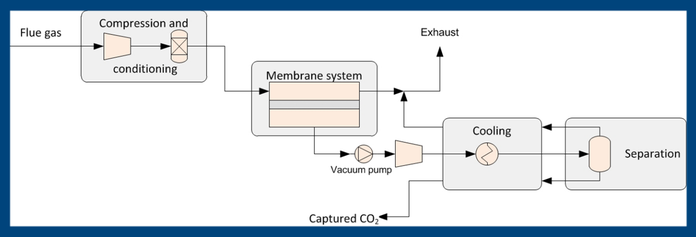
WP11: Membrane-assisted CO_2 liquefaction

CEMCAP

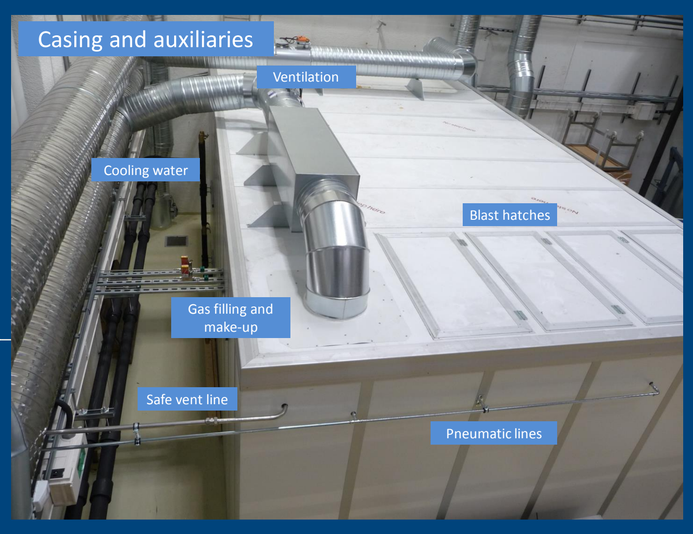
CEMCAP is a Horizon 2020 project with the objective to prepare the grounds for cost- and resource-effective CCS in European cement industry.

Principal layout of membrane-assisted CO_2 liquefaction process



Membrane material test setup (TNO)

CO_2 liquefaction pilot exterior (SINTEF). Max. capacity: 10–15 ton CO_2 per day



David Berstad
Jacob Stang
Stian Trædal
SINTEF Energy Research

Frank Vercauteren
Peter van Os
TNO

Contact:
david.berstad@sintef.no

www.sintef.no/cemcap
Twitter: @CEMCAP_CO2

This project is funded by the European Union's Horizon 2020 Framework Programme for research and innovation

Main conclusions

- The tested membrane material shows sufficient CO_2/N_2 selectivity to provide CO_2 concentration in the permeate flow to allow efficient CO_2 liquification and purification
  - CO_2/N_2 selectivity: approximately 45
  - H_2O/N_2 selectivity: > 100
- Lab pilot experimental results using binary CO_2/N_2 mixtures in low-temperature CO_2 separation and purification correspond to expectations from simulations
- CO_2 product purity can be controlled by the pressure level in the final separation stage

Experimental testing of pre-commercial membrane material

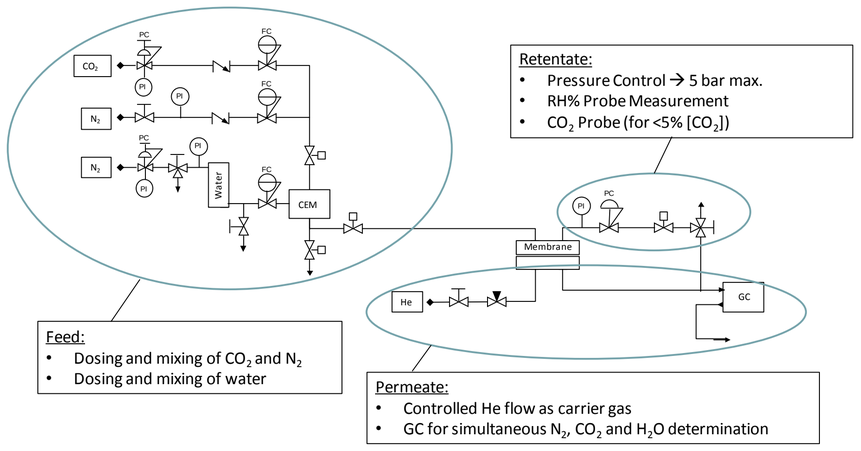


Fig. 1. Membrane Setup – Process Flow Diagram.

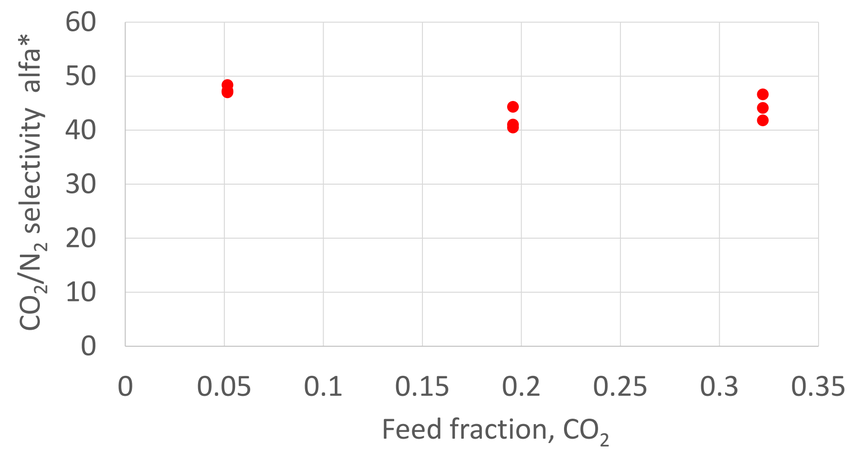


Fig. 2. CO_2/N_2 selectivity as a function of CO_2 fraction in the feed for pre-commercial membrane.

Experimental testing of the CO_2 liquefaction process

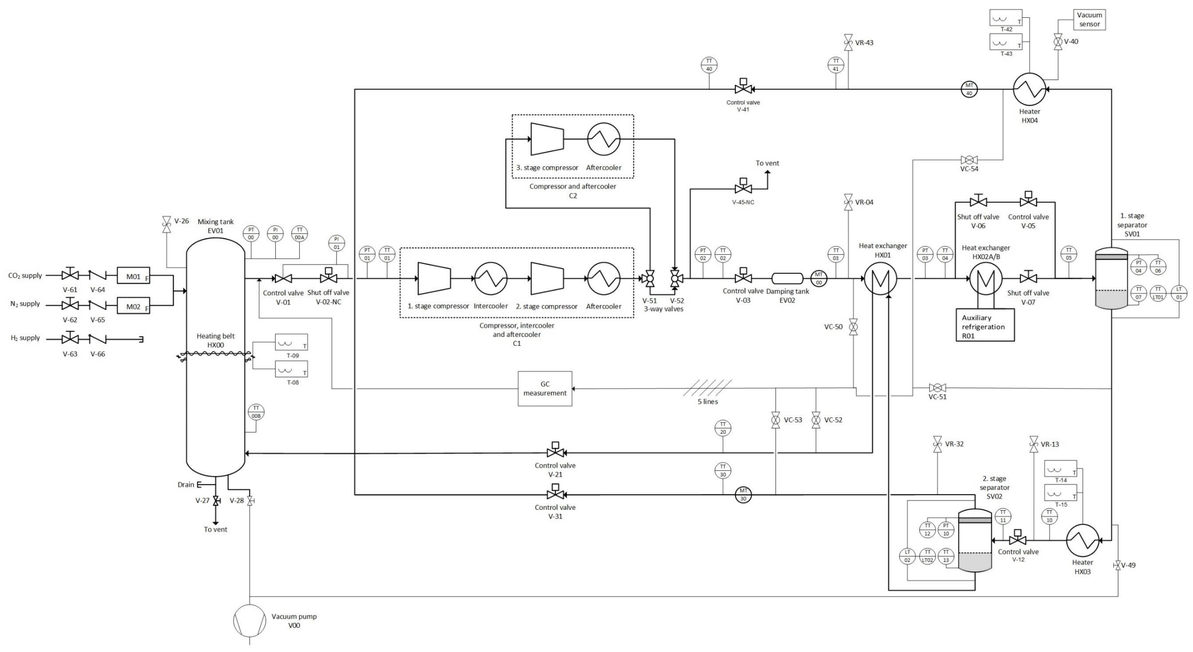


Fig. 3. Low-temperature liquid-vapour phase separation experimental set-up

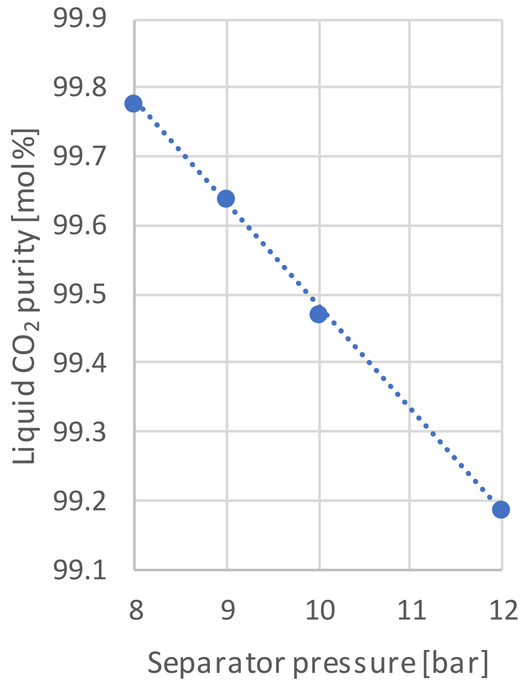
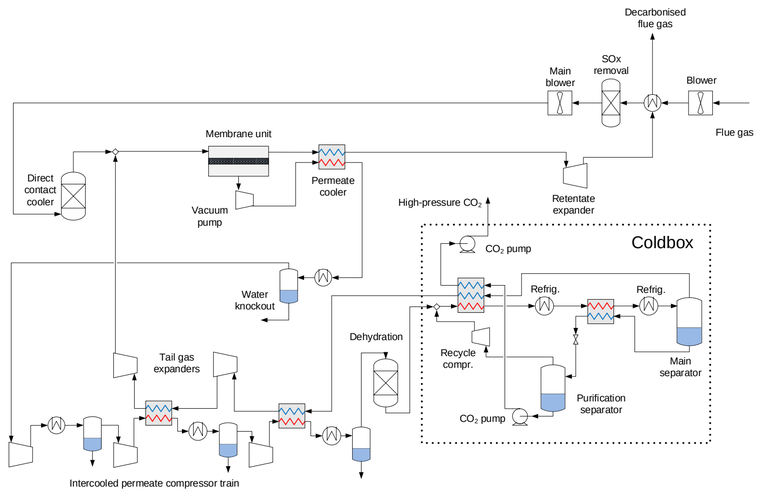


Fig. 4. CO_2 purity measurements vs. separation pressure in the CO_2 purification vessel SV02. Approximate separation temperature is -53°C

Hybrid process design and simulation



Case no.		1	2	3	4	5
Case description		Typical air leak, 90 % CO_2 capture	Low air leak, 90 % CO_2 capture	Typical air leak, 60 % CO_2 capture	Low air leak, 60 % CO_2 capture	Low air leak, 71 % CO_2 capture
CO_2 concentration at membrane inlet	mol%	20.17	24.17	18.91	23.48	23.71
CO_2 concentration at coldbox inlet	mol%	60.31	64.32	71.06	76.40	75.13
CO_2 capture ratio	%	90.0	90.2	59.9	60.5	70.9
Membrane area	m^2	228 000	228 000	152 000	152 000	152 000
Specific power	kJ/kg_{CO2}	1458	1253	1246	1066	1098

Further process development beyond CEMCAP

- On-site pilot testing of the membrane-assisted CO_2 liquefaction technology can be projected after preparatory qualifications:
  - On-site membrane-module durability and robustness test with real flue gas exposure
  - Laboratory pilot testing of CO_2 liquefaction using synthesized permeate gas containing impurities detected in permeate from preceding on-site membrane testing