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Sustainable biogas production in organic farming – Best Cases

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SUSTAINGAS

Best Case Examples

Biogas is an important renewable energy vector with impressive growth and installation rates in the EU. However, production of biogas from organic farms has not yet been sufficiently exploited. The European project SUSTAINGAS responds to the current lack of information on biogas produced in organic farms. SUSTAINGAS aims at promoting sustainable biogas supply by positioning sustainable biogas products from organic farming.

Nine partners from seven European countries are contributing to reach these objectives. One of the Sustaingas project contributions to this aim is to present Best Practice Examples, which have been carried out in different European countries within the field of organic biogas production in organic farming.

This report includes a compilation of examples from seven countries across the European Union, selected by technical criteria but also having in mind the interest for farmers with different status of organic farming and biogas facilities development in their countries. The best cases examples selected contain an homogeneous structure and information, and are presented in a comparable easy-to-read template.

STUDIA
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SUSTAINGAS

Summary

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Praktijkcentrum De Marke

Belgium (1)
Joluwa chicory plantation

France (2)
Biorecycle SARL
Agritexia

Biohof Joas

Family farm in the neighborhood

Family Joas run the farm since 1993 in Wertheim, in Baden-Württemberg, Germany. They converted to organic agriculture according to the guidelines from Bioland. The reason: information about organic farming from specified media drew his attention. He got the impression that conventional agriculture would be an impasse. Joas build species-appropriate stables, increased area and bought new machinery.

Focus is on milk production and the sale of crops, but also seed propagation of wheat. Part of rye and barley are delivered to a nearby organic bakery. The cows have a quite good milk yield of 7.000 liters per cow and year. The milk goes to an organic dairy or is sold directly from the farm.

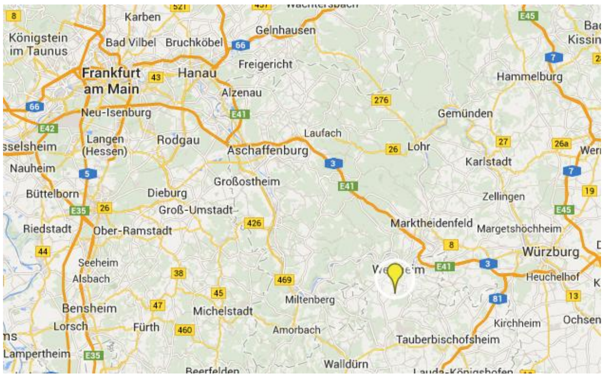
Cubicle barn for 40 cows, the manure is processed in the biogas plant.

On the fields Joas tried a lot, e.g. a new cultivation method. 2005 a self-made biogas plant was build on the farm with 60 kW electric power. It is feed with slurry, manure clover grass and grass from the own farm or from the cooperation farm (for exchange clover grass against biogas slurry), with additional input from conventional maize from a farmer in the village. The fermenter is belowground, in the residue storage tank he has a solid material, and thus he implemented a separation. With the separation he got an easier to handle biogas slurry for using it as fast effective fertilizer, while using the solid part for fields with cultures using up humus (e.g. the fields were maize for his cows is grown).

The heat is used for the house, for heating and warm water, and heat is supplied to the neighbor. In the beginning the family had some sleepless nights because of the investment costs and the profitability. But now they are satisfied, and have only sleepless nights when the engine is not running, since it means "red alert".

Residue storage tank with prior seperation (right) as flare (right in the picture), fermenter belowground under the solid dispenser (left). Also shown: gas line, stirrer, condensate pit (right behind the yellow bucket)

The farm is a demonstration farm for organic agriculture. These are farms, elected by the ministry of Nutrition and Agriculture, which are certified and run as organic farms for a long period. They are open to the public and media to show how organic agriculture looks in practice. Events for consumers, schools and all other interested people are organized. They are qualified partners for others farmers, interested in the production method and organize seminars and farm visits.



Biohof Joas farm location: 96 km. east from Frankfurt.

Name	Biohof Joas
Location	97877 Wertheim-Dörlesberg, Baden-Württemberg, Germany
Basic description	Farm size: 115 ha cropland 30 ha grassland 40 dairy cows 10 hens Certified organic since 1998 (Bioland certificate) Demobetrieb Ökologischer Landbau (demonstration farm organic agriculture) Lernen auf dem Bauernhof (learning on farms certificated) Tourist farm visits for bigger non-agricultural groups, also from abroad (e.g. from Australia) Wage labor with chuff cutter and combine harvester
Technical aspects	Year of construction biogas plant: 2005 Power: 60 kWel 1 digesters of 660 m3 Heat use: House (heating and warm water), workshop, and neighbour 200 working hours per year
Actors	GbR, only one farmer with his son
Inputs	7’5 tons per day: 4 t slurry, 1’3 conventional maize, 2 t clover grass and other grass, 0’2 t solid manure Only the maize is from conventional farming, from a farmer in the village. All material comes from the village or the next village. Transport distance approximately 2 km Farm cooperation with a stockless organic farmer for exchange of clover grass to manure

Outputs	Small part goes to the cooperation farm Rest is used on the own farm
Business environment	In good cooperation with neighbouring farms
Economy	Initial investment : 252.000 € (4,200 €/kW) Estimated investment return: 12-15 years Electricity sold to the grid at 0.024,3 €/kWh Value of heat use: own utilization
Lessons learned	With the new EEG he get more return per kWh for small slurry plants (Güllekleinanlagen)

Supported by the European Commission under the IEE programme.

Haslacher Hof

Crop rotation

The farm was established in 1972 mainly growing cereals. 2002 the farm was converted to organic agriculture. In 2003 the stable was build for ca. 40 suckler cows (+ calves). Shortly after converting its farm (approx. 300 ha arable, 100 ha pasture) to organic agriculture, the family Wiggert established a biogas plant in 2006 as an addition to crop production and the suckler cows on the farm. With technology from Agricomp, a general contractor focusing on biogas plants for a wide range of substrates, the Wiggert family has managed to process successfully a mix of input materials with up to 50% of clover grass. Since 2008 they deliver the heat to the district heating grid, which was set up to use the heat of the biogas plant.

The haslach farm close to Löfflingen

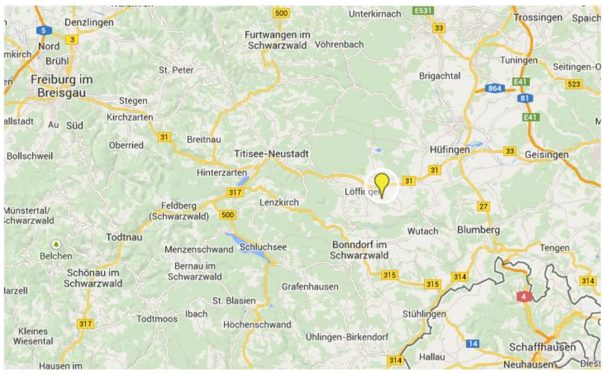
They have a wide crop rotation: two years alfalfa clover grass, they grow oat and spelt or small-spelt for selling. After that green-rye and maize for the biogas plant, than horse bean, winter-rye is grown. All material from the field is used and the manure from the stable goes to the biogas plant. The biogas slurry is used on the own fields.

The operation is run on a mix of substrates with clover grass, grass, whole crop silage, corn silage and cattle manure contributing biomass in variable quantities (see Table 2). About 30% of the total material can be classified as originating from “energy plants”, that means from plants grown primarily for the purpose of producing energy. About 10% of the input originates from conventional crop production. This includes part of the corn silage as well as some clover grass

The biogas plant has now three digester tanks. The first fermenter of the plant is fairly small. Farmer explained this was the reason why at the beginning of plant operation, it took fairly long for the microbiological process to be established.

The CHP engines

Farmer sees major factors for the success of his plant in long operating hours of the CHP (more than 8.500 hours per year), a high electric efficiency of the CHP engine (dual-fuel engine in his case) and low energy consumption for the process. And he also reports a successful operation of the plant more or less from the beginning. Choosing a general contractor experienced in dealing with difficult substrates has proven a worthwhile decision.



Haslacher Hof: 42 km. from Freiburg

Partners: STUDIA ECOFYS FiBL FundEko IFOAM EU GROUP MORE ORGANIC ORGANIC denmark protecma renac renewables academy

Name	Haslacher Hof
Location	79843 Löffingen, Baden-Würtemberg, Germany
Basic description	Farm size: 80 suckler cows and beef 80 ha alfalfa and clover grass 40 ha maize 40 ha cereal and pea or vetch mix (whole crop silage) 140 ha beans, spelt, oats and others Certified organic by Bioland certificate since 2002 Other: suckler cows, just feed with hay no cereals. Cereals are sold Direct marketing and farm visits
Technical aspects	Year of construction biogas plant: 2006 Power: 530 kWel (2 CHP engines, each 265 kW el) Energy production: 4.500 MW_{el}/year 4 workers (about 5,900 working hours/year 2 digesters with 18 x 6 m (ca. 1,500 m^3) and 1 digester with 20 x 6 m (ca. 1,850 m^3) 1 storage tank 20 x 6 m (ca. 1,850 m^3) (covered and stirred) 1 open slurry tank Heat use: 60 % is used for district heating. The district heating was set up because of the biogas plant
Actors	Farmer ownership
Inputs	12 tons dry matter per day (10500 tons per year): 30-50 % clover grass/grass, 20-30 % whole crop silage (including pulses), 10-20 % corn Silage, 15 % cattle manure 10 % from conventional crop production (corn silage and clover grass) 15 % of input material imported Transport distance approximately 2-3 km, max. 5 km
Outputs	4.500 MW_{el}/year and 4.500 MW_{th}/year

	No upgraded gas used in farm Digestate: completely used in own farm
Business environment	In good cooperation with neighbourhood
Economy	Initial investment : 3,000 €/kWh = 1.6 Mio. € Estimated investment return: 6-7 years Electricity sold to the grid at 0.023 €/kWh Value of heat use: for the first 10 Mio kWh, then 0.025 €/kWh
Lessons learned	If started again would change: He would choose to invest more where it leads to higher reliability of operation The fairly small building plot available for the plant has turned out to be less than ideal – a larger building site would have allowed for more economical arrangement of the components (e.g. fermenters in a group instead of a chain) He might invest in a larger first fermenter. With this he would attain a lower volume load. In the opinion of the operator, this would make the biogas process easier to control and may reduce the need for surveillance, adjustments and constant addition of enzymes A larger slurry storage would be useful to make best use of the slurry for crop production

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Krumbecker Hof

A working mixture

Since 1991, organic crop farming with low stocking rates has been the focus of the Krumbecker Hof, a north German farmstead cooperating closely with the neighbouring organic market gardener.

Since 2010, the activities on 230 ha have been supplemented by a biogas plant with 160 kW_{el}, supplied ready-made from a general contractor specialised in processing fibre-rich substrates.

The main factor influencing the decision of farm manager Gerhard Moser to start biogas production has been its effect on soil fertility and nutrient management. He explains: “The choice was to either step up cattle husbandry or to venture into biogas production.”

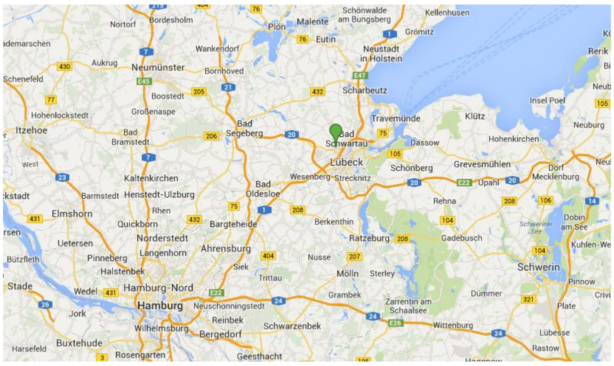
The biogas operation is run on a mix of substrates with clover grass, manure and by-products from the organic milling industry. In order to gain a higher feed-in tariff for the electricity produced, 30% of the biomass input needs to be slurry or manure. Even as a biodynamic farmer who particularly values the quality of cattle dung for soil fertility, Moser sees biogas production as a valuable alternative to livestock farming.

A biogas plant from a general contractor does the job at the organic Krumbecker Hof of farm manager Gerhard Moser (photo). Photos: F. Gerlach, FiBL.

At present 40 % of the crop area is planted with clover grass. For the future, a reduction to about 30% clover grass on the crop area is planned (through more efficient production and increase in land area). About 60 % of the substrate is made up of the farm’s own clover grass. Cattle and horse manure stabilise the fermentation processes. The ration in the fermenters is complemented by organic poultry manure from other organic farms and by-products from the organic milling industry. Moser relies on robust standard technology with some specific adaptions. After damages and standstills during the first year, partly caused by poor workmanship, the biogas plant is now running quite reliably.

Feeder, first fermenter and (far right) storage tank. Photos: F. Gerlach, FiBL

While the electricity is used in the national grid, The available thermal energy not needed for the biogas process is used to provide heating and warm water for 10 households on the farm as well as farm buildings and a cereal dryer. The electricity required for the plant's operation is produced by wind turbines in the neighboring fields. Therefore the farm produces energy from truly local and renewable sources



Krumbecker Hof: 65 km. from Hamburg.

Name	Krumbecker Hof
Location	23617 Stockelsdorf, Germany
Basic description	Farm size: 220 ha 10 cattle, 30 horses, 80-90 ha clover grass, 140-150 ha wheat, oats, spelt Certified organic since 1992 by Demeter (cooperating vegetable farm: Naturland) Other incomes: Horse boarding, hippotherapy, event hall
Technical aspects	Year of construction biogas plant: 2010 Power: 160 kW_{el} Energy production: 1,200 MW_{el}/year and 1,400 MW_{th}/year 2 digesters of 900 and 1,800 m3 Digestate storage: 1,500 m^3 4 workers (about 5,900 working hours/year) Heat use: 60% heat utilization: 10 households heating, cereal draining Methane emissions are analyzed regularly
Actors	Farmer ownership
Inputs	1,500 t/year animal manure 2,850 t/year crop biomass 60% clover grass and more, 30% cattle manure, poultry dung, 10% horse manure and milling by-products 80% organic substrates, 20% conventional cattle manure Silage: no more than 12 km, Poultry manure: further away (up to 40 km) (cooperation cereals/manure)
Outputs	Biogas used to produce energy: 1,200 MW_{el}/year and 1,400 MW_{th}/year No sale of digestate Separation of solid and liquid phase in digestate
Business environment	Limited availability of companies experienced in dealing with clover grass / manure mix

Economy	Initial investment : 900,000 € Funded by: own funds + bank loan Electricity sold to the grid at 0.024 €/kWh, Fixed feed-in tariff guaranteed via law for 20 years of operation Use of manure from other farms to get bonus payment for electricity
Lessons learned	Faulty maintenance and unsuitable stirring equipment has led to failures Good experiences with comparing prices for replacement parts. Good experiences with the use of milling byproducts as substrate: methane production is similar to that of whole grain, no need to crush or kibble them, good miscibility High wear and tear of the feeder. The auger had to be replaced already. For the replacement part, better quality (stainless steel) was used Stirring: With an increase of temperature in the fermenter from 43 to 46°C in recent months, the substrate has become easier to stir, significantly reducing power requirement of equipment +30 % yield increase (cereals) At the same time, there was an increase in weed pressure which Moser sees as a result of the increase in available nutrients Acquisition of organic biomass suppliers is difficult Important to ensure better quality of craftsmanship Future plans: Planning photovoltaic when farm roofs are renovate, waterproof surfacing for the storage of the solid digestate Avoiding methane emissions: regular measuring of methane emissions , long retention time Biogas plants uses own wind energy for own power supply separation: Cost must be regained by advantages in arable farming weed pressure increases because of higher nutrient level in soil

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Bioenergie Schmiechen

Just clover grass and solid manure

Biogas from 100 % clover grass was the aim of the long-term organic farmer Hubert Miller from the village of Schmiechen in Bavaria/Germany when he teamed up with four colleagues in 2005 to venture into biogas production. The biogas plant of the Bioenergie Schmiechen GmbH & Co. KG was individually planned and built on one of Miller's fields in the open countryside.

A focus on the use of clover grass as substrate led to the use of technical components rarely used in agricultural biogas facilities: A slim fermenter with the impressive height of 13 metres (m) is equipped with suspended central axial stirring to cope with viscous substrate. Instead of heating spirals inside the fermenter which may be blocked by fibrous material, the substrate is pumped through external heat exchangers. This keeps temperatures at a level of more than 40 °C and supports the mixing of substrate. Electricity from the 350 kW CHP unit is sold to the national grid at prices fixed for twenty years of operation.

Hubert Miller, organic crop farmer in Schmiechen/Germany since the 1980s, has been running a 350 kW biogas plant with extra high fermenter and vertical stirring for six years. He uses a substrate mix with up to 98 % cover grass from about 40 organic farms. Photo: F. Gerlach, MEP.

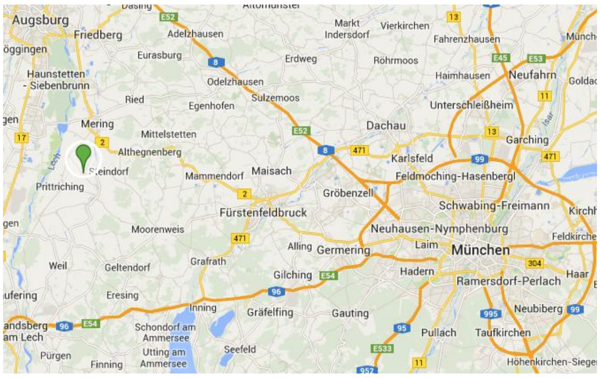
After several years of optimising the method of operation, the plant managers succeeded in producing biogas energy from a biomass mix with up to 98 % clover grass. About 40 organic farmers supplying the clover grass accept transport distances of up to 50 kilometres (km) to gain biogas digestate as fertiliser.

With mainly stockless crop farming in the region, for many partners the digestate is the only opportunity to obtain a flexible organic fertiliser. For the biogas farmers, maize silage as substrate is only a makeshift short term option when biomass suppliers drop out or fail to deliver the necessary quantities: "Biogas has to serve food production via improved nutrient supply", Miller says.

The robust technology enables Bioenergie Schmiechen to remain open for processing other surplus biomass as it becomes available. After years of using only plant materials, the biogas plant is presently operated on a mix of substrates including up to 40 % solid manure.

Using the heat produced by the CHP unit so far has been only moderately successful. Plans for a large drying facility for agricultural and other biomass have been blocked by the community. It will remain an open question if a dislike of industrial development outside the built-up area or scepticism towards biogas farming were the decisive reasons. However, heat is used for the biogas process and to dry wood chips and grass.

Miller, who manages the plant, admits that it took considerable experience to reach normal operation. Since the biogas plant was the first of this type focussing on clover grass only, extensive extensive alterations and adaptions were necessary to solve technical and biological difficulties in the first two years of operation. Today, Miller who is still testing and optimising, can base his work on a performing production system. He is convinced that organic farmers could take a faster route to successful biogas production by learning from experienced colleagues.



Bioenergie Schmiechen: 61 km. From Munich.

Partners:

Name	**Bioenergie Schmiechen**
Location	86511 Schmiechen, Bavaria, Germany
Basic description	Farm size: 20 ha clover grass, 20 ha triticale, 20ha wheat, 20 ha potatoes No animal husbandry Certified organic since 1999 by Bioland certificate Incomes from biogas
Technical aspects	Year of construction biogas plant: 2005 Power: 350 kWel Energy production: 2,800 MW_{el} /year, 1,360 MWh_{th} /year 1 high and slim main digester (1,500 m^3), Vertical downward stirring / Central axial stirring (15 kW), suspended from the concrete ceiling 1 low and wide "standard" secondary digester (1,300 m^3), horizontal stirring / Submersible mixer (10 kW) and paddle mixer Labour: 3 h /day (3x365= 1095 h/y) Heat use: Drying of wood chips (for energy) and of grass (feed)
Actors	GmbH & Co KG (limited partnership with limited liability company as general partner), cooperation of five stockless farms
Inputs	8,500 t/year crop biomass 60-98 % clover grass, 0-10 % maize silage, 0-2 % rye grain, 0-40 % cattle manure Clover grass from up to 40 organic farms, manure from organic and conventional farms Maximum transport for inputs: Up to 40 km
Outputs	Biogas to produce 2,800 MW_{el} and 1,360 MWh_{th} /year Digestate goes back to providers of substrate
Business environment	Not enough engineering companies with organic biogas competence, and particularly for the mixed substrate used

	Fixed feed-in tariff (electric energy) for first 20 years of operation (German legislation EEG)
Economy	Initial investment : 1,300,000 € Electricity sold to the grid at fixed prices, heat used for biogas process and for drying purposes on the farm Electricity sold to the grid at 0.22 €/kWh (2.8 Mio kWh sold per year) Value of heat use: Heat use generates a bonus for the electricity price (aprox. 2 Ct/kWh – already included in 0.22 €/kWh for electricity).
Lessons learned	Pioneering project, no similar concepts available at that time Cooperation with 4 other stockless farms and Landesanstalt für Landtechnik Initial issues with secondary fermenter, input materials percentage and heating system via heat exchangers Also stirring was improved with mechanical disintegrator for clover grass Cereal yield improved aprox. 20% with biogas integration Processing of digestate lead to decreasing loss of nitrogen, still better yields Special equipment: electrokinetic disintegration, no heating in first fermenter but pumping circuit with heat exchanger

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Bioenergie Hallerndorf GmbH

Bioenergie-Hallerndorf GmbH

The biogas plant of the Bioenergie-Hallerndorf GmbH is located in the North of Bavaria, Germany´s largest state. This state is also characterized by its significance for the bioenergy production and its high number of organic farms in Germany. Both factors combined, the Bioenergie Hallerndorf GmbH is a demonstrable representative.

The biogas plant is a commonly operated plant run by four organic farmers and an organic energy provider, Naturstrom.

Substrate storage, Foto: Volker Jaensch, RENAC AG

The special characteristic about Bioenergie Hallerndorf is that it is not connected to an organic farm but located in an industrial area. Since it is a commonly run biogas plant, all the shareholders are situated in an average distance of around 4.5km and transport their substrate and digestate to and from the biogas plant themselves.

The biogas plant is mainly fed with renewable resources, most of them clover grass and grass (58%), whereas 32% of the substrates is manure. Depending on the specialization of the organic farms, manure originates from cattle, milk cows or horses.
Substrate storage

A small amount of substrates still comes from additionally bought substrates like maize for example (10%) to be able to operate the biogas plant efficiently at all times.

The farm includes a biogas digester of 2,700 and a second step digester of 4,200 m3 which allow to produce 2,150,000 m3biogas/year.

The daily amount of feed for the biogas plant consists of 6.4t farm fertilizer and 13.7t biomass from plants. However the shareholders are currently investigating and researching the fermentation of wild plants as substrate.

Digester of Bioenergie Hallerndorf, Foto: Volker Jaensch, RENAC AG

Since the parcel of land in the industrial area was officially advertised, no legal process of approval for the biogas plant was necessary.
The planning phase lasted from winter 2010 to winter 2011.
A biogas plant provider specialized on organic biogas plants was contracted

Although it was a high investment to be taken, it was worthwhile for involved farmers in terms of their soil fertility. Since the digestate is a valuable and flexible organic fertilizer it can be utilized where normally no industrial fertilizer in organic farming can be applied.

Bioenergie Hallerndorf GmbH farm location: 45 km. from Nuremberg

Name	Bioenergie Hallerndorf GmbH
Location	Hallerndorf, Bavaria, Germany
Basic description	Bioenergie Hallerndorf is a cooperative between 4 shareholders and 1 energy provider (Naturstrom). The plant was launched 2011 and is feed by 4 organic farmers in Ø4,5km distance. Farmers cultivate a typical organic crop rotation and three of them also keep animal husbandry (dairy cows, cattle, horses, mother cows). Extension: The farm land ranges between 60ha and 250ha.
Technical aspects	Power: ~540 kW (250kWel + 290kWth) 1 digesters of 2,700m3, second step digester of 4,200 m3 (gross) Energy production: 3,900 Mm3/year 8,480 working hours/year (full load)
Actors	Management: Naturstrom (energy provider) and 4 shareholders (organic farmers of the region)
Inputs	Biomass Input: 32% =2,330t of manure/year 58% =5,000t of clover grass and landscape conservation residues/year Current research on wild plants as substrate substitute/addition A small amount of additional substrates is bought to use full capacity of biogas plant at all times = maize, manure and clover grass from neighbouring organic farms, (10%, planned to reduce to minimum)
Outputs	Produced electricity per year: 2,150,000kWh/year from biogas Energy production: 6,5% used for biogas plant, rest is fed in grid through EEG Heat: 2,4MkWh/year 75% of heat is utilized (goal: 90%): 30% of the heat produced is used for heating the digesters, part of the rest also for drying units
	Digestate: 5,900t/year Divided among the providers (shareholders and neighbouring farms that feed-in)
Business environment	The biogas plant is run in the form of a GmbH with limited liabilities for shareholders. With least risk and taxing advantages. Since the ground was officially advertised, no legal process for approval for the biogas plant was necessary. Planning phase from winter 2010 to winter 2011. A biogas plant provider specialized on organic biogas plants was contracted
Economy	Initial investment : 1,600,000 €, planning 3 months, building time 1 year Maintenance costs: Ø75,000€/year (mainly for block heat and power plant) Electricity sold to the grid at 13,8ct €/kWh Solid digestate sold for retail trade
Lessons learned	Securing operating safety, management of substrates necessary, research for potential of wild plants as substrate, utilization of heat (extension) Most profitable aspect of running an organic biogas plant is utilizing the digestate as valuable fertilizer for organic farms.

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Hofgut Räder

Hofgut Räder, Bastheim

The biogas plant of the organically run farm “Hofgut Räder” is located in the center of Germany. Although the area still belongs to Bavaria, the town of Bastheim lies directly at the border to the states of Thuringia and Hesse.

The organic farmer, Mr. Räder is convinced of the advantages of organic farming and their positive impact for the environment and lives and operates its farm since the year 2000 according to the principles of the German organic farming association Naturland. The family-run farm holds sows (150units) and cultivates among others brewing barley, radish, mustard, buckwheat and clover grass (40ha) and grassland (30ha). The overall extension of the farm has 105ha.

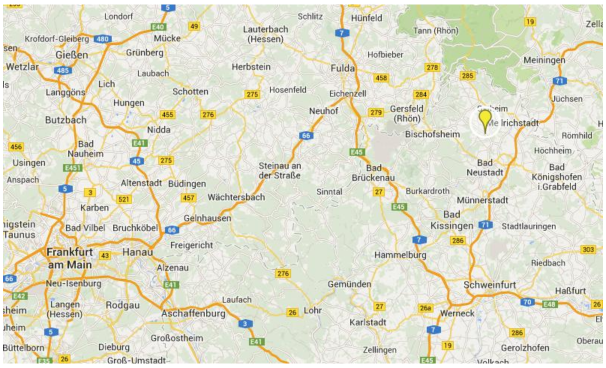
Mr. Räder in front of his CHP

The process of planning and the legal application phase started in 2007. Due to fear of increased odor emissions and transport emergence from the community of Bastheim, the application for building the biogas plant failed. However, in the second instance, the application was approved and the building of the biogas plant was finalized in 2009.

The biogas plant has an installed electrical capacity of 250kWel and thermal capacity of 260kWth. The first step digester has a volume of 1,700m3 and the second step digester 1,500 m3. The ultimate storage is 2,200m3 and 1,200m3 large.

Biogas digestor of Hofgut Räder

The substrates of the plant mainly consist of the energy plants clover grass, maize and cereals as well as farm fertilizer. While around 55-60% of the clover grass is produced organically, around 5% comes from conventional agriculture. Another share of 5% of maize and cereals is also bought from an external conventional farm. The amount of farm fertilizer however comes from the 150 sows on the own farm of Mr. Räder. For all substrates a maximum transportation distance of 12km needs to be covered.
The Amount of residues from animal husbandry therefore covers 2,100t/year (35%), while the amount of crop biomass is 3,900t/year. This comes down to a specific loading rate around 2.65kg organic dry matter per day per m3 volume of reactor.
These input materials produce energy of 4,000 MW/year, while running app.8,600 working hours/year.



Hofgut Räder farm location: 142km. from Frankfurt

Name	Hofgut Räder
Location	Bastheim (Bavaria), Germany
Basic description	Family Räder runs the farm organically since 2000 and built a biogas plant in 2009. The farm holds sows (150units) and cultivates clover grass (40ha), grassland (30ha) Extension: 105ha arable land (98ha used agronomically –brewing barley, radish, mustard, buckwheat rest grassland).
Technical aspects	Power: 250kWel + 260kWth Digester 1,700m3 and second step digester 1,500 m3, ultimate storage 2,200m3 + 1,200m3 Energy production: 4,000 MW/year 8,600 working hours/year Maximum transportation distance for substrates 12 km.
Actors	Managed by farmer in cooperation with 2 neighbouring farms, but no legal cooperative
Inputs	5-10% maize/cereals (from conventional agriculture) 35% manure 55-60% clover grass (40ha from own land, 90ha from neighbour) 5-10% bought from conventional agriculture Amount of residues from animal husbandry: 2,100t/year (35%) Amount of crop biomass: 3,900t/year 2,65kg organic dry matter per day per m3 volume of reactor
Outputs	Produced electricity per year: 2,150,000kWh/year (10% own usage) Methane yield: 1,120,000m3 methane/year 2,000,000kWh waste heat/year. 100% of the heat is utilized: 5-10% own use (biogas plant, housing, stalls, drying units), rest sale to local heat grid (several houses, town hall, school). Own yield increase through utilization of digestate 20% and increase of quality. Providers of substrate receive digestate as compensation
Business environment	The planning phase started in 2004. However the application process went through various instances before it was approved 2009. With a regional biogas plant manufacturer a quite robust plant was built.
Economy	Initial investment : 1,500,000 € (90% financed by bank) Plant ran efficiently from the beginning Electricity sold to the grid at 22,67€ct till 150kW, above 150kW 18.67€ct Heat sold to the grid at 7€ct/kWh
Lessons learned	As predicted the odor emissions from the animal husbandry on the farm were reduced drastically. The plant also contributed positively to the efficiency of the farm. Mr. Räder was able to increase the yield on his farm by 20% through the use of digestate. This he sees as a potential opponent to conventional agriculture, since due to yield increase organic farming becomes more efficient and mean a higher competition for conventional agriculture.

Supported by the European Commission under the IEE programme.

Leibertinger Biohöfe GbR

Leibertinger Biohöfe GbR

The biogas plant owner Mr. Braun-Keller runs his farm since 1985 called “Bäumle-Hof” with an area of around 250 ha. The farm is located in the south of Germany. The town Leibertingen is situated in the state Baden-Württemberg with a close distance to Swiss and France.In 1989 the farm was converted into organic agriculture under the roof of the German organic farming association “Bioland”.

Braun-Keller built his biogas plant in 1996 and launched it with an original installed capacity of 45 kW. Nowadays the size of the plant was increased to a more efficient size of 560 kW.

The Bäumle-Hof mainly cultivates Greenland as fodder or substrate for the biogas plant. Furthermore Braun-Keller keeps livestock: 15 mother cows and their calves, 90 fed cattle and 20 ewes with their lamb.

The digester of the Biogas plant of Mr. Braun-Keller, Foto by Lothar Braun-Keller

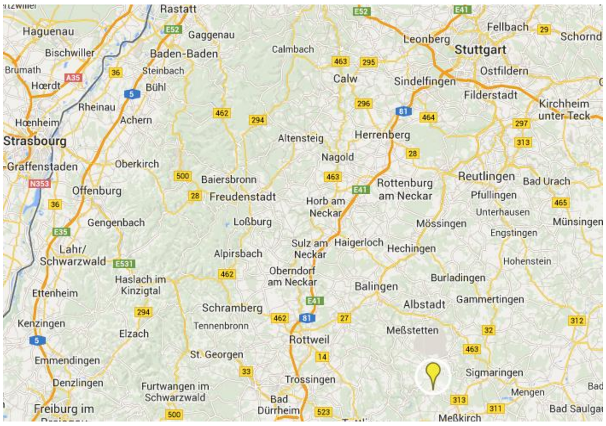
For assuring a constant utilization of the capacity of the biogas plant, Braun-Keller also buys substrate from neighbouring organic farms. The total amount of biomass from plants estimates to around 8,000 t (57%) annually. Only 5% of this amount originates from conventional agriculture. In exchange the delivering farms receive a certain amount of digestate.
The silage of greenland is not the only substrate inserted into the biogas plant, also the solid manure of cattle serves as important substrate. This sums up to a annually loading rate of around 6,000 t farm fertilizer (43%).

Hence the biogas plant on “Bäumle-Hof” is able to produce an amount of electricity annually of around 3.5 Mio kWhel and heat of 4.5 Mio kWhth.

Throughout the year about 75% of the waste heat generated from the CHP on the farm is utilized for heating the digester, the residential house on the farm, an affiliated butcher shop, workshop and drying units for cereals and wood chips.

CHP of the biogas plant, Foto by Lothar Braun-Keller

Additionally the biogas plant contributes to the local electricity and heat grid. The electricity and heat is not only directly produced on the farm where the biogas plant is located but also distributed via an app. 2km long biogas pipeline and fed into a CHP-heating system. The produced biogas is upgraded and dried and directed into the town of Leibertingen providing it with electricity and heat.



Leibertinger Biohöfe GbR farm location: 114 km. south from Stuttgart.

Name	Leibertinger Biohöfe GbR
Location	Lothar Braun-Keller, Leibertingen (Baden-Württemberg), Germany
Basic description	Braun-Keller built his biogas plant in 1996. The farm was converted in 1989 to organic agriculture within the association "Bioland". The farm cultivates Greenland for fodder and as substrate for the biogas plant. Braun-Keller keeps 15 mother cows and their calves, 90 fed cattle and 20 ewes with their lamb. Extension: 250 ha
Technical aspects	Power: 560 kW (2x160+1x250 engines) 2 digesters of 400 and 1,500 m3 Energy production: 4,000 MW/year The plant is divided into two parts = digesters + combined heat and power plant. They are located on the outsourced farm and the annexes (satellite CHP) from 2011 are situated on a commercial area as part of the heating control unit of the town Leibertingen
Actors	Managed by farmer Lothar Braun-Keller
Inputs	Around 6,000 t farm fertilizer (43%) and 8,000 t (57%) Greenland silage annually. The biomass from plants originates from the fields of Braun-Keller and neighbouring farms for the exchange of digestate. From this externally received Greenland silage only 5% comes from conventional agriculture.
Outputs	Produced electricity per year: 3.5 Mio kWhel/year (10% own utilization for regulation, agitator, pumps and 90% for EEG) Methane yield: 1,8Mm3 methane/year. Thermal capacity around 4.5 Mio kWhth/year, utilizes 75% of all heat (40% of the heat used for heating the digesters, rest warm water supply on farm, housing and garage, drying unit of cereals and wood chips). Provides another CHP in the town with biogas for the local heat and electricity grid. Uses digestate on own farm and exchange digestate with substrates from other farms close by. Could increase yield by around 30% on fields
Economy	Initial investment : Own contribution 30% and GLS Bank 70% = 150,000€ Electricity sold to the grid at 22 €ct
Lessons learned	Without financial support of the Renewable Energy Law (EEG) in Germany, a further establishment of organic biogas plants will not be feasible.

Supported by the European Commission under the IEE programme.

Sophienhof 3

Sophienhof, Neustrelitz

The biogas plant of Mr. Dudziak is located in the North-East of Germany in the state of Mecklenburg-West Pomerania.

Dudziak runs his farm since 1993 in Neustrelitz and converted his farm 2006 from conventinal agricultre to organic agriculture. The farm now is a member of the organic farming association Naturland.

The Sophienhof covers around 510ha in total. From this area, 120ha are cultivated as constant grassland, 120ha cereal, 20ha forest or meadow and on the remaining ha, Dudziak cultivates fodder for his livestock. The livestock consists of dairy cows (180 units), sows (450 units), gilts (60 units), boars (8 units).

In 2011 Dudziak decided to add a biogas plant to his farm with an installed electrical capacity of 195kW.
This plant includes one digester of 800m3, a second step digester with 1,600 m3 and a third step fermenter of about 1,200m3

Karsten Dudziak on his farm, source: Thönes Natur, Bollewick.

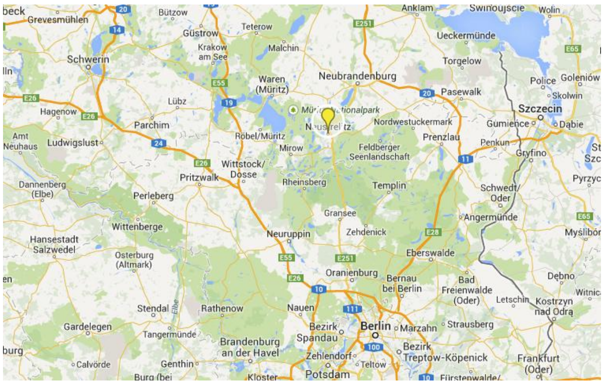
The daily substrate composition consists of manure, slurry, grass silage and a small amount of externally bought conventional maize. Besides the maize (app. 3t), the substrates originate from the Sophienhof itself: The organic loading rate per day is composed of (amounts in organic dry matter content) 5t solid manure, 10t liquid manure, 5t whole clover grass silage and 3t maize.

Therefore the amount of residues from animal husbandry cover around 40%. Whereas the amount of crop biomass holds a share 60%.

The biogas plant produces an annual amount of 1,57 Mio kWh electricity, that is fed into the gas grid. From this the biogas plant receives revenues from the German Renewable Energy Law. However, so far the biogas plant itself requires a relatively high amount of electricity, that is bought externally. From 2014 onward, this electricity is supposed to be delivered from an own wind power plant from Sophienhof.

Additionally Dudziak utilizes around 92% of the waste heat in wintertime. In an annual average the utilization sums up to app. 50-60%. The heat basically is used for the heating of stalls for piglet breeding though a warm water pipeline. Furthermore the plant itself has a thermal demand of 15-20%.

The digestate is applied as a valuable fertilizer to those fields, that served as substrate areas for the biogas plant. If more digestate is produced, than those areas need, further fields are fertilized with the mobile organic fertilizer



Sophienhof 3 farm location: 114 km. north from Berlin.

Name	Sophienhof 3
Location	Neustrelitz (Mecklenburg-West Pomerania), Germany
Basic description	The farm has been organic since 2006 and the biogas plant was constructed in 2011. The farm covers 510ha in total (120ha constant grassland, 120ha cereal, 20ha forest/meadow, and the rest fodder for livestock). Livestock consists of dairy cows (180 units), sows (450 units), gilts (60 units), boars (8 units)
Technical aspects	Power: 195kW 1 digesters of 800m3, second step digester with 1,600 m3 and a third step digester with 1,200m3 Energy production: 1,570,500 kWhel/year There is a gas storage and all three gas tanks are connected to each other to grant the gas exchange.
Actors	Managed by farmer Karsten Dudziak plus a cooperation with a chicken farmer
Inputs	Substrate composition: Manure, slurry, grass silage: - amount of residues from animal husbandry: 38,5%= 1825t/year - amount of crop biomass: 61,5% =2920t/year Organic dry matter/year (gross): 5t manure, 5t whole plant silage (mostly clover grass), 3t maize, 10m3 slurry = Will be delivered until 2020 with 30% of conventional agriculture (depending on price: maize, cereal, etc.)
Outputs	Produced electricity per year: 1,570,500 kWhel/year, energy is feed-in grid (EEG at 22,2ct€/kWh), but also plant demands high amount of energy The electricity needed for the plant is still bought externally but provided by wind mill from 2014 Heat: 92% of produced heat is used in summer (Øall year: 50-60%) Waste heat used mainly for piglet/farrow breeding barn (hot water passage heats barns from above), and 15-20% needed to heat tanks of biogas plant Digestate: Utilizes digestate as fertilizer for areas that served as biogas plant substrate, if there is a surplus it is yielded onto other areas on his farm.
Economy	Initial investment : 5,000€ per kWhel Partly biogas plant subsidised by state funds Electricity sold to the grid at 22,2ct€/kWh Solid digestate sold for retail trade
Lessons learned	Cultivation of energy plants adapted to legal regulations. Long term planning of cheap input material, that is suitable to the farm (e.g. millet, catch crops). Reduce own demand of power through adaptation of timing of agitating and pumping

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Bannsteinhof

Growing organically

Set in the hilly German region of Palatine, the Bannsteinhof is a classic organic farm with 150 ha arable land, grassland, about 45 cows, a 10 pigs and 250 laying hen as well as a small farm shop. For the family farm of Achim and Margit Ruf, the decision to run their own on-farm biogas plant was a process that started back in the 1990s, when they first read about biogas in an agricultural magazine. Today, the next generation is involved in the management of the organic farm.

Eight years after converting their farm to organic agriculture, the Ruf family established a small biogas plant with 75 kW_{el} on their holding. As it soon became clear that workload and investment would only moderately increase with a larger capacity, the plant was extended to 180 kW_{el} three years later.

Bannsteinhof: Separating the digestate (on the left) offers the organic farmer the choice of solid digestate and a liquid digestate with very low dry matter content suitable for application in growing cultures. Photo: A. Ruf, Bannsteinhof.

The Bannsteinhof biogas plant is a classic single-farm installation: More than two thirds of the biomass comes from the farm, most of the digestate is used on the farm's own fields, and the heat is used by the farm houses, farm shop and the grain drying facility. The fermenters are supplied with slurry, clover grass and silage from conservation farming on grassland with high biodiversity value. No energy plants are used.

Since October 2006, the farm operates a photovoltaic system of conversion of solar energy into electricity. Over the past few years, this extended and upgraded to the residential building and the stables. Biogas plan and photovoltaic system generate electricity for around thousand people.

Crops cultivated are among other wheat, barley, rye, spelled, oats, potatoes, fennel, caraway, false flax, peas, linseed, and millet on the Bannsteinhof.

Achim Ruf is confident with the technical operation of the plant and with the financial returns. However, it becomes clear that the family farmer's outlook is long-term: Since he will be running the plant for at least 20 years it is too early for an overall assessment of his biogas project. Anyhow with the sale of electricity and its own organic produce, the Ruf family reputation has made a name.

Bannsteinhof: 40 km. from Saarbrucken.

Name	Bannsteinhof
Location	66482 Zweibrücken - Mörsbach, Germany
Basic description	150 ha agricultural land 45 cows (mother cow and meat cows) Certified organic since 2001 (Bioland label) Biogas plant started production in 2009 Agricultural food processing Animal husbandry Direct marketing
Technical aspects	Power: 180 kW_{el} 3000 m3 of digester Energy production: 1,500 MWh_{el} /year 2,000 working hours/year Heat produced is used for district heating: living houses and shop, and cereal and spice plant drying
Actors	Single farm enterprise
Inputs	12m3 per day: 40 % manure (4,8 m3/day) and 60% organic clover grass and landscape material (7,2 m3/day) 70% of input coming from own farm, 30% imported from regional organic farms Max. transport distance 12 km.
Outputs	730,000 m3biogas/year 4,000 m³ digestate only for own use, no selling
Business environment	First contact with biogas in 1990 from agricultural magazine and farmer to farmer exchange Electricity sold to the grid guaranteed by law, after German Renewable Energy Act tariffs (EEG) were higher rewards Enough engineering companies with biogas competence and skilled technicians available to develop project
Economy	Initial investment : 1.2 million € No subsidies received for construction Estimated investment return: 15 years Electricity sold to the grid at 0.24 €/kWh No digestate sold Value of heat used: 600 €/year
Lessons learned	Return from investment good for now, but not sure about maintain this situation in the future No major operational problems, everything works quite well Future perspective in potential expansion of the plant

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Gut Kerkow Energie GmbH

Biogas plant and sophisticated fertilizer production

Gut Kerkow is located in the village Kerkow, in federal state Brandenburg in the North-East of Germany. This landscape area is also known as *Uckermark*. The original farm houses were built at the turn of the century in 1900 and got strongly battered in the two world wars. During DDR time the farm was run as a *nationally owned company* (VEB or VEG). J. Niedeggen and two friends took over the farm shortly after the fall of the iron curtain. Today, the farm is owned by community of heirs of J. Niedeggen.

The organic certified farm operates 180 ha grassland and 545 ha cropland. 350 ha are used for the biogas plant. About 350 cattle are living on the farm mainly for meat production.

The commercial activities of the farm are multisided. It varies from classical food production, direct marketing, slaughtering and biogas to tourism, gastronomy and production of fertilizer.

Birds view on the farm Gut Kerkow.

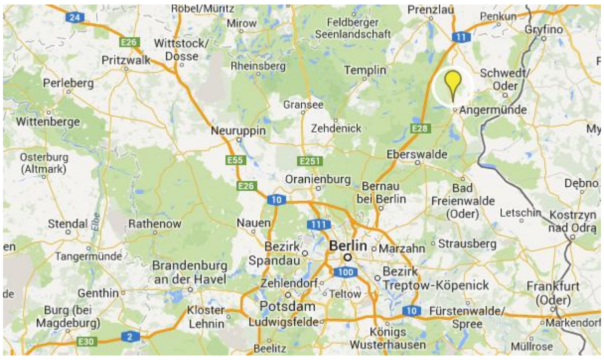
The biogas plant was built in 2005 and is operated as private limited company (PLC), owned by the community of heirs. The plant has one digester of 3,500 m³ and three disposal storage tanks between 1,000 m³ and 3,000 m³.
The input materials are 7,730 tons organic manure and dung, 2,800 tons organic clover grass and 8,430 tons conventional maize per year. 60% of the input comes from the own farm (organic) and 40% from 4 external farmers. The maximal transport distance of the input material to the biogas plant is 16 km. It takes 2.5 labours to run this medium-big biogas plant.

The 625 kW CHP (combined heat and power) engine produces 5,100 MWh power and 4,700 MWh heat yearly for external use. The power is sold to the public grid the heat is used to 100% for drying crops, heating and the biggest portion for the fertilizer production on the farm side.

Biogas digestor encased with wood for a better integration of the farm into the landscape.

The biogas plant leaves huge amount digestate, about 14,700 tons a year. 40% of the digestate is used as fertilizer directly by Gut Kerkow and the supplying farmers. Other external farmers can get it for free, if they pick it up by themselves. The transport costs are too high to sell the digestate on the market.

Unique about Gut Kerkow is that they process parts of the digestate further on in order to extract high class fertilizer in their onsite factory.
In a first step they separate the liquid and the solid part. The liquid remains (fugat) are vaporised and separated to valuable concentrated fertilizers. The high level products are used on the farm, but are sold to fertilizer companies as well.
The heat energy intensive process is totally covered by the heat produced in the biogas plants.



Gut Kerkow Energie location: 82km. north from Berlin.

Partners:

Name	Gut Kerkow Energie GmbH
Location	16278 Kerkow, Brandenburg, Germany
Basic description	Farm size:180 ha grassland, 547 ha cropland, 310 cattle (mostly meat purposes) 350 ha used for the biogas plant Certified organic since 2009 Other income sources from food processing, direct marketing, tourism, slaughtering for other farmers and private persons, gastronomy, production of fertilizer, apprenticeship institution
Technical aspects	Power: 625 kW_{el} 1 x 3,500 m^3 digester 2 x 1,000 m^3 disposal storage tank, (for the digestate) 1 x 3,000 m^3 disposal storage tank (for the digestate) 2-3 workers (about 3,700 working hours/year) Heat use: 4,700 MWh for drying crop, heating and for the production of fertilizer
Actors	Private limited company (PLC). 100% hold by the community of heirs of Johannes Niedeggen
Inputs	18,360 t/year in which: 7,730 t/year of farm organic manure/dung 2,800 t/year organic clover grass 8.430 t/year conventional maize 60 % input from own farm and 40 % imported inputs from 4 external farmers Maximum distance for inputs transport 16 km.
Outputs	Energy production: 5,100 MWh_{el}/year and 4,700 MWh_{th}/year 100% of the heat used for drying crop, heating and for the production of mineral fertilizer Digestate: 14,700 t/year Part is used for the production of fertilizer
	40% is used as fertilizer directly on the own farm and external farms. Not sold. The external farmer get for free if they pick it up by themselves (carrying the transport costs) Organic share of the digestate is min. 40%
Business environment	First contact with biogas in 2004 through German Biogas Association (Fachverband Biogas e.V.) Large choice of engineering companies with biogas competence to choose from and technicians availability is satisfactory Technical retrofit requirements, after the revised version of the *German Renewable Energy Act, e.g.:* Refitting a gas flare (torch), Line regulation according to the demand of the grid operator, Adaption for additional bonus (clean air bonus etc.)
Economy	Initial investment : 2,700,000 € Subsidies received about 20% of the investment cost Estimated investment return: 11 years Electricity sold to the grid at 0.21 €/kWh Digestate not sold Heat not sold, but used for the own fertilizer production, crop drying and heating the farm houses
Lessons learned	Expectations for investment return were distinctively higher The plant has high optimisation necessity and vast maintenance demand Additional information: Production of fertilizer (using the main part of the produced heat from the CHP): The biogas slurry (digestate) is separated into a solid and a liquid phase. The solid part is stored into the silo and used as humus fertilizer; it will be applied to the fields of the farm to improve the soil. The liquid remains go into an evaporator to concentrate and

separate the nitrogen content. The nitrogen (N) is a basic fertilizer. Part of it is also used on the farm ground according to the requirements and the remaining part is sold.
This production/process recycles about 50,000 kg pure nitrogen

Supported by the European Commission under the IEE programme.

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Bioenergie Häussler

A biogas plant pioneer

The Häussler farm is located in Schwörzkirch (Alemdingen), in federal state Baden-Württemberg in Germany. The biogas plant is run as BGB Company called *Bioenergie Häussler GbR*. Shareholders are the farmer Franz Häussler and his wife Ingrid.

The farm hosts 30 ha grassland, 50 ha cropland and 3.5 ha Forest. 60 dairy cows and about 30 young cattle are living on the farm. Beside the transfer payment the farms main income comes from food processing and direct marketing (i.a. cereals, lentils and legumes).

BIOENERGIE Häußler

In 1992 they turned to an organic farm and are certified as such since then. Family Häussler can be seen as pioneers in the biogas business. They had their first contact with biogas branch around 1990. In 1993 they installed their own plant. Back then engineering companies with biogas competence were scarce and many parts for the plant had to be custom made. Franz Häussler said that, it was a lot of trail and arrow to get the engines run properly when they first started. Luckily he had good contacts to a pioneer biogas plant constructer and knew how to help himself. Frank Häussler also mentioned that today's plant engines are more user friendly and therefore maintenance work easier. Additionally you can find good support by engineers companies for biogas plant quite easy these days.

The Häussler farm has one digestor with a size if 600m³. Main input material is manure, small portion of green waste (e.g. landscape material) and spoiled silage. The total daily input is 6 m³/d. The digestor produces around 64,000 m³ methane in a year.
The remaining digestate is directly used as organic fertilizers on their own farmland.

The small CHP (combined heat and power) generator with about 30-40 kW power engine, was replaced once since the first installation in 1993. It produces about 90,000-100,000 kWh power a year, which gets fed into the national grid, paid with the feed-in tariffs guaranteed via law. All the produced heat is used on the farm directly; for heating the digestor, warm water and house heating or drying crops depending on the season.
There were quite some changes in the legal regulations, since they have installed their biogas plant e.g. introduction of Germany Energy Act (EEG) with the feed-in tariffs, which were seen positive. Frank Häussler worries about future taxations especially, if farmer are entitled to deduct a pre-tax, which could be hardly feasible for some farmer or small scale biogas plant operator.

The Family Häussler's intention was never to earn big money with biogas plant rather the good will to contribute sustainability, close the nutrient-circle and to produce the own energy they consume. Additional benefit is the manure treatment (less methane emissions into the atmosphere) and less smell, which is an important for the neighbour's relation.

Bioenergie Häussler location: 95 km. from Stuttgart.

Name	Bioenergie Häussler
Location	Schwörzkirch (Allmendingen), Germany
Basic description	Farm size: 30 ha grassland 50 ha cropland 3.5 ha Wood 60 dairy cows 30 young cattle Certified organic since 1992 Other income resources: dairy production, cereals, lentils, legumes, transfer payments
Technical aspects	Power: 40 kW (first installed in 1993) 1 digestor s of 600 m3 Electricity production: 90,000-100,000 kWh/year (around 2500 working hours/year) 100% of the heat produced is used Winter: 50% for the digestor , 50% for hot water and heating two houses Summer: 33.3% for the digestor , 33.33% for hot water and heating houses, 33.33% drying crops
Actors	BGB Company (Civil Law Association): Two shareholder (the Farmer Franz Häussler and his wife Ingrid Häussler)
Inputs	6 m3 of manure a day: 5.3 Manure/Dung, 0.3 green waste, 0.3 spoiled silage No energy crops
Outputs	About 64,000 m^3 methane/year (170-220 m^3/ day) All the produced digestate is used by the own farm
Business environment	Fixed feed-in tariff guaranteed via law for delivery to grid First contact with biogas in 1990 through a friend farmer and pioneer biogas plant constructor. In the past it was really important. When they built their plant there were hardly any infrastructure for this kind of engine Today there are enough biogas companies with biogas competence and skilled technicians, when he built his first plant, no. But he had the right contacts
Economy	Initial investment : 200,000 DM (aprox. 102000€) A lot of pioneer work Subsidies received due to promotion for emission reduction, about 0.05€/kWh (0.10 DM/kWh (DM= German Mark) Estimated investment return: 10-12 years Electricity sold to the grid at 0.17€/kWh Digestate not sold, own use Value of heat use 5000-7000€/year
Lessons learned	The farmer intention was never to earn big money with biogas plant rather the good will to contribute sustainability, close the nutrient-circle and to produce the own energy they consume Additional benefit is the manure treatment; less smell (important for the neighbour's relation) In the beginning there were a lot of pioneer work and many operational problems Three years ago the farmer bought a new generator, ever since hardly any problems

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Bio Energie aus Japons

15% to 20% more yield with biogas

The 88 associates of the Bio Energie aus Japons (bio-energy from Japons) association are in part farmers and in part customers. This team composition reflects a high engagement and co-operation quality of producers and consumers. The general population was not very convinced at the beginning, but started to accept the plant when they observed it in operation. One of the reasons for acceptance is the plant's location in a small basin. Although located nearby the village, the plant does not dominate the landscape and its operation does not disturb daily life.

The production of biogas and organic fertilizer is based on a mix of slurry, clover grass and energy plants – most from organic agriculture. The biogas plant operation has been the reason that more catch crops are cultivated in the region (which has low animal husbandry), and that catch crops are used effectively, explains plant manager Erich Engelbrecht.

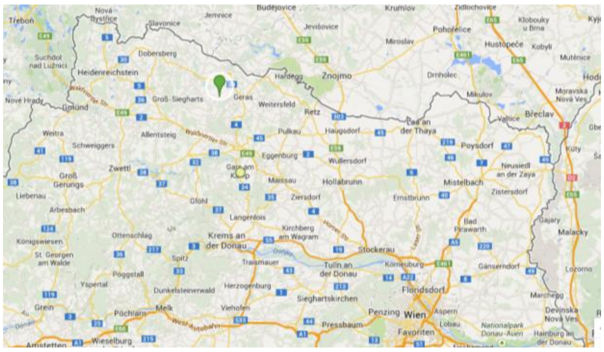
The plant is located in a small basin nearby the village.

The two digesters with a volume of 2500 cubic metres each are supplied with fluid and solid biomass. 2.6 million cubic metres of biogas per year fuel a CHP unit of 625 Kilowatt electrical power. The green electricity is inserted into the national grid. In addition, the CHP unit produces 6 million Kilowatt hours of heat. At present, less than 10% is used for the internal needs of the biogas plant, and 45% is fed into a district heating network.

The organic farmers have observed a yield increase of about 15% to 20% per cent since the start of biogas production; and more than 16% increase of protein content of crops. Even though the operation is not yet profitable. A reason for that have been planning mistakes, resulting in costly repairs of stirrers and feeding-in systems.

Pumpkin field in the near of Japons – the plants' heat could be used for drying purposes.

"Unfortunately, the real investment costs were 20 per cent higher than the planned investment", Engelbrecht explains. "But we expect the situation to improve, particularly with the recent installation of an extruder designed to disintegrate fibrous material," he adds forward-looking. Another aim is the installation of a biogas service station and a drying facility for agricultural products.



Bio Energie aus Japons facilities location: Japons, a village with about 750 inhabitants is located quite distant from large cities (105 km from Vienna), near the border to Slovakia.

Name	Bio Energie aus Japons
Location	3763 Japons 67, Niederösterreich
Basic description	250 to 280 Live stock units cattle 500 Live stock units pigs 14 of the member farms are certified organic farmers Since the year 2000 most of the farms operate organic The member farms are by enlarge cropping farms, some of them keep animals. Other income sources as direct-marketing or letting rooms play a marginal role.
Technical aspects	Power: 625 kWel 2 digesters (main and side fermenter, each 2.500 m3) Energy production: 5475 MWhel 1100 working hours/year Heat use: 5956 MWhth/y produced, out of this 2680 MWhth are sold into the district heating, supplying 660 houses in two villages, 582 MWhth/y (10%) are used to heat the fermenters, the rest (45%) is not used. Biogas service station and drying facilities are planed but not achieved yet.
Actors	Association situated in Japons (88 members) 41 of them farmers as suppliers and 47 as district heating customers
Inputs	Of farm manure: Fluids: 1400t/y out of this 1000t/y cattle slurry and 400t/y pig slurry Energy crops: Solids: 13.210t/y out of this 3300t/y silage maize (50ha), 2700t/y cattle manure; 300t/y pig manure; 400t/y grain cereals; 1300t/y sunflower (60ha); 1600t/y Lucerne (100ha); 1500t/y WCCS cereals (150ha); 110t/y red clover (80ha); 2000t/y potatoes Others: 400t/y grass (40ha) 90% of the input originate from the member farms; 10% are bought Transport distances: max. 10km (relates to agricultural input)

Outputs	2,6 Mio m3 Gas (approximately 55% methane) Digestate: 15000m3 biogas slurry 2000t solids Distribution on agricultural land of owners association; 2000t are sold
Business environment	First contact with Biogas in 2003 from Agraplus, a Lower Austrian innovation agency, 'Austrian Farmers' Association and 'Bayrischer Landwirteverband'. The working group was founded in 2004. Information was also gathered from planning agencies 7 to 8 farmers gathered in depth information. During the meetings the information was transferred to other farmers Not enough engineering companies with biogas competence to choose from, and more information was gathered from practitioners than from technicians
Economy	Initial investment : 2,3 Mio € net and enlargement 0,2 Mio € 18% investment subsidies After seven years no investment return Electricity sold to the grid at 18,08 cent per kWhel (2014) Value of heat use: not sold Solid digestate sold 2000t to 5 €/t Fixed feed-in tariff guaranteed via law for delivery to grid
Lessons learned	The economy of the plant was negatively influenced by the large repairs. Mixers needed to be changed only after two years. Feeding in system had to be repaired. 15% - 20% yield increase; change in crop rotation from clover to millet and sunflower; protein content of 16% is above average The cooperation within agriculture works very well. The general population was not very convinced to start with, but was convinced later. Special contractual criteria related to organic farmers concerning the seed

were established. Agreements for district heating were readily established beforehand. However in contrast to other plants it was settled on an increased basic price (60€ per kW installed and additional 90€/y metering price) and a lower energy price (25€/MWh). From the point of view of the plant operator, thermal energy is a waste product. 50% of the income from the sales of thermal energy is paid by the basic price. The heat customer accepted this model. It was open to them to select an alternative. But 80% supply themselves exclusively with heat from biogas.
Future perspectives: Installation of a biogas service station is planned, as well as a drying facility for wheat, maize, pumpkins, milk thistle etc. more scientific support for increased gas yields

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Graskraft Steindorf

Cooperative success

How about running a sustainable biogas project with a business volume of 430,000 Euro together with 54 farmers without displacing food production or using maize? The registered cooperative Graskraft Steindorf has been doing this successfully since 2010. From the yield of 250 ha grassland the partners – some of them organic farmers for more than 20 years – produce 1.2 million cubic metres (m^3) of biogas. “Especially the 3rd and 4th cut often can’t be used for hay production because of instable weather conditions. Using the grass in the biogas process is a real alternative”, reports a farmer.

The basis for this cooperation is open communication between all partners, for example concerning the coordination of harvesting times. Another important issue is quality management. Analysing the content of all incoming biomass is a standard process. This way nobody feels treated wrongly.

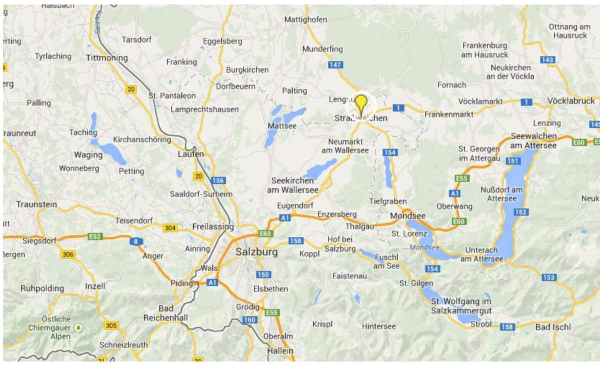
The Graskraft Steindorf cooperative shows how an economically feasible plant size can be attained by cooperation of many farmers. Photo: P. Stiegler; Energiewerkstatt.

In addition to 16 t of grass, 5 m^3 of slurry are daily fed into the two tank biogas plant. Even with 54 partner farms, the average transport distance is just 3.1 km. 70 % of the methane produced is upgraded and injected into the gas grid.

The low caloric gas is burned in a 65 kWel CHP unit. This micro gas turbine delivers beyond the electricity about 120 kW heat. Combined with the waste heat of the gas-compressors it ensures that the required process heat is available.

The associates of Graskraft Steindorf are still enjoying the cooperation. When asked about their future perspectives, they show that they are still open for more farmers in the region providing biomass to produce products people need – such as biomethane as car fuel replacing imported fossil fuels.

In Austria the energy supply of the transport sector relies to more than 90% on imported fossil energy sources. These sources are substantially responsible for the national emission of air pollutants and greenhouse gases. The use of natural gas can essentially reduce pollutant emissions. Biogas that is processed according to the natural gas grid directives becomes bio-methane and can be fed into the gas grid. Thus, from many manufacturers available standard natural gas vehicles obtain this biogas through the natural gas refueling stations. In addition biogas offers regional added values, energy-self-sufficiency and an efficient greenhouse gas reduction.
The range of a bio-methane-driven car is about 45.000 km per hectare grassland and year. In cooperation with the regional energy provider Graskraft Steindorf & Salzburg AG, fuel for about 1.000 cars, each running 15.000 km per year, is produced. Thus, the Kyoto protocol for 1.800 inhabitants can be met.



Gaskraft Steindorf: 28 km. from Salzburg.

Name	Gaskraft Steindorf
Location	5204 Strasswalchen, Austria
Corporate structure	Cooperative: 54 farmers and 4 non-farmers
Start of production	2010
Investment	2 million Euro
Plant size (CHP units)	330 kW_{el} + biogas upgrading
Biomass input	70 % grass (mainly organic), 30 % manure

Biomass supply from other farms	100 % of cooperation members
Energy yield per year	1.2 million m^3 biogas p.a. (equals 7.000 MWh)
Heat use	70 % of the biogas is fed into the gas grid

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Übleis

Family operated plant

The biogas plant Übleis is a family operated organic farm plant, located in Rutzenham, province of Upper Austria, Austria. The biogas production started in 2006. The farming area covers 45 hectares cropland and 20 hectare grassland. The farm is specialized on organic pig rearing. It has capacity for 400 pigs.

The raw material for the biogas plant originates to 52 percentages from the own farm, the remaining substrate is purchased from neighboring farmers. The maximum transport distance is 15km. In sum 60% of the input is from organic origin. The composition of the substrate is pig slurry, pig manure, maize, sunflower and grass silage.

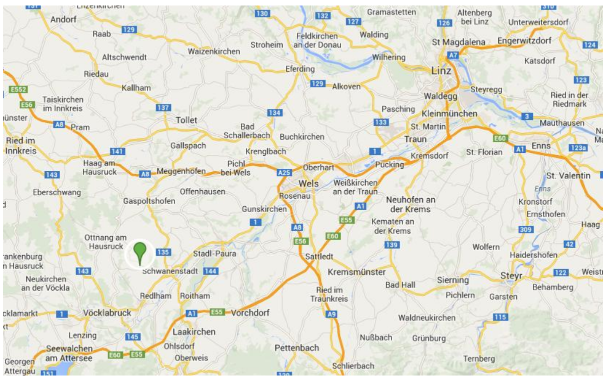
Gerhard Übleis operates a biogas plant in Schwanenstadt/Upper Austria with a mix of organic and conventional input. The heat is used for drying wood chips as fuel. Photo: F. Gerlach, FiBL

The plant consists of two fermenters in the size of $650m^3$ each. They produce $574{,}000m^3$ biogas and $2900m^3$ biogas slurry per year. The biogas slurry is used on the own farmland and an average of 1000 tons per year is sold to neighboring farms. The use of biogas slurry increased the yield of maize harvest from 7 tons to 10 tons per hectare. The biogas is processed in a 100kW CHP unit. It results in the production of $864MWh_{el}$ per year and 957 MWh_{th} per year. The electrical energy is sold to the regional energy supplier. The thermal energy is used for heating the fermenters (8%), for district heating (52%) and for drying the wood chips and maize grains (40%).

The initial investment for the plant was €750,000 and the investment funding was 30%. Biogas slurry is sold for €2 per m^3, electricity for €0.165 per kWh and thermal energy for €32 per MW for drying purposes and €66 per MW for heating purposes. The estimated return on investment amortization period is 12 years.

Heat provided by biogas plant is own used to dry wood chips

The information exchange with other biogas plant operators is seen as a very important factor for increasing knowledge. Asked if he would again start a project of the kind with his current knowledge, the farmer said he would be pleased to but this time using a more robust feeding system.



Übleis farm location: 70 km. west from Linz.

Name	Übleis
Location	Rutzenham 5, 4990 Schwanenstadt, Upper Austria
Basic description	20 ha grassland; 45 ha cropland 400 pigs for fattening Organic certified over more than 10 years Pig production income
Technical aspects	Power: 100 kWel 2x650m3 digesters Energy production: 864MWh_{el}/y (863.651kWhel/y) and 957 MWh_{th} /y 1000 working hours/year Heat use: 8%for heating digesters 52% for district heating 40% drying wood chips
Actors	In ownership of farmer
Inputs	Of farm manure: 1,5t/d pig slurry 1,5t/d pig manure 100% processed Energy crops: 3,6t/d maize 1,5t/d sunflower Others: 1,5t/d grass silage 53% of input from own farm Transport distances: 15 km maximum
Outputs	574.000m3 gas/y biogas Digestate: 2900m3/y, used on own farm and sold to neighbouring farms
Business environment	First contact with biogas in 2002 through planning companies, farmers with biogas plant and ARGE compost&biogas 10 plants were visited before building the own plant Enough engineering companies with biogas competence and technicians availability
Economy	Initial investment: 750.00 € 30% investment funding Estimated investment return 12 years Electricity sold to the grid at 16,5 cent per kWhel Solid digestate sold for retail trade: 1000t at 2€/m3 Value of heat use: 32€/MW for drying purposes 66€/MW for district heating Fixed feed-in tariff guaranteed via law for delivery to grid
Lessons learned	Investment return not yet achieved Feeding-in system is failure prone Integration with the farming system brought increase of crop yields Future perspectives marketing of biogas slurry

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Elmegaard Organic

An organic cooperation project

Elmegaard Organic is owned by Organic farmer Bjarne Viller Hansen and located at the arable farm in Bording, Denmark. The main production at the farm is organic carrots.

The biogas plant was established in 2009 as a demonstration project in cooperation with the organic farmer and Organic Denmark. The purpose of the project was to gather knowledge about organic biogas production and production of organic fertilizer, and thereby the possibilities to enhance organic farming.

The biogas plant was built by a Danish contractor as a conventional biogas plant. The technique appeared to be too underpowered for the organic biomass and it has been very difficult to get the plant on the right track. The farmer concluded that it would have been beneficial if he had had competent legal assistance during the negotiations with the biogas plant supplier company.

Elmegaard Organic. Mixer tank and fermenters Photo: Michael Tersbøl, Denmark

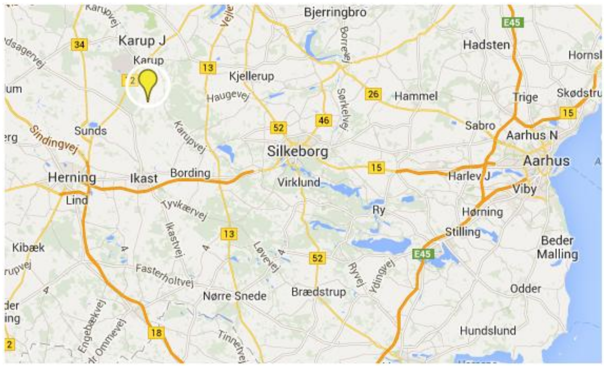
Today the biogas plant has changed:

- the substrates have changed from exclusive green biomass to include cattle manure
- added more mixers to the reactors
- bigger pumps
- build a chain crusher for pretreatment of difficult green biomass
- another feed-in-system for green biomass
- established a new kind of spray stirring system in one of the reactors.

In 2013 the biogas plant was divided into two lines, one organic and one conventional to be able to receive slurry from a conventional neighbor in order to get more liquid substrate.

Waste from the production of carrots becomes feed for biogas plant. Photo: Lone Klit Maln, Denmark

These changes seems to make the plant economical viable and easier to manage. In order to get an even better economy for the plant, there still has to be found solutions for utilization of the excess heat.



Elmegaard Organic location: 26 km from Silkeborg.

Partners:

Name	Elmegaard Organic
Location	Munklindevej 83, Agerskov 7441 Bording Denmark
Basic description	Elmegaard organic is an arable farm, growing primarily carrots and other crops. They harvest clover grass from approx. 100 ha and expect to buy grass from another 40 ha. All of the grass will be used in the biogas plant and some of it will be used in the biogas plant as fresh biomass to get as much energy from it as possible. The plant started out as completely organic but decided in 2013 to divide the plant in two lines: an organic line and a conventional line. This decision was taken because the biogas plant design wasn´t optimal for the use of green organic biomass. After the division the plant is easier to operate and is producing more biogas
Technical aspects	Power: 360 kW (MAN-engine) CHP Reactor size (organic): 4700 m^3 Mixing tank: 135 m^3 Spray stirring system to avoid floating layer
Actors	The biogas plant is owned and operated by farmer Bjarne Viller Hansen. The produced electricity is sold to an energy company
Inputs	Daily input to the organic biogas line: 15 tons of cattle manure and 12 tons of green biomass from the farm (most clover grass)
Outputs	8400 kW/day
Legal aspects	In 2012 there were given subsidies as an extra pay for produced electricity from biogas plant. With retrospective effect the farmer got the payment raised according to new subsidies in December 2013, which benefitted the economy of the biogas plant
Economy	Initial investment: 1,6 million Euro and no subsidies. The economy of the plant was based on 30% start-up grants, but the grants fell out and the farmer had to pay it all. The biogas slurry as fertilizer increased the yield of the carrots and the crop production between 20-40% and that had a positive impact on the economy of the farm
Lessons learned	It is important to choose the right design of the biogas plant for the planned biomass and very solid equipment for green biomass. Stirring of a big amount of clover grass is difficult and at the moment it looks as if the best method is a combination of stirring and recirculation through spray stirring to prevent floating layer. It is important to set the best team of advisors and be careful with the contracting with suppliers

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Foulum

Experiment platform

Foulum Biogas Plant is a large plant for biogas experiments. AU Foulum is a part of Aarhus University and is situated in the middle of Jutland in Tjele.
AU Foulum has an organic livestock platform for research as well.

The biogas plant at Aarhus University's Research Centre Foulum is the first in Denmark to be granted authorization to run periodic organic productions. A group of Organic farmers in the area has found this solution together with Foulum biogas plan, now they are able to get their organic biomass fermented in the biogas plant in a certain period and get the biogas slurry back as organic fertilizer for their organic farms.

Fermenter and feed in system at Foulum Biogas Plant. Photo: Søren Tobberup, Aarhus Universitet

This possibility is particularly important for organic farmers who often have a problem with sourcing organic manure. With the authorization, it will be possible for organic farmers to increase the amount of nitrogen they can apply to their fields.

Difficult biomass before the extruder. Photo: Michael Tersbøl, Organic Denmark

In order for the biogas plant at AU Foulum to run a periodic organic production, they will need initially to undergo a GMO quarantine period, which means that the plant can no longer receive biomass containing GMO.

Pretreatment with extruder. Photo: Michael Tersbøl, Organic Denmark

With the authorization for the biogas plant to produce an organic fertilizer product, organic farmers can set up an arrangement with the biogas plant where they supply an organic biomass and in return they receive a fertilizer product with a certain percentage from the organic production line.

With the authorization to run a periodic organic production, AU Foulum has been able to complete the organic cycle at the biogas plant. An extruder has already previously been connected to the plant, capable of handling biomasses such as meadow grass, hay, deep bedding material and grass-clover that all have a high dry-matter content. One of the advantages of the extruder is that it is very flexible as it is capable of handling dry-matter contents ranging from 20-85%. At the very high end of the scale, its capacity is, however, compromised and the next step, already implemented, was therefore to incorporate a straw briquette technology that has a large capacity at high dry-matter contents. There are now two feed-in systems that supplement each other.

Foulum plant location: 15 km from Viborg

Name	Foulum biogas plant
Location	Burrehøjvej 43, 8830 Tjele, Denmark
Basic description	The biogas plant was established and started as a conventional biogas plant in 2007. In 2013 it was possible to run the plant as an organic biogas plant for a period. The biogas plant is connected to a research institute The biomass for the biogas plant is primarily from permanent grassland and straw
Technical aspects	Power: 625 kW Reactor size: 1.100 m^3 active volume Energy production per year: 6,5 Mwh/year 20% of this energy is from the period where the plant is organic operated 25 % of the total running time per year is conducted with organic biomass Reactor temperature: 52°C The surplus heat is used for heating the buildings of the research institute The produced electric energy is sold and transferred to the national public grid
Actors	The plant is owned and managed by Aarhus University. The electric energy is purchased by the public grid The heat is used by Aarhus University (sold internally)
Inputs	In the period where the biogas plant is producing organic biogas the biomass input is about 73 tons/day
Outputs	Biogas produced: 1.500.000 m^3 biogas/year Electric energy produced:2.539.597 Kwh Heat produced: 4.073 Mwh Organic biogas slurry produced: 6.800 tons with an organic percentage of 16-20% The biogas slurry is not separated

Legal aspects	It is possible to run the biogas plant organic for at period. It is approved by the The Danish AgriFish Agency under the Ministry of Food, Agriculture and Fisheries provided that the biomass used is approved for organic use and fodder residues from conventional farming with risk of GMO contents is kept out of the biogas plant
Economy	Plant investment: 3.756.000 Euro including research reactors, test facilities etc. Additional investments of approx. 872.000 Euro for pretreatment and feeding system for organic biomass. Payback period: It is not possible to calculate this since a bigger part of the investment is for research. Payback time for the additional investment is approx. 5 years, and without subsidies it would be a 10 year period. Sold electric energy: 2.539.597 Kwh Sold heat: 4.073 Mwh The energy from the biogas plant replaces natural gas. The biogas slurry is not sold at a price, but the price is reflected in a lower cost for the biomass, as the farmer get the biogas slurry back. The economy is balanced in relation to the use of maize at 0,13 Euro/FU since the price of grass is settled from this premise. There is a balance in the economy for the suppliers with harvest of crops on large, non-water logged areas. To get a viable economy for the biomass suppliers it is important that the organic nutrients are valued
Lessons learned	It is possible to handle a large percentage of dry biomass in the form of grass, straw and deep litter. Pretreatment has ensured that there isn´t problems with stirring. However, the maintenance cost of the pretreatment equipment has been higher than expected

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Hagavik

Swedish pioneers

Hagavik is a farm just north of Oxie (municipality of Malmö in Sweden), with arable organic farming. Krister Andersson started organic farming in 1999 and the organic production has increased and now covers 235 ha.

The crop rotation on Hagavik is; grass outlay, canola, winter wheat, beans, winter wheat, spring wheat and grassland. In this crop rotation 4 hectares of red beets is included.

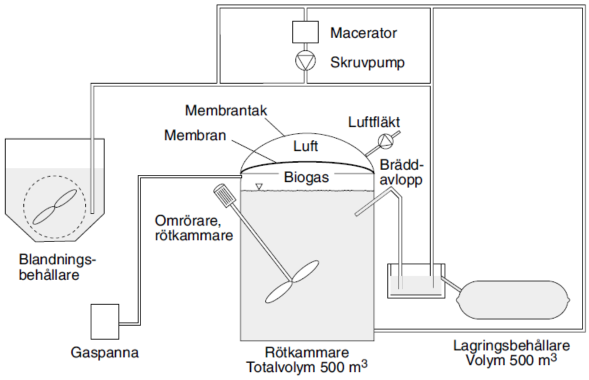
Hagavik has its own biogas plant where chicken manure, plant byproducts from farm and residues from food production is digested. The biogas is converted into electricity in a gas turbine and waste heat is used to heat the farm's two residential buildings and the grain dryer in the autumn. The digestate from the biogas plant is used in the organic crop production as readily accessible nitrogen fertilizer.

The Hagavik Biogas Plant in Sweden
Photo: Krister Andersson

The Swedish Institute of Agricultural and Environmental Engineering (JTI) has been in charge of the evaluation of the biogas plant. Evaluation of the start-up phase of the plant, regarding the technical and biological function, was accomplished in July – November 2003. During year 2004 focus has been on practical experience running the plant.

The plant electricity demand has been measured. Based on those measurements the calculated electricity demand running the plant with a biogas production at 600 m3/d (3,54 MWh/d) corresponds to ca 2-3% of the energy content of the biogas.

The calculated heat demand corresponds to 15 % of the biogas. At cogeneration (with assumed electrical efficiency of 34% and thermal efficiency of 55%) the net-energy production is 919 MWh/year where 44% will be electricity and the rest heat.



Hagavik plant process scheme
Illustration: Kim Gutekunst

Total investment for the plant is about 284.000 Euro The farmer has got a government investment subsidy of 65.500 Euro. The price of the net-energy production has to be at least 0.04 Euro/kWh in order to balance the costs. This calculation includes the investment subsidy.

Hagavik farm location: 8 km from Malmö city center

Name	Hagavik Organic Farm
Location	Hagavik, Malmö, Sweden Krister Andersson
Basic description	The organic farm Hagavik just outside Malmö in Sweden has 235 ha arable land, were they are growing canola, wheat, corn and peas. The farm has no animal production and because of that Krister Andersson chose to build a biogas plant to make organic fertilizer as a nutritional supplement. The biogas plant was built in 2003 and the production of electricity was started in 2006
Technical aspects	Power: 100 kW gasturbine (CHP) Reaktor tank: 500 m^3 Storage tank: 1.000 m^3 Storage tank (airtight rubber bag): 500 m^3 Retention time: 100 days Operating temperature: 37°C
Actors	The biogas plant is owned and operated by farmer Krister Andersson The biogas plant is constructed by Weltec Biopower www.weltec-biopower.de The gasturbine is from Turbec www.turbec.com
Inputs	700 tons household waste per year. 100 tons chicken manure per year
Outputs	650 MWh electricity/year. 90% is sold to Nord Pool 200 MWh heat/year for heating buildings at the farm 1500 tons of biogas slurry The slurry is 6,5% DM with 8kg N/ton, 1,5 kg P/ton and 3 kg K/ton
Legal aspects	For each 1000 kWh green energy produced at the farm, the producer gets a certificate This certificate can be sold and generate an extra income
Economy	Initial investment : 284.000 Euro, where 65.500 Euro was investment grants. The heat replaces 20 m^3 oil per year.
Lessons learned	The biogas plant works well. The owner has visited a lot of existing plants and learned about the technique and the possibilities before he build his plant. The production of heat and power from a CHP pays best if the majority of the energy can be used at the farm

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Långhult

Partnership biogas plant

The cooperation between neighboring farms Söderlind and Långhult began in 2010, when Emma and Marcus Söderlind were about to choose a heat source for their organic greenhouse and together the two farms had only a minimal amount of fertilizer available. Their growth plans appeared to fit together like hand in glove with the neighbor Dan Waldemarsson, a farmer with arable land and beef cattle. They did calculations up against each other and it turned out that cooperation would be beneficial for both farms, both economically and environmentally.

Söderlinds greenhouse was designed to fit the expected heat production from the biogas plant planned by Dan Waldemarsson. The wish to build a biogas plant was due to, among other things, that he could get a stable heat consum, produce needed fertilizer for the farms and also that he got a deal on waste from a candy factory. These things together show an acceptable correlation calculation.

Biogas plant. Photo: Marcus Söderlind

On Söderlinds they quickly established a greenhouse five times larger than the old one. On the farm Långhult the process of regulatory permits for the biogas plant took a long time and the knowledge about biogas was limited both by consultants and authorities. Therefore the cooperating neighbors became their own experts on biogas regulations and production.

They chose to buy a turnkey plant from a Swedish supplier. The establishing of the plant was started in the summer 2010 and took a year to complete. The plant was completed and became operational in 2011.

75 kW CHP. Photo: Marcus Söderlind

During startup of the plant there were problems with the biological process as the supplier failed to initiate the system correct according to the specific conditions at the Långhult biogas plant system. After an adjustment the biological processes went well and are mostly functioning as intended. The heat is delivered as expected so the greenhouse now has increased the growing season by several months. In the summer there is a surplus of heat. This surplus heat is being considered right now, how it can be used.

Together the two neighbors made a sound business and created more jobs in the local area.

Långhult farm location: 24 km north from Jonkoping

Name	Söderlinds Ecologiska Grönsaker & Långhult Biogas
Location	Långhult 2, 56692 Habo, Sweden
Basic description	The partnership between the two farms was formed in 2010 because Söderlinds needed heat for their tomatoes and Dan Waldemarsson could see the benefit in producing heat, electricity and fertilizer with a stable heat consumer and a need for fertilizer on the farms Together they made the development plans for their farms and since there has been close cooperation to carry out plans for the biogas plant Söderlinds Ekologiska Grönsaker have 3 ha, 2,5 employed in growing organic vegetables, greenhouse and open field production Their turnover is 0 - 273.000 Euro Långhult Biogas AB has 100 ha pasture and grain, meat production, 1 employed and a turnover of 273 – 546 thousand Euro
Technical aspects	Power: 75 kW Cheva 350 V8 engine, CHP Reactor sizes: mixing tank 40 m^3, digester 500 m^3, second reactor with cooling coils 20 m^3 and storage tank 3.500 m^3 Temperature in the fermenter: 38°C
Actors	Biogas plant: turnkey plant constructed by Götene Gårdsgas, Sweden The biogas plant is run by farmer Dan Waldemarsson. The greenhouse is managed by Marcus and Emma Söderlind
Inputs	Substrate: 3000 ton cattle manure and 200 ton waste from a candy factory
Outputs	Excess heat is piped via a 64 m cable to the waterborne heating system of the greenhouse. Electricity 40 kWh Electricity production per year 350000 kWh, of which 250.000 are sold and 100.000 are used at the farm. Heating for greenhouse 60 kWh Heat for the biogas process 10 kWh Heat production per year: 650 kWh Reduced purchases of fertilizer of 5-10.000 per year
Legal aspects	The rules/legislation turned out to be way more comprehensive than we could imagine
Economy	Total investment: 525.000 Euro 30% investment grant The economic result is not as good as expected because the price for the electricity has dropped 50% compared to the price in 2010. This means that the payback period will be longer that the calculated 12 years. Heat sales 2013: 17.500 Euro/year Electricity net income 2013: 8.200 Euro/year el-certificate approx. 7.600 Euro/year Savings: 5.500 Euro/year (100 000 kWh x 0,05 Euro) Reduced need for purchased fertilizer: 550-1.100 Euro/year
Lessons learned	If we had known the extent of the legislation and rules around biogas we would have had second thoughts to go into the process of building a biogas plant. We had to develop our own expertise, it was not enough to trust the supplier or the consultants, they didn´t have the right expertise. It has been important for both partners to be fully open and know each other's assumptions

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Granja San Ramón

A family effort

San Ramón farm is located in Requena, province of Valencia, Spain. San Ramon started their business in the decade of 1970 with a small quantity of cows near Valencia city. In year 2005 they changed location to get more space to develop their processes and to be more competitive. It remains as a family farm, but now is one the biggest dairy farms in Spain, and the first sustainable livestock farm.

The whole production (15.5 million milk l/year) is served to one of the largest manufacturers of dairy products in the country.

The farm is home to 2200 animals, including cows and calves. Each year 500 new calves are bred in the own facilities to increase the number of livestock.
The new location is ready to expand the number of livestock to 5000 in the coming years.

Livestock accommodation area.

The raw material for cattle feed comes in part from own crops outside the boundaries of the farm, and other certified providers, including grain and forage and farming discards.

The farm includes 2 biogas digesters of 800 and 2,200 m3 which allow to produce 2,000,000 m3biogas/year.

These digesters are feed with 80m3 of manure a day (80% of the total from the farm) and co substrates as hay and orange pulp. Now San Ramon is investigating about use of other materials as onion waste.

A gas engine with a power of 500 kW working 8,400 working hours per year allows an energy production of 4,000 MW/year.

Electricity is sold to the national grid, and 30% of the heat produced is used for heating the digesters to 42ºC, the rest is dissipated although they are studying ways of using it.

Biogas digester

The strongest point of the biogas plant is its automation and security systems which allow the plant to be under monitoring 24/7 and problems can be foreseen.

The commercial activity of the farm is completed with the valuation of the high quality digestate, used for fertilizer production through composting process and separation of liquid and solid phase.

Main problems found are the actual renewable energy situation in Spain, with no special feed-in tariff and the availability of an adequate co substrate at good price. The perception is that these products for co substrate use are easily found but it's not like this.

San Ramon farm location: 68 km west from Valencia.

Name	**Granja San Ramón**
Location	Requena, Spain
Basic description	San Ramon started their business in the decade of 1970 with a small quantity of cows near Valencia city. In year 2005 they changed location to get more space to develop their processes and to be more competitive. 2,200 cows: of which 1100 are for lactation and the rest for breeding Biggest dairy farm in Spain Plans to grow to 5,000 cows in 5 coming years 15.5 million milk l/year Extension: 100 ha
Technical aspects	Power: 500 kW 2 digesters of 800 and 2,200 m3 Energy production: 4,000 MW/year 8,400 working hours/year 30% of the heat produced is used for heating the digesters to 42ºC, the rest is dissipated although they are studying ways of using it. 6-7% of the biogas is used for own usage, engines and taking into account the auto consumption when obliged to do it (when connection to the grid is down).
Actors	Management: AD3 Energy, Spin off of Granja San Ramón
Inputs	80m3 of manure a day (80% of the total from the farm) 4,000 t/a manure+ hay+ orange pulp (without limonene) Plan to research other co substrates such as onion waste)
Outputs	2,000,000 m3biogas/year 30% of the heat used for heating the digesters High quality digestate used for fertilizer production through composting process and separation of liquid and solid phase

Business environment	Electricity sold to the grid and auto consumption when connection to the grid is cut.
Economy	Initial investment : 2,000,000 € Estimated investment return: 8 years Electricity sold to the grid at Solid digestate sold for retail trade Liquid digestate filtered for "fertirrigation" Heat from cooling down the motors used for digester heating, all the rest of the heat not used.
Lessons learned	Very good valorisation of the plant. The strongest point is its automatization and security systems which allow the plant to be monitored at all times and problems can be foreseen. Main problems found are the actual renewables situation in Spain, with no special feed-in tariff and the availability of an adequate co substrate at good price. The perception is that these products for co substrate use are easily found but it's not like this. It is very important to control the quality of the co substrates going into the plant if planning to obtain and use a good quality digestate for fertilization or retail commerce

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Kernel Export

Integration and auto consumption

Kernel Export SL (www.kernelexport.es) is an OPFH nº 588 established in 1996, a producer organization of 10 growers, grows almost 2000 ha of Salads, Vegetables and Melons of which 400 ha are organic production. The company has been investing in the last years into fixed asset to improve the efficiency in all the production steps to improve environmentally and in the production chain such as harvesting rigs, robots in the harvestings rigs flow packing in fields, optical sorters, improving the production of fridges reducing the environmental impact and others.

As part of this company philosophy Kernel decided in 2012 to build the first Bio plant to convert the vegetables waste into energy for auto consumption and for developing organic fertilizers back to their own fields.

Kernel Export facilities, plantations and packaging plant. Photo: KernelExport.

The company has a biogas plant with a digester of 3.600 m^3 which allow producing 1,700,000 m^3biogas/year.
This digester is feed with 40 tons per day of vegetal wastes and other 10 to 15 tons per day of local agroindustrial organic by-products.

A gas engine with a power of 370 kW working 8,000 working hours per year allows an energy production of 3,000 MW/year.
The electricity is used for the self-consumption of the industry. The biogas plant covers approximately 60% of the energy needs of the factory.

The heat will be used for the production of advanced fertilizers, as well as for keeping the temperature of the digester.

Biogas plant, developed by Ludan Renewable Energy. Photo: KernelExport.

The biogas plant has a composting facility attached, so the dried fraction of the digestates is composted and mixed with other products to improve its value as organic fertilizer.

The plant also incorporates a system for the treatment of the liquid fraction of the digestates, always focused on the recovery and use of the valuable nutrients and organic matter present in the digestates.

Kernel Export farm location: 52 km from Murcia.

Name	Kernel Export SL
Location	Pol.Ind. Los Alcázares, Av Trece de Octubre, 2, 30710 Los Alcázares, Murcia
Basic description	Kernel Export is one of the largest salad and processed vegetables producers of Spain. It also owns more than 2,000 ha of agricultural lands for the production of ecologic and conventional vegetables and fruits. The goals of the plant are three: 1- Generation of energy for the self-consumption of the vegetable processing factory 2- Treatment of the vegetable wastes 3- Production of high quality organic fertilizers for their own lands
Technical aspects	Power: 370 kW Complete-mix mesophilic range 1 digester 3.600 m3 Energy production: 3,000 MW/year 8,000 working hours/year Heat to be used for heating the digester and for the production of fertilizers 6-7% of the energy produced by the plant is used for self-consumption
Actors	Construction: Ludan Renewable Energy Management: Kernel Export
Inputs	40 tons/day of vegetable wastes 15 tons/day of food industry wastes

Outputs	1,700,000 m3biogas/year 3,000 MW of electricity 10 tons/day of solid compost derived from fertilizer
Business environment	Electricity used for the self-consumption of the Kernel Export factory No feed in tariffs neither any incentives to the generation of electricity Requested Carbon Credits to the Ministry of Environment under CLIMA projects
Economy	Initial investment : 2,000,000 € Estimated investment return: 8 years
Lessons learned	The plant is starting operation in summer 2014. As we are still in start-up phase no lessons can be yet presented here.

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BBE Biogas Anerveen

BBE Biogas is a Dutch company in the anaerobic digestion industry. This specific plant is located in Anerveen, Overijssel in the Netherlands. The construction of the biogas plant started in 2006 under the supervision of BBE Biogas. The biogas plant installed in this farm is a solo digester and it uses 50% manure and 50% organic waste, reaching 36 000 tons of input per year. The output is approximately 7,500,000 m³/year biogas. The power of the plant is 2.1 MWe and the yearly energy production is 16800 MWh.

Biogas plant aerial view

BBE Biogas BV

Biogas plant entrance

The plant was designed and created as a turnkey project. It was initially managed for 5 years by the company and then it was transferred to the new owner. The concept of anaerobic digestion started by the CEO of BBE Biogas, Henk Nijman in the beginning of the 21st century. At that time he was working for an engineering company which finally decided not to continue with anaerobic digestion. Henk Nijman believed in the concept and started his own company. When BBE Biogas started, the concept was still quite new but there were already some companies that were able to assist with the development and construction phase.

Location of the plant: 158km. from Amsterdam

Partners:

Name	BBE Biogas Anerveen
Location	Anerveen, Overijssel, Netherlands
Basic description	For this project BBE Biogas was backed by non-farming investors. The plant was developed, designed, engineered and constructed as a turnkey project. BBE Biogas operated the plant for approximately 5 years before transferring to the new owner. The new owner is a local farmer that also owns a manure transportation company. 50% manure and 50% organic waste are used, 36.000 ton/year.
Technical aspects	Power 2.1MWe (2100kWe) Number and size of digesters: 5 pcs, 26m diameter and 7m height. Double membrane roofs. Pre-treatment by means of a hydrolysis unit and post treatment of the digestate by decanter, pasteurisation (hygienisation) and dryer for the solid part of the digestate. Yearly energy production is approximately 16.800 MWh. All the heat, 100% from the CHP's (water, exhaust) is used in the drying process and in the general anaerobic digestion (AD) process for heating the digesters and the pasteurization. In the pasteurization, the digestate is heated for one hour to 70 degrees C.
Actors	BBE Biogas, Netherlands http://www.bbebiogas.nl/en/
Inputs	Input per day is about 50t manure and 50t organic waste products. Crops include maize silage, corn and other agricultural waste like onions, carrots, peas (mix), etc. Liquid feedstock products include fat, food waste and glycerine.
Outputs	7,500,000 m3/year biogas. Digestate is separated by a decanter. Liquid is either fed back into the system or exported; solid is dried and exported as a fertiliser. It is sold abroad (Germany) and locally in Netherlands. The site is quite close to the German border, where they have better conditions in terms of prices.

Business environment	Subsidies are received for every kWh production. The subsidy is 0.097 Euro/kWh. Furthermore the general electricity price, of about 0.05 Euro/kWh is added, so total 0.147 Euro/kWh. Subsidy period is normally 10 years but it is expected that the period will be extended for existing AD plants. Without extension of subsidy period, many AD plants will face bankruptcy.
Economy	Initial investment was about €6.000.000 with an estimated return of 5-7 years. Due to the surplus of manure in the Netherlands, digestate has a negative value. Also, waste products like food and agricultural waste have high prices, which put pressure on the business cases. At this point, biomass prices seem to be stabilising a bit.
Lessons learned	The first AD plants in the Netherlands were highly profitable due to low feedstock prices and high electricity prices. Gradually, the feedstock prices have risen significantly and with the economic crisis, general electricity prices went down and banks were afraid to invest. This caused severe problems for the AD industry in the Netherlands in general. BBE Biogas is now utilising their knowledge to develop more projects internationally. They try to identify many opportunities worldwide and make the world a greener place by transforming organic materials into sustainable energy. This kind of biogas plants are highly efficient and bring solutions to farmers that are looking to improve their efficiency in terms of waste disposal and electricity and/or heat usage.

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Partners:

Praktijkcentrum De Marke

Demonstration dairy farm

The knowledge Transfer Centre De Marke is an experimental dairy farm that participates in research conducted by Wageningen UR (Livestock Research and Plant Research International). The aim of its activities is to minimise environmental impacts of milk production by mitigating gaseous emissions and by enhancing mineral utilisation. The first installation has been running since 2003. In 2012 the plant is renewed as described in this hand-out.

De Marke is one of the nine European Knowledge Transfer Centres in the INTERREG project "Dairyman". Knowledge which is gained at De Marke, is implemented on farms which are involved in the Dutch project called “Koeien and Kansen” (Cows and Opportunities).

In addition, the DAIRYMAN project collaborated with research institutions and farmers in north-western Europe.

About 4000 people visit De Marke per year.

For more information please visit:
www.wageningenur.nl
www.projectdemarke.nl
www.koeienenkansen.nl
http://www.interregdairyman.eu/en/dairyman.htm

Location of the plant: 131km. from Amsterdam

Partners:

Name	PRAKTIJKCENTRUM DE MARKE
Location	Hengelo GLD, Netherlands
Basic description	Agro climatic conditions: Light sandy soil with an organic matter content of 4.5%; Precipitation surplus: 300 mm/year. Farm characteristics: Total area: 55 ha, grassland and pasture: 33 ha (thereof 11 ha permanent grassland), arable crops: 22 ha, crop rotation: grass-clover – maize – barley. Maize is seeded with a catch crop: Italian ryegrass (under-sow) Number of livestock: non-organic, milking cows: 85, ca. 50 calves & heifers. Other income sources: milk production per cow: 8,500 kg/year, production intensity: 13,000 kg milk/ha. Sold to Royal Friesland Campina.
Technical aspects	The (new) plant is a small scale, two-step system. First a hydrolyse tank (35m3) then the digester (80)m3. Total passing time one week. Energy production: around 100.000 – 150.000 kWh/year. Heat use: no (part of the inefficiency)
Actors	Animal Sciences Group (ASG), Wageningen UR Livestock Research and Plant Research International.
Inputs	Inputs: 3000m^3 of cow manure and 100 tons of additional dry biomass from local sources per year. The dry biomass is solid cow manure and natural grass.
Outputs	The two step digester produces 90000 m^3 biogas and from that 100.000 – 150.000 kWh per year are generated. Partly the electricity is used on the farm, partly it is sold. There is no exportation of digestate. Outputs: The production of biogas and energy delivery is important, but not the only goal. The second target is to reutilise the manure in the most efficient way. This contributes to the sustainability of the farm and the decrease of pollution. After digestion, the digestate is separated in a liquid and a solid fraction. Lastly we implement the bio-refinery at farm level (in the setup that fits the De Marke's objectives best) to monitor and judge the practicability.
Legal aspects	The project is subsidised by the Dutch Government, by farmers, the National Government, and a project paid by European Union for the new installation.
Economy	Investment: about 250.000 Euros total The biogas plant has been built and maintained for innovation and demonstration purposes, therefore costs are not comparable to cases in practice. The new installation runs with one hour a day labour.
Lessons learned	Experiments with chemical gas cleaning systems for different and better energy use were not really successful. Therefore, a new system needs to be developed. The mineralisation of slurry is improved, the plants take it up better. So the pollution out of animal manure is reduced, which is the main target of the farm.

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Joluwa chicory plantation

Biogas plant on a chicory plantation-hydroculture farm

Joluwa, which is located in Nivelles - an area in the outskirts of Brussels, Belgium - is a conventional chicory plantation with 120 ha land. Chicory is grown on the field for one season after which the root and stem are harvested. Root and stem are then used to produce chicory sprouts - which happens by using hydroculture and has to be done in the absence of sunlight in order to prevent the leaves from turning green and opening up.

Biogas plant

Greenwatt, a company that designs and builds bio-methanisation units, decided to conduct research in this farm which eventually led to a project through which a biogas plant was built. The plant started working in 2010. The objective of this project is to generate power through the bio-methanisation of the organic waste coming from the chicory plantation; basically the roots, the stems and other by-products after the buds are separated.

GreenWatt
BIOGAS PLANTS FITTING YOUR WASTE

The biogas plant works mainly with the use of plant waste and no animal manure. The amount of the organic waste used is 15 to 17 tons per day out of the 25 tons of chicory picked and packed. According to GreenWatt, each ton of organic waste produces 60m³ of biogas which is 4.500m³ weekly. The biogas plant works five days per week and 50 weeks per year. The biogas produced is transformed into electricity and heat. The electricity produced is 530MWh/year and the heat production reaches 300MWh/year. The electricity is consumed on site, whereas part of the heat is sold to a printing company located close to the plantation, called Rossel Printing. There is a separate circulation system for warm water to reach the company's premises.

Substantial improvements have been introduced to the economy of this plantation. With the use of the biogas plant, the plantation became energy self-sufficient. In addition, waste is efficiently used in the biogas production process, so there is no need for waste treatment anymore. On the contrary, the digestate coming from the digestion process is valorised: It is used as organic fertiliser and spread directly out on the land of the owner. It also needs to be underlined that not only savings have been made, but also the plant has generated further income for the owners of the plantation through the sales of the digestate and of the surplus of heat and electricity.

Finally and very importantly, the greenhouse gas emissions have lowered significantly with the introduction of the biogas plant. In this case, this is even more significant because chicory sprouting is one of the most energy intensive crop production methods and this means that it requires larger energy input and it is more water intensive compared to other farms. Based on the data, 440 tons of CO_2 are saved every year. The Joluwa plantation is the first CO_2 neutral chicory plantation

Joluwa's location, approximately 30 km outside Brussels

Name	Joluwa
Location	Biogas plant on a chicory plantation-hydroculture farm Chaussée de Hal 150, 1400, Nivelles
Basic description	A 120 ha chicory plantation based on hydroculture, owned by Joost de Paepe GreenWatt decided to carry out a study which led to the installation of the first biogas plant on site in 2010. 25 tons of chicory per day is picked which generates 15 to 17 tons of organic waste per day The energy produced is transferred into electricity and heat to be consumed on site and the remaining is sold to a nearby printing company (Rossel printing, 1000 m close to the farm). http://www.greenwatt.be/
Technical aspects	The biomass can differ; liquid or solid materials, single or mixed, of animal or organic waste Hyfad and multi-stage technologies Electric power: 100 kWh Energy production: 500 MWh/year Electrical energy: 80kWe/day Thermal energy: 94 kWe/day 440 tons CO2 saved every year
Actors	GreenWatt is a Belgian company that designs and builds on-site biomethanisation units for agri-food industries, fruit and vegetable producers and small-sized farms Each unit is adapted to the needs of each client. The Research and Development team has found solutions to processing different types of plant byproducts and even waste water The name of the owner of the plantation is Joost de Paepe and he has been cultivating chicory for the past 30 years. In 2006, he won an award for sustainable agriculture
Inputs	3000 tons/year of organic vegetable waste (roots and stems, leaves and other byproducts)

Outputs	Biogas: 240.000 Nm^3/year Heat: 300 MWh/year Electricity: 530 MWh/year 650 tons/year of quality digestate (fertilizer) Water: $14m^3$/ day Each ton of organic waste produces $60m^3$ of biogas. Therefore, the weekly production reaches 4500 m^3 for an average of 75 tons of organic waste
Business environment	The Walloon Region has subsidised 40% of the project.
Economy	Total investment: 1,400,000 Euros Payback time: 3.5 years GSC (certificate for electricity generated through renewable energy) 85€/GCS/mWhe WSC (certificate for thermal energy generated in cogeneration) 85€/WSC/mWtth
Lessons learned	During this project, various difficulties came up and had to be faced. The scientific team of GreenWatt along with external experts dealt with the challenges successfully Some of the challenges met are for example the optimisation of the heat circulation towards Rossel Printing and the insulation of the 1km long pipes. Another challenge faced was the acquisition of the permits, but the fact that the farm is located in an area with very few neighbours played a major role in the process. It also needs to be noted that the generated energy output is higher than originally expected

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Biorecycle SARL

The first biogas unit on a farm in France

Biorecycle is a small company (SARL) located in Migneville, France. There are two associates, with Francis Claudepierre being the farm owner and manager of the installation. This installation produces three different products: electricity, heat and fertiliser for the agricultural land.

Cow manure is one of the biogas plant inputs

In 2000 Francis Claudepierre, inspired by the German example, decided to create one of the first biogas installations on a 100% organic farm in France. As soon as 2001, the feasibility study was complete and positive, and the building work started. At the end of 2003, a biogas unit of 21 kW was ready and started working. After seeing the positive effects of the first biogas unit and in a policy context that favoured the development of such units, Mr Claudepierre decided to create a new biogas plant, integrating the elements of the first one. A year after, the SARL Biorecycle was created and in 2008, the new unit of 190 kW started being constructed.

Biogas facility landscape

In order to ensure the sustainability of the business, the company tries to achieve a good socio-economic balance through the creation of local jobs. The unit requires in average 4 hours of work per day. Furthermore, in the context of “Route des Energies Renouvelables”, three positions for facilitators were created in order to host the 6000 visitors per year (schools, extra-curricular, various groups).

The project is based on an agricultural and environmental approach and it allows a diversification of the activities: food waste are utilised, renewable energy is produced and through the use of the fertiliser, the agricultural production is improved and there is a limitation of the odours. The biogas unit is also integrated in a regional project. The installation was awarded with the title “Pôle d’Excellence Rural” and it was integrated in the “Route des Energies Renouvelables” of the community of Vezouse area (organisation of educational visits).
Biorecycle also plays a major role when it comes to Greenhouse Gas Emissions. After the installation of the unit, the GHG emissions were reduced from 319 tons/year to 107 tons/year of CO_2, equivalent to a 66% reduction of GHG emissions. Another very important aspect is that the installation produces almost 10 times more energy that it consumes; the installation needs fossil energy equal to 223.600 kWh/year, while it produces 1.968.000 kWh/year of renewable energy.

Biorecycle SARL location, near Nancy city

Partners:

Name	Biorecycle SARL
Location	Migneville, France
Basic description	Farm : 115 ha (95 ha of grasslands and 20 ha of croplands) 65 dairy cows (+ 100 of dairy heifers) certified organic in 2000 No other income sources
Technical aspects	250 Kw 1 digester 1000 m3 1 storage tank 2000 m3 1,7 MW per year Labour input : 2200 to 2400 hour per year Heat use : yes 30% for heating the digesters 40% for heat network (for heating 6 houses) 30% to dry fodder Gas use : 100% to produce electricity and heat
Actors	SARL 1 Farmer (70% of share) and 1 associate
Inputs	6 m3/day of farm manure (85% are processed in the biogas plant) 1 m3/day of energy crops 8 m3/day other 60% are imported (200 Km max)
Outputs	1 000 000 m3 of biogas per year 5000 m3 of digestate per year (spread on agricultural lands: spreading plan) Digestate is not processed
Business environment	Subsidies received for construction : 50% (32% from the State, 9% from the French agency for energy (Ademe), 9% from the Lorraine Region Fixed feed tariff guaranteed via law: 11 c€ + 3 c€ when the contract was signed in 2009. Since then the tariff has been raised to 17c€. Since then more biogas plants were constructed, which means increased competition
	for the inputs. The technicians were chosen from Germany, as this is the country where the necessary skills are available.
Economy	Initial investment : 1 000 000 € Estimated investment return : 10 years Electricity sold to the grid at 17 c€/kW No digestate sold Value of heat use : 74 000 €
Lessons learned	The return on investment is good but everyday some technical problems have to be fixed. The labour necessary for maintenance on average is 10 hours per week. The supply of inputs needs to be regular and the sales of heat to the network need to be agreed by contract. The law regulating the use of digestate is very stringent in France and it is forbidden to sell digestate, there has to be a spreading plan Future project : use the heat to process cheese with milk production from the farm

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Agritexia

The first project of a collective agricultural biogas unit in Rhône-Alpes

In 2009 the dairy crisis forced many dairy producers to make important changes: evaluate and change their production system, try to achieve food autonomy and diversify their income. Therefore, 8 GAEC (agricultural civil partnerships allowing farmers to work on common projects on a farm) involved in mixed farming (intercropping and livestock production, recently converted to organic farming) in Ardèche decided to start SARL AGRITEXIA in order to create and implement the first collective agricultural biogas project in the area. The company was founded on July 5, 2010.

AGRITEXIA set up two biogas plants located in Cheminas and Ardoix, with a total power of 440 kW.
The result is that 8,500 tons of wastes are recycled. The net production of renewable energy reached 4905 MWh (electricity and heat from cogeneration) and the emission of 1592 tons/year of CO_2 is avoided. A positive impact on water resources is achieved, the level of food autonomy for the animals on the farms has reached around 65% and, most importantly, the farms now enjoy an additional income.

One of the digesters and the technician of AgriKomp during a training session with one of the farmers

There are 3 major points that make this project stand out as a best practice example. Firstly, it is the way the project is run; AGRITEXIA is based on collective thinking for the development of common work tools (workshops for manure drying, wood pellets and recovery of slurry and manure). The way the decision-making process works requires a high level of involvement from each GAEC which leads to the formation of a dynamic and enriching group that works effectively in the field. The second point is the technical dimension of the project. The installation of two biogas units in Cheminas and Ardoix respectively instead of a very big one as initially planned is an ideal solution to split the distance among the farms. A third biogas plant will be constructed in Eclassan. These three units will be located in a radius of 16 km. The first one is 190 kW, the second 250 kW and the third one will be 250kW.
The third reason is the optimized financial plan of the project. Only 21.7% of the budget comes from public subsidies (FEADER, French energy agency Ademe, and the Regional Council). This allows a payback time of 6.8 years. Moreover, the Ecosystem Foundation (Danone) did an analysis on whether crowdfunding would be an option for the project, but this option proved impossible due to legal and technical difficulties. However, AGRITEXIA and Danone have a continuous relationship which has facilitated the implementation and the funding of the first phase of the project.

Location of the three plants, aprox. 100 km. south of Lyon

First unit has been funded by two regional banks, which have also offered their expertise and they are also reviewing the case of funding the second site. This work started in 2013 with an end date in 2015. The first biogas unit in Cheminas was completed in September 2014. The public sponsors have imposed monitoring for the first 4 years of the project. AgriKomp, the construction company of the unit is in charge of its proper functioning. The farmers have attended training sessions so that they can monitor installation and perform the technical routine maintenance of the equipment. There is also an electronic management cabin where the whole equipment is monitored and production recorded. An agricultural Consultancy (SCARA) is also involved in the project; they work as project management assistants and are highly involved in the different aspects.

The only real difficulty that has come up so far with the implementation of the project is a significant delay in the hearing about the application for connection to the electricity grid, which led to a general delay of the project and to the necessity of adapting the administrative deadlines linked to the FEADER funding.

Name: Agritexia

Location

Ardèche, Rhônes-Alpes, France
Municipalities where the plants are located: Cheminas , Ardoix (Eclassan in construction)
Municipalities where the farmers are located (see the map): Arras-sur-Rhône, Cheminas, Ardoix, Quintenas, Boirayons, Vaudevent.

Basic description

8 farms certified organic.
GAEC de l'orée du bois (located at Arras sur Rhône)
GAEC Coste (located at Cheminas)
GAEC Feasson (located at Ardoix
GAEC Blaches (located Quintenas)
GAEC Boirayons (located St Romain d'Ay)
GAEC des Vents (located (Vaudevent)
GAEC de Marsan
GAEC Bardon
Total: 1800 hectares- 713 dairy cows – 3 goat shed, 1 poultry shed.

Technical aspects

Equipment	Plant in Cheminas	Plant in Ardoix
Receiving pits	2 receiving pits (liquid and solid) – storage capacity 14 days	idem
Digesters	2 digesters (1200 m3) in parallel + 1 post-digester + 1 pit for storing the digestate	idem
Biogas storage	High quality double membrane	idem
Dual-fuel cogeneration	190 kW	210 kW
Biogas treatment to remove hydrogen sulphide and for recooling the biogas	Treatment of condensates and active carbon filtering	idem

Actors

Information thanks to contact and meeting with SCARA (private consulting company providing advice to farmers)
Farmers lead the project ("a farmers group project above all")
Technical choices delegated to SCARA
Producer of equipment; AGRIKOMP. Good reactivity in case of technical problems.
The farmers received a technical and biological formation by AGRIKOMP in order to be able to do the routine maintenance.

Inputs

Data for substrates	Tons/year	% Dry Material	Origin
Dairy cattle slurry	4 027	8.5	Agricultural
Dairy cattlemanure	6 010	25	agricultural
goat manure	575	23.9	agricultural
chicken manure	1 120	73	agricultural
Grass silage	792	30	agricultural
Wheat middlings	240	88.1	agricultural - exogenous
Grass clippings	350	26.85	Local community
Residues from apples and fruits	100	22	agricultural - exogenous
Fresh whey	2 500	5	agricultural - exogenous
TOTAL	15 714 tons	Maximum distance : 16 km.	

Outputs

Energy balance: Electricity (see table below)

	Cheminas	Ardoix
Production of electricity MWh	1 520	1 680
Consumption for their own use	91,2	100 ,80
Net production of renewable electricity MWh	1 248,80	1 579,2
TOTAL Net production of renewable electricity MWh	2 828	

injection into the grid ; Income/year : 599 000€

Energy balance: Heat

	Cheminas	Ardoix
Gross production of heat MWh	1 483,81	1 640
Net production of heat MWh	1 023,221	1054,05
TOTAL net production of heat MWh	2 077,27	

Energy balance: synthesis of the material balance and and biogas recovery

	Site de Cheminas	Site Ardoix
Raw materials	6 819 tonnes	8 894 tonnes
Biogas	599 949 m3	701 258 m3
digestate	6 170 m3	8 155 m3
Electric power	190 kW	210 kW
Electric efficiency	42%	42%
Thermal power	180 kW	200 kW
Thermal efficiency	40%	40%
Heat production	1 447, 6 Mwh/an	1 600 Mwh/an

Use of the heat in the digester	32%	37%
Thermal energy recovered	77% (1 115,7 Mwh/an)	80,9% (1 294 Mwh/an)
Production of electricity from the cogeneration	1 520 Mwh	1 680 Mwh

Legal aspects

Private company created in 2010 by 8 already existing "groupements agricoles d'exploitation en commun" (GAEC) (farmer's economic interest groups).
100% of the capital of the company belongs to the farmers.
Predicted budget: 3 596 121€ (but cost reductions are already obtained due to the commercial negotiations facilitated by the exemplary aspect of the project)
Public subsidies: 780 000 € (Region Rhône-Alpes, ADEME, Europe – FEADER) = 21,68%)
Private investors: Crédit Agricole sud Rhône-Alpes+ Crédit Agricole Centre-Est + the 10 farmers
Subsidies (see the table below)

	Provisional financial plan on the amount of expenses		Provisional financial plan on the amount of eligible expenses	
	Montant € HT	%	Montant € HT	%
ADEME	290 028,50	8,10	290 028,50	8,45
DRAAF	290 028,50	8,10	290 028,50	8,45
Conseil Régional	200 000	5,6	200 000	5,85
Farmers	2 818 064	78,20	2 648 064	77,25
TOTAL	**3 598 121**	100	**3 428 121**	100%

Economy

Initial investment: 3.428.121 Euros Estimated investment return: 8 years without subsidies
Cost of Operation and amounts of eligible expenses (see the table below)

Posts for investment	Cheminas unit €HT	St Romain unit €HT	Eligible amount €HT
Studies	15 000	15 000	0
Drying of hay	70 000	70 000	0
Biogas processing	841 887	843 183	1 685 070
Concrete, earthworks	331 463	425 031	756 494
local technics	30 000	30 000	60 000
Connection	80 000	100 000	180 000
Woodwork	11 000	14 100	25 100
Finishes	102 660	102 660	205 320
silos	45 900	52 000	97 900
Heat resources	156 007	104 230	260 237
Building material storage	0	30 000	30 000
Material loading and weighting bridge	20 000	20 000	40 000
AMO	44 000	44 000	88 000
Amount of expenses per unit	1 747 917	1 850 204	
Amount of total expenses		3 598 121	

Lessons learned

Managing such a big project is the main challenge, maybe harder than finding money or dealing with the technical aspects. The challenge is to keep the motivation and consensus.
The farmers chose a "1 man 1 vote" system to adopt all the decisions, which sometimes needed many meetings, but in the end, the process was fluid enough. SCARA (the technical partner) played a big part all along the project.
Future perspective: unit number 2 at Cheminas (2015)
To be confirmed: unit number 3 at Eclassan (2016).
The French minister of Agriculture visited the operation in 2013, and promised he would come back for the official inauguration (2015).

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