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ZERO FOSSIL ENERGY USE CONCEPT OF A FACTORY OPERATING IN THE FOOD INDUSTRY

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ABSTRACT

The limited availability of fossil energy resources and constantly increasing energy prices motivate today's companies to search for new solutions to provide for the energy needs of their production processes. These new solutions should be not only cheaper compared to the fossil energy resources currently in use, but also sustainable in the long term. In the case of the food industry, processing generates large quantities of by-products with high organic matter content. These byproducts can be used to produce bio-energy. This study shows a byproduct-based energy supply concept of a food factory with extremely high energy demand, the Sugar Factory of Kaposvár. The main goal of this study is to work out a biogas production system based on industrial byproducts that could cover the total energy demand of sugar production. The concept is based on three pillars. The first pillar of the system is the enlargement and intensification of two extant and operational biogas fermenters. The second pillar is biogas production from still active biogas sludge produced by the two main fermenters. The third is a biogas cleaning plant in which the produced biogas can be converted to natural gas quality. After the cleaning process, the gas can be fed into the natural gas distribution network. This creates the possibility of continuous biogas production throughout the year. The key of the concept is to keep the supply of raw materials needed for the biogas production at the lowest cost possible. The calculations show that the byproducts of sugar production (sugar beet pulp, molasses, beet tops, and pieces) and organic waste (weeds, other organic materials) can cover the total energy demand of sugar production. With plant-based byproducts coming from outside the sugar industry (bran, by-products of biodiesel production), the system becomes a net energy producer. The excess energy can be sold as biogas locally or can be fed into natural gas distribution network and even sold on international markets.
Keywords: sugar factory, bio-energy, biogas, biogas cleaning, by-products

INTRODUCTION

One of the world's largest capacity biogas plants was installed in the sugar factory of Kaposvár in autumn 2007, which produces biogas from sugar industry organic by-products. The investment consists of two biogas fermenter, each with 12,500 m^3 volume and the biogas system. The originally planned nominal capacity was 120,000 m^3 biogas per day but during the last campaign in 2010 a capacity was 150,000 m^3 biogas per day, which is equivalent of 75,000 m^3 of natural gas. The biogas is burned directly in industrial stream-boilers. The steam is converted to electrical energy through the stream-turbine, the resulting heat energy is used in the sugar

boiling process. The current system can cover 55% of the total energy demand during the campaign period.

MATERIALS AND METHODS

Data are provided by Hungarian Sugar Ltd Sugar Factory of Kaposvár. To be able to compare different data all biogas production and use quantity data are converted into natural gas equivalent. The converting ratio between biogas and natural gas was 50%, because of the average methane content of the biogas was 51% and methane content of natural gas is 98% (51x0.98 = 50).

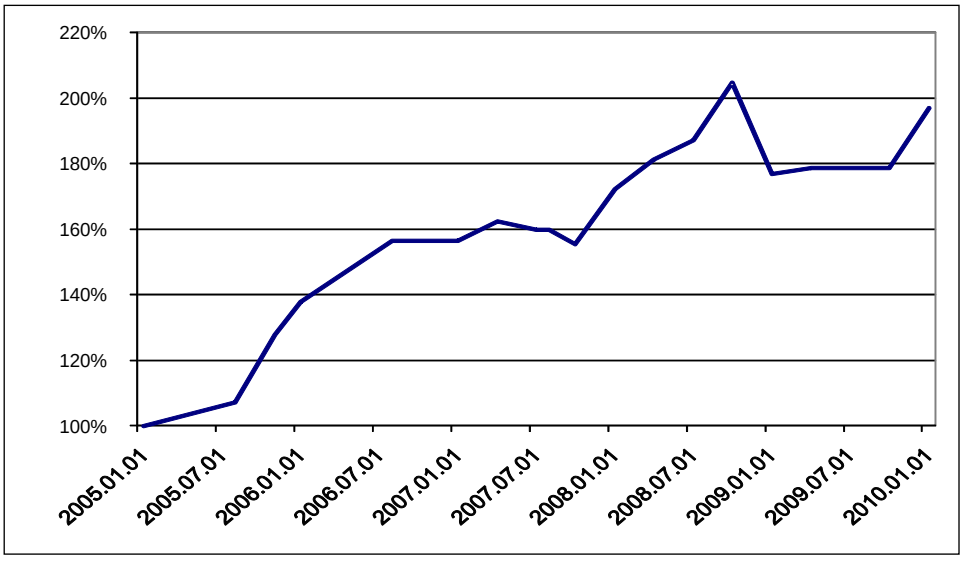
RESULTS AND DISCUSSION

Motivation for bioenergy use

Analysis of primer fossil energy resources during the last five years showed that price of the traditionally used energy resource the natural gas in the Sugar Factory of Kaposvár increased dramatically (*Figure 1*).

Figure 1

Natural gas price change (non residential, without tax)
1. January, 2005 = 100%



Source: *Hungarian Energy Office*

The daily natural gas demand of the sugar production is around 130,000 m^3 during the campaign period. The almost 100% price increase of fossil energy resource made the sugar production more expensive from 2005 to 2010. Another problematic area of using natural gas during the campaign period in winter is the

risk of gas limitation for industrial clients in case of shortage in the residential natural gas supply. In that case all major industrial natural gas users are limited or even stopped to be able to cover the natural gas quantity needed for heating of households.

After the sugar manufacturing process large quantities of organic by-products remain. Pressed sugar beet pulp and sugar beet tops and parts were traditionally used in the cattle feeding. In the last two decade number of cattle feed decreased and transport cost increased, consequently the demand for sugar factory organic by-products decreased. There was a need to find alternative possibilities to use organic by-products.

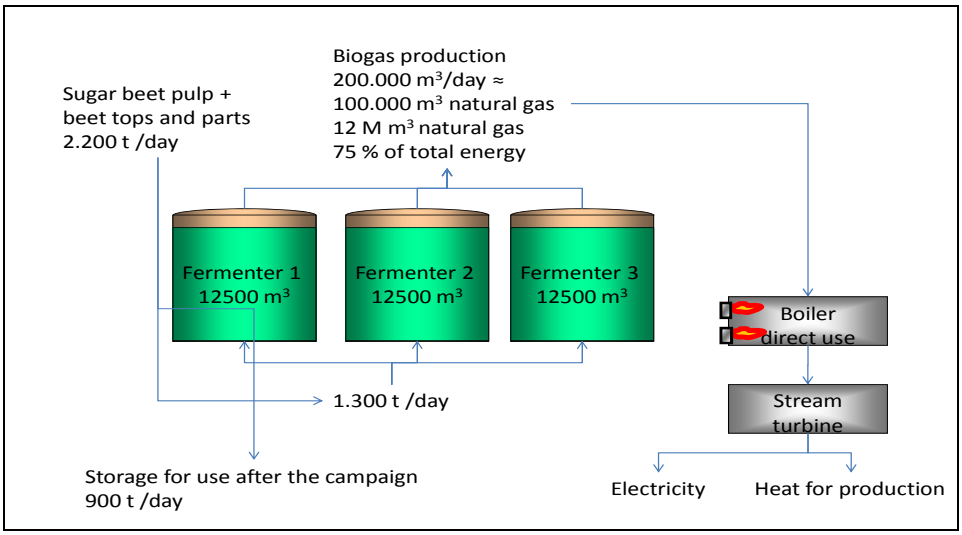
The combined solution for the two mentioned problem situations was bioenergy production out of sugar beet organic by-products. The good results during the campaigns from 2007 to 2010 made possible to work out a concept called "Zero fossil energy use". With the realization of the concept of "Zero fossil energy use" a total energy autarky would be possible, and the sugar production could be independent from external energy sources. With using renewable organic by-products the concept fully meets the requirements of sustainability.

Zero fossil energy use concept

The total yearly energy demand of Sugar Factory Kaposvár is 17.4 million m^3 natural gas, if we consider 120 days long campaign period and an additional 120 days heating period where there is no sugar production but all buildings should be heated. The available raw materials in the sugar factory are 264,000 t (120 days x 2.200 t/day). One ton of sugar beet pulp produces 700 m^3 natural gas equivalents so the total energy potential from sugar factory by-products is 18.48 million m^3 natural gas which can cover the total demand of the factory. The main problem is that the 90 % of the energy is needed during the campaign period from September to January, but the production of biogas is rather homogenous during the whole year. The solution of the problem is to feed the biogas during the non campaign period into the official natural gas system and recover it during the campaign period. The precondition of feeding biogas into the official natural gas pipe system is to have the same parameters (methane content) as the natural gas. To convert biogas into natural gas quality a gas cleaning system is needed which separates the carbon-dioxide from methane. The total capacity of the biogas plant makes it possible even higher biogas output up to a total quantity of 28.8 million m^3 natural gas equivalent. The difference of the production and use is 11.4 million m^3 which can be sold free on the natural gas market. The organic raw material need to use the total potential of the biogas plant is 396,000 tons. The total available quantity of sugar factory organic by-products (sugar beet pulp + beet tops and parts) is 264.000 tons. The difference of 132,000 tons can be covered by either other sugar factory by products (molasses) or by organic by products from other food industry segments (e.g. soapy water from biodiesel production, bran from flour-factory). Energy production during campaign, heating period and after heating period are shown in *Figure 2, Figure 3* and *Figure 4*. Biogas production and use data are summarized in *Table 1* and *Figure 5*.

Figure 2

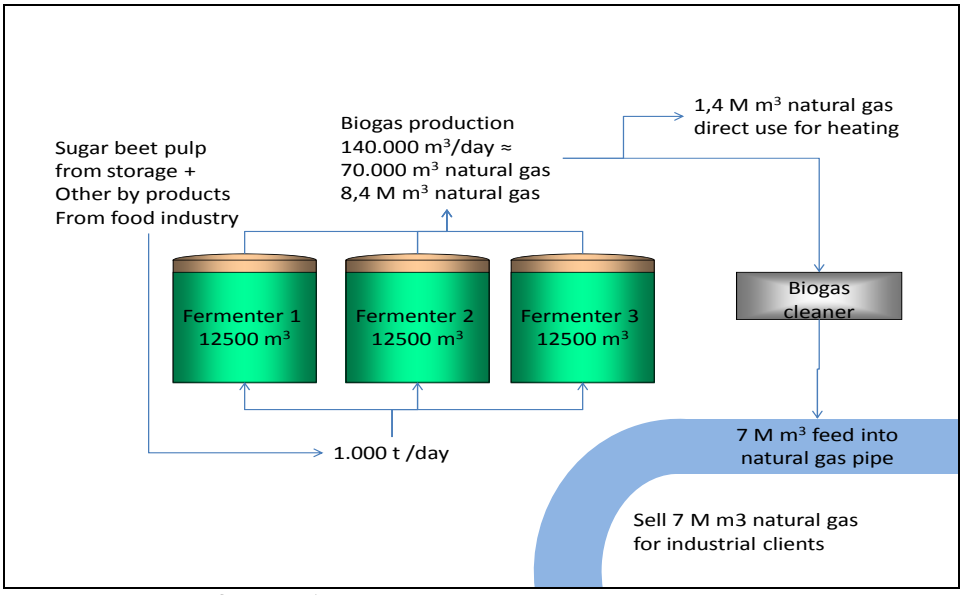
Energy production during the sugar beet campaign 120 days (September-December)



Source: *Hungarian Sugar Ltd*

Figure 3

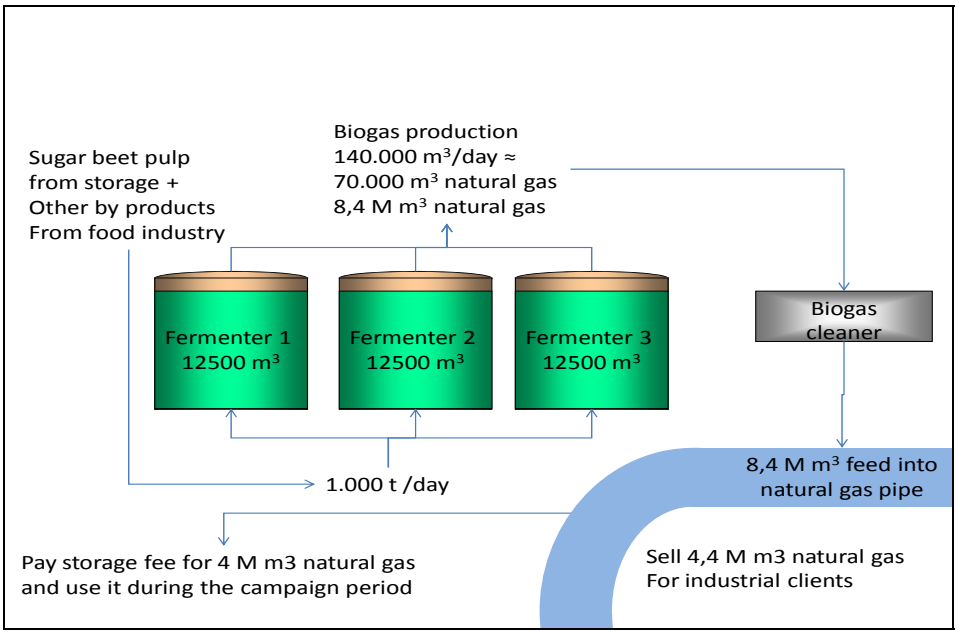
Energy production in the heating period 120 days (January-April)



Source: *Hungarian Sugar Ltd*

Figure 4

Energy production after campaign and heating period 120 days (May-August)



Source: *Hungarian Sugar Ltd*

Table 1

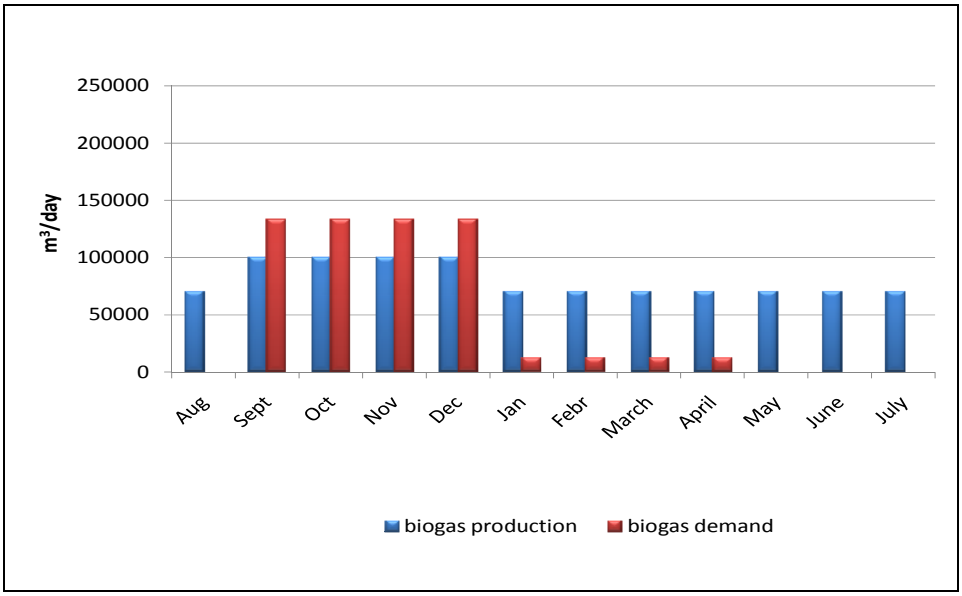
Energy production and use in natural gas equivalent

	Production	Direct use	Feed into pipe	Recapture (indirect use)
Campaign period	12.0 M m³	12.0 M m³		4.0 M m³
Heating period	8.4 M m³	1.4 M m³	7.0 M m³	
Period after campaign and heating	8.4 M m³		8.4 M m³	
Total	28.8 M m³	13.4 M m³	15.4 M m³	4.0 M m³

Source: *Hungarian Sugar Ltd*

Figure 5

Biogas production and demand (m^3 natural gas equivalent / day)



Source: *Hungarian Sugar Ltd*

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