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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_2 selective membranes

Multistage membrane system for CO_2/CH_4 separation

Optimization of process conditions based on Hysys simulations

Techno-economical evaluation of multistage membrane system for 97.5% CH_4 purity and 99.5% CH_4 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_2, O_2, N_2. 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_2 permeance (0.021 m^3(STP)/m^2.h.bar) and CO_2/CH_4 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^3/h mixture of CO_2/CH_4 containing 30-50% CO_2 at feed pressures 6, 8 and 10bara, was simulated and process designed to recover 99.5%