This document is intended to outline the performance improvements in a wet biomethanation process after having treated the organic waste from source-separated collection, the residuals from mechanical treatment or the remaining material from organics, through a thermal hydrolysis system patented by ECONWARD TECH known as BIOMAK®.

The conclusions submitted are the result of two years of investigation, during which a multistage testing protocol was conducted. Initially, a laboratory trial was carried out by Energylab Technology Centre. The good results obtained allowed for a further, broader study that was progressively developed until reaching a semi-industrial scale level at ECONWARD TECH´s facilities, in Rivas Vaciamadrid (Madrid) and at R&D CLAMBER Biorefinery, in Puertollano (Castilla La Mancha), for a period of five months. The latter testing was carried out using the fines from the source separated waste collected in the city of Madrid, provided by the FCC company in agreement with the City Council of Madrid.

At the same time, this study has also considered a number of results obtained by the Genia Global Energy company after elaborating a basic engineering assessment to integrate the BIOMAK® in a standard AD operation.

The most significant improvements achieved are detailed below:

1. Increase in specific biogas production

The thermal hydrolysis process helps anaerobic microorganisms access to organic matter, by partially hydrolysing and partially degrading the material. Thus, the specific biogas production yield per tonne is improved between 25% and 50% compared to a standard wet biomethanation facility.

2. High quality biogas

The biogas obtained from the biomethanation of the hydrolysed waste is considered of high quality due to its high content in methane and low content in impurities and contaminants.

The content in methane shows maximum values over 70% with an average methane concentration of 65%-68%[4]. Regarding impurities or contaminants, the degree of concentration is the following: sulfhydric acid between 120 and 1,500 ppm mol[4], siloxanes between 0.5-1.6 mg/Nm^3[4] and total silicon between 0.2-0.4 mg/Nm^3 [4].

These results are derived from measuring the parameters on the raw biogas obtained from the process, that is, directly from the digester without using any chemical reagents for pH maintenance or sulfhydric acid abatement. As a result, the biogas produced is very appropriate for upgrading systems or energy valorisation in a cogeneration system.

3. High biodegradability

The BIOMAK® changes the chemical structure of the waste which increases the anaerobic digestion performance. These changes generate a highly biodegradable waste, obtaining 87% to 91%[4] removal efficiency (conversion rate of solids into biogas) of the total solids sent to the digesters. This directly reduces the amount of solid digestate that has to be matured and managed after the biomethanation process.

4. Residence time reduction

The time necessary to complete the anaerobic digestion process is significantly reduced due to the hydrolysis process previously carried out in the BIOMAK®. Specifically, the hydrolysed waste can be digested in Hydraulic Retention Times (HRT) of 15 to 20 days[4] (depending on the waste composition) whereas in standard AD, retention times are set between 25 to 30 days.

This is a significant improvement, since the number of digesters needed for a new build facility and at an equal digestion capacity, would be reduced from 6 to 4, achieving up to a 30% reduction in CAPEX[2]. At the same time, both for a new build as for an existing facility, the treatment capacity would increase, resulting in a subsequent reduction in OPEX.

5. Process stability and robustness

The BIOMAK® eliminates pathogens, biocides and antibiotics and breaks down the organic matter, producing a homogeneous, inhibitory substance-free biomass.

This homogeneity of the biomass, in conjunction with a partial hydrolyzation, allows to operate – without adding any chemical reagents to the process - with high organic loading rates of up to 8 kg COD/m^3, without producing acidification or inhibitions in the system.

The absence of inhibitory substances together with the low concentration of residuals in the substrate sent to the AD process, provides greater stability, flexibility and robustness to the biomethanation process compared with the raw waste that has not been subjected to a thermal hydrolysis process[2].

6. Substrate with high organic content

During the thermal hydrolysis process, the organic matter undergoes a decomposition process that reduces the particle size and changes its physical properties. Organic matter separation from residuals is more efficient than in conventional systems, recovering greater amount of organic matter and separating a greater amount of residuals. Thus, the loss of organic matter during the separation of residuals (lower than 10%) is minimised, as well as the performance of this separation is improved.

The resulting substrate sent to anaerobic digestion after cleaning has an average organic matter content of 98% on a wet basis. This minimises the accumulation of residuals inside the digesters that usually hinder their operation, and improves the performance of the biological process.

7. Increase in net biogas production

The net biogas production in biomethanation plants increases due to four reasons:

- Stability in the biogas production process
- Increased specific biogas production per tonne of organic waste received at the facility.
- Greater recovery of organic matter during the residuals separation process.
- Lower Hydraulic Retention Time (HRT)

8. Greater mechanical simplicity

The thermal hydrolysis process breaks down the organic matter, resulting in a greater fluidity associated with a particle size reduction and a lower viscosity. These features simplify the plant design and reduce investment and operating costs: pumping, agitation, piping, etc.[2] .

9. Digestate quality

The thermal hydrolysis process improves the properties of digestate. During the semi-industrial scale testing, a decrease of ammoniacal nitrogen content has been observed in the digestate when the waste is preatreated by a thermal hydrolysis process. Additionally, a pathogen-free digestate is obtained without the need to use additional equipment (pasteuriser)[2].

After subjecting the digestate to maturation process in windrows, the compost obtained meets the requirements of the RD/ 506/2013 to be classified as a Class B Compost.

10. Electricity production

The present integration model estimates that the electricity production by using a thermal hydrolysis process is of 300-350 kWe/t of organic matter received in the facility's receiving pit. In a conventional case, electricity production is estimated at 150 -175 kWe/t of organic matter received in the facility's receiving pit.

11. Reduction in anaerobic digestion CAPEX

Using this thermal hydrolysis treatment reduces the number of digesters, simplifies pumps and agitators design, and eliminates the need of additional equipment required in conventional processing operation (pasteuriser, hydrolysers, etc.). This reduction in the usable volume of digestion needed for the process would represent a reduction in CAPEX of digesters about 30% for a new build facility.

12. Reduction in OPEX

The thermal hydrolysis treatment enhances the fluid-dynamic characteristics of the substrate, improving the pumping and agitation systems, and getting a 45%-60% increase in energy efficiency in both systems for the digester process[2].

In addition, the substrate fed into the digester has high organic matter content, so the digester maintenance is reduced due to the absence of residual accumulation. Moreover, the cost to heat the digesters is lower because the biomass leaves the thermal hydrolysis process at very high temperature (about 55-65 ºC).

The biomethanation process of the hydrolysed waste at semi-industrial scale was carried out without using chemical reagents, neither for the process control nor for the impurities removal from the biogas [4]. This contributes to a significant reduction in the total operating costs of the facility.

Integrating the BIOMAK® into a biomethanation plant which valorises all the biogas produced through a cogeneration system, is considered, under nominal operating conditions, an energetically self-sufficient facility, both electrically and thermally.

Given the high automation of the BIOMAK® and due to a greater stability of the biomethanation process, the overall operation requires less labour than a conventional facility.

In conclusion, the BIOMAK® reduces the operating cost ratio per treated tonne of waste since it improves the total yields of the facility because can process greater amount of organic matter per digestion volume.

13. Efficient removal of residuals

During the semi-industrial testing, the separation of residuals was carried out in a two-stage process: in the first stage light residuals (plastics, light metals, textiles and lignocellulose) are recovered and the heavy residuals (inerts, glass, sands) are recovered in a second one. The BIOMAK® produces a physical degradation of the organic fraction which improves its fluid-dynamic characteristics, making the organic matter easier to clean. This helps recover between 90% and 95% of the organic matter received at the facility compared to the 82% recovered in conventional systems[2].

From the residuals separation, light residuals can be recovered as SRF, and inerts can be disposed in a licenced landfill site due to the near abscence of organic material. Thus, the organic waste disposal to landfill is significantly minimised, contributing to the achievement of the European Union's Recycling Targets in alignment with the United Nations Sustainable Development Goals (SDG).

14. Energy self-consumption

For a treatment facility that valorises biogas in Combined and Heat Power systems, the electricity demand of the BIOMAK® accounts for less than 1% of the total electricity production produced in the cogeneration plant. The thermal energy demand represents 89% of the heat recovered from high-temperature combustion of gases[1], depending on various factors such as humidity percentage, organic matter or hemicellulose content. There is an energy surplus at low temperature recovered from the combined cycle that can be used for internal consumption or export to other facilities (district heating). In this regard, the BIOMAK® integrated in a biomethanation facility with CHP system increases energy self-consumption.

15. Odour reduction

In biomethanation plants, storage and handling practices cause odour nuisances. The BIOMAK® treatment reduces odours when storing and handling, which is a great advantage over other conventional treatments[2].

16. Carbon footprint reduction

Comparing the biomethanation process of the hydrolysed organic waste after applying the BIOMAK® treatment and the cogeneration system for biogas valorisation with organic waste sent to landfills or electricity production from natural gas, the carbon footprint reduction is 12,000 tonnes of CO_2 / year, equivalent to safeguarding 3,400 hectares of forest, per each 60,000 tonnes of treated waste.

REFERENCE REPORTS

[1] Feasibility Study and Conceptual Engineering for MSW treatment plant. February 2020. Genia Global Energy. Internal reference: R020-G-TS00-001V_00_AP.

[2] TPH competitive advantages compared with other MSW treatments. February 2020. Genia Global Energy. Internal reference: R020-G-TS00-002V_00_AP.

[3] Ratio report for Integration model of Thermal Hydrolysis Treatment and Biomethanation Process. February 2020. Genia Global Energy. Internal reference: R020-P-RE00-001V_00_AP.

[4] CLAMBER Report 2020/2021 verified by Bureau Veritas. Internal reference: R020-P-RE00-002V_00_AP.