



STEPWISE: cost effective capturing of CO₂ in the Iron & Steel industry

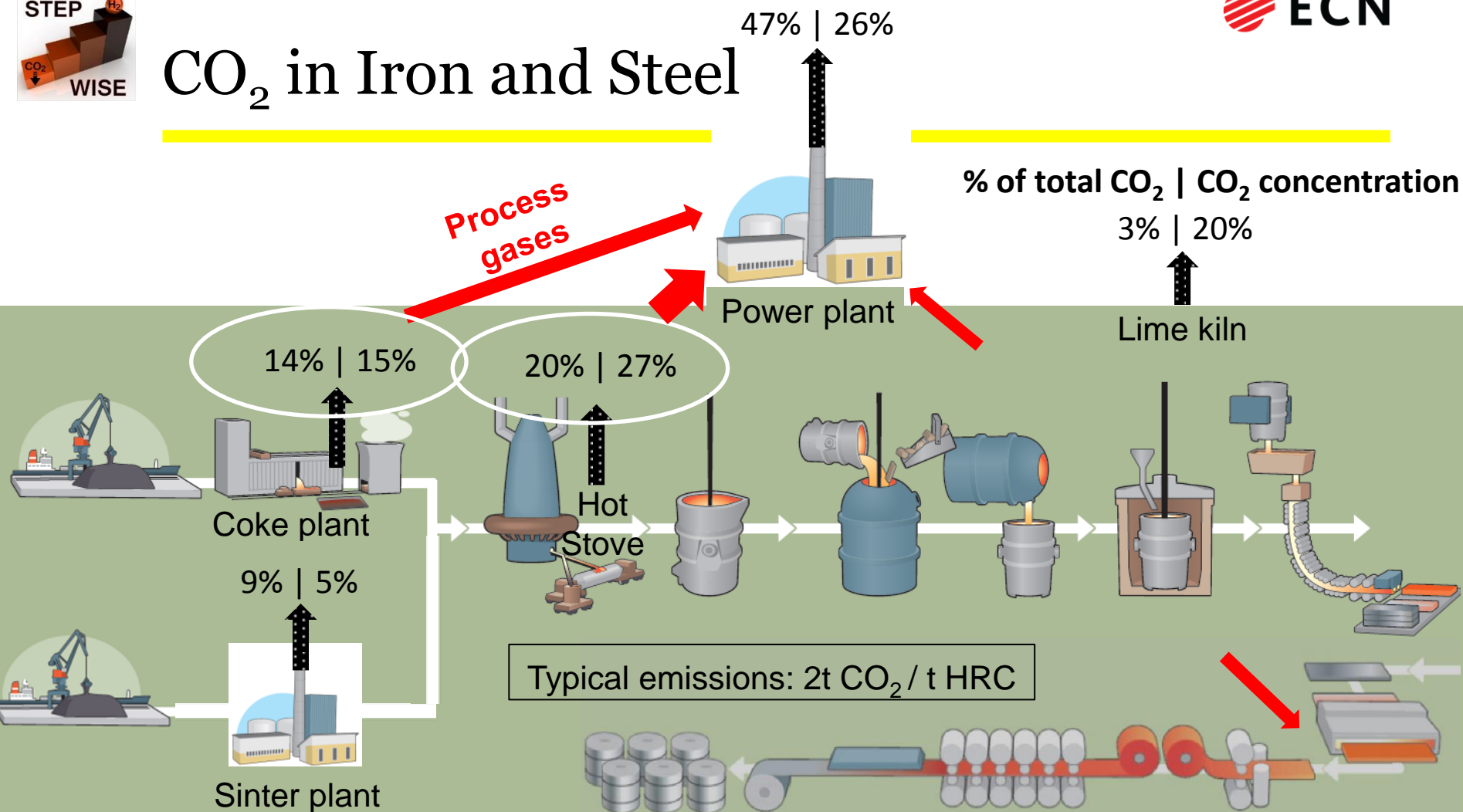
Sorption-Enhanced Water-Gas Shift (SEWGS)

Paul Cobden
Matesa dissemination day
16-6-2016



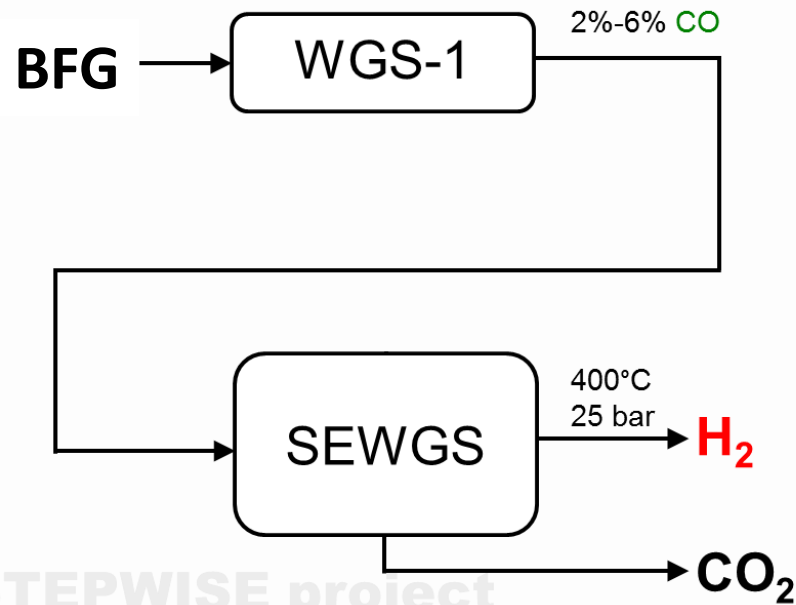
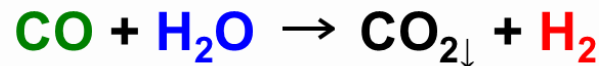
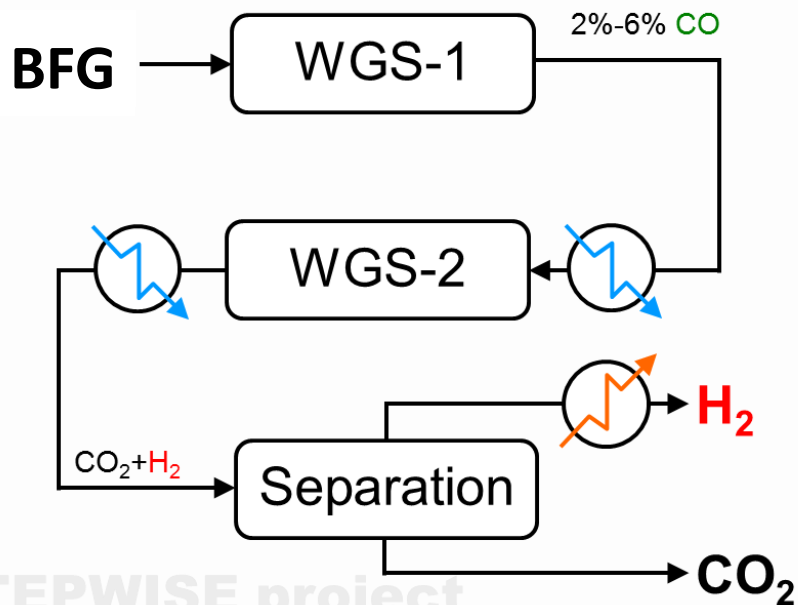
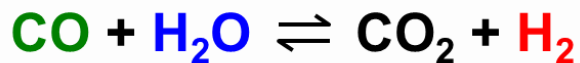


CO₂ in Iron and Steel





Stepwise Principle

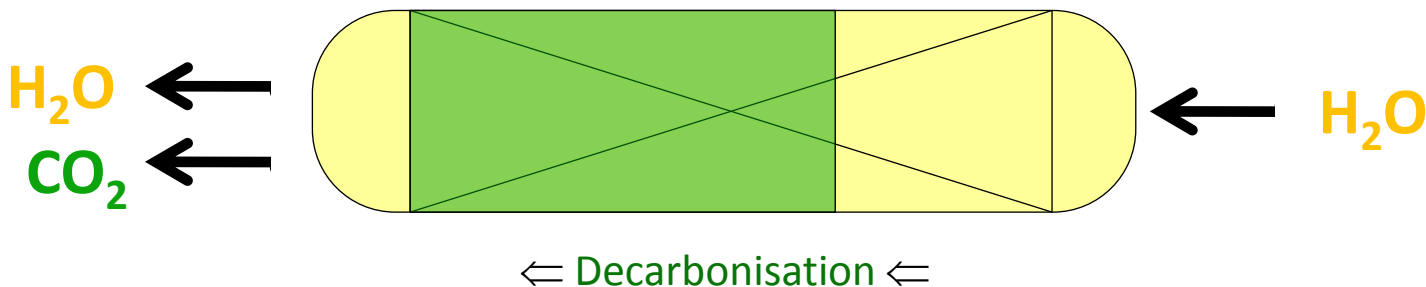
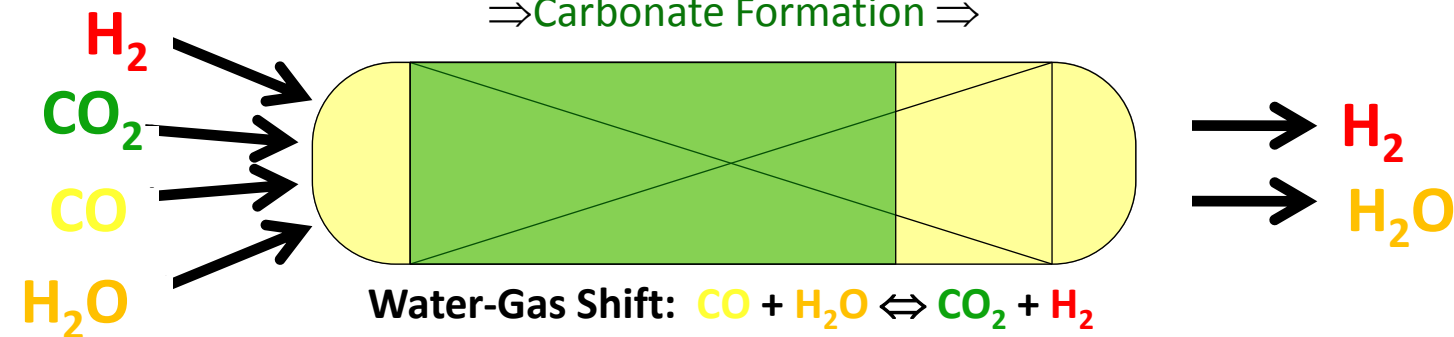




The Intensification Step

- Combines the Water-Gas-Shift reaction with sorbent material to simultaneously produce H_2 at high temperature whilst also capturing CO_2

⇒ Carbonate Formation ⇒





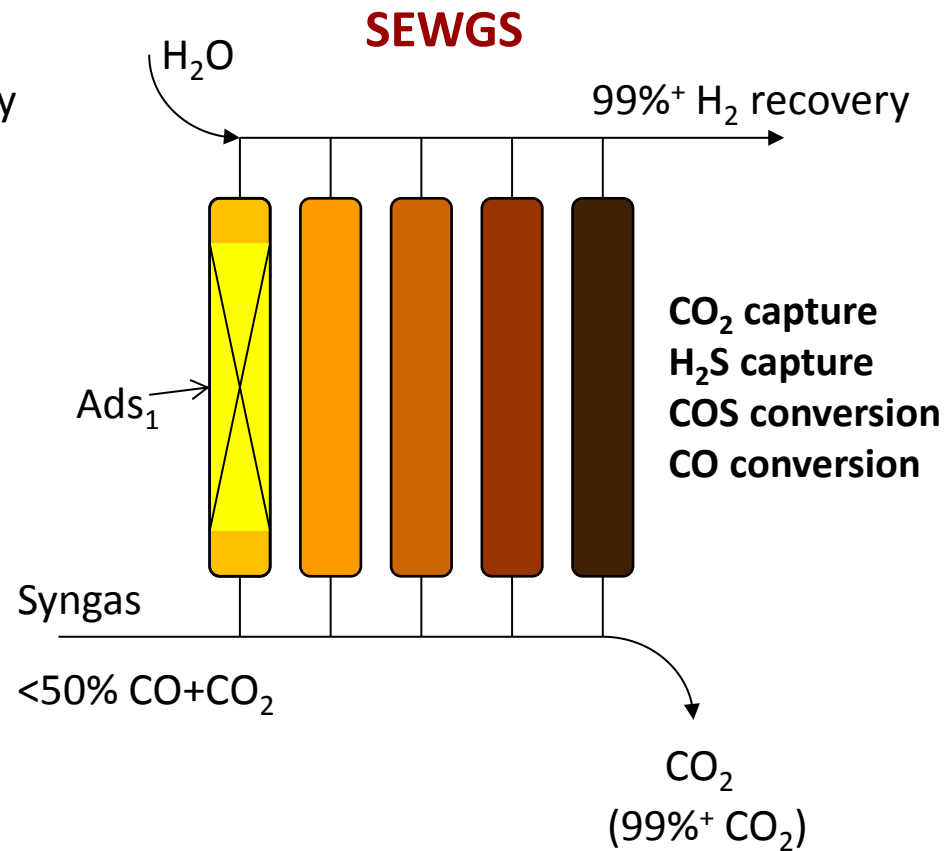
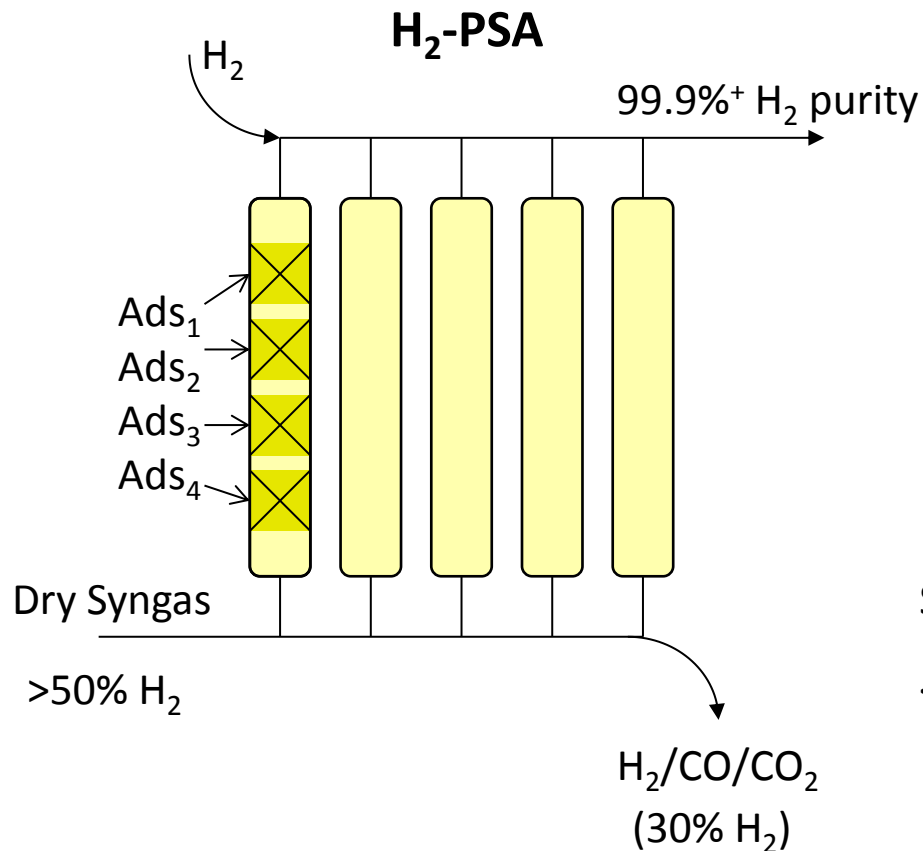
Sorption Enhanced Water-Gas Shift

Sorption-Enhanced Water-Gas Shift - SEWGS

- **Platform Technology for Syngas Treatment**
 - Upgrade Blast Furnace Gas: remove CO_2 , convert CO to H_2
 - Valorization of H_2 in CO_2/CO containing syngas streams
- **Technology**
 - High CCR at low steam use ($\text{H}_2\text{O}/\text{CO}_2 < 1.0$)
 - Co-capture of H_2S with CO_2
 - SEWGS technology is PSA system
 - Process intensification
 - Highest efficiencies for short-to-medium term developments
- **Most cost effective CCS solution in IGCC and BFG**
 - For IGCC, costs per ton CO_2 avoided estimated to be 35% lower than state of the art
 - For BFG, costs per ton CO_2 avoided estimated to be 25% lower than state of the art



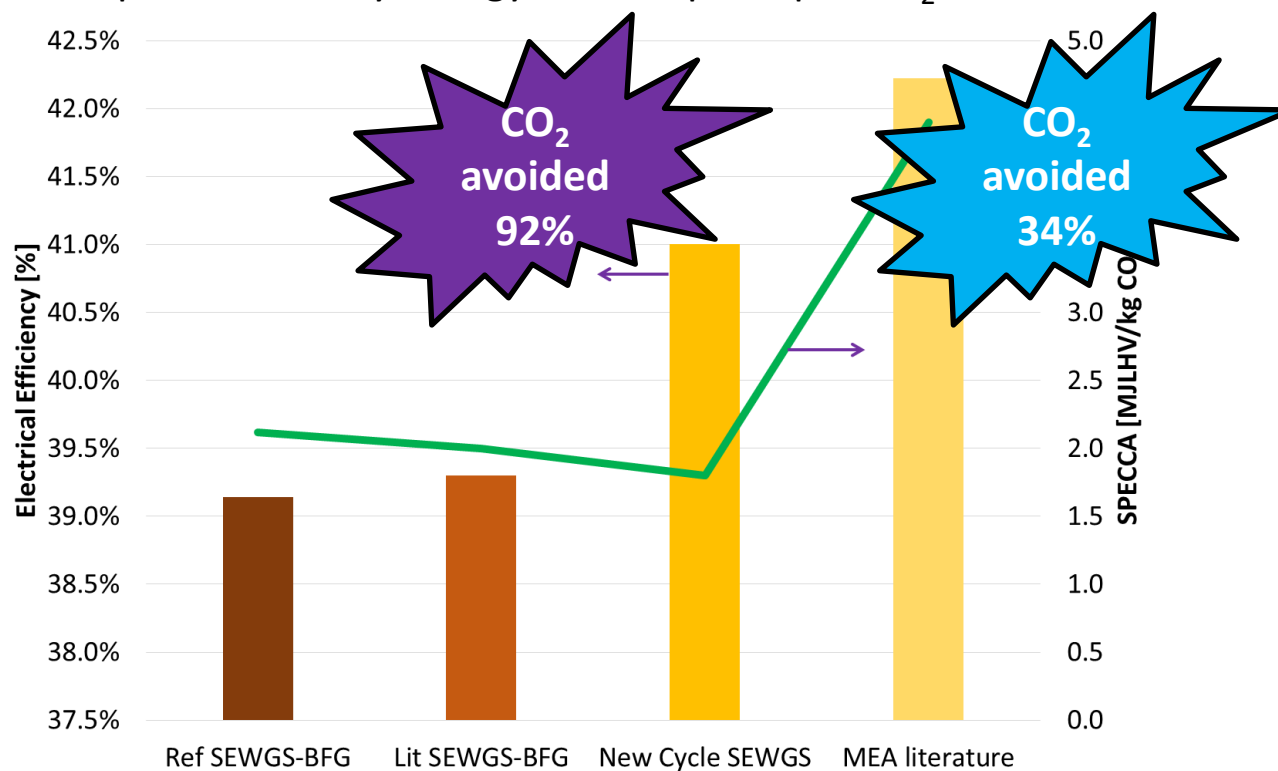
Process Intensification Intensified





Improved Performance

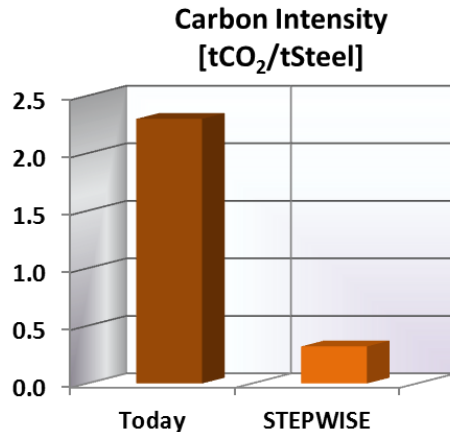
SPECCA = Specific Primary Energy Consumption per CO₂ avoided



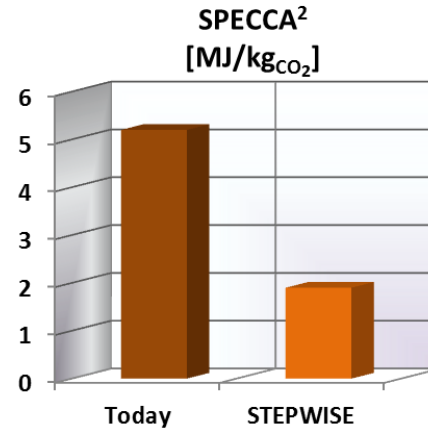


Stepwise: SEWGS for Blast Furnace Gas

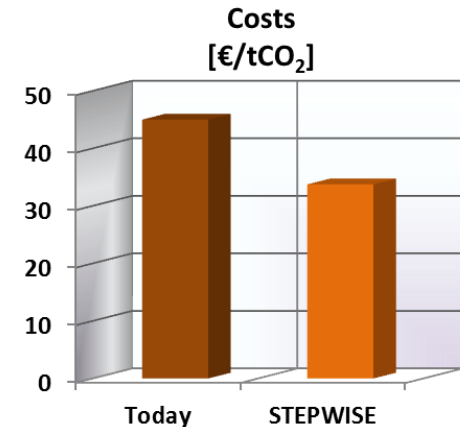
- Pilot Scale Validation
- Comparison with State-of-the-Art:



85% reduction



60% reduction



25% reduction



Project at a glance

pilot

Pilot construction
800 Nm³/h BFG



Johnson Matthey



materials

Catalyst & Sorbent
development, prod.
and testing

swerea | MEFOS

TATA STEEL

SSAB

modelling

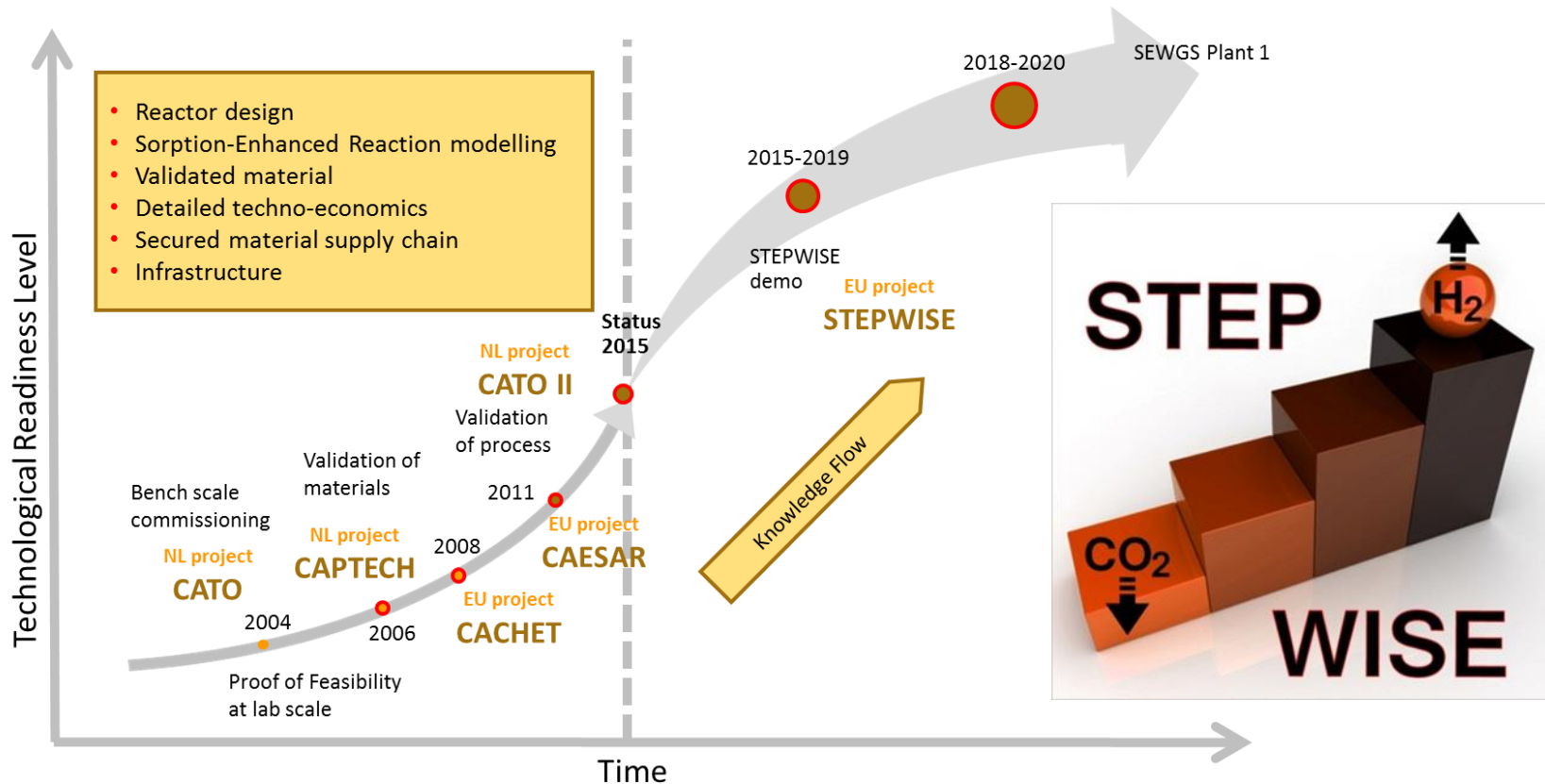
Techno-economics,
LCA and alternative
applications



outlook

Full scale design
and costing

SEWGS: moving into the future





Status: Scale

- Multiple scales
 - Facilitating testing of new material and new conditions
 - Many reaction can benefit from this approach

8 x 2g



High Throughput
Comparative Testing

10g



Adsorption Isotherms
Realistic Conditions

2kg



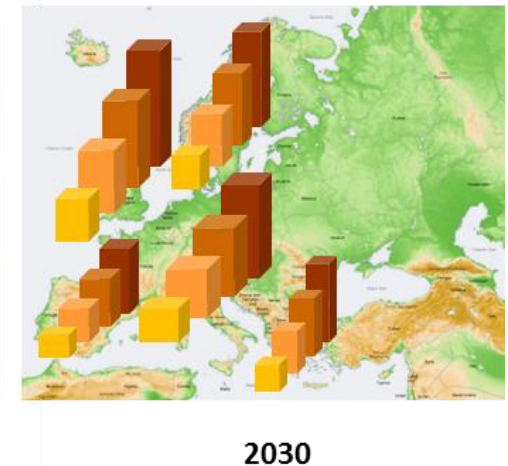
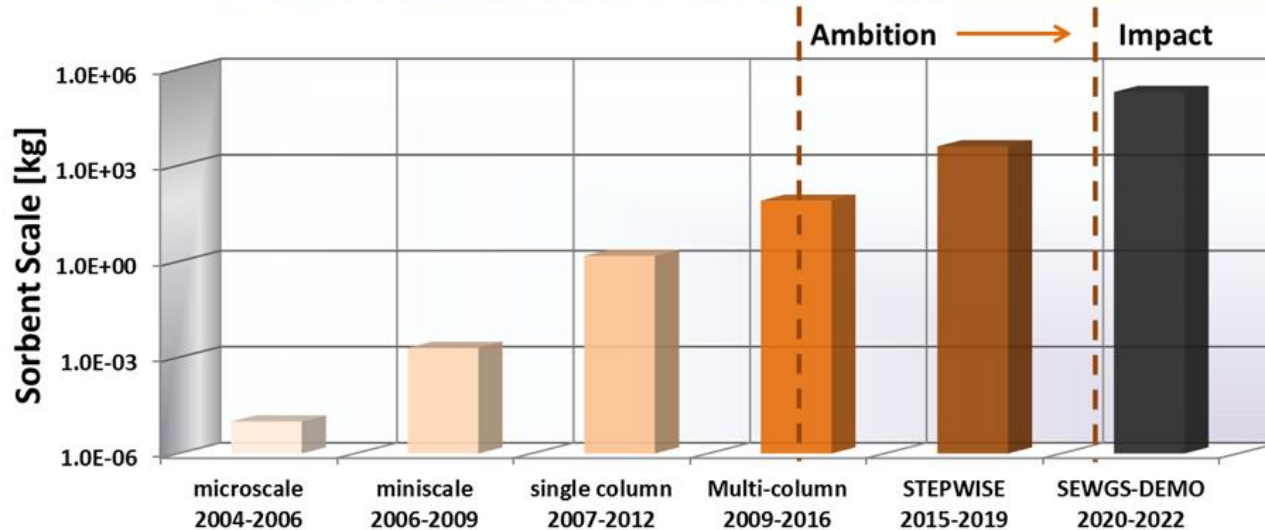
Industrially Relevant
Materials

100kg



Pre-pilot Full-Cycles

Ambition Level





Pilot location





Main Message in One Sheet

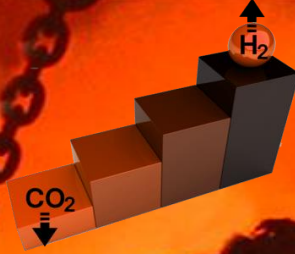
Sorption-Enhanced Water-Gas Shift - SEWGS

- **Technology**

- High carbon capture ratio with unique low steam use
- Able to operate under sour conditions and to remove H_2S as well as CO_2
- SEWGS technology builds further on the vast industrial experience with PSA systems.
- Combination of several process steps into one (process intensification)
- Highest efficiencies
- For IGCC, costs per ton CO_2 avoided estimated to be 35% lower than state of the art
- Better understanding of $\text{H}_2\text{O}/\text{CO}_2$ interaction leads to new cycle design

- **Platform technology for syngas treatment, near future**

- **STEPWISE** will extend the SEWGS technology to TRL6 for BFG



**STEP
WISE**

a H2020 Project

www.stepwise.eu

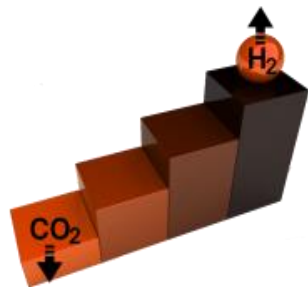
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Acknowledgement



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Visit ECN in 3D virtual reality

Visit the STEPWISE pilot station at Swerea MEFOS in September 2017