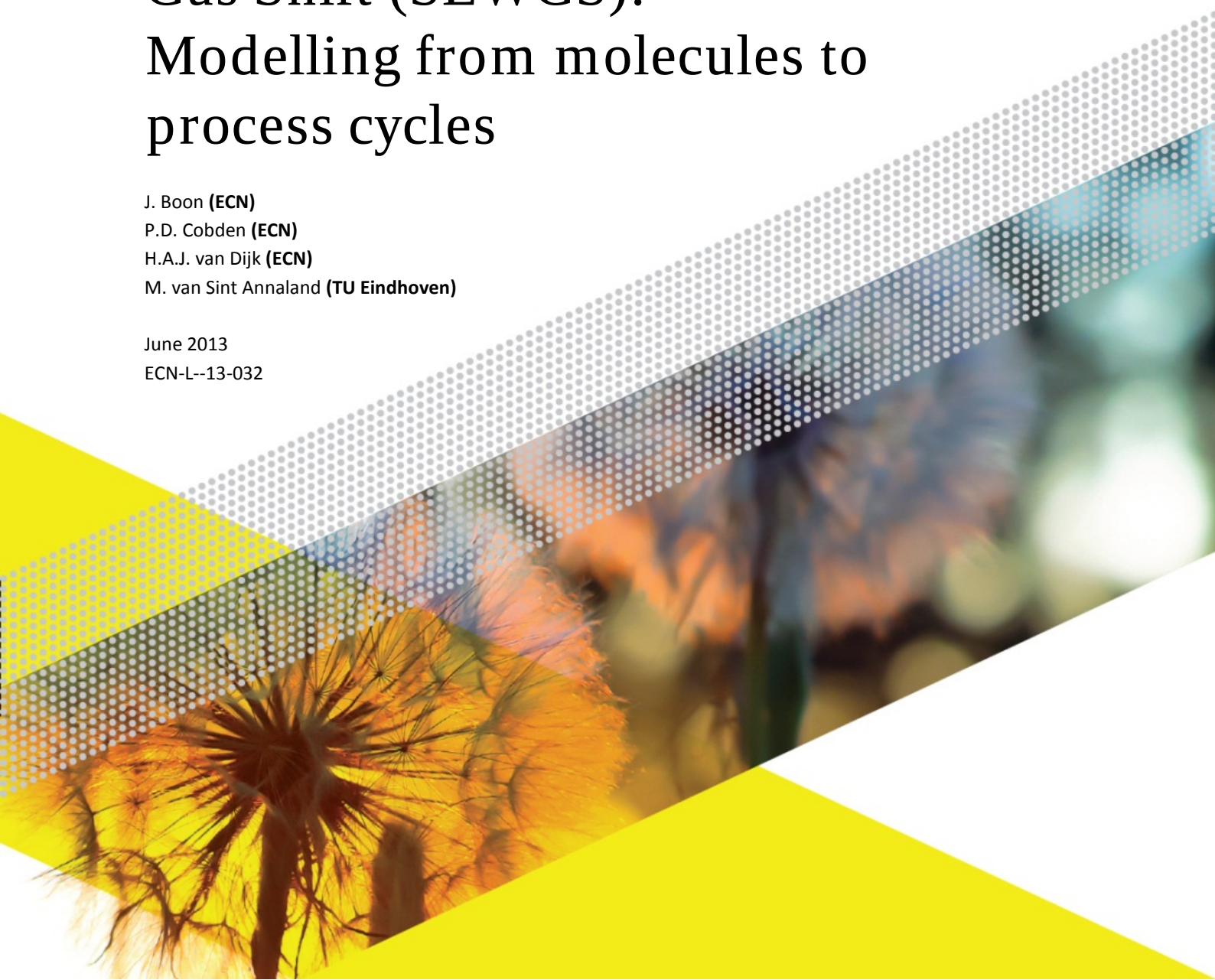


Pre-combustion CO₂ capture by Sorption-Enhanced Water- Gas Shift (SEWGS): Modelling from molecules to process cycles

J. Boon (ECN)
P.D. Cobden (ECN)
H.A.J. van Dijk (ECN)
M. van Sint Annaland (TU Eindhoven)

June 2013
ECN-L--13-032

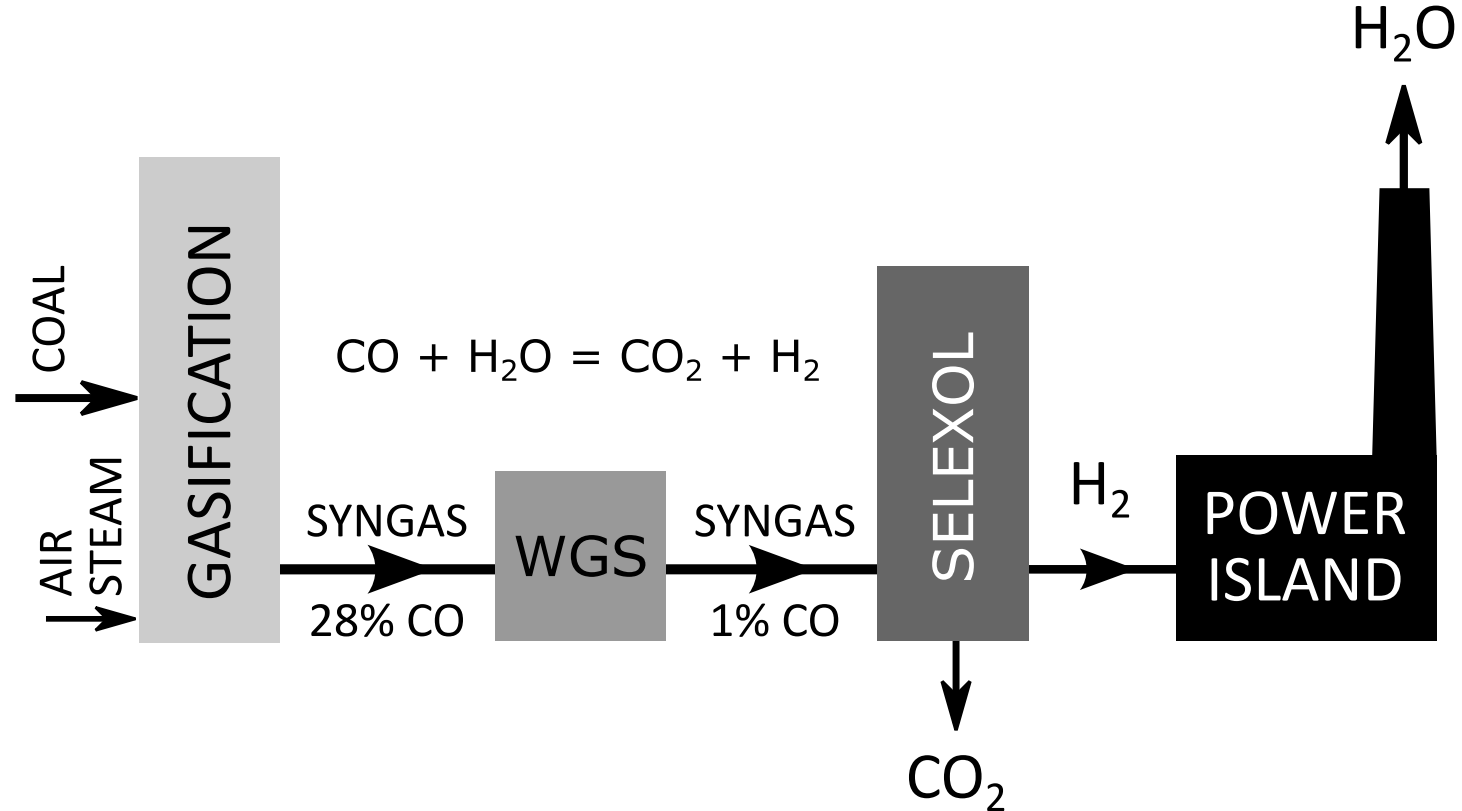


Pre-combustion CO₂ capture by Sorption-Enhanced Water-Gas Shift (SEWGS): Modelling from molecules to process cycles

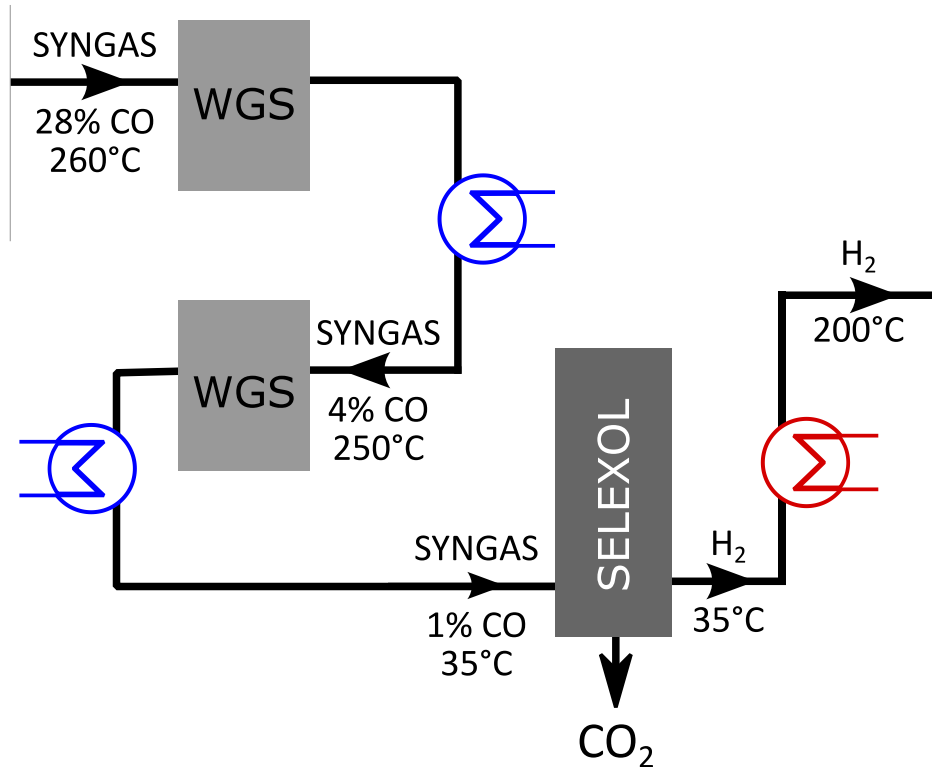
Jurriaan Boon, P.D. Cobden,
H.A.J. van Dijk, M. van Sint Annaland

7th Trondheim CCS Conference (TCCS-7)
4-6 June 2013 - Trondheim, Norway

Pre-combustion CO₂ capture

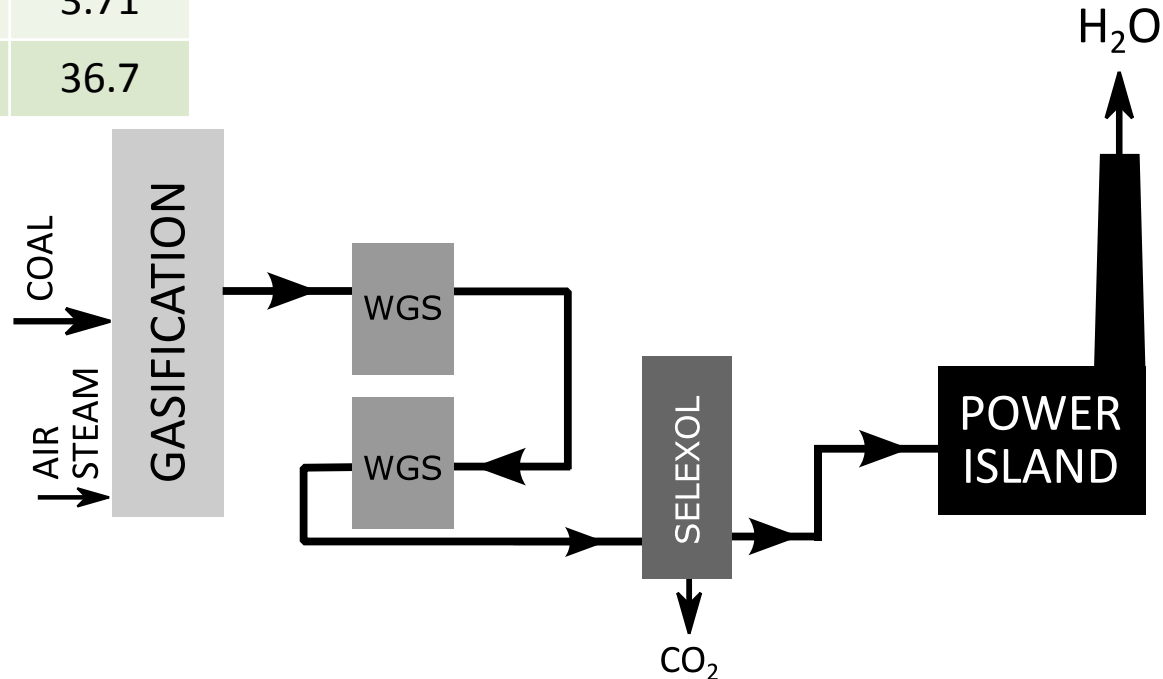


Pre-combustion CO₂ capture WGS and CO₂-H₂ separation

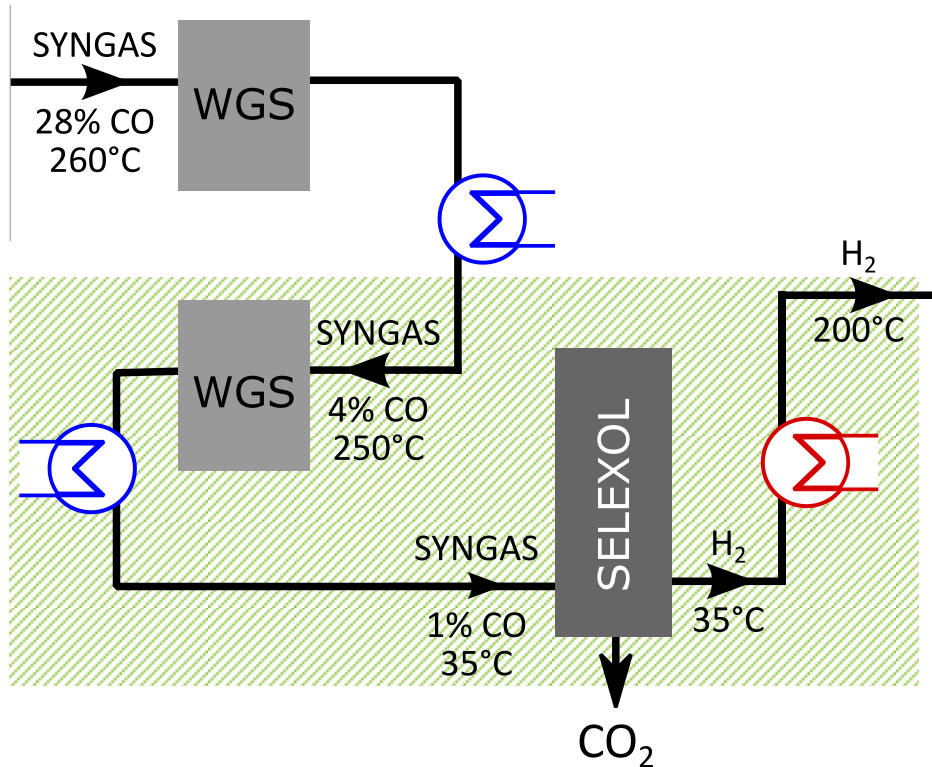


Pre-combustion CO₂ capture WGS and CO₂-H₂ separation

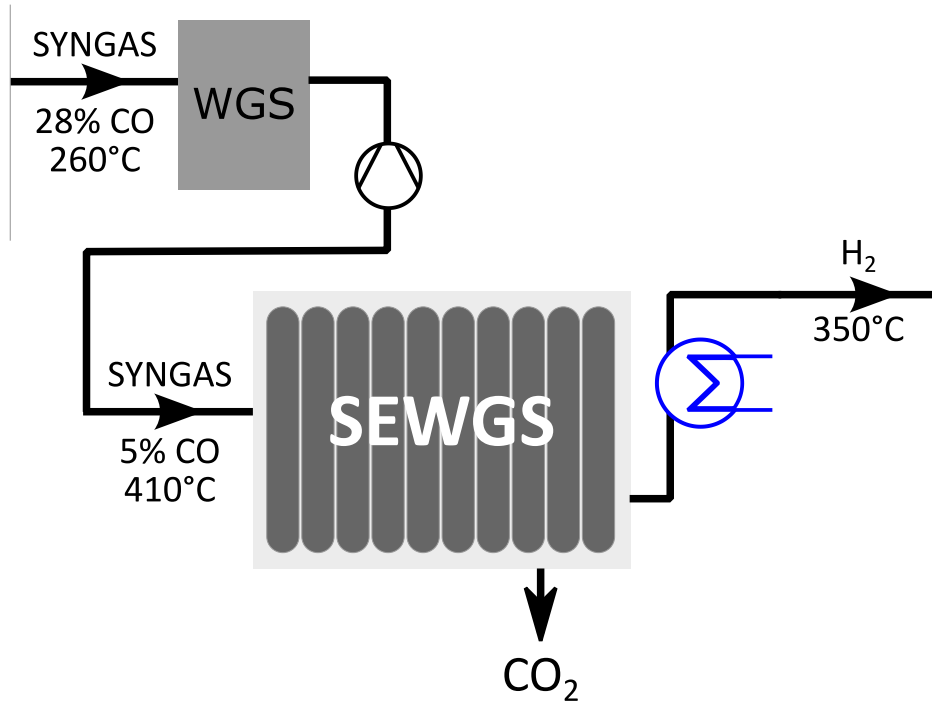
		Selexol
CO ₂ avoided	%	86.5
SPECCA	MJ _{LHV} / kg _{CO2}	3.71
Cost	€ / t _{CO2}	36.7



Pre-combustion CO₂ capture WGS and CO₂-H₂ separation

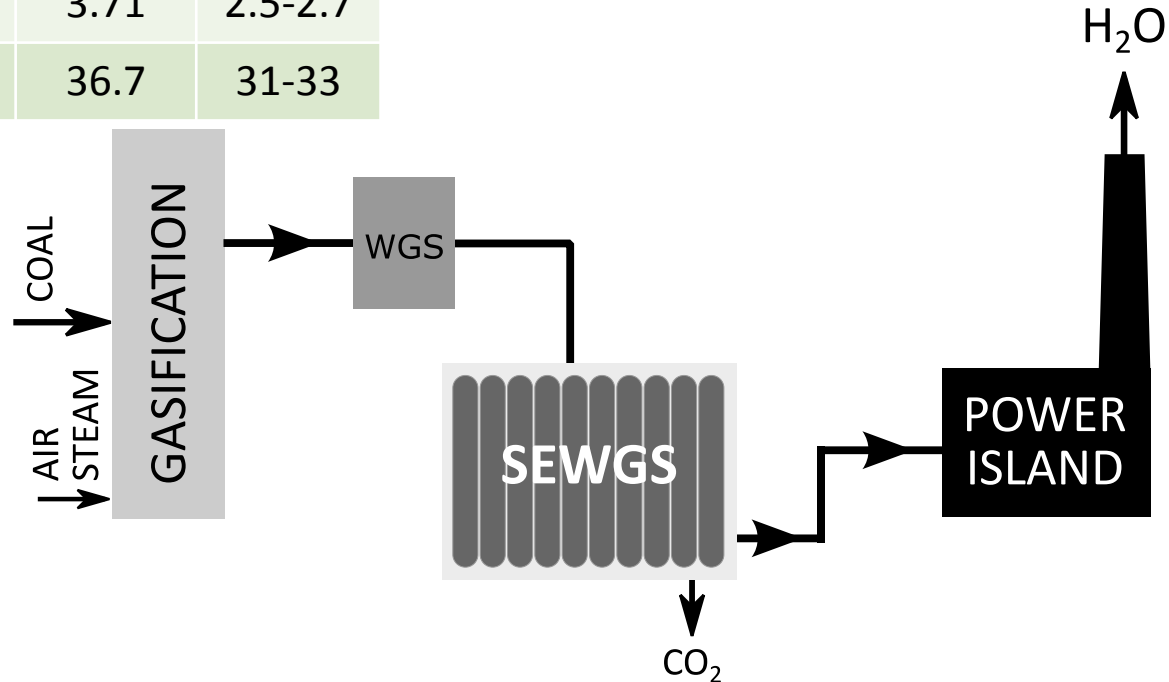


Pre-combustion CO₂ capture WGS and CO₂-H₂ separation



Pre-combustion CO₂ capture WGS and CO₂-H₂ separation

		Selexol	SEWGS
CO ₂ avoided	%	86.5	93-97
SPECCA	MJ _{LHV} / kg _{CO2}	3.71	2.5-2.7
Cost	€ / t _{CO2}	36.7	31-33



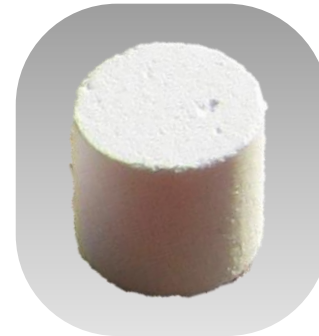
SEWGS

‘Bench’ scale



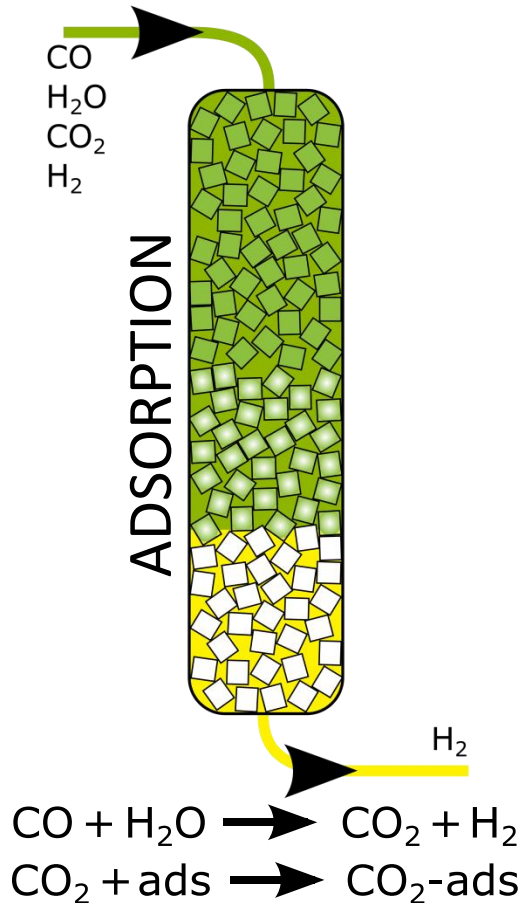
6 m

K-promoted
hydrotalcite
‘Alkasorb’



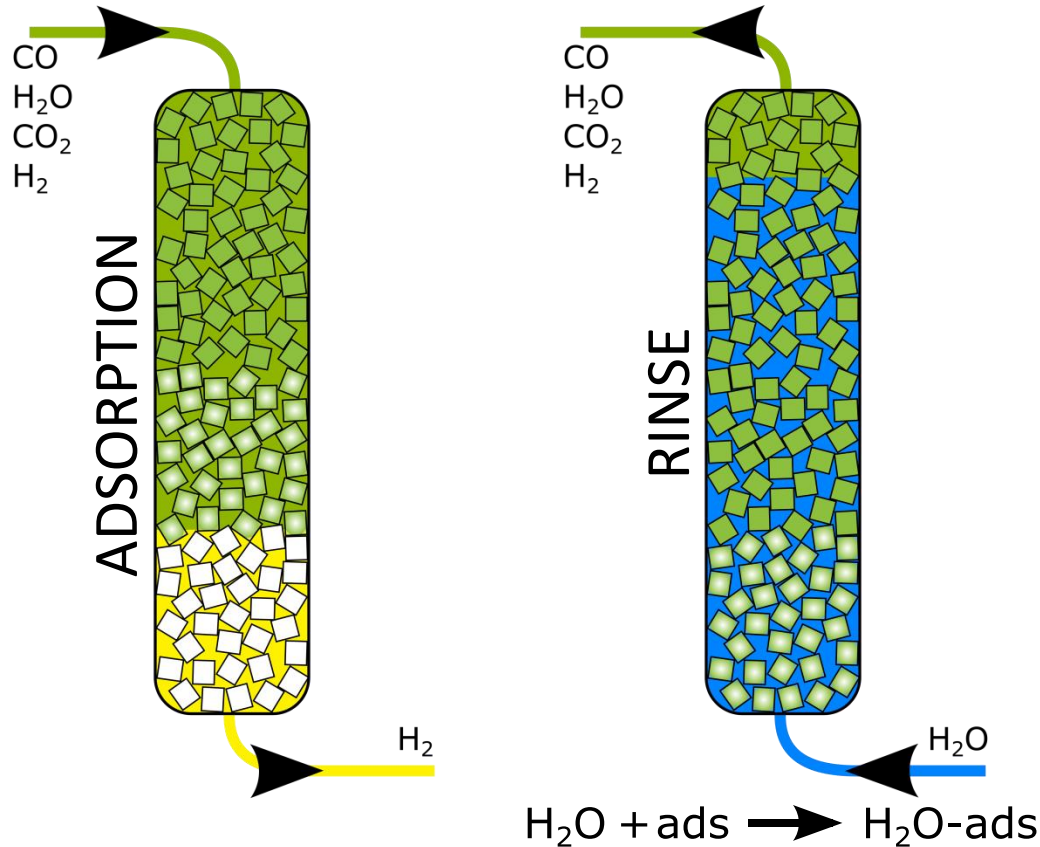
SEWGS process steps

Loading and regeneration



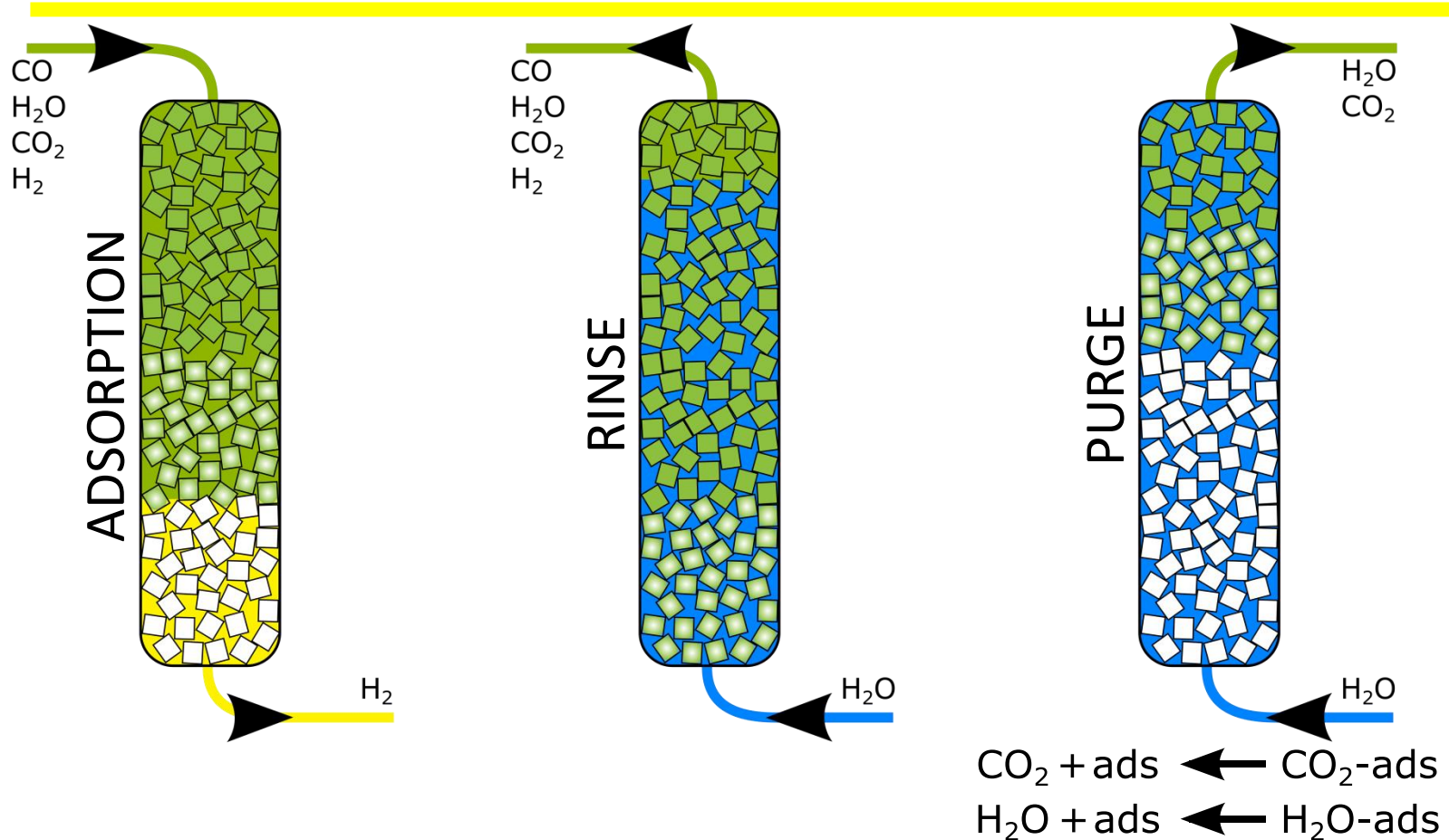
SEWGS process steps

Loading and regeneration



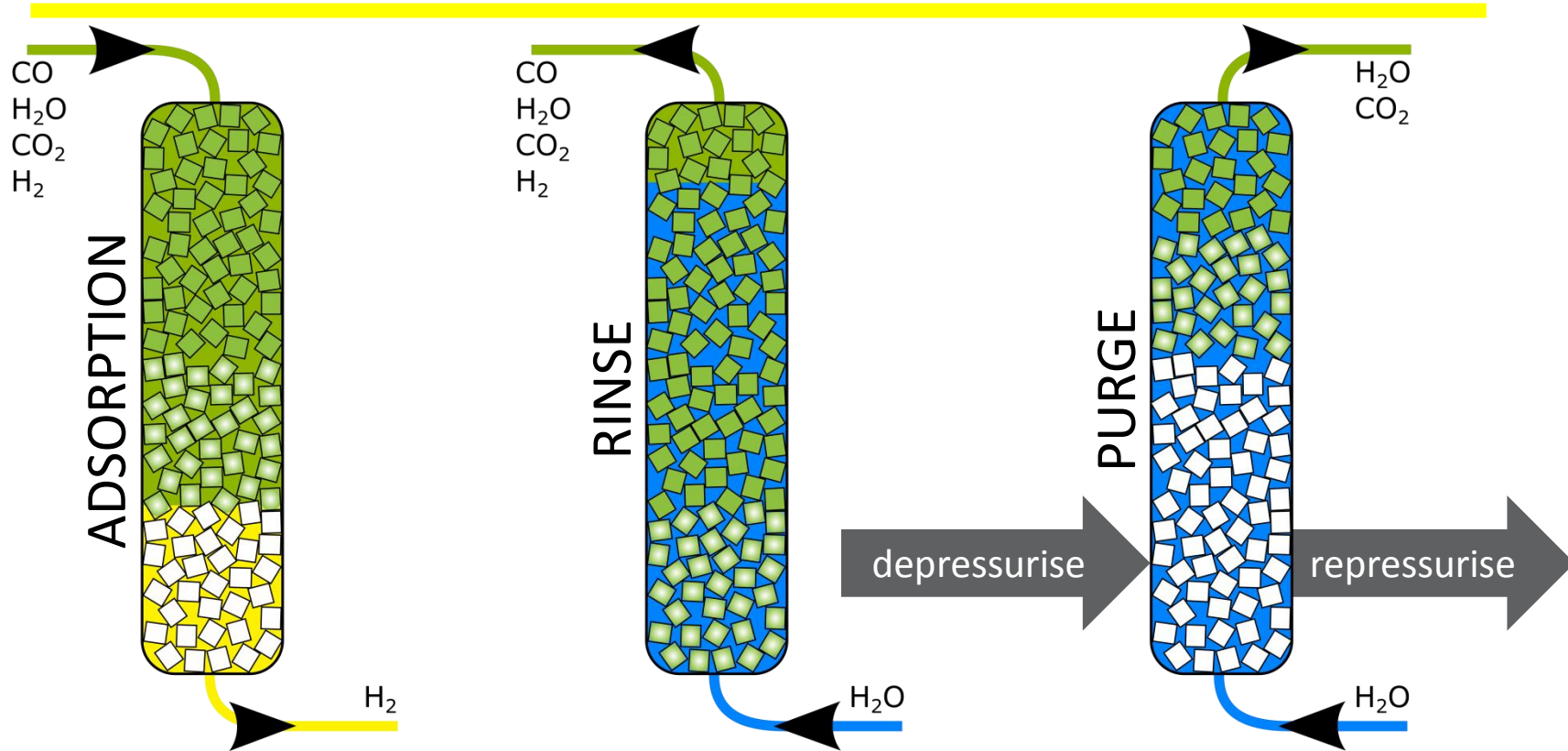
SEWGS process steps

Loading and regeneration



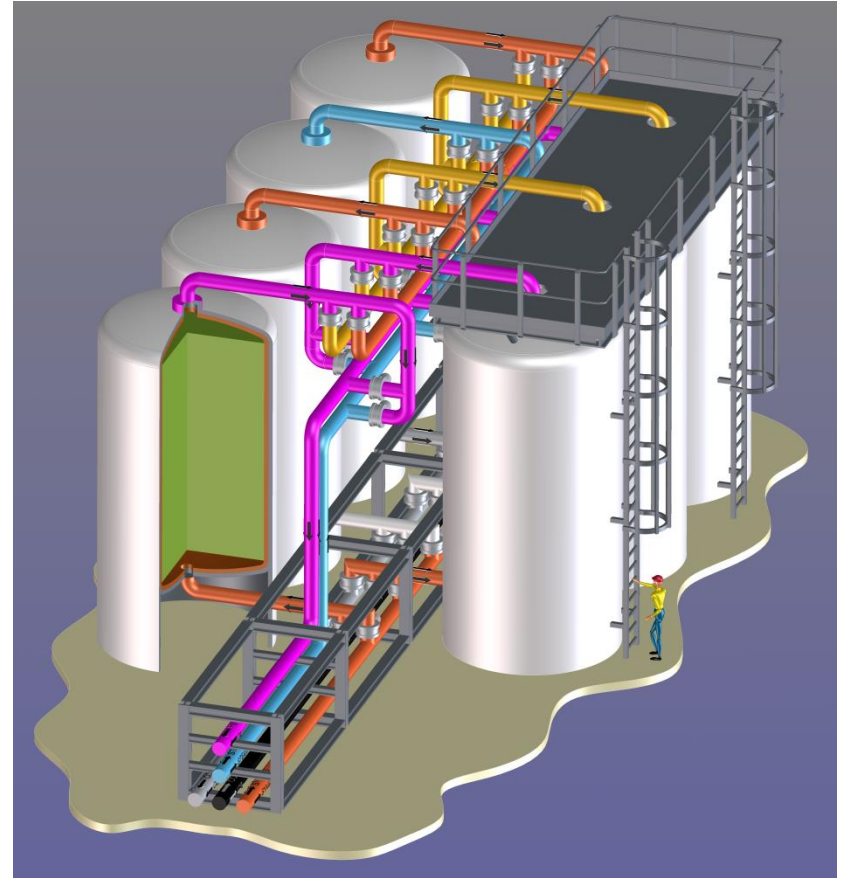
SEWGS process steps

Loading and regeneration



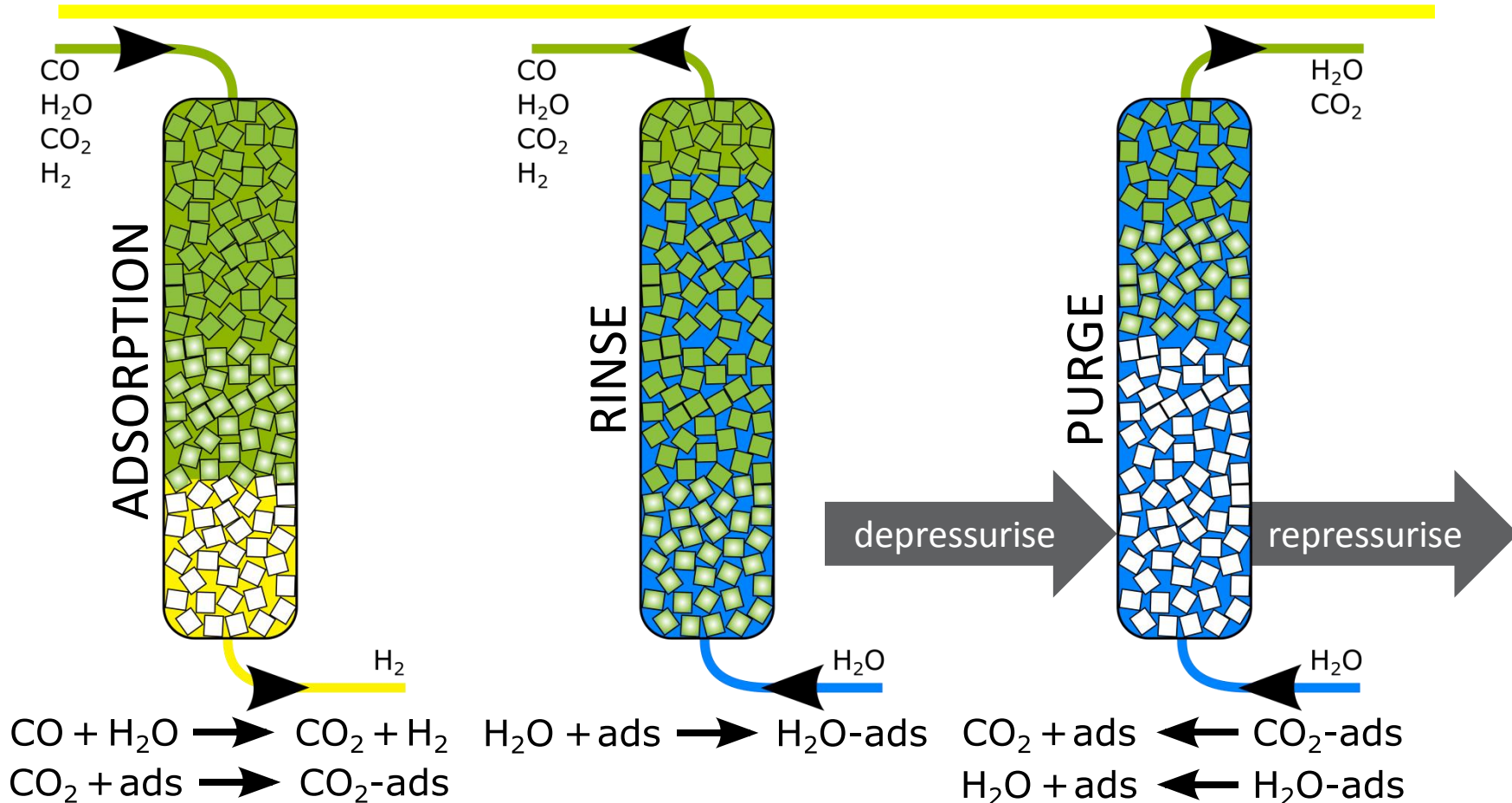
Multicolumn SEWGS

- Cyclic process, repeating
 - Adsorption
 - Rinse
 - Depressurisation
 - Purge
 - Repressurisation



SEWGS process steps

Modelling fundamentals



SEWGS

Experiments and modelling



Breakthrough
experiments

Cyclic
experiments

Experiments and modelling



Breakthrough
experiments

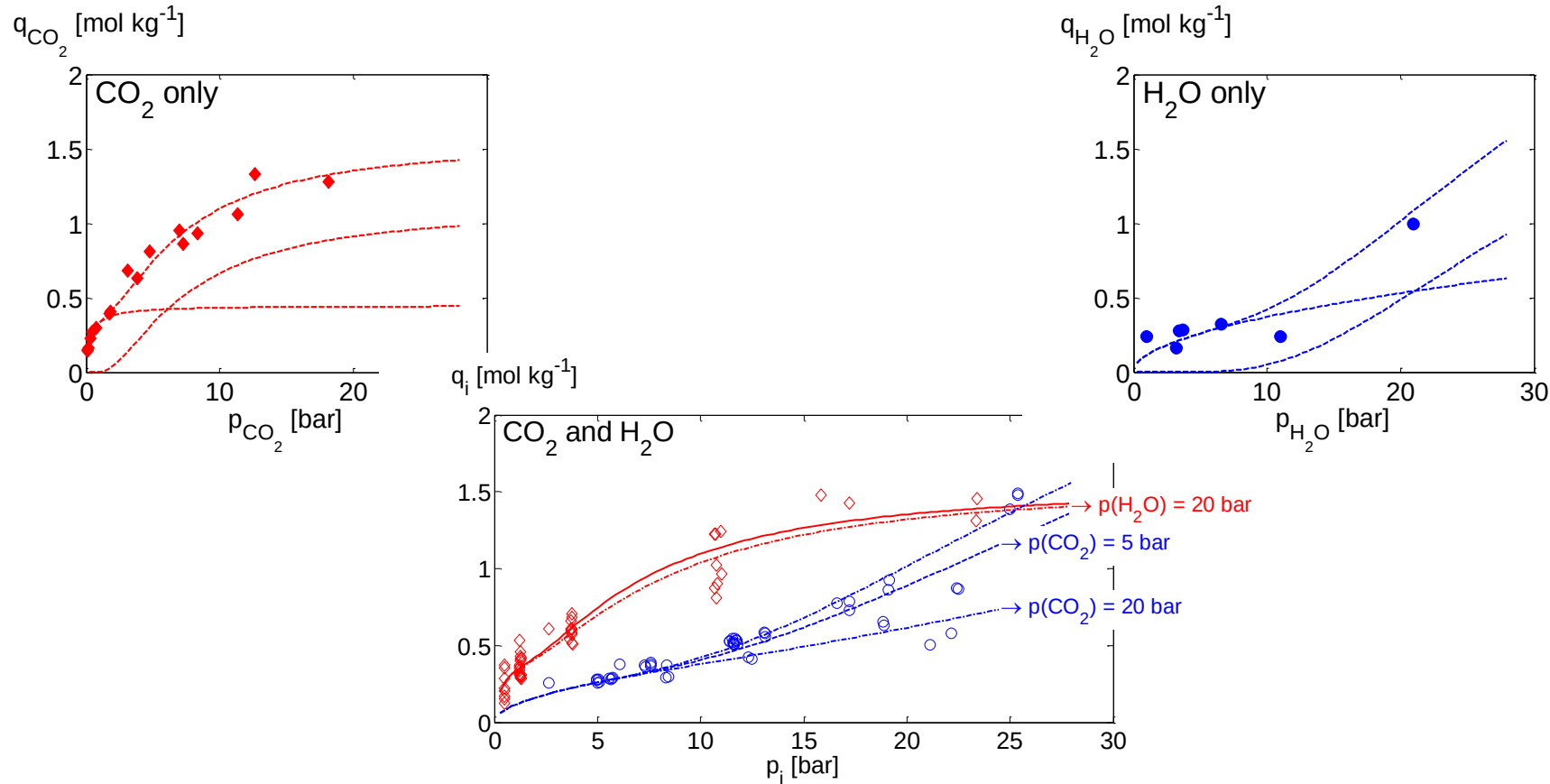


Adsorption
isotherms

Cyclic
experiments



Measured & fitted isotherms



SEWGS

Reactor model



Breakthrough
experiments



Adsorption
isotherm



Reactor
model

Cyclic
experiments

Reactor model

CO₂ and H₂O adsorption

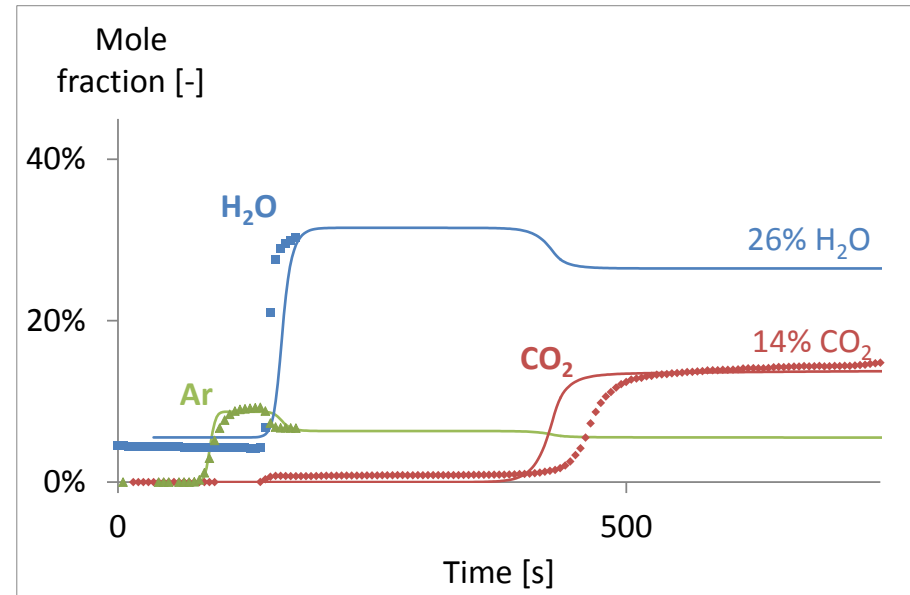
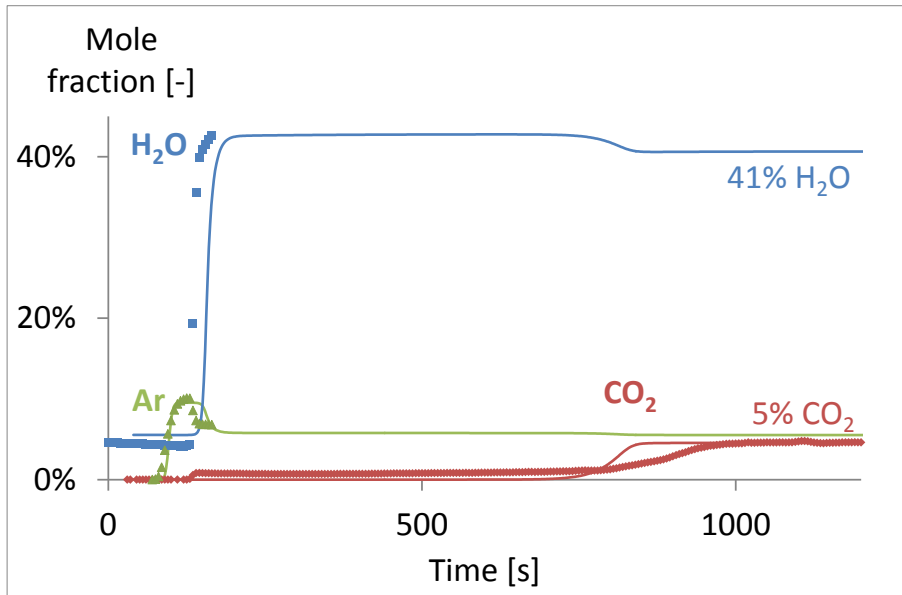
- New isotherms
 - CO₂: surface and micropores
 - H₂O: surface and micropores
 - Interaction
- Intraparticle model
 - Accumulation in the gas phase
 - Accumulation in the solid phase

$$\frac{\partial \langle c \rangle}{\partial t} = k_{LDF} (c_i - \langle c \rangle)$$
$$k_{LDF} = \frac{15}{R^2} \frac{D_e}{\epsilon_p + (1 - \epsilon_p) \rho_p \frac{\partial q}{\partial c}}$$

Reactor model

CO₂ and H₂O adsorption

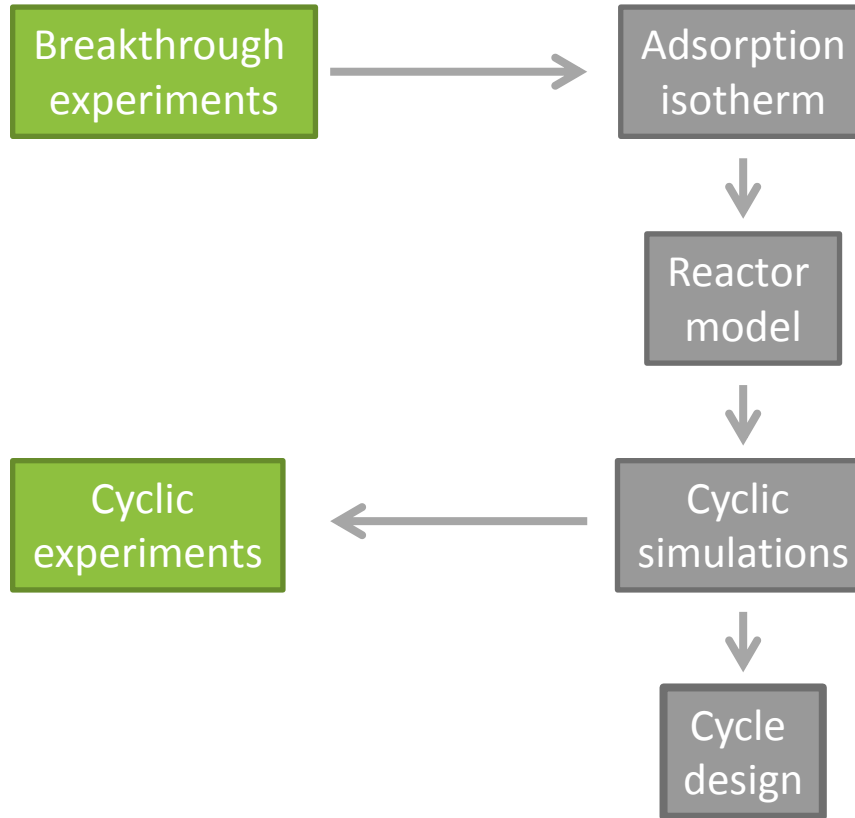
- New isotherms, linear driving force



- Breakthrough curves match

SEWGS

Cycle design



Cycle optimisation

- Fix the number of columns, cycle
- Vary total cycle time, rinse steam flow, purge steam flow
- Calculate carbon capture ratio, CO₂ purity

SEWGS

Conclusions & Outlook

- SEWGS
 - WGS with H_2 - CO_2 separation
 - New isotherm and particle model for CO_2 - H_2O adsorption
 - Impact on cycle performance to be assessed
- Alkasorb → Alkasorb⁺
- Application to other processes
 - H_2 production for ammonia
 - Syngas conditioning
 - Iron and steel making industries
 - Acid gas processing
- Ready for scale-up and demonstration!

Thank you for your attention

ECN Sustainable Process Technology

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TU/e Chemical Process Intensification

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