS

ABOUT BIOGAS 1

Process temperature: c. 40 °C
Reactor type: CSTR
Digesters volume: 2 x 1 900 m^3
Covered storage tank volume : 4 700 m^3
Hydraulic retention time (HRT): 80 days
Engine: Jenbacher mod. JGS 320;
Installed power capacity: 1 MWe
Annual power output: 8 000 MWh (net)

ABOUT BIOGAS 2

Process temperature: c. 40 °C
Reactor type: CSTR
Pre-tank, hydrolysis step: 470 m^3
Digester volume: 1 x 3 000 m^3
Hydraulic retention time (HRT): 70 days
Engine: Jenbacher mod. JGS 320;
Installed power capacity: 1 MWe
Annual power ouput: 8 000 MWh (net)

Small scale biogas boom in Cuba

Normal street view dominated by horse carriages in Cuban city of Gardenas in Cuba.

ayakovlevcom / Shutterstock.com

A political legacy, in veteran car circles Cuba is known for having vintage cars still in operation.

The cooperative main building 10 km from city of Gardenas.

On the spot reporter in Cuba, Markku Björkman.

A massive societal transition is looming in Cuba as relations with its former "arch-enemy", the US, began a normalisation process in 2015. This transition will impact, not only Cuban society but also on its energy profile. Yet Cuban farmers already have much greater experience in biogas than farmers in many more technologically advanced countries.

CUBA IS STILL A POOR DEVELOPING COUNTRY, with a very shaky power supply system, but stands out for its free education, free health care and cultural and sporting success. On the other hand Cuba stands out for its very serious shortcomings in terms of democracy, freedom of speech and influence for the individual citizen. As an occasional visitor one could hear complaints about power outages, notice a glaring lack of housing, the rundown infrastructure and of all the obstacles for those who wish to start their own economic activities in order to improve their standard of living.

However, today many Cubans observe a trend towards a more open climate not least when it comes to farming. Because pork is the most widely consumed meat in Cuba, many private farmers and families raise pigs. This is one of the reasons why the Ministry of Science, Technology and the Environment is promoting the installation of biodigesters, to help boost biogas production.

During the two last years the authorities in Cuba installed six larger facilities, which are now providing biogas. The country has today around 2 000 small scale biodigesters and, according to Cuban Ministry of Mines and Energy, some 700 biogas plants operate on state farms and in the private farm sector, where this technology is being promoted to conserve energy and protect the environment. The country needs to build an additional 7 000 units, mainly using pig and cow manure.

– Most of all Cuba needs an additional 500 industrial biogas plants using the residue from distilleries, canning factories, sugar mills, slaughterhouses and pulping factories, the Cuban Vice-Minister of Energy recently stated.

The energy ministry is also considering cogeneration at sugar mills and alcohol plants. According to an official study, Cuba has the potential to produce more than 400 million Nm^3 of biogas annually, which if administered appropriately could support 85 MW of power generation capacity. By doing so, this would avert 3 million tonnes of carbon dioxide (CO_2) emissions and save around 190 000 tonnes of oil.

Cooking help by pigs and cows

The agricultural cooperative near the Cuban city of Gardenas is typical. Surrounded by astonishingly beautiful and lush tropical vegetation this cooperative grows crops like corn and fruits like bananas and mango. In addition, the cooperative has a considerable number of cows and pigs. The director of the cooperative, Hector Correa, says that it was during his visit to the Soviet Union in the 1980's when he got the idea to use animal droppings for the generation of biogas. He saw several small-scale farm holdings in the context of his round trip. Hector has even lectured and consulted on biogas production around the Cuba.

–In that way Cuban agriculture has become a net producer of energy. Biogas and biofuels can be produced and consumed locally. A cow produces up to three kilowatt hours (kWh) of energy per day. The farms that have a surplus can sell it even to a local market, but biogas is still used mostly for cooking in Cuba, said Correa.

Another staff member, Cladys Marrero, has witnessed firsthand how the daily cooperative life has changed. Replacing the use of firewood, kerosene and petroleum-based products with biogas makes household work more humane. She demonstrated how the manure is led via open canal from the pig barn to a large fermenter. It is placed about 4 meter deep under the earth. After the digesting process the raw gas is pumped from the fermenter to storage and from there to cooperative kitchen.

Top of the small scale biogas fermenter, which bottom plate is placed about 4 meter deep under the earth.

The costs for building a complete local small scale digester for fermentation of pig or cow manure in Cuba lies around US$2 000. Cuban farmers make use also of simple method to store and distribute biogas, large plastic bags. After digestion the raw biogas is then carried in bags to the neighbors who gratefully receive gas. According to officials, the biodigesters help to reduce soil and groundwater pollution, and curb the cutting of trees for firewood.

Plans for more Cuban biogas

The Biogas Promotion and Development Centre at the Cuban Swine Research Institute is drafting a national plan to encourage the use of biodigesters in state companies and agricultural cooperatives. One of biggest biogas plants in the country has recently been completed at Guayos in the central province of Sancti Spiritus. The facility will have some 740 m^3 of biogas capacity, which will supply up to 1 MWh of electricty a day to the grid. This agro-industrial complex will run the first generator that is connected to the national power grid on the island. It will have an average production of 350 kW per hour of which 310 kW are destined for internal consumption at the complex with the excess supplied to the grid. It takes advantage of all available resources of the farm sector to give rise to a source of cleaner energy.

Taking a closer glance into the fermenter. After the digesting process the raw biogas is pumped from the fermenter to storage and the cooperative kitchen.

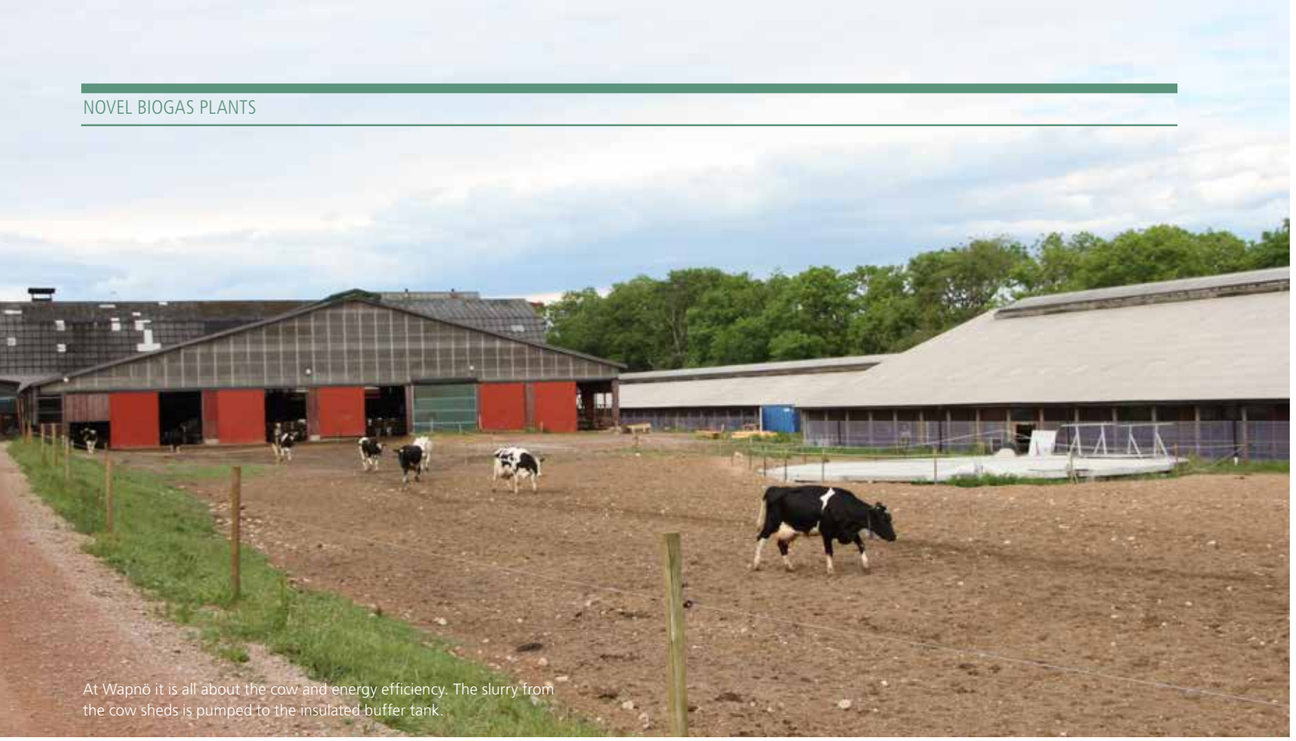
The digestate is used as fertiliser on the cooperative farmland.

In its current draft, the national plan projects the construction of some 1 000 biodigesters a year by 2020. Nine projects implemented by the Agriculture Ministry and the non-governmental National Association of Small Farmers, will receive financing from the United Nations Small Grants Programme. Residues from sugar cane have so far been used as fuel for production of rom, but there is a huge untapped capacity for the production of biogas. There are calculations which show that Cuba within a few years could replace all its fossil oil consumption with biogas from the sugarcane industry. That would mean a further reduction in CO_2 emissions and independence of Venezuelan oil imports.

¡Viva! And thank the cows and pigs, that there is lots of gas to use in the kitchen for cooking. Cladys Marrero likes being self-sufficient when it comes to energy. The biogas can also be used for heating, but the temperature in the region of Cladys' cooperative drops hardly ever under 17°C.

However, there is still many challenges in Cuba regarding more environmental friendly power supply. Nearly all the energy in the form of oil is imported cheaply from Venezuela. The huge and ecologically very dirty nickel mine can be seen even from the space. Lot of waste is still dumped in sea inlets. Cuba's economy is simply not yet an example of sustainability more than any other poor country in Africa or Asia. Hopefully that is all set to change as US-Cuban relations turn a page to begin a new chapter.

Text & photos Markku Björkman
BI85/5186/AS



At Wapnö it is all about the cow and energy efficiency. The slurry from the cow sheds is pumped to the insulated buffer tank.

VERY COOL WITH COW HEAT AND POWER

Wapnö is an integrated dairy farm with own on-site dairy products processing. Located just outside the city of Halmstad on the west coast of Sweden, Wapnö recently installed an innovative biogas-based energy system. Using only manure as feedstock, the biogas is used to supply the entire Wapnö agri-complex with heat, power and -11 °C cooling. Along with odourless fertiliser and 2 MW energy to spare, it is perhaps the most energy-efficient and environmentally optimal biogas system ever built.

THE GLOBAL DEMAND FOR MEAT AND DAIRY products continues to grow at profound rates, especially in the developing world. According to the U.N. Food and Agriculture Organization (FAO), the per-capita milk consumption in developing countries almost doubled and meat consumption more than tripled between 1980 and 2005. During the period 1980 to 2010 the global cattle population grew 17 percent to reach 1.4 billion animals. The Consultative Group on International Agricultural Research estimates that by 2050, the global cattle population will have almost doubled to 2.6 billion animals to provide for an estimated human population of 9.7 billion.

Local production

It follows that as animal and human populations increase, so too does the need to increase the production of food, fodder and feed in an energy efficient and environmentally sustainable way. Wapnö's current contribution to the global cattle population is around 3 300 animals of which 1 300 are milk cows and the rest calves and heifers. The 2 200 hectare (ha) holding is made up of 1 650 ha arable land, 100 ha pastures and 450 ha forest and it is run as a limited company with some 50 employees.

In fact Wapnö is an agri-business complex that has evolved around its focus on the cow. Today the on-site business operations include milk and associated dairy products that are sold to supermarkets in the region, a 21-bed hotel and conference venue, a restaurant that sources its ingredients, including beef, from the farm, and a "Farmer's Market" shop for products from the farm.

The company has a strong local production and sourcing ethos. According to Wapnö CEO Lennart E. Bengtsson the primary task for arable production on the farm is to provide feed, fodder and bedding for the cows, thereafter food production. The animals are kept open range year-round having free access to large sheds with bedding, feed and water. On an annual basis about 10 000 tonnes of grass and whole crop silage, 3 700 tonnes of grain and 1 110 tonnes of straw of which 400 tonnes is chopped for bedding, is produced.

Energy optimisation

Wapnö's energy "hoof print" however is very different to any other livestock farm or dairy. In June 2011 a decision was made to invest in an innovative biogas-based energy system to cater for the entire energy needs of its operations, that is cooling, heat and electricty. The Danish company Lundsby Bioenergi A/S was given the c. 12 million DKK contract to provide the biogas system on the pre-condition that it could commit to a minimum daily biogas output. Furthermore the only feedstock for the biogas plant that would be made available to achieve this output were going to be residues from the farm, 36 000 tonnes of slurry, 3 000 tonnes of solid manure and 700 tonnes of feed residues. The plant was commissioned in April 2012.

– This is more of a challenge than it sounds. Cattle manure on its own has a relatively low methane yield and long retention time. And we had to ensure a minimum daily biogas yield that would be enough for the downstream energy system, said Karsten Hjorth, project manager Lundsby Bioenergi A/S.

From a plant perspective this is usually compensated by blending a percentage of a crop-based feedstock such as maize silage. However at Wapnö this is not an option as company policy forbids the use of any purpose-grown feedstock, the arable land has too high a "food value" and is used for food and feed production.

Unconventional

The biogas plant itself is a conventional mesophyllic two-stage anaerobic digestion plant with a number of special adaptations and features all designed to make it as energy efficient as possible, in particular with the use of heat. What makes the Wapnö setup unique for a farm-based biogas plant is that apart from supplying electricity and space heating to the entire complex, the heat is used to supply cooling.

Slurry from the cow sheds is collected and pumped to an insulated buffer tank that is buried at ground-level. Manure, bedding material and feed residues are fed into a Trioliet double-auger stationary feeder mixer using a front-loader. The luke-warm, 10-20 °C, slurry from the buffer tank and the macerated material from the feeder mixer are fed into an insulated mixer tank where the material is stirred to a homogenous mass.

The mixer tank is also heated as the incoming material from the feeder mixer is cold. A special feature is that it is heated by using a heat exchanger to capture the heat from the outgoing warm digestate before this goes into storage. The pre-heated and mixed material passes a stone seperator before being pumped into the 3 800 m^3 digester where 70-85 percent of the biogas volume is produced. Here the temperature is increased to around 40 °C by heat exchanger on a hot water circuit. The digester also doubles for biogas storage with hydrogen sulpide (H_2S) reduction to 100-200 ppm. This enables scheduled stops on downstream equipment such as maintenance services without biogas loss due to flaring or plant shutdown.

From the digester the still biologically-active material is fed into the 3 800 m^3 post-digester unit where the remaining 15-30 percent of the biogas is produced. From the post-digester the digestate is fed past the mixer-tank via a heat exchanger to extract the heat before going into the digestate storage tank.

Solids are separated from the digestate and water is added when it is applied as an odourless organic fertiliser on Wapnö's fields. The fiberous solids are dried, packed in fertilser bags and sold as a soil improvement product.

"Wapnö is a very innovative project, using 37 °C manure to supply -11°C cooling as well as heat and power"

KARSTEN HJORTH, Project Manager
Lundsby Bioenergi A/S

Power and cooling

Water is removed from the biogas and the condensate returned to the mixer tank. The biogas is piped to the combined heat and power genset located next door to the dairy some 400 m away from the biogas plant. To keep emissions of nitrogen oxides (NOx) down, a urea-based NOx reducing agent is used.

The heat from the water-cooled 300 kW capacity rated MAN gas engine genset is used as the heat source for the Absorbption Refrigeration Plant (ARP) as it provides a high and stable flow and water temperature, which is important for the overall efficiency for both the engine and the ARP. The heat in the flue gas is also used. The outgoing engine exhaust has a temperature of 500-600 °C and has two heat exchanger circuits in succession.

The first one is connected to the engine cooling and the ARP circuit to ensure the stable operating temperature. This brings the flue-gas temperature down to around 180 °C. The second flue-gas heat exchanger is connected to the existing hot water network for space heating including the digester. Other heat pumps that are connected to this network include the engine room to utilise radiant heat from the engine and in the dairy.

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Photo Wapnö

(1) Karsten Hjorth (left), Project Manager, Lundsby Bioenergi A/S and Lennart E. Bengtsson, CEO, Wapnö signed the c. 14 million DKK project deal in June 2011. The plant was comissioned in April 2012. (2) Jan Thorbjörnsson, Halmstad Kylservice AB explaining the complex heat and cooling flows at Wapnö. (3) Some of the dairy products from Wapnö, Sweden's largest dairy farm and smallest dairy. (4) Wapnö is an open farm that receives visitors year round. Here a group of international attendees to World Bioenergy. (5) – A PLC steer and regulation system is used to monitor and control the biogas plant operation, said Karsten Hjorth. (6) Heavy insulation and heat pumps capture radiant heat from the genset.

cont. from page 29

By using the heat from the milk the heat pumps installed in the dairy can raise the water temperature from 38 °C to 60 °C to supply the digester with heat if there is no heat in the rest of the system, for instance a very cold winter's day.

– This is a unique set-up because normally we would use the heat from the gas engine for the digester. It is really exciting as we have enquiries for biogas projects where heat is not needed but cooling is, commented Karsten Hjorth.

The CHP genset and ARP are located next to the dairy, a urea based agent is used to reduce NOx emissions.

Heat to cool

The ARP uses ammonia as the refrigerant medium, can cool down to -11 °C and supplies all the cooling and refrigeration needed at Wapnö; the dairy production process, cold storage as well as the shop and space cooling on the entire premises. Supplied by Dutch chiller specialists Collibri BV it was developed together with the local heat and cooling installation company Halmstad Kylservice for Wapnö.

– The task was to extract as much cooling as possible from the supplied heat. Once the calculations and flows were worked out we had to find a supplier who would build such a chiller that could use 90 °C water and cool to -9 °C, said Jan Thorbjörnsson from Halmstad Kylservice.

An ARP consists of a high-pressure and a low-pressure part and, just as in a conventional compression refrigeration plant (CRP), the refrigerant is liquefied under high pressure in the condenser and evaporated under low pressure in the evaporator.

The ARP absorption cycle

The main components of the solution cycle are the absorber, the desorber and a liquid pump. The solution cycle uses the ability of water to dissolve ammonia vapour to form a solution. This process takes place in the absorber, which works on the same low pressure level as the evaporator.

The solution entering the absorber is weak with a low concentration of ammonia and is able to absorb the ammonia vapour coming from the evaporator and dissolve it. The now ammonia-rich solution has a high ammonia concentration and is pumped to the desorber, which works on the same high pressure level as the condenser.

By heating up the desorber, this concentrated ammonia solution re-separates into ammonia vapour and a weak ammonia solution. The weak solution flows back into the absorber and the ammonia vapour is purified in the rectification column, so that nearly pure ammonia vapour enters the condenser, where it is liquefied.

A CRP only needs cooling from the environment for the condenser, in an ARP the amount of environmental cooling is more than the double because in addition to the condenser, the absorber needs cooling as well. To improve the coefficient of performance (COP), a term to describe the ratio of useful heat movement per work input, two heat exchangers are installed in an ARP for internal heat exchange: the solution heat exchanger and the condensate cooler.

– The key difference between the two refrigeration plant types is that to transport the refrigerant vapour from low pressure to high pressure, a CRP uses electricity to power the compressor, whereas an ARP uses a thermal driven solution cycle, a "thermal compressor" if you will. The CRP is 100 percent driven by electrical energy for the compressor. The ARP on the other hand only needs 5 percent of its energy as electricity for the pump and 95 percent as thermal energy to heat the desorber, said Jan Thorbjörnsson.

It is this difference that has enabled Wapnö to go from an oil and power purchaser to a combined heat, power and cooling producer. Not only has the manure-based biogas system fulfilled current cooling, heating and electricty, needs there is room for future expansion. Roughly 2 MWh per annum of heat is still unused and the biogas plant has additional capacity, up to 4 000 head of cattle. There are plenty of ideas and plans, time will tell what is next for this very cool cow heat and power plant.

Text & photos: Alan Sherrard
BI74/4076/AS

Wapnö

TECHNOLOGY SUPPLIERS
Biogas plant (incl. CHP genset): Lundsby Bioenergi A/S
Absorbent Refrigeration Plant (ARP): Collibri BV & Halmstad Kylteknik AB

INPUT (per annum):
c. 36 000 tonnes cow slurry
c. 3 000 tonnes cow manure
c. 700 tonnes bedding & feed residues

OUTPUT (per annum):
c. 2 100 000 Nm^3 biogas
c. 37 000 digestate

ENERGY OUTPUT (per annum):
3 MWh electricty
3 MWh heat to provide 1.7 MWh cooling
1.5 MWh heat for tap water, space heating etc
c. 2 MWh heat potential unused

ESTIMATED ENERGY SAVING (per annum):
1.7 MWh electricty from the grid
25 m^3 fuel for the grain dryer
13 m^3 fuel oil for space heating

"Renewing Sweden" together by officiating at the ribbon-cutting ceremony held on August 30, for E.ON Sverige's biogas plant at its Högbytorp closed-loop waste recycling and energy recovery facility were Camilla Jansson (left), Council Chairman of Upplands-Bro Municipality, Upplands-Bro Municipality; Marc Hoffmann, CEO, E.ON Sverige and Per Ängquist,Per Ängquist, Secretary of State for the Environment and Energy Department.

E.ON inaugurates Sweden's largest dry fermentation plant

E.ON Sverige AB, the Swedish subsidiary of Germany-headed energy major E.ON AG held a ribbon-cutting ceremony on August 30, 2018, for Sweden's largest dry fermentation biogas plant. Designed to treat organic waste and residues to produce biogas, liquid biofertilizer, and compost, the plant is part of an integrated closed-loop waste recycling and energy recovery plant being built at Högbytorp in Upplands-Bro, northwest Stockholm.

THE NEW BIOGAS PLANT, that has just begun the first substrate loading, uses food residues and other organic waste including green waste and horse manure from households and companies in the greater Stockholm area to produce biogas, liquid biofertilizer, and compost.

The biogas is then upgraded to vehicle-grade biomethane, compressed and distributed to natural gas vehicle (NGV) refuelling stations – stations that E.ON too is rolling out.

– By using recovered energy, we can sustainably manage global resources while providing a fast-growing Stockholm region with sustainable electricity, heat and biogas. We have promised our customers that all the energy we produce and deliver will be one hundred percent recovered or renewable by 2025. The closed-loop facility at Högbytorp is, therefore, an important piece of the puzzle to achieve that goal, said a notably pleased Marc Hoffmann, CEO of E.ON Sverige.

Along with Hoffmann, the ribbon cutting ceremony was officiated by equally upbeat Camilla Jansson, Council Chairman of Upplands-Bro Municipality and Per Ängquist, Secretary of State for the Environment and Energy Department, who deputised on behalf of the Minister for the Environment, Karolina Skog.

– Biogas is undoubtedly the most environmental fuel we have. Instead of letting methane into the atmosphere, we get a fuel that can be used in transport and industry, for example. Therefore, for every biogas plant that is inaugurated, we are one step closer to our climate goals, said Per Ängquist reciting a statement on behalf of Minister Skog.

On a personal note, Ängquist added that Sweden will be "one of the world's first fossil-free welfare countries. It takes a lot of steps to get there and today's opening is a step on that road."

Major Climate Step investment

Announced by E.ON in January 2017, the entire Högbytorp integrated recycling and energy recovery facility is expected to be commissioned during 2019. Once fully operational, it will produce 425 GWh of district heating, 165 GWh of electricity, 60 GWh of biogas and 60 000 tonnes of biofertilizer annually of which 52 000 tonnes is in a concentrated liquid form and 8 000 tonnes as compost.

Of the total SEK 2.5 billion (≈ EUR 265 million) investment, the Swedish Environment Protection Agency (Naturvårdverket) provided a SEK 74.7 million (≈ EUR 7 million) grant towards the biogas plant under its Climate Step programme.

– We are delighted that E.ON chose Upplands-Bro Municipality for its unique closed-loop facility. In addition to creating new jobs, our cooperation means that the municipality becomes an example and inspiration for climate work, nationally as well as internationally, said Camilla Jansson, Council Chairman of Upplands-Bro Municipality.

A Kompogas first in Scandinavia for HZI

According to E.ON Sverige, by integrating the biogas plant and the combined heat and power (CHP) that is under construction, a number of synergies can be achieved. Reject from the biogas process such as plastics or wood is separated in the composting stage and used on-site in the CHP.

Residual heat from the CHP is used in the digesters and the biogas upgrading process. The residual heat from the latter process is then used in the final composting stage.

The biogas plant employs a Kompogas dry fermentation technology supplied by the engineering, procurement, and construction (EPC) contractor Hitachi Zosen Inova AG (HZI), a Switzerland-headed energy from waste technology provider.

The Högbytorp biogas plant also marks the first installation for HZI of its Kompogas dry fermentation technology in Scandinavia but not the only one – in April this year HZI announced it is going to build Scandinavia's second Kompogas facility – a smaller unit in Jönköping.

Text & photos: Alan Sherrard
BI101/6138/AS

Johan Eskengren, Business Development Manager, HZI in front of one of the three Kompogas dry fermentation digesters.

Crete has many breathtaking mountains like these to the west of Chania. It is this kind of scenery that is loved by hundreds of thousands of tourists who, unfortunately, also leave lots of waste on the island. However, it is efficiently taken care of by three recycling and biogas facilities.

Biogas expansion on Crete

On Crete, the largest Greek island, biogas was produced by two existing landfills, as well as from the sewage treatment plants in Chania and the capital Heraklion. As of May 2017, biogas is also produced in a new anaerobic digestion (AD) and cogeneration plant. Bioenergy International paid a visit.

– THIS BIOGAS PROJECT Techniki Bioenergeiaki Kritis 2, was designed by the SYCHEM S.A. It is an expansion of the existing cogeneration plant located in the Industrial Area of Heraklion. The primary purpose of this biogas application is the production of electrical energy, which is sold to the public power corporation, explained Giannis Petrakakis, Plant Manager for the biogas facility plant.

Giannis Petrakakis, Plant Manager of Sychem Biogas says that his company is able to provide integrated solutions for the management of organic waste and the production of biogas by designing plants incorporating novel technologies such as odour control biofilters, fully automated feeding system and advanced biological treatment of the liquid digestate.

Petrakakis explained that the first plant started at the end of 2016 with an installed power capacity of 500 kW.

– Already during 2018, we could increase the power capacity to 1 MW. Our plant receives more than 14 000 tonnes per year of slaughterhouse waste, food waste, expired food products from supermarkets, food processing industry waste including cheese whey, pig manure, chicken manure, oils and fats from the entire island of Crete, giving a viable solution to the management of such organic waste, Petrakakis added.

In the beginning, the plant was using GE:s Jenbacher JMS 312 GS-B. L v. D25 cogeneration unit fueled with biogas which is produced by the AD plant.

– The second GE:s Jenbacher unit, model JMS 312 GS-B. L v. D225, was installed to extend the electrical power capacity. The thermal energy produced from the CHP unit is used for heating the digester, said Petrakakis.

SYCHEM Group plant

The biogas plant was constructed by SYCHEM Group, that according Petrakakis, applied "cutting-edge technology" at the most critical points of the production process such as the collection and management of the incoming organic waste, the deodorisation system, heat recovery and the innovative wastewater system for the digested effluent treatment.

The EUR 6 million green investment by the European Financing Tool «JESSICA» was used to protect the environment and create new jobs at the plant.

– This biogas power plant manages all types of organic waste ranging from slaughterhouse residuals to manure, and its great advantage of being odourless recognises it, Petrakakis said.

Deodorization system

– Our innovative digestive treatment system, ZERO land application, our odour control system and our waste reception and processing line, all of which were also engineered and constructed by SYCHEM group, Petrakakis underlines.

The Biogas Plant features a unique deodorisation system that enables plant's integration into the urban environment and a highly specialised wastewater treatment system for the effluents avoiding any contamination of the environment. – We have built a fully sealed underpressurised plant building to prevent odour escape into the environment. Also, we installed innovative biofilters for odour neutralisation, Petrakakis stated.

Only a few characteristic waste odours were noticable but these came from the trucks leaving the facility. Those should not though bother anybody because the plant is middle of a vast area of compactly built factory halls.

The automated process in the facility and management secures the separation of the organic fraction from the packaging material

– Our new anaerobic digester with a capacity of 4 500 m^3 is almost ready för production. The investment regarding the mechanical equipment is just over EUR 4 million, while the total including land purchase and civil works is estimated at EUR 6 million, said Giannis Petrakakis.

Greek energy and water major

Apart from energy, Sychem Group is the biggest Greek manufacturer regarding water desalination plants with significant share in private sector engineering and industrial construction projects such as oil refineries, power plants, hotels,. The Group is also the biggest manufacturer of open loop geoexchange energy projects in Greece with a focus on the sea water energy exploitation and the most prominent private producer of water in Greece.

The company, with headquarter in Athens, is also an international provider of cathodic protection equipment and anodes and industrial facilities and keeps offices in Crete, Cyprus and China.

A few years ago the Sychem Group relocated and expanded its Hydrominoan subsidiary to the new modern desalination facility within the industrial area of Heraklion.

Hydrominoan S.A is the largest private water producer in Greece, owning the largest desalination unit for potable water production and is currently the only desalination plant in Crete.

The installed capacity is 5,000 cubics per day and owns a modern production and quality control equipment.

Along with the future desalination units development in the Almiros river of Malevizi, the plant will contribute significantly to the final resolution of the drought issue in Heraklion and to the assurance of high-quality potable water.

Text and photos: Markku Björkman
BI105/6308/AS

The new biogas fermentor/digester at Sychem's plant in Heraklion. The digester will be operational soon and which will further increase the plant's total capacity (photo courtesy Sychem Group).

The Heraklion Biogas Plant features here in this part of the facility a special deodorization system that enables plant's integration into the urban environment and a highly specialized wastewater treatment system for the effluents avoiding any contamination of the environment.

Chania, the tourist hot spot of Crete. The DEDISA waste-processing centre of this seasonally crowded city serves a population of 155 000 inhabitants, which represents around 25 percent of the island's total population. Furthermore, the Chania prefecture also provides another 88 000 beds for tourists, and most of the region's municipalities fall within the DEDISA plant's catchment area.

Novel biogas liquefaction enables cost effective biofuel distribution

The Finnish energy and marine technology major Wärtsilä Corporation recently inaugurated in Norway its first commercial biogas liquefaction installation. By converting household food waste into liquid biomethane, this novel facility at EGE Biogass is able to produce enough liquid fuel to run 135 buses in Oslo. The plant marks a breakthrough for Wärtsilä in developing liquefied biomethane (LBG) markets.

BOTH THE BIOGAS PLANT and biogas liquefaction plant are co-located in Nes, Romerike, which is an agricultural region just northeast of Oslo. Built adjacent to a former landfill site the plant produces biogas from household food waste. The biogas is then upgraded, liquefied and transported to a dispensing depot where it is used as biofuel for buses. Liquefied natural gas/biogas (LNG/LBG) is gas that is condensed to liquid form by cooling it to a temperature of about -160°C for storage under pressure.

In operation since late 2013 the EGE Biogass plant it is run by Cambi AS, a Norwegian specialist in bio-waste treatment technology, on behalf of Energigjenvinningsetaten (EGE), the city's Waste-to-Energy Agency. Serving some 600 000 citizens EGE operates under the supervision of Oslo's Department of Environmental Affairs and Transport and is responsible for the city's waste management. EGE operates two waste-to-energy plants treating around 410 000 tonnes per annum supplying 840 GWh district heat and 160 GWh electricity.

– Under full operating conditions this plant will mean that 135 Oslo region buses will be able to run on biogas. As a result, carbon emissions will be reduced by some 10 000 tonnes a year and particle emissions will also be significantly lowered. The air will be cleaner and noise levels will be reduced, and these are benefits that everyone in the region will enjoy, commented Christoffer Back Vestli, communications adviser with EGE, during the official inauguration of the LBG plant.

Biogas to bio-CNG

The original deal was for a biogas plant, capable of treating up to 50 000 tonnes per annum of household bio-waste, with an upgrading and compression facility for compressed biomethane (bio-CNG). The contract was awarded to Cambi in 2011 to design, supply and install the plant. In early 2012 it was decided to complement the plant with a biogas liquefaction unit as a more cost effective means of transporting and distributing the biomethane.

In February 2012 the UK based Hamworthy Oil & Gas Systems, a leading developer and supplier of gas handling and liquefaction technology, was acquired by Wärtsilä and subsequently integrated as part of of Wärtsilä Oil & Gas Systems. In March 2012 Wärtsilä was given the contract for the biogas liquefaction plant by Cambi AS. The agreement included feed gas compression, biogas cleaning and liquefaction and LBG storage and export.

–We are proud and delighted to be involved in this groundbreaking project to produce a new, renewable, and environmentally sustainable transportation fuel. There is huge potential for the use of LBG from renewable energy sources as fuel for trucks and buses, and we see this project as an important step forward in developing this market, said Tore Lunde, Managing Director, Wärtsilä Oil & Gas Systems, during a tour of the LBG facility.

Thermal Hydrolysis

Most of the material for the biogas plant comes from households who deposit their food waste in green bags which is collected together with residual refuse via conventional refuse collection trucks. Using an Optibag sorting system at the waste to energy plants, this material is retrieved from the refuse stream and trucked over to the biogas plant. Solid and liquid food waste from supermarkets, food processing plants and restaurants arrives directly to the biogas plant. On arrival the material is mixed and size reduced, contaminants and metals are removed before entering a buffer storage tank.

The heart of biogas plant is double line-up of an advanced digestion system based on Cambi's patented thermal hydrolysis processes (THP) technology. Unlike other biogas pretreatment and hygienisation technologies that operate at around 70°C, the THP process operates at 165 to 170°C using steam. By doing so, organic matter is dissolved into an easily digestible substrate before being cooled via a heat exchanger to 40°C for the following anaerobic digestion step.

According to Cambi this enables a higher biogas yield per unit substrate while any potential pathogens are destroyed. This also allows the plant to be able to treat a wide variety of biological wastes, including categories II and III animal by-products. Furthermore the process is energy efficient, requires a smaller footprint and eliminates odour, an issue commonly associated with bio-waste treatment plants. The remaining end-product from the entire process is a ready to use pasteurised and pathogen-free digestate that, according to Cambi, fulfils all

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(Top) View of the Wärtsilä biogas liquefaction plant at EGE Biogass during the official opening. Key components are (1) the LBG control system, (2) the glycol pre-chiller, (3) the raw biogas pre-treatment unit, (4) the liguefaction unit and (5) the onsite LBG storage and export station. The bus used ran on biogas too. (Above) – This same mixed refrigeration technology can also be used in small liquefaction projects with other sources of gas as well, and we are very excited about the future possibilities, said Tore Lunde (left), Managing Director, Wärtsilä Oil & Gas Systems seen with Christoffer Back Vestli, Communications Adviser, Oslo Waste-to-Energy Agency and Reidar Strande, LNG Business Unit Director, Wärtsilä Oil & Gas Systems.

EGE Biogass - biogas & LBG

Start-up: Biogas plant completed early 2013 (commissioning ongoing), LBG unit October 2013

Treatment capacity: 50,000 tonnes/year household bio-waste

Total cost: NOK 520 million (approx. US$ 86 million) including NOK 35 million (approx. US$ 5.8 million) an investment grant from ENOVA

Biogas output: Approx. 4.5 million Nm^3/year

LBG output: Approx. 4 000 - 4 200 tonnes/year (10 - 11 tonnes/hour)

Liquid bio-fertilizer: Approx 90 000 m^3/year

Bio-solids: Approx. 10 000 - 12 000 tonnes/year

Energy supply: Landfill gas, 100% of biogas production goes to LBG

Environmental impact: Approx. 12 000 tonnes/year CO_2 reduction (LBG used as fuel, enough for 135 buses/year), significant reductions in SOx, NOx, particulate matter, noise compared to fossil diesel & landfill avoidance

INSTALLED TECHNOLOGY

Biogas plant: x 2 reactor of Thermal Hydrolysis Processes (THP)

LBG unit: x 1 Mixed Refrigerant (MR) liquefaction process

cont. from page 35

existing and proposed standards for agricultural uses. Landfill gas is used as fuel in a gen set unit providing the heat and power for the plant.

Mixed refrigerant

The incoming raw biogas is supplied under pressure, 5.5 bar (gauge), to the LBG plant at a rate of anywhere between 0 – 140 Nm^3 per hour. Before the raw biogas can be liquefied it needs to undergo a pre-treatment or upgrading process to reduce the concentration of carbon dioxide (CO_2) to 50 ppm and hydrogen sulfide or "rotten egg" gas (H_2S) to 4 ppm. Furthermore water needs to be removed to 1 ppm to avoid freeze-out in the liquefaction process. At EGE the pre-treatment consists of two steps, a water scrubber and a CO_2 polishing unit.

–The pre-treatment is the challenge as concentrations of unwanted gases vary and the pre-treatment technology used is dependent on the raw gas source, commented Tore Lunde explaining that different feed gas sources, such as biogas, landfill gas and coal-bed methane, have different compositions.

From the pre-treatment the biomethane is initially cooled by a glycol pre-chiller before entering the cold box where it is liquefied at around -160°C before being stored in a 180 m^3 pressurized tank. The tank has a 600 litre per minute pump capacity. The LBG plant has a capacity of 10 - 11 tonnes per day or about 4 200 tonnes per annum.

Modular and scalable

The core mixed refrigerant liquefaction technology developed by Wärtsilä is based on over 50 years of experience in the marine and oil and gas markets in particular the more recent experiences with small-scale, 20 000 – 84 000 tonnes per annum, land based LNG projects in Norway and Finland. A 2.6 tonne per day fully automated mixed refrigerant demo plant was developed in 2012 to conduct various operational testing. The installation at EGE is the first commercial installation of this new mixed refrigerant technology. A single standard oil-type compressor and one aluminium plate-fin heat exchanger (PFX) are the main components in the system. A standard glycol pre-cooling unit is incorporated to improve energy efficiency and to ensure stable operation of the process.

According to Wärtsilä the plant is fully automatic designed with unmanned operations in mind requiring only electricity as energy supply. The technology is robust and designed to handle 0 – 100 percent raw biogas inlet loads. Combined with modular containerized plug'n'play engineering this results in low investment costs and low OPEX due to low power consumption and simple unmanned operation. Energy consumption, for the liquefaction unit exclusive pre-treatment, is given as 0.68 kWh per kg LBG. Furthermore Wärtsilä say that the technology is scalable upwards to a capacity of at least 60 tonnes per day and already today the company offers a standardization of capacities at 10, 17 and 25 tonnes per day.

– Liquefying natural gas or biomethane reduces its volume to about one six-hundredth of its volume in gaseous state concentrating large quantities of energy into easily transportable volumes by specially designed ships, containers or trailers. This makes LNG or LBG the best option in locations where pipelines are not available or viable, for instance when only limited volumes are needed. As demonstrated here at EGE, our mixed refrigerant technology enables the cost effective satellite production of a transportable energy rich biofuel, concluded Tore Lunde.

Text: Alan Sherrard
Photos courtesy: Stig Jarnes/Wärtsilä
BI71/4305/AS

UNIQUE CANADIAN LANDFILL GAS-TO-ENERGY FACILITY

The EBI Énergie Saint-Thomas facility recovers aftercooler and jacket water heat from the landfill-gas engines to heat leachate treatment ponds in colder months.

Through anaerobic digestion, biogas can replace natural gas as a renewable fuel source, providing numerous benefits to the environment, economy and energy market. Not only does biogas help reduce greenhouse gas (GHG) emissions, it also generates reliable power at a fraction of the cost of traditional power sources.

AS THE BIOGAS-TO-ENERGY formula became more efficient, the Canadian government passed a mandate to promote the generation of green electricity to reduce greenhouse gas emissions. As a result, electric power generation suppliers began working with government utility officials to create more sustainable options for electricity.

In 2010, Hydro-Québec – a state-owned utility in Québec, Canada – took the movement one step further by issuing an invitation for bid (IFB) for 125 MW of electricity derived completely from biomass. At the time, Québec did not have many renewable energy projects that could support such a large greenenergy mission.

In 1999, EBI Énergie, a Québec-based waste management and processing company, installed its Dépôt Rive-Nord landfill facility. It was built to capture and flare off landfill gas as a means to limit the amount of methane gas released into the atmosphere. In 2003, EBI Énergie installed a gas treatment and upgrading plant to turn the landfill gas into biomethane for injection into the local gas pipeline.

25-year supply deal

In 2010, after seven years of successful operation of the gas treatment plant, EBI Énergie won the IFB and signed a 25-year agreement with Hydro-Québec to produce 9.4 MW of renewable electricity through 2036 using excess biogas not already being sold into the gas grid.

– Québec-Hydro asked us to guarantee capacity, and their requirements were strict, said Luc Turcotte, General Manager for EBI Énergie.

– We were able to demonstrate that we will have enough landfill gas to produce the required amount of electricity for 25 years. It was a good opportunity for us.

Located 40 miles north of Montreal, EBI Énergie's Saint-Thomas cogeneration facility provides Québec-Hydro with electricity derived from landfill biogas. Using a sophisticated process, landfill gas is gradually transformed into pipeline quality gas through a combination of dehydration, compression, filtration and membrane separation.

Unique in Canada

The Saint-Thomas cogeneration power plant takes excess fuel from the gas treatment facility before it is stripped of carbon dioxide and injects it into the pipeline.

The facility is unique to Canada, representing the only location in the country where biogas is used for power generation as well as upgraded and injected into the gas grid. At the cogeneration plant located less than a mile from the biogas processing facility, EBI Énergie pumps 4 500 standard cubic feet of methane per minute to six Cat® G3520C gas generator sets that convert the gas to electricity. A seventh unit serves as a swing generator. The G3520C generator sets are specifically designed to operate on biogas fuel.

Service key

EBI Énergie also required a fully automated facility that could be operated remotely. Local Cat dealer Hewitt Energy developed the SCADA control interface, which includes mobile capabilities, for the automated system. Operators can restart the plant using an iPhone app that connects to the SCADA system for engine monitoring in real time.

- It gives us a lot of flexibility to operate the plant, and it gives some comfort to the operator. They are not tied to the plant, and yet are able to interact when required, Turcotte explained.

Hewitt Energy also provides EBI Énergie operations personnel with service training, equipment support and parts maintenance.

– The main thing that we considered was the service aspect. We plan to be in business for at least 25 years, and we want to have a reliable partner. It was clear in evaluating the quotations that the after-sales service and the parts support » » set Hewitt apart. If we have a problem on Christmas Day or January 1st, we know that Hewitt technicians will be available to assist us, said Turcotte.

Utilise more heat

The Saint-Thomas co-gen plant began producing electricity in July 2012 and the generator sets have exceeded uptime targets having operated at 99.9 percent availability, producing enough energy to power more than 7 000 homes.

– These engines perform very well – it's perfect for us. When we started the project, we all knew that generator performance was a key to success, said Turcotte.

The Saint-Thomas facility is pending approval as a Leadership in Energy and Environmental Design (LEED) Platinum facility an environmental engineering – the highest rating in environmental engineering by the US Green Building Council. The plant recovers aftercooler and jacket water heat from the engines to heat leachate treatment ponds in colder months. The microorganisms require a specific temperature for breaking down leachate that is collected and treated before being released to a recipient. The heat recovery aspect is crucial as the facility would not be eligible for platinum certification otherwise.

– We are using the energy from the engine to heat the building, and also to heat the leachate. At this point, we are recovering only 13 percent of the waste heat, so when it makes sense to expand, we'll be looking to Hewitt for a combined heat and power solution to improve efficiency, ended Luc Turcotte.

Editor's note: This article along with photos is based on a client case study originally commissioned by Caterpillar. It is used with permission.
BI75/4562/AS

ebi énergie

EBI Énergie is a company within the EBI Group of companies. EBI is Québec based family business active in the waste management, environmental consulting and renewable energy sectors. EBI also produce and distribute biomethane CNG for the transport sector.

CRYOGENIC UPGRADING WITH CRYO PUR

French cryogenic technology developer Cryo Pur has gone from strength to strength having raised EUR 6 million in a second round of financing through the Xerys funds. Two years after its creation and a first fundraising of EUR 3 million, the additional funds will be used to finance its development, strengthens its equity and its industrial organization to ready itself for a growing order intake.

Promoting the benefits of cryogenic biogas upgrading and biomethane liquefaction in a single energy efficient process Benjamin Berg and Simon Clodic.

– THIS NEW FUNDRAISING will enable us to achieve our main objectives, namely taking orders on the one hand and industrial growth, on the other hand, said Denis Clodic, CEO and Founder of Cryo Pur.

Three step cryogenic upgrading and liquefaction

In short Cryo Pur's technology uses cryogenics to purify the biogas, separate out and liquefy the carbon dioxide (CO_2) and the biomethane in a single energy efficient process. With a portfolio of seven global patents, the proprietary three-step process is the culmination of 15 years of R&D in the field of cryogenic CO_2 capture at Mines ParisTech led by Denis Clodic and his team.

The process consists of pretreatment, CO_2 separation and liquefaction and biomethane liquefaction. The incoming raw biogas is first treated with activated carbon filters to remove hydrogen sulfide (H_2S). The biogas is then cooled to -40°C for a first dehumidification step by alternately frosting and defrosting water on two heat exchangers with volatile organic compounds (VOC's) and siloxanes removed together with the water. The biogas is then further cooled to -75°C for a second round of dehumidification and pollutant removal.

After this step the cold dry, pretreated and cleaned biogas is ready for the removal and liquefaction of CO_2. The biogas is further cooled to -120 °C, so that CO_2 is captured through alternate frosting and defrosting on two heat exchangers, which ensures that biomethane reaches the required purity for liquefaction. During this step, pure biogenic CO_2 is recovered in liquid form making it directly usable as a product.

The remaining biomethane is then compressed to 15 bar and liquefied at -120°C. The bio-LNG product is finally stored in a cryogenic vessel. If needed, a boil-off and re-liquefaction loop allows to produce bio-LNG at 2 bar and -160°C. Both of the separated and liquefied gases are in excess of 99 percent purity and compliant with relevant industrial gas norms and standards such as the European Industrial Gases Association (EIGA), Vehicle Gas standards, LNG logistics and natural gas grid injection.

Maximum recovery and energy efficient

According to Cryo Pur, unlike other biogas upgrading technologies there is no biomethane loss or slippage in the process. In the case of landfill gas (LFG) with high nitrogen and oxygen content, biomethane loss is 1 percent. Working with gases at pressure and low temperatures suggest high energy consumption but according to Clodic, electrical consumption is kept to a minimum by combining cryogenic upgrading and liquefaction as it leverages on the synergies in the production of low temperatures.

– In addition the process enables the recovery of a significant amount of heat from the refrigeration systems, which could cover the entire digester heating needs of the upstream biogas plant, said Clodic.

Commercial rollout

The company has been quickly spotted by industrial players in the waste and biogas sectors and has focused its commercial development in Western Europe: France, the United Kingdom, Italy, the Netherlands, and Scandinavia.

In July 2016, it signed its first commercial contract for a bio-LNG with Greenville Energy in Northern Ireland. Commissioned in 2012, Greenville Energy operates a 500 kWe biogas plant in Co. Tyrone that processes around 25 000 tonnes per annum of regionally sourced food waste and cow slurry from its dairy farm. The plant has a capacity of 300 Nm^3/hour raw biogas thus it will be capable of producing three tonnes per day of bio-LNG or 10 GWh per annum of storable and transportable renewable energy.

– Signing the first commercial contract with Greenville Energy is the validation of our strategy to cost-effectively build integrated bio-LNG production units, with a great potential in the UK and Ireland markets, commented Clodic.

The company has also been selected as a turnkey supplier for two agricultural biogas projects in France based on the remote injection model: liquid biomethane produced on an agricultural site is transported by truck to a site connected to the natural gas grid, with a sufficient capacity for year-round biomethane intake.

Clodic also reveals that the company is "in advanced discussions" to launch a project in Italy using biogas from municipal organic waste, as well as several projects with landfill management companies, where the gas requires a specific treatment, including the liquefaction of biomethane.

BioNGVAL a successful demonstrator

According to Clodic, the industrial demonstrator in operation at the SIAAP wasterwater treatment plant (WWTP) in Valenton, outside Paris, France has acted as a showcase and business catalyst for the technology. The BioNGVAL project has, as it was anticipated, enabled Cryo Pur to convince its first customers to invest in its industrial bio-LNG units, which cost from EUR 2 million to EUR 6 million per contract.

Launched in February 2013 with the support of the French Environment and Energy Management Agency (ADEME) under its "Investissements for the Future" programme, the Valenton (Val-de-Marne region) wastewater treatment plant (WWTP) was selected as the site for the BioGNVAL project. Treating 800 000 m^3 of water per day SIAAP's (Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne – Paris regional wastewater authority) Valerton is one of the largest WWTP's in Europe. Officially inaugurated in May 2016, the BioGNVAL industrial demonstrator can treat almost 120 Nm3 per hour of biogas, to produce one tonne per day of bio-LNG, or two full tanks for a heavy goods vehicle (HGV).

Under the coordination of SUEZ along with several partners including SIAAP, Cryo Pur, Iveco and Thermo King together with GNVert and LNGeneration, the latter two wholly owned subsidiaries of ENGIE that supply and distributes liquefied natural gas (LNG) to industrial and commercial end-users, the project aimed to demonstrate the technical and economic feasibility of producing liquid biomethane from biogas, with a view to developing the process on an international scale.

Cryo Pur's growth prospects have led the management team to commit dedicated resources to the design and manufacture of industrial units as well as the supervision of subcontractors. The company is currently developing a range of units able to treat 100 to 2 000 Nm^3 per hour of biogas, which represents production rates between approximately 1 and 20 tonnes of liquefied biomethane per day, and allows it to cover practically all the opportunities the company has under consideration today.

Text & photo: Alan Sherrard
BI93/5735/AS

FUTURE BIOGAS INAUGURATE FIRST TRIOGEN ORC IN THE UK

Photo: Raymond Taylor

Future Biogas and Triogen have opened the first UK installation of a Triogen ORC power unit at the Oak Grove Renewables biogas site in Norfolk. The event was officiated by the deputy Dutch ambassador to the UK, Margriet Leemhuis.

ORIGINALLY COMMISSIONED IN 2013 by Future Biogas Ltd, the Oak Grove Renewables site is a 2 MWe biogas power plant in Scottow, Norfolk. Future Biogas was set up in 2009 up to develop, construct and operate biogas plants across the UK. Supplied by German turnkey biogas technology providers, Agraferm Technologies AG, the Oak Grove plant utilises around 35 000 tonnes per annum of maize and grass silage. This is sourced from Aylsham Growers Renewables Ltd (AGRL), a group of local farmers all within a 12 km radius of the plant. The digestate is put through a press screw from German FAN Seperator GmbH before used as a bio-fertiliser.

Residual heat to power

Future Biogas has currently eight biogas plants including a biomethane-to-grid facility in operation and has another two projects under construction. The plants use a range of biomass feedstock sourced in partnership with local farmers.

– We see that more can be done to optimize performance of the biogas plants, commented Philipp Lukas, CEO of Future Biogas and Board Member of the Anaerobic Digestion & Bioresources Association (ADBA).

Lukas was referring to utilizing the residual heat from the gas-fired engine, a challenge considering the rural location of the plant with no obvious heat sink such as space heating in the vicinity. Applying the high-temperature organic rankine cycle (ORC) technology from Dutch providers Triogen, the residual heat from the engine is converted into electricity. The plant is expected to increase its electrical output by up to 10 percent without any additional input material.

– We are pleased to work with Triogen as they offer a mature solution with long track record and very high efficiency levels. This allows us to build an attractive business case while reducing the overall cost of generating power from this site, said a notably pleased Lukas.

The celebratory event also featured a discussion by industry experts on "the future of efficiency and cost reduction in AD".

– Bioenergy based energy generation is an important contributor to achieving the UK's emissions targets. Government and industry need to work together to reduce the cost of bioenergy based energy generation. I believe that significant cost reductions are possible and turning heat into electricity, as demonstrated by Oak Grove and Triogen, is an important piece to this puzzle. We encourage the government to continue the dialogue with this industry to realize its potential, said Charlotte Morton, CEO of ADBA in her address.

– Our technology is a contribution to making decentralized generation more affordable which will be an important factor for reaching the politically agreed emission targets. Converting the excess heat available from a biogas plant into electricity reduces the cost of producing power from the plant by 5 percent. Thus, we offer a key technology to making biogas more cost effective, said Henning von Barsewisch, CEO, Triogen.

A showcase of successful Anglo-Dutch business cooperation as symbolically demonstrated by Margriet Leemhuis (centre) deputy Dutch Ambassador to the UK together Philipp Lukas, CEO, Future Biogas (left) and Henning von Barsewisch, CEO, Triogen during the ribbon cutting ceremony. With the market entry in the UK, Triogen is now active in eleven countries across Europe.

Text & photo: Alan Sherrard
BI83/5081/AS

Sweden's largest biomethane producer

The investment in the new uppgrading plant from Carbotech was SEK 93 million (≈ EUR 10 million) and the annual capacity is 125 GWh.

Scandinavian Biogas has recently commissioned a new biogas upgrading system at the Henriksdal wastewater treatment plant (WWTP) in Stockholm, Sweden. Michael Olausson, Director of Business Development at Scandinavian Biogas spoke to Anders Haaker about the new facility and future plans for biomethane production.

THE HENRIKSDAL WASTEWATER treatment plant (WWTP) in Stockholm, Sweden has undergone major refurbishment as part of a larger project for Stockholm Vatten, a municipality owned company charged with supplying potable water and wastewater treatment services to the city of Stockholm.

The plan for Stockholm Vatten is to close its Åkeshov WWTP in Bromma, west Stockholm and instead pipe the wastewater to the Henriksdal facility. The new sewer system from Bromma to Henriksdal is scheduled for completion by 2024 and the entire project has a budget of about SEK 5 billion (≈ EUR 540 million). To be able to handle the increased volume of wastewater a new treatment process has been installed at Henriksdal.

New upgrading plant

This also means that larger volumes of biogas can be produced and, as part of the overall project, Stockholm Vatten has invested around SEK 93 million (≈ EUR 10 million) in a new biogas upgrading facility. The biogas to biomethane unit was built and is operated by Stockholm-based biogas plant designers and operators Scandinavian Biogas and was officially inaugurated at the end of April this year.

– We have also increased the biogas production capacity at Henriksdal. The raw gas from the digester has a methane content of 62-63 percent and we want as pure methane as possible. There is already an upgrading plant at Henriksdal with a capacity of 75 GWh per annum. The new upgrading plant has an annual capacity of 125 GWh, which means Henriksdal now has an annual upgrading capacity of approximately 200 GWh. This will be sufficient even after the wastewater from Bromma has been led on to Henriksdal. The capacity should also be sufficient for a projected increase in population in Stockholm for at least 20 years, Michael Olausson, Business Development Manager for Scandinavian Biogas, explained.

In the meantime, to make use of the available biogas production capacity while waiting for the new sewer system from Åkershov WWTP to be connected, the company has installed three reception tanks for external substrates. This is for feedstock such as residual fats, oils and grease (FOG) from the food industry and glycerol, a by-product of biodiesel production.

– We receive the substrates by tanker truck and then dose them into the biogas digesters. We expect to reach an output of between 110-120 GWh in 2016 and 140-150 GWh in 2017, said Olausson.

High availability

- The new upgrading plant is of extremely high quality. We have had over 99 percent availability on Carbotechs equipment, said Michael Olausson and described the process. A row of six white tubes each of which contains activated carbon is used to separate carbon dioxide (CO_2) from the raw biogas. However it is not a continuous process but a sequential one. A tube is filled with the raw biogas and put under pressure. The CO_2 is absorbed into the activated carbon. Once a certain pressure is reached, the biogas is released and moved over to the next tube while the absorbed CO_2 remains in the activated carbon. A vacuum is then induced in the tube so the activated carbon releases the CO_2 and it is removed from the tube. This process is repeated along the row of tubes.

Easy installation

– We completed all the groundwork, the equipment arrived in complete modules on a truck and a crane lifted everything in place. It was a very smooth process. Everything had been set up at the factory in Germany and test run before it was shipped to Stockholm, said Michael Olausson.

Production, distribution and marketing

An estimated 240 GWh of biomethane will be produced from food waste and WWTPs in Stockholm during 2016. Scandinavian Biogas expects to produce 200-210 GWh at Henriksdals, Åkeshov and Gladö Kvarn whereas the Käppalaverket Lidingö WWTP makes about 30 GWh. The demand for biomethane exceeds production and several operators are transporting compressed biomethane (CBG) to Stockholm from biogas plants outside Stockholm.

Scandinavian Biogas sells its biomethane either directly to some customers such as Stockholm Public Transport (SL) and fuel distributors.

In Stockholm, the proportion of biomethane in vehicle fuel is around 75 percent, which is higher than the average in Sweden. The remaining 25 percent is fossil gas that is brought into Stockholm as liquefied natural gas (LNG) and fed into the vehicle gas grid. The fossil gas is either Russian that has been liquefied in Finland or Norwegian liquefied at source.

Cooperation with Stockholm Vatten

Stockholm Vatten built the first biogas upgrading plant in Henriksdal around 2000. In 2010 Stockholm Vatten decided to divest the upgrading facility to a private contractor in an effort to focus on its core business while increasing availability and biogas production »

» the amount of biogas. Scandinavian Biogas bought the plant in competition with other players.

– One of the reasons that we won the bid to buy was that we could present a development plan, and a plan to build the part that we have built. We were able to show that we are focused on increasing production. Already in 2010 we began to sketch out an expansion, remarked Olausson.

Later the city of Stockholm bought back the property and the facility after coming to the conclusion that it would be easier to implement the entire project, Åkershov WWTP relocation and Henriksdal WWTP refurbishment, if Stockholm Vatten owned the entire property and plant. Therefore Stockholm Vatten bought back the existing biogas upgrading plant at Henriksdal and signed a 25-year lease agreement with Scandinavian Biogas.

– We undertook to buy the raw biogas and to manage the operation of the plant, explained Olausson.

1 TWh by 2020

– With the facilities in Gladö Kvarn, Åkershov and Henriksdal we have a biomethane capacity in Sweden today of approximately 300 GWh. We are building a facility in Norway with liquid biomethane (LBG) that will provide approximately 125 GWh. It will be completed by the summer of 2017. In South Korea, we produce approximately 70 GWh. The plan is that we have start another two to three plants and reach a capacity of 1 TWh by 2020, ended Michael Olausson.

Text & photos: Anders Haaker
BI88/5390/AS

According to Michael Olausson Business Development Manager for Scandinavian Biogas, the company has the capacity to produce 300 GWh biogas from food waste and wastewater treatment in the Stockholm area.

KUMAC FOR PROCESSING SLURRY AND DIGESTATE

Apart from turn-key biogas plants Germany-headed biogas plant manufacturer Weltec Biopower GmbH has also a proven system for post-treatment of digestate that also can be used on cattle slurry or industrial wastewater treatment.

In a multi-stage process, the Kumac processing system separates solid matter from water to yield about 50 percent clear water, approximately 25 percent solid matter and about 25 percent liquid nutrient concentrate.

According to Weltec, this technology has already been in continuous use for several years and is successfully applied at numerous locations in the Netherlands and Belgium with intensive livestock breeding or large biogas plants.

A four-stage process

One of the key benefits of the solution is the high technical plant availability. The scalable modular system can be used from an amount of 50 000 tonnes per annum. If processing needs are higher, a combination of several Kumac lines can easily be implemented.

In the first stage, additives are mixed with the source material with a custom-developed mixer. This enables a short reaction time and economical use of individually composed flocculants. At the same time, the addition of polymers facilitates the separation of certain substances from the water and the minimisation of odour.

In the first step, additives are mixed with the source material with a custom-developed mixer enabling a short reaction time and economical use of individually composed flocculants. At the same time, the addition of polymers facilitates the separation of certain substances from the water and the minimisation of odour.

In the next step, the substances are dewatered in a special belt filter process. In this process, they are transported on a belt filter over various rolls and cylinders and pressed against a second water-permeable belt with increasing pressure. Depending on the material, the dewatered solid matter has a dry matter content of about 30 percent and can subsequently be used as fertiliser, compost, litter or biogas substrate.

The remaining liquid phase is first treated in a stainless flotation tank where suspended particles are separated into sludge and a floating layer by using fine air bubbles. The foam and sludge are then recirculated back to the treatment process. The other solid components of the liquid phase are separated by a filter.

The final process step comprises the application of a three-stage reverse osmosis procedure. The remaining liquid phase has already reached a very clean state. The semipermeable membranes in the three-stage reverse osmosis procedure can separate 95 to 99 percent of the dissolved salts and nutrients. The separated nutrient concentrate can be used as liquid fertiliser that is easy to transport. The clean water that is left over from the treatment in the ion exchanger can be used at the local facilities or be returned to the water cycle.

DBS1/6493/AS

Experts in Weltec Biopower's slurry and digestate processing system Kumac, Jens Flerlage (left) and Thomas Sextro had a busy four days at the Weltec booth in Hanover during Energy Decentral / EuroTier 2018 explaining how it works and where it can been seen in operation. A new installation in Reichenbach, Saxony in Germany commissioned in 2019.

More value from biowaste with unique biogas measurement solution

Jutta Hakkarinen from Vaisala Oyi at the launch of the Vaisala MGP261 multi-gas probe at the UK AD & Biogas 2019 tradeshow in Birmingham.

Most countries want to treat their biowaste in an environmentally friendly way and return the nutrients to agriculture by anaerobic digestion (AD) and composting the waste. A challenging environment for a biogas measurement instrument.

ONE OF THE MOST common solutions is to produce combined heat and electricity at the anaerobic digestion site using combined heat and power (CHP) engines.

Finland-headed Vaisala, a global leader in weather, environmental and industrial measurement, took on a measurement challenge to develop a biogas measurement instrument that could not only withstand the extreme conditions of biogas production in a mixture of methane (CH_4), carbon dioxide (CO_2), and different trace gases, but also add value to the process.

Knowing moisture and methane contents

One of the keys was to focus on humidity measurement in addition to methane and carbon dioxide. Humidity measurement is a critical process control tool in many industries, with several technical solutions to choose from. Excess humidity or moisture can cause major problems in industrial production processes. Corrosion, engine breakdowns, increased exchange rate of active carbon filters and low quality biogas can be challenges in biogas production and gensets.

With continuous humidity measurement, however, the operating expenses can usually be kept much lower by being able to control and react to the changes in the process. Knowing the water content of the biogas during the treatment stage allows the operator to maximize the lifetime of activated carbon filters, which have optimal performance in a given relative humidity range and are relatively expensive to replace. Further increases in efficiency can be gained by monitoring the composition of the fuel gas entering the CHP engine.

Knowing the methane content of the gas allows the operator to make more precise adjustments to the engine, while being able to detect elevated levels of water vapour in the gas inlet allows them to respond quickly to gas-quality issues that would otherwise cause premature engine wear.

One consequence of accidental condensation is increased flow resistance in the pipelines. Also, the action of valves controlling the supply of fuel gas and air to the engine is impaired if moisture begins to collect in the valve.

Measuring moisture and methane

Measuring humidity in the biogas process and especially directly in the gas pipes was challenging for a long time. When measurement is performed in a flammable gas mixture and in the presence of corrosive chemicals, the range of suitable technologies becomes more limited.

Optical humidity measurement in the infrared (IR) wavelength range, however, has many attractive properties. The measurement is inherently non-contact as the infrared light source and detector are protected from process gases, eliminating issues with sensor corrosion. Recent advances in microglow IR sources and tunable Fabry-Pérot interferometer filters allow the devices to be Ex approved for atmospheres where flammable gases are continuously present.

Many people associate optical humidity measurement in an Ex zone with expensive TDL lasers measuring in a cross-duct configuration. A recent development based on two decades of Fabry-Pérot interferometry allows the measurement of water vapour with a simple, compact probe-type NDIR device.

Furthermore, it is now possible to combine humidity measurement with other gases such as methane and carbon dioxide in a true multi-gas in-situ gas analyzer with a very compact form factor.

Robust and Ex-rated

Selecting the technology was straightforward, but the starting point for the development project was the requirements of the Ex standards, which meant that rigorous testing in real operating conditions was essential.

As Vaisala's customers can install the instrument directly into the biogas pipeline, the instrument must tolerate high temperatures and corrosive substances like hydrogen sulfide (H_2S) at concentrations of up to 10 000 ppm. The robustness of the instrument was tested in audited in-house and third-party testing stations to ensure that it could tolerate corrosive environments and high humidity, heat, and process gas flows. Choosing the right materials was critical as well, as is ensuring gas tightness.

The development project resulted in Vaisala MGP261 multi-gas probe, which is a completely new kind of humidity, methane, and carbon dioxide probe based on the extremely reliable NDIR measurement principle.

In near-condensing conditions many capacitive humidity and dew point sensors do not perform optimally and suffer from corrosion of the measurement element, but the optical measurement technology used in the MGP261 is immune to such problems and therefore uniquely suited to these demanding conditions.

BI105/6307/AS

A 100 PERCENT FRENCH RENEWABLE GAS MIX BY 2050? FEASIBLE NEW STUDY SUGGESTS

Could France achieve a 100 percent transition to domestically produced renewable gas? It could by 2050 according to a joint study on the technical and economic feasibility of 100 percent renewable gas published by the French Agency for Environment and Energy Management (ADEME), Gaz Réseau Distribution France (GRDF), a wholly owned subsidiary of France-headed energy major Engie and Europe's largest developer, owner and operator of gas grids and GRTgaz, a gas grid owner and operator.

OFFICIALLY LAUNCHED JANUARY 30, 2018, at the Assises européennes de la transition énergétique, Bruno Lechevin, President of ADEME, together with Édouard Sauvage, CEO of GRDF and Thierry Trouvé, CEO of GRTgaz, presented the key findings of the exploratory study entitled *'La France indépendante en gaz en 2050: Un mix de gaz 100 % renouvelable en 2050?'*

Using different assumptions about how each of the production sectors may develop as its starting point and as part of an ongoing process to improve energy efficiency and gain greater control over energy consumption, the study presents four scenarios, three of which envisage a 100 percent renewable gas mix.

According to the study, the theoretical potential for "injectable renewable gas" in France is estimated to be 460 TWh per annum. This would be sufficient to cover the country's entire projected gas demand 2050 in all four scenarios studied.

Three technology pathways

Three main production pathways for renewable gas are highlighted in the study: methanisation could account for up to 30 percent of the renewable gas production whereas emerging technologies pyrogasification and power-to-gas (PtG) could account for up to 40 percent and 30 percent respectively.

The technical potentials in the study are based on available feedstock resources which do not compete with food use and raw materials. To ensure that these technical potentials are fully accessible to 2050, the study identifies several legislative, logistical and technical issues that need to be addressed:

Greening the French gas grid by 2050 is both technically and economically feasible, a newly released exploratory joint study suggests. A gas demand of between 276 and 361 TWh in 2050 can be satisfied by renewable gas for an overall cost of between EUR 116 and EUR 153 per MWh (graphic courtesy ADEME).

- obstacles to agricultural methanisation need to be removed
- the growing of cover crops – intermediary crops which protect the soil between two saleable crops – needs to become a widespread practice
- more unused agricultural and forestry resources need to be harnessed
- technologies with strong potential but which are not yet commercially mature such as pyrogasification and gasification of algae need development.

Reasonable costs

The study also suggests that a gas demand of between 276 and 361 TWh in 2050 can be satisfied by renewable gas for an overall cost of between EUR 116 and EUR 153 per MWh. This includes the cost of production, storage, use and adaptation of the gas networks. The investment cost needed to adapt the networks is described as "reasonable".

The mass production of renewable gas will involve more decentralised management of the gas grid network and the use of still significant underground storage of gas. The study also shows that it is possible to collect most of the resources by planning adaptations to the gas networks to enable reverse-flow facilities.

A 100 percent renewable gas mix would avoid direct emissions of about 63 million tonnes of carbon dioxide (CO_2) per annum, which at a carbon tax level of EUR 200 per tonne, would incur EUR 12.6 billion annually in carbon tax alone. Furthermore, with a 100 percent renewable gas mix, the country's trade balance would be improved and its energy independence strengthened.

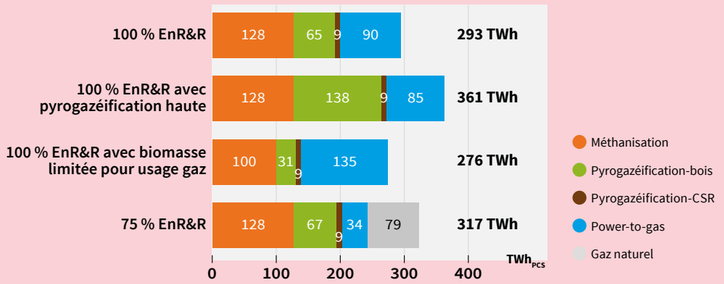
Interaction of gas and power grids

The study emphasises the complementary nature of the electricity and gas grids and stresses that with a high level of renewable energy production, natural gas and electricity grid systems will interact strongly and jointly evolve.

Power-to-gas (PtG) will be used to ensure that surplus production of renewable electricity is not wasted by providing inter-seasonal storage capacity in the gas network. Renewable gas will also contribute to balancing the electricity system with thermal power plants by using renewable gas to provide energy during peak periods.

Text & photo: Alan Sherrard
DBS1/6496/AS

FIGURE 3: MIX DE GAZ RENOUVELABLE DANS LES 4 SCÉNARIOS



Biogas Technology Suppliers Directory 2020

Interest in anaerobic digestion (AD) is gaining traction in many countries and industry sectors. According to the C40 Cities Climate Leadership Group, a network of the world's megacities committed to addressing climate change, 80 percent of all global wastewater discharged has not been treated with AD and C40 has described biogas as "key" to tackling global methane emissions.
The purpose of the directory is to provide an overview and the table gives a general presentation of internationally active companies and activities. It includes turnkey providers of biogas plants as well those that supply ancillary components and equipment needed for biogas and/or biomethane production. To qualify companies have to be engaged in export and/or have subsidiaries in other regions, the country shown is where it is headquartered. Although comprehensive the listing is not exhaustive neither is it an endorsement. Not on the list? Do not hesitate to get in touch.

COMPANY	COUNTRY	WEB
2G Energy AG	Germany	www.2-g.com
4R Group	UK	www.4r-group.co.uk
A-Consult	UK	www.aconsult.co.uk
Aardvark EM	UK	www.aardvarkem.co.uk
AAT Biogas Technology	Austria	www.aat-biogas.at
AB Energy SpA	Italy	www.gruppoab.it
AcrEnergy	UK	www.acrenergy.com
ADI Systems	Canada	www.evoqua.com
Aero Thermal Group	UK	www.aerothermalgroup.com
Againity	Sweden	www.againity.com
Agraferm GmbH	**Germany**	**www.agraferm.com**
agraferm	Global provider for biogas plants – in agro and food industry, for power suppliers. Builds plant at about 35 MW for both, power and biomethane, really strong in dry and solid materials.	
Agrar Plus Beteiligungs-GmbH	Austria	www.agrarplus.at
Agrico Engineering Sales Ltd	UK	www.eisele.de
Agriest Distribution	France	www.agriest.com
Agrikomp UK	UK	www.agrikomp.co.uk
Agrotel GmbH	Germany	www.agrotel.eu
Aikan A/S	Denmark	www.aikantechnology.com
Air Liquide Advanced Business	France	www.airliquideadvancedbusiness.com
Alvan Blanch	UK	www.alvanblanchgroup.com
Ambient Energy LLC	USA	www.ambientnrg.com
Amitec Oy	Finland	www.amitec.fi
Andritz MeWa GmbH	Germany	www.bio-qz.de
Aprovis Energy Systems Gmbh	Germany	www.aprovis-gmbh.de
Aritor	UK	www.turboseparator.co.uk
Asia Biogas Co. Ltd.	Thailand	www.asiabiogas.com
Awila Anlagenbau GmbH	Germany	www.awila.de
Awite Bioenergie GmbH	Germany	www.awite.com
Balmoral Tanks	UK	www.balmoral-group.com
BDI - BioEnergy International AG	Austria	www.bdi-bioenergy.com
BioConstruct Gmbh	Germany	www.bioconstruct.com
Biogest Biogas	Austria	www.biogest-biogas.com
Biotec Sistemi S.r.l	Italy	www.biotecsistemi.it
Biothane Systems International	Netherlands	www.biothane.com
Biotrix Asia Company, Ltd	Thailand	www.biotrix.asia
Bright Biomethane	**Netherlands**	**www.brightbiomethane.com**
BRIGHT BIOMETHANE	Offers well-proven systems with membrane separation technology to upgrade biogas to biomethane / renewable natural gas. the system can be extended with a CO_2 recovery unit to recover and liquefy CO_2 to a food-grade quality.	
BTA International GmbH	**Germany**	**www.bta-international.de**
BTA	Leading specialist for the wet mechanical pre-treatment of different organic waste streams and the subsequent anaerobic digestion according to the BTA® Process for the production of biogas and compost	
Cambi AS	Norway	www.cambi.no

COMPANY	COUNTRY	WEB
Camlin	UK	www.camlingroup.com
CCI Bioenergy	Canada	www.ccibioenergy.com
Cellwood Machinery AB	Sweden	www.cellwood.se
Chinese Academy of Agricultural Mechanization Sciences	China	www.caams.org.cn
Clearfleau Limited	UK	www.clearfleau.com
Colsen	Netherlands	www.colsen.nl
Conveco S.r.l.	Italy	www.conveco.com
Cryo Pur	France	www.cryopur.com
CTU- Concepte Technik Umwelt AG Clean Technology Universe	Switzerland	www.ctu.ch
Ductor Oy	Finland	www.ductor.com
Demeca	Finland	www.demeca.fi
DH Industries	Netherlands	www.dh-industries.com
DMT Environmental Technology	Netherlands	www.dmt-et.nl
Doppstadt Calbe GmbH	Germany	www.doppstadt.com
Doranova	Finland	www.doranova.fi
Dorset Group BV	Netherlands	www.dorset.nu
DP CleanTech	China	www.dpcleantech.com
Dr.-Ing. K. Bush GmbH	Germany	www.buschvacuum.com
Dreyer and Bosse Kraftwerke GmbH	Germany	www.dreyer-bosse.com
DSM Bio-based Products	Netherlands	www.dsmbiogas.com
EConvert Water & Energy	Netherlands	www.econvert.nl
Ecoprotech	Finland	www.envorprotech.fi
Eggersmann Gruppe GmbH&Co.KG	**Germany**	**www.f-e.de**
Supplies anaerobic digester systems, digestate treatment and handling, instrumentation, monitoring and control.		
ElectraTherm Inc	USA	www.electratherm.com
Eliopig S.r.l.	Italy	www.eliopig.it
Ellmann Engineering GmbH	Gemany	www.ellmann-gmbh.de
Eneco	Netherlands	www.eneco.nl
Ennox Biogas Technology	Austria	www.ennox.at
Enspar Biogas GmbH	Germany	www.enspar.de
Entec Biogas Gmbh	Austria	www.entec-biopower.at
EnviTec Biogas AG	Germany	www.envitec-biogas.de
Erich Stallkamp ESTA GmbH	Germany	www.stallkamp.de
ETW Energietechnik GmbH	Germany	www.etw-energie.de
Evonik Fibres GmbH	Austria	www.evonik.com
Excellent Biogas	Netherlands	www.excellent-biogas.com
Exergyn Ltd	Ireland	www.exergyn.com
Extech GmbH	Germany	www.extech-de.com
Farmatic Anlagenbau GmbH	Germany	www.farmatic.com
Feniks Pro d.o.o	Slovenia	www.feniks-pro.com
Fluence Italy Srl	Italy	www.fluencecorp.com
Franz Eisele u .Söhne GmbH u.Co.KG	Germany	www.eisele.de
Fraunhofer UMSICHT	Germany	www.umsicht-suro.fraunhofer.de
Gazpack	Netherlands	www.gazpack.nl
Geneset	Finland	www.geneset.fi

COMPANY	COUNTRY	WEB
GM Green Methane Srl	Italy	www.gm-greenmethane.it
Green Gas International B.V	Netherlands	www.greengas.net
Greenlane Biogas	Canada	www.greenlanebiogas.com
Hennlich s.r.o.	Czech Republic	www.hennlich.cz
Hexagon Purus GmbH	Germany	www.hexagonxperion.com
Hitachi Zosen INOVA AG	Switzerland	www.hz-inova.com
Honeywell International Inc.	Finland	www.honeywell.com
Host Bio-Energy Installations	**Netherlands**	**www.host.nl**
HoST BIO-ENERGY INSTALLATIONS	Offers a total bioenergy plant solution. The expertise of HoSt focuses on the technological development and innovation of the processing of organic waste streams, and the turnkey supply of advanced bioenergy plants.	
HRS Heat Exchangers Ltd	UK	www.hrs-heatexchangers.com
IES Biogas s.r.l	Italy	www.iesbiogas.it
Innio Power previously GE Energy Jenbacher gas engines	Austria	www.gejenbacher.com
Jones Celtic Bioenergy	Ireland	www.joneseng.com
Keppel Seghers Pte Ltd	Singapore	www.keppelseghers.com
Kinetic Biofuels A/S	Denmark	www.kineticbiofuel.com
Kirk UK	UK	www.kirk-environmental.com
KIS Group	India	www.kisgroup.net
Landia A/S	**Denmark**	**www.landia.dk**
Supplies pumping and mixing solutions to many different industries, with the most important ones being agriculture, wastewater, biogas plants and the fish industry.		
LJM Lind Jensens Maskinfabrik A/S	Danmark	www.ljm.dk
Lukeneder GmbH	Germany	www.lukeneder.de
Lundsby Biogas A/S	Denmark	www.lundsby.dk
Malmberg Gruppen AB	Sweden	www.malmberg.se
MannTek AB	Sweden	www.manntek.se
Martin Gmbh für Umwelt-und Energietechnik	Gemany	www.martingmbh.de
Mavitec Green Energy	Netherlands	www.mavitec.com
Megtec Systems Inc.	USA	www.megtec.com
Membrane System Europe	Netherlands	www.biogasmembrane.eu
MRU Messgeräte fur Rauchgase und Umweltschutz	Germany	www.mru.de
MT-Energie Biogas Technologie	Germany	www.mt-energie.com
MTL Eaton (Crouse Hinds Group)	UK	www.eaton.com
MWM GmbH/Caterpillar Energy Solutions	Germany	www.mwm.net
Netzsch Pumpen & Systeme GmbH	Germany	www.netzsch-pumpen.de
New Eco-tec Verfahrenstechnik	Germany	www.new-eco-tec.com
Nexterra Systems Corporation	Canada	www.nexterra.ca
OMEX	UK	www.omex.co.uk
Paques BV	Netherlands	www.paques.nl

COMPANY	COUNTRY	WEB
Parker Hannifin Manufacturing Germany	Germany	www.parker.com/hzd
Pentair process Technologies	Netherlands	www.pentair.com
PlanET Biogastechnik GmbH	Germany	www.planet-biogas.com
Pumpenfabrik Wangen GmbH	Germany	www.wangen.com
Pyreg GmbH	Germany	www.pyreg de
Pöttinger Entsorgungstechnik GmbH	Austria	www.poettinger-oneworld.at
Ramboll Group A/S	Denmark	www.ramboll.dk
Renecon Energy	Nigeria	www.reneconenergy.com
Renergon International AG	Switzerland	www.renergon.com
Revis Bioenergy GmbH	Germany	www.revis-bioenergy.de
Rotaria Energie -und Umwelttechnik	Germany	www.rotaria.com
RWL Water Italia	Italy	www.rwlwater.com
Sandifirden Technics B.V.	Netherlands	www.sandfirden.nl
Scandinavian Biogas Fuels AB	Sweden	www.scandinavianbiogas.se
Schaumann BioEnergy GmbH	Austria	www.schaumann-bioenergy.eu
Schmack Biogas AG	Germany	www.schmack-biogas.com
Schnell Motoren GmbH	Germany	www.schnellmotor.com
Serge Ferrari	France	www.sergeferrari.com
Steverding Agitator Technology	Germany	www.rt-st.com
Strabag Umwelttechnik GmbH	Germany	www.strabag-umwelttechnik.com
Stream BioEnergy	Ireland	www.streambioenergy.ie
Streisal Gmbh	**Germany**	**www.streisal.de**
streisal	Develops, manufactures and globally markets innovative agitators and mixing systems for biogas plants, wastewater technology and industrial applications.	
Sulzer Management Ltd	Switzerland	www.sluzer.com
Sychem S.A	**Greece**	**www.sychem.gr/el/**
SYCHEM ADVANCED WATER TECHNOLOGIES	Offers Biogas Plant turn-key solution, including plant design, process technology, equipment for processing of organic waste and advanced treatment of the biogas digestate.	
Tecon Textile Constructions GmbH	Austria	www.tecon.biz
Three Es S.r.l.	Italy	www.three-es.it
Thöni Industriebetriebe GmbH	Austria	www.thoeni.com
Tianjin HI-Tech Enterprise co., ltd	China	www.tj-hitech.com/
TNO Energy	Netherlands	www.tno.nl
Triogen NL	Netherlands	www.triogen.nl
University of Rostock Institute for Biogas	Germany	www.biogasundenergie.de
Vaisala	**Finland**	**www.vaisala.com**
VAISALA	Manufacturer of innovative measurement solutions for multiple industries, has developed first multigas instrument for smart control of biogas quality.	
Valmet	Finland	www.valmet.com
Vogelsang GmbH& Co. KG	Germany	www.vogelsang.info
Vomm Impianti e Processi S.p.A	Italy	www.vomm.it
Wackerbauer Maschinenbau	Germany	www.wackerbauer.net
Weltec Biopower GmbH	**Germany**	**www.weltec-biopower.de**
Provider of turnkey biogas plants made from stainless steel (waste to energy, sewage water treatment and agricultural plants).		
Wuhan Cubic Optoelectronics Co.,Ltd	China	www.gassensor.com.cn
Wärtsilä Corporation	Finland	www.wartsila.com
Xebec Adsorption Inc	Canada	www.xebecinc.com
Xergi A/S	Danmark	www.xergi.com
Xylem Water solutions AB	Sweden	www.xylemwatersolutions.com
Zorg Biogas AG	Switzerland	www.zorg-biogas.com

BIO360 NANTES – THE NORDICS ARE COMING

At Bio360, a trio of parallel bioenergy conferences and expos in Nantes, France, Nordic technology and know-how providers are taking a prominent position.

Thirty-three leading Nordic bioenergy names, representing the world-renowned and exemplary bioenergy know-how of the Nordic region will be in Nantes, both "ready and willing" to share their deep knowledge of bioenergy and to reach out to foster new partnerships for a brighter bioenergy future.

– One pavilion dedicated to wood energy, is located in the Bois Energie hall and the other dedicated to biogas, is located within Biogaz Europe, said Paul Stuart, Director, of the organiser BEES Bioenergy Events.

According to Stuart, the Nordics are not only respected for their research and technical expertise but also for their political, societal and business commitment to replacing fossil fuels from their energy mix with renewables – the latest Eurostat figures from 2018 show that Sweden, Finland and Denmark have already reached their respective 2020 renewable energy targets. Bioenergy including biogas and biomethane makes up a significant portion of renewables and is set to continue to grow in all the Nordics.

– Norway is home to the world's largest factory for the production of liquefied biogas (LBG), Paul Stuart pointed out.

Renewable gas technologies are another hot topic. In France, GRTgaz is committed, in accordance with the mandate given by the energy regulatory commission (CRE), to identify the economic conditions allowing the development of new renewable gas sectors including methanation, pyrogasification, hydrothermal gasification, and Power-to-gas (PtG) technologies.

GRTgaz initiates and supports numerous partnership approaches aimed at testing the technology while at the same time, GRTgaz is a stakeholder in the creation and management of this new sector to define its future regulatory framework on the technological and financial level (support mechanism).

With the aim of achieving the first industrial projects in France by 2024/2025, GRTgaz wishes to initiate by 2022 the setting up of a first pre-industrial demonstration project on a site with around 10 000 tonnes per year of liquid biomass waste or residue.

"We are delighted to welcome the "Nordics, Country of the Year" to Nantes this year hosted on two Nordic Pavilions representing Denmark, Finland, Norway, and Sweden"

PAUL STUART, Director of the organizer BEES Bioenergy Events

PROGRAMME 29-30 JANUARY / BIOGAZ EUROPE

WEDNESDAY 29 JANUARY

EVOLUTION OF SUPPORT MECHANISMS FOR THE ANAEROBIC DIGESTION SECTOR

29/01 10:00 - 11:30 Room : Salle Biogaz (Gd Palais)

- Changes in legislative and pricing contexts for injected biomethane, DGEC
- Biomethane news, Christophe Bellet, GRDF
- Rights to direct injection, Nathalie Cloatre, GRTgaz
- How to take into account the externalities of anaerobic digestion in support mechanisms? Jean Lemaistre, France Gaz Renouvelables
- Progress Update Greenhouse Gases Working Party, Jihane Loudiyi, GRDF
- Progress Update Water Quality Working Party, Armelle Damiano, AILE
- Launch of the Info Metha (AD Info) website, Alice l'Hostis, CTBM
- Open to the floor

Moderator : AAMF, Hélène Berault

NORDIC PERSPECTIVES FOR BIOGAS

29/01 10:50 - 12:00 Room : Pavillon Nordique Biogaz (Gd Palais)

- Biométhane / biogaz durable par la biomasse de deuxième génération, René Rasmussen, Lundsby Biogas
- Reliable automations to enhance the biogas process, Anna Sydänmaa, Valmet Auomation
- Biogas Upgrading with Amine, Alexander Ryhl, Ammongas

INAUGURATION AND THE INNOVATION COMPETITION AWARDS CEREMONY - BIOGAZ EUROPE

29/01 11:30 - 13:00 Room : Salle Biogaz (Gd Palais)

COOPMÉTHA 44: AN OPERATIONAL PARTNERSHIP TO ASSIST PROJECT DEVELOPMENT (Language french)

29/01 13:15 - 13:45 Room : Biogaz room (Gd Palais)

Presentation by M. Freddy HERVOCHON, Vice-Pdt «Natural resources and environments, land action, sea and coast and inland waterways», and Sofia Tendron, Engineer in Climate Energy, Department of Loire-Atlantique. Created in 2016, the CoOpMétha 44 partnership (Operational Coordination for Methanisation in Loire-Atlantique) brings together ten structures, with the common interest of developing methanisation projects. Without a priori on the type of projects, the partners mobilize collectively to support project leaders. Information meetings for farmers, raising awareness among communities and elected officials about the development potential of anaerobic digestion, support for land research via the CartoMétha tool, but also putting them in touch with other key partners: several tools and levers are mobilized to facilitate the emergence and development of projects.

THE KEY SUCCESS FACTORS FOR MY AD PROJECT

29/01 13:45 - 15:45 Room : Salle Biogaz (Gd Palais)

- Benefit from AD operator experiences, AAMF testimonial
- What is new in training ? Jérome Bécot, Cluster Methatlantique
- The first Qualimétha accreditations, Marion Melix, Club Biogaz + témoignagede S3D
- Health and Safety on biogas sites, Maxime Brissaud, CH4 process
- Mistakes to be avoided, Anthony Kerihuel, Cluster Methatlantique
- Open to the floor. Moderator : AILE

LOW CARBON BIONGV MOBILITY FOR INDUSTRY (Language french)

29/01 14:00 - 15:00 Room : Salle bioGNV (hall 1)

- The advantages of bioNGV, AFGNV, Gilles Durand
- Development of bioNGV in the West of France, Méthatlantique - bioNGV club, Bertrand Hibert
- Testimonial: Anjou Bois Energie, Lucien Gerbier
- Testimonial: Transport Jouve, Mikaël Jouve
- Testimonial: the involvement of local authorities in bioNGV mobility, SémA-E, Aurélie Kaminski
- Open to the floor

Moderator : GIlles Durand, AFGNV

NORDIC PERSPECTIVES FOR BIOGAS

29/01 14:00 - 15:30 Room : Pavillon Nordique Biogaz (Gd Palais)

- Les nouveaux modèles de méthanisation Scandinave agricole collective pour le maintien de l'élevage, par Nature Energy / Xergi avec témoignage d'une Coopérative Française
- La valeur de la mesure du méthane sur base humide dans le biogaz, Lilian Robert,Vaisala français
- Simplifying bioLNG energy transfer management, Jani Hautaluoma, Valmet Automation
- Biométhane / biogaz durable par électrification de l'unité de méthanisation, René Rasmussen, Lundsby Biogas

DIGITALISATION AND OPTIMISATION OF THE AD PROCESS

29/01 15:45 - 17:45 Room : Salle Biogaz (Gd Palais)

- MAPPED : digital tools to boost biogas production at the unit and regional level, Charlotte Richard, Engie et Julien Budin, BioEnTech
- Improving biogas performance with the use of trace elements, Mme Birgit Pfeiffer et Mme Emna Dahmen, Schaumann France
- Bringing the advantages of integrated operations to biogas plants, Anna Sydänmaa, Valmet Automation
- An innovative 3-in-1 insitu biogas measurement instrument, Antti Heikkilä, Product Manager, Vaisala
- Reducing methane slip to <1% : an important environmental benefit and a direct revenue gain, René Rasmussen, Lundsby Biogas
- Use of biochar for AD process optimisation, Jan Mumme, Carbogenics
- Efficient conversion of biogas into methanol by electrically heated steam reforming, Peter Mortensen, Haldor Topsoe
- Enhancing biogas production by integration of pyrolysis, Dr. Oda Kjoerlaug Svennevik, Scanship

THURSDAY 30 JANUARY

THE ATTRACTIVENESS OF MICRO-SCALE AD : MODULAR, SCALABLE, LOCAL, READY TO GO

30/01 09:45 - 11:30 Room : Salle Biogaz (Gd Palais)

- Ready for the resource revolution thanks to decentralised units, Pascal Peu, Irstea et Pablo Kroff, Suez
- How to accelerate the deployment of territorial micro-ad units, Jimmy Colomies, Sébastien Gacougnolle, Tryon Environnement
- Méthania International, Selim Kanzari
- Micro AD = I act and I decide for my operation, it's easy !, Norbert Irissou, MicroMétha
- Micro AD: Exploring opportunities for the urban organic circular economy including nutrient recovery, Rokiah Yaman, Leap Micro AD et Angie Bywater, Methanogen

THE BIONGV FILLING STATION : A VECTOR FOR REGIONAL DEVELOPMENT (Language french)

30/01 10:00 - 11:30 Room : Salle bioGNV (hall 1)

- Presentation of the regional dynamics of the bioNGV station of Saumur, Aurélie Kaminski, Director General SémA-E
- Support for project developers and prospects for the development of bioGNV filling stations in the West of France, Benjamin Simon, Mobility Manager GRDF Ouest
- Creation of the bioNGV Club for the Pays de Loire Region, Mickael Thomas, Délégué général de l'Association Méthatlantique

Moderator : Gilles Durand, AFGNV

NORDIC PERSPECTIVES FOR BIOGAS

30/01 10:30 - 12:00 Room : Pavillon Nordique Biogaz (Gd Palais)

- The value of wet basis methane measurement in biogas, Antti Heikkilä, Vaisala
- Biométhane / biogaz durable par la biomasse de deuxième génération, René Rasmussen, Lundsby Biogas
- Reliable automations to enhance the biogas process, Anna Sydänmaa, Valmet Auomation
- Biogas Upgrading with Amine, Alexander Ryhl, Ammongas

LOCAL DIALOGUE AND CONSULTATION

30/01 11:30 - 13:00 Room : Salle Biogaz (Gd Palais), Moderator: Grégory Lannou, Biogaz Vallée®

- Introduction, Grégory Lannou, Directeur de Biogaz Vallée®
- Restitutoin of the Methasocio programme, Caroline Depoudent, Chambre régionale d'agriculture de Bretagne
- Testimonial of a regoinal agricultural project, Sébastien Benoist, Responsable énergie - environnement à Roche aux Fées Communauté - tbc
- Testimony of an agency that supports project leaders in the integration of sensitive regional projects, Fanny Bousquet, Consultante chez TACT - tbc
- Testimony of an industrial operator, Pierre Landel, Président de Bionerval
- Testimony of an association for the protection of nature and the environment, France Nature Environnement Pays de la Loire - tbc
- Open to the floor

WHICH SOLUTIONS FOR INTEGRATING RENEWABLE GASES INTO GAS INFRASTRUCTURES? (Language french)

30/01 11:30 - 13:00 Room : Salle bioGNV (hall 1), Moderator : Laurent Blaisonneau, ENEA Consulting

- Introduction, Laurent Blaisonneau, Associate, ENEA Consulting
- Update on the development of the right to injection and focus on trailer biomethane injection, Hubert Nicolas, GRDF, Biométhane Management
- Presentation of the West Grid Synergy Project GRTGAZ - Romain Verles - Directeur du Projet West Grid SYNERGY
- Presentation of an innovative offer to optimise and maximise the injection of biomethane into the network, Claudio Bucella, Director, AZOLA
- Towards the structuring of a BioLNG sector - Synergies with LNG infrastructures - speaker tbc, ELENGY

INTEGRATING INTERMEDIARY ENERGY CROPS INTO CROP ROTATION : TECHNICAL AND ECONOMIC ROUTES

30/01 14:00 - 15:45 Room : Salle Biogaz (Gd Palais), Moderator: Cecile Hubert, CRA PdL

- Integrating intermediary energy crops into crop rotation : technical and economic routes
- Choice of cultures and technical routes: feedback
- Retour d'essais et expérimentations, Thierry Seguin, Chambre d'agriculture de l'Oise
- Feedback from trials and experiments, Seguin (Chambre d'agriculture de l'Oise)»
- Let's be innovative in CIVE culture and the livestock system, Grégory Vrignaud, ACE Méthanisation
- Testimonials of CIVE producers for AD, AAMF member
- Economic approach of CIVE from harvest to methanizer hopper, Grégory Vrignaud, ACE Méthanisation

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ReGen Europe Biogaz Europe BOIS ENERGIE

LOW CARBON BIONGV MOBILITY FOR INDUSTRY (Language french)

30/01 14:00 - 15:00 Room : Salle bioGNV (hall 1)

- The advantages of bioNGV, AFGNV, Gilles Durand
- Development of bioNGV in the West of France, Méthatlantique - bioNGV club, Bertrand Hibert
- Testimonial: Anjou Bois Energie, Lucien Gerbier
- Testimonial: Transport Jouve, Mikaël Jouve
- Testimonial: the involvement of local authorities in bioNGV mobility, SémA-E, Aurélie Kaminski
- Open to the floor

Moderator : GIlles Durand, AFGNV

NORDIC PERSPECTIVES FOR BIOGAS

30/01 14:00 - 15:30 Room : Pavillon Nordique Biogaz (Gd Palais)

- Biogas Upgrading with Amine, Alexander Ryhl, Ammongas
- La valeur de la mesure du méthane sur base humide dans le biogaz, Lilian Robert, Vaisala
- Simplifying bioLNG energy transfer management, Jani Hautaluoma, Valmet Automation
- Biométhane / biogaz durable par électrification de l'unité de méthanisation, René Rasmussen, Lundsby Biogas

DIGESTATE : UTILISATION APPROACHES (Language french)

30/01 15:00 - 17:00 Room : Salle bioGNV (hall 1)

- Introduction AILE
- Waste is only a resource in the wrong place : digestate + CO2 = fertiliser + chp + carbon storage, Peter Hammond, CCm Technologies
- Utilising the digestate via micro-algae, Luc Chauchat, AC3A
- Sustainable biowaste management and biogas production, Paal Nilsen, SCANSHIP
- Digestate: Experience feedback from the Brittany methanisation, Pièrre Quideau, Britanny Chamber of Agriculture, AAMB

Moderator : AILE

FUNDING OVERVIEW FOR AD PROJECTS

30/01 15:45 - 17:00 Room : Salle Biogaz (Gd Palais), Moderator: Mickael Thomas, Méthatlantique

- Opportunities for crowdfunding (direct funding, investment structure)
- Purchasing groups to optimize your project (multi-project clustering, grouped consultation of manufacturers)
- Round Table : Financing an anaerobic digestion project in 2020 (Bank financing in 2020 - new features and developments, Special features of different financing models, Supply chain aspects)

Pictures from previous events