Grassification

D1.3.1
System design and preparation

Document Control Page

Title	D1.3.1 - System design and preparation
Editor	Tom de Vrieze – Vanheede
Contributors	Kristof Vanmaldeghem – Vanheede; Marc Braet - Vanheede
Nature	Document
Dissemination Level	Public
Version number	3.0
Planned Delivery Date	01 05 2019
Version date	28 01 2020
Abstract	PP7, LP, & PP6 will design & specify the goals, parameters & set-up. Due attention to compliance of residual streams with the WP2 goals (LP: fertiliser, PP6: fibre). LP & PP6 will use demo as research topic for students. PP7 will use an existing land fill operation & CHP installation to accommodate the demo.

Version	**Date**	**Modified by**	**Comments**
0.1	01.05.2019	Vanheede	First version
2.0	02.05.2019	Ghent University	Improvements, Quality check
3.0	28.01.2020	Vanheede	Inclusion of changes second batch

Contents

Table of content

Document Control Page 2
Executive summary 4
Digester cell 4
Cross section 6
Organic load calculation, dimensioning 8
Process control 10
Organic reactor load 10
Temperature control 10
Leachate 10
Gas production 11
Analysis grid .... **Error! Bookmark not defined.**
Steering of the process .... **Error! Bookmark not defined.**
GRASSIFICATION consortium 12
Attachments .... **Error! Bookmark not defined.**

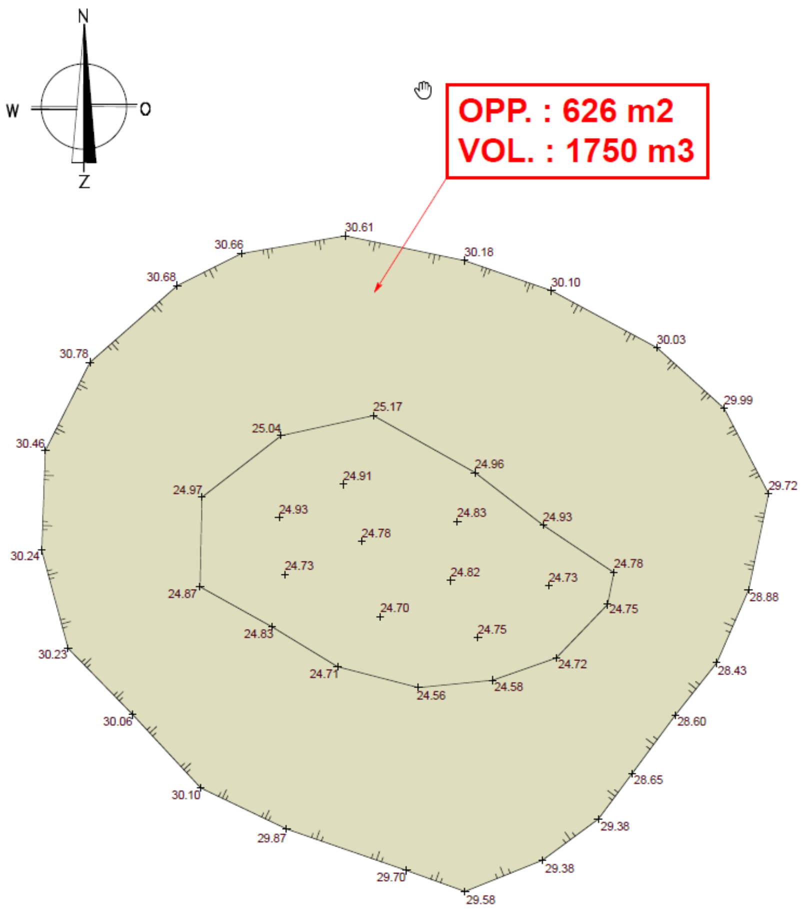
Executive summary

This 200 t pilot will allow processing and valorisation of low quality grass wastes that are unsuitable for refining. Biogas yield and conversion into renewable heat and electricity obtained from treated grass waste will be measured through gass flow analysis. Anticipated production of 100 Nm^3 of biogas per tonne of grass waste (50-60% CH_4; 500-600 kWh/t calorific value converted in 200-250 kWh electricity / ton waste + 200-250 kWh heat / ton waste) as compared to a 0 baseline currently (no valorisation).

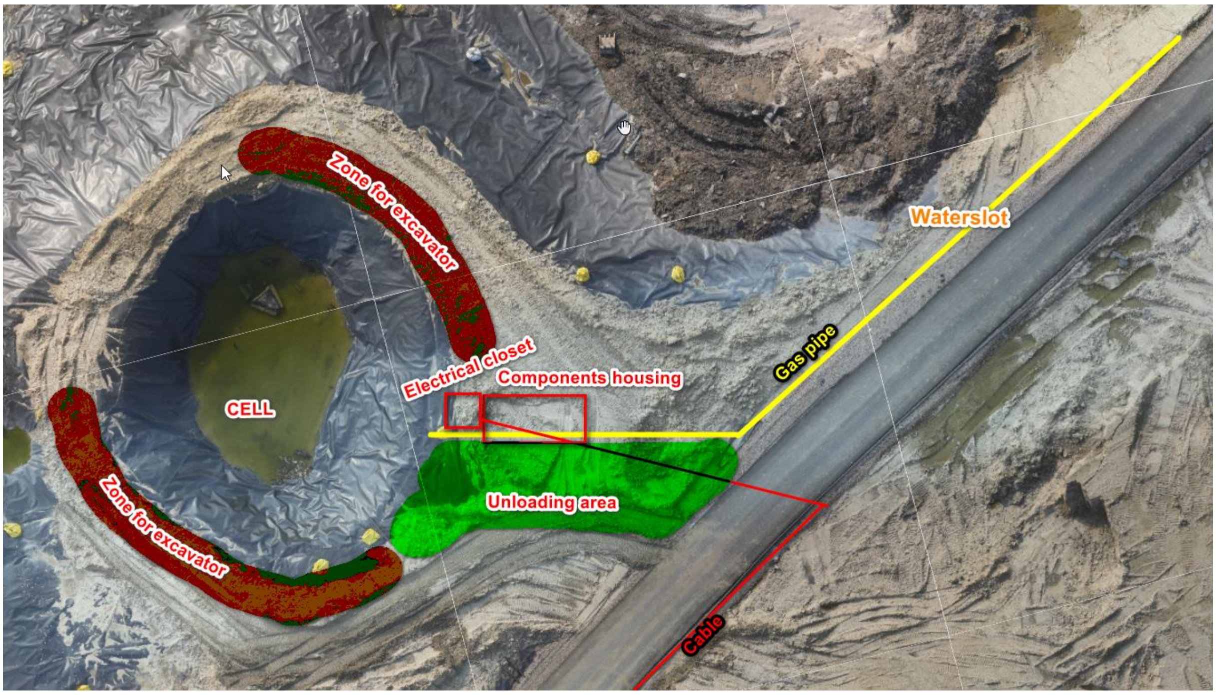
Digester cell

The pilot digester cell measures, on the outer rim, about 25 by 29 meters, and over 5 meters deep, creating a volume of 1750 m^3. HDPE film is used as liner and top cover to create a closed reactor.

Measurements by surveyor:



Reality top view

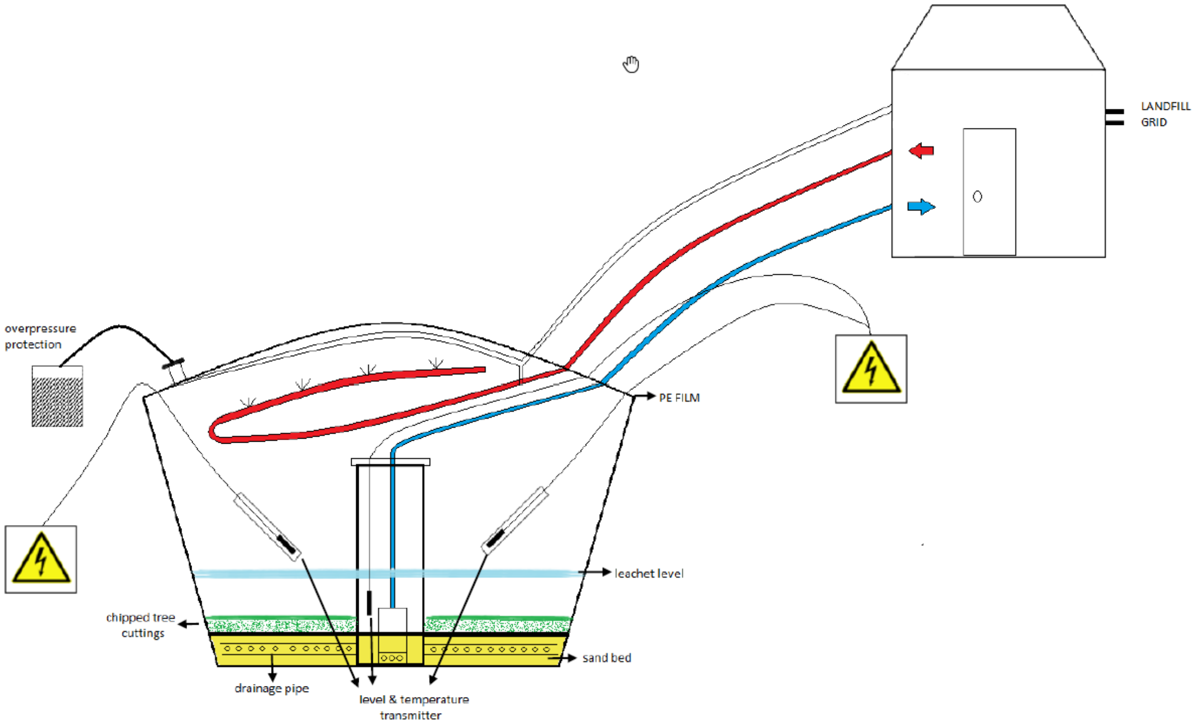


Realization of the cell

HDPE film is used as a liner and top cover to create a closed reactor.

Cross section

The cell consists of a digester bed with a drainage system below and a degassing system on top. The leachate runs through a buffer layer (low biodegradable clippings) and a sand bed into drainage pipes that are connected to a pump shaft. The collected leachate can be pumped back to the top of the digester bed by means of a permeable piping system or collected outside of the digester cell. The inline flow meter and temperature transmitter register the circulation or drain events.

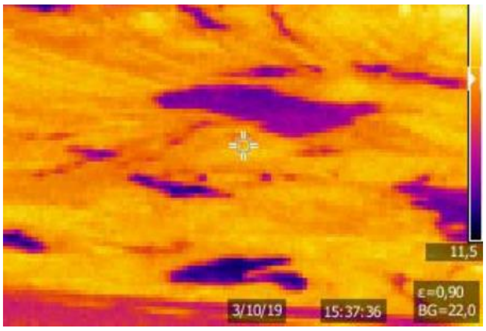


<u>Adaptations second batch (winter)</u>

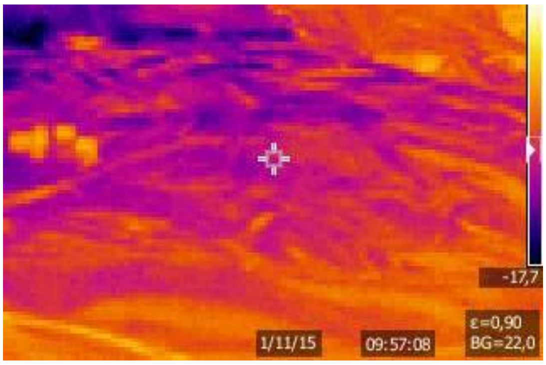
Keeping the temperatures within mesophilic range throughout the hole cell is a challenge during colder periods, therefore extra precautions needed to be made:

1) Isolation of the top surface: isolation panels are installed between 2 layers of non-woven textile and covered with HDPE film.

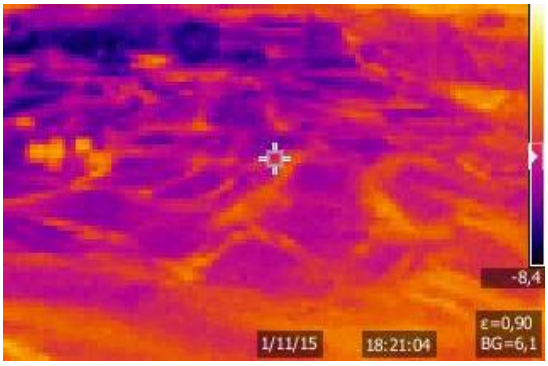
Images with an infrared camera:



3/10/19: end of batch 1, no isolation panels installed nor heating system. The purple zones are the result of small water puddles on the HDPE surface.



28/01/20: batch 2 with isolation panels, heating not active.



28/01/20: batch 2 with isolation panels, heating active.

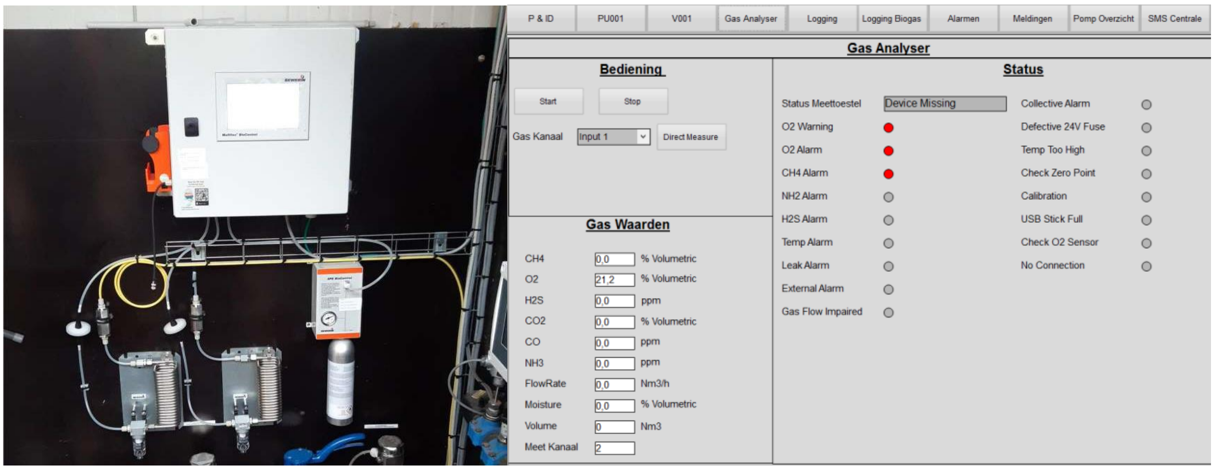
2) Heating up the recirculation water: by means of a 21kW electric hot water heater and a 500 L reservoir with heat exchanger, the recirculation water is heated up to 50°C. During colder periods, this system can add extra heat to the digester in case this is required.

3) Inline gas analysis

Keeping the digester in a negative pressure creates a risk of air penetration in case of problems with the HDPE film, cable crossings or one of the gas pipes. This can be monitored by means of a biogas analyser, which measures oxygen. The presence of oxygen in the grass cell has a negative impact on the anaerobic process, influences the biogas flow measurement, methane measurement and energy valorisation.

Oxygen levels above 0.3% require an adjustment of the process to minimise the effects. Depending of the size of the physical opening, the negative pressure on the grass cell needs to be decreased or levelled with the atmospheric pressure. This action will results in a lower biogas production.

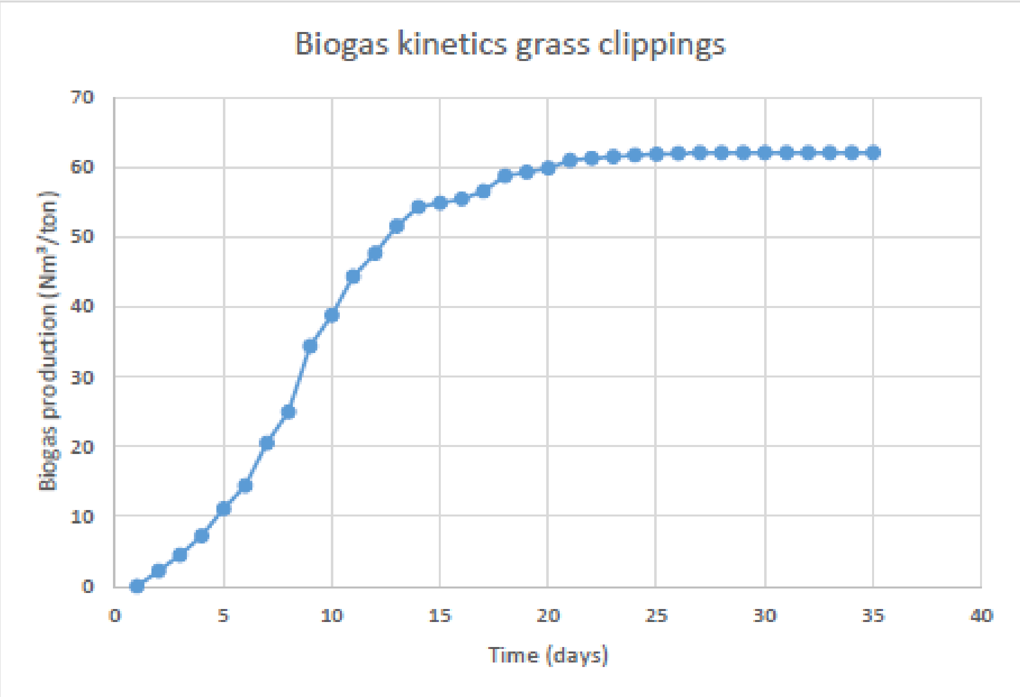
During the first batch and beginning of the second batch, measurements with an offline biogas analyser showed high fluctuations in oxygen levels (hot season between 0.1% and 0.9% oxygen; cold season between 0.1% and 5.3% oxygen). As the impact on the process and the measurement results is high, an inline sampling device was installed, which is coupled to a biogas analyser. Measurement frequency can be adjusted and values can be consulted in the biogas log.



Organic load calculation, dimensioning

Without going too much into detail about anaerobic digestion in this report, we can say that the organic matter is digested and transformed to methane in four stages: hydrolysis, acidogenesis, acetogenesis and methanogensis. The bacteria that make the methanogenesis happen do not support a low pH level. It is important that they can transform the acids from the former stages directly to methane. Therefore, the organic load of the biological system must not be too high and there must be enough bacteria too do the job. The minimum quantity of inoculum (digestate) was determined by calculating the OLR and taking into account all practical constraints. It will be recalculated based on analysis of the incoming material (see below).

The dimensioning of the gas collection system is based on the kinetics of a lab analysis of grass clippings @ 38°C.



Based on reactor load calculations and permeability requirements of the digester bed, the input material for trial 1 was determined as:

- Roadside grass clippings: 250 ton
- Liquid digestate: 250 ton
- Chicory chips: 40 ton

To verify the quality of the delivered materials, a sampling routine needs to be organised. The dry matter content is to be determined by means of a quick analysis tool and this will allow the operators to control the input composition based on the organic load calculation. Samples for further analysis in an external lab are required for more precise characterization. The choice of the digestate has been done according to logistical and biological specifications. Transport has to be minimized, but it is also important that the digestate is an appropriate inoculum for the anaerobic digestion of the grass. It should come directly from a digestor (not from a digestate storage) with a similar substrate.

The mixing and spreading of the input materials is done with a grab bucket crane and a bulk tank with slurry spreading system. The chicory roots are chipped with a hydraulic feeder on a mobile tele handler.



To achieve higher density of the digester, bed compaction tools installed on a heavy excavator are used. When the digester bed is finished, the gas collection piping and circulation piping are installed. Finally the HDPE cover is welded to the liner to seal off the digester. The leachate level in the pump shaft is measured and is used for circulation control.

Process control

Organic reactor load

Managing the organic reactor load is key when creating a stable anaerobic digestion process. In a batch process, the ORL is defined during the mixing and filling process; correcting this afterwards is difficult and in most cases impossible. By using average analysis results on the input materials, the organic reactor load can be calculated with a theoretical model; the difficulty is to define the characteristics of the real input material and adjust the mixture accordingly. As the mixture and filling process takes place in a limited number of days, the characterization should be done by fast analysis on site, complemented with thorough analysis in an external lab. The later will be used for calibration of the fast tests and support of the later process control.

Temperature control

The temperature evolution in the digester bed is uncertain, and so is its impact on the biogas kinetics. It is likely that a temperature control is required to achieve complete digestion of the input materials in the available time interval. During trial 1, the temperature of the leachate and inside the reactor bed were measured and the changes described above were implemented based on the results of the summer batch to ensure a minimum temperature for the winter batch.

Leachate

The anaerobic digestion will create volatile fatty acids (VFA) as predecessors of CH_4; therefore, the composition and concentration of the volatile fatty acids gives direct information of the balances in the biologic process. By means of a FOS/TAC analysis - VFA (mg equivalent of acetic acid per litre)/ Total Alkalinity (mg equivalent of calcium carbonate per litre)- which can be done on site, the stability of the process can be measured. Based on these parameters, the circulation process will be managed.

Gas production

As different organic molecules produce biogas with a different CH_4 / CO_2 composition, a fluctuation of the biogas quality is to be expected. Other than that, as a result of the batch methodology, residual air is present in the digester and will impact O_2, CO_2 and N_2 levels during the process.

The biogas flow and composition are key parameters to follow the biologic process and degradation potential.

GRASSIFICATION consortium

Project No. 2S03-014:

With the financial support of
Interreg 2 Seas Mers Zeeën

www.interreg2seas.eu/en/grassification