


STEP WISE

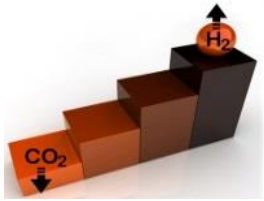
a H2020 Project

# STEPWISE GRAND OPENING

Eric van Dijk

Energy Research Center of the Netherlands

ECN




STEP WISE

a H2020 Project

# Contents

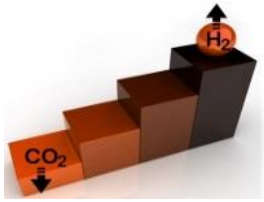
- Why are you here ?
- STEPWISE: what does it mean ?
- How did we get here ?
- Who is involved ?
- What next ?

STEP WISE

a H2020 Project

# GRAND OPENING

# STEPWISE: project data

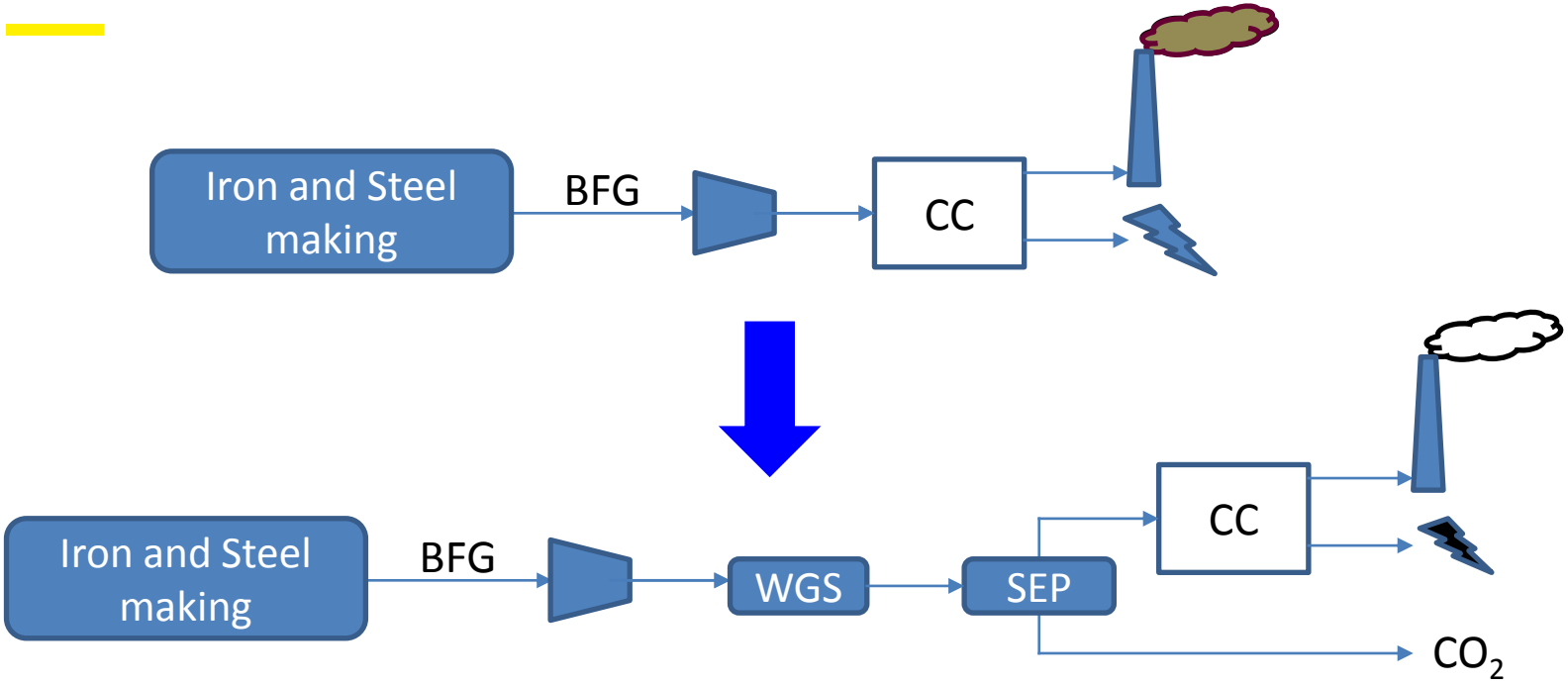



STEP WISE

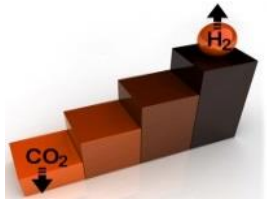
a H2020 Project

| | |
|---|---|
| **EU Funding program :** | **HORIZON 2020, LCE-15-2014** |
| **Grant agreement reference :** | No. 640769 |
| **Project duration :** | 1 May 2015 – 31 April 2019 |
| **Estimated project total cost :** | 20 M€ |
| **EU contribution :** | 13 M€ |
| **Consortium :** | 9 parties from 5 member states |
| **Coordinating entity :** | ECN, Westerduinweg 3, 1755ZG Petten, The Netherlands |
| **Coordinator :** | H.A.J. van Dijk, +31–88 515 4259, h.vandijk@ecn.nl |
| **Project web site :** | www.stepwise.eu |

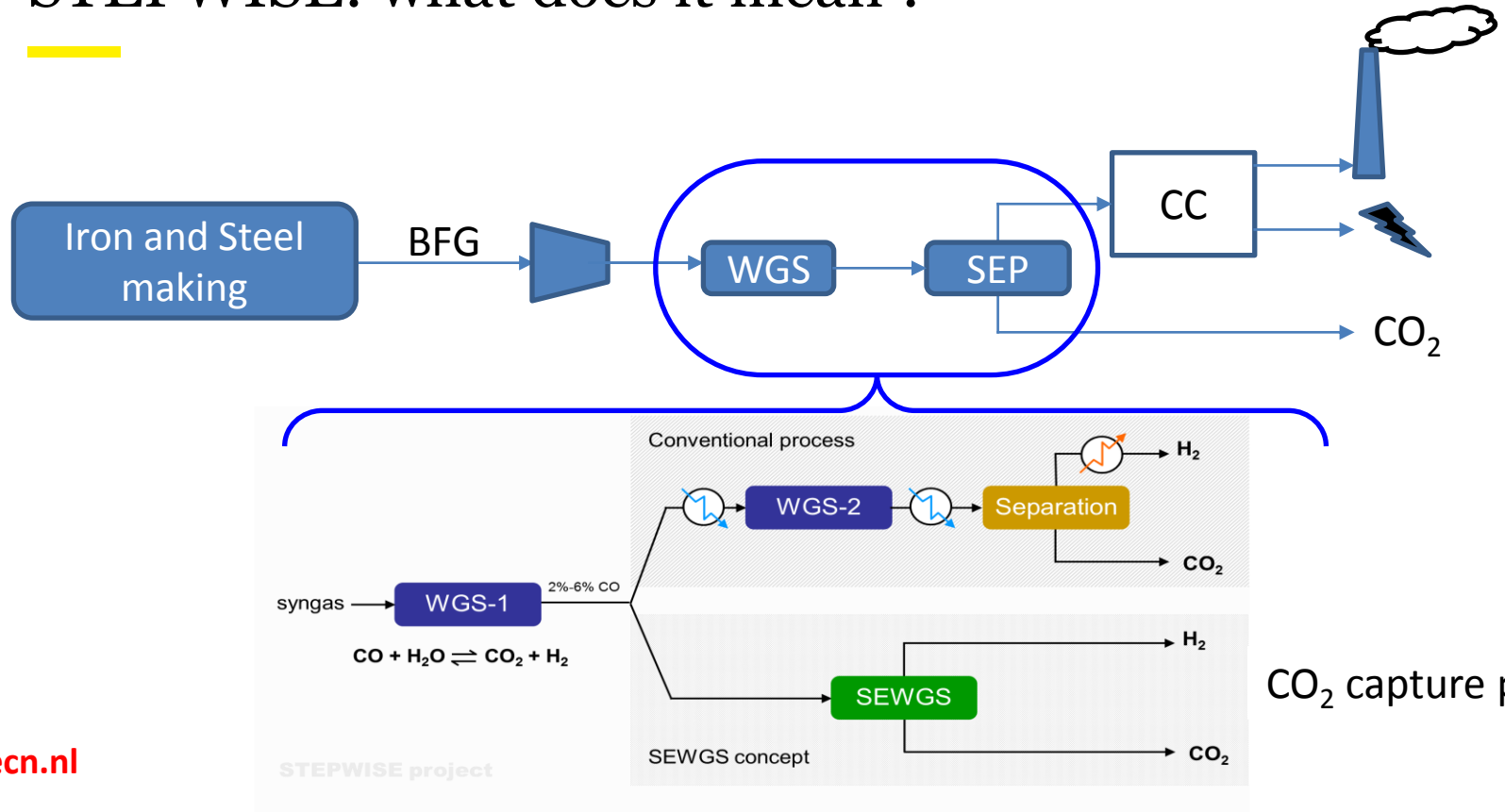
# STEPWISE: what does it mean ?



# STEPWISE: what does it mean ?




STEP WISE
a H2020 Project




$CO_2$ capture penalty↓

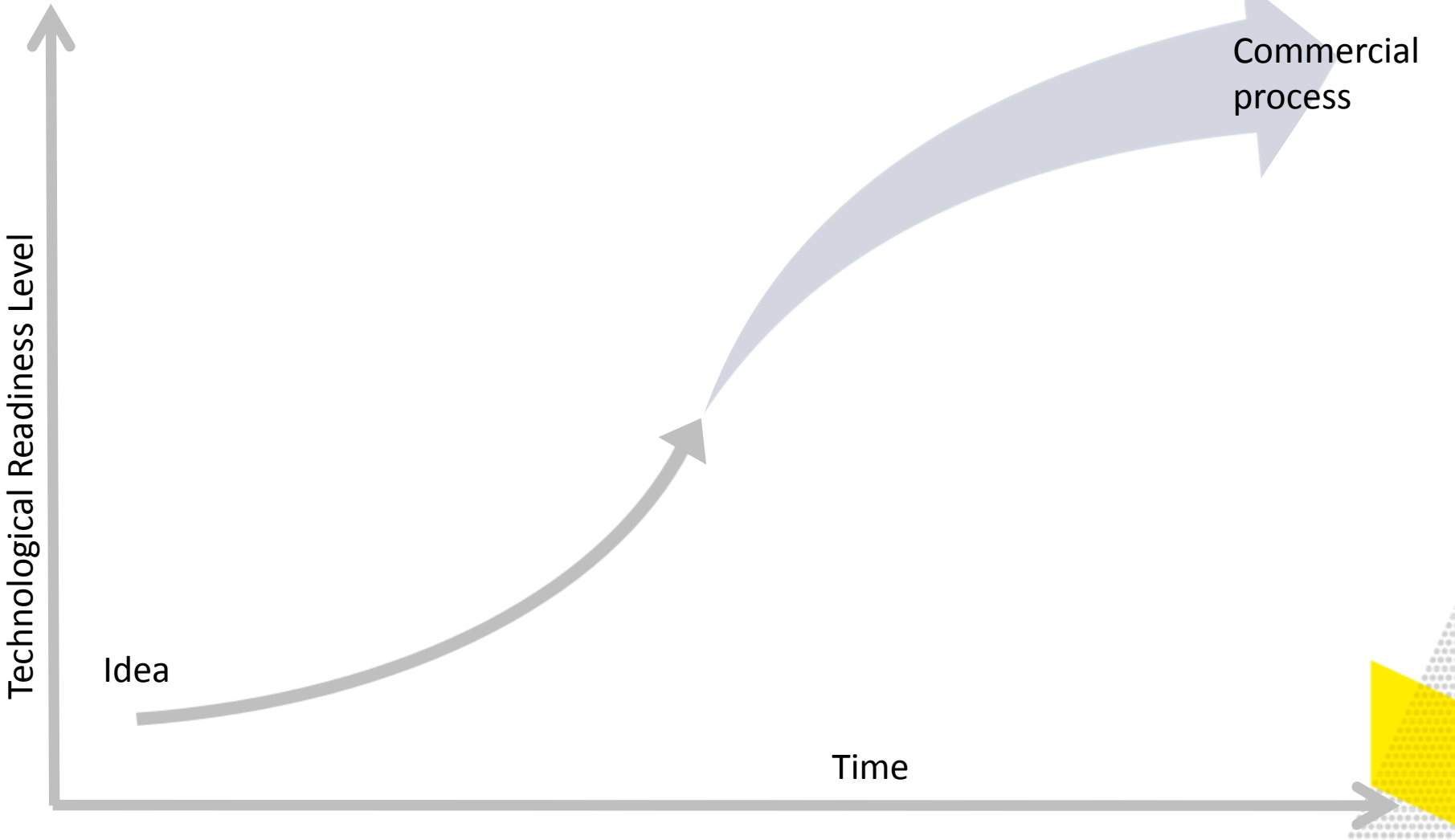
# STEPWISE: what does it mean ?

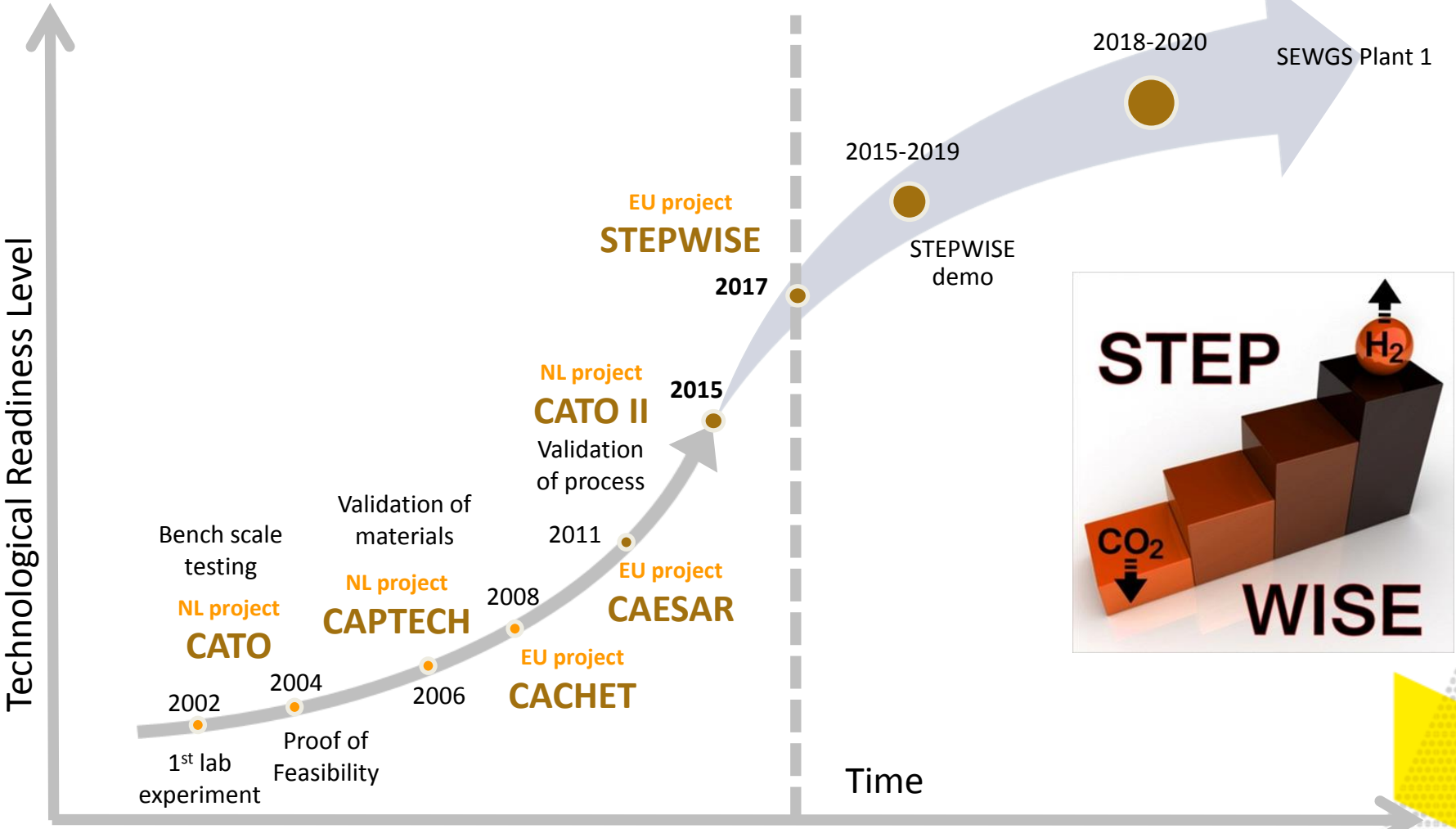
- Iron & Steel : No easy incorporation of renewable energy

  → $CO_2$ Capture and Storage (CCS)

- STEPWISE : Cost effective $CO_2$ capture

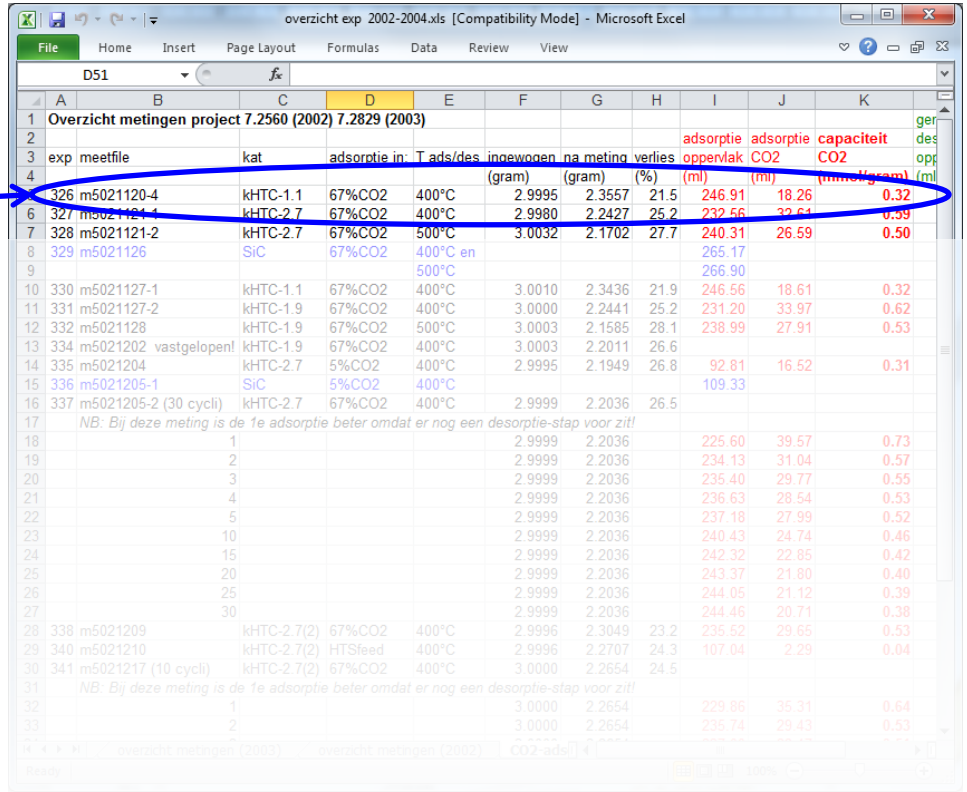
- Maintain competitiveness of the Iron & Steel industry and secure jobs


Technological Readiness Level
Idea
Time
Commercial process

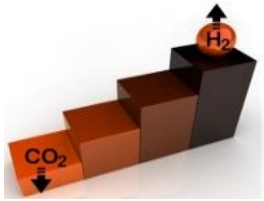

Technological Readiness Level
Time
2002
1st lab experiment
Bench scale testing
NL project
CATO
2004
Proof of Feasibility
Validation of materials
NL project
CAPTECH
2006
2008
EU project
CACHET
2011
NL project
CATO II
Validation of process
EU project
CAESAR
2015
EU project
STEPWISE
2017
2015-2019
STEPWISE demo
2018-2020
SEWGS Plant 1
STEP
WISE
H2
CO2

# First step …. material

1st experiment
20 November 2002




| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Overzicht metingen project 7.2560 (2002) 7.2829 (2003) | | | | | | | | | | |
| 2 | | | | | | | | | adsorptie | adsorptie | capaciteit |
| 3 | exp | meetfile | kat | adsorptie in: | T ads/des | ingewogen | na meting | verlies | oppervlak | CO2 | CO2 |
| 4 | | | | | | (gram) | (gram) | (%) | (ml) | (ml) | (mmol/gram) |
| 5 | 326 | m5021120-4 | kHTC-1.1 | 67%CO2 | 400°C | 2.9995 | 2.3557 | 21.5 | 246.91 | 18.26 | 0.32 |
| 6 | 327 | m5021121-1 | kHTC-2.7 | 67%CO2 | 400°C | 2.9980 | 2.2427 | 25.2 | 232.56 | 32.64 | 0.59 |
| 7 | 328 | m5021121-2 | kHTC-2.7 | 67%CO2 | 500°C | 3.0032 | 2.1702 | 27.7 | 240.31 | 26.59 | 0.50 |
| 8 | 329 | m5021126 | SiC | 67%CO2 | 400°C en | | | | 265.17 | | |
| 9 | | | | | 500°C | | | | 266.90 | | |
| 10 | 330 | m5021127-1 | kHTC-1.1 | 67%CO2 | 400°C | 3.0010 | 2.3436 | 21.9 | 246.56 | 18.61 | 0.32 |
| 11 | 331 | m5021127-2 | kHTC-1.9 | 67%CO2 | 400°C | 3.0000 | 2.2441 | 25.2 | 231.20 | 33.97 | 0.62 |
| 12 | 332 | m5021128 | kHTC-1.9 | 67%CO2 | 500°C | 3.0003 | 2.1585 | 28.1 | 238.99 | 27.91 | 0.53 |
| 13 | 334 | m5021202 vastgelopen! | kHTC-1.9 | 67%CO2 | 400°C | 3.0003 | 2.2011 | 26.6 | | | |
| 14 | 335 | m5021204 | kHTC-2.7 | 5%CO2 | 400°C | 2.9995 | 2.1949 | 26.8 | 92.81 | 16.52 | 0.31 |
| 15 | 336 | m5021205-1 | SiC | 5%CO2 | 400°C | | | | 109.33 | | |
| 16 | 337 | m5021205-2 (30 cycli) | kHTC-2.7 | 67%CO2 | 400°C | 2.9999 | 2.2036 | 26.5 | | | |
| 17 | | *NB: Bij deze meting is de 1e adsorptie beter omdat er nog een desorptie-stap voor zit!* | | | | | | | | | |
| 18 | | 1 | | | | 2.9999 | 2.2036 | | 225.60 | 39.57 | 0.73 |
| 19 | | 2 | | | | 2.9999 | 2.2036 | | 234.13 | 31.04 | 0.57 |
| 20 | | 3 | | | | 2.9999 | 2.2036 | | 235.40 | 29.77 | 0.55 |
| 21 | | 4 | | | | 2.9999 | 2.2036 | | 236.63 | 28.54 | 0.53 |
| 22 | | 5 | | | | 2.9999 | 2.2036 | | 237.18 | 27.99 | 0.52 |
| 23 | | 10 | | | | 2.9999 | 2.2036 | | 240.43 | 24.74 | 0.46 |
| 24 | | 15 | | | | 2.9999 | 2.2036 | | 242.32 | 22.85 | 0.42 |
| 25 | | 20 | | | | 2.9999 | 2.2036 | | 243.37 | 21.80 | 0.40 |
| 26 | | 25 | | | | 2.9999 | 2.2036 | | 244.05 | 21.12 | 0.39 |
| 27 | | 30 | | | | 2.9999 | 2.2036 | | 244.46 | 20.71 | 0.38 |
| 28 | 338 | m5021209 | kHTC-2.7(2) | 67%CO2 | 400°C | 2.9996 | 2.3049 | 23.2 | 235.52 | 29.65 | 0.53 |
| 29 | 340 | m5021210 | kHTC-2.7(2) | HTSfeed | 400°C | 2.9996 | 2.2707 | 24.3 | 107.04 | 2.29 | 0.04 |
| 30 | 341 | m5021217 (10 cycli) | kHTC-2.7(2) | 67%CO2 | 400°C | 3.0000 | 2.2654 | 24.5 | | | |
| 31 | | *NB: Bij deze meting is de 1e adsorptie beter omdat er nog een desorptie-stap voor zit!* | | | | | | | | | |
| 32 | | 1 | | | | 3.0000 | 2.2654 | | 229.86 | 35.31 | 0.64 |
| 33 | | 2 | | | | 3.0000 | 2.2654 | | 235.74 | 29.43 | 0.53 |




STEP WISE

a H2020 Project

# Next steps ....

- 2004 – **First experimental feasibility**
- 2005 – **First systems analysis**
- 2006 – **High Pressure Single-Column Unit**
- 2007 – **SEWGS for gasification**
- 2008 – **Multi-Column Unit**
- 2010 – **Process Improvements**
- 2011 – **New sorbent class**
  - boosting performance by 100%
- 2012 – **Techno-economic evaluation**
  - 35% lower that base-case state-of-the-art system IGCC
- 2014 – **Further reduction in steam demand**
  - New cycles for Blast Furnace Gas
- 2015 – **Industrial Scale Production of Sorbent**
- 2016 – **Start construction pilot plant 800 $Nm^3/hr$**

**Major Innovations**

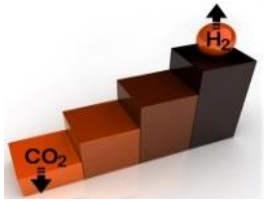
Sorbent Stability

$H_2S$ Recovery
Shift Activity

Stress Test
Low steam demand WGS

Pilot Scale Demonstration

# STEPWISE: Who is involved ?




STEP WISE

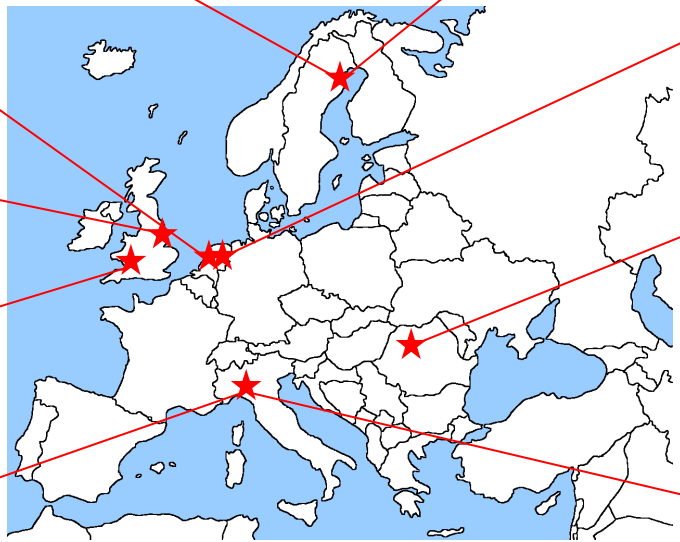
a H2020 Project

ECN

SSAB

KISUMA CHEMICALS

swerea | MEFOS



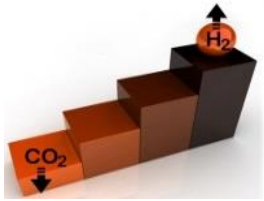
JM Johnson Matthey

UNIVERSITAS NAPOCENSIS 1581 ROMANIA BABEŞ-BOLYAI

TATA STEEL

POLITECNICO MILANO

amec foster wheeler




STEP WISE

a H2020 Project

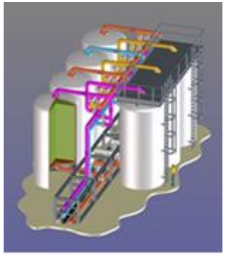
# What next ?

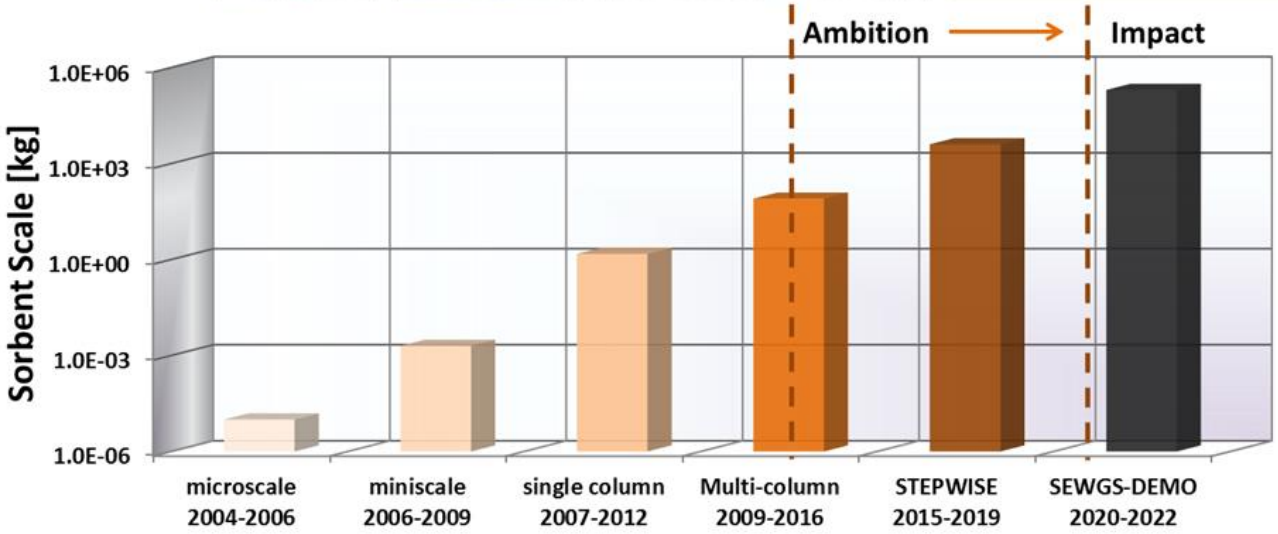
- STEPWISE project : filling reactors and start demonstration

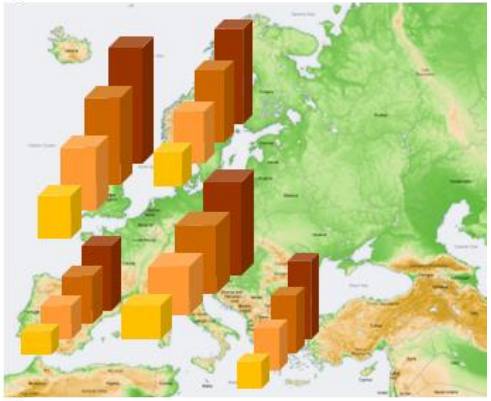
- SEWGS-technology : TRL6 demonstration

  → Reducing risk for scale-up

# What next ?





2030

# Impression

STEP WISE
a H2020 Project

BFG compression

BFG

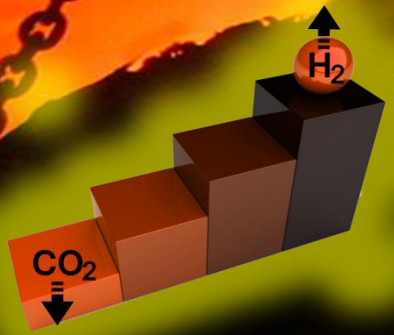
WGS reactor

SEWGS reactor

$H_2$

$CO_2$

# Thank you for your attention




STEP WISE

a H2020 Project

www.stepwise.eu

stepwise@ecn.nl

This presentation is part of the STEPWISE project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 640769