DEVELOPMENT OF

A COMMON FRAMEWORK FOR A SUSTAINABLE AND CIRCULAR BIOECONOMY

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Exemplary case for a sustainable and circular bioeconomy in the Polish South Baltic Area Region

Production of sugar at Malbork Sugar Factory

Mission and vision

Malbork is located in Pomerania Region, close to the border with Warmia and Mazury. The factory was founded in 1880. In Poland there are 4 main sugar companies that are sharing the entire market. The largest one is the Krajowa Spółka Cukrowa S.A. (National Sugar Company Ltd) which has almost 40% share of the market. It has seven factories including one in Pomerania, in Malbork. In 2002, the Malbork sugar factory was taken over by the Polish group Krajowa Spółka Cukrowa S.A. and since then products have been sold under the Polski Cukier (Polish Sugar) brand. The company deals with the entire production chain, starting from sugar beet growing to the packaging of sugar including selling by-products such as molasses or beet pulp.

The factory itself is a very large plant, which is evidenced by the fact that it also has its own heat and power plant, which is used to prepare hot water and produce technological vapour, along with electricity. This is a coal-fired power station. Energy produced in this plant is used for the sugar factory purposes but a small surplus is sold to the city of Malbork. The factory also has its own sewage treatment plant and a technological water intake. Only water for sanitary purposes comes from the municipal water supply.

The last sugar season according to the old rules, with production limits imposed by the European Union on member states, was in 2016. On October 1, 2017 all the quotas were waived and the Malbork sugar factory became eligible to produce as much sugar as possible and sell as cheaply as possible in order to survive in the global, customer-oriented market.

Principle 1: Cascading approach
Promising opportunities for utilization of residues, leftovers and waste for production bioplastic, animal feed, biogas, CO_2, bio-ethanol and biofertilizers.

Principle 2: Use of waste, by-products and residues
Beet pulp and tails.

Principle 3: Circular economy approach
Promising opportunity for recycling nutrients from biogas production as fertilizer on agricultural soil.

Technology description

The Malbork sugar factory produces not only white sugar, but also molasses, fresh pulp, pressed pulp and dried pulp pellets. Production of white sugar amounts to about 900 tons per day. In the 2013/2014 sugar season over 560.000 tons of sugar beet were delivered from the local land to the factory. This is less than in the 2012/2013 season but more sugar was still produced, namely about

87.000 tons. In 2016/2017 the yields raised and the factory produced slightly less than 100.000 tons of white sugar from about 700.000 tons of sugar beets. In the latest year (2017/2018) the Malbork sugar factory acquired 706.602 tons of sugar beets which resulted in production of 101.873 tons of white sugar.

The average acreage from which beets are harvested amounts to over 10.000 ha. The average land yield is almost 70 tons per ha which gives an average of 11 tons of sugar per hectare. The sugar season lasts 110 to 130 days. The season starts in September and ends in January. The factory produces about 100.000 tons white sugar, 20.000 tons molasses and 480.000 tons beet pulp per annum. There are 170 permanent employees working and about 130 seasonal employees hired for the peak of the sugar season.

The contracted sugar beet without leaves is delivered to the sugar factory. Beets are washed and separated from soil, stones, and other admixtures. Soil management presents a huge problem for the company, which the company is seeking to help to solve in the next few years. Then, clean beets are stripped from their tails. Beet tails are used in a different process. Beets without tails are cut into small stripes, known as cossette. Cossette is about 80% of the mass delivered to factory (raw sugar beets). After adding water in a 1:1 ratio, the raw sugar beet juice is released by diffusion. In this process, called the juice extraction, the beet pulp is obtained. Raw juice is subjected to the filtration process where the result is the thin juice, while carbonation lime is a by-product. Thin juice is then boiled to evaporate water and thick juice is obtained. The last step is called centrifuging and here the white sugar is obtained. The very high-value by-product (molasses) is also obtained after adding water.

Figure 1. Heaps of sugar beet.

Figure 2. Malbork sugar factory, Poland.

Investment and economy

Most of the information regarding investment and business is subject to trade secrecy and may not be disclosed on that basis. The fact is that in recent years the turnover has increased and economic results are improving. The actual operational costs cannot be extracted from open sources. The Malbork sugar factory is trying to manage all waste and sell all by-products to increase profit. In 2013, the cost of repairs and investment activities before the sugar season amounted to approx. PLN 16 million (approx. € 4 million). In 2017 the plant realized following investments: construction of a new beet plant, reconstruction of the product plant, construction of a B continuous boiler, increased the filtration area and enlarged the wastewater treatment plant. The Krajowa Spółka Cukrowa S.A. has not revealed the real amount of expenditures, regarding it as a trade secret.

Material flow

Krajowa Spółka Cukrowa summarized the results of the sugar season 2017/2018. In all seven sugar factories, the company raised a total of over 6 million tons of sugar beet. In total, it produced over 900.000 tons of white sugar. The highest average yield was obtained in Kruszwica sugar factory - 73 tons/ha. Yields of over 70 tons per ha have also been reached by the Dobrzelin and Nakło Sugar Factories. In 2017, sugar beets were grown on an area of approx. 96 thousand ha, by about 15.800 farmers.

Malbork sugar factory has electricity consumption of 2,7 GWh and about 670 GJ of thermal energy. The connected boiler house serves as the energy centre of the factory and supplies electricity and steam. In 2013, the coal combustion installation consisting of two OSR-32/25 boilers and one OR-32/40 boiler was modernized. The modernization made on the OSR- 32/25M boiler no. 2 resulted in an efficiency increase from 73% to 80% and power increase from 19,4 MW to 26,4 MW whereas in the case of boiler OR-32/40M No. 3 the efficiency improvement rose from 75% to 80% and power capacity increased from 23,3 MW to 28 MW. The wastewater is purified in a biological water treatment plant. The sewage treatment plant treats sugar wastewater of up to 80 m^3/h depending on the Chemical Oxygen Demand (COD) concentration of raw sewage in the front of the tank.

Sugar beets contain more than 75% water and this is released as the condensate from evaporation during the production process. This water is reused to the greatest possible extent; e.g. for washing the sugar beets or hosing down the trucks which transport beet pulp, as their return load. Any remaining water is treated and filtered before being pumped back into the surface water reservoirs.

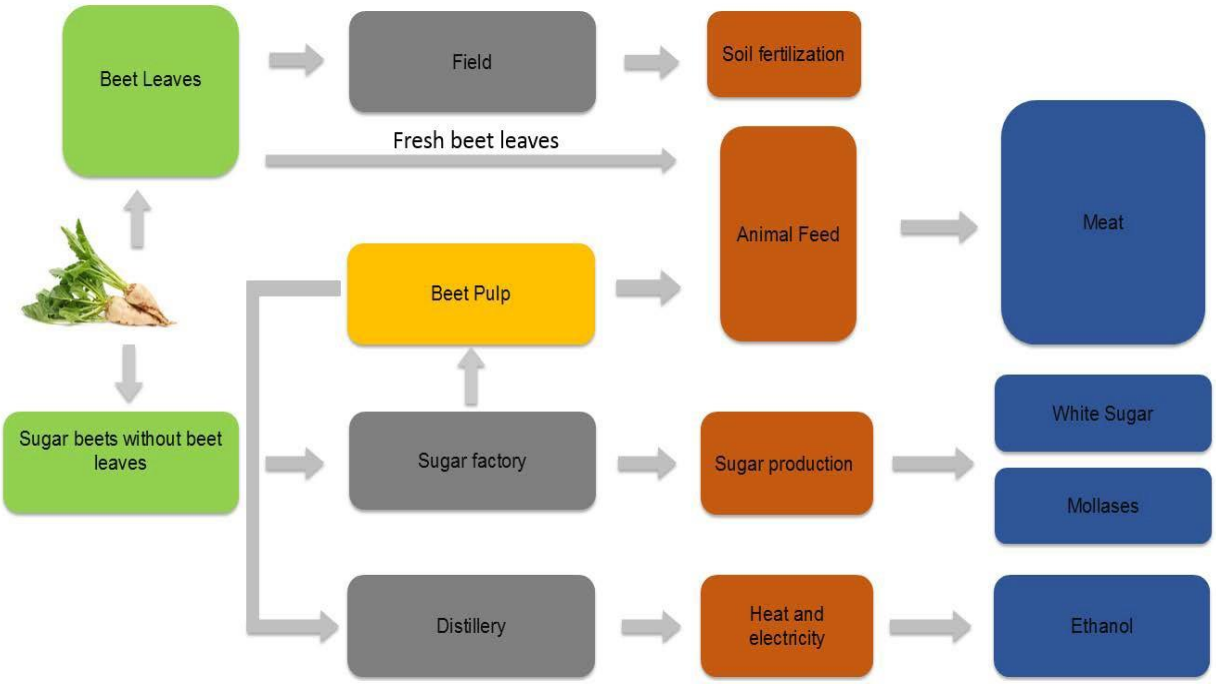

Figure 3. Flow chart for the process.

Estimated environmental and economic benefits

All sugar industries produce a significant amount of air pollution and odours. The Malbork sugar factory is no exception. In 2014-2015, investments were made to minimize these inconveniences, including:

- implementing desilting and desalination of boiler waters - reducing the amount of coal burned and decreasing in the amount of pollution,
- installing inverters on devices (pumps, conveyors, etc.) - reducing electricity consumption, fossil fuel consumption and pollutant emissions,
- modernization of grates in industrial boilers - improving the coal combustion process,
- improving the efficiency of dust removal from cyclones in the pulp dryer,
- a programme of thermal insulation work on devices in order to reduce the fuel consumption as well as to improve the technological process.

An important action taken by the Malbork Sugar Plant was to reduce emissions of odoriferous substances. For the neutralization of odours, the BIOSAN KZ200 preparation was used. The preparation is used in the technological process during the sugar season, when contaminants in the form of sludge from cleaning and washing sugar beets are directed to the settling tanks. Thanks to the use of the preparation, a good odour neutralization result has been obtained since 2010.

According to the data obtained from Krajowa Spółka Cukrowa S.A. in the years 2014-2015, investments were made to minimize noise around the Malbork sugar factory. The activities below have been accomplished:

- making an acoustic casing for the loading point of a lime kiln,
- execution of a new roof with insulation and new windows in the product building and the implementation of a new skylight,
- skimming of the inner surface of lime stone dispensers,
- works to increase the acoustic insulation of windows and doors,
- limiting the number of opened accommodation units in production rooms,
- installation of inverters on exhaust fans from the boiler room,
- installation of an acoustic silencer on the fan in the gas pumps building,
- assembly of acoustic blinds on the fan in the gas pumps building,
- repair of the roof and walls of the filtration building,
- execution of an air duct with a silencer for the fan after the sugar cooler,
- construction of sound absorbing screens around exhaust fans in the boiler room,
- refurbishment of the raw materials building,
- construction of sound absorbing screens for boiler room extractors,
- construction of sound absorbing screens near the entrance for trucks, on the lines of raw material evaluation and coach scales,
- replacement of windows.

Krajowa Spółka Cukrowa S.A. Malbork Sugar Plant has spent over PLN 2 million on the works related to the implementation of the above tasks. Since 2011, the factory is meeting the day and night noise standards.

During operation of the factory, by-products are created (previously regarded as waste), which include: pulp (PN-85/R-64808) - animal feed, rootlets and beet chips - sold for fodder, molasses (PN -76/R-64772) - used in the fermentation industry, defecosaturating lime (PN- 93/C-87007/02) - used in the fertilization of agricultural fields (defecosational lime is waste plant mass and solid sludges from cleaning and washing beets are subjected to process recovery of R3 and R11).

The Malbork sugar factory processing following wastes: waste used for fertilization and soil improvement, R14 - waste from cleaning and washing beets, limestone processing, ash-slag mixtures from the discharge of wet furnace waste, construction waste.

Lessons learned and recommendations

Malbork sugar factory should start cooperation with Universities, Research Centers or biological and chemical laboratories to find new solutions in the field of bio-plastic production from the products directly available, such as beet pulp, bio-ethanol or molasses. It seems that sugar beet leaves have big potential for new applications, especially when taking into account the volume of leaves which is about 70% of sugar beet roots. Leaves could be utilized in the chemical industry e.g. biopolymers.

A big issue for a sugar plant is rinsing water management. Presently water is taken into a sedimentation tank and mud is sent to landfill. This is a huge cost for factory. At the moment the plant is considering forcing the beet farmers to pay for that mud. An innovative idea is to dry the mud and sell it as a garden product or utilize mud as a flood barrier in areas threatened by floods.

Sugar factories should also make investments in order to condense ammonia out of the vapours produced in various processes, meaning that ammonia emissions to the outside air could be practically eliminated. Such activity has taken place in the Vierverlaten factory (Suiker Unie GmbH & Co. KG.). The effect of such operations was a significant reduction of odour emission and almost no ammonia emission to the environment.

The future

The Malbork sugar factory is in the process of implementing a quality control system for sugar beet already in the field. At the moment, the factory pays farmers for the sugar content in beet. In the future, thanks to this system, it may be that Malbork will pay for the amount of sugar produced from sugar beet. The system should improve the quality of beet grown resulting in greater efficiency, i.e. more sugar beet per hectare and even more sugar produced per hectare.