Biogas Action Brochure on Best Regional-Integrated Biogas Plants

Biogas Action Project: Promotion of Sustainable Biogas Production in the EU

Biogas ACTION

Biogas Action

Biogas Action aims to promote the production of sustainable biogas throughout the EU, especially by exchanging best practice, creating new business models, and increasing investments in biogas production.

The project's purpose is to serve as a vehicle for a rapid development of the European biogas/biomethane sector. This undertaking will contribute to the EU 2020 targets, by focusing on the removal of non-technical barriers to the widespread production of biogas from manure and other waste. The project is based on a deeper cooperation between the different policy levels (European, national and regional), and on its implementation in various EU regions.

Deliverable:	D.2.4 Comprehensive guidelines for biogas promotion at regional/local scale with associated institutional-building, tools development and market support
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This brochure is a deliverable within Work Package 2. It aggregates information on the top ten most interesting biogas plant projects of the Biogas Action project countries. The reader is provided with background information on the starting conditions and the Technical Data of these biogas plants.

The brochure contains a detailed analysis of the current situation and environment when the project was planned. The drivers for the idea of the biogas project and the construction of the plants are explained. It gives an idea of the obstacles operators faced, the involvement of the municipality and the residents of the area around the biogas plant.

The Financial Background Conditions available are described giving a detailed analysis of local support tools and financial subsidies. The Technical Data of the biogas plants are described in detail, explaining the type and amounts of feedstocks and the products of the biogas process. The use of the products biogas, heat and digestate are important for an efficient and sustainable biogas project.

This brochure describes biogas plants that are not only highly outstanding and special but also feasible to apply to other European regions.

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Bioplinsko Postrojenje Gradec

Waste to Energy and Fertiliser

Municipality of Gradec, Vrbovec

Contact details

Agrokor-Energija

www.eihp.hr

Technical Data

Year of construction	2012
Plant size	2,134 MW_{el}
Digester volume	• Fermenters: 6,000 m^3 • Post-fermenter: 2,500 m^3 • Two hydrolysis tanks: 1,256 m^3
Gas Storage	2,000 m^3
Hydraulic retention time (HRT)	35 - 40 days
Process temperature	Mesophilic at 42° C
Digestion technology	CSTR, two-stage digestion

Background Story

The guideline of this project was the company's waste to energy strategy. As the plant is very close to the Croatian capital Zagreb, many food processing industries offer a large spectrum of wastes which can be treated in a biogas plant. Also, Agrokor group, a vertically integrated agricultural and food processing, retail entity in the Republic of Croatia, has a series of strategically important locations with extremely large amount of different resources that ensured high-quality raw materials, by-products and wastes for the AD production process. It also owns companies which are consumers for part of the output of the production process (heat and organic fertilisers) on mutual benefit.

This plant was the demonstration/learning plant for a string of biogas investments (9.8 MW in five plants).

Municipalities/Regions Involved

Agrokor Energija had to gain public acceptance by organising numerous discussions with the local community and a study tour for local people to biogas plants with digestate lagoons. The existing pig farm gained the acceptance when the smell nuisance was decreased in vicinity after building a biogas plant.

Main Interest in the Project

This project is very interesting because many different technologies which are used in the biogas industry are implemented at one place. The hydrolysis-step of the two-phase fermentation makes sure that substrates are digested most efficiently. Additional thermomechanical equipment is installed (heat exchangers, thermal oil and storages) to allow as much heat utilisation as possible. The sterilisation and other specialised equipment makes the use of many different wastes possible. The plant generates income from sold electricity, thermal energy, waste collection and agricultural soil fertiliser which makes this project highly feasible to be applied in many different regions.

Specialties

At first, the Biogas Plant Gradec was built as a 1 MW_{el} plant with a CHP but was advanced with two separate hydrolysis tanks and a 2nd CHP in 2015. Production with 2 MW capacity started in the 4th quarter of 2015.

It is built next to the pig farm and meat processing industry, within Agrokor Group. The maximum efficiency of the CHP engine can be reached by utilising most of the heat: there are two heat storages for heat from biogas CHP: two water tanks (2 x 100 m^3) and two thermal oil tanks (2 x 20 m^3). Heat from exhaust fumes at the exhaust pipe with use of additional thermo-technical equipment is stored at thermal oil tanks at up to 300 °C. The heat, combined with natural gas (as back up), is used for pressure sterilisation (133 °C at 3 bar at 20 minutes) of slaughterhouse waste. Heat is also used as process heat to support hydrolysis in pre-fermenter and AD in the main fermenter and for the digestate thickener.

Pig slurry is connected to an underground gravity piping system from the farm to the AD to avoid smell nuisance.

Financial Background Conditions

Total investment costs: 9.2 Mio EUR

Investors: The investor is a private company Agrokor-Energija ltd. (est. 2010) member of Agrokor Group which is vertically and horizontally integrated in the food & beverage company.

Investment support: One part was provided by EBRD loan

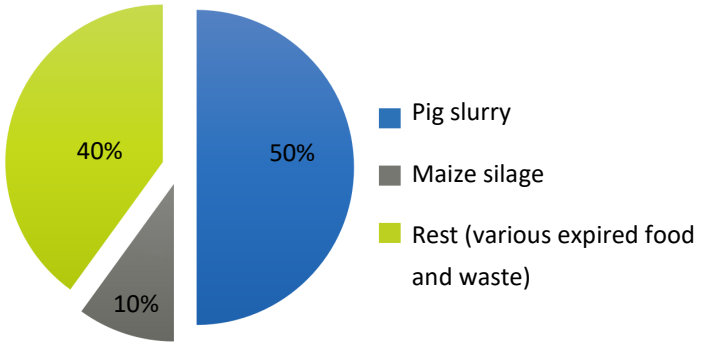
Operation support: FiT with a 14-years-guaranteed price of ~0.17 EUR per kWh incl. 'local community' bonus for mandated 50% energy efficiency of the CHP.

Additional support: -

Feedstock/Substrates

The plant processes 80,000 tonnes per year mixture of 11-20 different types of substrates. The largest share in volume (55-60%) refers to pig slurry, while the other is related to animal by-products and waste from various stages of food processing industry and food retail within the Agrokor Group and third parties waste (ex-food, slaughterhouse waste, flotation sludge, glycerine, beer yeast, various grains not intended for human consumption…). Maize silage is used for balancing the process with 11-15% volume share.

Feedstock amount ~ 220 tonnes per day



Use of Products from Biogas Process

Use of biogas: In form of electricity and heat

CHP/electricity: Yes

Amount of generated electricity: 10,177 MWh (data is for 2015 with remark that 2nd CHP started with production in 4th quarter of 2015).

Use of electricity: Electricity is injected into grid and sold

Biomethane generation/injection: No

Amount of injected biomethane: Not applicable

Use of biomethane: Not applicable

Heat use: Heat is used as process heat for fermenters, post-fermenter, hydrolysis tanks, digestate thickener, management offices and pig stables. Heat from oil tanks is used for sterilisation of slaughterhouse waste.

Amount of heat produced: 6,288 MWh (used heat)

Use of digestate: Digestate is collected at lagoons and used as fertiliser within the own cropping system. One part of digestate is treated in mechanical separators to get solid phase which is also used as a fertiliser.

Plant Zdar nad Sazavou

Remote Cogeneration: Biowaste to Power and Heat for Industry and Municipality

Vysocina, Czech Republic

Contact details

Iva Zeronikova, zeronikova@odas.cz

Technical Data

Year of construction	December 2010
Plant size	0.6 MW_{el} 0.608 MW_{th}
Digester volume	7 × 1,050 m^3 (operational volume ca 75%)
Gas Storage	467 m^3 (max pressure of 0,15 kPa)
Hydraulic retention time (HRT)	RT is more than 120 days work cycle of one fermenter is 28 days, ca. 70% of the digestate is used as inoculum and mixed with new substrate
Process temperature	Mesophilic at 38 °C
Digestion technology	One-stage digestion in batch mode, dry fermentation with 7 digesters, batch regime

Municipalities/Regions Involved

Neither the municipality nor the region was involved in the project. However, the town is cooperating with the organisation of the biowaste separation. The town is also the heat consumer.

Background Story

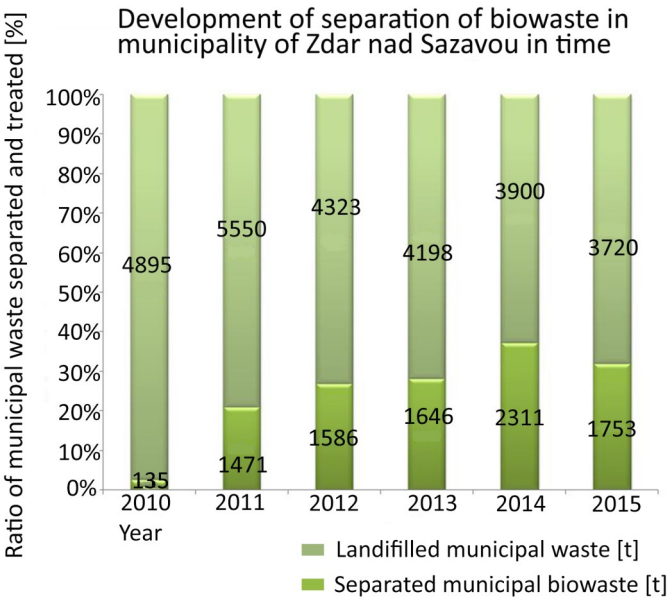
The idea was to provide a possibility to the surrounding municipalities to treat biowaste without limitations of the standard composting facilities and with higher added value – energy production. The investor assumed that legal obligation to treat biowaste would come earlier for the municipalities than it actually did in the end. The biowaste has not been separated or treated almost at all in the region until the facility has been built.

Main interest in the project

This project is not economically feasible under current conditions. But that is partially caused by the lack of legislation on biowaste treatment in the Czech Republic at the time of its start up and years after, as well as lower operation support for biogas plants treating waste – compared to energy crops.

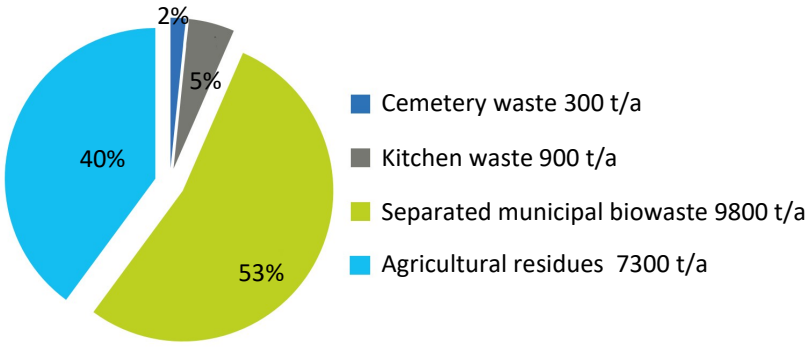
Batch dry fermentation is a suitable technology for biowaste treatment. The project also has a very high efficiency of energy use (both heat and electricity).

Biogas plant is very beneficial for the region bringing reduction of the organic waste being landfilled, electricity for a local industrial company as well as heat for the municipality. Nutrients are also recycled as the digestate is being spread on the arable land.



Feedstock/Substrates

The plant processes up to 18,300 tonnes of biowaste per year.



Specialties

Biowaste utilising biogas plant based on dry fermentation

- Biogas transported by a pipeline to an industrial enterprise ZDAS (distant CHP unit)
- All the heat and electricity used at the place
- Very good co-operation of municipalities (production of biowaste/substrates), other producers of biowaste (industry, restaurants), operator (SME) and consumer (large industrial enterprise)
- Suitable not only for municipal waste systems

Financial Background Conditions

Total investment cost: 103 Mio CZK (3.8 Mio EUR)

Investors: Waste treatment company ODAS ODPADY, Ltd.

Investment support:

- 35.9 Mio CZK (ca. 1.33 Mio EUR) from European Structural and Investment Fund - Cohesion Fund (35%)
- 6.3 Mio CZK from the State Environmental Fund of the Czech Republic (6%)
- A loan for 30 Mio CZK (ca. 1.1 Mio EUR) from a bank

Operation support: The operational support in the form of Green bonus.

Additional support: -

Use of Products from Biogas Process

Use of biogas: Biogas is transported by a 1.5-km-long pipeline to an industrial enterprise ZDAS, a.s, where the CHP unit is located. All heat and electricity is used at the place which is a unique concept in Czech conditions.

CHP/electricity: Yes

Amount of generated electricity: 0.6 MW_{el}

Use of electricity: In an industrial company ZDAS, a.s.: (Manufacturing programme of the company ZDAS is focused on production of forming machines, forging presses, metal scrap processing equipment, rolled product processing equipment, castings, forgings, ingots and tooling, especially for the automotive industry).

Biomethane generation/injection: No

Amount of injected biomethane: Not applicable

Use of biomethane: Not applicable

Heat use : Central heating system of the municipality of Zdar nad Sazavou

Amount of heat produced: 0.6 MW_{th}

Use of digestate: The digestate is being regularly analysed and spread on the arable land.

Solrød BiogaS

Biogas Plant Solving Nutrition Oversupply and Seaweed Problem at Bay of Køge

Zealand, Denmark

Contact details

Mikkel Busck, mbu@solrod.dk

Technical Data

Year of construction	2015
Plant size	5.4 Mio $_N m^3$ biogas per year 200,000 tonnes biomass per year
Digester volume	2 x 8,000 m^3 primary 2 x 1,500 m^3 secondary
Gas Storage	2,000 m^3
Hydraulic retention	37 days
Process temperature	Thermophilic at 52 °C
Digestion technology	CSTR , two-stage digestion, only first stage is heated

Municipalities/Regions Involved

The Municipality of Solrød was involved in the project. The municipality wished to take action regarding the climate challenge and wanted to reduce their CO_2 emissions. They saw a great potential in building a biogas plant that could both solve the climate issue and the seaweed problem at the beach.

Background Story

Large parts of the beach area at Bay of Køge used to be covered by fouling seaweed and the odour was a great nuisance to visitors and residents.

This was the reason why the Municipality of Solrød and the homeowner associations along the beach decided to establish a beach cleaning association to solve this challenge.

Hence, the idea was born to build a biogas plant digesting collected sea-weed, organic residues, and livestock manure for the generation of ener-gy.

Main Interest in the Project

The idea to build a biogas plant in Solrød emerged from the need to find a sustainable solution for the community's odour problem, caused by seaweed fouling at the beach. Simultaneously, the Solrød Municipality also wished to fight against climate change by generating green energy.

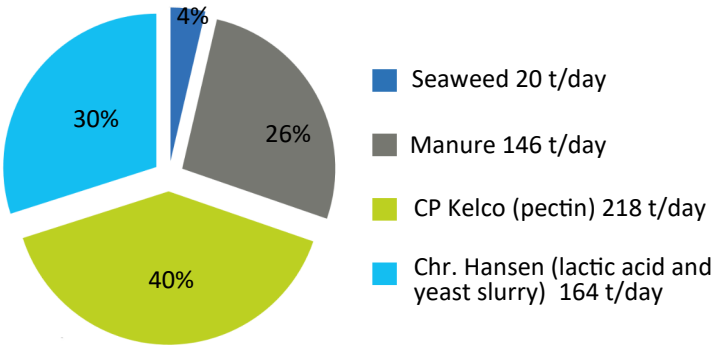
This project shows how a municipality can contribute to sustainable energy production with a growing focus on sustainability and environmental issues and how a cooperation between different partners can lead to new solutions. The different partners, both private and puplic partners, gained from the collaboration of one project.

Specialties

Solrød BiogaS is one of the only public based plants in Denmark. It was built from 2014 to 2015 as a result of the growing focus on sustainable energy in the municipality and is owned by the municipality of Solrød. It was developed in close connection with private companies in the municipality who had unused bio resources. The biogas plant helps both the private companies and the municipality to address different challenges and solve problems.

Feedstock/Substrates

The biogas plant has a treatment capacity of 200,000 tonnes feedstock per year.



Financial Background Conditions

Total investment costs: 11.5 Mio Euro

Investors: The plant was established and is operated by Solrød Biogas A/S, founded May 28, 2014.

Investment support:

The plant received financial support from the EU programme 'Mobilizing Local Energy Investments' in the project development phase.

- Investment, 11.5 Mio Euro (ex. CHP unit)
- EU grant 0.5 Mio EUR; annual revenues 30 Mio DKK
- 480,000 EUR/4% (only in the design phase)

Operation support: Feed-in tariff to boost the biogas production from 2012 to 2019

- A price of 79 DKK (10.5 EUR) per GJ (2012 prices). Regulated per price index.
- A price supplement of 26 DKK (3.5 EUR) per GJ (2012 prices). Regulated per natural gas prices.
- A price supplement of 10 DKK (1.35 EUR) per GJ (2012 prices). Reduced by 2 DKK each year from 2016

Additional support: 480,000 EUR/4% (only in the design phase)

Use of Products from Biogas Process

Use of biogas: The biogas production of 6 Mio m^3 per year results in a supply of 60,000 MWh per year renewable energy, comprising 23,000 MWh per year of electricity and 28,000 MWh per year of heat used for district heating.

CHP/electricity: Gas engine

Amount of generated electricity: 23,000 MW_{el}

Use of electricity: Electricity is sold to the grid

Biomethane generation/injection: No

Amount of injected biomethane: Not applicable

Use of biomethane: Not applicable

Heat use: The heat is supplied to the local district heating system which is operated by Vestegnens Kraftvarmeselskab I/S and owned by 12 municipalities as stakeholders.

Amount of heat produced: 28,000 MW

Use of digestate: The produced digestate is used as biofertiliser for farmers.

Agribiomethane

'Valorisons nos lisier en Gaz Vert'
Slurry to Green Gas

Cholet, France

Contact details

AILE France

agribiomethane@orange.fr

Technical Data

Year of construction	2013
Plant size	In 2014: 201,560 $_{N}m^3$ biogas per hour Since January 2016: 80 $_{N}m^3$ biogas per hour During the first year (7/2014-6/2015): 447,209 $_{N}m^3$ biogas per hour
Digester volume	Net volume: • Main digester: 1,665 m^3 • Post digester: 1,066 m^3
Gas Storage	1100 m^3
Hydraulic retention time (HRT)	45 days
Process temperature	Mesophilic at 37 °C
Digestion technology	Wet-fermentation, one preliminary tank for manure and two preliminary tanks for fats which are heatable

Municipalities/Regions Involved

The plant is close to a district border and so the district council supported the project by public subsidies under the condition of building the plant in their district.

Background Story

The main driver for the project was a joint effort of farmers to improve the nutrient management in the region. As the investment for a shared slurry treatment is the same as for one farm only, investors decided to find a joint solution. Another driver was the fact that farmers must line up for the creation of storage capacities.

Main Interest in the Project

This biogas project is model for other regions because of its shared investment. The advantages for farms are the a diversification of production, the new source of income and to help keep livestock breeding in the area. Farmers profit from a new personal endeavour on behalf of a new industry and from exchanges with people they did not know before. For the cooperative structure, the local treatment solution for organic waste (and avoiding a lot of transport) brings added value.

Specialties

AgriBioMethane has been working for three years and has been the first in the region producing biomethane and injecting it into the grid. It has been important for the farmers to keep the organisational and financial majority of the project. The first three years have proven that a collective-farmers-project can be successful when the preparation is well thought-through. The biomethane project results from that work and so ten farmers from four different agricultural structures invested in one shared biogas plant project. The additional substrate is delivered from slaughterhouses that are owned by agricultural cooperatives already working with these farmers.

Financial Background Conditions

Total investment costs: 3.4 Mio EUR

Investors: The investors are ten farmers on four farms, Terrena and Lyonaise des eaux. The French investment fund for green energy is part of the consortium.

Investment support: 760,000 EUR by National Waste and Energy Agency (ADEME)

- 60,000 EUR by the district council
- 195,000 EUR FEDER attributed by the district council
- 70,000 EUR subsidies by water supply agency Loire Bretagne

Operation support: Investors received support from consultants for technical and social/economic planning and for the applying process for public financing.

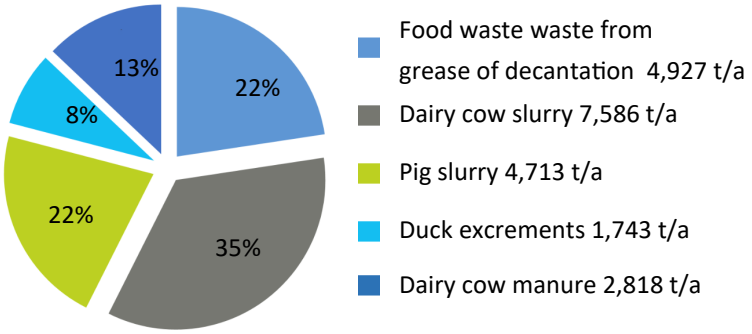
Feed-in tariff: Without the price for the certificate of origin in the beginning of the project in 2014 the production volume was 65 $_{N}m^3$ per hour for 13 euro cent per kWh HHV (higher heating value). This price is related to the production volume and with the recent rise of production volume to 80 $_{N}m^3$ per hour price sinks to 13 euro cent per kWh HHV.

Additional support: Tax Exemption: Plants with more than 50% of capital investors with agricultural activity and 50% of substrate with agricultural origin are exempt of local taxes.

Feedstock/Substrates

Feedstock amount 59 tonnes per day

Investors deliver manure and slurry. The overall treatment charge is 34,000 EUR per year for the benefit of the biogas plant and 25,000 EUR per year to buy substrates from waste producers.



Use of Products from Biogas Process

Use of biogas: Upgrading to biomethane and grid injection

CHP/electricity: No

Amount of generated electricity: Not applicable

Use of electricity: The energy is sold as biomethane to ENGIE (ex GDF). Another increase in the production volume is decided by the plant investors to 85 $_{N}m^3$ per hour.

Biomethane generation/injection: Yes

Amount of injected biomethane: 65 $_{N}m^3$ per hour

Use of biomethane: The biomethane is consumed locally by a big bakery but the certificates of origin are sold to local authorities. Additionally, the foreseen of the project is a filling station for gas vehicles (busses and lorries) using compressed biomethane.

Heat use : No

Amount of heat produced: Not applicable

Use of digestate: The digestate was originally separated by a screw press and is now separated by a newly installed centrifuge. The liquid phase is spread by an external company and the solid phase is composted by FertiEveil (cost 10 EUR per tonne solid phase for the transport).

TERRAGR'EAU

Biogas Plant to Protect the Quality of Evian Mineral Water

Féternes, France

Contact details

Eric VAN TROYS , eric.vantroys@serfim-recyclage.fr

2, chemin du Génie – CS 60222 – 69633 Vénissieux Cedex

Technical Data

Year of construction	2016 First injection in January 2017
Plant size	111 $_{N}m^3$ biomethane per hour
Digester volume	2 X 3,617 m^3
Gas Storage	6,750 m^3
Hydraulic retention time (HRT)	65 days
Process temperature	Mesophilic at 38 °C
Digestion technology	Infinity-mixed wet fermentation, two-stage digestion

Municipalities/Regions Involved

The main support for this project was the municipality (communauté de communes du Pays d'Evian) of Evian because there is 1300 jobs in the Evian water company and farms are very important for tourism, landscape and cheese production. They initiated the feasibility study, and decided to be the owner of the plant and delegate building and operation to a private society. They found subsidies for financing the project.

Background Story

EVIAN, as a provider of natural mineral water has high requirements: absence of chemical and bacteriological contaminants, stability of the mineral composition, maintaining a very low nitrate content. Compliance with regulatory requirements is essential to the sustainability of the activity and related jobs. Preserving the quality of the mineral water is intrinsically linked to the protection of the supply or the catchment area evian deposit, located on the territory of the Community of Communes Pays d'Evian (CCPE).

However, the water source is in an area where spreading of manure represents risks for the water quality because of nitrates pollution. Thus, almost 50% of the impluvium are grasslands. The local authority of Evian and Danone made a commitment to protect the territory.

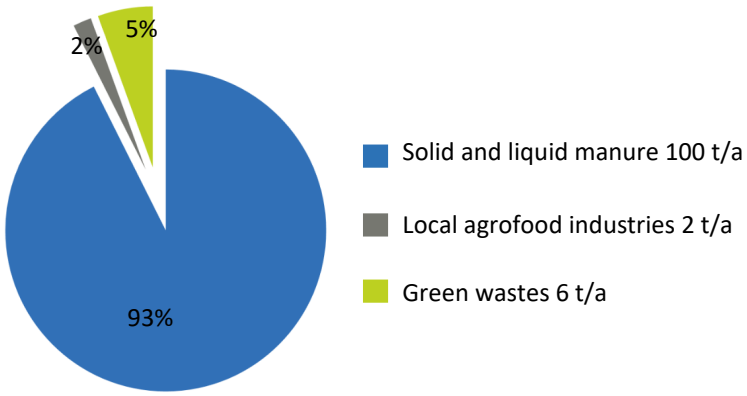
Main Interest in the Project

TERRAGR'EAU is an example of territorial integration of biogas plant involving farmers, local companies and the local community. The origin of the project is to collect all organic matters (especially manure) to protect the evian waters impluvium and secure the quality of Evian water sells by Danone. The local authority is the project owner and also initiated the project. TERRAGR'EAU provides biomethane for gas grid injection and has a territorial approach. All involved farmers supply manure and use the digestate later. This is not a renewable energy project but a project to protect water of an impluvium. This approach is interesting to all regions with water sources.

Feedstock/Substrates

40,600 tonnes of substrate

- Solid and liquid manure from 42 farmers, 92% of substrates
- Green waste 6%
- Local Agrofood industries 2%



Specialties

Terragr'Eau project is in line with local (departmental) and national policies. Particularly the programme thousand biogas plants promoting nitrates control through the management and spreading conditions of digestate is of importance.

One of the key element of the project is the establishment of a farmers cooperation dedicated to the management of the digestate and its spreading conditions, in order to protect the quality of water. This cooperation was recognised in February 2015 as one of the first Economic and Environmental Interest Groups (EEIG) by the Minister of Agriculture. Holders of the project are convinced that Terragr'Eau has all the qualities to be a role model for other regions.

Financial Background Conditions

Total investment costs: 9.3 Mio EUR

Investors: In Evian, the local authority opened a call to privately structure, finance, build and operate the plant as a public service delegation: SAS TERRAGR'EAU has been created by a private company that monitors building and operating the plant. The second partner is DANONE.

Investment support:

- The local authority Communauté de Communes du pays d'Evian 20%
- Danone 40%
- SAS Terragr'eau 14%
- Subsidies from EU, Regional council, Department, ADEME 26%

Operation support: The project is a gas grid injection plant under construction. A feasibility study was performed in 2006, the plant will be in operation in 2017.

Feed-in tariff: 117.6 EUR per MWh.

Additional support: Tax Exemption for local taxes paid by the local authority.

Use of Products from Biogas Process

Use of biogas: Biogas upgrading to biomethane

CHP/electricity: No

Amount of generated electricity: Not applicable

Use of electricity: Not applicable

Biomethane generation/injection: Yes

Amount of injected biomethane: 111 $_{N}m^{3}$ per hour

Use of biomethane: The gas will be injected into the grid and sold to an energy supplier, the price will depend on size and percentage of manure, around 117.6 EUR per MWh injected, 111 $_{N}m^{3}$ per hour.

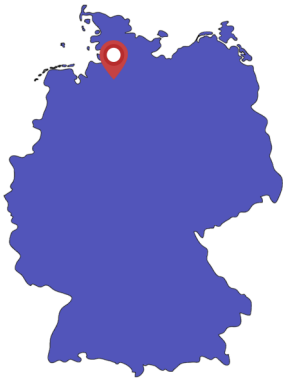
Heat use: No

Amount of heat produced: Not applicable

Use of digestate: The liquid digestate will return to the field and the dry digestate will be composted and will return to the field of the farmers who provided substrates.

Agrogas & Wärme GmbH & Co KG

Agricultural Waste to Electricity, Heat and Biomethane



Malstedt (Lower Saxony)

Contact details

Agrogas & Wärme GmbH Co. KG
agrogas@gmx.de
www.malstedt.de/bioenergiedorf

Technical Data

Year of construction	2010
Plant size	Installed electrical capacity of 1,250 kW Annual electricity production of 10,950,000 kWh Annual produced amount of bio-methane of 3,066,000 $_N$m³
Digester volume	Two digesters: 4,247 m³ One post digester: 3,619 m³ Three digestate storages: 5,655 m³
Gas Storage	10,279 m³ sufficient for a storage period of about 13 hours
Hydraulic retention time (HRT)	151 days
Process temperature	Mesophilic at 40 °C
Digestion technology	CSTR, two-stage digestion

Municipalities/Regions Involved

The former mayor of the town is also shareholder of the project. His proactive work increased the acceptance in the rural district Rotenburg (Wümme) and the municipality Malstedt, the location of the biogas plant and the satellite-CHP units. He was also mainly responsible for the side project "Wärmenetz" to construct a district heating system in the area.

Background Story

All stakeholders of this project were in dialogue which led to a rise in team spirit within the municipality. The former mayor of the municipality was a great supporter who brought the idea of the project to life.

The idea of building a biogas plant in combination with a heating grid was a joint decision of residents, local farmers, representatives of the municipalities and authorities. Many heating systems of households in the municipality were out of date and consequently the idea of realising a heating grid was positively anticipated from the beginning.

Main Interest in the Project

The biogas plant "Agro Gas & Heat" is very well integrated into the regional agricultural structure. Agricultural enterprises which do not have sufficient resources to build their own biogas plants benefit from the project. The biogas project has become an important economic pillar in the region and brought added value to it. 72% of the total investment (7 Mio EUR from 9 Mio Euro) went into local economy. The operation and maintenance of the biogas plant provide 4.5 new and eco-friendly jobs in the municipality.

In 2012, the project was awarded as "Seminal Biogas Plant" by a brains trust at the National Competition Biogas of the German Ministry of Agriculture (organised by KTBL) as best practice exemplary and sustainable biogas plant.

Specialties

The biogas plant was designed to maximise the overall efficiency of produced biogas and use it in three different pathways: providing electricity, heat and biomethane. Two CHP units are located on-site but three CHP units are so-called satellite- or remote-CHP units located a few kilometers from the biogas plant. They are located strategically where the heat demand is above average. The waste heat is transported from the three satellite-CHP supplies via two heating grids to a farm and to provide 91% of the local households. During summer the produced waste heat of the CHP is sufficient to provide the full heat demand.

Financial Background Conditions

Total investment costs: 9.7 Mio EUR (plus the own financial contributions of 1 Mio EUR)

Investors: This is a joint biogas plant project with 17 involved farmers. This cooperation carries the total investment and is the only owner of the whole biogas plant and the two heating grids.

Investment support: No investment support.

Operation support: The electricity provided by this plant is injected into the electric supply network and is remunerated per Renewable Energy Act (German EEG, version 2009).

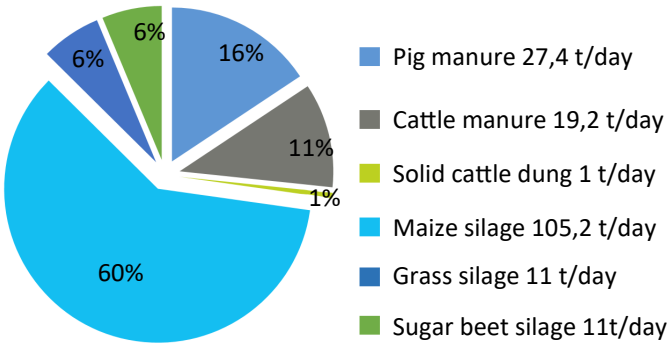
Feed-in tariff: The biogas plant and the three satellite-CHP receive four different feed-in tariffs for the energy produced and injected into the electric supply network. The average value is about 20 euro cent per kWh_{el}.

The incentives with the price supplements was to boost the biogas production from 2012 to 2019.

Additional support: -

Feedstock/Substrates

The whole feedstock comes from agriculture:



Use of Products from Biogas Process

Use of biogas: 1/3 is used in five CHP units (two CHPs on-site and three remote CHP units); 2/3 is sold to a biomethane upgrading system which runs in cooperation with the plant.

CHP/electricity : Yes, in combination with an upgrading system

Amount of generated electricity: 10,600 MWh per year

Use of electricity: 89% is fed into the electric supply network. 11% is used for operating the biogas plant and the on-site upgrading system.

Biomethane generation/injection: Operated by a pool of different public services

Amount of injected biomethane: 3 Mio $_{N}m^3$ per year; The natural gas grid limits the max. injection volume of the produced biomethane to 350 m^3 per hour. The upgrading system is designed for a max. raw gas quantity of 900 m^3 per hour.

Use of biomethane: The biomethane is sold by the operator and owner of the upgrading system to different public services.

Heat use: The two local heating grids provide a total of 69 customers. The heat supply is ensured with a peak load boiler for supporting in the winter months. The price for the sold heat is linked to the price of heating oil and ranges from 0.04 to 0.06 EUR per $kWh_{th.}$

Amount of heat produced: 11,280 MW per year:

2,500 MW per year are sold via two heating grids. Part of it is being used for drying wood

3,350 MW per year are necessary for the upgrading system

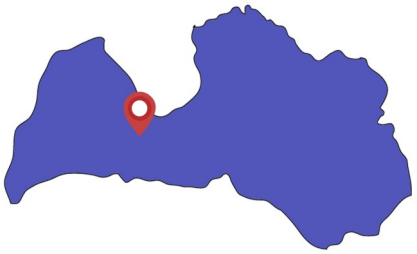
The operation of the biogas plant itself needs about 3,170 MW per year

The heat utilisation rate of the whole project is about 80%

Use of digestate: 50,000 tonnes per year are used as a fertiliser by participating farmers.

Bio Ziedi Ltd.

Biogas Cogeneration with wide Operating Range



Dobele region, Latvia

Contact details
Uldis Pilveris
e-mail: upilveris@gmail.com

Technical Data

Year of construction	2011
Plant size	Installed electrical power: 1,998 kW 850 $_{N}m^3$ per hour of gas 7,446,000 $_{N}m^3$ per year of gas 90,000 tonnes per year of digestate
Digester volume	4 digesters: 2078 m^3 1st post-digestion tank: 2078 m^3 2nd post-digestion tank: 3400 m^3
Gas Storage	10,000 m^3
Hydraulic retention time (HRT)	65 days
Process temperature	Mesophilic, 34 – 40 °C
Digestion technology	Three-stage digestion

Municipalities/Regions Involved

The municipality or region was not involved in the development of the biogas plant (no specific support for the construction of biogas plant), but importantly, there weren't any considerable barriers.

Background Story

When the biogas plant construction was started, there was an agricultural crisis in Latvia and it was very problematic to raise financing for the plant construction. Banks in Latvia did not know about the biogas CHP plants, which is one of the reasons why the beginning of the biogas plant project implementation was difficult and uncertain. It was an important problem that responsible institutions did not know how to administer and manage such projects.

Main Interest in the Project

The main advantage of this project is the ability to work with any agricultural organic products, i.e. no specific requirements for high-quality raw materials. Plant Bio Ziedi Ltd. has a very wide operating range; for instance temperature range could be 30-55 °C and dry mass range from 5-13% resulting in a varying methane content of 35-70%. Such a biogas plant model can be adapted for almost any operating conditions and materials.

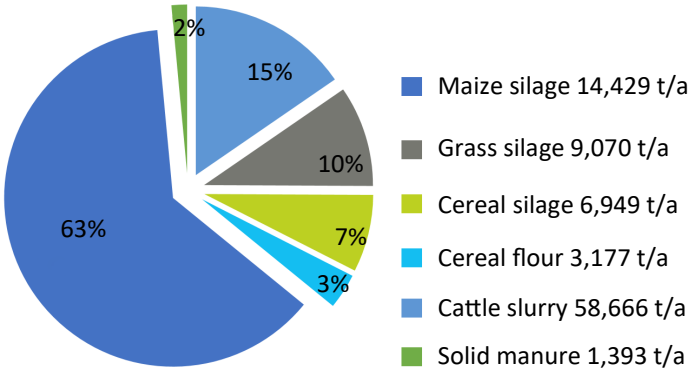
Specialties

The Plant Bio Ziedi Ltd. is one of the largest biogas plants in the Baltic States with the electricity generation capacity of 2 MW and heat production capacity of up to 4 MW. BIO ZIEDI Ltd. was one of the first projects built in Latvia, so they have gone through different challenges, providing assistance to other biogas plants in technical matters. This biogas plant has gained one of the best and the most stable indicators in biogas production where not only electricity is used efficiently but also the heat energy.

Feedstock/Substrates

Total of 240 tonnes per day

The price depends on actual cost of raw material. Grain flour is purchased through procurement. In 2015, total costs for raw materials were 1.7 Mio EUR.



Financial Background Conditions

Total investment costs: 6 Mio EUR

Investors: Existing dairy farm owners invested their own funds and received a loan from a bank.

Investment support: Rural Support Service provided 40% of the total eligible costs for the establishment of biogas plant.

Operation support: Mandatory purchase of electricity generated from renewable energy sources (feed-in tariff), according to Cabinet Regulation No. 262 (Regulations Regarding the Production of Electricity using Renewable Energy Sources and the Procedures for the Determination of the Price). Since 2014, incomes from the sold electricity are liable to 5%.

Feed-in tariff: 19 euro cent per kWh + VAT before subsidised electricity tax (15,984 kWh per year)

Additional support: EU structural funds

Use of Products from Biogas Process

Use of biogas: CHP to provide energy and heat

CHP/electricity: Yes

Amount of generated electricity: 15,821 MWh_{el} (in 2015)

Use of electricity: Bio Ziedi Ltd. sells electricity to JSC 'Latvenergo', which is the main energy service provider in Latvia.

Biomethane generation/injection: No

Amount of injected biomethane: Not applicable

Use of biomethane: Not applicable

Heat use: Heat energy is transferred to the parent company without cost. The parent company uses the heat energy to heat a dairy farm and a recently started fish (sturgeon) and shrimp production.

Heat balance:

- 30% for fermentation tanks
- 45% for cow farm complex
- 25% for fish and shrimp production and processing plant

In 2015, heat energy of 4,786 MWh was transferred. Transferred heat energy is accounted in Bio Ziedi Ltd.

Amount of heat produced: 4,786 MWh in 2015

Use of digestate: All digestate is dispersed on agricultural land of Bio Ziedi Ltd. The cost of digestate use for biogas plant is between 3 – 6 EUR per tonne.

Greendal vergisting

Digesting up to 70% Chicken Litter in a CSTR

Dalfsen, the Netherlands

Contact details
info@cocos.nl

Technical Data

Year of construction	2015
Plant size	1.54 MW_{el}
Digester volume	3 x 4,000 m^3
Gas Storage	Unknown
Hydraulic retention time (HRT)	80 days
Process temperature	Mesophilic at 38 ^{o}C
Digestion technology	CSTR, two-stage digestion

Municipalities/Regions Involved

No municipalities were involved.

Background Story

The main driver for implementing the biogas plant Greendal vergisting was the need for manure processing at acceptable costs and an additional source of income for the farmer.

The construction of the plant took several years; the general acceptance was relatively good. The need for manure treatment was more and more recognised. Subsidies for innovation were available which made this project feasible.

Main Interest in the Project

The use of a high share of chicken litter makes this project very interesting. Chicken litter has a high biogas potential, comparable with maize silage. Furthermore, the ammonia stripping results in a nitrogen fertiliser that can be sold as artificial fertiliser.

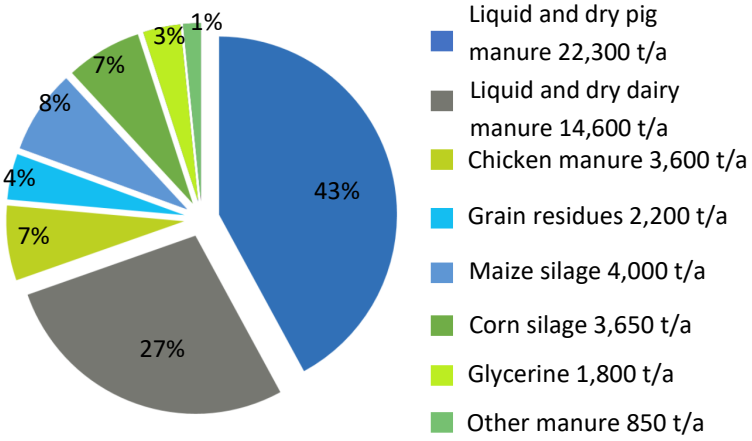
In many countries chicken litter is not used for biogas production on large scale. With this set-up, its potential can be exploited and replaces the use of maize in this concept, making it more sustainable. Therefore, it is called “digestion 2.0” referring to a second generation of biofuels.

The capacity is about 50,000 tonnes input per year. The size is manageable for a farmer and makes the Greendal vergisting biogas plant a good example for other farmers throughout the EU.

Feedstock/Substrates

Total feedstock:

- preliminary amount 52,000 tonnes per year
- share of chicken manure will gradually increase to 70%



Specialties

Greendal vergisting biogas plant is based on a chicken farm with the idea to use a high share of chicken litter as substrate (> 50%). Due to the high nitrogen loading such a high percentage of chicken litter in the substrate has not been used in any plant before.

One of the innovations this project offers is a nitrogen stripper that works in parallel operation on the main digester. This way, the ammonia level can be controlled.

Furthermore, the digestate is separated into a thick and a thin fraction. The thick fraction is being pasteurised and exported to garden centres and abroad.

The thin fraction is used in ponds to grow algae which will be fed to chicken. This represents an innovative nutrient and protein cycle on the farm.

Financial Background Conditions

Total investment costs: 10 – 15 Mio EUR

Investors: The farmer, regional investment fund for renewable energy, banks

Investment support: An innovation subsidy for innovative, nitrogen rich, fermentation

A provincial subsidy for renewable energy production capacity

Operation support: SDE+ subsidy, a compensation for the difference between cost price and market price per MWh_{el} produced

Additional support: Tax reduction for the implementation of an algae pond.

Use of Products from Biogas Process

Use of biogas: Electricity and heat

CHP/electricity: CHP

Amount of generated electricity: 11,500 MWh

Use of electricity: Electricity is sold to the grid for market prices

Biomethane generation/injection: No

Amount of injected biomethane: Not applicable

Use of biomethane: Not applicable

Heat use: The heat is used for ammonia scrubbing, digestate pasteurisation and for growing algae.

Amount of heat produced: 13,000 MW

Use of digestate: Digestate is either spread over the fields (cost) or pasteurised and exported, which accounts for manure treatment under the Nitrogen Directive. Pasteurisation is related to costs but the certificates for the exported phosphate can be sold, so there is a net income. A minor part of the digestate is used to grow algae.

More Biogas Småland AB

Biowaste to Biomethane for use as Vehicle Fuel

Läckeby Kalmar , Sweden

Contact details
Gunnar Bergström,
gunnar.bergstrom@mbdrift.se

Technical Data

Year of construction	2014
Plant size	80,000 tonnes of substrate per year 500 $_{N}m^3$ biogas per hour 2 Mio $_{N}m^3$ biomethane per year
Digester volume	6000 m^3
Gas Storage	No
Hydraulic retention time (HRT)	~ 30 days
Process temperature	Thermophilic at 54 °C
Digestion technology	CSTR, one-stage digestion

Municipalities/Regions Involved

The municipal energy company is one of the co-owners.

Background Story

The initiative to start the production of biomethane was taken by the farmers. By using manure as a feedstock, they can industrially process the digestate making it economically possible to spread it to a bigger area and to buy more livestock without the need to buy more farmland. The over-fertilisation of the Baltic Sea was recognised by the county government and is one important reason for the decision to use biogas for public transportation. The producers can capture the methane gas reducing thus the greenhouse gas emissions. The investment will contribute to the target of no net CO_2 emissions in Kalmar County by 2030.

Main Interest in the Project

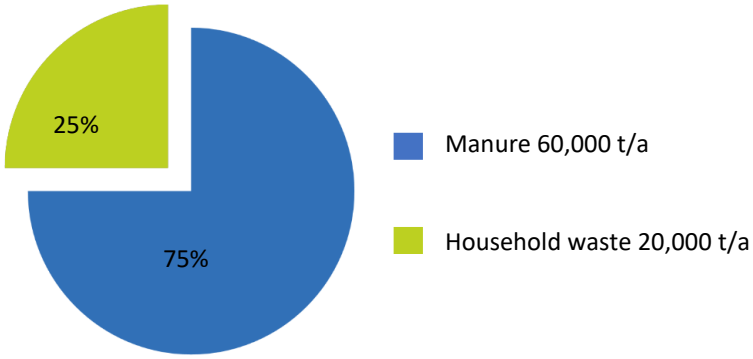
The use of waste to produce vehicle fuel leads to a double reduction of greenhouse gas emissions: first when the manure is taken from the stock and is used as feedstock in biomethane production and second when it is used as biomethane in our vehicles. It is a local produced vehicle fuel that reduces the emissions by more than 70%. It can be mixed with natural gas for a more secure supply and used in heavy vehicles. The concept of More Biogas Småland AB can be applied to all municipalities in every country because they have waste i.e. substrate that can be used for biogas and biomethane production.

Specialties

This plant uses mainly manure as feedstock. It is the most used substrate in Sweden because of its many environmental benefits. Even though the plant represents a replicable good example of private investments in biomethane, there are still very few plants of this kind. In this, as in other similar cases, the investments are made by farmers and other private investors. The farmers can separate phosphorus and nitrogen and spread them where they are needed and finally they get a fertiliser that is better than the manure they deliver to the plant.

Feedstock/Substrates

The substrates used consists of manure (approx. 60,000 tonnes) from the farms that are co-owners of the plant and of household waste (approx. 20,000 tonnes) from five neighbouring municipalities. The price for the substrate depends on gas potential, nutrient content other potential uses and market potential. Occasionally, material from local food processing industry is also digested.



Financial Background Conditions

Total investment costs: 75 MSEK (7.66 Mio EUR)

Investors: The company has 29 owners/investors of which 18 are local farmers. The other owners are: an engineering industry (Famax AB), ALMI Invest AB (an investment company), a globally operating supplier of turnkey plants for bio-methane (Purac), CA Fastigheter (a real estate company), Hund Holding and the municipal company Kalmar Energy. The share of the farmers is approx. 35%. The company was established in 2011 and the production of biomethane for the use as vehicle fuel started in 2014.

Investment support: 10.5 Mio SEK. (1.07 Mio EUR)

Operation support: The company receives operational support i.e. support for the production of biomethane from manure.

Additional support: Biomethane is exempted from energy tax and CO_2 tax until the end of 2020.

Use of Products from Biogas Process

Use of biogas: The production is approx. 20 GWh per year

CHP/electricity: No

Amount of generated electricity: None

Use of electricity: None

Biomethane generation/injection: No injection

Amount of injected biomethane: None

Use of biomethane: Vehicle fuel

Heat use: Produced heat is by a wood chip heated furnace to produce heat for pasteurisation of substrate and for process heat for the upgrading unit.

Amount of heat produced: -

Use of digestate: The digestate is returned to neighbouring farms and used as bio-fertiliser.

Lodge Farm, Holt, Wrexham

Small, On-Farm, Biogas Plant with Varying Feedstocks

Holt, Wrexham, Wales, UK

Contact details
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Holt, WREXHAM, LL13 9TE; info@fre-energy.co.uk

Technical Data

Year of construction	2010
Plant size	0.16 MW_{el} and 0.155 MW_{th}
Digester volume	1000 m^3
Gas Storage	250 m^3
Hydraulic retention time (HRT)	Currently 90 days (historically pre food waste 34 days)
Process temperature	Thermophilic at 52 ^oC
Digestion technology	Modified CSTR – some gas agitation of digestate but also deliberate acceptance of stratification within digester, one-stage digestion

Municipalities/Regions Involved

The local authority was not involved (other than as land-use planning authority) but the Welsh Government provided a grant.

Background Story

The proposal came from an organic dairy farmer who could see the advantages of anaerobic digestion for his farm, as well as a business opportunity for the generation of renewable energy. The original plan was to import residues from the nearby major food production industries – providing a waste management service as well as energy generation, but the local planning authority refused to allow the importation of such material to the site. The scheme (reluctantly) proceeded utilising agricultural wastes only. The plant was designed by a long-experienced AD practitioner and became the prototype for a business installing similar plant elsewhere.

Main Interest in the Project

The most interesting aspects of this project are the de-gritting capacity, the higher capacity for digesting chicken litter and the deliberate stratification to allow fully digested material to be removed from the tank. It has proved to be an excellent digester and farm for research purposes. This site provides good evidence to support AD as an agronomically beneficial process. A new project that is raising finance via crowd funding will provide further interest. This project has raised the funds locally to build an on-farm digester with many local investors using crowd funding the individual investors have shares in a cooperative which is purchasing the plant.

Specialties

The plant is relatively small and has been operating consistently and successfully for years now. The primary feedstocks were animal manures – including an unusually high proportion of chicken litter. The digester contents are deliberately allowed to stratify and the digestate extracted from a zone where only fully digested material congregates. The technology used is interesting because it incorporates de-gritting that does not involve emptying the digester. Interesting academic research at this site points strongly towards the agronomic advantages of utilising digested slurries instead of the raw material.

Financial Background Conditions

Total investment costs: -

Investors: The business was set up by the three directors: Chris Morris who had the time and experience to deal with the business set-up process; Jonathon Tomlinson who had the engineering capability to build a digester; Richard Tomlinson who has had a dairy herd and land to feed the digester and utilise the by-product (digestate).

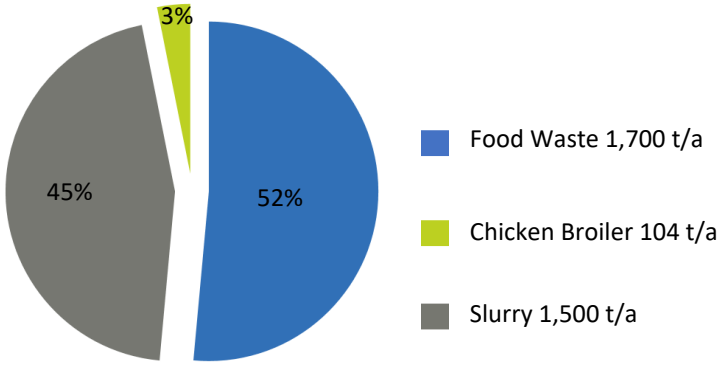
Investment support: The project was directly funded by the three Directors plus a £45,000 (52,784 EUR) innovation grant from the Welsh Government. The grant did not directly support the construction of the plant and thus did not impact upon the ability to claim FiT.

Operation support: All the electricity production (including the sacrificial load on the plant) is subject to FiT payments. The FiT payments would be likely to have started at 12.7 p (17.9 euro cent) per kWh. This payment is index-linked and for a period of 20 years. The electricity used on-site displaces imported power and thus valued mostly at a business tariff. That which is exported to the grid is subject to around 4.5 p (5.28 euro cent) per kWh (also index-linked).

Additional support: -

Feedstock/Substrates

Historically the digester was fed with cattle slurry and chicken litter. Over recent years the plant has been modified and authorised to take in food waste and this now contributes significantly to the feedstock supply. The plant still utilises cattle slurry and a much reduced quantity of chicken litter. 30 tonnes per day of feedstock were used. With the food waste this has reduced to 5-15 tonnes per day, dependent on the energy potential of the food waste.



Use of Products from Biogas Process

Use of biogas: Biogas is used in a SHCP with the outputs of 0.16 MW of electricity and 0.2 MW heat.

CHP/electricity: Yes

Amount of generated electricity: 1,103 MWh (over the last 12 months)

Use of electricity: Approximately 0.3 MW of electricity is used on-site to power the engineering business, the Fre-energy office, and a large 7-bedroom-farmhouse. The remainder of the electricity is exported to the national grid.

Biomethane generation/injection: No

Amount of injected biomethane: Not applicable

Use of biomethane: Not applicable

Heat use: A district heating system was constructed to make use of the available heat at the house, office, shop, drying room, food waste pasteuriser and engineering business. The heat has to be metered and only the productively used receives a Renewable Heat Incentive RHI subsidy, which is unique in the EU. The payments were negotiated with the government regulator (OFGEM).

Amount of heat produced: Generation and utilisation over the last 12 months:

- Heat generated 1,100 MWh
- Heat used productively 957 MWh
- Heat lost or rejected by the radiators 145 MWh

Use of digestate: The digestate was originally run through a separator. The liquid was spread onto the grassland. The solid digestate was used for growing winter crops. The new operating regime extracts the solid portion of the digested material via the patented de-gritting process. Digestate used on the farm.

EC Network

EC Network

ECNet | Denmark

AILE
Local Energy Agency of Western France

Ekodoma
Latvia

Czech Biogas Association
Czech Republic

Energy Agency for Southeast Sweden
ESS | Sweden

Cornelissen Consulting Services
CCS Energy advice | Netherlands

Fedarene
Belgium

Danish Technology Centre for Biogas
DFFB | Denmark

The International Biogas and Bioenergy Centre of Competence
IBBK | Germany

European Biogas Association
EBA | Belgium

Rhônalpénergie-Environnement
RAEE | France

Energy Institute Hrvoje Pozar
EIHP | Croatia

Severn Wye Energy Agency
SWEA | United Kingdom

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