

## Explanation of the model.

### Introduction

A model was designed to determine the biogas production of a single stage CSTR digester with perfect mixing. A method for the economical comparison between different feedstocks is constructed based on the characteristics and price of the feedstock, the biogas production in the reactor and the price for the digestate.

### Current plant and feedstock characteristics

On top of the first page, the input page, general information about the plant and the country must be filled in. The volume of the reactor is necessary to calculate the residence time of the feedstock. The price of digestate and biogas are important for the calculation of the economic feasibility of the different feedstocks. The cost to process the digestate can differ depending on the country and the processing method. If you receive money for the digestate, a negative value should be filled in. The produced biogas has an economic value of 0.4957 Euro/Nm<sup>3</sup> in Flanders. Values for other countries depend on the subsidies in that country. These values should be inserted here.

In the second table one should fill in the feedstock, average daily loading rate and price for each type of feedstock. One can choose between 8 different feedstocks. Negative values indicate that a gate fee is asked for the feedstock. If grass is already used as a feedstock it should be indicated on the line reserved for grass. The specifications asked about grass are: date of mowing, storage method and grassland type. For the latter there are 3 possibilities. Type 1 is grass comparable to that from agricultural fields, it is well maintained and the biogas potential (BGP) will be high. Type 3 is grass from fields also containing more lignified species, is harvested less often and has a lower yield per hectare. The BGP of type 2 grassland is intermediate between type 1 and type 3. Figure 1 shows the 3 types of grasslands.



Figure 1: the 3 types of grassland, from left to right: type 1, 2 and 3

In the table at the bottom of page 1 the assumptions can be found regarding the feedstock. This data can be altered by the user. For grass the BGP and DM is calculated based on data found in the literature.

Table 1: Biomass information grid

Feedstock	BGP(l/kg DM)	%DM	time to make	
			75% of BGP (d)	C/N ratio
Pig slurry	150	10	19	5
Manure	270	10	19	12
Maize silage	610	35	15	40
Cattle slurry	250	10	19	5
Glycerol	910	80	12	500
Oil and Fat	910	100	13	400
Grass silage	...	...	18	30
Others				

### Economic output

When the BGP of the feedstock, the price and the cost of the produced digestate are taken into consideration the model compares the profit of different feedstocks. In the first graph on the second page, the profit for every ton of biomass is represented. Different feedstocks are compared here. The second graph represents the profit per Nm<sup>3</sup> biogas produced.

### Technical output

It is advised to limit the grass use to 15-20 % in a wet digester. The fibers can cause problems for the pumps and mixing systems. Depending on the pre-treatment (for example extrusion) or digester type (for example a dry digester) the advised limit can be increased to up to 90 %.

The dry matter content (DM) is calculated based on the input material and should be managed properly in the reactor.

The C/N ratio in the reactor represents the carbon over nitrogen ratio. This parameter is important for the microbiological community in the reactor. High concentrations of nitrogen cause ammonia inhibition and can decrease the biogas production with 15% or more. Very low nitrogen concentration can also result in a significant decrease in biogas production because nitrogen is an essential element for microbiological growth.

### Interpretation and conclusion

Based on the purchase price, the BGP and the digestate cost, different feedstocks are compared against each other and against nature and roadside grass. This model does not take into consideration any processing or transport costs. Also equipment costs or labor costs are not taken into consideration. In case some costs are specific for one feedstock, these costs should be added to the feedstock price.

This model is designed to evaluate different feedstocks. Therefore, costs which are the same for all feedstocks should not be taken into consideration. This is only relevant to assess whether the digestion process as a whole is economically feasible.