

# ArcelorMittal

## Carbon Neutrality plan



April, 2023  
AM Group CTO



# Table of Content

**Presentation of AM steel production Group**

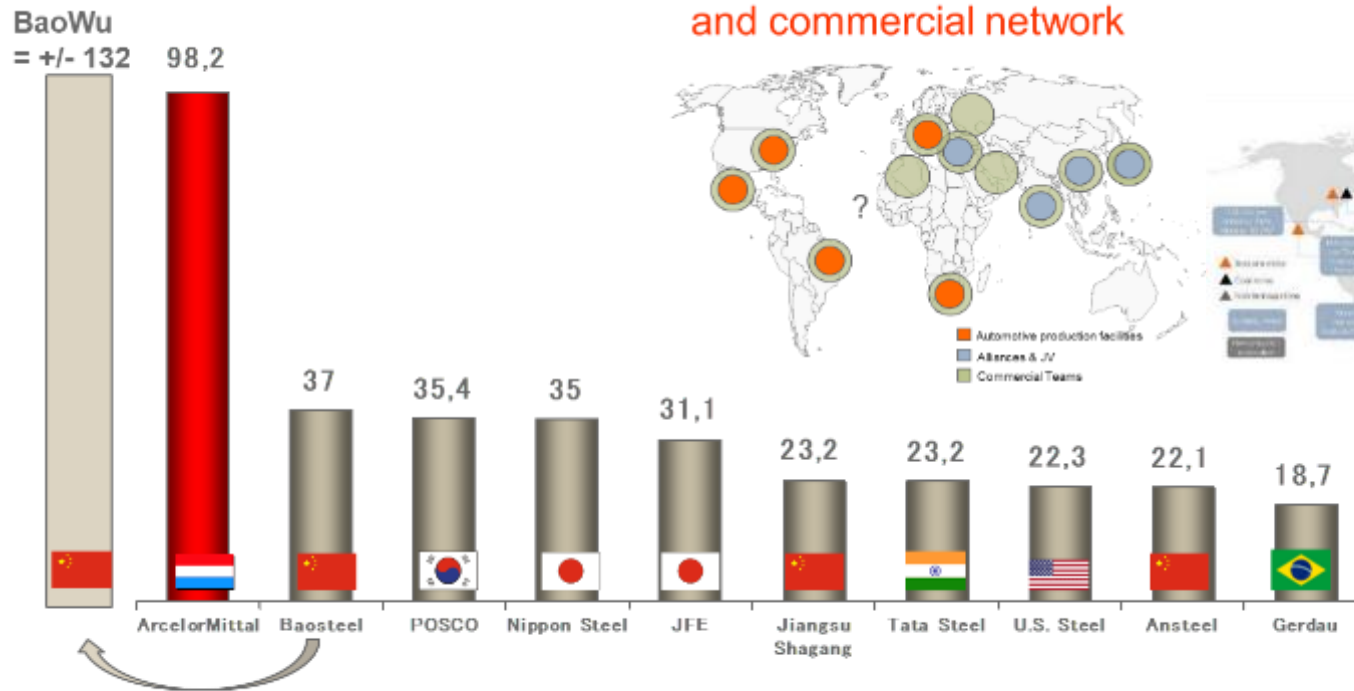
**The AM carbon neutrality plan**

Three pathways

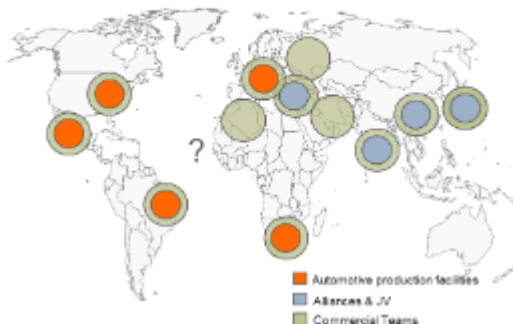
- Electrical steelmaking
  - Gas based steelmaking
  - Carbon based steelmaking
- CCU and CCS are complementary

## The ArcelorMittal steel production group

## Largest steel producers (in mt crude steel)



### ArcelorMittal's industrial and commercial network



### Mining business portfolio

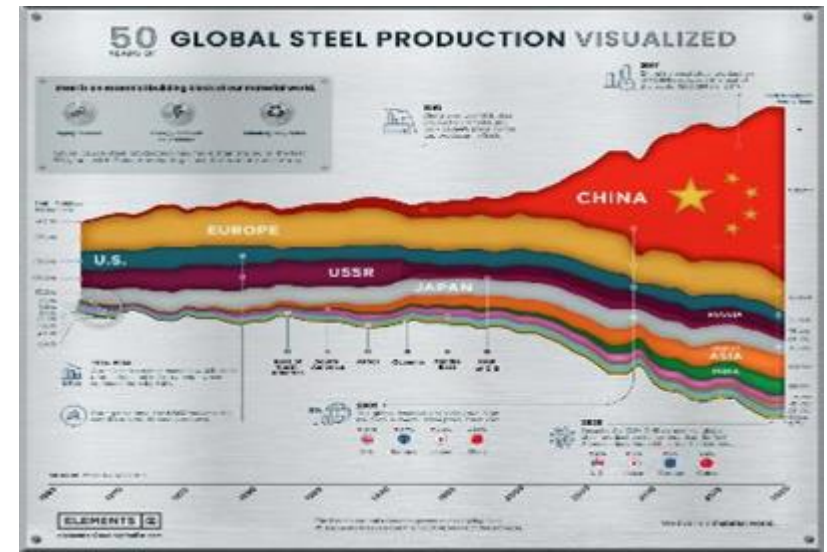
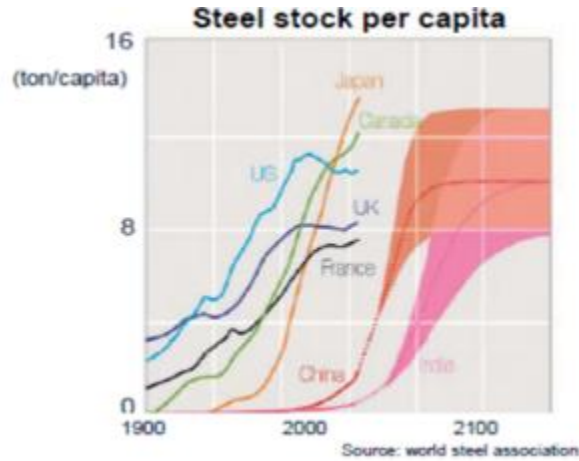


\* Source: Worldsteel

**Steel is a product of the past that has largely  
contributed to our current standard of life .....**

**And will continue to do so on our road to Carbon  
Neutrality...**

# Steel : a product of the past and for the future



Steelmaking = generating 7% of the anthropogenic emissions

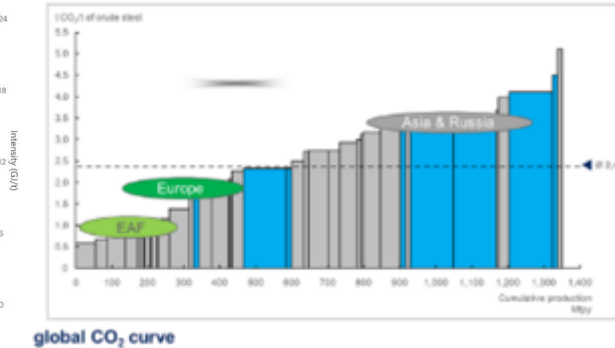
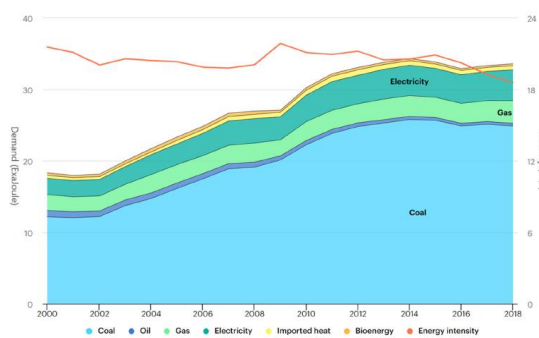


Figure 1. Global emissions from the seven most CO<sub>2</sub>-intense industrial sectors in the IEA Energy Technology Perspectives (ETP) analysis

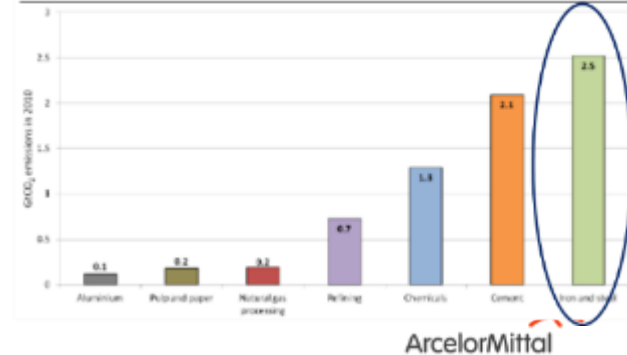


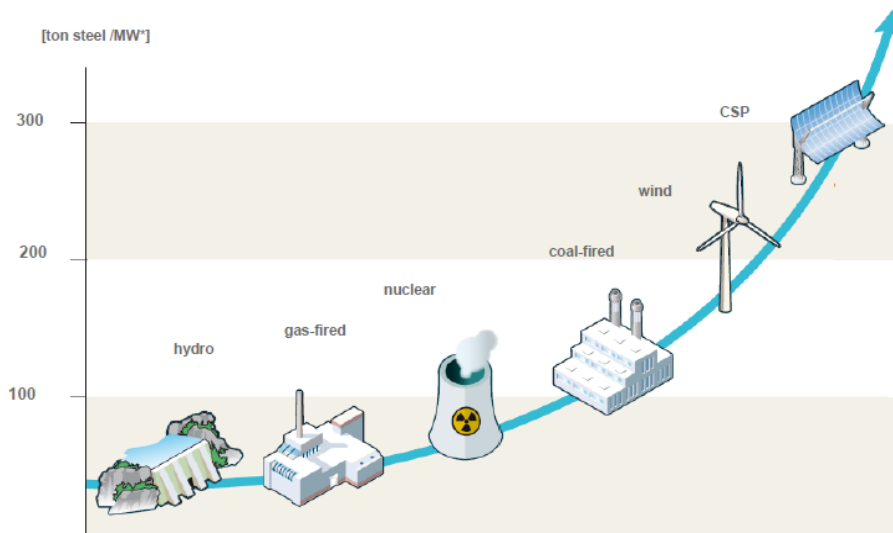
Fig. 1. Energy demand and intensity of the global iron and steel industry (2000-2018).

## Steel : a product of the past and for the future



# [ Steel supports a Sustainable Circular Economy ]

- Steel is fully recyclable (magnetic) -> real C-footprint = 0,86 t CO<sub>2</sub>/T
- It can be produced in a carbon neutral way
- Steel is base material to install equipment for renewable technologies



\* steel consumptions per installed MW capacity

Classified as ArcelorMittal Public



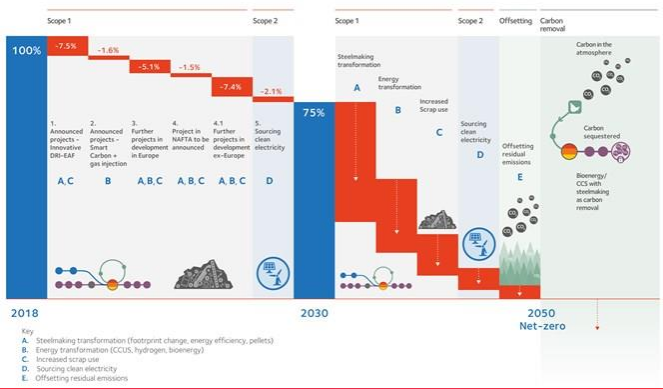
# Sustainable development

## The ArcelorMittal carbon neutrality plan

Climate Impact ArcelorMittal

ca 200mt CO<sub>2</sub> Emissions

# The 3 pathways of the ArcelorMittal decarbonation plan .....



Climate Action  
Part 1  
2019

ArcelorMittal has adopted an ambitious set of carbon targets that will lead our sector in reaching net-zero by 2050

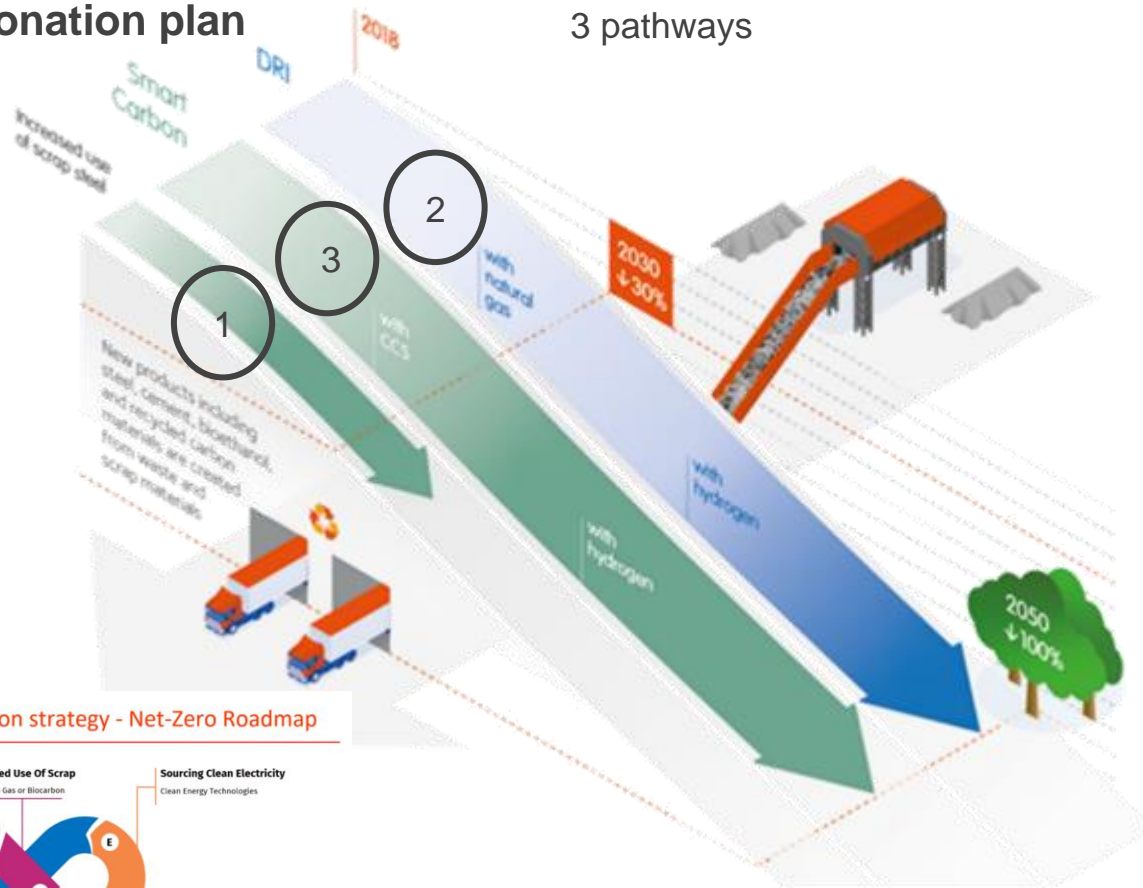
Our ambition is to significantly reduce our carbon footprint."





# AM : decarbonation plan

3 pathways



Smart Carbon includes:



Carbalyt



Torero



IGAR



3D - carbon capture

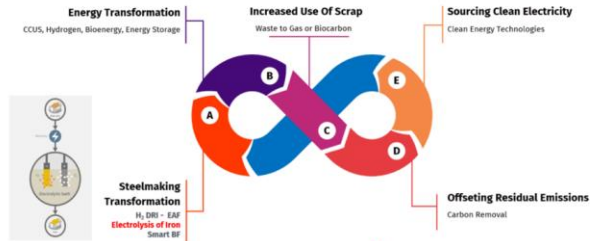


DRI includes:



ArcelorMittal Hamburg hydrogen project

## ArcelorMittal decarbonisation strategy - Net-Zero Roadmap

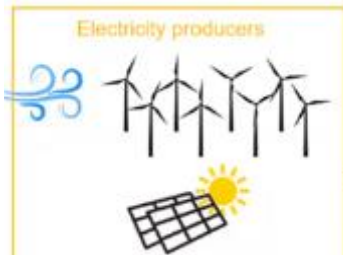


Our roadmap features five groupings of actions and initiatives that act as stepping stones to achieving carbon-neutrality by 2050.

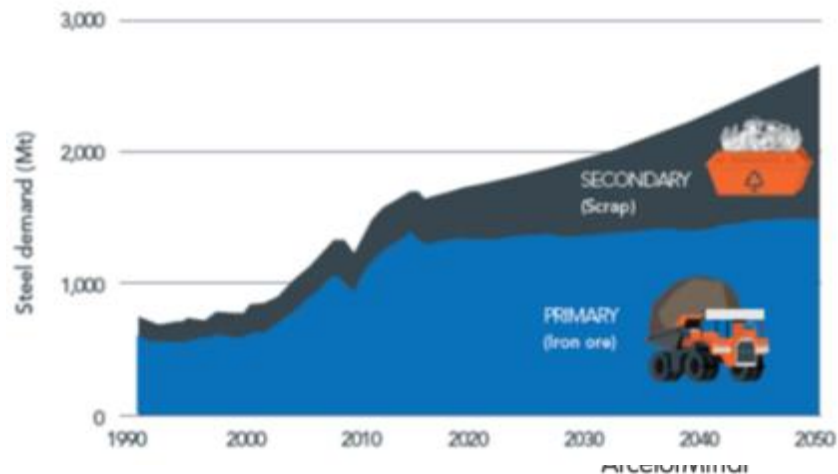
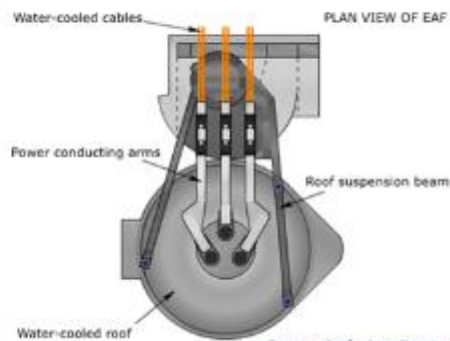
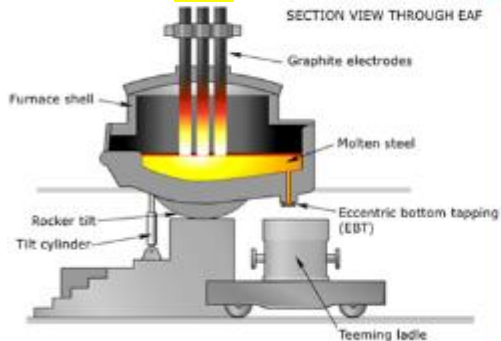
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# AM : decarbonation plan : pathway 1

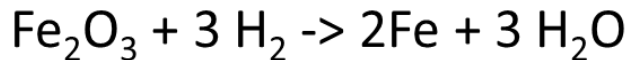
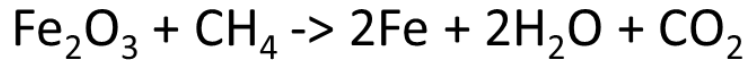
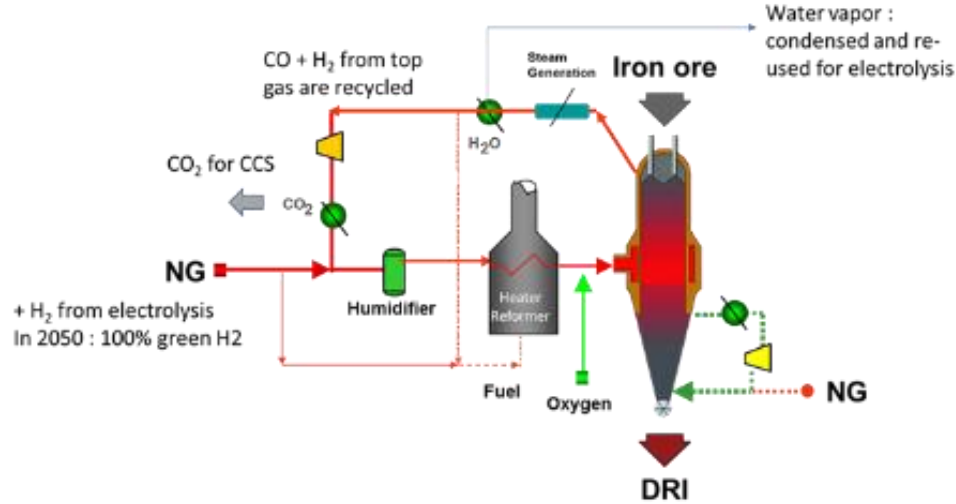
Electrical steelmaking using low carbon electricity :



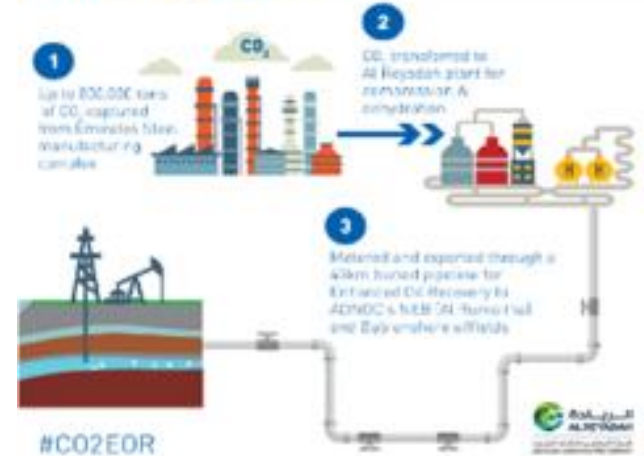
Section and Plan View of Electric Arc Furnace



## HYL-ZR Process



## Al Reyadah Carbon Capture Usage and Storage (CCUS)



## Principles of the ArcelorMittal Carbon Neutrality plan In conventional steel making

3 Use of biomass and circular carbon feedstocks

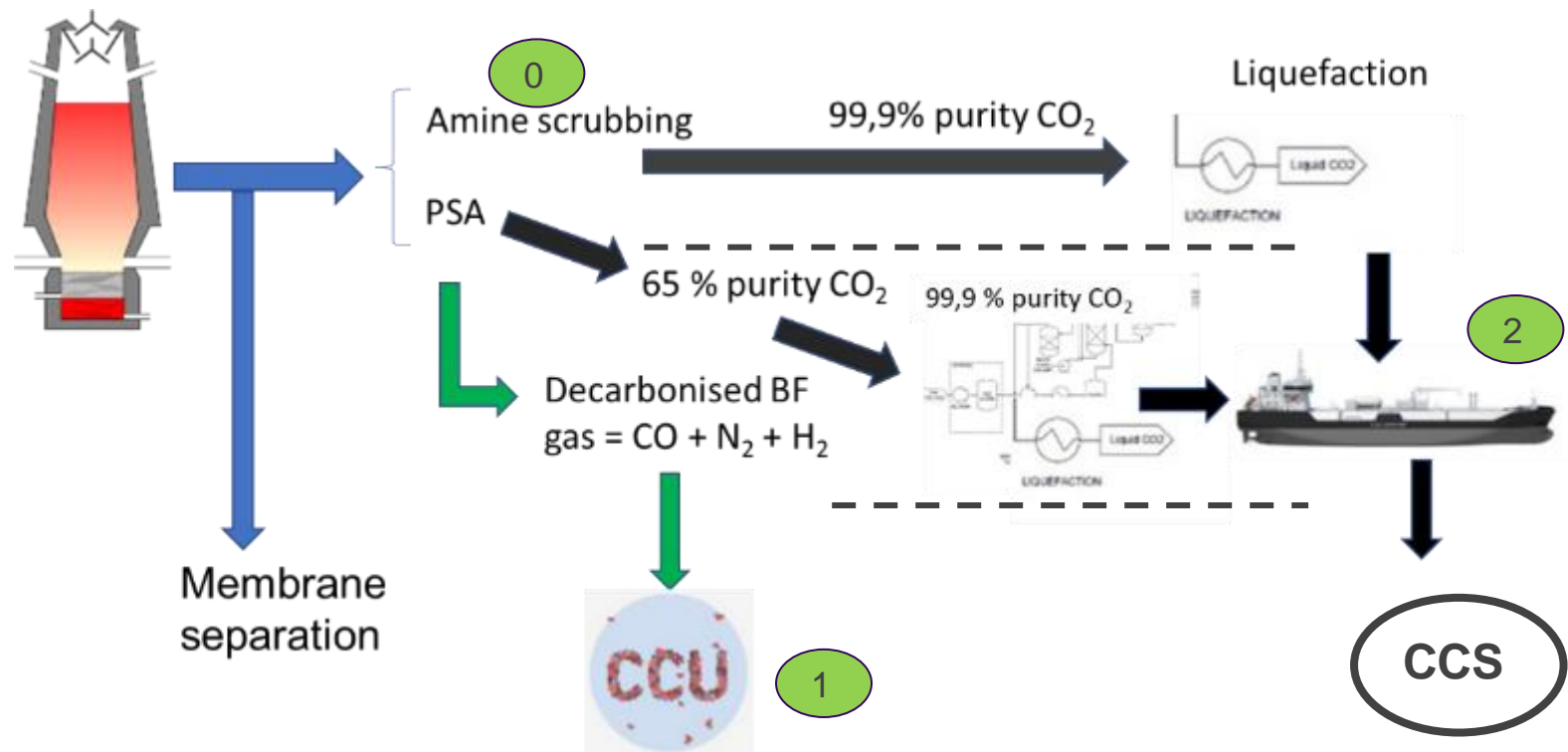


(Re)-Injection of  
alternative or  
recycled gaseous  
reductant agents

CCS : Capture from CO<sub>2</sub> from steel mill gasses for re-use and storage



Separation of the chemical energy of the gasses allows to re-use it instead of burning it



2,5 Mt CO emission -> **4 MtCO<sub>2</sub> emission**  
+ 3,5 Mt CO<sub>2</sub> emission

# ArcelorMittal : Smart Carbon Usage

0

## CO/CO<sub>2</sub> separation pilots :

Carbon2Value : pilot project 2018 – 2020  
INTERREG sponsored project



Steelanol : PSA  
100.000 Nm<sup>3</sup>/h  
(320 kT CO<sub>2</sub>/a)

GENESIS :  
Membrane pilot  
at Schwenck  
cement plant  
(Latvia)



AM Dunkirk : 3D pilot

Membrane separation : AM pilot in cement plant



Tubular vertical modules for the PolyActive membranes



Capture of 0,5 t/h CO<sub>2</sub>  
from 1.100 Nm<sup>3</sup>/h BF-  
gas to study feasibility



# ArcelorMittal : Smart Carbon Usage

## CO/CO<sub>2</sub> separation pilots : from our colleagues



11/04/2023



RPB Absorber

voestalpine



Carbon2Chem®



**TOSHIBA**

Study, pilot is at power plant of Mikawa

CCS Facility for Shougang Jingtang United Iron & Steel Company's Caofeidian Steel Plant, China



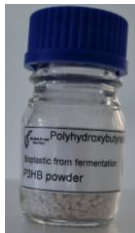
ArcelorMittal



# ArcelorMittal : Smart Carbon Usage

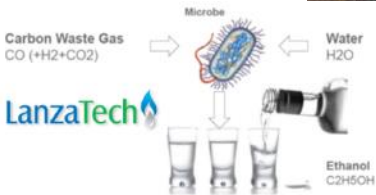
## CCU plant and pilots : 1

BioConCO2 :  
Acetate ->  
PHB from BF  
gas



Steel2Chemicals : Naphtha from BF gas and COG

FReSMe : MeOH from BF Gas

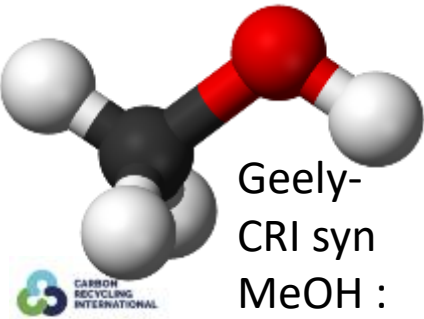


Steelanol : EtOH  
from BF gas





CCU : it is technically possible : CHINA is delivering the proof : producing RFNBIO's and RCF's !  
In Europa industry is still waiting for the delegated acts !



RCF-Methanol from Coke Oven gas at the Shunli group : 150 kT/a



### THE SHUNLI CO<sub>2</sub>-TO-METHANOL PLANT: COMMERCIAL SCALE PRODUCTION IN CHINA

Carbon Recycling International is designing a new CO<sub>2</sub>-to-methanol production facility to be located adjacent to a coke oven gas production (COG) in Anyang city, Henan Province, China. Upon commissioning in late 2021, the plant will become the world's largest production of fuel from CO<sub>2</sub> with a capacity of 100,000 tons low-carbon intensity methanol per year. The total investment in the Shunli plant design and equipment is USD 90 million with funding raised through debt and equity financing. The Shunli plant is owned by CRI shareholder Geely Tech, Shunsheng group, Shunji, Shunfeng and MHC Shanghai.



World's largest CO<sub>2</sub>-to-methanol plant starts production — CRI - Carbon Recycling International



#### CRI SIGNS AGREEMENT WITH JIANGSU SAILBOAT FOR A 100,000 TONS PER YEAR CO<sub>2</sub> TO METHANOL PLANT

Chinese petrochemical corporation Jiangsu Sailboat Petrochemicals Co. Ltd signed an agreement with Carbon Recycling International (CRI) to design a chemical plant based on CRI's Emission-to-Liquids (ETL) technology.

The plant will recycle approximately 100,000 metric tons of CO<sub>2</sub> and 20,000 metric tons of H<sub>2</sub> per year from other on-site processes to produce 100,000 tons of methanol annually. The methanol will be used for a wide product range of polymers and plastics, including products used for making solar panels and piping.

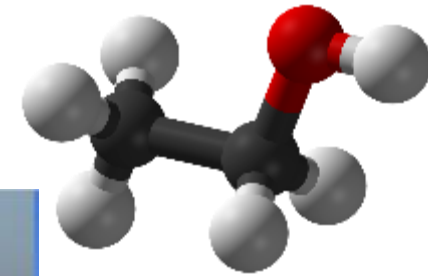


Site of Jiangsu Sailboat Green Methanol plant



RFNBIO-Methanol from solar cell CO<sub>2</sub> production at Jiangsu Sailboat

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RCF-Ethanol at the Capital Steel group  
2 plants



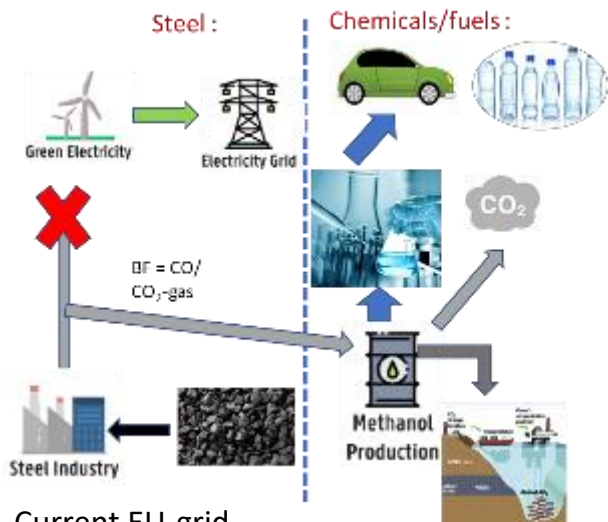
**Shougang Commercial Plant** 47 kT/a

Shougang Jiyuan Commercial Ethanol Production Facility



**Feedstock:** Ferro alloy off gas  
**Location:** Shijiushan, Ningxia

# CCU is an enabler of CCS : MeOH LCA shows the complementarity of CCU and CCS



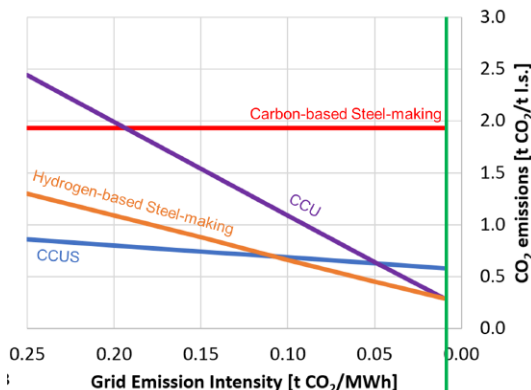
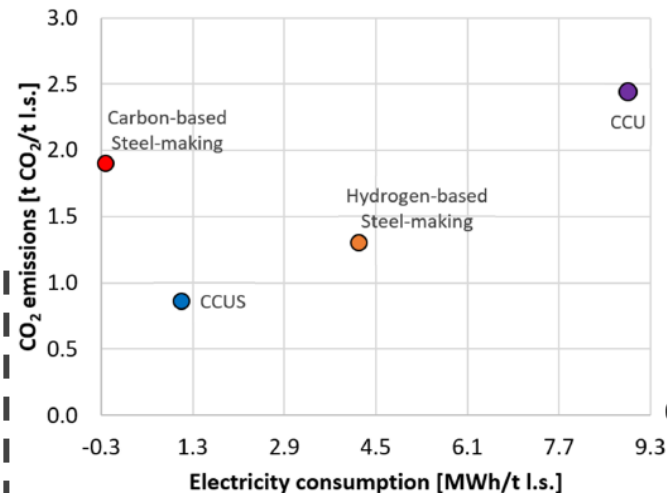
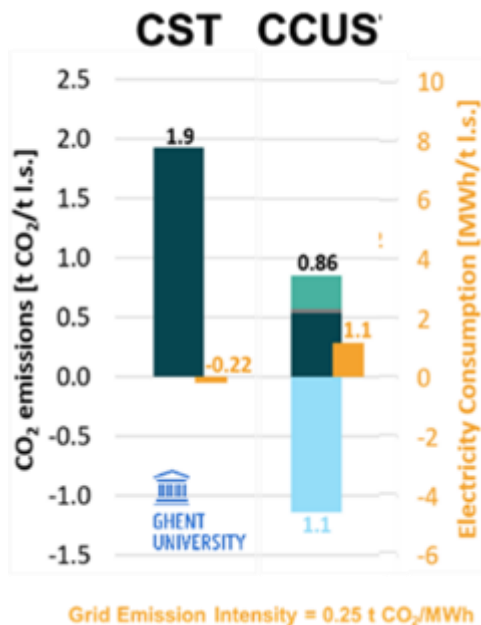
## Current EU-grid

If all of the steel mill gas is converted, the CO<sub>2</sub> abatement potential is :

- CCU = 360 kg/t by MeOH-production (30%)
- CCS = 740 kg/t by storage of the CO<sub>2</sub> (70%)
  - 400 kg/t of the steel gas CO<sub>2</sub>
  - 340 kg/t of the electricity CO<sub>2</sub>

Total abatement = 1.100 kg/t

Need for renewable electricity = 1,1 MWh/t steel





# ArcelorMittal : Smart Carbon Usage



## Technologies of Smart Carbon Usage Integrated Processing of Steel Mill Gases

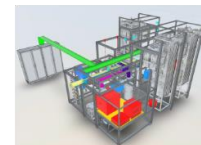
Products in test :

$H_2 + CO \rightarrow$

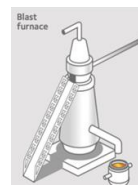
$H_2 + CO_2 \rightarrow$

Ethylene  
Naphtha  
Ammonia  
Butanol  
Hexanol  
Butyrate  
isobutene  
Urea, Ad Blue  
PHB and 3-HP  
Proteins

Ethanol  
IPA  
Acetone;  
methanol  
E-crude/ e-kerosene /  
e-jet fuel  
E-Naphtha  
E-CH4  
Polyols  
Lactic acid and PLA  
Acetate  
Caprylic acid  
Caproic acid  
Formic acid



COG = X Nm<sup>3</sup>/h



BFG = Y Nm<sup>3</sup>/h

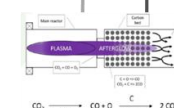
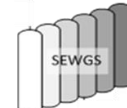
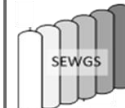


BOFG = Z Nm<sup>3</sup>/h

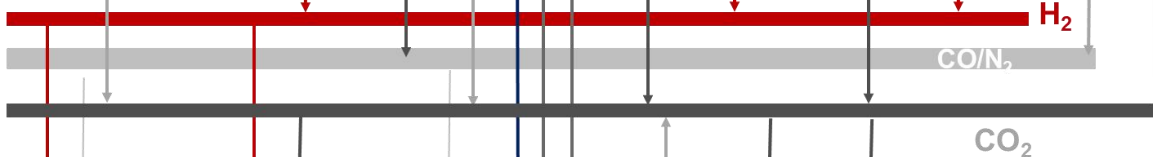


CH<sub>4</sub>  
X/2 Nm<sup>3</sup>/h

H<sub>2</sub>  
X/2 Nm<sup>3</sup>/h



CO<sub>2</sub> plasma → CO + O → High T → 2 CO



Naphta



Methanol



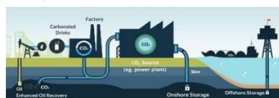
Ethanol



Polyol



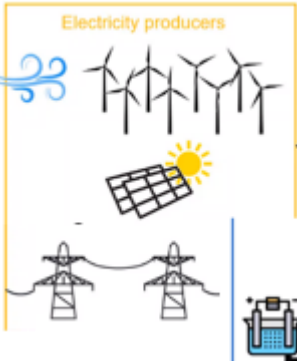
Urea



CCS

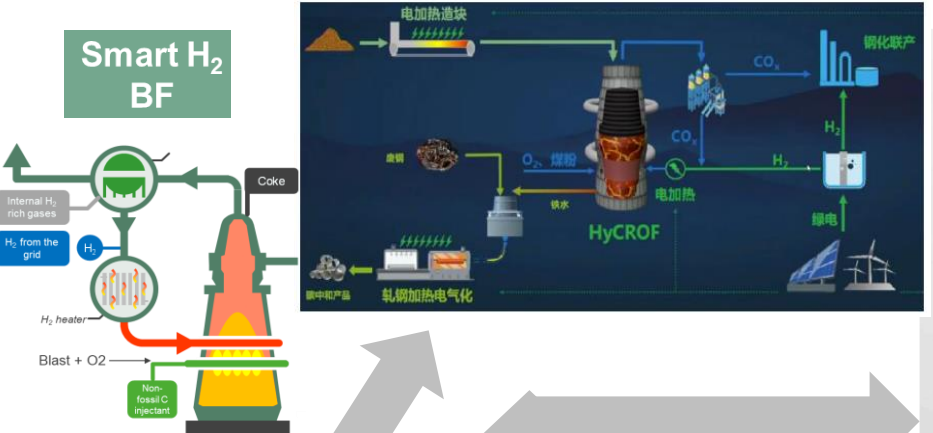
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2



# Other continents than Europe, are not abandoning the blast furnaces !!!

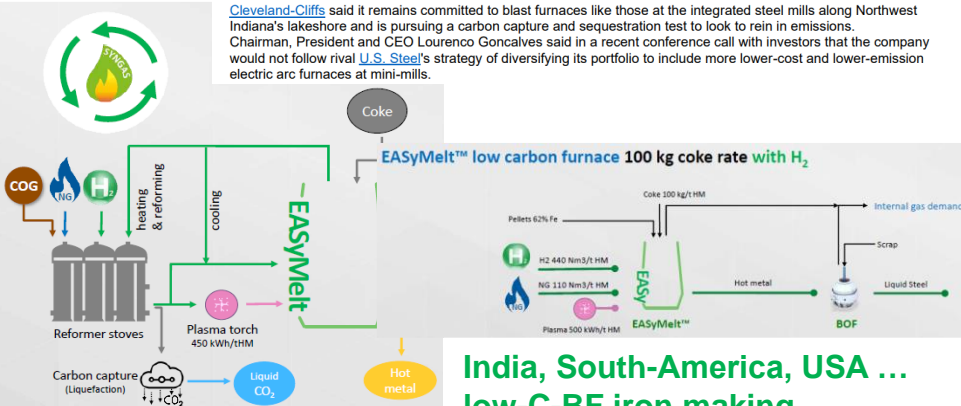
## Baowu hydrogen rich carbon recycle oxygen BF (HyCROF)



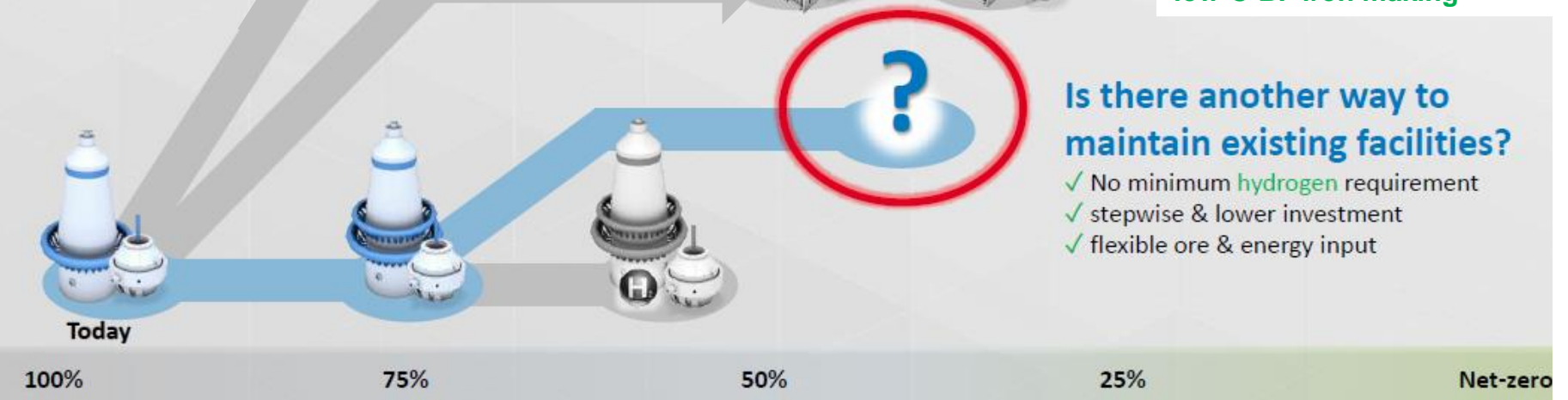
Northwest Indiana Times 28.2.2023

## Cleveland-Cliffs remains committed to blast furnaces, pursuing carbon capture trial at Burns Harbor

Cleveland-Cliffs said it remains committed to blast furnaces like those at the integrated steel mills along Northwest Indiana's lakeshore and is pursuing a carbon capture and sequestration test to look to rein in emissions. Chairman, President and CEO Lourenco Goncalves said in a recent conference call with investors that the company would not follow rival U.S. Steel's strategy of diversifying its portfolio to include more lower-cost and lower-emission electric arc furnaces at mini-mills.



India, South-America, USA ...  
low-C-BF iron making



Is there another way to maintain existing facilities?

- ✓ No minimum hydrogen requirement
- ✓ stepwise & lower investment
- ✓ flexible ore & energy input