INNOMEM

ICI POWERING EVOLUTION

MEREA

Hydrogen production derived from renewable sources is becoming essential for the energy transition. Sources of hydrogen are biogas and syngas derived from gasification of biomass/waste streams.

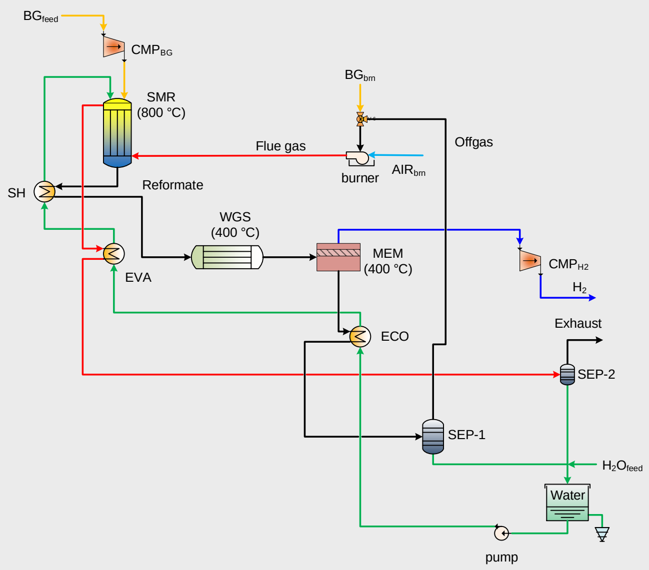
THE CONTEXT

Upgrading of biogas has gained increased attention due to rising oil and natural gas prices and increasing targets for renewable fuel quotes in many countries. New plants are continually being built. The number of upgrading plants was around 100 in 2009.

The process of upgrading biogas generates new possibilities for its use since it can then replace natural gas, which is used extensively in many countries. However, upgrading steps increases enormously the cost of biogas production.

In this project especially different reactor configurations will be studied with the focus on solutions that can be easily scaled-up and commercialized. This includes not only membrane reactors but also series of reaction and membrane separation to increase flexibility.

The project tested several membranes and reactors and made use of detailed modelling for system analysis.



One of the several configurations modelled in the project

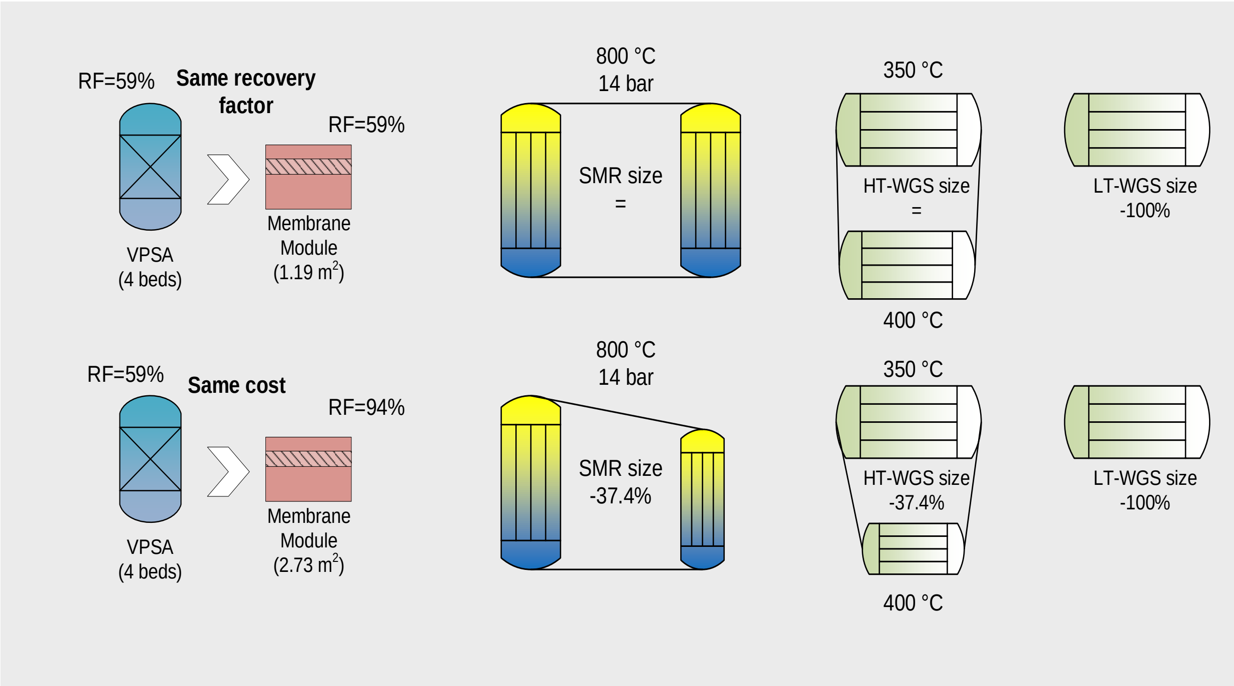
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862330

THE CHALLENGE

The process of upgrading biogas generates new possibilities for its use since it can then replace natural gas, which is used extensively in many countries. However, upgrading steps increases enormously the cost of biogas production. Biogas produced in AD-plants or landfill sites is primarily composed of methane (CH4) and carbon dioxide (CO2) with smaller amounts of hydrogen sulphide (H2S) and ammonia (NH3). Trace amounts of hydrogen (H2), nitrogen (N2), carbon monoxide (CO), saturated or halogenated carbohydrates and oxygen (O2) are occasionally present in the biogas. Usually, the mixed gas is saturated with water vapour and may contain dust particles and siloxanes.

Biogas is available at smaller flow rate compared to natural gas, thus an increase of efficiency is needed to make the production of hydrogen economic at smaller scales.

Additionally, the membranes can be used inside the reactor, or after the reactors as separation units, which configuration is best, needs to be evaluated from a technical point of view.



THE RESULTS

Several membranes, 50 cm long, have been produced and tested for permeation. The results are in line with literature, although the selectivity is slightly below the target of the project.

Membranes have been tested at high pressure and in the conditions required by the company.

Simulations have been carried out in several configurations, with integrated membrane reactors as well as with series of membranes and reactors. In some cases reduction of sizes and increase of efficiency has been reported.

Membranes used for the testing.

CONCLUSION

The membrane integration inside the reactor is the configuration that most benefit for process intensification (smaller volumes and higher efficiencies).

However, membranes after the reactors are also possible and allow increasing efficiencies as well, also with less stress on the membranes.

Membranes have been scaled up and tested also with news sealings developed at TUE.

TECHNIQUES USED

Membrane preparation for hydrogen separation

Testing facilities for membrane permeation

Design of reactors

Aspen simulations for technical design of the systems and comparison (from a technical point of view) of the different configurations

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