Scenario for near-term implementation of partial capture from blast furnace gases in Swedish steel industry

CO2stCap

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Cutting Cost of CO_2 Capture in Process Industry

Financial support:
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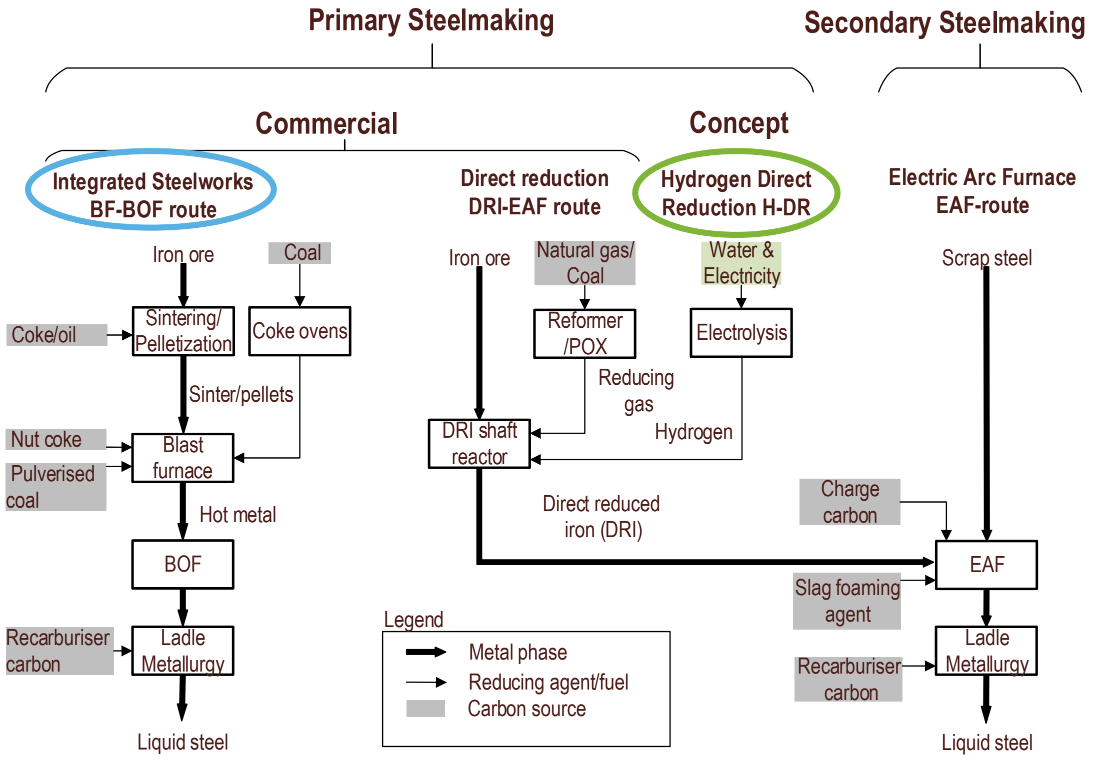
SINTEF, CHALMERS, USN, RISE, SWERIM, SSAB, Elkem, NORCEM HEIDELBERGCEMENTGroup, A Member of The Linde Group AGA, GLOBAL CCS INSTITUTE, ieaghg, GASSNOVA, Swedish Energy Agency

Steelmaking

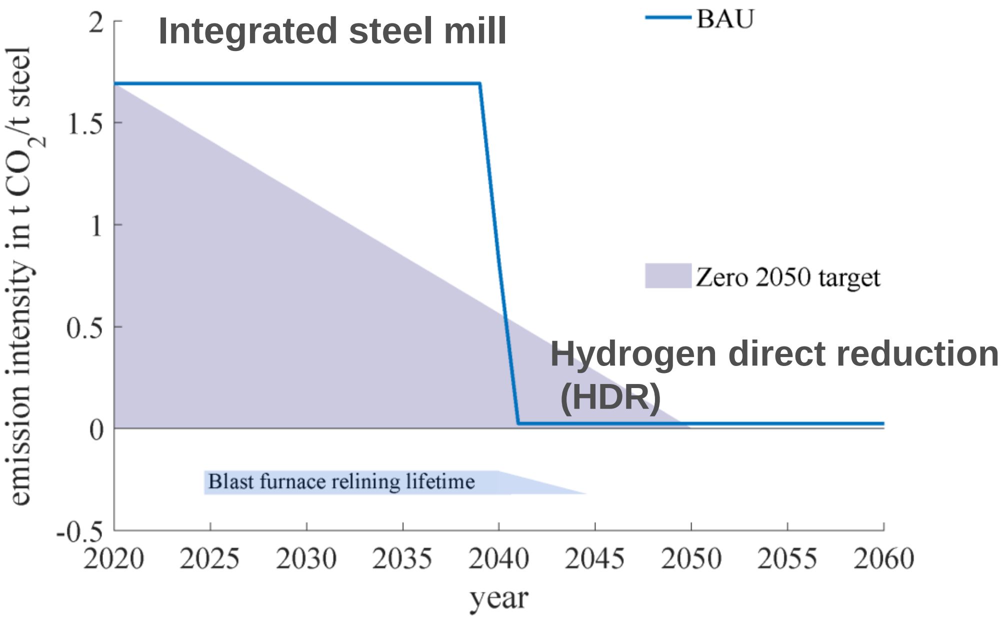
Carbon is used as reducing agent

→ Primary steelmaking has to be decarbonized, while secondary steelmaking is ramped up



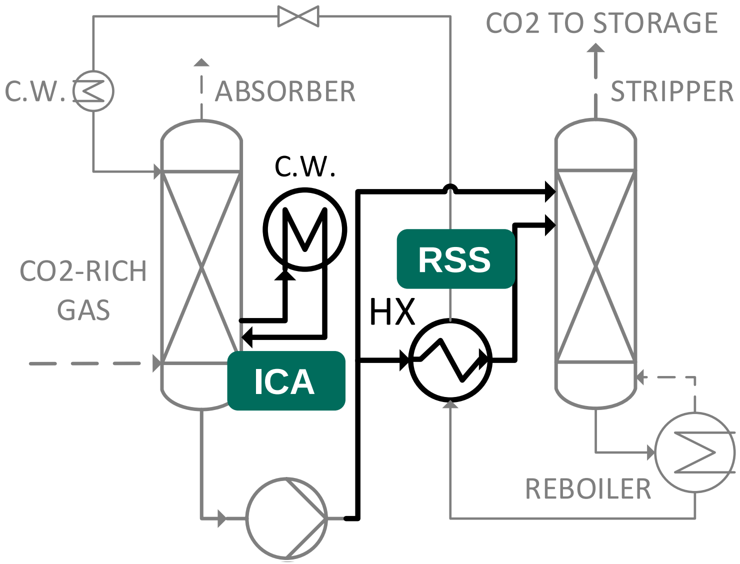
How does CCS fit in?

How can CCS contribute to starting mitigation in the near term and in synergy with HDR? What are the techno-economic conditions for this?



Major steel producers in Europe work with **hydrogen direct reduction (HDR)** to reach close-to-zero CO_2 emissions by Year 2040-2050

Steel case: design & economics



Parameter	Value
Economic plant life time	25 years
Construction time	2 years
Plant availability	**95%**
Rate of return	7.5%
Annual maintenance cost	4% of investment cost
Annual labor cost	821 k€/annum
Utilities	
MEA make-up	1867 €/m^3
Cooling water	0.022 €/m^3
Electricity	**0.030 €/kWh**
Steam	**assessed separately**

Bottom-up approach in assessing value of excess heat !

Entire gas flow into absorber, lower L/G ratio
→ separation rate in absorber <90%;
→ lower specific heat demand

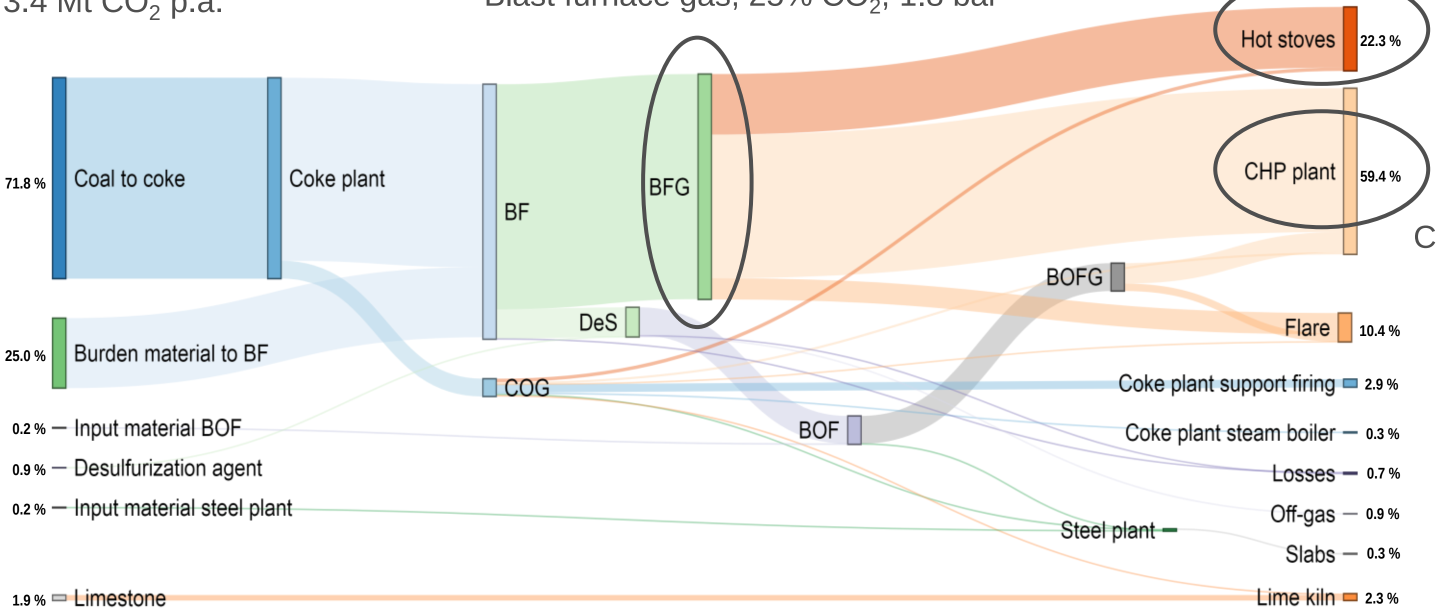
Biermann et al. *Partial Carbon Capture by Absorption Cycle for Reduced Specific Capture Cost*. Ind. Eng. Chem. Res. **2018**

Luleå steel mill - CO_2 sources

- Iron production from iron ore pellet 100%
- No rolling mill
- ~ 2 Mt steel slabs p.a.
- ~ 3.4 Mt CO_2 p.a.

Blast furnace gas, 25% CO_2, 1.8 bar

Hot stove flue gas
25% CO_2, atm



CHP plant flue gas
30% CO_2, atm

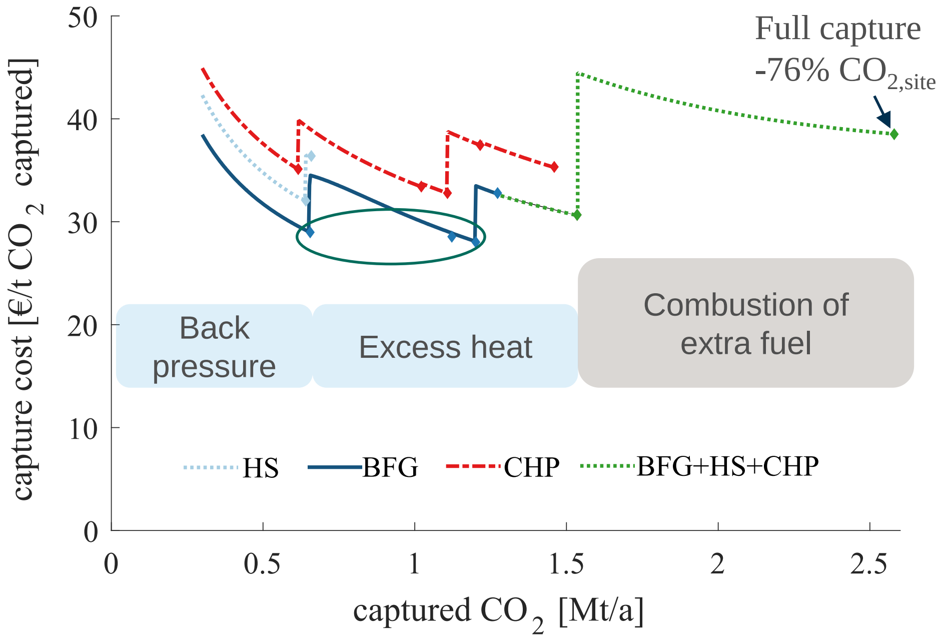
Emissions reductions and capture cost

- Capturing from blast furnace gas is most economic
  → 20%–38% less CO_2 emissions

- Excess heat sources; at constant load:
  - Flare gases
  - Flue gas heat recovery
  - Dry Coke Quenching
  - Dry Slag Granulation

- Partial capture with excess heat costs less than full capture with external energy

capture cost, no transport & storage



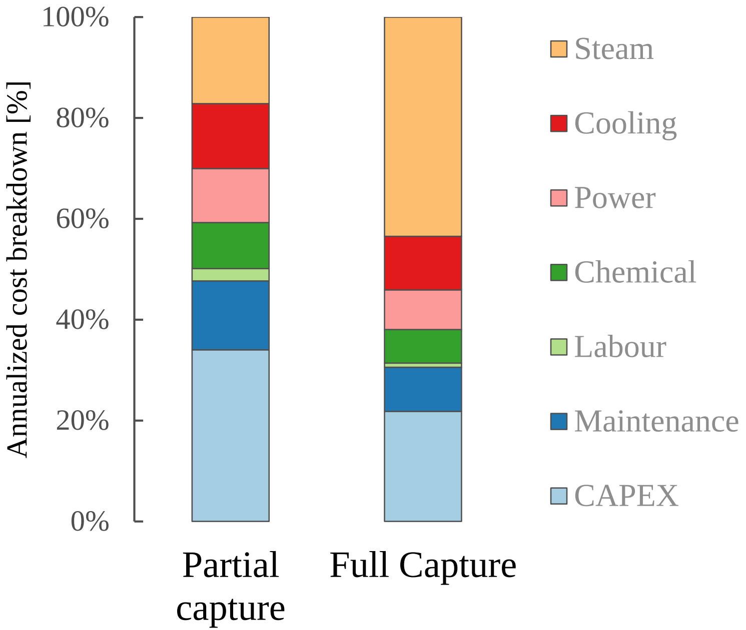
Capture cost structure

i) Partial capture with excess heat is dominated by CAPEX;

ii) Full capture is dominated by steam cost and is thus more sensitive to changes in energy markets

iii) Production cost for steel slabs increase by 4 – 17%* for investigated cases;

capture cost, no transport & storage

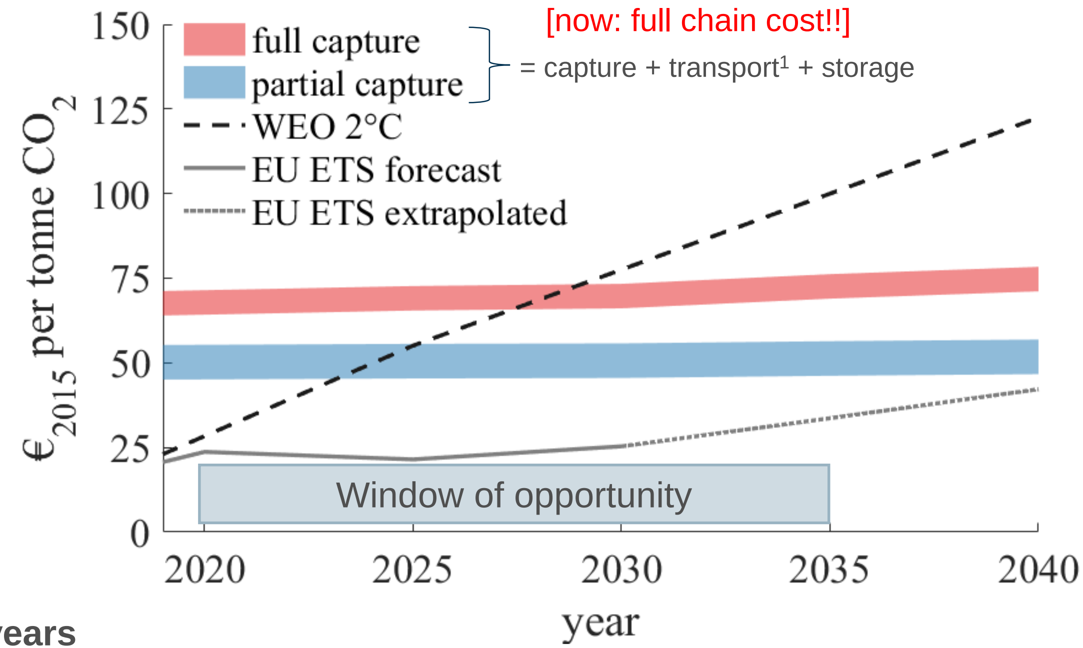


Partial capture	Full Capture
28 €/t_{CO2}	39 €/t_{CO2}
34 M€ p.a.	99 M€ p.a.
+6% cost steel slab	+17% cost steel slab

*based on 280 €/t slab steel; source: IEAGHG. *Iron and Steel CCS Study (Techno-Economics Integrated Steel Mill)*; 2013/04, July, 2013.

Near-term implementation

Partial capture with excess heat requires a carbon price of 40-60 €/tonne CO_2



Window of opportunity: coming 5-15 years

Later: economic lifetime of partial capture unit (25yrs) would be too short before policies will require close to 100% emission reduction

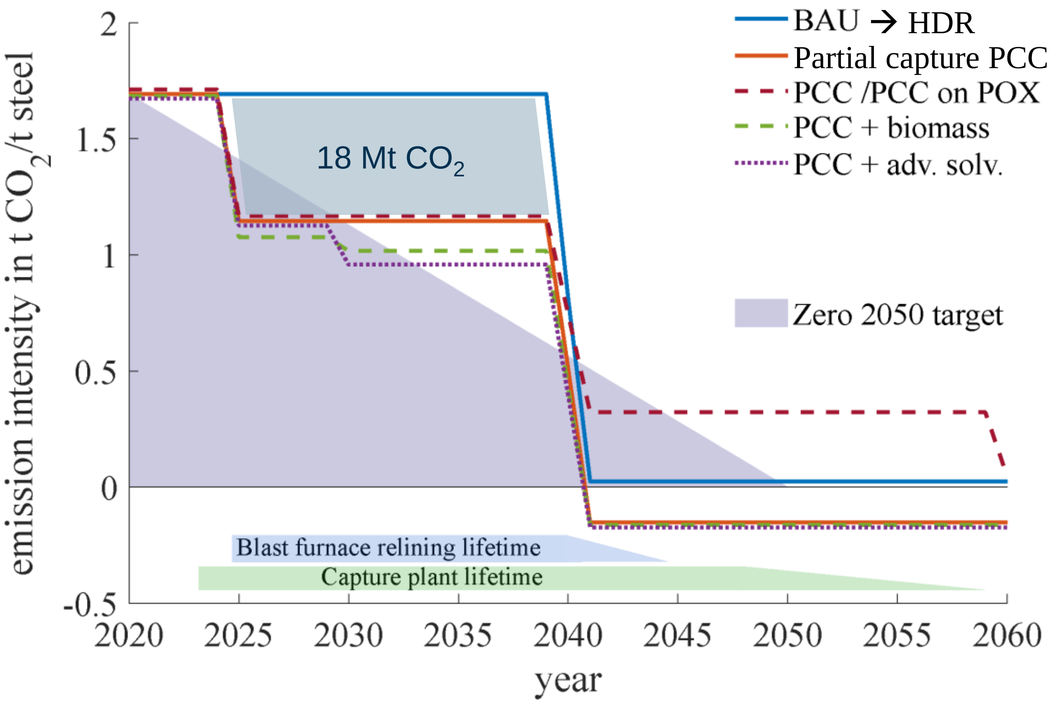
[1]Assuming ship transport to storage

Transition to low-carbon technologies

i. Accumulated emissions are relevant! Partial capture could de-risk late arrival of HDR

ii. CCS infrastructure could be used in HDR concepts
- capture remaining fossil & biogenic emissions
- produce ”blue” hydrogen from fossil fuels

iii. Partial capture could evolve
- co-mitigation with biomass
- solvent improvement



Integrated steel works with 2Mt steel slabs p.a.

Key findings – steel case

- Integrated steel mills: Partial capture powered by excess heat is more cost-efficient than full capture that relies on external energy
- Near-term implementation in 2020s: possible if policies value carbon at 40-60 €/t CO_2
- Window of opportunity for implementation of partial capture, before low-carbon technologies are required to meet CO_2 emission targets!
- Partial capture may allow for synergies with other mitigation options (biomass, electrification, etc.)
- Partial capture could be a step toward the transition to low-carbon technologies, such as hydrogen direct reduction (HDR), to enable the low-carbon economies of the future.

Partial Capture: ”Some is better than none!”

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Profile page @Chalmers

with publication list

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