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## INTRODUCTION

Anaerobic digestion is a process that generates a biogas, composed of several gases, i.e. methane (60%-70%), CO<sub>2</sub> (30%-40%), nitrogen (<1%), and H<sub>2</sub>S (10-2,000 ppm). Although, the composition of biogas is various, methane is its principal component. Biogas can be used as a fuel, and can thus be regarded as a productive and cost-effective source of energy. However, first it must be enriched and all pollutants eliminated. Of the gases that need to be eliminated, hydrogen sulphide (H<sub>2</sub>S) is the most harmful because of its corrosive effect. Furthermore, if the biogas is to be upgraded to standard natural gas or car fuel, CO<sub>2</sub> must also be eliminated because it reduces the energy content of the biogas (Appels et al., 2008). The first phase of our research study (Osorio and Torres, 2009) involved the optimization of the chemical desulphurization of biogas. The second phase carried out consisted of treating the biogas in a pilot plant where it underwent chemical scrubbing with amines (Osorio et al, 2011).

## METHODS

Our pilot plant is located in the wastewater treatment plant in Murcia (Spain), and the first phase consisting of chemical scrubbing receives the direct inflow of gas coming from the anaerobic digesters there (see Figure 1). The second step consisted of the separation of the two main compounds in the gas, namely, methane and carbon dioxide. The process involved was chemical absorption or the reaction of carbon dioxide with mono-ethanol-amine, MEA, at 20%. However, for this process to be economically viable, it was necessary to be able to recover the saturated amine from the carbon dioxide. This regeneration was carried out by means of chemical desorption, which involved increasing the temperature to invert the process, thus making it possible to reuse the amine (see Figures 2 and 3).

During the experimentation phase, the H<sub>2</sub>S concentration of the wastewater plant inflow varied from a minimum of 579 ppm to a maximum of 6790 ppm. The resulting mean level was 3349 ppm.



Figure 3.- Photographs of the pilot plant

For an H<sub>2</sub>S concentration of less than 2000 ppm, the H<sub>2</sub>S outflow concentration was systematically close to 0 working in all conditions. For any of the stages, the outflow concentration of trace compounds other than H<sub>2</sub>S was less than the minimum quantity detectable by the standard laboratory methods used for their analysis.

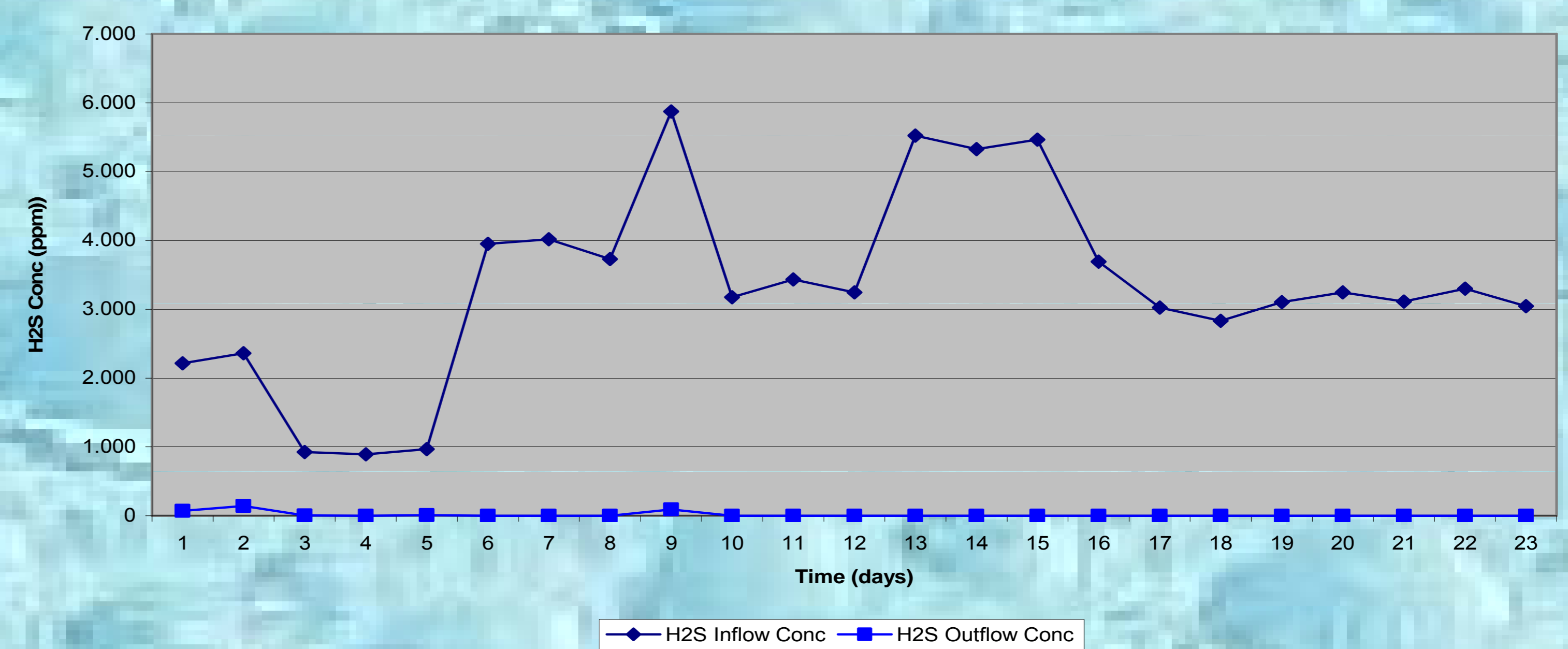


Figure 4.- Stage 1: H2S inflow concentration–H2S outflow concentration

## Second phase (absorption with MEA and desorption system)

In this phase, a high concentration of CO<sub>2</sub> of around 39% was used, in order to understand how CH<sub>4</sub> (in biogas) affected the absorption of CO<sub>2</sub> in the amine. The following two experimental studies were designed in the second phase:

- 1) Study of the efficiency of the number of packed towers in the absorption tower, and the optimal flow rate of amine in the tower.
- 2) Study of the optimal temperatures in the desorption tower. For this purpose, the entry temperature of the amine was optimized. This temperature was based on the temperature set in the preheated boiler as well as the heat contribution of the resistances of the desorption tower.

In all cases, with minimal fluctuations, the biogas flow was almost 10 m<sup>3</sup>/h; the mean temperature was 30° C; and the pressure, 1,25 bar. The mean content of the resulting biogas was 85% methane, 2.2% oxygen, and 0.1% carbon dioxide. 200 l/h was selected as the minimum optimal flow rate for absorption. The maximum CO<sub>2</sub> rich loading using 20 wt.% of MEA with a dosage of 200 l/h in two towers, was 1.1 mol L<sup>-1</sup> during the first cycle of absorption. It should also be taken into account that in our study, operation was at a very low pressure (1.250 bar). In relation to the second study, based on the results, the optimal temperature was found to be 85°C.

## CONCLUSIONS

The biogas from anaerobic digestion in wastewater treatment plants can be sufficiently purified so that it can be used as biofuel for vehicles. One way of purifying biogas is chemical desulphurization in gas scrubbing towers, followed by removal of carbon dioxide by means of absorption with MEA (mono-ethanol-amine). When the process was optimized, the outflowing biogas had a mean CO<sub>2</sub> concentration of 0.1%.

## REFERENCES

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- Osorio, F. and Torres, J.C. (2009). Biogas Purification from Anaerobic Digestion in a Wastewater Treatment Plant for Biofuel Production. *Renewable Energy* 34(10): 2164–2171.
- Osorio, F., Sánchez, M. and Torres, J.C. (2011). Preliminary studies for the obtention of biofuel by absorption with mono-ethanol-amine from anaerobic digestion biogas in a wastewater treatment plant. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*. Accepted.

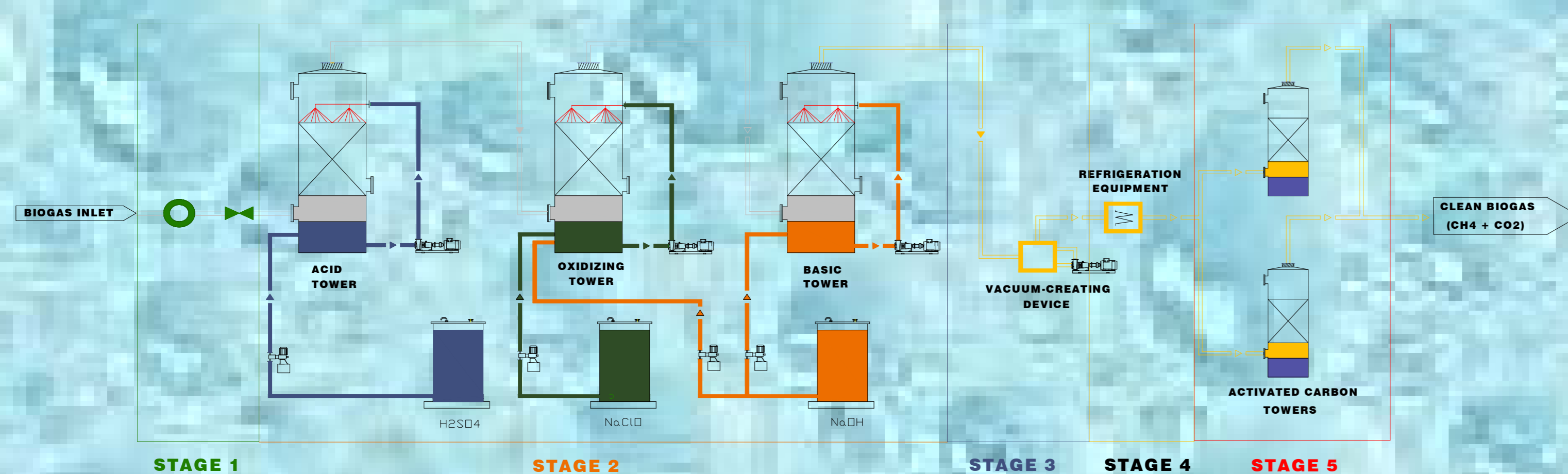


Figure 1.- Schema and flow diagram of the pilot plant (first phase)

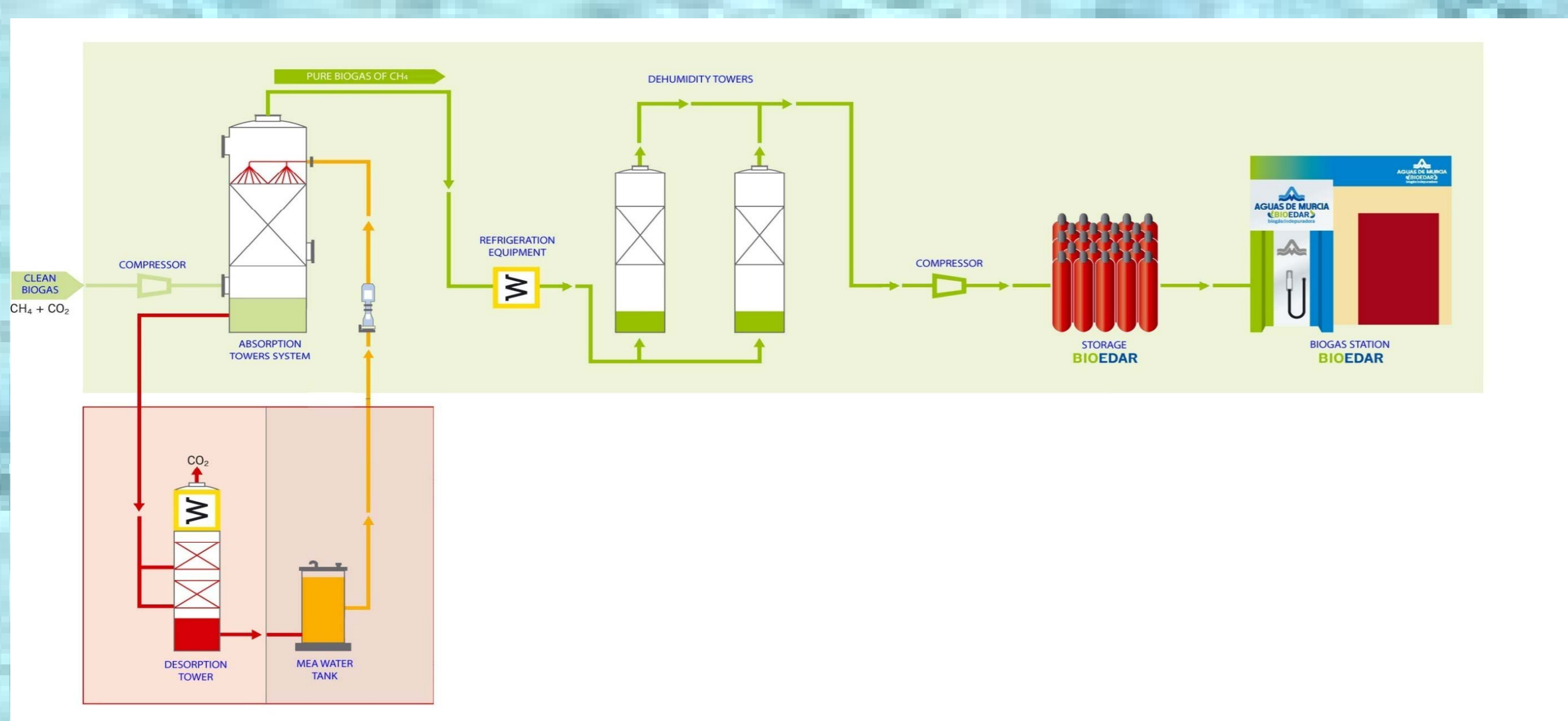


Figure 2.- Schema and flow diagram of the pilot plant (second phase)

## RESULTS AND DISCUSSION

### First phase (chemical desulphurization)

The main objective of this first research stage, when biogas desulphurization occurs, was to optimize the operation of the three scrubbing towers: T1, acid tower; T2, oxidizing tower; T3, basic tower. In all cases the biogas flow was 5 m<sup>3</sup>/h. Different combinations between towers and operation conditions of pH were tested. The most effective chemical desulphurization system with the scrubbing towers tested consists of one basic tower with the addition of NaOH (see Figure 4).