



# CO<sub>2</sub> Reduction Through Industrial Symbiosis

Linking steel and chemical industries

Stamicarbon Symposium 2022

18<sup>th</sup> May 2022

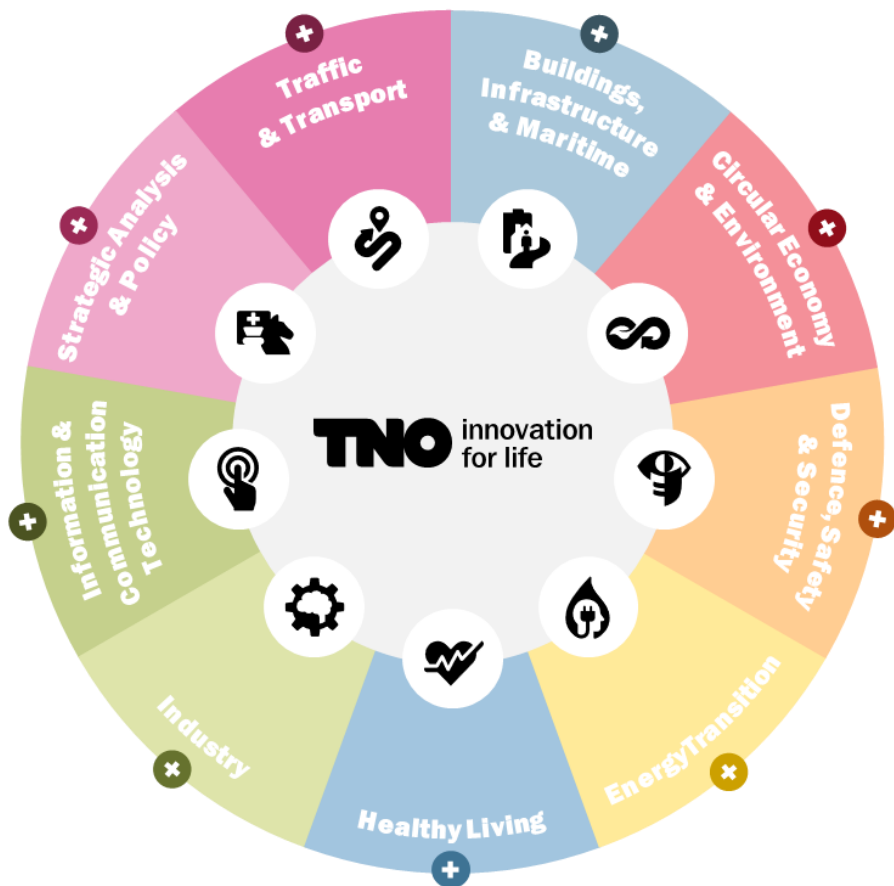


The INITIATE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958318

**PUBLIC**

# Dutch Institute for Applied Research

TNO in The Netherlands



# Smart Solutions for Clients & Partners



# INITIATE in a nutshell

21 M€ project to demonstrate Industrial symbiosis



Demonstrate operational reliability for commercialization



Demonstrate continuous production of 5 t/d of  $\text{NH}_3$  from steel gases



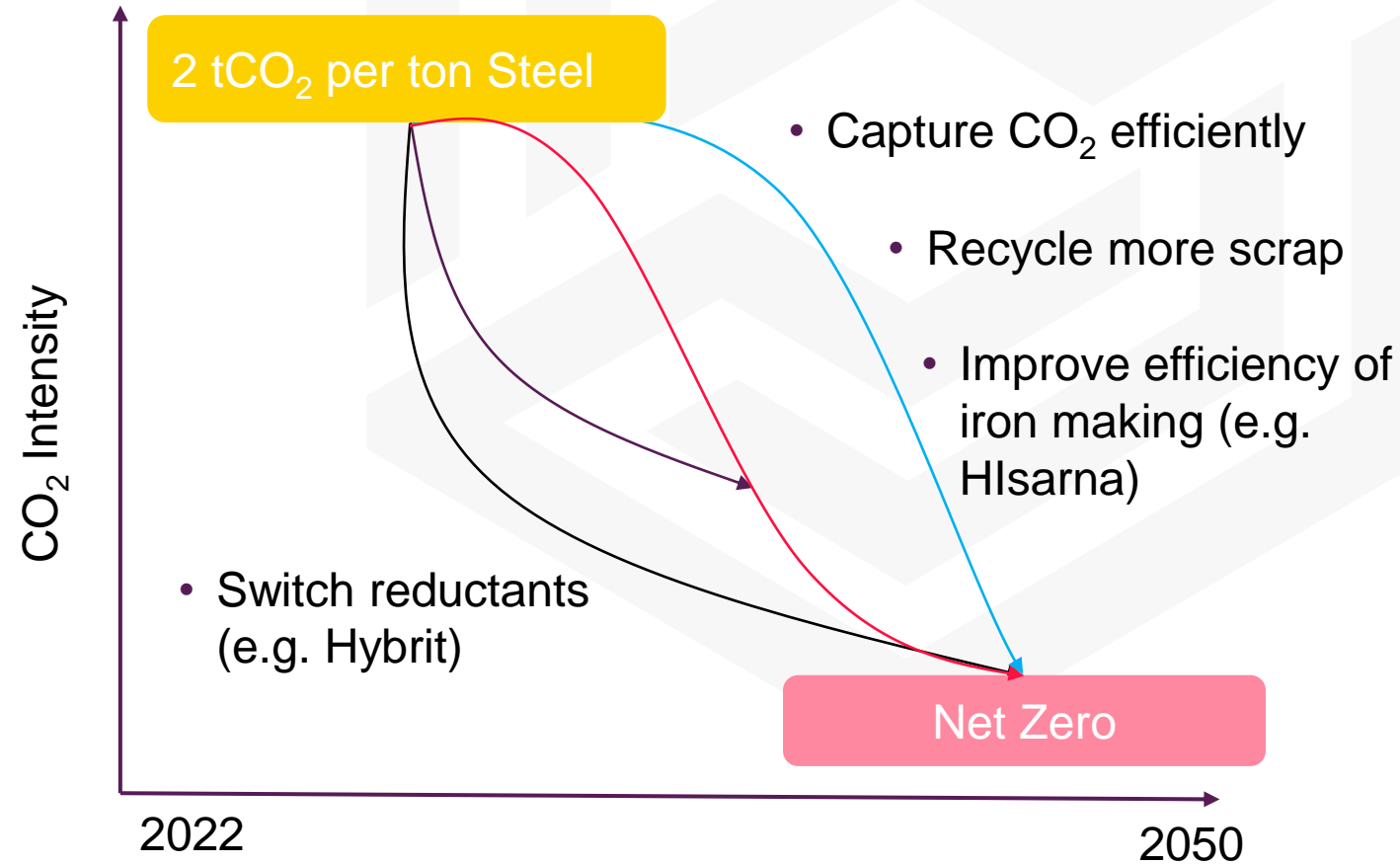
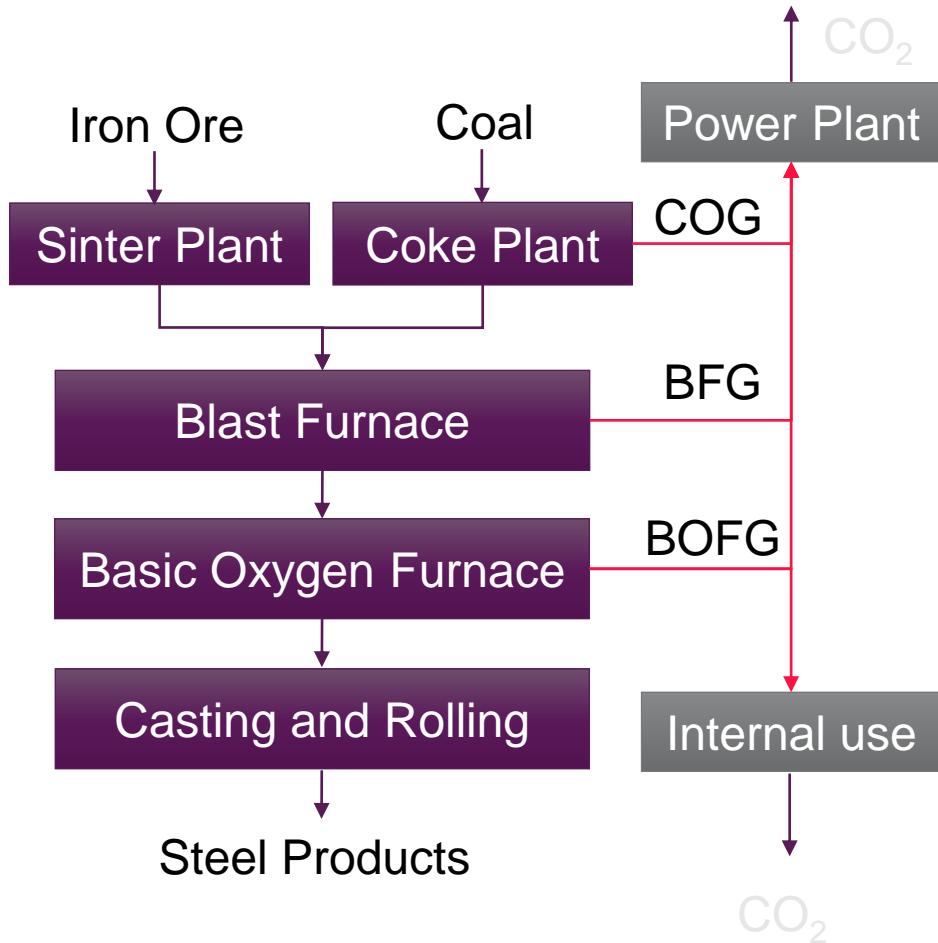
Confirm positive business case (target IRR > 15%)

Existing TNO-Swerim infrastructure in Sweden will be expanded.



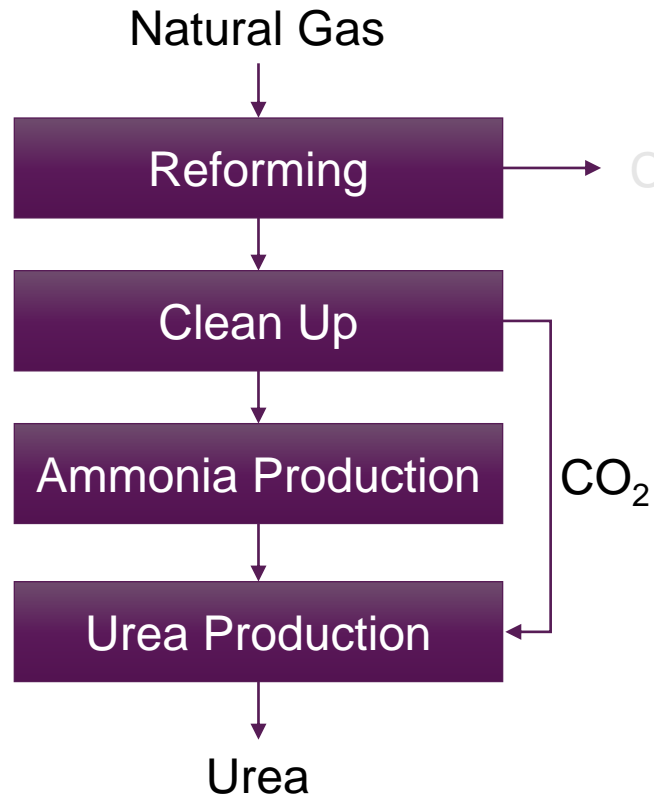
# Iron & Steel

## Multiple Routes to CO<sub>2</sub> Neutrality





# Ammonia and Urea



## Production:

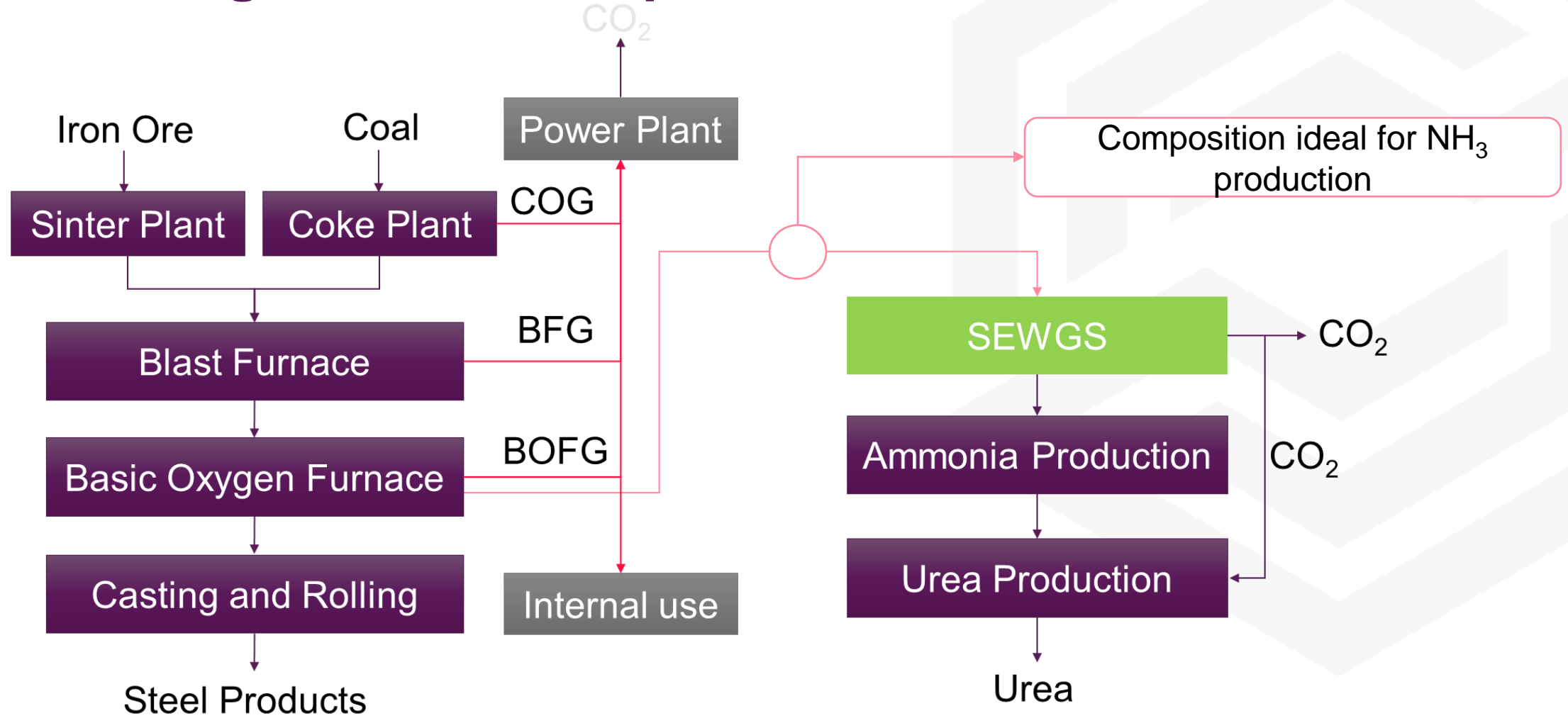
- Primary feedstock is natural gas.
- 1.8 ton of CO<sub>2</sub> per ton Ammonia (0.5 if excluding process CO<sub>2</sub>)<sup>[1]</sup>

## Reducing CO<sub>2</sub> Footprint:

- Post-combustion CO<sub>2</sub> Capture
- Power to Ammonia
- Symbiosis?



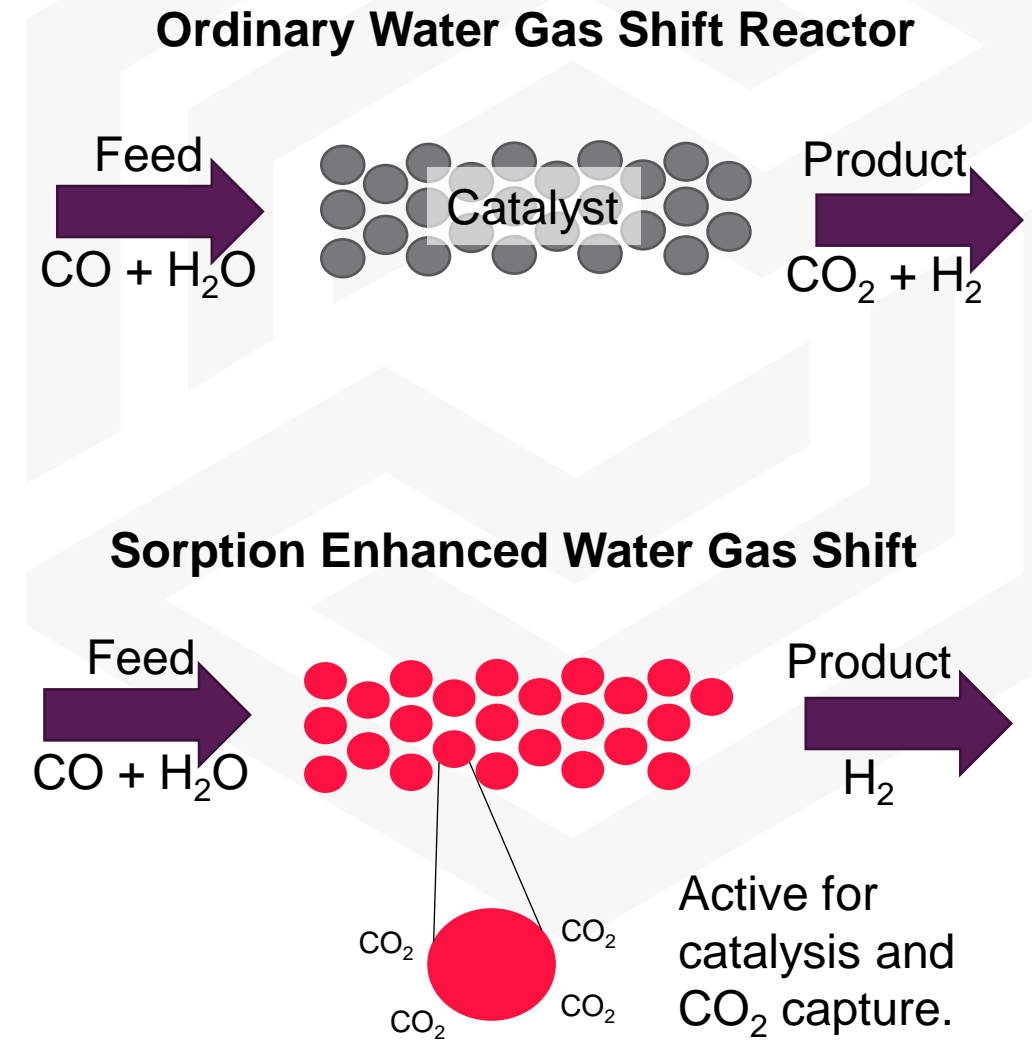
# Sustaining the cost of capture on the value of Urea



# Enabling Technology

## STEPWISE Technology

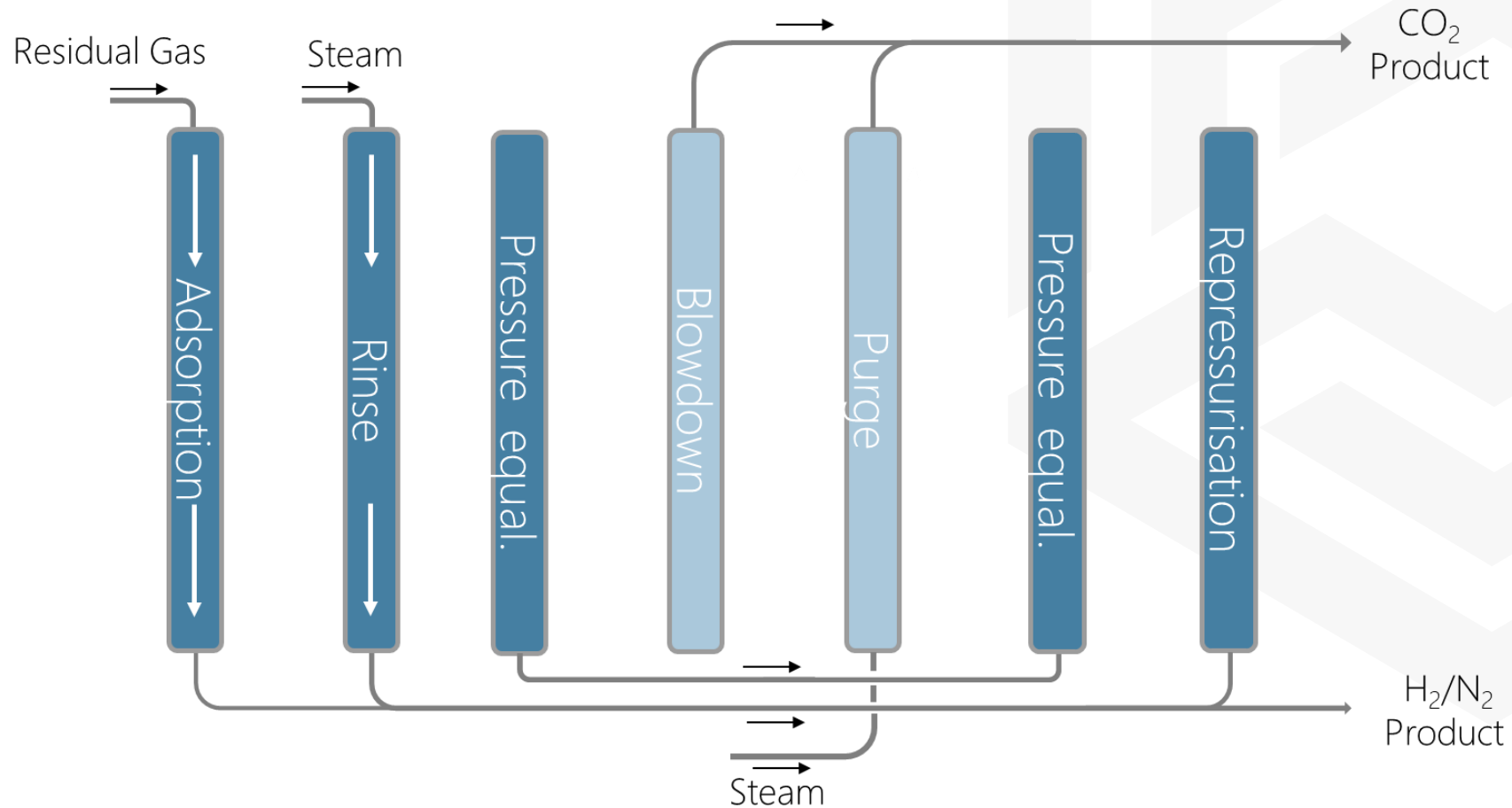
- TNO developed technology that combines reaction and separation
- Capture  $\text{CO}_2$  and produce  $\text{H}_2$  at the same time, achieving higher efficiency.
- Application possible in iron & steel, blue hydrogen & ammonia production.
- Demonstrated for Iron & steel at TRL 6 (14 t/d  $\text{CO}_2$ ) with real steel gases.





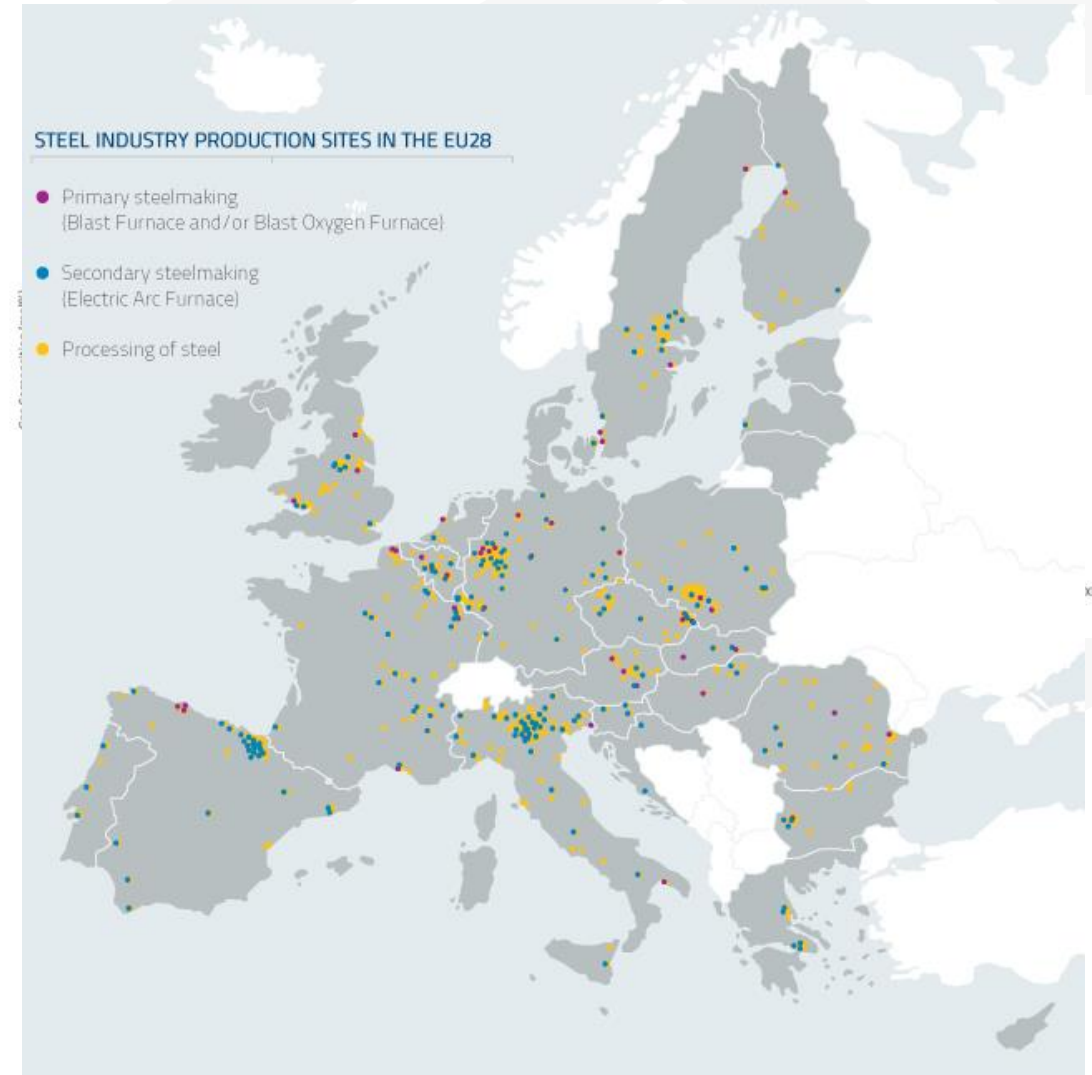
# Enabling Technology

## STEPWISE Technology



# Technically and Economically Feasible

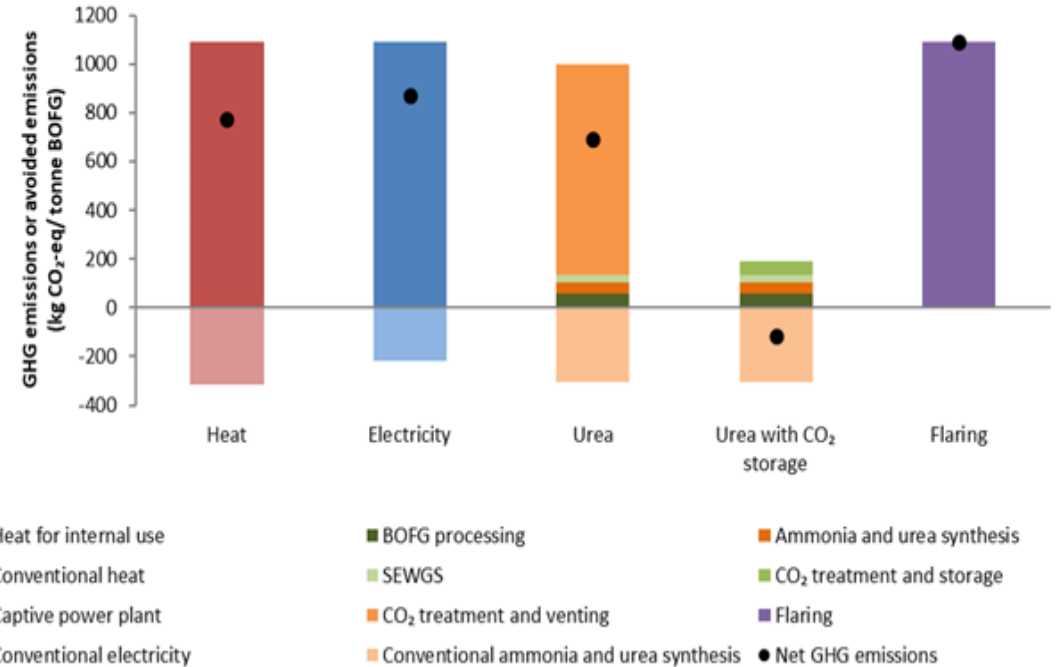
- **Technical:** Production of urea from BOFG using SEWGS is technically feasible. Challenge due to variable composition and intermittency.
- **Economic:** Production of urea from BOF is economically viable:
  - Positive business case for urea derivatives (IRR of >10%)
  - Locations of BOF availability and urea product demand have been identified



# Environmentally Benefits

## › Environmental:

- › Life Cycle Assessment compared different uses of BOFG against their contrafactual (reference).
- › Urea production shows a CO<sub>2, eq</sub> reduction potential of 40%.
- › One of the few opportunities to substantially decarbonize urea production on short notice.
- › Potential also applied to (blue) ammonia based on steel gases.



# Towards a first of a kind plant

## Demonstration

- TRL7 demonstration of  $\text{NH}_3$  production from BOFG at relevant scale.
- Existing infrastructure in Luleå, Sweden for  $\text{CO}_2$  Capture from other steel gas using STEPWISE.
- Convert existing installation to multi-column STEPWISE, add  $\text{NH}_3$  production unit (Stamicarbon) and tie-in BOF supply.

European Commission Grants 21.3 M€ for the INITIATE Project

Gas pipeline



Compressor



Pre-Shift



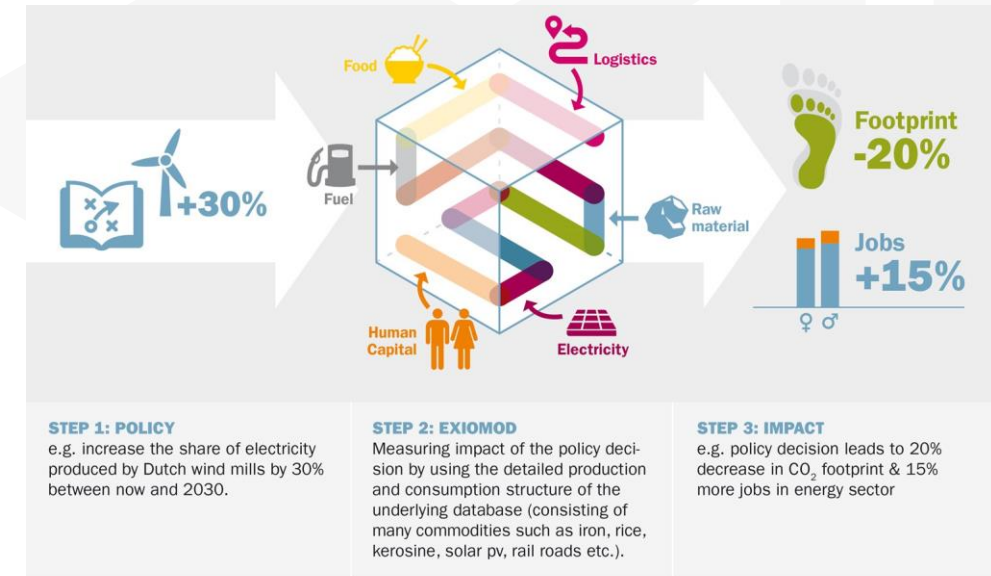
SEWGS – Single Column



# Towards a first of a kind plant

## Beyond demonstration

- Value engineering and integration to reduce cost and increase IRR (15%).
- Preparing pre-FEED for a bankable, first-of-a-kind plant at selected location.
- Deploying AI based control to address challenges of dynamic operation.
- Quantifying social, economic and environmental impact of industrial symbiosis in Europe.





# Partnership and Advisory Board

The complete value chain

Coordinator

**TNO** innovation  
for life

 **Maire  
Tecnimont**

  
**POLITECNICO**  
MILANO 1863

 **KISUMA**

 **SWERIM**

**Radboud University**  
Nijmegen, the Netherlands



 **CO<sub>2</sub> VALUE  
EUROPE**

**JM** **Johnson Matthey**  
Inspiring science, enhancing life



ArcelorMittal

**SSAB**

**worldsteel**  
ASSOCIATION

  
**Fertiberia**

**OCI**  
NITROGEN

  
**ESTEP**  
European Steel Technology Platform

 **INITIATE**  
A STEPWISE PROJECT

CO<sub>2</sub> Reduction Through Industrial Symbiosis



# INITIATE in a nutshell

23 M€ project to demonstrate Industrial symbiosis



Demonstrate operational reliability for commercialization



Demonstrate continuous production of 5 t/d of NH<sub>3</sub> from steel gases



Confirm positive business case (target IRR > 15%)

Existing TNO-Swerim infrastructure in Sweden will be expanded.





# INITIATE

A STEPWISE PROJECT





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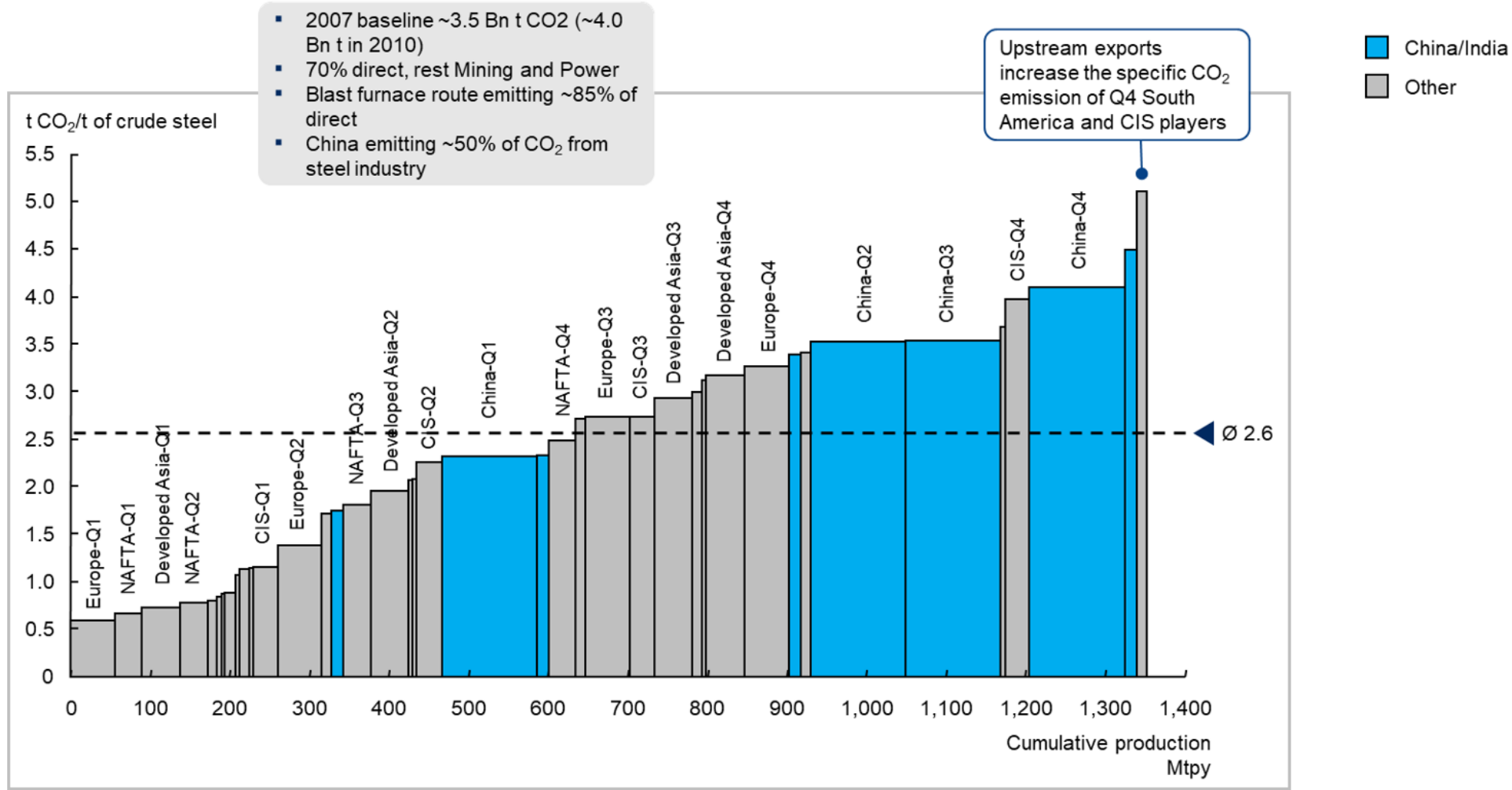
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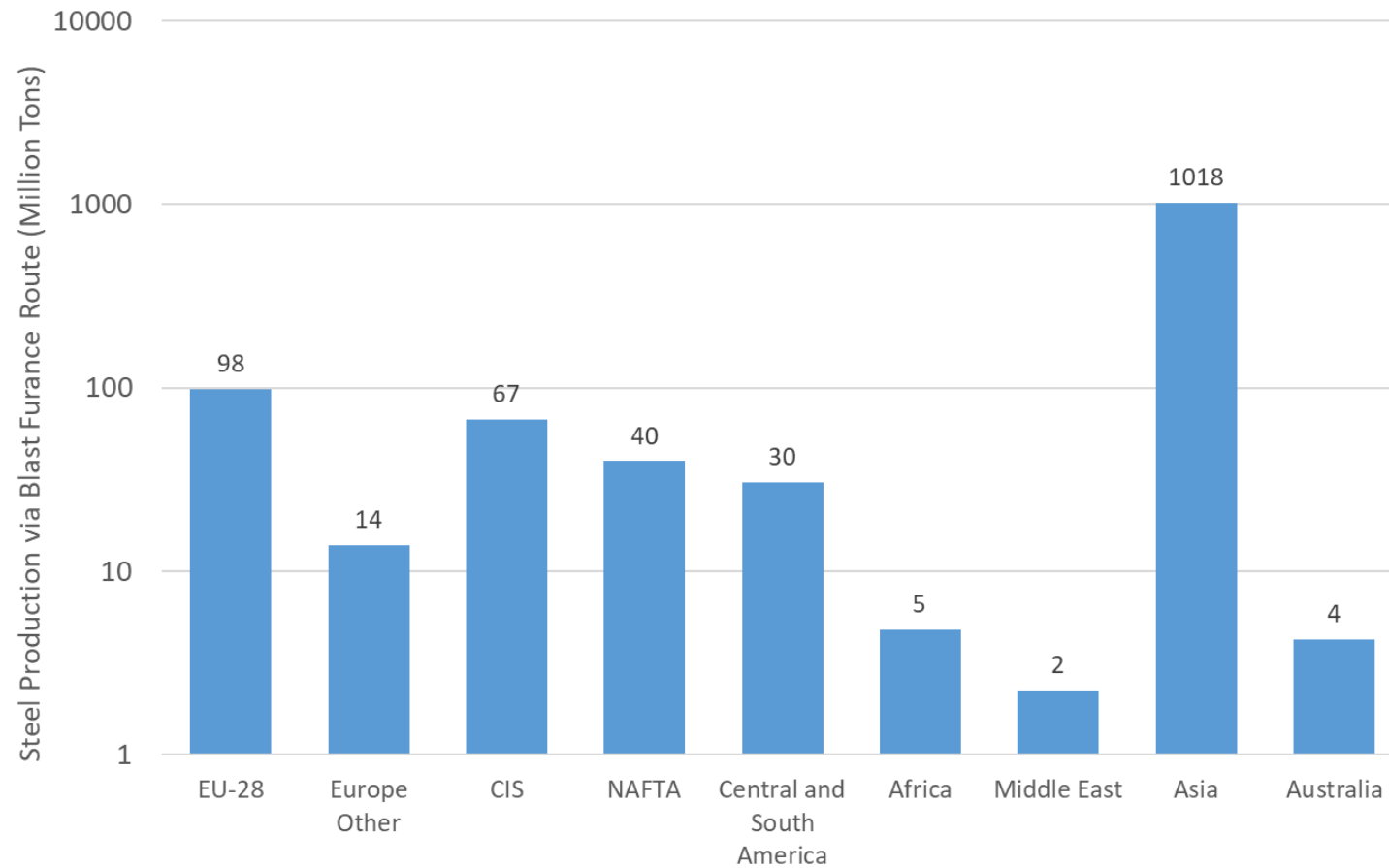
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# Iron & Steel in Europe



# Feedstock Potential of steel gases



## Europe

- 100 Million tons of crude steel
- The energy in the gases (BFG and BOFG) sent to power production is ~320 PJ/yr.
- In the same year ~630 PJ/yr were consumed for ammonia production.

# Towards a first of a kind plant

