D6.1: Kalundborg-Symbiosis:
Successful case and role in ValueWaste

Work Package No	6
Work Package Title	Future large-scale projects
Work Package Leader	ITAINNOVA
Issue Date	30/10/2019

Disclaimer and acknowledgements

Horizon 2020
European Union Funding
for Research & Innovation

"This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 818312"

DOCUMENT INFORMATION	
Acronym	VALUEWASTE
Title	Unlocking new VALUE from urban bioWASTE
Grant Agreement Number	818312
Call	H2020-SFS-2018-1
Project Coordinator	Asociación Empresarial Centro Tecnológico De La Energía Y Del Medio Ambiente De La Región De Murcia (CETENMA)
Document Type (R/DEM/DEC/OTHER)	R
Dissemination Level (PU/CO/CI)	PU

DOCUMENT HISTORY			
Issue	**Date**	**Comment**	**Author**
V1	29/10/2019	Dates stated in the Grant Agreement	Per Møller Johan Ib Hansen

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VERIFICATION AND APPROVAL		
	Date	**Name**
Verification final Draft by WP leader	29/10/2019	ITAINNOVA
Approval Final Deliverable by Coordinator	30/10/2019	CETENMA

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LTP - 16	Kalundborg Symbiose / Symbiosis Center	Symbiosis	DK	Business association
17	European Biomass Industry Association	EUBIA	BE	Industry cluster

Contents

Executive summary

Brief summary of the deliverable purpose (associated task objectives) and structure.

D 6.1 describes and exemplifies more than 40 years of experiences in Kalundborg working with industrial symbioses.

The document firstly presents how the Kalundborg Symbioses has developed through the years, and how the knowledge from the industrial symbiose activities are disseminated through activities in Symbiosis Center Denmark.

The second part of the document is an example on how Danish Symbioses Center works with organic wastes, as an example of specific interest for the ValueWaste project

Introduction

Symbiosis Center Denmark (SCD) is responsible for deliverable D6.1. SCD is a programme within the development department of Kalundborg Municipality (KM), and therefore KM is the legal entity of SCD. The identity of SCD is created based on the concept of Industrial Symbiosis based on the development of Kalundborg Symbiosis model – a unique public private partnership with a long and lasting history. KM development department, in housing the secretariat of Kalundborg Symbiosis and staff of SCD are facilitating the activities within Kalundborg Symbiosis. Through this symbiotic working partnership, a combined knowledge platform is constantly developing supporting e.g. capacity building, identification of new symbiosis potentials, mapping of resource flows and building a tool-box, to support both local, regional, national and transnational urban and industrial symbiosis in a circular economy.

The role of SCD and KM in ValueWaste is to contribute experience on how symbiosis is established and works. KM also contributes with knowledge from more than 30 years of experience in sorting waste, including especially bio-waste. KM has many years of tradition of involving and informing the citizens, in order to get effective introduction of new waste sorting initiatives.

The purpose of D 6.1 is to describe how KM and SCD work with circular economy and industrial symbiosis, so that the experience can be used in the further work in ValueWaste. This is done by briefly reviewing the history of Kalundborg Symbiosis, the development of SCD and by giving examples of what has been achieved through the work on industrial symbiosis. Kalundborg Municipality's experiences and handling of the citizens' residual products are also relevant to VW and are discussed in D 6.1.

Description of the work

In the first part of D 6.1, SCD and KM review experiences from many years of work with industrial symbiosis, partly through Kalundborg Symbiosis and partly through international project work in SDC. Examples of international results and current global challenges are also provided.

The second part of D 6.1 describes specific experiences with symbiosis with organic residues, as an example of experiences of interest in ValueWaste.

1.1 Organization

Symbiosis Center Denmark is a unit organized as part of Kalundborg Municipality's development department. SCD develops symbiosis collaborations between the members of Kalundborg Symbiosis, while at the same time disseminate the experiences through project participation nationally and internationally.

1.2 Background

Kalundborg Symbiosis (Figure 1) is an example on the great potential of the circular economy and the green transition. Especially because it is not a static collaboration, but constantly being renewed to continue to be advantageous for all parties and for the environment.

Figure 1. Overview of the Kalundborg Symbiosis and the participating partners

Since the Financial Times in 1990 brought the article about Kalundborg Symbiosis (1) the symbiosis has been in the spotlight nationally as well as internationally. A corporation with a circular approach started as early as 1972 (www.symbiosis.dk) and it is hard not to be impressed by the persistence and belief in the good idea, that the companies and municipality have realized , and have made it a success for decades. It is important to point out that one of the primary reasons why Kalundborg Symbiosis has such a long history and that the cooperation continues is that it provides economical and environmental advantages to all members to this day since the symbiosis is constantly renewed.

Kalundborg Symbioses has a vision of being "the world's leading industrial symbiosis with a circular approach to production" (2; Figure 2). With the vision follows an obligation to learn from the outside world as well as passing on learning.

Figure 2: SCD has three focus points in the work

1.3 What has the symbiosis achieved

A life cycle assessment carried out by the Danish Symbiosis Center based on Kalundborg Symbiosis exchanges of water, energy and materials in 2015, (3) showed that the collaboration saves the environment for a full 635,000 tons CO_2 / year when a conversion of the Asnæs powerplant is completed.

The Asnæs power plant has for many years been Denmark's largest coal-fired power plant. Recently, the power plant has been through a major transformation, which is now completed and the plant is now 100% wood chip-fired plant.

https://orsted.com/en/Media/Newsroom/News/2019/07/Asnaes-Power-Station-getting-ready-to-phase-out-coal

The ability of the symbiosis to adapt to changes is reflected in the diagram in Figure 3 showing the residual streams, a diagram that is constantly updated when new streams are added or existing streams close down – based on business case evaluations.

The Symbioses network may not be static but remain flexible to stay valuable to the involved partners and to the environment. It is pointed out in research that the good example and shared knowledge about green transition is important factors for getting companies on the road on the track (4).

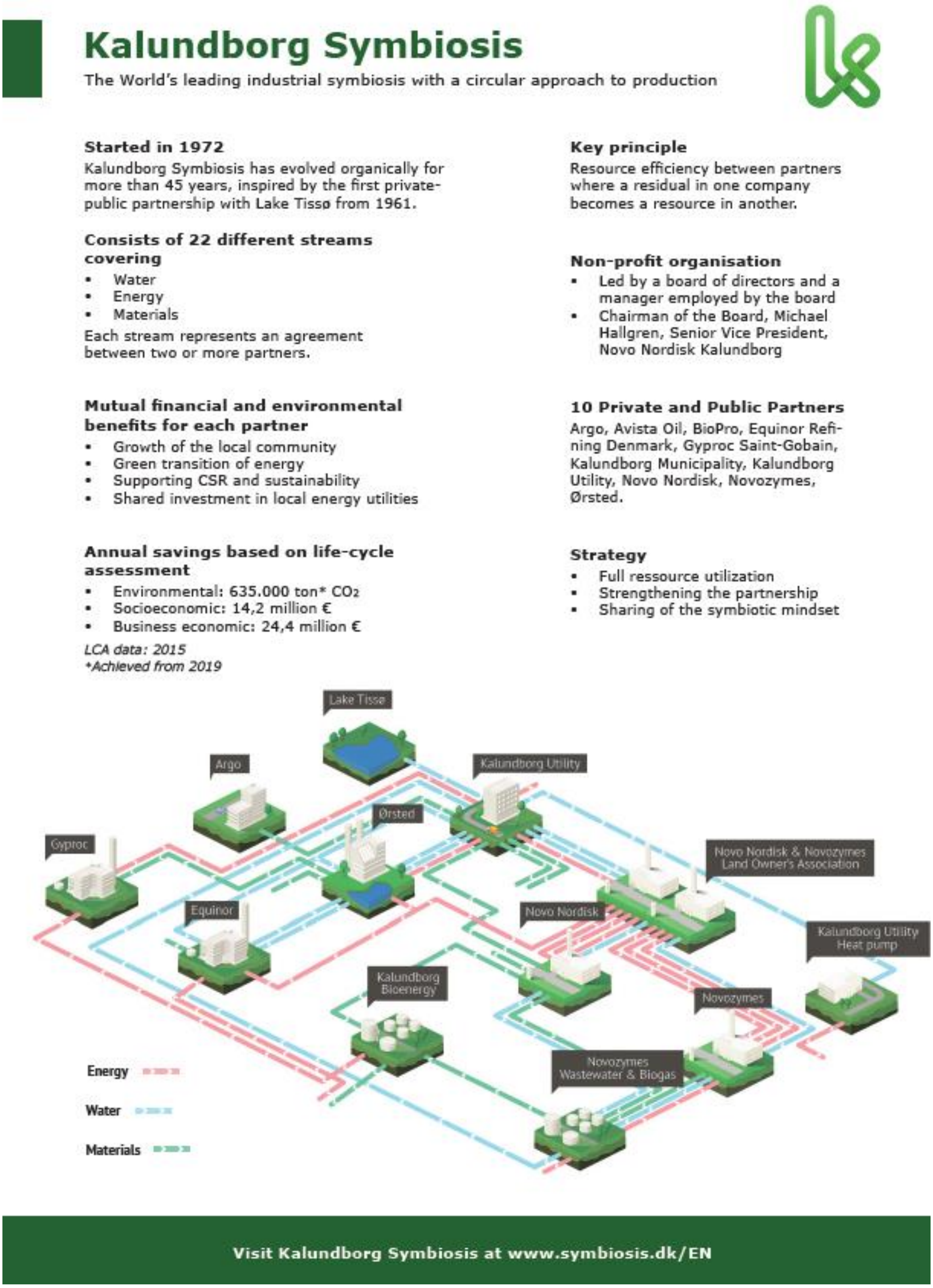

Figure 3 – Streams and partners in the Kalundborg Symbioses 2018 (www.symbiosis.dk)

1.4 Not easy to reproduce but easy to learn

Kalundborg Symbiosis is not easy to reproduce, and in few locations it will be realistic or particularly advantageous to carry out an identical constellation. There are many learning points from the symbiosis, which can inspire and benefit elsewhere. Kalundborg Symbiosis has an ambition to inspire different types of businesses by communication of knowledge and experiences from the Kalundborg Symbiosis. This happens through dissemination, project participation and collaboration, both locally and internationally.

1.5 The circular economy potential

It has often been highlighted that the potential of the circular economy and green transition is large. In the Ellen MacArthur Foundation report titled “Delivering the circular economy: A toolkit for policymakers” (5), a methodology and an actionable toolkit is presented. The toolkit is designed for policymakers to apply to their own contexts, while using Denmark as a case study to illustrate the scale of the opportunities. (4) In the toolkit, the potential for an increase in GDP is calculated of up to 1.4% while at the same time up to 13,000 new jobs can be created – only considering Denmark.

On the international stage, it is it is widely accepted that the green transition, including industrial symbiosis, will have many beneficial effects in terms of wider dissemination internationally. The OECD considers industrial symbiosis an important tool to get more value out of the scarcely available resources (6).

At EU level, it is considered that the potential of industrial symbiosis as a tool for sustainable consumption and resource use is EUR 1.4 billion / year (7).

1.6 SCD Project Experiences

Many of the projects in where SDC participate are funded or supported by EU funds such as Horizon 2020, the EU's Regional Fund, Interreg ÖKS, Interreg BSR and Interreg South Baltic. SDC works with the challenges through participations in various projects, e.g., the Interreg South Baltic project Urban Baltic Industrial Symbioses “UBIS” (8), the Interreg BSR project Baltic Industrial Symbioses “BIS” (9), and the Horizon2020 project ValueWaste (10).

The UBIS project includes partners from Sweden, Denmark, Lithuania, Poland and Germany. They have joined the project to develop methods and tools for starting industrial symbioses. In five locations, new industrial symbioses have been launched or further development of existing resource exchange collaborations have been completed. By including investment support, the project handles one of the major challenges of industrial symbiosis; that the most sustainable solution often is not the cheapest solution in the short term, and that lack of start-up capital can be a significant barrier for companies (11).

To further promote the formation of symbiosis in the project, the role of SDCis particularly related to passing information on best practice from Kalundborg Symbiosis as well as other projects. In this way, the SDC complements investments by ensuring that the project partners can draw on over 50 years of experience with industrial symbiosis and circular economy projects.

SDC brings knowledge and awareness of industrial symbiosis business models to their beneficial long-term economic effects out to companies and other players; a knowledge often needed in order to boost sustainable initiatives (12).

For KM, knowledge and learning will naturally also flow the other way. Although KM has long been involved in the work of industrial symbiosis, it is necessary, as mentioned, to focus on further development of Kalundborg Symbiosis and its creation of new symbioses locally to ensure its continued existence. Additionally, Kalundborg Utility is also a project partner. Kalundborg Utility is a central player in the Kalundborg Symbiosis and participates in further development of symbiosis, as one in five international locations in the project.

Through the SDC, K exchanges both knowledge and experience while the Kalundborg Symbiosis works with the development of specific flows of resources.

1.7 The Future

There is a great goodwill in the Municipality of Kalundborg as well as Kalundborg Symbiosis to continue mutual learning about sustainability and the circular economy through project collaborations internationally.

Kalundborg Symbiosis has a goal to implement 10 new projects by 2025, and if the goal has to be achieved, it is necessary to have both a systematic approach to partner flows and resource optimization. It is important and valuable to learn from the many other symbiosis-like projects that are now found all over the world.

2.1 SYMBIOSES WITH ORGANIC RESIDUALS

SDC has through participation in many national and international projects conducted analyses in many different industries and different residuals (e.g. Symbioses with wood residuals, Symbioses opportunities for surplus heat, Symbioses with secondary water, Symbioses with organic residuals, Symbiosis with residual acids and bases).

By participating in projects, SCD has helped many companies define existing symbiosis and develop new ones. This work has also led to new collaborations between different companies. Based on a large number of projects that SCD has participated in over a number of years, the national funded project "Det Regionale Symbiosecenter" (The Regional Symbiosis Center) has described several cases in different areas. The section presents experiences with companies that, in collaboration with SCD, have developed symbiosis with bio waste.

2.2 ORGANIC RESIDUALS

An organic residual fraction is a generic term for a wide variety of material flows of biological origins. Typically, organic residual fractions are associated with household waste, but there are also many other examples of industries that generate organic residual fractions:

- Food waste from large kitchens at hospitals, military barracks, hotels, canteens, etc.
- Green waste from supermarkets
- Meat and bone waste, blood, etc. from slaughterhouses
- Grease from grease and oil separators
- Oil from fryers
- Waste from the fishing industry
- Mash from breweries
- Potato waste and other green waste
- Deicing liquid (glycol) from airports
- Milk condensate from dairies
- Livestock manure (e.g. slurry) and wastewater sludge

Organic residuals contain several different and often complex molecules. Typically, there is a relatively high water content, but the fraction also contains important nutrients such as phosphorus, nitrogen and potassium. Additionally, organic residuals contain several organic substances such as proteins, carbohydrates and fat.

2.3 MAIN POINTS

Industrial symbiosis with organic residuals creates both economic and environmental benefits because many industries generate several organic fractions which can be reprocessed or utilized in other companies' production. It can save costs for both waste disposal and raw material procurement, while valuable resources are reused.

A wide variety of industries generate organic residual fractions. It can be food waste from large kitchens, waste from slaughterhouses, mash from breweries and much more. Typically, these fractions are sent to incineration or to municipal wastewater treatment plants, which is costly for the companies that generate them. However, there are other ways to use the organic residual fractions where both a higher economic value and environment benefits can be obtained.
Through industrial symbiosis, organic residual fractions can be utilized for purposes outside the company's primary production, for example by combining the fraction with other residual products or by allowing another company to use the fraction directly in its production. Such cooperation can reduce operating costs, increase profit and thus strengthen competitiveness.
Organic residual fractions can be used in the production of high-value chemicals, animal feed, fertilizers and bioenergy production.

It is different from fraction to fraction what kind of utilization can be possible through industrial symbiosis and thus also what financial gain can be achieved.

2.4 GREAT SAVINGS

Since many organic residual fractions are associated with incineration costs, either cost-neutral disposal or even an income can easily be obtained by entering an industrial symbiosis. Thus, the industrial symbiosis that utilizes organic residual fractions can contribute to increasing resource efficiency and strengthening competitiveness.

For example, financial gains can be achieved in the form of increased biogas production if the organic residual fractions are added to a biogas reactor. Another example is a symbiosis between two companies - Karup Kartoffelmelfabrik (a manufacturer of potato flour) and Kongerslev Kalk (mining of agricultural lime), which will produce a fertilizer product of residues from potato flour production and lime. The two companies can obtain a product of much higher value compared to the two residual products separately, which is advantageous for both companies.

2.5 UTILIZATION

Today, many organic residues are sent to traditional waste incineration. Some fractions are discharged into the sewage system for sewage treatment. Organic residual fractions are therefore well suited to be included in an industrial symbiosis, as an alternative utilization possibility with more significant economic and environmental benefits can often be found. The two examples at the end of this section describe two specific symbioses that have been identified in connection with the Danish Business Authority's program for Green Industrial Symbiosis.

Utilization of organic residuals can be illustrated as a pyramid where each level represents utilization with higher economic and environmental value. It is different from fraction to fraction which level can be achieved; some fractions contain molecules of very high value; other fractions can be used for animal feed or bioenergy production. In the following, various utilizations are presented, in which the organic residual fractions obtain a higher value than by incineration or wastewater treatment.

HIGH-VALUE INGREDIENTS AND MOLECULES
ANIMAL FEED
BIOENERGY PRODUCTION
FERTILIZER
INCINERATION
HIGH-VALUE INGREDIENTS AND MOLECULES

The most optimal utilization for organic residuals is as food for humans, for example, by selling food that cannot be sold in supermarkets because of packaging label errors that do not significantly impair the quality of the product. By utilizing the fraction as food for humans, the fraction avoids being "down-cycled". However, it is not possible to avoid the production of organic residues that are not suitable for human consumption. In this case, industrial symbiosis allows the fraction to be utilized at a higher value compared to incineration, where organic residual fractions are typically being utilized.

Some organic residual fractions can contain specific molecules that are of great value in the production of new products. As an example, Heparin, the drug which is used as a blood thinning medicine, can be extracted from pig intestines, and thus the pig intestines are of higher value than the utilizations lower in the pyramid.

2.6 ANIMAL FEED

Various organic residues can be used for animal feed replacing other fractions, for example, feed for fur animals or the cultivation of crops for pig and cattle feed, which are costly both economically and environmentally.

Not all types of organic residues are suitable for animal feed.

The following are examples of organic fractions that are suitable for animal feed production and are already widely used for this:

• Mash, trub and yeast cream from breweries
• Green waste from supermarkets
• Pulp from the potato industry
• Pulp and molasses from sugar mills
• Dregs and vinasse from alcohol production
• Citrus peels from pectin production
• Fruit residues from the fruit industry
• Waste from the cleaning of fish
• Waste from slaughterhouses

2.7 BIOENERGY PRODUCTION

Bioenergy is a common term for energy produced on biomass, including energy produced on organic residual fractions. Incineration also represents an energy production but is ranked lowest in the hierarchy, as it typically excludes other utilizations for the organic residuals. Bioenergy can also be liquid fuels (e.g. bioethanol) or gaseous (biogas). The latter is currently the most widely used form.

The production of advanced liquid biofuels, such as biofuels for aviation, represents the highest energy utilization of organic residual fractions. If they are produced as a part of a major biorefining process, several other fuels and products can be produced simultaneously. However, the production technologies and the market for these products are not very mature, and the production is therefore mainly conducted at development and demonstration levels.

Biogas production is biodegradation of organic residual fractions where methane gas and carbon dioxide are formed. The biogas can be used in gas generators for electricity generation, where the excess heat can be utilized either internally or as a contribution to the district heating network. It can also be upgraded to natural gas by purifying the gas of carbon dioxide and supplying it to the natural gas grid. In this way, biogas can also be utilized in the transport sector. Biogas can also be included in the production of more advanced liquid fuels.

In Denmark, there are two types of biogas plants:
• Biogas plants based on animal manure (e.g. slurry)
• Digesters at wastewater treatment plants based on sewage sludge
Biogas production can be increased in both types of plants by adding other organic fractions, because both slurry and sewage sludge have a very high water content (about 95%) compared to the organic fractions described previously and therefore do not generate much energy.

At the same time, manure and sewage sludge is already partially biologically reacted, and thus the yield from these fractions is even lower.

Virtually all organic residual fractions are suitable for biogas production, and the exploitation is widely known and used. Biogas production is a well-established technology, and since both biogas plants and digesters can receive organic fractions, there are many utilization opportunities in Denmark, as seen in, for example, the bio-symbiosis in Bornholm (see below).

There are alternative gasification technologies apart from the well-established bio-gasification. As an example, pyrolysis plants where organic residual fractions are gasified and at the same time, the residual product BioChar is produced. BioChar is a material that can be used for soil improvement. Alternative gasification technologies are of interest to fractions that, for economic or regulatory reasons, are not well suited for traditional biogas production.

2.8 FERTILIZER

After biogas production, the degassed livestock manure or sewage sludge can be used as fertilizer for agriculture or afforestation. Thereby, nutrients are added to the soil. The fertilization properties of the fraction depend on the composition of the fraction. For example, wastewater sludge polymer is added before dewatering, which limits the leaching of nutrients. It is advantageous when the wastewater sludge is used as fertilizer.

Using some organic residual fractions for bioenergy production is not economically viable, because they are often not conducive to a significant energy yield or it is not economically viable to transport them to the plant. Some of these fractions can be used directly as fertilizers as in the symbiosis between Kongerslev Kalk and Karup Kartoffelmelfabrik. The disadvantage of this utilization is that no energy is produced from the fraction. Instead, nutrients and carbon are returned to the soil, which is not the case if the fraction is sent for incineration.

2.9 BIOREFINING - FUTURE UTILIZATION OF BIOMASS

In the future, as technologies mature, it will be possible to utilize the various molecules in organic residual fractions even more efficiently than in feed and bioenergy production. It can be through the concept of biorefining, where the utilization of organic residual fractions to a greater extent exploits the various molecules contained in the fraction, for example, by extracting high-value molecules with subsequent production of biofuels and by returning nutrients to the environment.

2.10 EXAMPLE - UPCYCLING OF RESIDUALS FROM POTATO FLOUR PRODUCTION

Today, Karup Kartoffelmelfabrik (potato flour producer) generates significant amounts of "potato protamylasse", which is a residual compound occurring during the industrial production of starch/potato flour from potatoes. It is currently being used as a fertilizer in agriculture. Kongerslev Kalk (lime miner) extracts and dries lime, which is also used for agricultural and gardening purposes. The two companies will produce a fertilizer by mixing the residual product from potato flour production with lime. The intention is to create a fertilizer with a higher value than the two products have separately.

2.11 EXAMPLE – BIO-SYMBIOSIS IN BORNHOLM

The bio-symbiosis in Bornholm tries to upgrade the utilization of organic residual fractions that are either incinerated or transported to wastewater treatment plants. If the bio-symbiosis is established, residual fractions from various companies in Bornholm will instead be collected and used for biogas production. The fractions are supplied to the island's only biogas plant, Biokraft, in order to increase the biogas yield and at the same time return valuable nutrients to the soil. The symbiosis also considers alternative utilization technologies in addition to bio-gasification.

Increased utilization of the organic residual fractions in Bornholm is both economically and environmentally beneficial, and it is a step towards a more circular economy where resources are recycled and utilized locally.

In addition to the economic and environmental benefits, the participating companies may reduce operating costs, increase bioenergy production and strengthen agricultural production.

Both symbioses can contribute to increasing profit or reducing operating costs for the partners involved and contribute to a positive impact on the environment.

2.12 ECONOMIC PROFIT

The economic gain for the residual supplying company comes from a reduction in the costs of waste handling as the quantities of waste the company must dispose of are reduced by the separation of the organic residual fractions. In some cases, the cost can even be turned into an income depending on the quality of the organic residual fraction. If the fraction is of a high enough quality, it can be sold and lead to a profit for the company, which can help ensure a better bottom line.

For the receiving company, the financial gain comes from increased sales of the product the company derives from the organic residual fraction or from the sale of a product produced directly from the fraction, for example, in the form of an increased gas yield by adding a fraction with a high biogas potential to a biogas reactor.

The economic gain of symbiosis can also be reduced commodity prices, in the case where organic residual fractions are used, for example, to produce animal feed and high-value molecules. In these cases, the utilization of the organic residual fraction does not necessarily lead to higher production but can replace a raw material that would otherwise have been purchased at a higher price.

In the example of the symbiosis between Karup Kartoffelmelfabrik and Kongerslev Kalk, the two parties can get a significantly higher price for potato residue and lime if they are combined into a new fertilizer product. Therefore, both companies expect increased competitiveness through increased earnings from fertilizer sales, because the raw materials used for production are so cheap. The parties thus expect an increase in turnover of DKK 500,000-600,000 per year on the sale of the fertilizer and within the next three years, an increase in the number of employees at Kongerslev Kalk of 1-2 people.

Bornholm has a logistical challenge in relation to the utilization of residual fractions, as transport away from the island is costly, and local disposal and utilizations for different residual fractions are limited. If the organic residual fractions can be utilized in an industrial symbiosis, it can lead to a better economy for the participating companies. Establishing the bio-symbiosis will result in increased biogas production, which will increase earnings for Biokraft's biogas plants. If the internal logistics challenge is solved, the companies that allocate residual fractions to the symbiosis can achieve reduced costs and at the same time strengthen the companies' and the island's green profile by contributing to the green transition.

2.13 ENVIRONMENTAL VALUE

The environmental gains vary depending on how the fraction is used before the symbiosis is established. The starting point for most of the fractions is that they are currently incinerated or transported to wastewater treatment plants.

To assess the environmental benefit of an industrial symbiosis, what is displaced by applying organic residual fractions to new products is mapped. If the fraction is used to produce high-value chemicals, the synthetic manufacturing of these chemicals is displaced.
Similarly, the use of conventional raw materials in animal feed production is displaced by using organic residual fractions.

A significant environmental benefit of using organic residual fractions for biogas production rather than incineration, is the opportunity to return nutrients to the soil. Nitrogen, potassium and phosphorus are necessary for plant growth and can be added to the fields either through synthetic fertilizers or through degassing of sewage sludge and livestock manure. Biogas production thus displaces synthetic fertilizers, which are often imported. Especially phosphorus is a resource that merits a particular focus as it can only be extracted from a few places in the world and is a non-renewable resource.

If biogas is sold as heat to the district heating network, the fuel that the district heating is otherwise produced will be replaced. The environmental and climatic benefits of it are, of course, greater if the district heating is otherwise produced on fossil fuels such as coal or natural gas. Upgraded biogas displaces natural gas and can help replace fossil fuels in heavy transport where there are few other alternatives.

2.14 BARRIERS

Various technical or regulatory barriers can make it challenging to establish industrial symbiosis. Some of them are reviewed below. The section is not exhaustive, and other obstacles may arise that require technical or legal clarifications before a symbiosis can be realized and be financially attractive to the participating companies. However, utilization of organic residual fractions is generally increasing, and, with growing interest and need, there are more and more solutions that overcome these barriers.

2.15 COLLECTION OF ORGANIC RESIDUALS

SCD and KM have combined experience in the collection and recycling of biowaste. Experience shows that there are major challenges. A significant barrier to the utilization of organic residual fractions that they decay relatively quickly, which is associated with odor and in some cases, it degrades the residual fraction's value for utilization. The barrier can be overcome in various ways. For example, it is possible to collect the fraction frequently or to use sealed waste containers (possibly with the addition of enzymes) which may prevent the odor. An alternative is bio milling solutions where food waste is refined into a bio pulp that is sent to a closed tank. The tank is emptied as needed simultaneously with the company's grease and oil separator, and the contents are sent to a biogas reactor. If there is not enough volume to set up a bio mill for a company, several companies physically located close to each other can deliver their waste to a centrally located bio-mill.

Experience on this must be integrated to the ValueWaste project, which must have special focus on this problem. It is important that the value of the bio-waste collected is maintained so that maximum yield is achieved in all three value chains, Bioprotein, Insect protein and fertilizer for agriculture. For an industrial symbiosis to be economically attractive for the waste generating company, its logistics costs must be reduced as much as possible. It often requires enough quantities of the organic residual fraction, or that the fraction originates from several companies located close to each other.

Finally, there is a risk that the organic residual fraction is not properly sorted. It can cause damage to the plant that handles the fraction or can also damage the new product

In ValueWaste, there is a special focus on bio-waste from households. In order for biowaste from households to have a usable quality, it is important to focus on the factors as degree of fermentation of bio-waste before it is collected and the purity and composition of the biowaste.

One of the focus points in ValueWaste is information campaigns in which citizens are informed about the importance of properly sorting the waste and thereby remain a valuable resource. Other factors as temperature condition before collection and necessity of a necessity of a sufficient collection frequency are important to include in ValueWaste.

2.16 BIOGAS PRODUCTION - UTILIZING OF DIGESTATE ON AGRICULTURAL LAND

In the biogas production in traditional biogas plants and digester tanks, a residual product - “digestate” remains, since it has not been converted to biogas after degassing. The digestate is typically spread on agricultural land, depending on what the biogas is produced of and the restrictions on where it can be used.

In Denmark, according to the By-Products Regulation, kitchen and food waste must be sanitized at 90˚C for at least 60 minutes before it is spread on agricultural land. It also creates some challenges regarding the use of organic residual fractions, as there are requirements about, for example, traceability and quality to avoid contagion.

These conditions must be clarified before a symbiosis can be established, as it may be necessary to sanitize the fraction prior to biogas production. A sanitation system will require a large amount of organic residue before it is economically viable.

This case reviews symbiosis possibilities for organic residual fractions 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.

Conclusions

The Danish Symbiose Center experiences with companies, and Kalundborg Municipality's experiences with waste management provide valuable knowledge which will be useful for the ValueWaste project. The specific contribution can be understood through:

- Networks and collaboration between companies that want to develop sustainable business models based on the further use of residual products - circular economy.
- Knowledge from 30 years of experience in sorting waste, and with contact with citizens.
- Contact with citizens. KM can also contribute to studies of their readiness to accept new sources of protein as part of their food.

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