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# Techno-economical evaluation of membrane based biogas upgrading system; a comparison between polymeric membrane and carbon membrane technology

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## Key words:

Carbon membrane; Biogas upgrading; Techno-economical analysis; NPV calculations

## Highlights:

Biogas upgrading using CO<sub>2</sub> selective membranes

Multistage membrane system for CO<sub>2</sub>/CH<sub>4</sub> separation

Optimization of process conditions based on Hysys simulations

Techno-economical evaluation of multistage membrane system for 97.5% CH<sub>4</sub> purity and 99.5% CH<sub>4</sub> recovery

Comparison between polymeric membrane and carbon membrane technologies

## ABSTRACT

A shift to renewable energy sources will reduce emissions of greenhouse gases and secure future energy supplies. In this context, utilization of biogas will play a prominent role. Focus of this work is upgrading of biogas to fuel quality by membrane separation using a carbon hollow fiber (CHF) membrane and compare with a commercially available polymeric membrane (polyimide) through economical assessment. CHF membrane modules were prepared for pilot plant testing and performance measured using CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>. The CHF membrane was modified through oxidation, chemical vapor deposition (CVD) and reduction process thus tailoring pores for separation and increased performance. The post oxidized and reduced carbon hollow fibers (PORCHF) significantly exceeded CHF performance showing higher CO<sub>2</sub> permeance (0.021 m<sup>3</sup>(STP)/m<sup>2</sup>.h.bar) and CO<sub>2</sub>/CH<sub>4</sub> selectivity of 246 (5bar feed vs 50mbar permeate pressure). The highest performance recorded through experiments (CHF and PORCHF) was used as simulation basis. A membrane simulation model was used and interfaced to 8.6V Aspen HYSYS. A 300 Nm<sup>3</sup>/h mixture of CO<sub>2</sub>/CH<sub>4</sub> containing 30-50% CO<sub>2</sub> at feed pressures 6, 8 and 10bara, was simulated and process designed to recover 99.5%

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