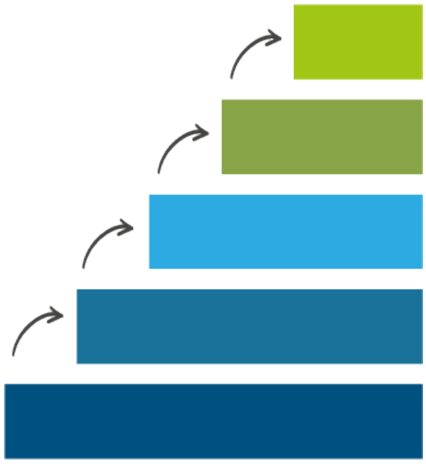
BALTIC INDUSTRIAL SYMBIOSIS

Generic case

# SYMBIOSIS OPPORTUNITIES FOR BIOGAS



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## THE MAIN POINTS

Industrial symbioses, which increase production or recycling of biogas, can generate economic and environmental benefits.

There are often several internal opportunities to increase biogas production, but an even larger output and improved utilization can be achieved by cooperating with other companies. For example, through industrial symbiosis, utilizations of industrial wastewater, residual organic fractions and/or surplus heat can lead to increased production of biogas. Disposal of these resources is typically very expensive, but through symbiosis, it can constitute a source of income.

At sewage treatment plants, unused surplus biogas from digestion tanks can be utilized by nearby companies, which can convert fossil consumption for process into renewable energy. Thus, the bottom line can be strengthened for both suppliers and recipients.

You can read more about the utilization of residual organic fractions in generic case “Residual organic fractions”.

## UTILIZATION

Surplus biogas can be utilized in several different ways, including:

- For transport purposes where it can displace petrol/diesel
- For process heating where it can replace fossil fuels
- Upgrading to natural gas and possible storage, and utilization as balancing power in the overall energy system
- Power and heat production in a gas engine

## GREAT SAVINGS AND ENVIRONMENTAL BENEFITS

Both increased production and higher utilization lead to an improved economy. For example, in the form of increased revenue, as a result of further sales of biogas or internal use of biogas at a wastewater treatment plant because of reduced costs for wastewater treatment or reduced energy demand from an external energy source.

Environmentally, increased production and utilization of biogas lead to a higher proportion of renewable energy in the energy system. Additionally, biogas is a renewable energy source that can be used where there are only a few other green alternatives. For example, heavy road transport can be converted into renewable energy by using biogas.

There are also several other positive environmental effects of increased production and utilization of biogas, such as emission of significantly fewer ultrafine particles, compared to burning of diesel for transport purposes. Ultrafine particles are harmful to humans.

## INCREASED BIOGAS PRODUCTION

Biogas is mainly produced either at dedicated biogas plants (which are typically based on animal manure and added organic residual fractions or energy crops) or in connection with the digestion of sludge at treatment plants, where the production of biogas is a part of the treatment of sludge from a purifycation process. Biogas is typically burned in a gas engine, where the produced electricity is supplied to the electricity grid, and the produced heat is sold as district heating. Typically, the generated heat is used internally at the treatment plant.

In both cases, there are several possibilities for increasing the biogas production. One option is to add residual organic fractions with a high gas potential or add sewage sludge with a high content of biologically convertible material (e.g. primary sludge).

The increase in biogas production usually creates a surplus of biogas - a larger production of biogas than what a wastewater treatment plant or a biogas plant can utilize.

It creates potentials for utilization of surplus biogas by other companies through industrial symbiosis. Several examples indicate that use of this surplus gas in e.g. transport is both environmentally and economically beneficial.[1]

A wastewater treatment plant or a dedicated biogas plant can increase biogas production through internal optimization, for example by:

• Switching from mesophilic to thermophilic digestion which means that the temperature in the biogas reactor increases from approx. 38 degrees to about 55 degrees[2]. At such a temperature increase, the rate of gas production increases, whereby larger gas yield can be obtained at the same retention time

• Adding pretreatment steps, e.g. low-temperature hydrolysis[3]

• Installing a heat pump on an outlet from a treatment plant and thereby utilize the produced heat as heating of biogas reactors

• Establishing a primary sedimentation tank or another separation, since the sludge has a higher biogas potential than sludge that has gone through chemical/biological purification processes

### UASB REAKTORS

A UASB (Up flow Anaerobic Sludge Blanket) is a newer biogas reactor type which is particularly suitable for (pre-) treatment of wastewater with a particularly high content of biologically convertible material. Compared to a traditional digester, a more substantial proportion of biologically convertible material is converted by treatment in a UASB reactor. The reactor can advantageously be applied early in the cleaning process, and thus, reduce the need for aeration in a next purification step.

The advantage of the method is that it reduces the energy consumption for the wastewater aerating and ensures a higher overall biogas production. Thus, a more significant total energy surplus can be achieved.

[1] See "Optimal udnyttelse af varmeenergi fra spildevand", Feasibility Studie, Grontmij | Carl Bro, August 2010

[2] The microbes that are involved in the biogas process have better growth conditions, so faster gas production is achieved. The process has a higher energy consumption for heating but can result in relatively higher energy output.

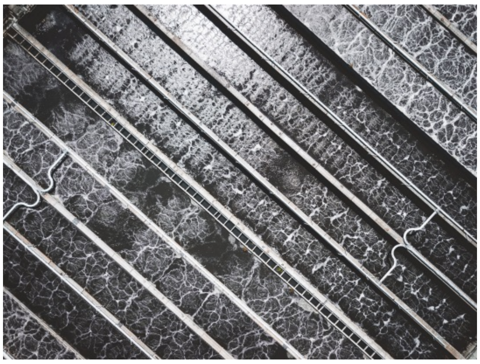
[3] Low-temperature hydrolysis is a pretreatment method in which complex and long-chain molecules are decomposed into an easily degradable organic substance which is easier to convert to the fermentation process in a digester. Thus, a more significant amount of material is converted, and more biogas is produced.

The following describes two general scenarios in which biogas production is increased through industrial symbiosis, either by conversion of a plant or by changes in added materials.

## SCENARIO 1 - INCREASED BIOGAS PRO-DUCTION BASED ON ORGANIC RESIDUAL FRACTIONS

A company delivers organic waste with a high gas potential to a dedicated biogas plant or a digester at a treatment plant, which increases its gas production. The company purchases part of the increased production, either in a form of biogas or energy produced from biogas as offsetting to the input resources.

## SCENARIO 2 - INCREASED BIOGAS PRODUCTION FROM ADDED WASTEWATER



A company discharges wastewater with a high content of biologically convertible material. This content can lead to increased costs for water cleaning at a treatment plant. However, the biologically convertible material provides the opportunity to increase gas production; either in an existing digester or even better in a so-called UASB reactor (see the info box). The increased gas production can be utilized to reduce the treatment plant's need for input energy and thus reduces costs. In several cases, if the quantities of biogas are large enough, the biogas can be exported or used for energy production, which also can be sold. It will create a source of income that can either offset the company's costs for wastewater cleaning or be shared between the company and the treatment plant.

## UTILIZATION

Biogas can be used for many purposes and, is a very versatile renewable energy source. The following describes various ways in which biogas can be utilized. As with the production of biogas, the utilization of biogas can be improved both through internal optimization and through symbiosis with other companies.

As a starting point, the usefulness of biogas can be increased by burning the gas in a modern condensing gas furnace rather than in an (older) gas engine. The gas furnace produces only heat but represents a significantly higher annual efficiency (if all energy is sold).

It is also an option to upgrade the biogas to pure methane (natural gas), whereby it can be sent to a natural gas network and transported to other applications or stored for later use. When upgrading to biogas, the existing natural gas infrastructure is used; otherwise, challenging storage of renewable energy is possible. The storage of biogas can be advantageous, as it increases flexibility and provides more utilization purposes.

Traditionally, biogas is upgraded by removing the original content of $CO_2$ (about 40% of the volume of biogas) through one of several possible cleaning techniques. Potentially, basic industrial residues, such as lye products or slaked lime, will contribute to $CO_2$ purification and thus constitute an industrial symbiosis. New technologies are also being developed, where $CO_2$ in biogas is microbially converted to methane, which increases the total amount of natural gas. The latter technology requires addition of hydrogen, which can be produced by using e.g. surplus wind power. It makes the technology even more attractive, as it can help to integrate wind turbine flow and thereby bind the energy systems together.

As an alternative to upgrading and transmission through a natural gas network, biogas can be used to displace process energy based on fossil fuels. Such conversion can be one of the only real alternatives to fossil fuels, as requirements for the process or the process plant, for example, exclude the use of district heating.

### SYMBIOSIS EXAMPLES

**ENERGY SYMBIOSIS FAXE** - "Energy Symbiosis Faxe" is a collaboration between four companies in Faxe, Denmark, based on utilization of several surplus energy flows. One of the symbiosis's real cooperation potentials lies in the utilization of surplus biogas production from Faxe Utility's treatment plant to produce process heat at Haribo Lakrids A/S (producer of candy).
In the symbiosis, biogas is produced in a UASB reactor, where both wastewater from Haribo and another neighboring company is treated. A biogas surplus is created by a wastewater treatment plant if an efficient condensing gas furnace with high annual efficiency is installed. Surplus biogas can be used in connection with Haribo's production, which thus saves on the purchase of natural gas.

**SKÆLSKØR SYMBIOSIS** - Today, two neighboring companies SK Forsyning (utilities) and Harboe Bryggeri (brewery) each have their own sewage treatment plant. By converting to an overall treatment of these two wastewaters fractions, an improved purification process can be achieved because a mixture of the fractions is better for the biological process than separately. In addition to the interconnection of the wastewater fractions, a reorganization of the plants with the establishment of a primary sedimentation tank is investigated. The sludge from this tank can be digested in a possible newly established digester or transported to a digester at one of SK Forsyning's other treatment plants. Such treatment will result in a significantly increased production of biogas that can be used locally or upgraded and distributed via a natural gas network.

## ECONOMIC PROFIT

The financial gain for a company or utility that increases the production of biogas or releases a more significant amount of gas for external use comes from the surplus that can be generated by selling surplus gas.

The best opportunities for a financial gain can be found if it is possible to make necessary changes in the production or selling of biogas in connection with, for example, another planned reorganization of plants. It could be in connection with the proposed restructuring of treatment plants to handle more copious amounts of wastewater, or in connection with the replacement of worn-out equipment. In these cases, a holistic approach in which external symbiosis possibilities are considered, can lead to significant improvements in the overall economy.

### SYMBIOSIS EXAMPLE

#### ECONOMIC PROFIT IN ENERGY SYMBIOSIS FAXE

If the Energy Symbiosis Faxe project with surplus biogas utilization is realized, it can displace a considerable amount of natural gas consumption at Haribo. It reduces costs and strengthens competitiveness. The savings are estimated to be large enough to repay investments in, for example, pipe laying and new burners in boilers in under three years, if energy saving subsidy or similar subsidies can be used.

Ratifying the allowance for biogas to process further strengthens the economy and the project partners can jointly reap an even higher financial gain.

As the overall utilization rate in a modern condensing gas furnace can be more than 30% higher than in a gas engine, there are good opportunities to increase profit and thus improve the bottom line. For a utility company, it means a better overall economy for consumers and for the company that produces biogas, higher income means stronger competitiveness.

### SYMBIOSIS EXAMPLE

#### ECONOMIC PROFIT IN SKÆLSKØR SYMBIOSIS

The merging of cleaning processes in Skælskør symbiosis will not only save costs for wastewater treatment. The symbiosis will also lead to a reduction in the purchase of natural gas at the two companies, as natural gas is displaced by produced biogas. Overall, the financial gain can amount to 1 million euro annually.

## ENVIRONMENTAL PROFIT

A higher utilization rate of the produced biogas means that a more considerable amount of fossil fuels can be displaced and thus reduces greenhouse gas emissions.

Biogas, and especially bio natural gas, is a particularly attractive renewable energy source, as it is now one of the only real alternatives to fossil fuels that can be stored. It can replace diesel in heavy transport. Another example is that bio natural gas can replace fossil fuels such as heavy fuel oil (HFO) or natural gas in processes where alternatives such as woodchips are either not profitable or technically feasible. It can, for example, be in asphalt or brick production.

The possibility of storing energy, in the form of bio natural gas stored in the already existing natural gas network, is also advantageous. New advanced methods also provide opportunities for upgrading biogas directly to methane using hydrogen generated with surplus electricity from e.g. wind turbines.

In this way, $CO_2$ is not removed from the gas and discharged to the atmosphere, but converted to methane, which results in higher overall yield and reduces greenhouse gas emissions.

If biogas is used for transport purposes, reduction of ultrafine particles emission can also be achieved, which means improved air quality, as these particles are harmful to humans.

## SYMBIOSIS EXAMPLES

### ENVIRONMENTAL PROFIT IN ENERGY SYMBIOSIS FAXE

Surplus biogas from the Faxe Wastewater treatment plant can potentially displace more than 10% of the natural gas consumption for process heat at Haribo Lakrids A/S. It will lead to an annual reduction in $CO_2$ emissions of about 500 tons of $CO_2$. At the same time, a reduction in the discharge of greenhouse gases from the displaced natural gas saves limited fossil energy resources.

### ENVIRONMENTAL PROFIT IN SKÆLSKØR SYMBIOSIS

In Skælskør symbiosis, the interconnection of the two wastewater fractions, as well as the utilization of sludge and biomass for biogas, will result in an estimated reduction of a total of 2000 tons of CO2 per year. Additionally, the improved biological process in the interconnection of the wastewater will result in cleaner wastewater.

## BARRIERS

There are several different technical and/or legal barriers that can hinder the establishment of a symbiosis which can increase the production or utilization of biogas.

### RATIFICATION OF SUBSIDY TO BIOGAS IN THE EUROPEAN COMMISSION

One of the main barriers to biogas symbiosis cooperation is the lack of acceptance of subsidies to biogas within process and transport in The European Commission. Until the ratification of biogassubsidy, there will be significant distortion in possible subsidies, which strongly favors biogas burning in a gas engine for cogeneration. It means that several projects, where an industrial company would like to convert their consumption to biogas, must be shelved, and instead invest in a less optimal solution.

Similarly, the lack of ratification is a significant barrier to the utilization of biogas in the field of transport.

### NEED FOR INVESTMENT

There may be a relatively significant investment required for the conversion of biogas plants and process or transport consumption to biogas, which can be an essential barrier to the establishment of green industrial symbiosis with utilization of biogas. As mentioned earlier, it is therefore particularly advantageous to make such investments if there is a need for reconstruction or new equipment.

### UNCERTAINTY REGARDING THE FUTURE FRAMEWORK CONDITIONS FOR BIOGAS

The uncertain prospects for the framework conditions for production, sales and use of biogas reduce willingness to invest in both biogas plants and biogas processing plants.

This case reviews symbiosis possibilities for biogas and aims to inspire with better utilization of this residual by describing options and benefits of such symbiosis. Please, don't use the case as a design or decision basis.