Optimization of the biogas upgrading process with CO_2 recovery using membrane contactors at pilot scale

J.M. Martín-Marroquín1,2, D. Hidalgo1,2, S. Bedate1, F. Nieto1,2,3
1.- CARTIF Technology Centre, Circular Economy Area, Boecillo (Valladolid), 47151, Spain
2- ITAP, University of Valladolid, Paseo del Cauce, 59 - 47011 Valladolid, Spain
3- Mechanical Engineering Department, University of Valladolid, Paseo del Cauce, 59 - 47011 Valladolid,

Introduction

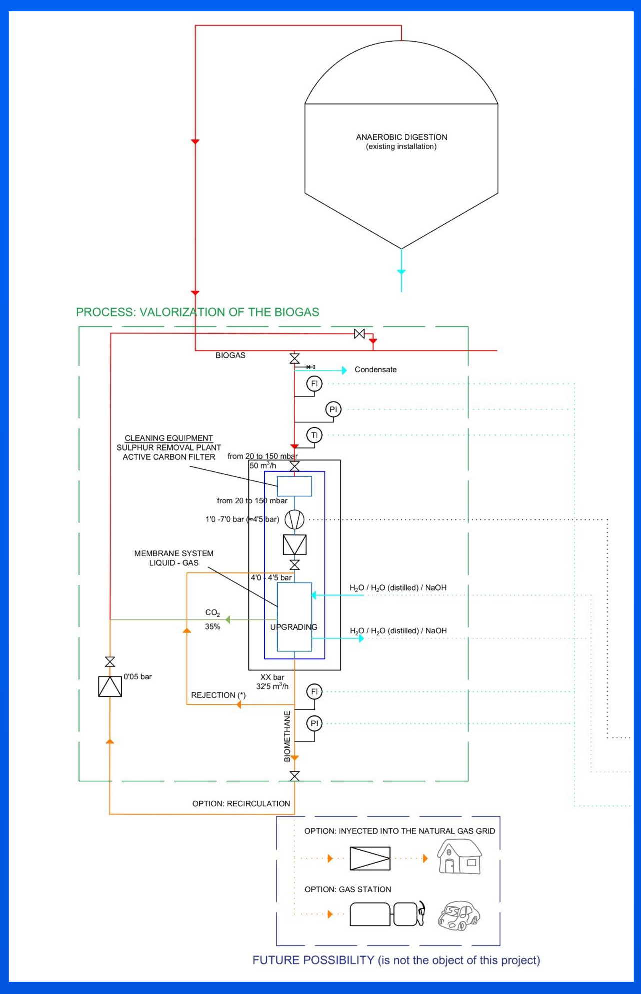

Figure 1:Biogas upgrading process scheme

Demand for methane-rich biogas (renewable natural gas) and other renewable fuels is increasing worldwide as use of this product as vehicle fuel or injection into the natural gas grid become common practice. Nowadays, there are several commercially available technologies for biogas upgrading, but due to their high investment cost, high energy consumption or use of polluting chemicals, it is difficult to decide which of them to implement on an industrial scale. This study at pilot scale seeks to develop a reliable, low-risk and low-cost biogas enrichment system based on membrane contactors, capable of efficiently treating the biogas generated in different production environments.

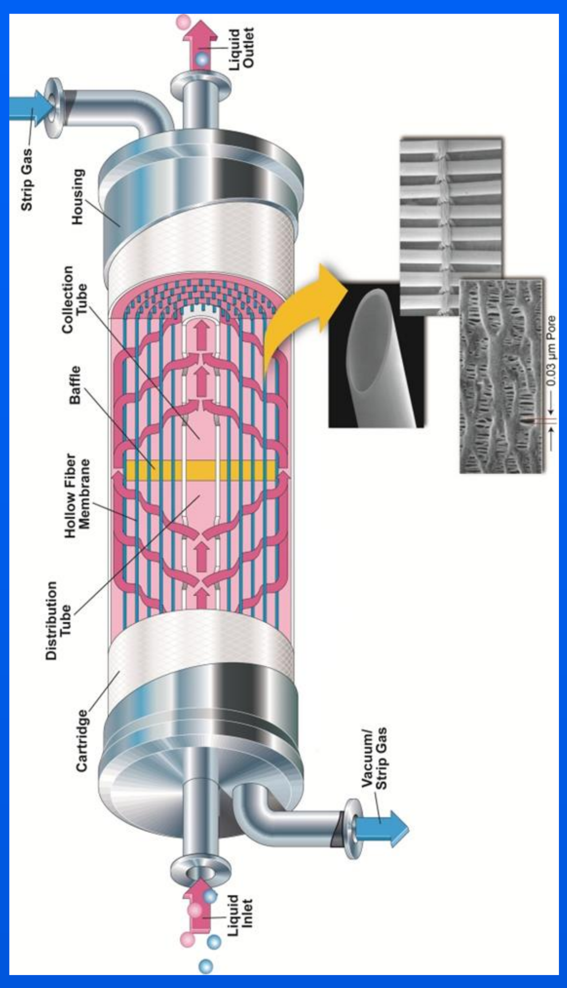

Figure 2: Membrane Contactor

The novelties that these membrane contactors introduce with respect to the existing upgrading systems are the following:

- Use of a gas-liquid membrane technology that allows the CO2 to be separated from the CH4 contained in the biogas at low pressure (4 bar), thus minimizing safety problems, needed investment, and the operation and maintenance costs associated with works under high pressure, commonly associated with gas-gas membranes upgrading systems (16 bar).
- Use of low-cost technology, since the necessary infrastructure is widely spread for gasification/degassing applications in the carbonated beverage industry, thus solving the great problem of upgrading processes related to high investment costs in equipment.

Results & Discussion

The biogas upgrading pilot plant is composed of three main steps:

a) Cleaning of contaminants such as xyloxanes, water vapor and hydrogen sulfide (2 activated carbon tanks and a condenser)

b) Biogas upgrading system made up of 5 lines, each of which has 2 membrane contactor capable of treating 10 m3/h of biogas.

c) Recovery of the CO_2 absorbent solution, using similar membrane contactors and a liquid ring vacuum pump

Figure 3: Condenser and activated carbon tanks

Figure 4: Biogas upgrading and CO_2 recovery parts

- The solvent must be selected carefully in order to achieve a high separation performance minimizing operational complexity.
- The solvent:
  - Should have a high absorption capacity for CO2 and high selectivity.
  - Should be compatible with the type of membrane used.
  - Easy regeneration.
- Temperature, pressure, and flow rates, both gas and solvent streams, should be carefully controlled to avoid gas losses and increase gas absorption.
- Biogas upgrading showed better performance at higher L/G ratio, but this entails an increase on operation costs.

Figure 5: Biogas upgrading pilot plant

Conclusions

- Hollow fiber membrane contactors for biogas upgrading have a large improvement path until become a stable industrial process.
- For further development of CO2 absorption membrane, the challenge is how to improve membrane durability in operation in the presence of contaminants such as H2S.
- It is necessary to continue the study. over a long period, at least 1 year, to see the robustness of the process (membrane degradation, solvent life cycles, operation and maintenance costs, etc.).

The authors would like to express appreciation for the support of the sponsors:Programme of subsidies for the implementation of R&D projects for SMEs in Castilla y León, co-financed with FEDER funds, under the responsibility of the Institute of Business Competitiveness (ICE) of Castilla y León– Spain - (project CONTACTGAS, Ref. 04/18/VA/0109)