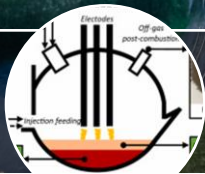


Pilot for Transition Toward a CO₂- Neutral Metal Industry with Increased Circularity – Recent Swerim Experiences

Guozhu Ye
Principal Metallurgist, Swerim, Sweden



1. Pilot and Pyro



2. Before Covid

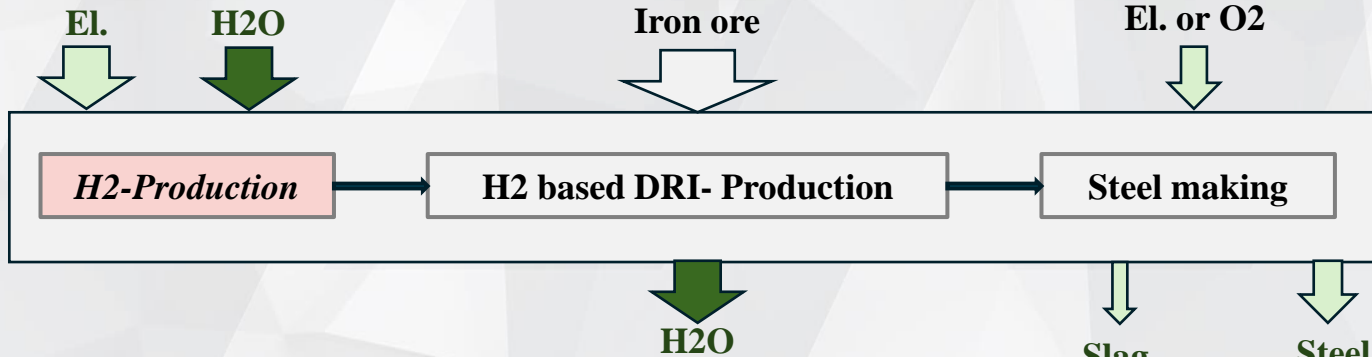
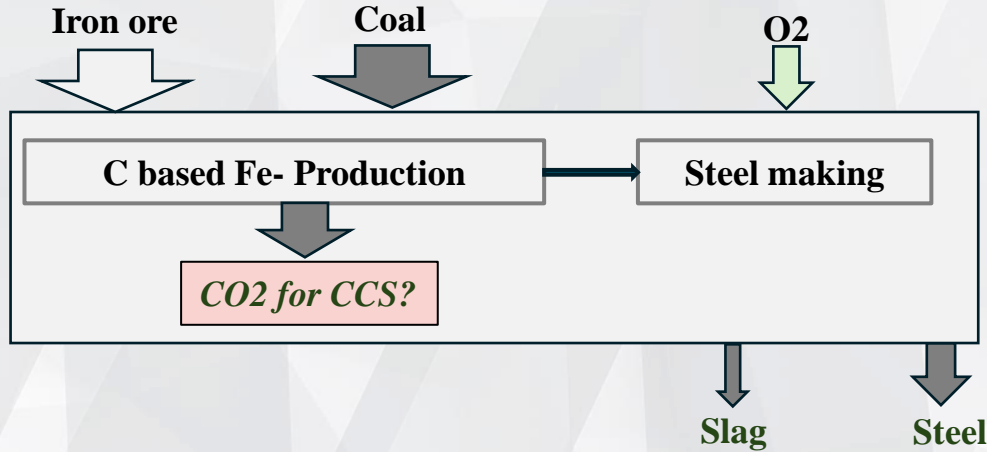


3. After Covid

Challenges C- vs H2-based

C-based any future?

- CCS accepted?
- Inexpensive enough?



H2-based Challenges:

- Extremely large amount of H2 needed
- Extremely energy intensive
- Energy efficiency
- H2-efficiency

H₂ vs C

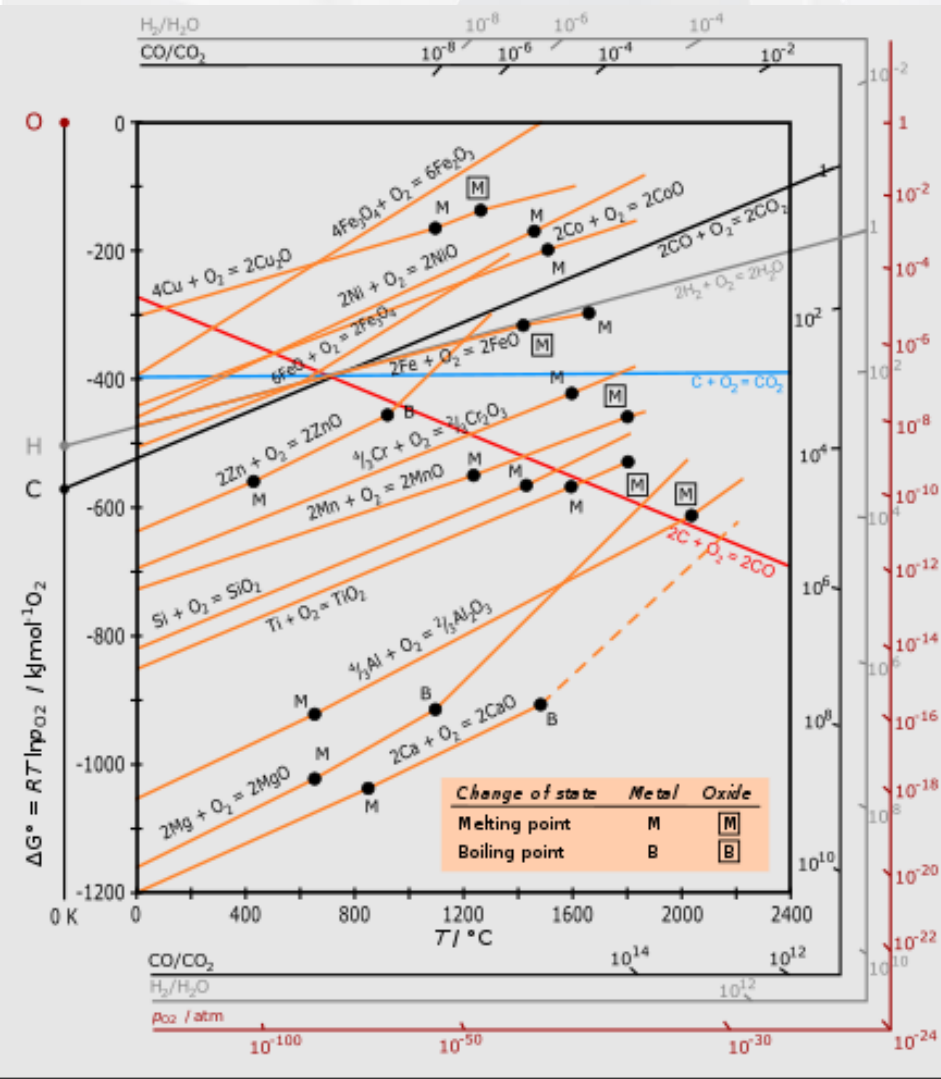
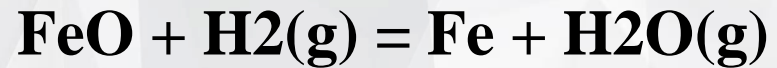
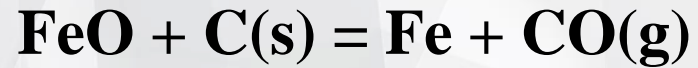
$$\Delta G = \Delta H - T \cdot \Delta S$$

ΔG = Gibbs free energy

ΔH = Change in enthalpy

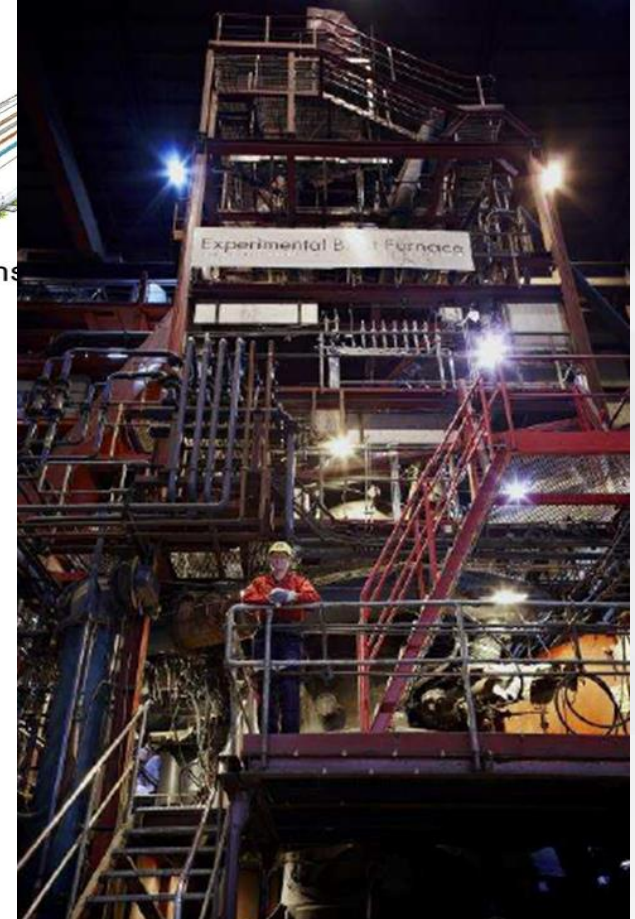
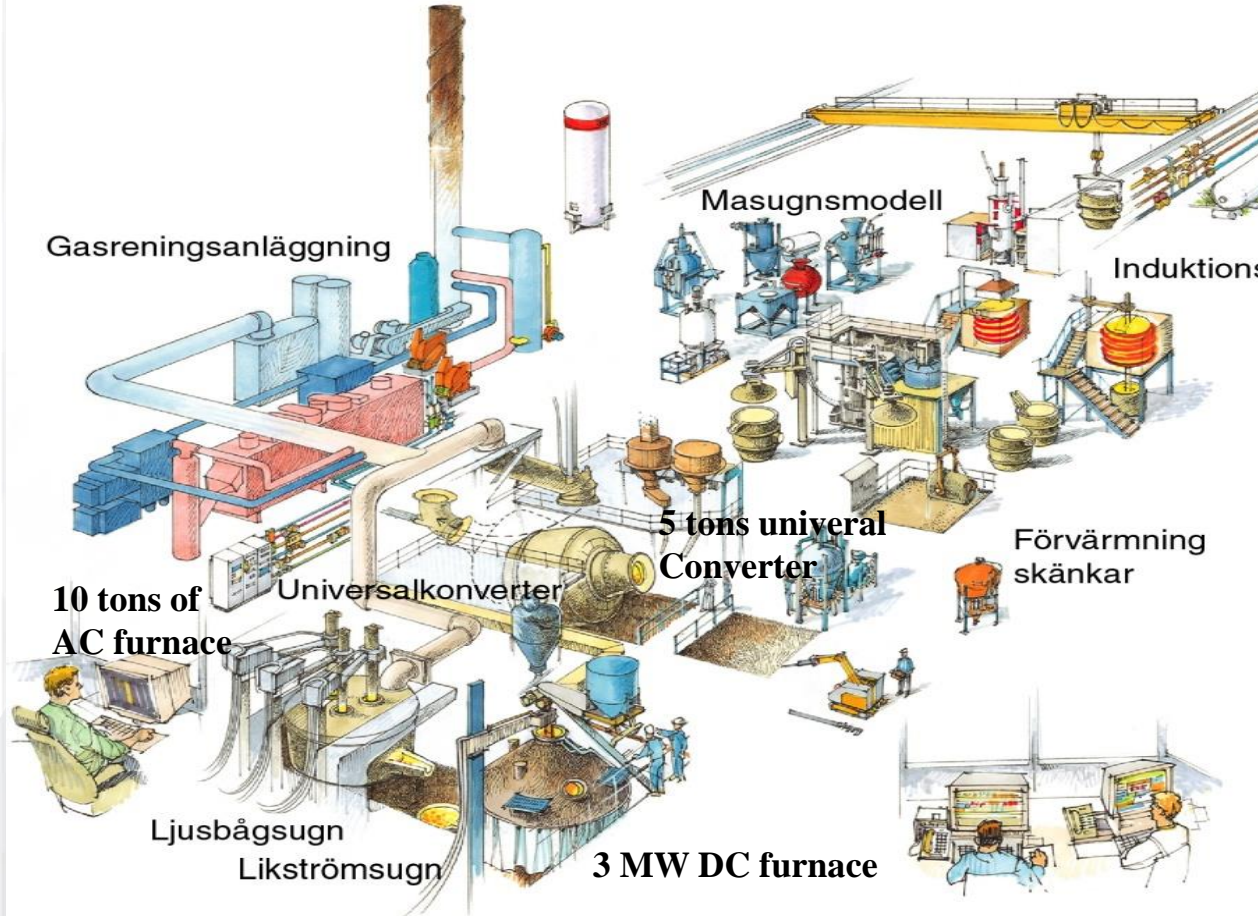
ΔS = Change in entropy

T = Temperature in K



Unique pilot equipment

SWERIM



Major Demonstration Plants from 80s to 2015

SWERIM

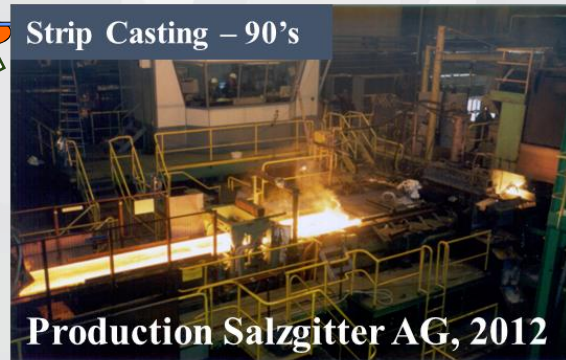
Coal gasification 80's; 45 M€
Sumitomo Metal - KDH



ULCOS – COURSE 50 2012



Strip Casting – 90's

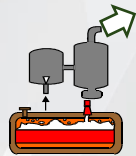


Production Salzgitte AG, 2012

LKAB EBF



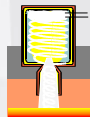
ROTOVERT



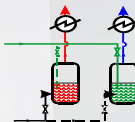
WORCRA



ELRED



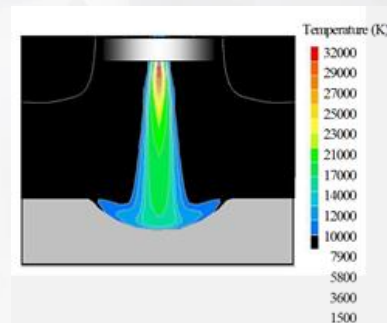
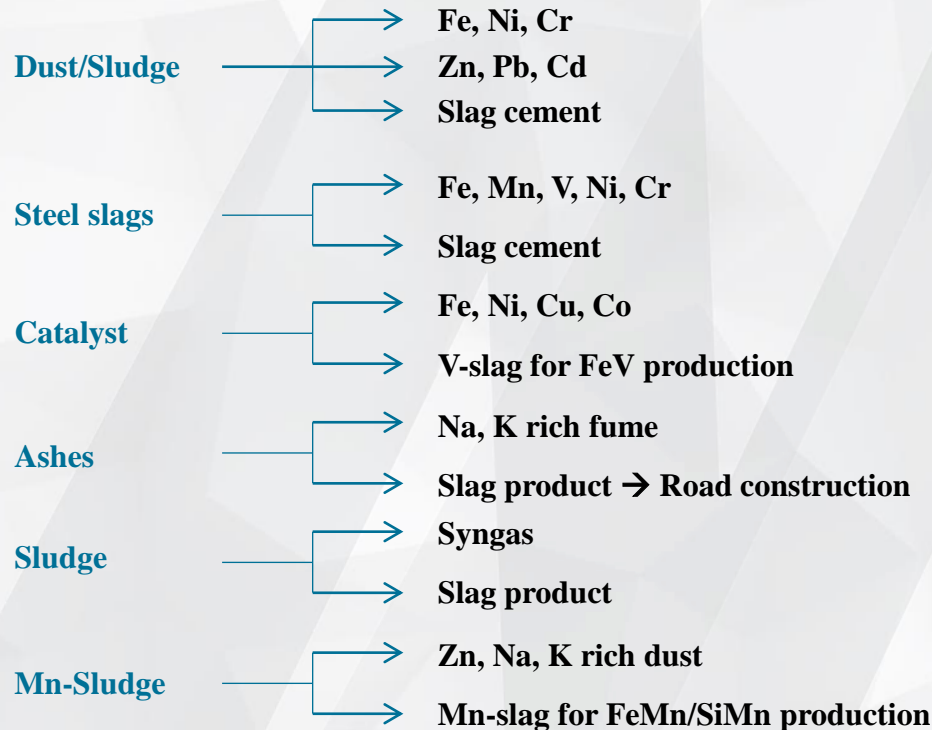
KALDO



INRED



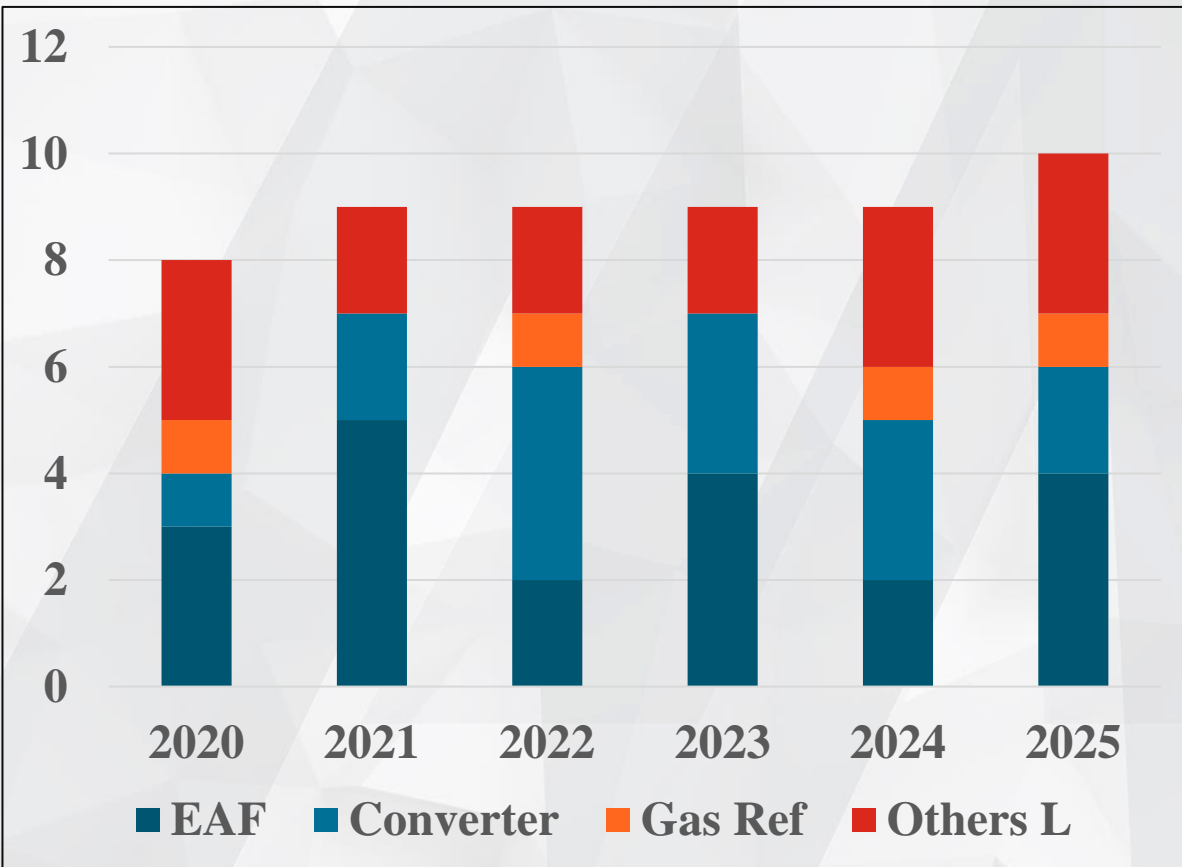
Pilot trials with DC/AC furnace technology SWERIM



AC/DC: Ilmenite smelting, direct MC FeMn, Slag foaming, DRI-smelting

Converter: New processes, AOD, High temp roasting, slag reduction/fuming/slag granulation/Battery/el-scrap

Post Covid Pilot Activities at Swerim



Pilot for CO2-neutral transition: since 2020

SWERIM

HYBRIT
FOSSIL-FREE STEEL

- EAF 10 ton
- From Hybrit DRI/HBI to Steel
- 12 Test campaigns since 2020
- Slag foaming
- Energy
- Biocarbon

Nonferrous

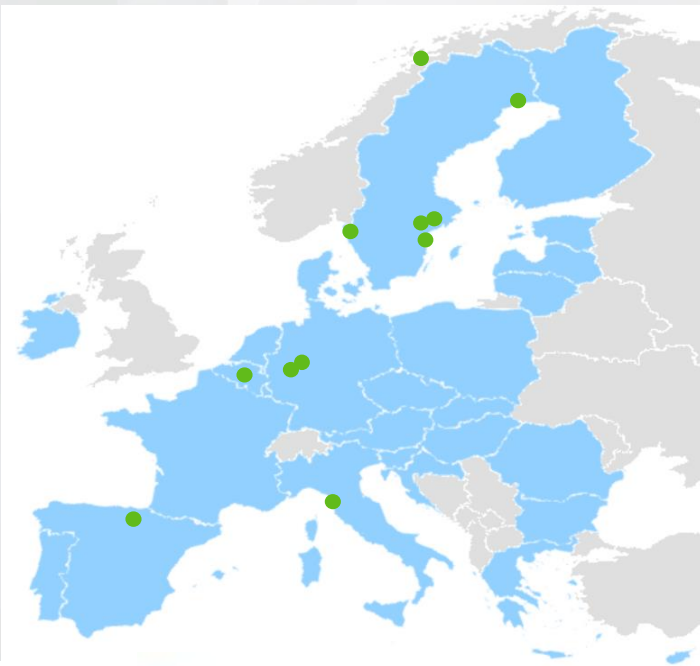
- Universal converter
- Slag processing
- Numbers of test campaigns since 2021, still ongoing
- Fuming using H₂
- Slag for cement



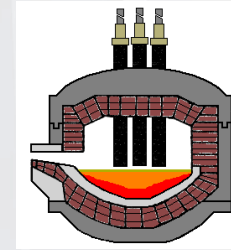
Gradual integration of REnewable non-fossil ENergy sources and modular HEATING technologies in EAF for progressive CO2 decrease **SWERIM**

GreenHeatEAF key facts

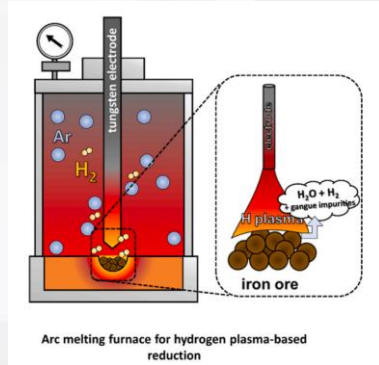
- Duration: 42 months (January 2023 – June 2026)
- Budget: 3.5 million Euro
- Type of Action: Innovation Action
- CALL TOPIC: HORIZON-CL4-2022-TWIN-TRANSITION-01-16 Modular and hybrid heating technologies in steel production
- 11 partners from 6 countries
- **Marianne Magnelöv**; Marianne.Magnelov@swerim.sei



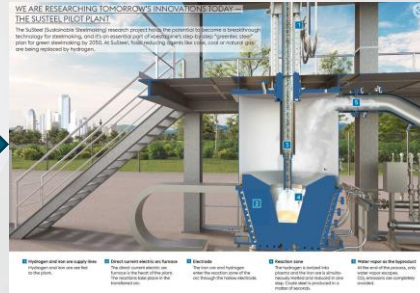
- Integration of **non-fossil gases flows** in EAF processes with different charge materials and configurations towards GHG reduction and green transition of steelmaking
- Development of **modular regenerative and alternative heating technologies** for increasing in-process **heat recovery from off-gases** and **maximizing slag latent heat exploitation** for their valorization
- Demonstration of the technical feasibility of **biomass/biochar exploitation for non-fossil energy intake** in EAF process
- Coupling of **novel measurement techniques** and **optimized control strategies** to manage exploitation and facilitate integration of novel non-fossil heat/energy sources and streams



HEU project: Hydrogen Plasma Reduction of Iron ore



Fundamental studies



Demo in hundred-kilo scale at
Donawitz Voestalpine



Demo in tone-scale at Swerim

Project partners



- Budget: 6 M€
- Project duration: 2024-2027
- Increasing the TRL from 5 to 6-7

Gas Processing Technology Platform



TRL 2

0.002 kg



TRL 3

0.05 kg



TRL 4

2 kg



TRL 5

100 kg

Development
without Swerim

More (2-4) spin-off
development projects
expected from
STEPWISE facilities

TRL 6



3000 kg



Development with Swerim

More spin-off (2-3)
development projects
expected from
INITIATE facilities

TRL 7



20000 kg

More spin-off (1-2)
projects expected
from industrial trials

Industrialisation

Swerim's Budget (€23m from total €61m development)

€8m

BFG pipeline

Heat Management of
Technology

H2 + CCS

€4m

H₂ electrolyser

Production of Methanol
from BFG

Methanol/Stena

€3m

Utilisation of H₂ in
reheating processes

Post-combustion CO₂
capture (paving way for
EAF)

H2 + reheating

€8m

BOF pipeline

Bankability proof for
ammonia and Urea
production

Fertilizer

“Reductive” capture

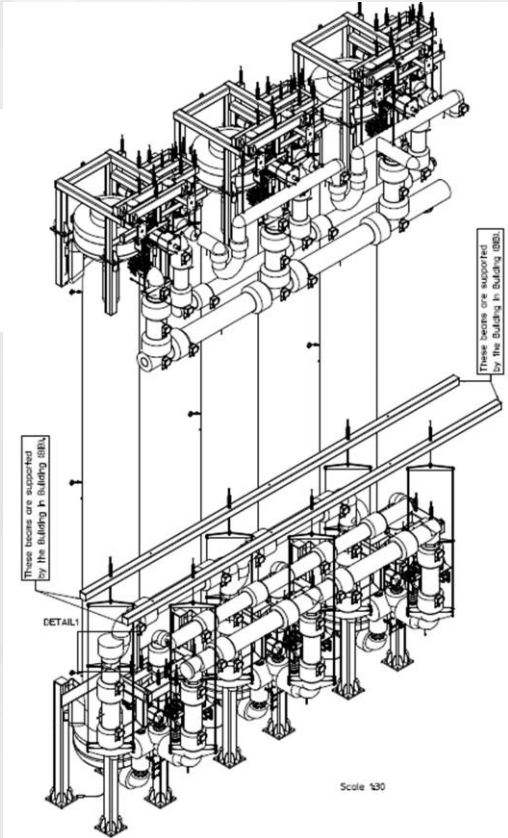


Batch – Single Column



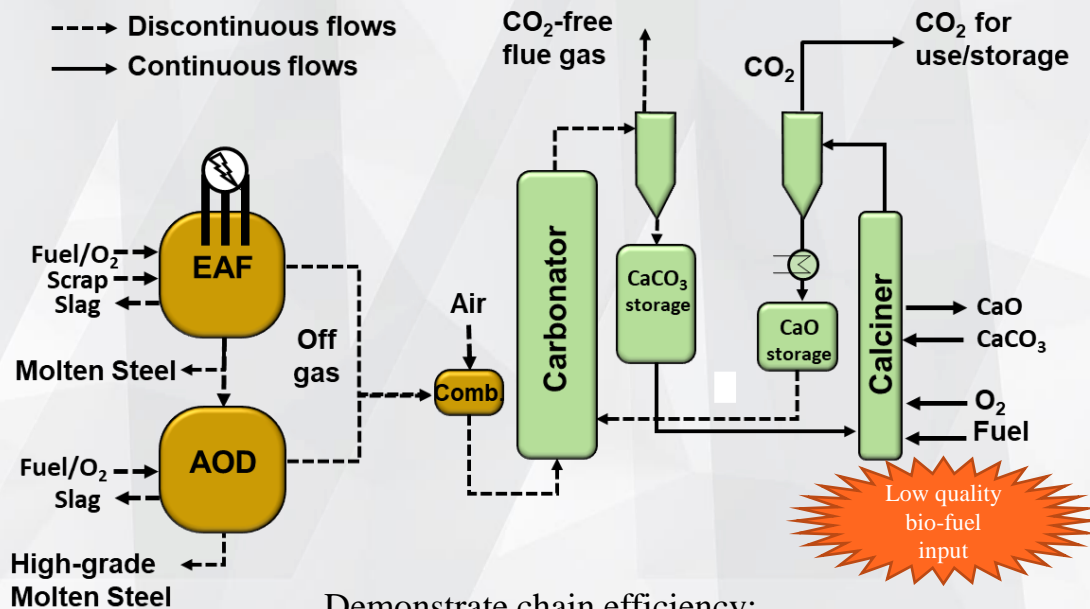
Demonstrate chain efficiency:

- BOFG variability
- Advanced WGS+CO₂ removal
- Novel ammonia loop process



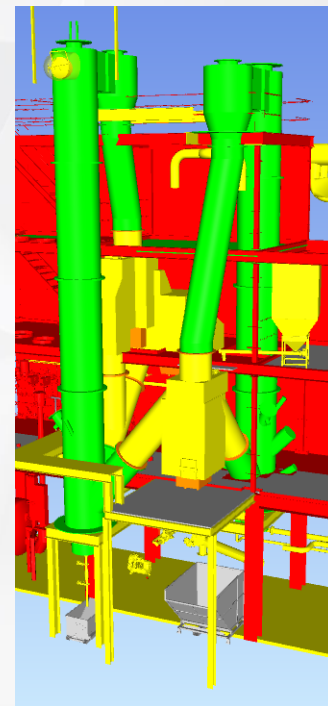
Continuous – Multi-Column

“Oxidative” capture

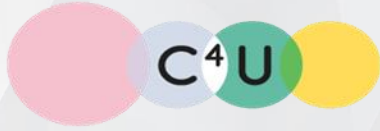


Demonstrate chain efficiency:

- Build the Pilot
- EAF and AOD variability
- Dust load



Re-using H_2 -recovered from steel gases in a reheating furnace



Boliden slag cleaning and granulation



Other pilot installations:

- Gas Heater (400 kW)
- Fossil free burner technology for calcination etc
- Simulator for battery shredding and pyrolysis

Pilot for a fossil free metal industry – Swerim Experiences

Intensified interests in low CO2 technologies for the metal industry

- Game change since 2020/Paris agreement
- Fossil free steelmaking (15 test EAF campaigns Hybrit alone, 2020-2023)
- Fossil free/low CO2 ironmaking (substitution of BF, to come)
- CO2-minimized technologies for nonferrous industry (Numbers of test campaigns)
- Fossil carbon substitution, H2 and biocarbon
- Efficient use of process gases including CCS
- Slag to cement – a big CO2 saver

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All time high interest in piloting – Pilot plant strongly needed, almost fully booked until 2026, global interest!!!

