

Sorption-enhanced water-gas shift (SEWGS): H₂ from syngas in a single process

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ECN-L--13-066

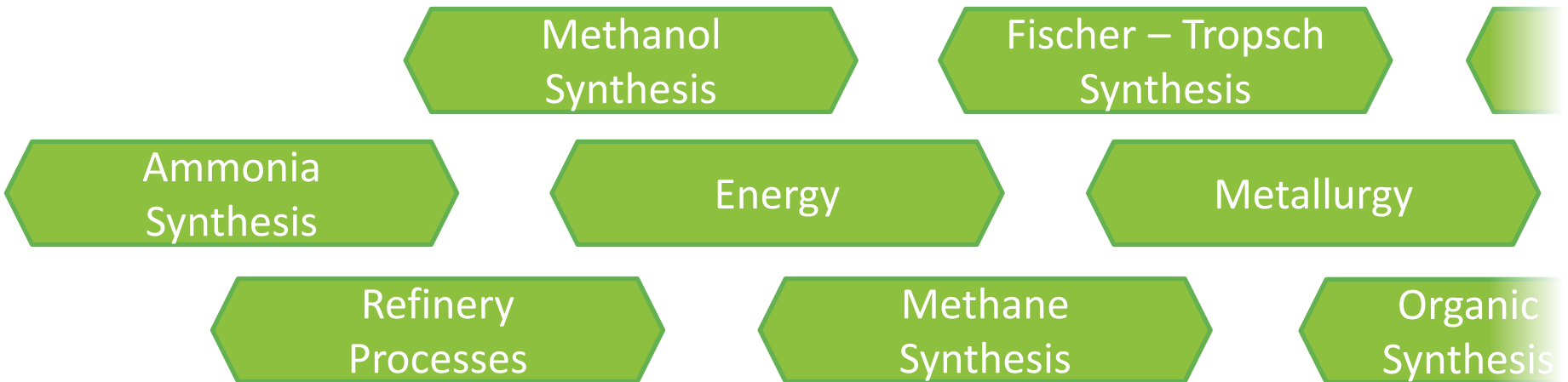


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(WHTC2013), Shanghai, China
28 September, 2013

We need H₂

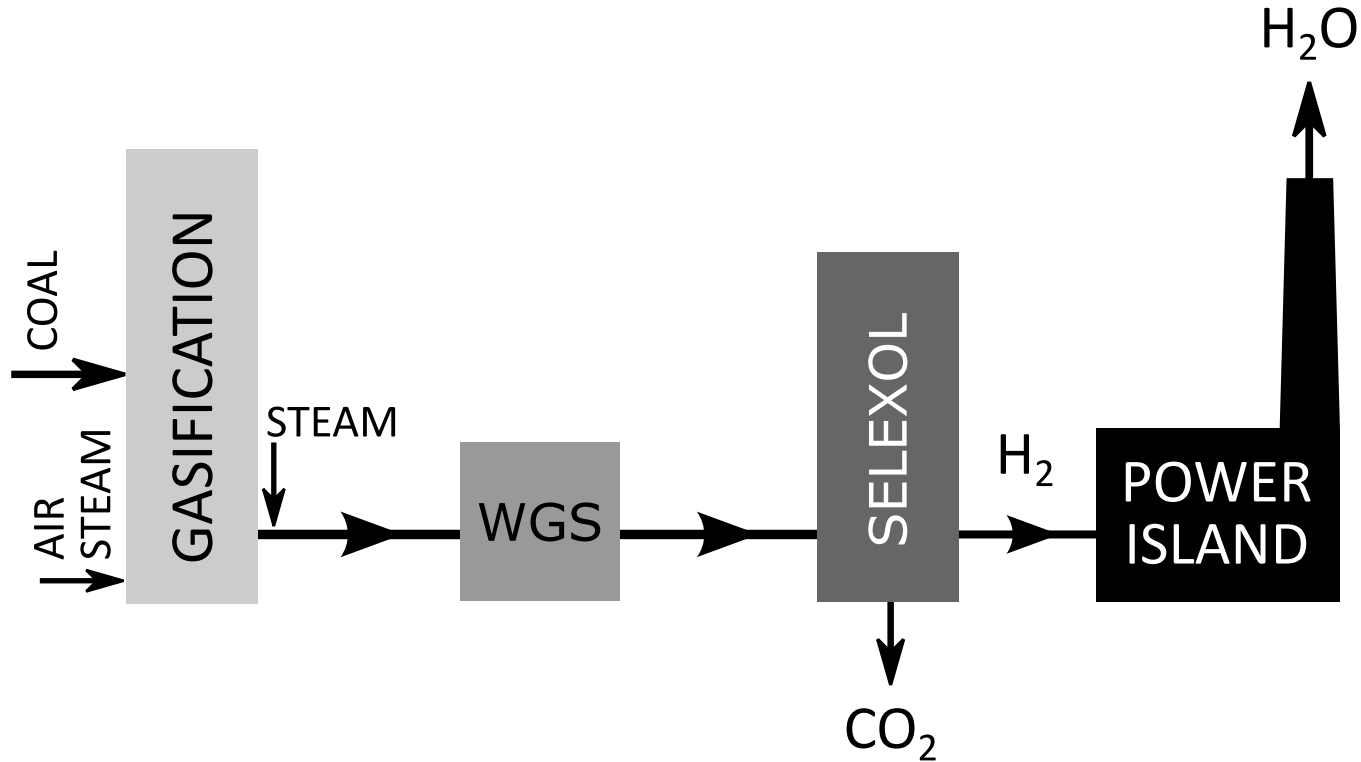


We need H₂



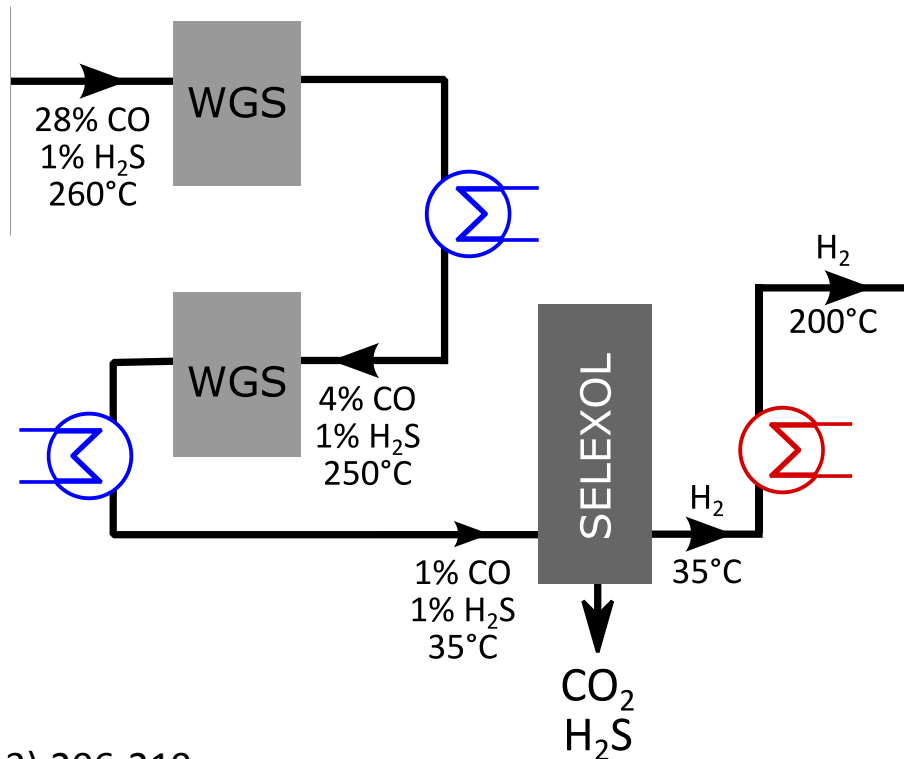
Energy

Pre-combustion CO₂ capture

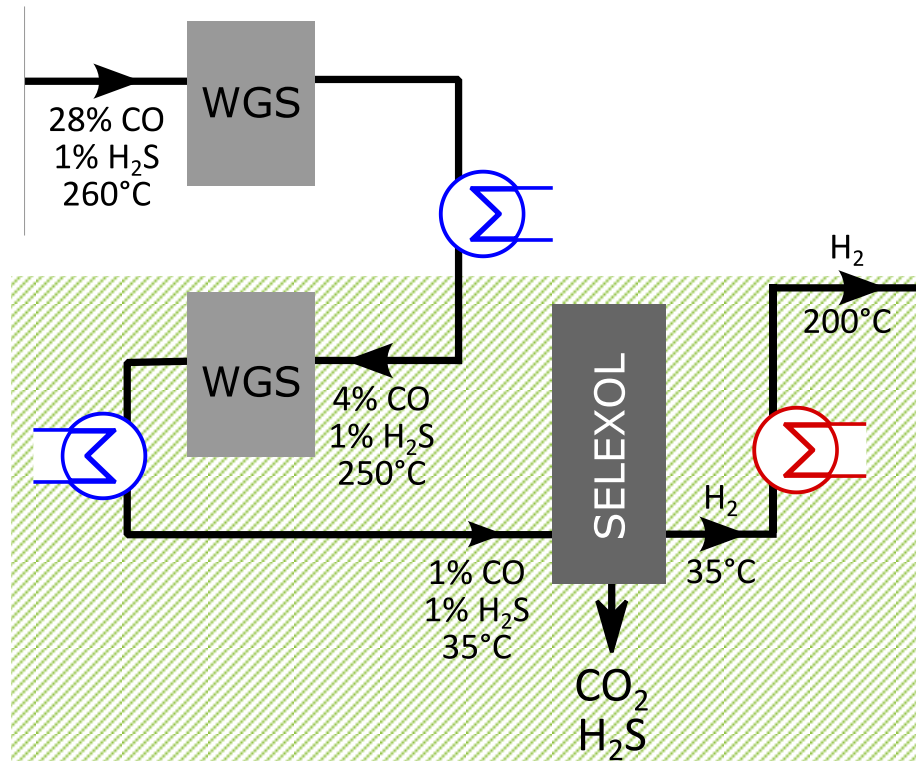


Pre-combustion CO₂ capture

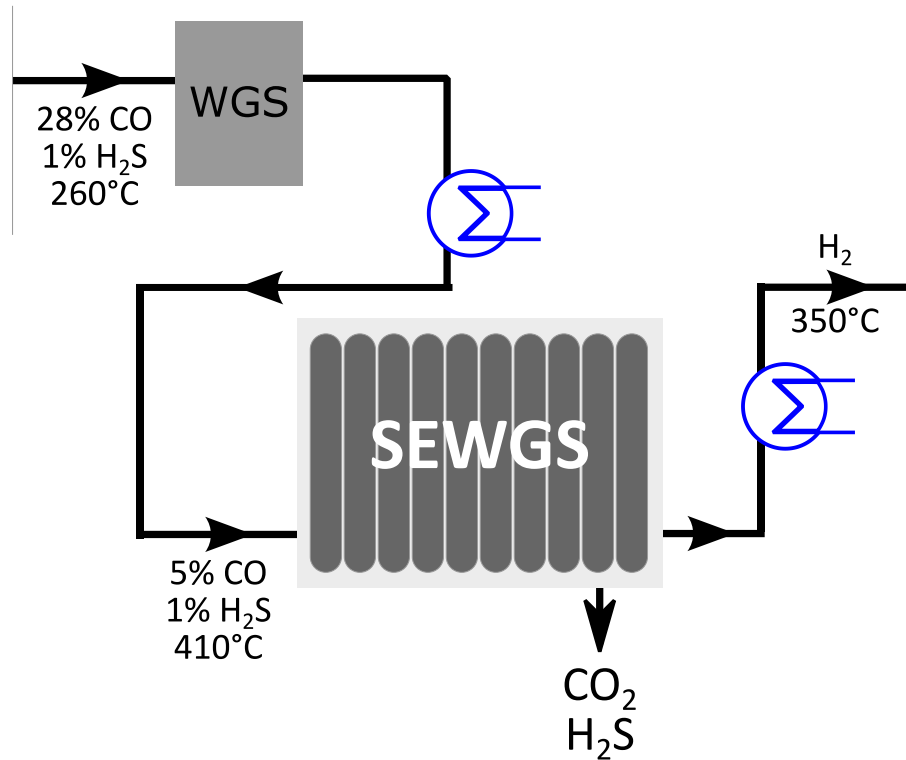
- WGS and CO₂-H₂ separation



Pre-combustion CO₂ capture



Sorption-enhanced water-gas shift SEWGS

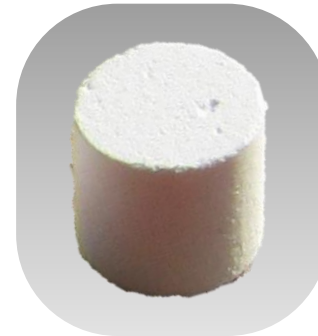


SEWGS

‘Bench’ scale

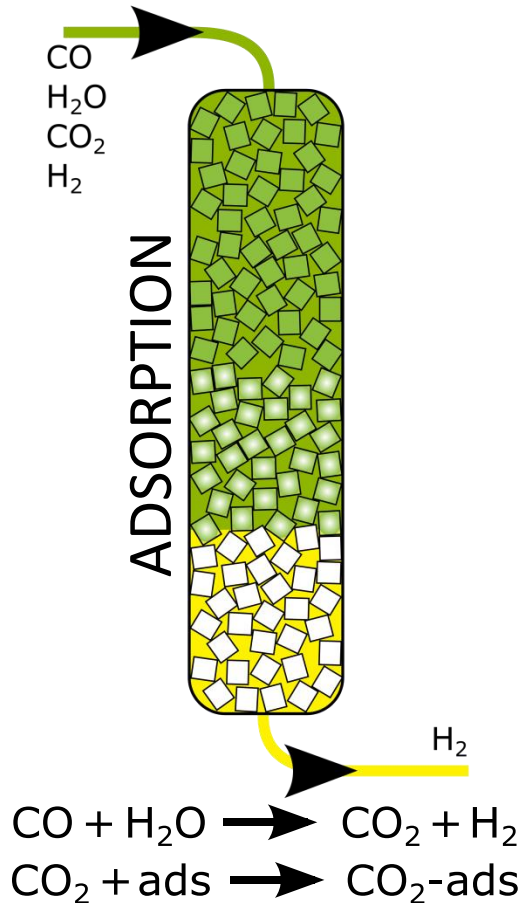


K-promoted
hydrotalcite
‘Alkasorb’



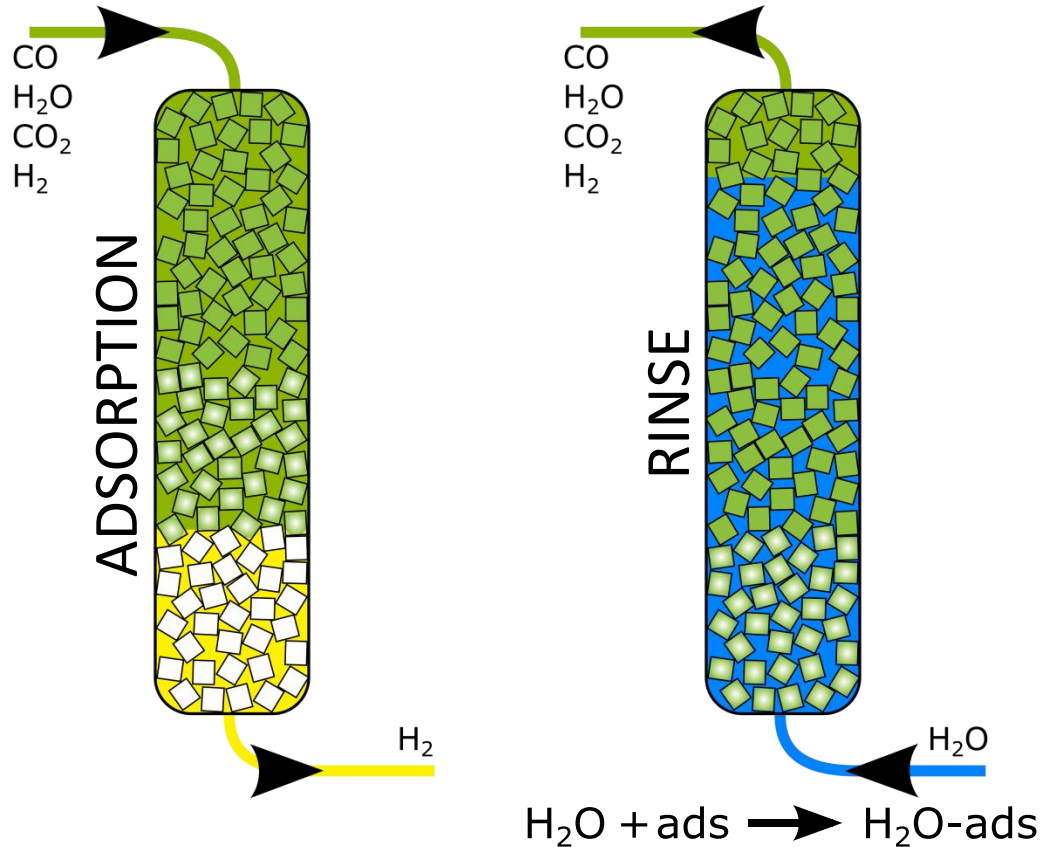
SEWGS process steps

Loading and regeneration



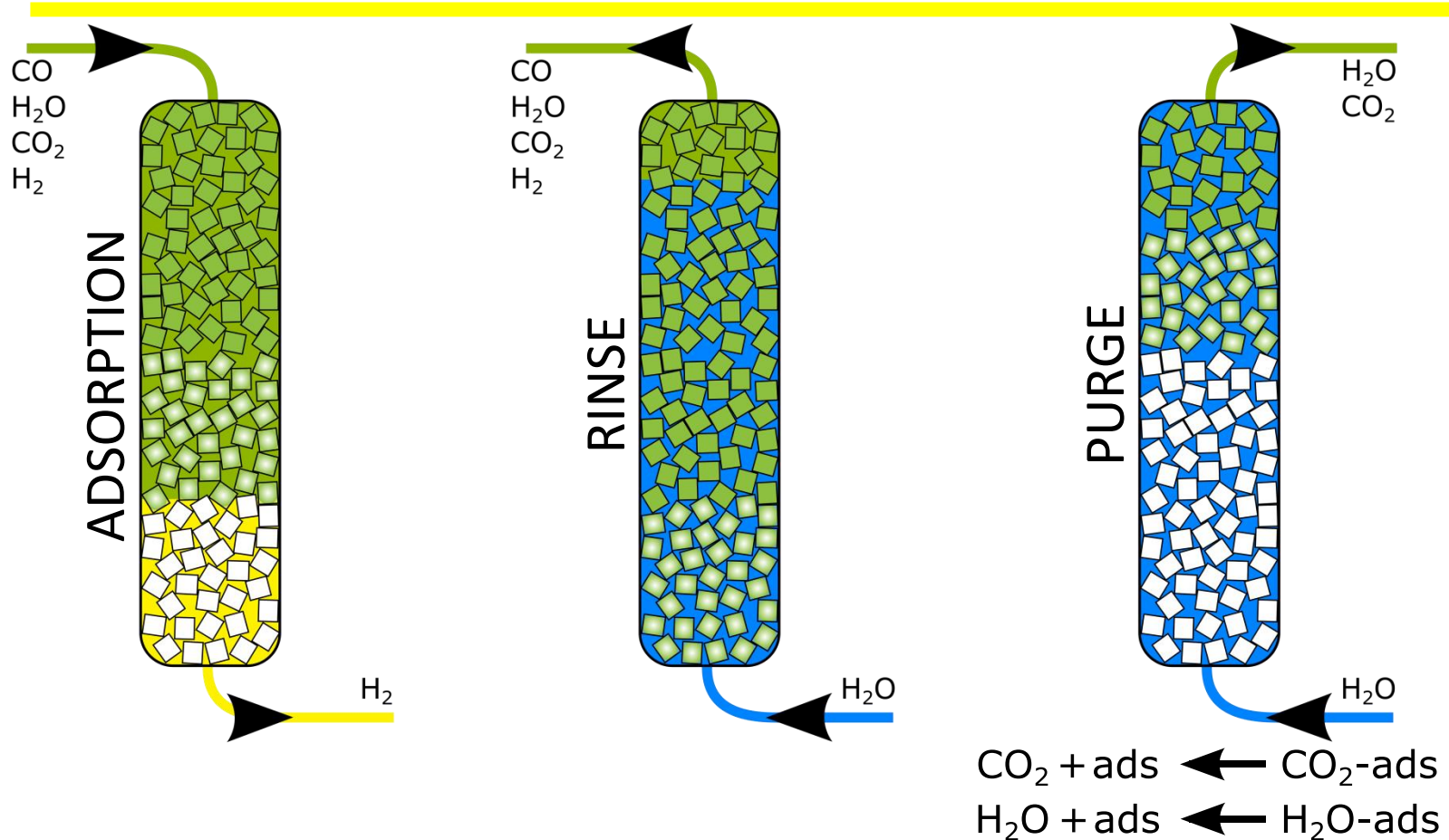
SEWGS process steps

Loading and regeneration



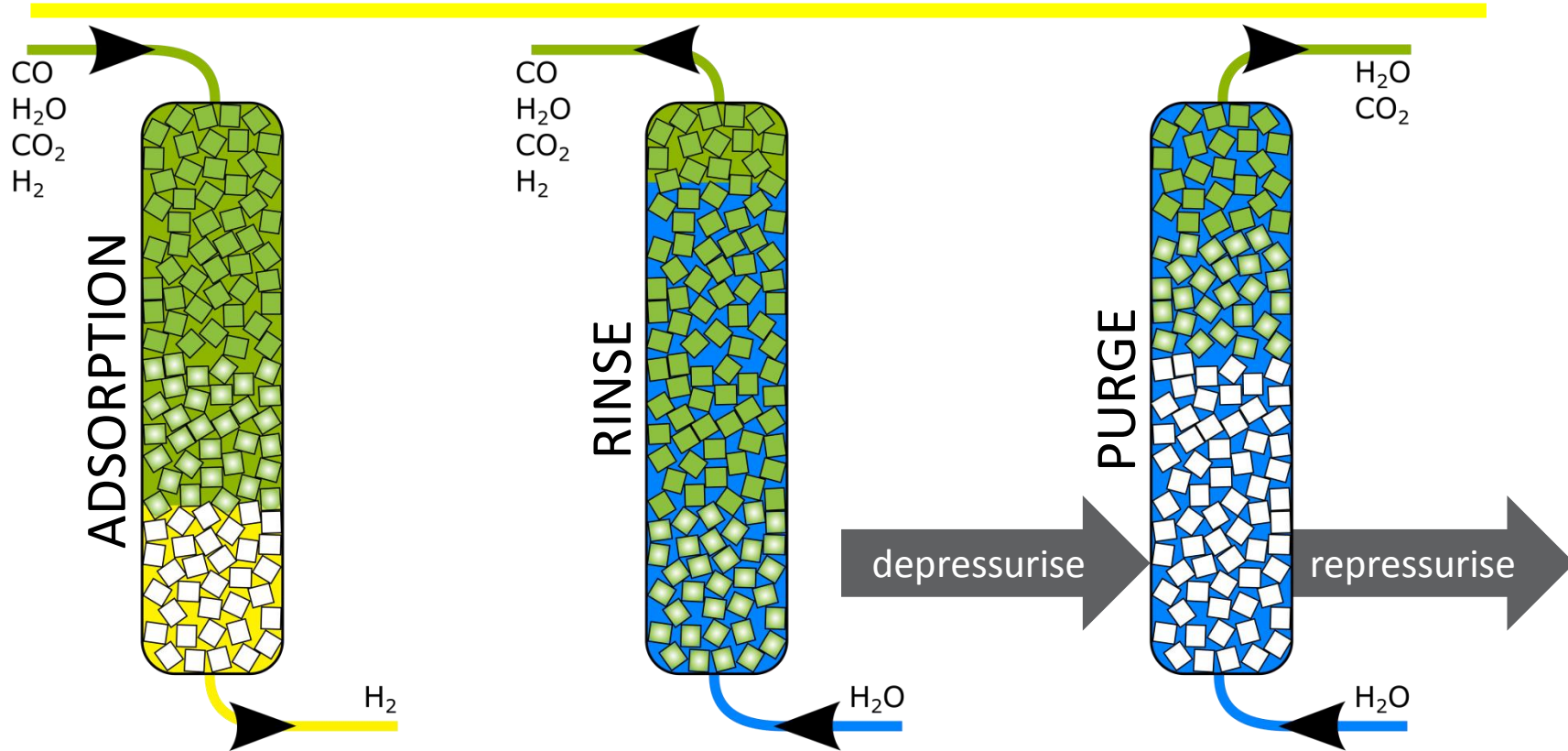
SEWGS process steps

Loading and regeneration



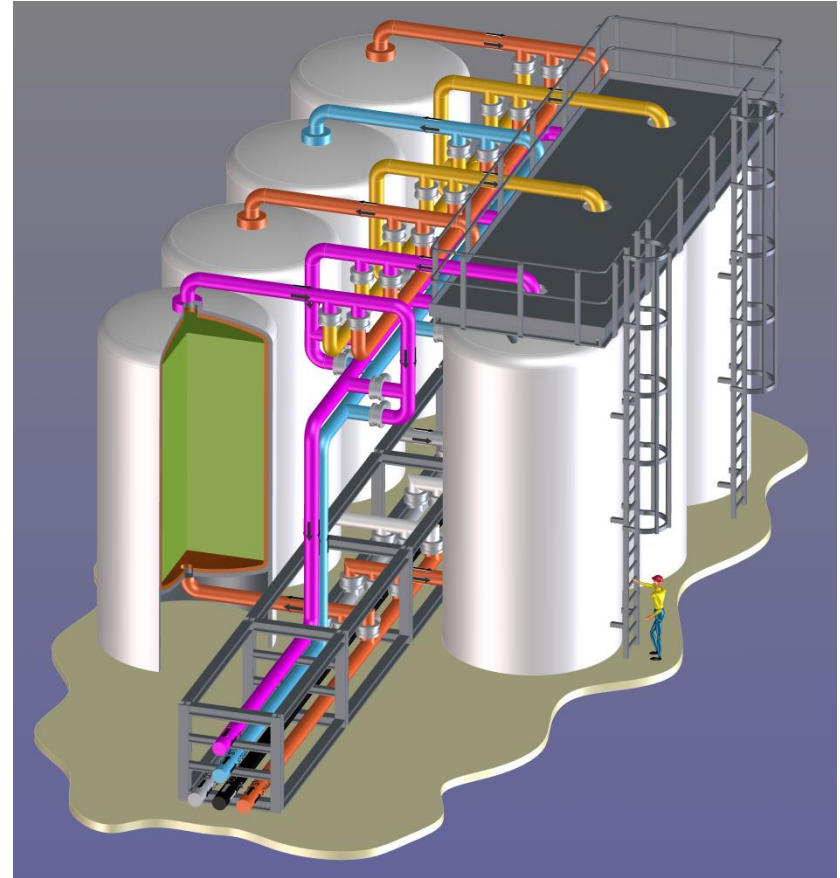
SEWGS process steps

Loading and regeneration



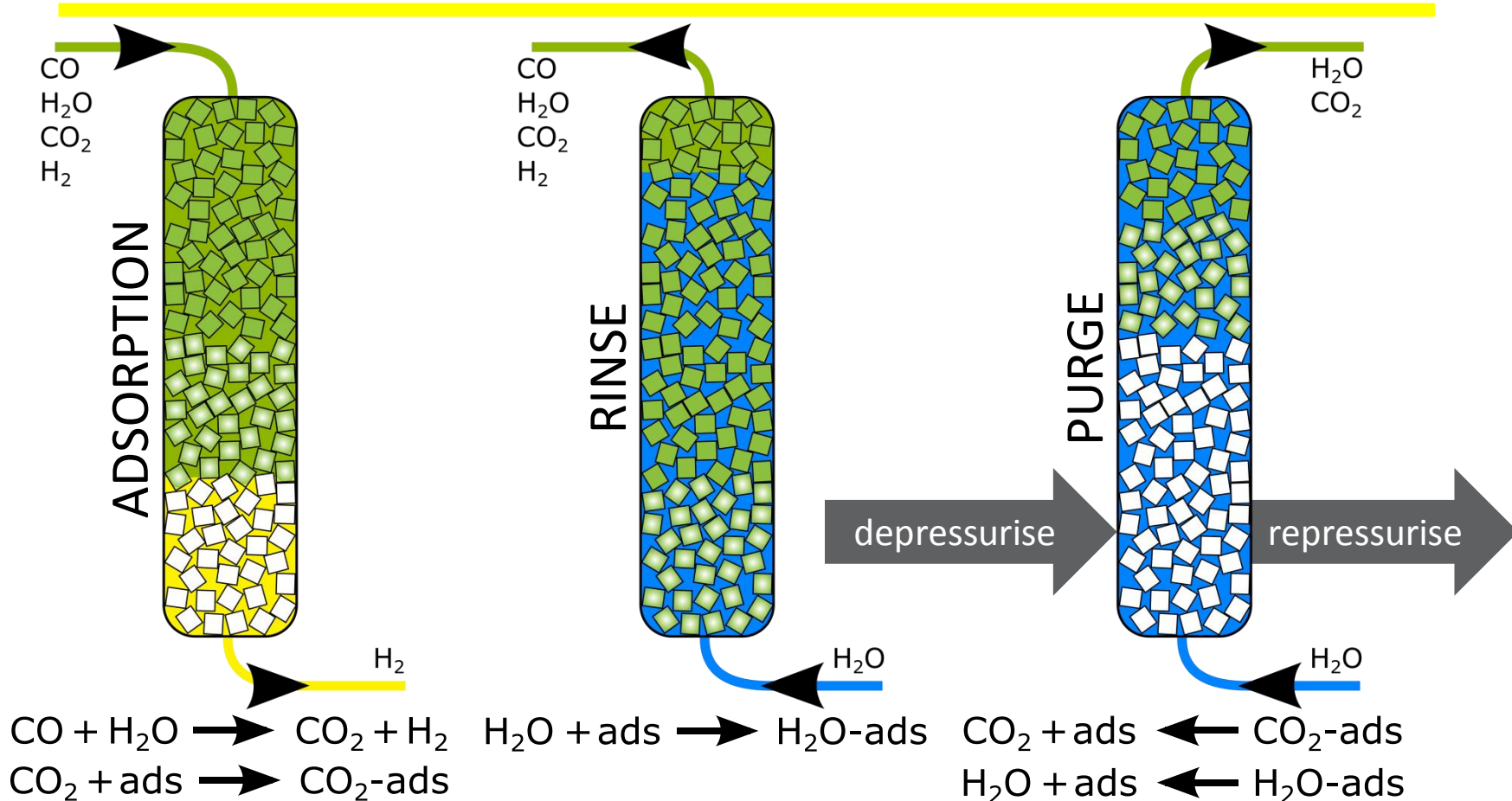
Multicolumn SEWGS

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



SEWGS process steps

Modelling fundamentals



SEWGS

Breakthrough experiments

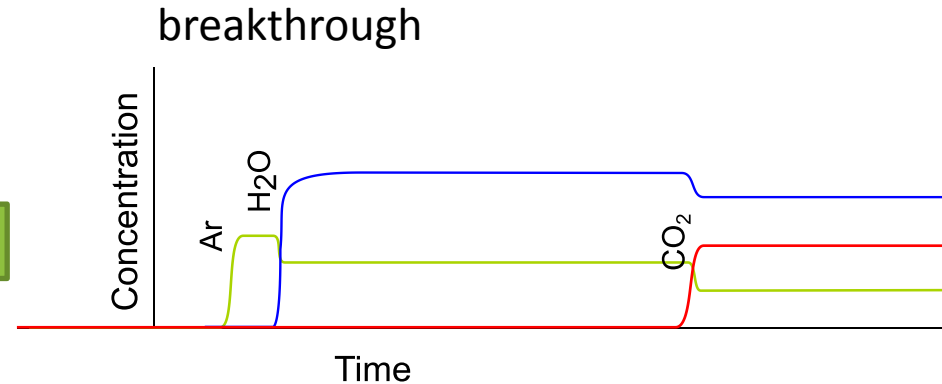
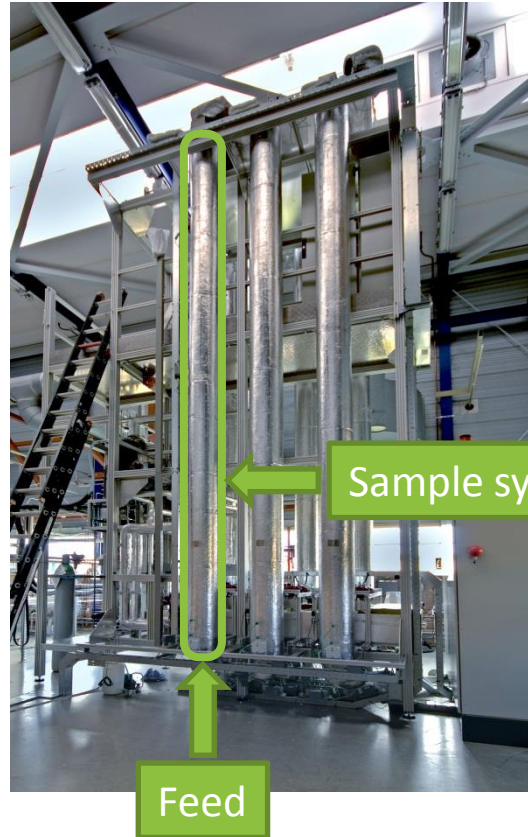


Breakthrough
experiments

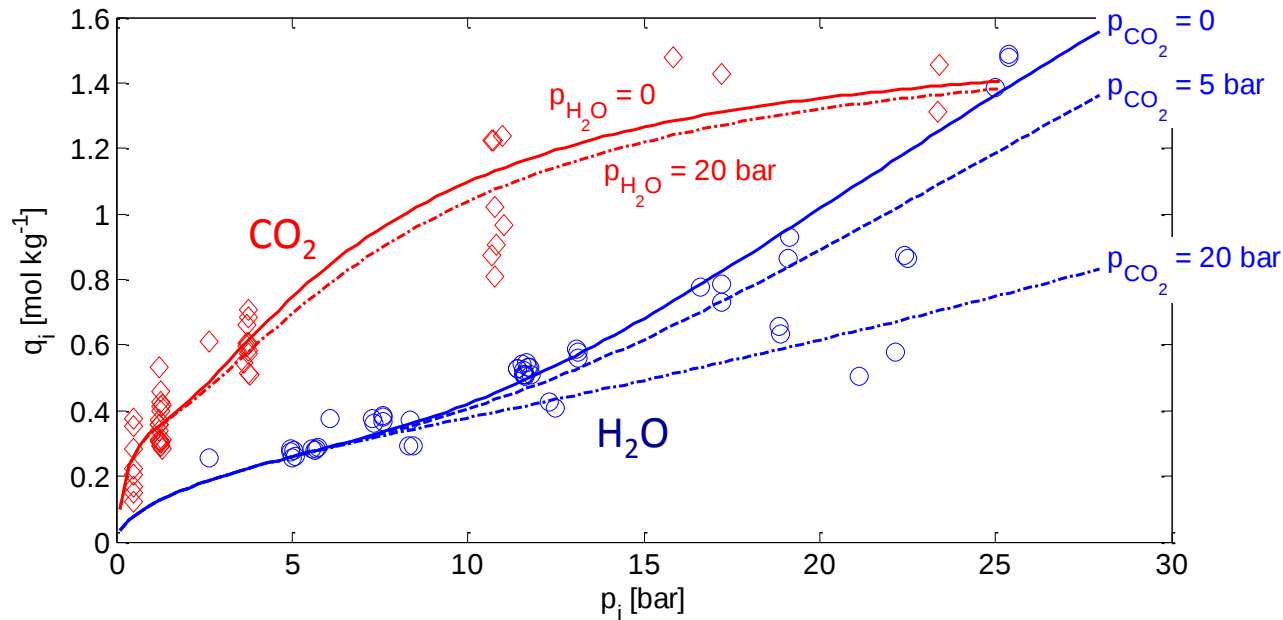


Adsorption
isotherm

Breakthrough experiments



Measured & fitted isotherms



- Competitive adsorption of CO₂ and H₂O on surface sites, in micropores

SEWGS

Reactor model



Breakthrough
experiments



Adsorption
isotherm



Reactor
model

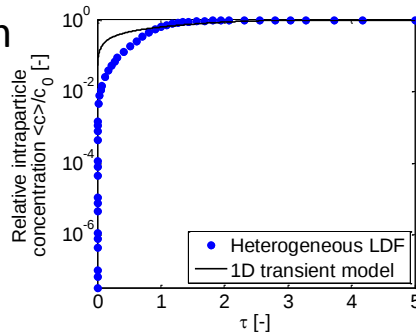
Reactor model

CO₂ and H₂O adsorption

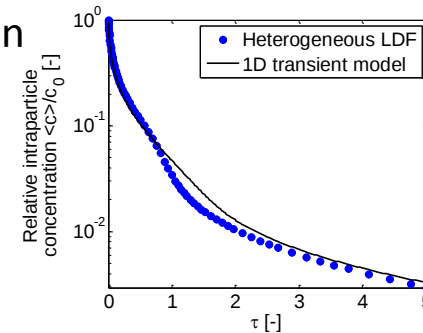
- Intraparticle model
 - Accumulation in the gas phase
 - Accumulation in the solid phase
- Linear driving force approximation

$$\frac{\partial \langle c \rangle}{\partial t} = k_{LDF} (c_i - \langle c \rangle)$$

adsorption



desorption

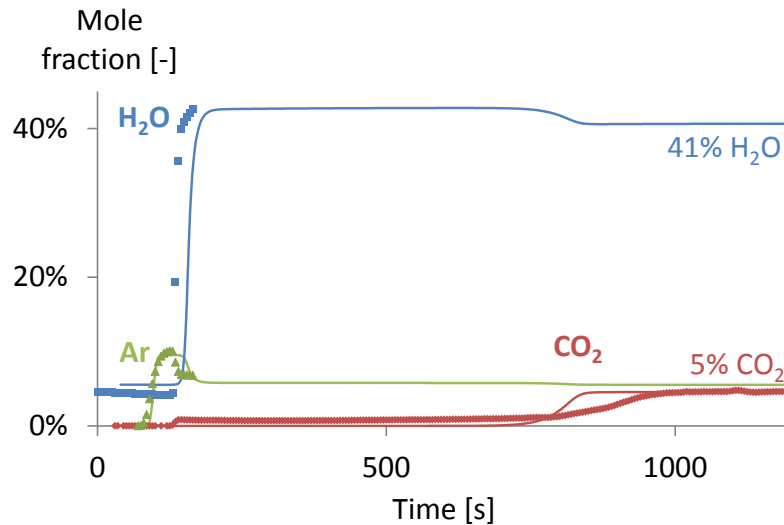


- Computationally efficient approximation of more rigorous 1D transient model for adsorption and desorption

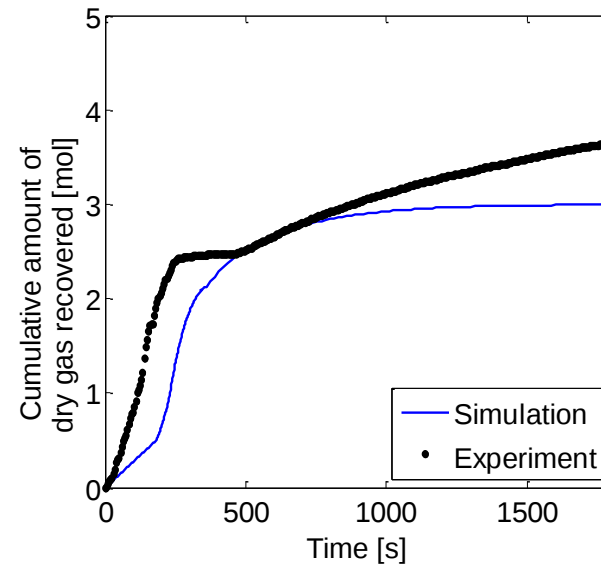
Reactor model

CO₂ and H₂O adsorption

- New isotherms, linear driving force



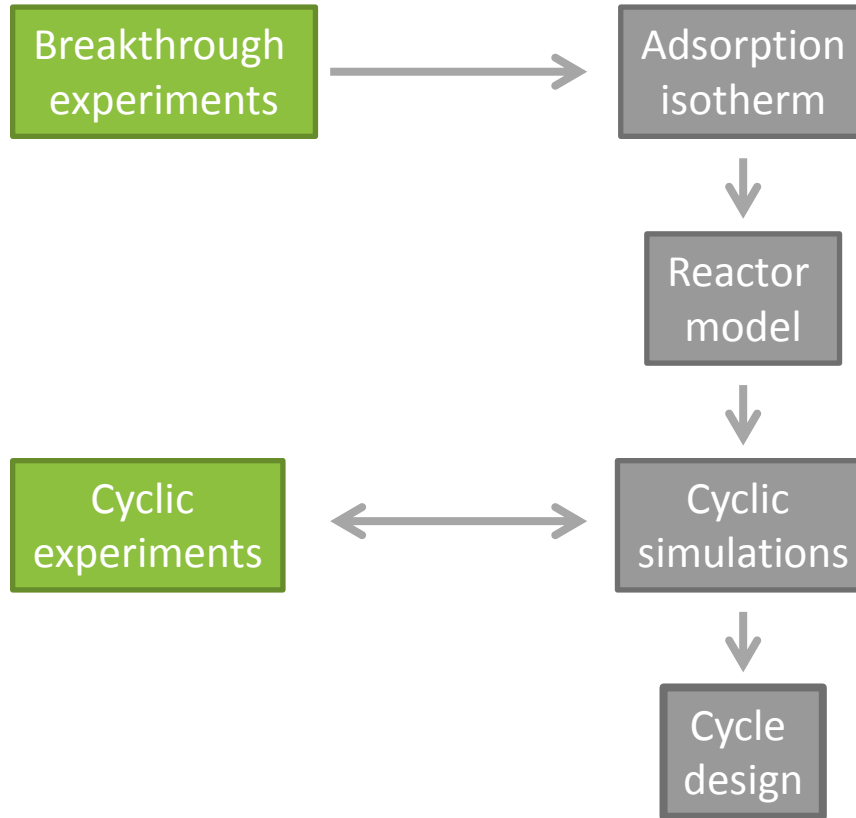
- Breakthrough curve



- Desorption curve

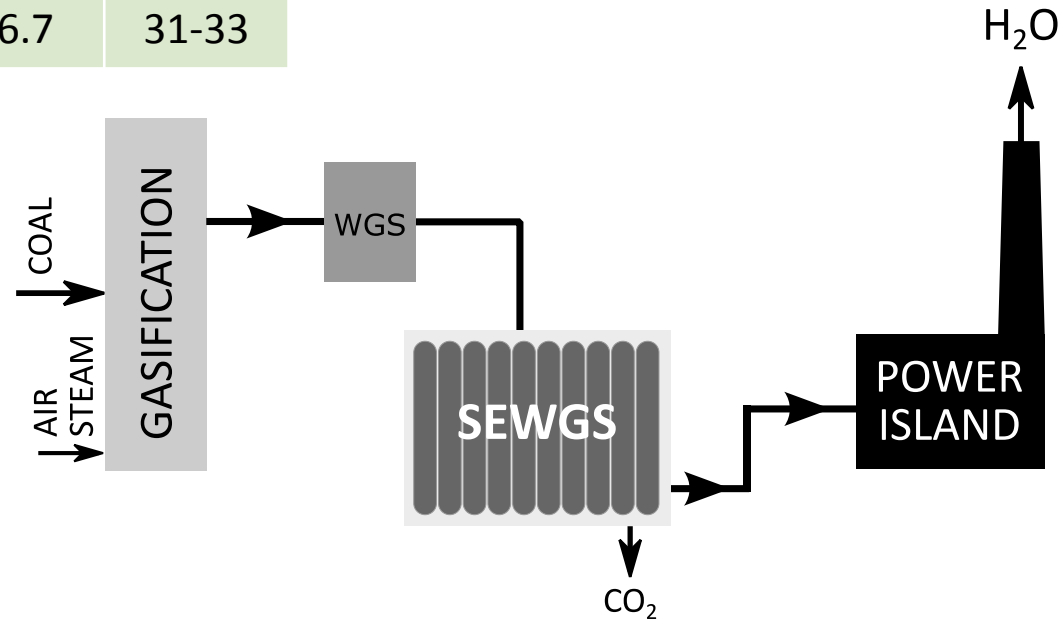
SEWGS

Cycle design



Sorption-enhanced water-gas shift SEWGS

		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

Conclusions & Outlook

- SEWGS
 - WGS with hot H_2 - CO_2 separation
 - New isotherm and particle model for CO_2 - H_2O adsorption
 - Cycle design and performance assessed by simulations
- 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

Acknowledgements

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