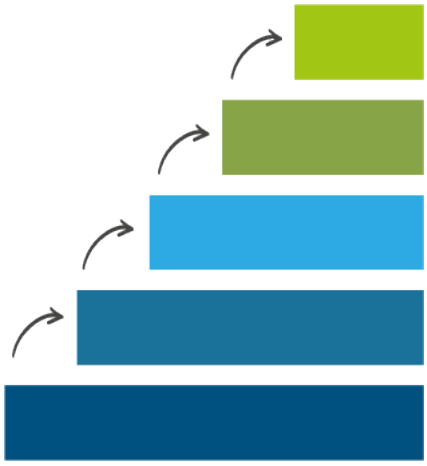
BALTIC INDUSTRIAL SYMBIOSIS

Generic case

SYMBIOSES WITH SEWAGE SLUDGE



SYMBIOSIS CENTER DENMARK
DANSK SYMBIOSECENTER

interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

THE MAIN POINTS

The utilization of sewage sludge in industrial symbiosis generates both economic and environmental benefits. Sewage sludge is in some cases already utilized as an energy source and fertilizer. On the other hand, it is possible to achieve even greater benefits by cooperating with other companies and thus increase the value of the sludge.

In Denmark, approx. 1,400 wastewater treatment plants generate sewage sludge.

Sewage sludge is a valuable resource with high contents of nutrients and organic matter that can be converted into energy.

The value of sewage sludge can be optimally utilized through collaborations between companies. Such cooperation can help reduce operating costs and increase earnings, and thus, is advantageous for both the bottom line and the environment.

UTILIZATION

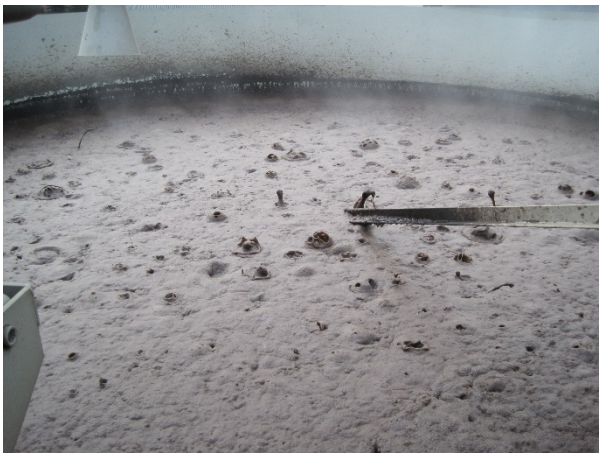
Sewage sludge is already utilized at some wastewater treatment plants where biogas is produced by anaerobic decay. The nutrients can then be applied for soil improvement. Other treatment plants incinerate sludge, utilizing its energy content.

Anaerobic decay is an attractive utilization opportunity for sewage sludge, as it is possible to utilize both energy content and recycle nutrients. However, not all wastewater treatment plants have an in-house digester, but through a symbiosis, a company can send the sludge to another wastewater treatment plant or a biogas plant based on manure (slurry).

It is also possible that other companies deliver organic residual fractions to a wastewater treatment plant's tank rather than traditional waste incineration. As a result, the treatment plant's biogas production can be increased and result in a financial gain.

GREAT SAVINGS

Sewage sludge handling is typically associated with utility expenditure on treatment and spreading of sludge, incineration tax or the like. Usually, symbiotic cooperation results in a financial gain, as operating costs of the treatment plant can often be reduced. The partner company achieves a financial benefit reducing disposal costs by delivering residuals to a digester tank for biogas production.



FERRIC SLUDGE

Sewage sludge is a residual product from processes at a wastewater treatment plant and can be roughly divided into two types:

- Primary sludge that forms if the treatment plant applies primary precipitation or other separation. In most cases primary sludge is treated by anaerobic decay before any reuse.
- Secondary sludge is sedimented sludge after biological/chemical purification. Secondary sludge is not necessarily sent to a digester, as it can, for example, be spread directly on agricultural land.[1]

The type of sludge is decisive for what it can be used for. Typically, small treatment plants produce only secondary sludge that undergoes aerobic stabilization. Sewage sludge from larger wastewater treatment plants usually consists of both primary and secondary sludge that undergo anaerobic digestion.

In addition to water, sewage sludge consists mainly of organic material suitable for energy production and nutrients that make wastewater sludge suitable as fertilizer.

UTILIZATION

Today, most of the sewage sludge is spread on agricultural land. The rest is incinerated, exported or sent to landfill. Sewage sludge is well suited for an industrial symbiosis, as there are typically alternative exploitation opportunities where economic and environmental benefits are increased. To achieve the highest possible economic and environmental benefit, the nutrients and energy content of the sludge should be recycled as best as possible, which can be illustrated as a pyramid. An increase in level represents an improved utilization of the residual's properties and thus, a higher economic and environmental value.

The following describes various potentials for symbioses based on traditional ways of utilization and provide opportunities to reduce disposal costs and/or increase earnings. Finally, a concrete example is described that was identified in connection with the Danish Business Authority's program for Green Industrial Symbiosis.

In Denmark, biogas production is approximately half of all sewage sludge anaerobic decay at a conventional biogas plant which produces biogas from manure (slurry). At a wastewater treatment plant, primary sludge precipitates and is diverted to the digester tank for similar utilization.

Usually, the produced biogas is incinerated in a gas engine. The generated heat is used internally at the treatment plant or sold as district heating. The produced electricity is supplied to the grid. Biogas can also be upgraded so it can be distributed via the natural gas network and used for transport or process purposes. In some cases, upgraded biogas is the only real alternative to fossil fuels and therefore has a great climate and environmental value in these uses.

Biogas can also be sent directly to another company and used for process purposes. Principally, in this case, the biogas does not need to be upgraded. By installing an extra burner in a boiler that produces process heat, it is possible to alternate between natural gas and biogas or switch entirely to biogas. This utilization of biogas not only displaces fossil fuels but also contributes to higher use of the gas, as modern condensing boilers typically have a higher annual efficiency than cogeneration gas engines.

The financial gain from the utilization of biogas depends on a number of tax factors, which make it more advantageous, for example, to use biogas for heating rather than for process purposes. Symbiosis potentials for biogas are described in more detail in the generic case "Symbiosis potentials for biogas"[2].

[1] This assumes that the sludge meets the limit values in The Danish Sludge Order (BEK no. 1650 of 13/12/2006)

[2] For Symbiosis Center Denmark and the Danish Business Authority, 2014

It is possible to increase biogas production in a digester by adding organic residual fractions from, for example, large kitchens and food-producing companies. Grindsted Biogas, which is operated by Billund Utility, is an example of a biogas plant that processes both sewage sludge, household waste and organic fractions from the industry. It can be economically advantageous if companies that generate organic residual fraction are located physically closer to a digester tank than a biogas plant. See more about the utilization of organic residual fractions in the generic case "Organic residual fractions".[3]

For smaller wastewater treatment plants without an internal digester, it is possible to transport the sludge to a biogas plant that produces biogas from animal manure or a digester on another wastewater treatment plant. The most significant financial gain is achieved if the biogas plant or the other treatment plant are located physically close to the treatment plant. Blåbjerg Biogas is an example of a biogas plant that produces biogas from slurry, sewage sludge and organic residual fractions.

FERTILIZER

Most types of sludge are suitable as fertilizers in agriculture, where phosphorus is an important contribution that in many cases can completely cover the needs of the field. Sewage sludge also contains other nutrients such as nitrogen, potassium, magnesium and sulfur.

The spread of sludge is regulated by the Danish Sludge Order, which contains a number of limit values, e.g. environmentally harmful substances and heavy metals. Furthermore, a method of utilizing sludge depends on whether the sludge is hygienic or not. Sanitized sludge can be spread on all types of agricultural land and in private gardens and can thus be applied to several areas supplementing commercial fertilizers. Sanitation can be achieved either by heat treatment or by the addition of burnt lime, thereby raising the residual's pH. In this way, the economic value of the sludge as fertilizer is increased. In a symbiotic context, companies, whose residual products supplement nutrients in sludge or contribute to its sanitation, can reduce their costs. Thus, it makes sanitation more profitable.

COMBUSTION

Combustion is a way to utilize sewage sludge if the sludge exceeds the limit values in the Danish Sludge Order and thus is not suitable for spreading on agricultural land. The municipality can also decide not to utilize sewage sludge in agriculture.

The high water content of sewage sludge means that it must be dried before incineration. The advantage of using this residual for combustion is the utilization of its energy content. The calorific value of sludge is approx. 12 GJ/ton of dry matter. The dry sludge can be burned either in an in-house or a conventional waste incinerator. It is also a possibility to utilize sludge as fuel and raw material in production at an industrial company. An example is the cement manufacturer Aalborg Portland, which receives dried sewage sludge from Aalborg Municipality's wastewater treatment plant. The dry sludge replaces coal, and the ash, left after its combustion, is utilized as a part of the finished cement. The excess heat from the cement production is supplied to the district heating network in Aalborg Municipality.

The disadvantage of incineration is that the nutrients in the ash become inaccessible to plants and thus are not recycled. New technologies are being developed to extract phosphorus from the ash, so nutrients can be reused on, for example, agricultural land.

[3] Ibid.

ECONOMIC PROFIT

The economic benefits of utilizing sewage sludge in industrial symbiosis are reduced operating costs for water treatment and increased revenue. The financial gain is dependent on how the sludge is disposed of, which usually depends on the size of the treatment plant and thus, the amount of sludge handled. Combustion of sludge is relatively expensive, as establishing a drying plant is costly.

In addition, landfill charges follow if the produced ash is not used in products such as cement. Therefore, a significant economic gain can be achieved if the sludge is instead used for biogas production with subsequent spreading on agricultural land.

The wastewater treatment plant in Holbæk is a medium-sized plant with a total capacity of 60,000 PE, and is operated by Holbæk Utility. Secondary sludge is spread on agricultural land after rotting. Strandmøllen Industrigas in Holbæk produces acetylene gas used for welding. One of the by-products of this production is slaked lime used in agriculture.

Both products are costly to dispose of, but by combining them, fertilizer can be produced, which is of a higher value than the two products separately. The lime stabilizes the sludge by increasing the pH. The new product is being tested on the fields belonging to Ryegaard and Trudsholm Godser.

A wastewater treatment plant can achieve increased biogas production by adding organic residual fractions to the digester tank and thus increase its income if this energy is sold. By adding primary sludge to a digester, besides an increased biogas yield, a wastewater treatment plant reduces its operating costs as sludge does not need to go through a biological/chemical purification process.

Utilization of sewage sludge for agricultural purposes is typically costly for a wastewater treatment plant. If the fertilizer value of the sludge is upgraded by, for example, adding lime, this cost can potentially be reduced as the value of the fertilizer increases.

Holbæk Utility and Strandmøllen pay a total of approx. EUR 133,820 per year for disposal of sewage sludge and slaked lime. This expenditure can be reduced by combining the two fractions since the resulting fertilizer product has a higher economic value than the two fractions separately.

ENVIRONMENTAL VALUE

The environmental benefit varies depending on how the sludge is used before a possible symbiosis. Currently, most of the fractions are incinerated or spread on agricultural land.

A significant environmental benefit of using sewage sludge for fertilizers rather than combustion is to return nutrients to the soil. Nitrogen, potassium and phosphorus are necessary for plants to grow and can be added to the fields either through commercial fertilizers or through degassed sewage sludge and animal manure. The latter can also help to displace commercial fertilizers, which in the case of Denmark are mainly imported. Phosphorus is a resource that is highly relevant in terms of recycling, as it is extracted from only a few places in the world and is a non-renewable resource.

If sewage sludge is incinerated and the produced energy is deposited as heat in a district heating network, it replaces the fuel that the district heat is otherwise produced of. The environmental and climatic benefits of it are highest if the heat is produced of fossil fuels such as coal and natural gas.

The environmental benefit of Holbæk Lime Symbiosis is achieved by the use of sanitized sludge in areas where it has hitherto not been spread. In these areas, the use of commercial fertilizers and virgin lime is displaced. The reuse of phosphorus could ensure diversification of supply and less dependency on imported nutrients.

BARRIERS

Barriers that can make it difficult to establish an industrial symbiosis with sewage sludge vary depending on how the sewage sludge is utilized.

In the following, two examples of barriers are reviewed. The list is not exhaustive, and other obstacles can arise. They require technical or legal clarification for a symbiosis to be realized and be financially attractive for the participating companies.

PRESENCE OF HEAVY METALS AND ENVIRONMENTALLY HARMFUL SUBSTANCES IN SEWAGE SLUDGE

Sewage sludge can contain heavy metals and a variety of environmentally harmful substances from e.g. detergents. The concentration of them depends on the treatment plant design and especially the composition of the wastewater.

If the sewage sludge does not meet the limit values, it reduces the utilization possibilities, as the sludge cannot be used on agricultural land. In these cases, combustion will be a solution where the energy content of the sludge is utilized, and the nutrients can potentially be extracted from the ash in the longer term. Furthermore, sewage sludge can be exported to Germany, where the regulation for heavy metals is not nearly as restrictive as in Denmark since it is assessed how large a proportion of heavy metals can be applied on a given field.

The wastewater treatment plants can by source tracing identify the source of the heavy metals or the environmentally harmful substances that exceed the limit values, thus, reducing their emissions. By doing this, the sewage sludge can, in many cases, live up to the limit values according to "The Sludge Order", and therefore, its nutrients can be recycled to Danish agricultural land.

Presence of sewage sludge from households is also an obstacle if the sludge is to be treated at a biogas plant. Only a few biogas plants receive sewage sludge, as it limits possibilities for digestate (the degassed slurry and sludge) is applied in agriculture. These regulations include traceability requirements that sludge from household wastewater cannot meet.

TRANSPORTATION OF SLUDGE

Sewage sludge contains only 3-5% of dry matter before decay and/or drying. The nutrients and organic matter constitute a relatively small proportion of the total mass.

If sludge is utilized elsewhere than at a treatment plant where it is generated, transportation of the sludge is necessary, which increases the costs because of the high amount of water to be transported together with the desired substances.

The high water content and increased transport costs are especially a barrier if the sludge is to be transported to a digester or biogas plant. Here, the sludge is typically drained, but still has a relatively high water content - it can always be profitable to transport sewage sludge from a total economic point of view, as the increased biogas production results in an increased income.

This case reviews symbiosis possibilities for sewage sludge and aims to inspire better utilization of this residual by describing options and benefits of such symbiosis. Please, do not use the case as a design or decision basis.