



# Sustainable small-scale biogas production from agro-food waste for energy self-sufficiency

## D6.4 Papers in international specific journals (2)



Co-funded by the Intelligent Energy Europe  
Programme of the European Union

IEE/13/477/SI2.675801

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## ***PUBLICATION 1.***

- *JTI sought for a small-scale biogas plant in Sweden, who uses some kind of agri-food waste for biogas production, and found a pig farmer just outside the small town Skara (in the middle of Sweden). The farmer uses pig manure and used cooking oil from a food processing facility just four kilometers away, and the plant provides electricity and heat to his farm.*
- *The article about his business idea was published in an international paper made in Sweden: Bioenergy International No 76, 7/2014 ([www.bioenergyinternational.com](http://www.bioenergyinternational.com)). The paper is produced in cooperation with the European Biomass Association (AEBIOM) and published 7 times a year.*



## Pig manure and used cooking oil for heat, power and odour reduced fertiliser

Anders Gustafsson uses pig manure and used cooking oil in his biogas plant on a farm in Sweden. Located just on the outskirts of the town of Skara, the biogas plant provides electricity and heat to his farm. It is a good example of how small-scale biogas production can be used in urban areas to minimise odour from animal husbandry.

**ANAEROBIC DIGESTION OF PIG** manure greatly reduces odour associated with the manure. Furthermore the digestion process makes the nitrogen in the manure more accessible to the crops when it is used as a fertiliser.

— It is important for me to be able to spread the liquid manure on our fields without disturbing my neighbours, explained Anders Gustafsson the owner of the farm-based biogas plant.

### Pig manure and used cooking oil

His farm is located just outside Skara, a busy market town with a population of around 11 000 in southwest Sweden. Gustafsson has 270 hectares arable land cultivated with cereals although pig production is his main business. His 6 000 pigs generate about 5 000 cubic meters of manure at 8.6 percent dry matter content annually that is used in the biogas plant. The rest of the feedstock is used cooking oil sourced locally from Scan, a food

processing facility just four kilometers away. He buys about 40 cubic meters oil a year through a farmer-owned joint purchasing company Kretslopp Skaraborg.

— I took part in the foundation of Kretslopp Skaraborg so the owners of nearby biogas plants would not have to compete with one another for energy-rich feedstock, said Anders Gustafsson.

### Enough supply

The supply of cooking oil is still good, since none of his neighbours that planned for biogas production four years ago have built their plants yet.

Anders Gustafsson previously digested residues from a potato processor in Skara, but that industry is now closed.

— Potatoes are rich in energy and a good feedstock, but it also contained a lot of water that made it less valuable, commented Anders Gustafsson.

Gustafsson thinks that it is difficult to quantify exact gas produc-

tion from the different feedstocks because the quality varies a lot and you have to try each feedstock out.

— You cannot even say how much biogas that manure can provide, because the energy content of manure depends on the feed ratios given to the animals.

### Investment help

The biogas plant at Brunsbo Farm is constructed from small-scale Swedish technology. It was built in collaboration with the episcopate of Skara and received investment help from the Swedish Board of Agriculture. Up until 2013, farmers and other rural entrepreneurs in Sweden could get a grant covering up to 30 percent of the cost of building a biogas plant. The feedstock at Brunsbo, like most other small-scale biogas plants in rural Sweden, is based on manure combined with various rest products from the food processing industry.

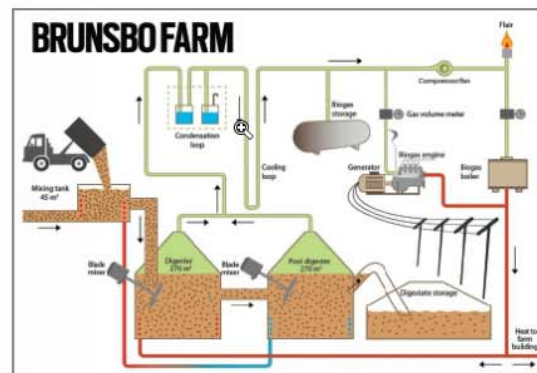
The Brunsbo plant has been in operation since 2010 and generates 150 000 Nm<sup>3</sup> of raw gas annually.

The gas is converted to 750 MWh of energy, with equal parts going to electricity, heat for external application, and heat used internally in the process to pre-warm the plant's substrates.

— It took us around two and a half months to get the biogas plant going. We took 80 cubic meters of digester inoculum from a biogas plant nearby, Gustafsson said.

### Two-stage digestion

Digestion takes place in two stages, each with its own 270 cubic meter digester. The primary digester receives the substrate from a 45 cubic meter mixing tank where the substrate is also preheated with heat recovered from the post digester through heat exchange tubes. The digestion takes place in a mesophilic process at 38 degrees Celsius. Both digesters are equipped with oblique blade mixers. From the constantly stirred primary digester, material flows to the post digester, and then to the digester storage that is covered to minimise gas leakage.



A schematic of inputs and outputs of the two-stage biogas plant at Brunsbo Farm. According to ITI, a plant this size would require a ballpark investment of SEK 3 - 6 million (Illustration: Tove Insk/Godnatbild.se).

The produced gas is taken out of the top of the digesters and led through a cooling loop for drying. Subsequently, the gas can either be stored in a low-pressure storage unit or used directly as fuel in the gas engine generator, a rebuilt V6 engine with a 40 kW generator, to produce electricity and heat — or in a gas boiler that only produces heat. The post digester is cooled by heat exchange with the mixing tank.

The surplus heat is used to heat the piggery, farm shop and staff areas. The electricity is used on the farm and the excess is sold to the national grid.

— It has been very easy to sell the electricity. We have been treated very well by our local power company, Skara Energy, commented Anders Gustafsson.

### Low profit

Evaluators following the development of the biogas plant consider it to be commercially viable. But is it profitable?

— It breaks even, but I had honestly expected more. With these low energy prices that we currently have it's pretty tough to get good profitability in such a facility, says Anders Gustafsson.

Gustafsson does, however, see many advantages of the facility beyond the pure economics. Having a good relationship with his neigh-

bours and reducing nitrogen runoff from the fields are two benefits that are hard to put into monetary terms. Anders Gustafsson has a passion for environmental management and a strong belief in the potential of bioenergy production, and he thinks that the biogas plant is an exciting project that contributes to the overall development of his farm.

### Manure-based grant?

Like many other Swedish farmers with manure based biogas plants, Gustafsson hopes that national plans for grants based on biogas production from manure will be a reality. The Swedish Board of Agriculture has petitioned the European Commission (EC) and is waiting for confirmation that the suggested grant scheme is in compliance with EU state aid rules. In order to start receiving requests for assistance. However, the situation at the end of November is still unclear. According to the plan the manure-biogas grant would last for ten years and could involve up to 0.02 Eurocents per kWh produced.

— I personally think that all operations should set out to support themselves, but a biogas manure grant at 0.02 Eurocents would give me an extra 6 500 EUR a year, and that would mean a lot to me, says Anders Gustafsson.



— It is important for me to be able to spread the liquid manure on our fields without disturbing my neighbours, explained Anders Gustafsson.



Text: Carina Johansson, ITI – Swedish Institute of Agricultural and Environmental Engineering Photos: Anders Inroberg and Scan

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### FACTS

• **Biogas3** – biogas for self-sufficiency  
The biogas plant at Brunsbo Farm is an example of a type of biogas plant promoted within the EU project Biogas3. In this two-year project ITI – The Swedish Institute of Agricultural and Environmental Engineering is cooperating with actors from six European countries (Spain, France, Italy, Germany, Poland and Ireland). The goal is to promote small biogas plants where waste and by-products from the food industry and agriculture are converted to energy for self-sufficiency. The project is led by the Spanish Institute, AINIA.

• **Energy-rich substrate** from Kretslopp Skaraborg  
The company Kretslopp Skaraborg (name meaning Recycling in the geographic area Skaraborg) brokers energy-rich substrate from the food industry and agriculture to biogas plants in the region. The company is probably the only one of its kind in Sweden. Started in 2011 and owned by farmers, it aims to secure agricultural biogas production in the area Skaraborg from economical and quality aspects. Demand for substrates is now greater than availability. Kretslopp Skaraborg plans to build their own hygienisation plant so that small biogas plants can afford to utilise animal by-products from slaughterhouses while complying with the EU animal by-product regulation.

• **The biogas plant at Brunsbo Farm** is situated near the city Skara in Sweden. Anders Gustafsson runs a biogas plant with feedstock from pig manure and cooking oil. The Brunsbo Farm biogas plant is constructed from small-scale Swedish technology, with two digesters of 270 cubic meters each. In the 45 cubic meter below-ground mixing tank, the substrates are preheated with heat recovered from the post digester. Some of the feedstock at Brunsbo Farm comes from used cooking oil from meatball production at the local food processing facility Scan. Photo: Scan.

## ***PUBLICATION 2.***

- *Summary related to different terms for biogas production in Europe. The article includes an overview about the situation of small-scale in Europe providing examples of the support (or lack of support) in some BIOGAS3 involved countries.*
- *The article about the insufficient profitability as a general problem for small-scale biogas investment in Europe and current support for BIOGAS3 participating countries: Bioenergy International No 84, 1/2016 ([www.bioenergyinternational.com](http://www.bioenergyinternational.com)). The paper is produced in cooperation with all the partners of the project and coordinated by JTI.*





# Different terms for biogas production in Europe

Equipped with a 105 kW microturbine this biogas plant is sited on an organic crop farm in Hagevik, Sweden. Here the co-digestion of by-products from food industry and manure from nearby animal production provides high value digestate for the arable farmer. Photo courtesy JTI.

Insufficient profitability is a general problem for small-scale biogas investments in Europe. Something that a recently concluded EU-funded project called BIOGAS<sup>3</sup> sought to address. The aim is to assist agro-food companies improve plant sustainability and profitability by providing concepts for energy self-sufficiency and business collaboration models.

**ECONOMICAL SUBSIDIES** are important for stimulating investment into small-scale biogas production, but they differ a lot between European countries. Apart from having an attractive business model the establishment of small biogas plants are governed by legal and financial frameworks. However as discovered by the 10-partner BIOGAS<sup>3</sup> consortium, on top of EU-laws and directives each country has its own financial regulations and even its own legal frameworks based on the EU rules, and both change over time.

## German cut backs

While some countries are at the beginning of a biogas expansion, the European biogas forerunner Germany is cutting back financial support for biogas production. For a long time Germany has had generous support for biogas production, with a guaranteed 20-year bonus for electricity from biogas supplied to the national electricity grid. But with a new law for renewable energy sources (RES) in 2014, all bonuses were cut and the basic feed-in tariff considerably reduced.

— Since 2014, the establishment of new biogas plants in Germany as well as the installed electrical capacity has almost come to a complete stop, commented Katharina Hartmann, Project Manager Bioenergy at Renac, a Germany-based leading international provider of renewable energy training and energy efficiency education.

## New French feed-in tariff

In France there is a goal for 1 000 agricultural biogas plants to be built by 2020. Currently there are 200 farm units out of a total of 400 biogas plants in urban, farm and industrial sectors. Of these 200 farm plants approximately 35-55 are 100 kW or smaller.

— This is an over-optimistic goal. The public finances are not good enough to support such an expansion, said Pascal Levasseur, engineer at the French Institute for

Pork (IFIP), a research institute specialized in the agricultural food industry.

A new feed-in tariff for farmers with existing plants is designed to compensate the lack of profitability. The energy-efficiency bonus is now systematically integrated in the basic feed-in tariff. Thus far the tariff is only applicable for plants built before October 2015 and with an installed capacity of less than 500 kW, which means farm scale plants up to medium size. The new feed-in tariff in EUR 0.18 per kWh for power less than 80 kW, EUR 0.165 between 80 and 500 kW and a linear interpolation between 80-500 kW.

— If at least 60 percent of the substrate is manure, you can get an additional PLN 0.04 per kWh, explained Levasseur.

All together it comes to EUR 0.22 per kWh. Furthermore, an on-going evaluation may result in expanding the new feed-in tariff to also cover new-build biogas plants after October 2015.

— That would be important for

the development of small-scale biogas production in France. It is very expensive to build biogas plants here, about EUR 10 000 per kWh for a small-scale plant, so everybody is hoping for the new rules to be expanded to include new plants, remarked Pascal Levasseur.

## Promoting manure use

In Italy there is a law promoting smaller biogas plants, under 100 kW, that use various organic wastes including manure giving EUR 0.0085-0.0216 per kWh depending on the effect of the electric engine.

In Sweden there is a corresponding support scheme for biogas from manure digestion, which gives about EUR 0.04 per kWh with 2016, a doubling of the 2015 rate. However, unlike many other countries Sweden has a market based green electricity certificate system instead of a fixed feed-in tariff system for renewable power. The total compensation rates for electricity sold to the grid are set on case-by-case basis and are dependent on the interest from the local utility com-

pany. The maximum total rate is currently around EUR 0.11 per kWh including base rates, green certificates and the manure bonus. In reality though most plants receive much less.

## Power price and self-consumption

Sweden has comparably low electricity prices due to significant hydropower resources, and an active policy ensuring high electricity production capacity to enable a competitive advantage on the export market for its energy intensive base industries such as iron and steel and forest industries.

— This makes biogas-based cogeneration extra challenging here. But with a continuation of the capital investment support programme, a grant for up to 40 percent of investment, we still hope that some new small-scale biogas plants with particularly favourable local conditions will be built over the coming few years, commented Gustav Rogstrand, at JTI - Swedish Institute of Agricultural and Environmental Engineering.

As in Sweden there is no feed-in tariff system for electricity from new biogas plant installations in Spain. Instead some new regulations for self-consumption of biogas entered into play at the end of 2015. For electricity self-consumption installations larger than 10 kW, a biogas producer is forced to pay a fee to support the system but can then also sell any excess electricity to the market.

Also in Poland there have been some positive changes for small-scale biogas production in the last years. The responsibility and cost for installing security and measurement systems have been pushed from the plant owners to the power utilities. The utilities can no longer charge small biogas producers an electricity grid connection fee.

A new law on renewable energy sources (RES) with a feed-in tariff for biogas plants up to 10 kW with PLN 700/MWh (= EUR 0.16/kWh) is expected.

## Big potential in food industries

Small-scale biogas plants in Europe are often located on farms, with access to substrates from organic feedstock like manure and crops.

Even though significant amounts of organic waste are coming from food- and beverage industries, there have been few investments in biogas plants at small food industries. An analysis by the BIOGAS<sup>3</sup> project reveals that a lack of knowledge, lack of skills and lack of confidence in biogas technology are reasons why, in addition to a strong dependence on economical subsidies.

— There is though a big potential for businesses in both agriculture and the food industry to cut waste management costs while producing their own energy, by using food- and other organic waste in a small-scale biogas plant, said Gustav Rogstrand, at JTI.

Rogstrand added that the expansion of small-scale food processing businesses on or in the direct vicinity of farms that cater to the increasing market for locally produced organic food was one such growth area in Sweden.

In contrast Levasseur said that the French food industries do not seem interested in biogas production.

— The supply of food waste is uncertain. You can't get a food waste contract for more than 6-12 months. That contributes to the unprofitability for co-digestion plants, said Levasseur.

According to him this is the reason for the growing interest amongst French farmers for energy crops.

— I think that the development in France will be the same as in Germany, where energy crops are used for digestion. But it will take several years to get social acceptance for this, because of the fear of competition with food production, said Pascal Levasseur.

Gustav Rogstrand at JTI in Sweden thinks that focusing on production of biogas from food



At the Baechler cheese factory in France, the steam for cheesemaking comes from a biogas-fired boiler. 2 GWh/year biogas from wastewater treatment.



The Campile Community plant (c. 100 kW heat only) in Kilkenny is one of only three small-scale units in Ireland. Photo courtesy Noel Gavigan/BEA.

processing waste would be a faster way forward, at least in the short term.

— I am not against energy crops if implemented in a sustainable manner, but no one can dispute that biogas production from food processing waste is an easier sell politically. I think it is time to ensure uniformly adequate conditions for

the small-scale waste based biogas industry. That would allow the biogas industry in Europe, at least the small-scale part of it, to grow while avoiding the food and fuel debate, said Rogstrand.

Text: Carina Johansson, JTI - Swedish Institute of Agricultural and Environmental Engineering BB4/S179/A/S

## Facts: BIOGAS<sup>3</sup> project

Ten partners from France, Sweden, Spain, Poland, Germany, Italy and Ireland have participated in the two-year-project, co-funded by the EU Intelligent Energy Europe (IEE) Programme. BIOGAS<sup>3</sup> (Sustainable Small Scale Biogas from Agri-food Waste for Energy Self-Sufficiency) has been dedicated to developing and promoting small-scale anaerobic digestion (AD) technology for biogas plants ≤ 100 kW to allow farmers and food processors convert animal slurries and food processing wastes into biogas that can be used on site for heating and electricity – or potentially for vehicle fuel. Details available on <http://www.biogas3.eu/>

## No. of ≤100 kW plants

Estimated number of small-scale biogas plants in some EU countries at farms and agro-food industries:

France	35-55
Germany	660
Poland	6
Italy	69
Spain	9
Sweden	25-40
Ireland	3