12 Plant Design

The plant design is executed to a level of detail in which the main specifications of the individual components of the biogas installation are determined. The process of designing the plant is implemented in the Excel tool in which the energy potential is generated, based on the given biomass quality and quantity. As aforementioned two scenarios are considered. The plant design is based on the scenario excluding the abattoir waste. The main reason is that the legislative landscape for biogas plants that handle abattoir waste is relatively non-transparent and ever changing. In turn, this leads to uncertainty in terms of finances and time. Nevertheless, future developments in the aforementioned landscape might lead to a stronger position for biogas plants including abattoir waste.

12.1 Components

This chapter highlights the team's proposed main specifications of the individual components this power plant will feature: the biogas digester, a gasholder dome, the scrubbing system (although this was not explored in detail, due to time constraints) and the generator.

Geometry

The chosen digester type will be cylindrical in shape. By defining a height to radius ratio, the calculated slurry volume can be broken down into the two variable dimensions of the chosen geometric figure. In this work a slurry level to radius ratio of $\frac{h_{slurry}}{R} = 1$ was chosen. To prevent overflow a safety factor of $S_{tank} = 1{,}2$ as a factor for additional height of the digester was chosen. Thus determining the ultimate height and volume of the digester.

TABLE 24: KEY GEOMETRICAL DATA OF THE PROPOSED DIGESTER DESIGN.

Description	Value	Unit
Digester Volume	246	m^3
Slurry Volume	123	m^3
Buffer Volume	123	m^3
Radius	3,4	m
Thickness	0,15	m
Digester Height	6,8	m
Slurry Level	3,4	m

Input and Output
The input and output of the biogas digester is based on a mass balance as visualized in Figure 4.

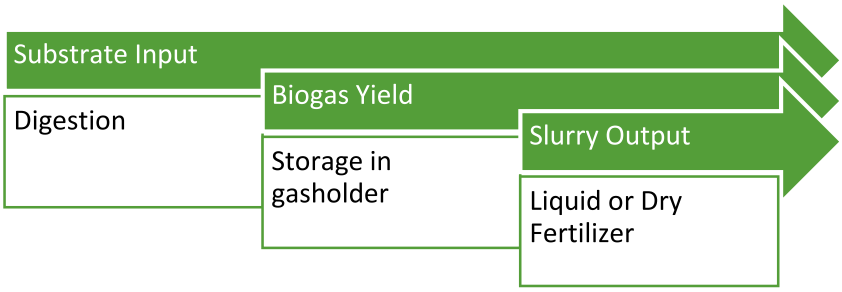

FIGURE 4: FLOW-CHART DEMONSTRATING THE SUBSTRATE CONVERSION INTO 2 PRODUCTS.

Table 25 shows the most important input and output values. The calculations of these values can be found in Energy Potential.

TABLE 25: INFLOW AND OUTFLOW VALUES OF THE DIGESTER.

Description	Value	Unit
Substrate input	4,1	m^3/day
Liquid fertilizer output	4,0	m^3/day
Dry fertilizer output	396	kg/day
Biogas yield	110	m^3/day

12.1.1 Gas Storage
Functional Requirements
The gas will be stored separately. It is designed to hold approximately 12 hours, $t_{storage}$, of gas produced per day to compensate for the load duration of 16 hours per day. Due to the material strain the pressure inside cannot exceed a certain threshold. In this case the maximum pressure difference cannot exceed 5 mbar (Steinhauser, 2008). If the pressure exceeds this threshold the gas must be flared off, which will be the case during maintenance. The relevant design parameters of the gasholder can be found in Table 26.

TABLE 26: PARAMETERS THE GAS STORAGE IS DESIGNED FOR.

Description	Value	Unit
Biogas Storage Capacity	12	h
Maximum pressure difference	5	Mbar
Volume	66	m^3

12.1.2 Slurry Basin

This basin, which will act as an overflow tank, in which the slurry can be stored in temporarily post-digestion. As the fertilizer will not necessarily be picked up daily, it can be stored for a certain amount of time. In this case the team chose seven days — weekly pick-ups — approximately one fourth of the retention time. The global geometrical design parameters, with exception to the thickness can be found in Table 27.

TABLE 27: : GEOMETRICAL DESIGN PARAMETERS OF THE SLURRY BASIN, INCLUDING.

Description	Value	Unit
Volume	29	m^3
Side A	5,4	m
Side B	5,4	m
Depth	1,0	m

12.1.3 Scrubber

The approximate content of 0,5 vol.% of H_2S in the gas will be reduced to a concentration of 0,05 vol.% of H_2S, to prevent corrosion downstream the installation (Steinhauser, 2008). The gas treatment system must handle a flow rate of approximately 4,8 $\frac{\mathrm{m}^3}{\mathrm{h}}$.

12.1.4 Generator

The team recommends installing a generator of the power of 16 kW. This CHP engine, will also provide the digester with the heat required to maintain a digester temperature of 32°C to 42°C. The global generator design parameters, can be found in Table 28.

TABLE 28: GENERATOR DESIGN PARAMETERS.

Description	Value	Unit
Energy Anually	72.257	kWh
Full-load Hours Annually	4416	h
Average Daily Duration	16	h
Average Load Factor	80	%

12.1.5 Biogas Digester

The team recommends the construction of a concrete and heated continuously stirred tank reactor (CSTR) under mesophilic conditions, as a proven technology for commercial biogas applications worldwide. Moreover, this is the only technology available in South Africa that has been proven on a commercial scale so-far. The tables below demonstrate the conditions the digester will be operating at, the proposed geometry, and the input and output (mass balance).

13 Financial Analysis