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

$CO_2$stCap

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**This work is part of the CO2stCap project**
Cutting Cost of $CO_2$ Capture in Process Industry

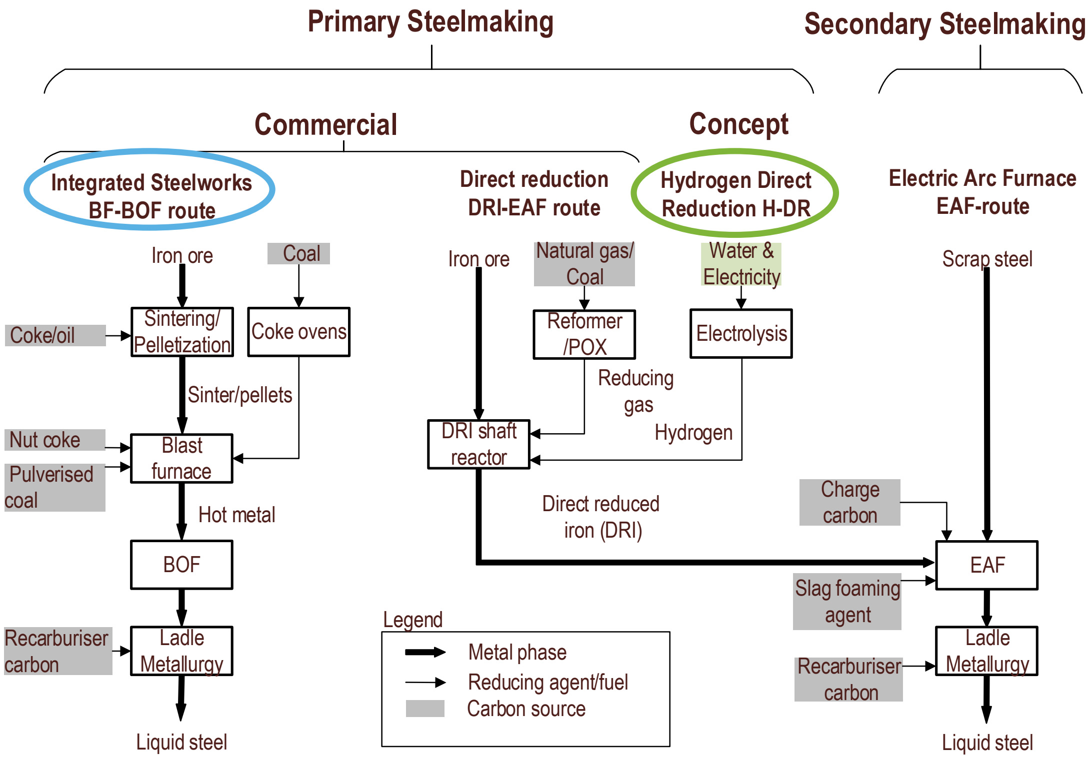
**Financial support:**
Gassnova (CLIMIT Demo)
The Swedish Energy Agency

**Project partners:**
SINTEF, Chalmers, USN, RISE, SWERIM, SSAB, Elkem, NORCEM HeidelbergCement Group, A Member of The Linde Group AGA, Global CCS Institute, ieaghg, GASSNOVA, Swedish Energy Agency

# Steelmaking

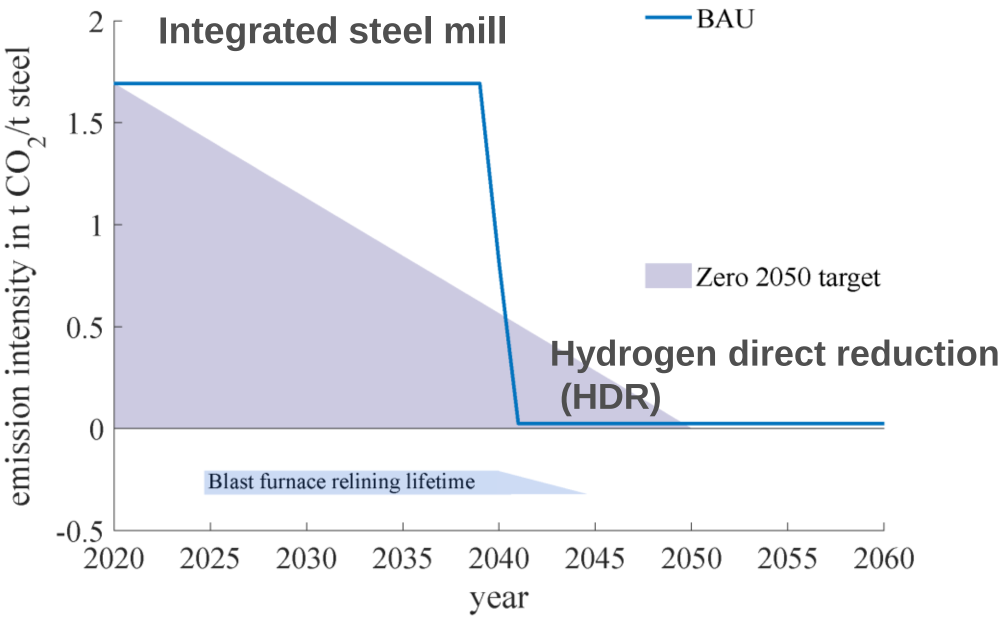
Carbon is used as reducing agent

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



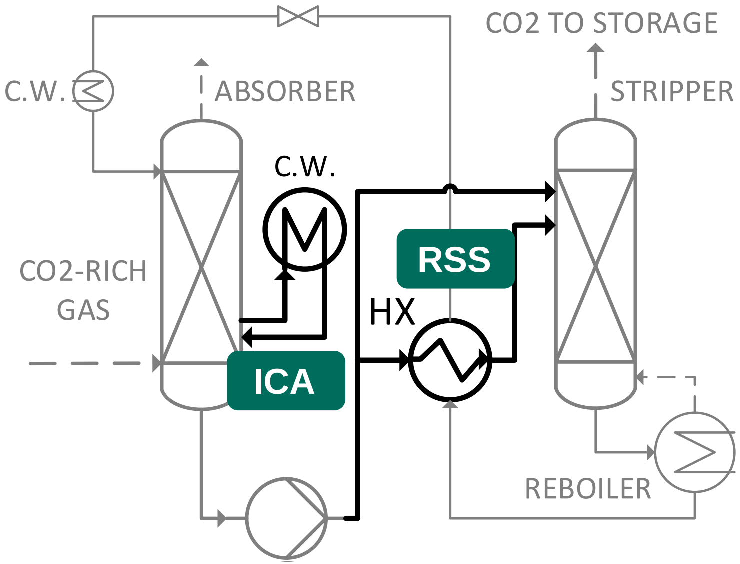
# How does CCS fit in?

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 €/m³ |
| Cooling water | 0.022 €/m³ |
| **Electricity** | **0.030 €/kWh** |
| **Steam** | **assessed separately** |

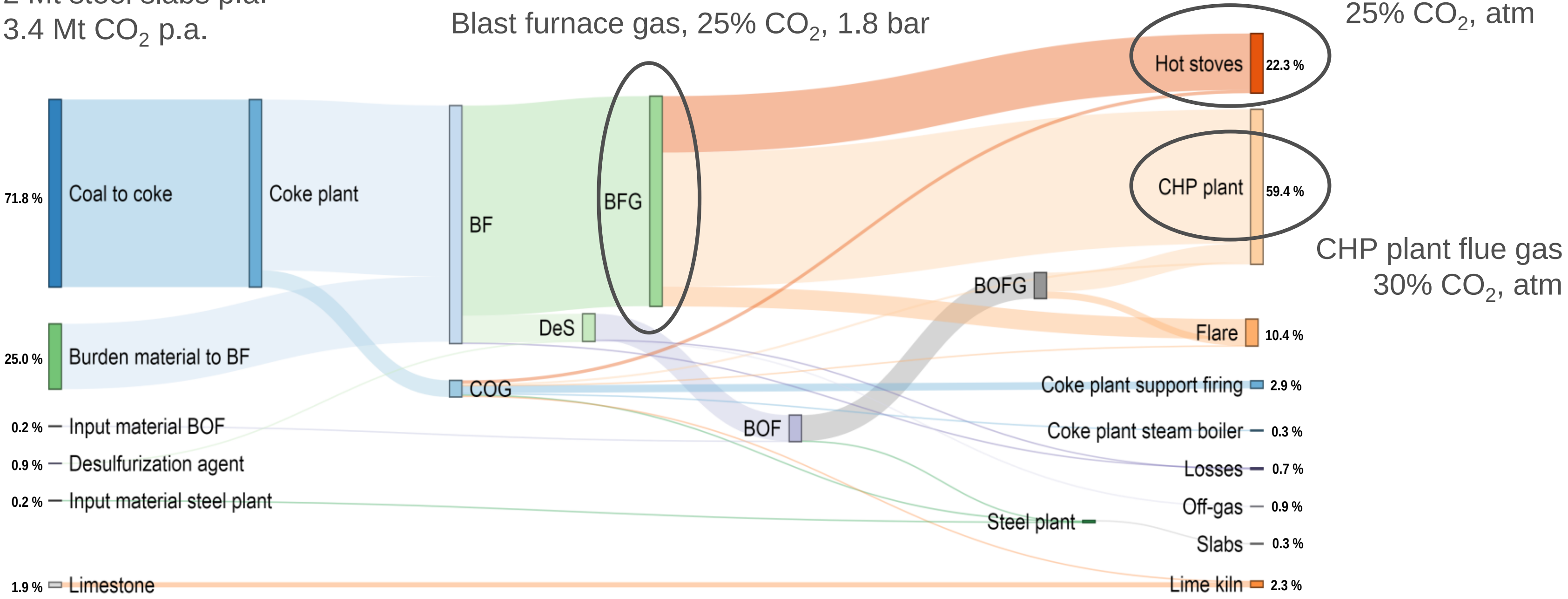
**Bottom-up approach in assessing value of excess heat !**

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.



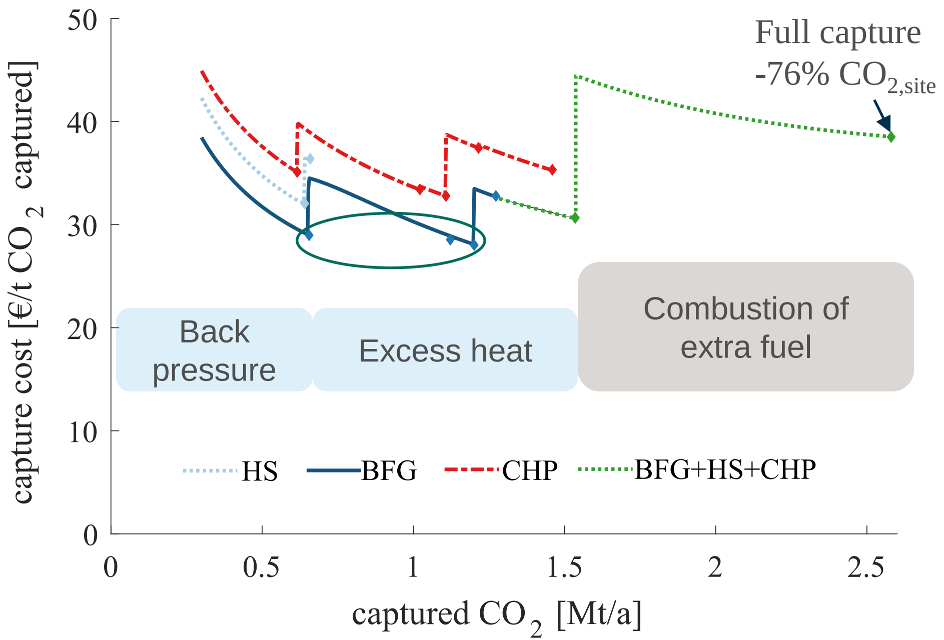
# Emissions reductions and capture cost

- 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

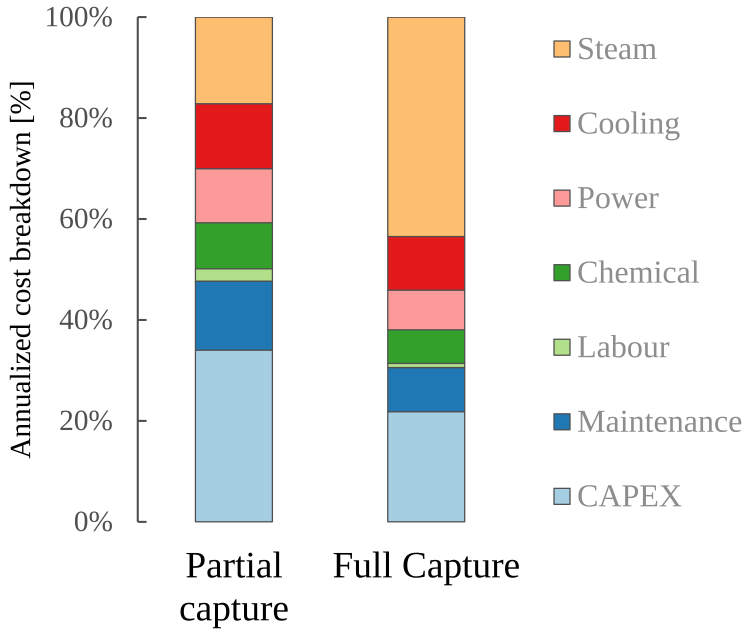
i) Partial capture with excess heat is dominated by CAPEX;

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;

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

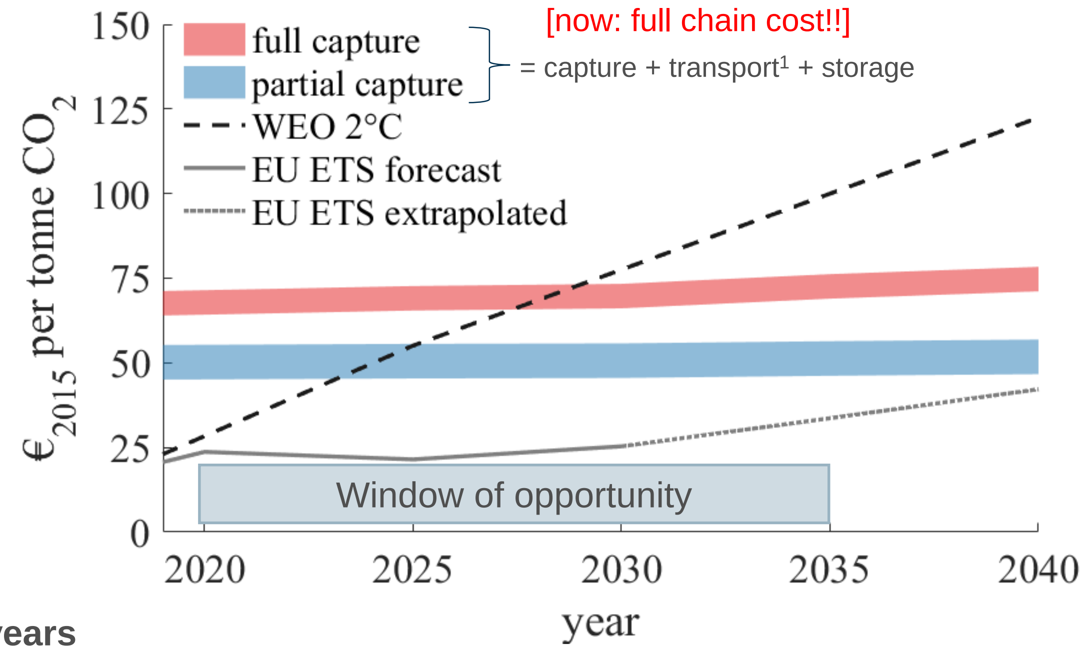
capture cost, no transport & storage




| 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 |

# 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

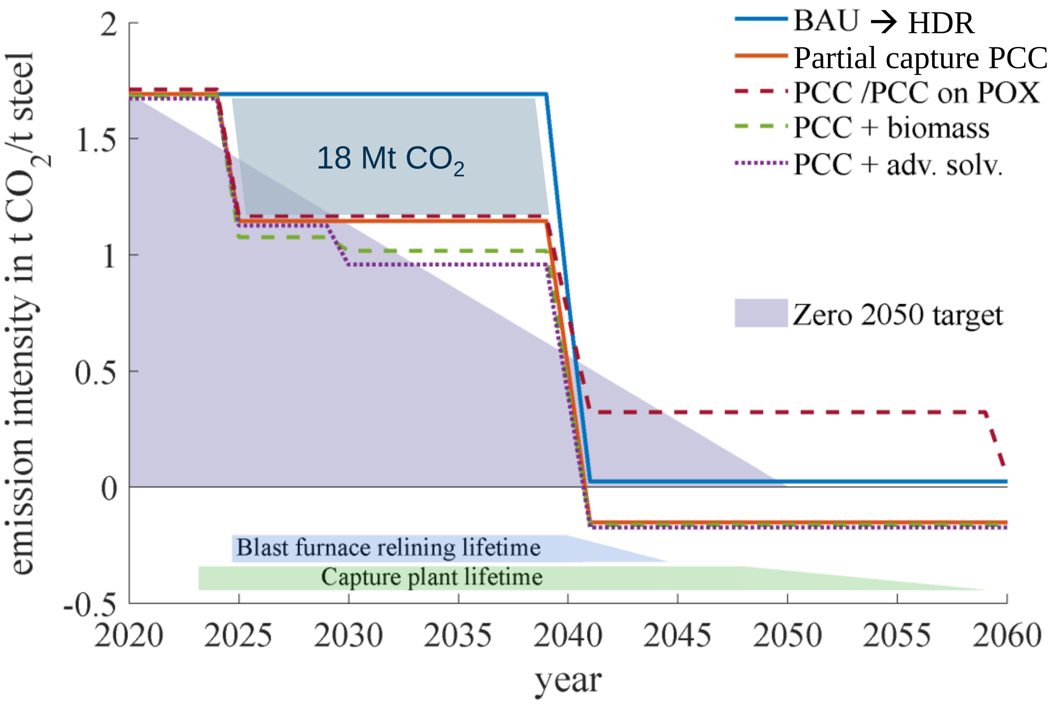
[1]Assuming ship transport to storage

# 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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