PRIMET
TECHNOL

CHALLENGES OF STEEL INDUSTRY

LEAVING CARBON BEHIND

presented by Martin Hackl

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Facts & figures about steel

1,860 Mt

70% of the steel production runs on coal

1 t

CO_{2e}

~2.0 t

Steel industry produces more CO_2 than steel

3.7 Gt CO_2

Steel production causes 7-9% of global CO_2 emissions.

2,200 Mt by 2050

Demand is inevitably going to grow, particularly in emerging markets

Decarbonizing steel requires massive amounts of green electricity

Ramping up green electricity and e-mobility will need massive amounts of steel

Decarbonizing plants – A phased approach

Optimization phase	Transition phase	Final phase (Green Steel)
10-30% CO_2 reduction	**30- 40% CO_2 reduction**	**70- 90% CO_2 reduction**
• Process optimization • Energy optimization • Technology improvements • Raw material optimization (scrap)	• Use of low carbon fuels • H_2 enrichment in DRI plant to 30% • H_2 injection in BF/Pellet/EAF • Endless processes • Hybrid flexible meltshops • Starting phase for CCUS • Low grade ore utilization	• Carbon Direct Avoidance • H_2 based DRI plants • Renewable powered EAFs • Increased deployment of CCUS
2021-2025	**2025 - 2030**	**2030 - 2050**

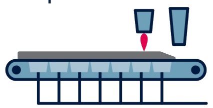
PRIMETALS TECHNOLOGIES

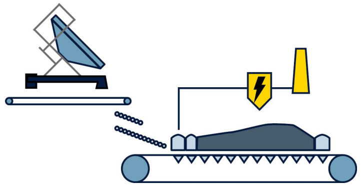
Decarbonizing your plant
Optimizing integrated plants (short-term)

Agglomeration

- BF-gas injection into waste-gas recirculation system (-6–9%)
- BF-gas ignition furnace (-0.5–1%)
- (Selective) waste-gas recirculation (-7–10%)
- Shaft cooler (-6–13%)
- Waste-heat recovery circular cooler (-5–12%)
- L2 automation (-2–3%)

Sinter plant

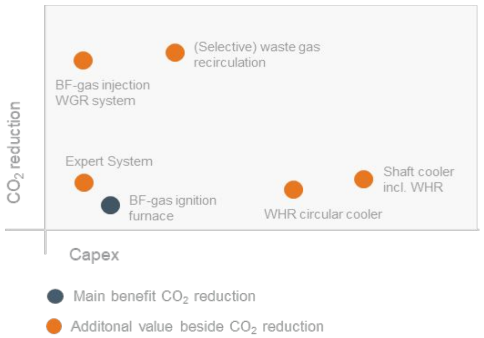




- 25%*

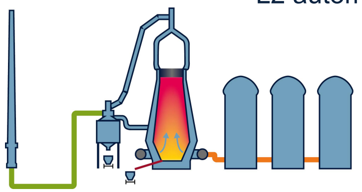
CO_2 equivalents

* (Selective) waste gas recirculation, shaft cooler incl. WHR, BF gas injection WGR, BF gas ignition furnace



Blast furnace

- HBI/scrap feed (-5–10%)
- Stove optimization + waste heat recovery (-6%)
- TRT & MERIM dry dedusting (-2-3%)
- COG injection (-5–7%)
- Dry slag granulation + waste heat recovery (-1–2%)
- Top gas recovery turbine
- (TRT) (-1.2%)
- H_2 injection (up to -20%)
- L2 automation (-2.5%)



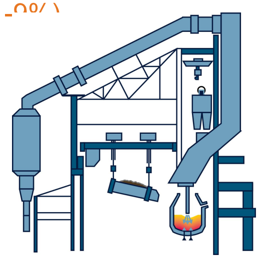
- 40%*

CO_2 equivalents

*H_2 injection, HBI feed, advanced stove system, MERIM dry gas cleaning incl. TRT & DSG dry slag granulation

Basic oxygen furnace

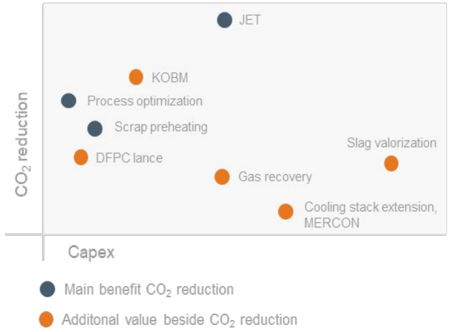
- Gas recovery (-2%)
- Cooling stack extension & MERCON (-0.7%)
- KOBM / Jet Process (up to -23%)
- Process / heat optimization (up to -
- Scrap preheating (-8%)
- DFPC lance (-4%)
- Slag valorization / ZEWA (-6%)



- 25%*

CO_2 equivalents

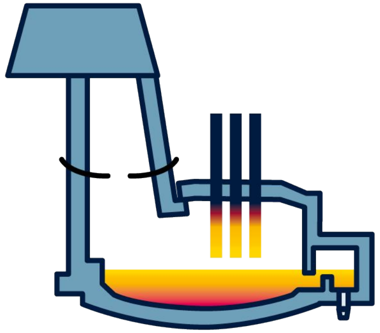
*Combination of process optimization, scrap pre-heating, DFPC Lance and KOBM without hot blast (JET), gas recovery, MERCON & cooling stack extension



Decarbonizing your plant — Electric Arc Furnaces (today)

Potentials and solutions

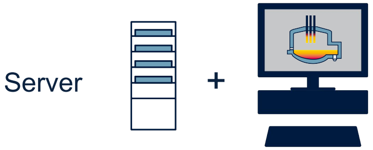
EAF Quantum **(-13%)**
With scrap preheating compared to conventional EAF (both 150 t heat size)



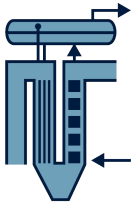
TOTAL

-25%*
CO_2 equivalents

*Quantum Scrap Pre-Heating, Waste-heat recovery EAF & RHF, Energy Saving Assistant.
Total CO_2 savings potential 115,200 tons p.a.



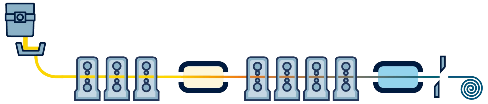
Energy Saving Assistant **(-1%)**
Improved control of gas cleaning plant



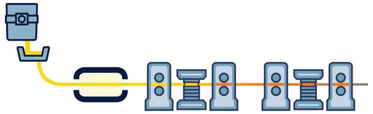
Waste-heat recovery EAF **(-12-14%)**
Energy recovery of off gases

Waste-heat recovery reheating furnace **(-2%)**
Uses off gas heat for steam production

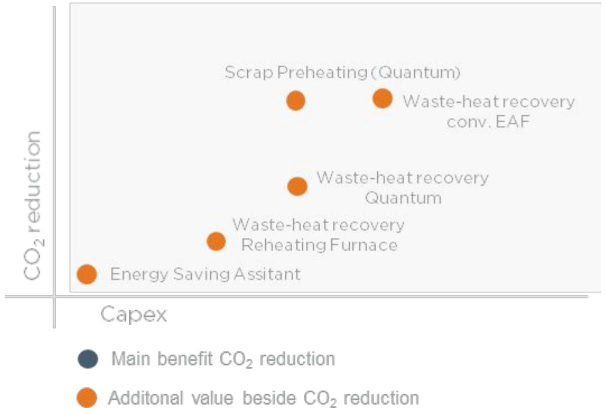
Waste-heat recovery EAF-Quantum **(-6-9%)**
Energy recovery of off gases



Arvedi ESP **(-39%)**
Combined casting/rolling



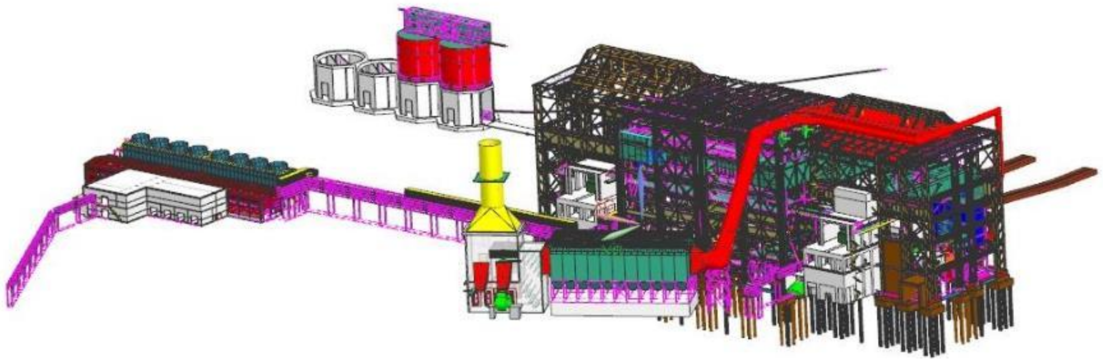
WinLink **(-40%)**
Direct rolling of long products



THE FIRST REAL DECARBONIZATION PROJECT IN EUROPE

Salzgitter places large order with Primetals Technologies for electric arc furnace as part of major green steel transformation program

- Salzgitter AG orders Electric Arc Furnace Ultimate designed to produce 1.9 million tons of steel per year
- An important step toward long-term aim of green steel production
- Start of production planned for end of 2025



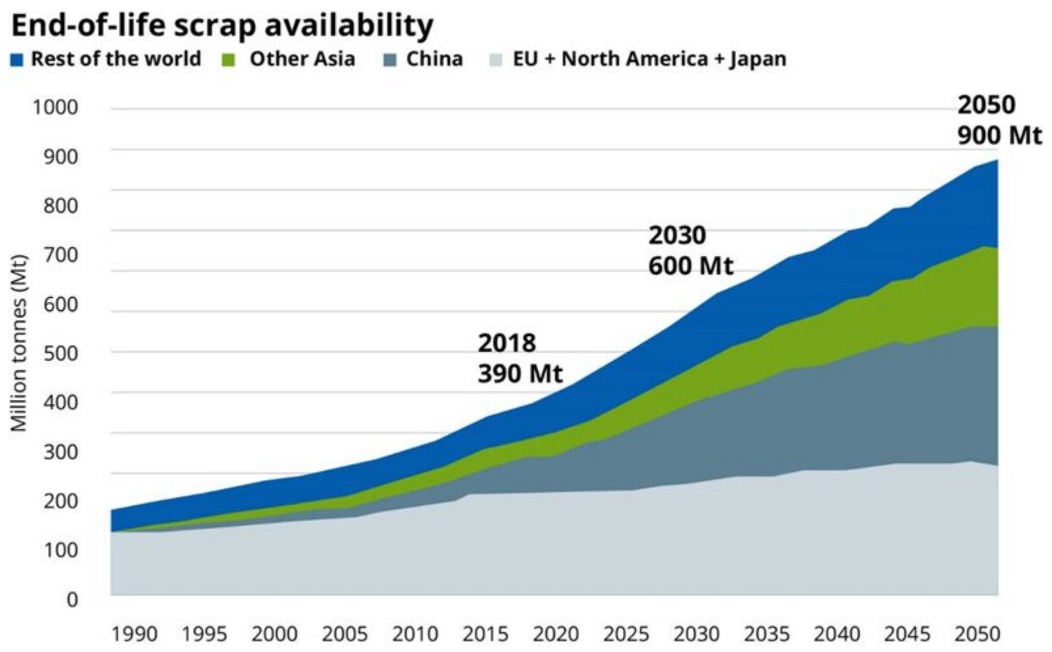
Representatives from Salzgitter and Primetals Technologies at the contract signing ceremony

Source: https://greensteelworld.com/primetals-technologies-to-build-the-first-electric-arc-furnace-in-salzgitter

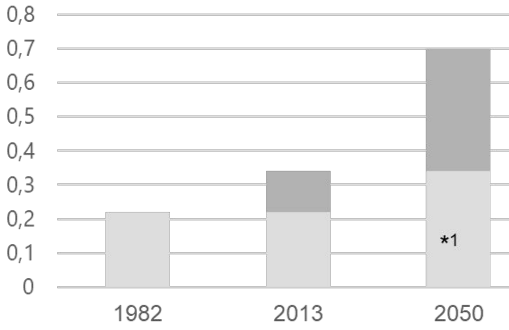
RAW MATERIALS AND RENEWABLE POWER - THE KEY DRIVERS

Iron ore & scrap dilemma

- Scrap recycling in an EAF allows the lowest carbon footprint
- Scrap availability is limited, and virgin material feed will remain the dominant material for steel
- Scrap comes with contaminants like Cu, S, P and scrap cleaning will be required to meet grade certification
- Most scrap types available contain more residuals than is allowed for premium steel products
- Scrap processing (sorting, cleaning) gain importance
- Automatic identification and sorting based on physical characteristics
- Integration into automatic scrap yard and EAF/BOF process control system



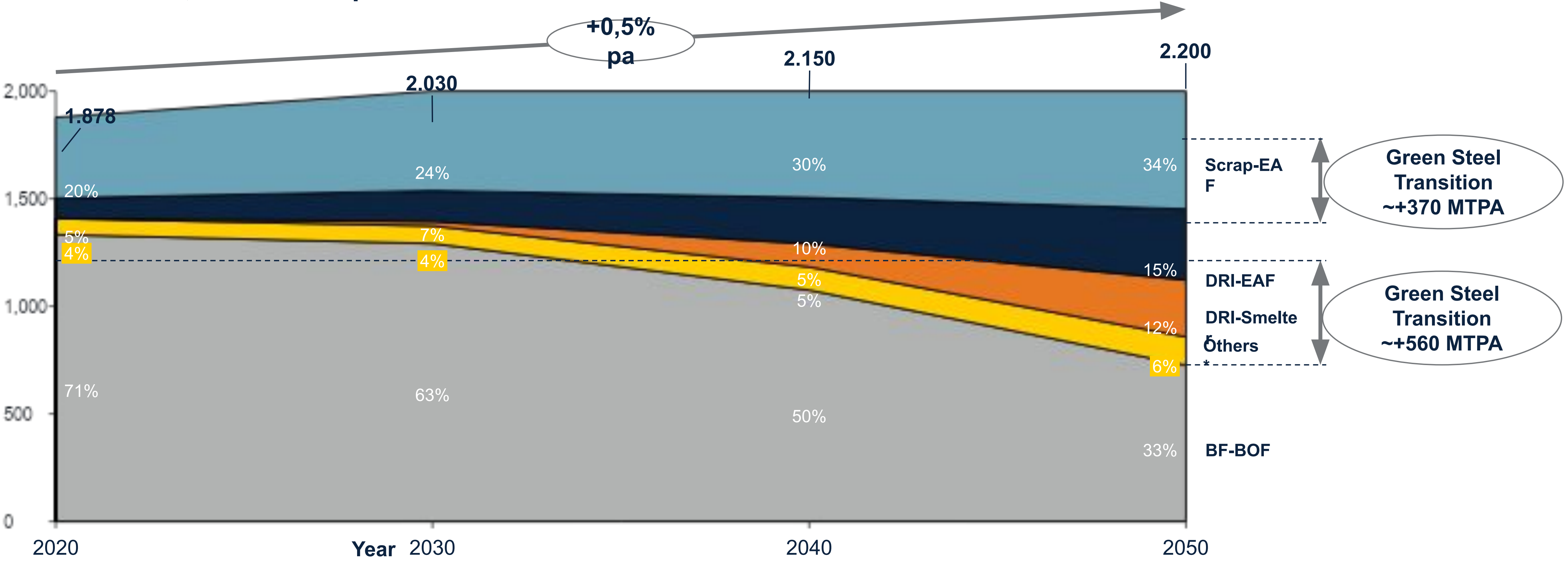
Increase of Cu in Shreddered scrap



Is this still a raw material or waste?

Growth in steel production is limited, but transition to green steel is huge!

Steel Production, Million Ton p.a.



* includes coal based DRI, Induction Furnace, Corex/Finex, Open-hearth Furnaces

Source: PT estimation

Steel will decarbonize in stages

Traditional (blast furnace)
(84% hot metal and 16% scrap in BOF)

1,674[1)*]
kg CO_2 / t liquid steel

Direct reduction + EAF
(80% hot DRI and 20% scrap in EAF)

577
kg CO_2 / t liquid steel

Recycled scrap
(100% scrap in EAF)

134
kg CO_2 / t liquid steel

Green steel (H_2DRI–EAF)
(80% hot DRI and 20% scrap in EAF)

187
kg CO_2 / t liquid steel

-65% CO_2 emissions

-91% CO_2 emissions

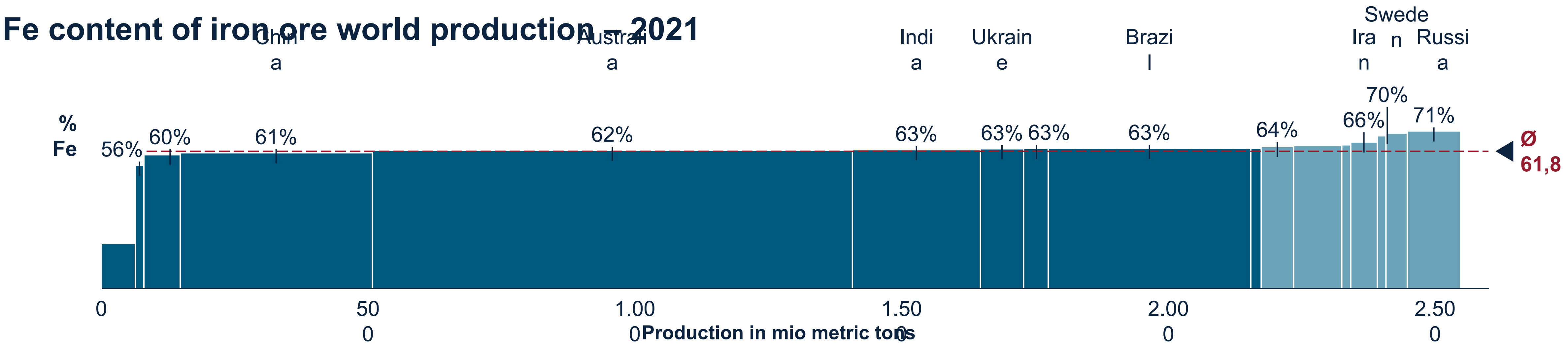
-88% CO_2 emissions

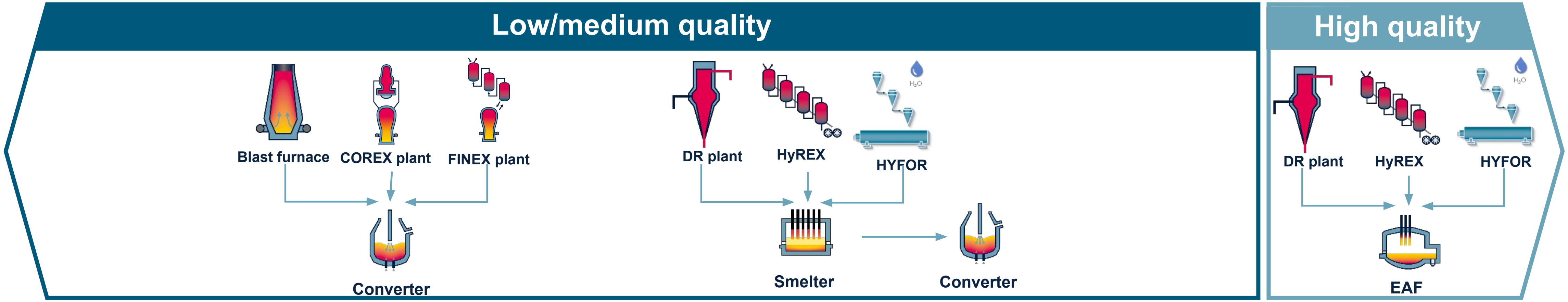
1) Applying CCUS would reduce GHG emissions of the traditional route by 50–70%

* Based on BAT and includes credits for slag and gas utilization

All figures based on emission factor of **80 g CO_2** / kWh

The iron quality determines the process route

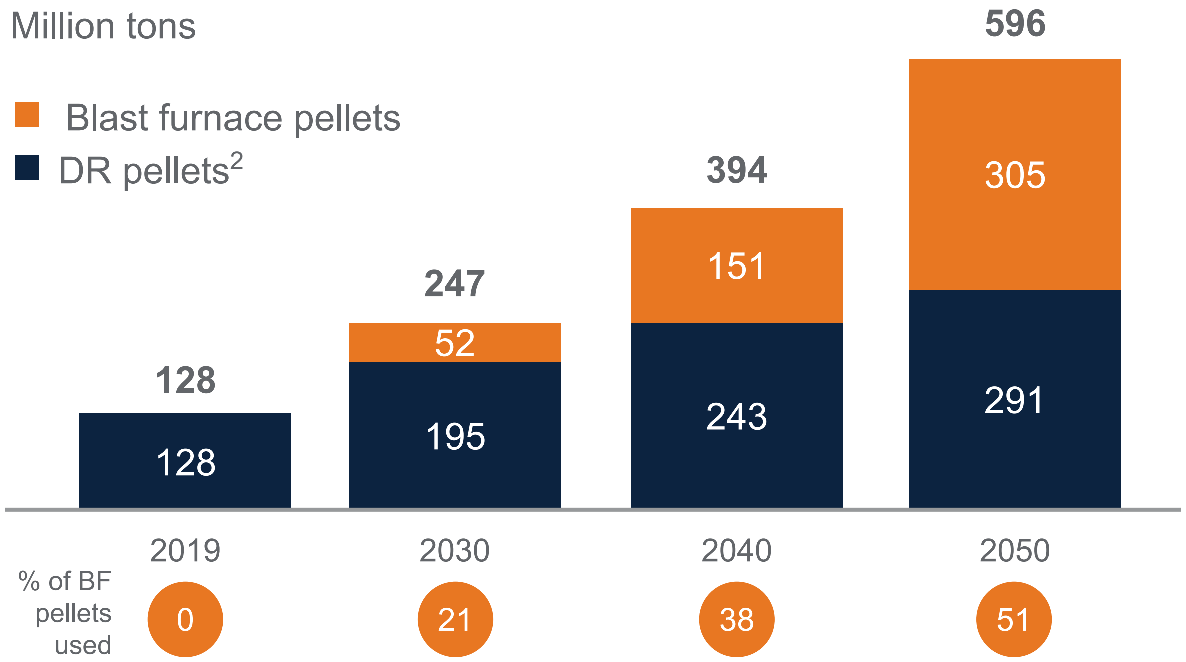




Source: National Minerals Information Center USA, Primetals

Direct Reduction Forecast

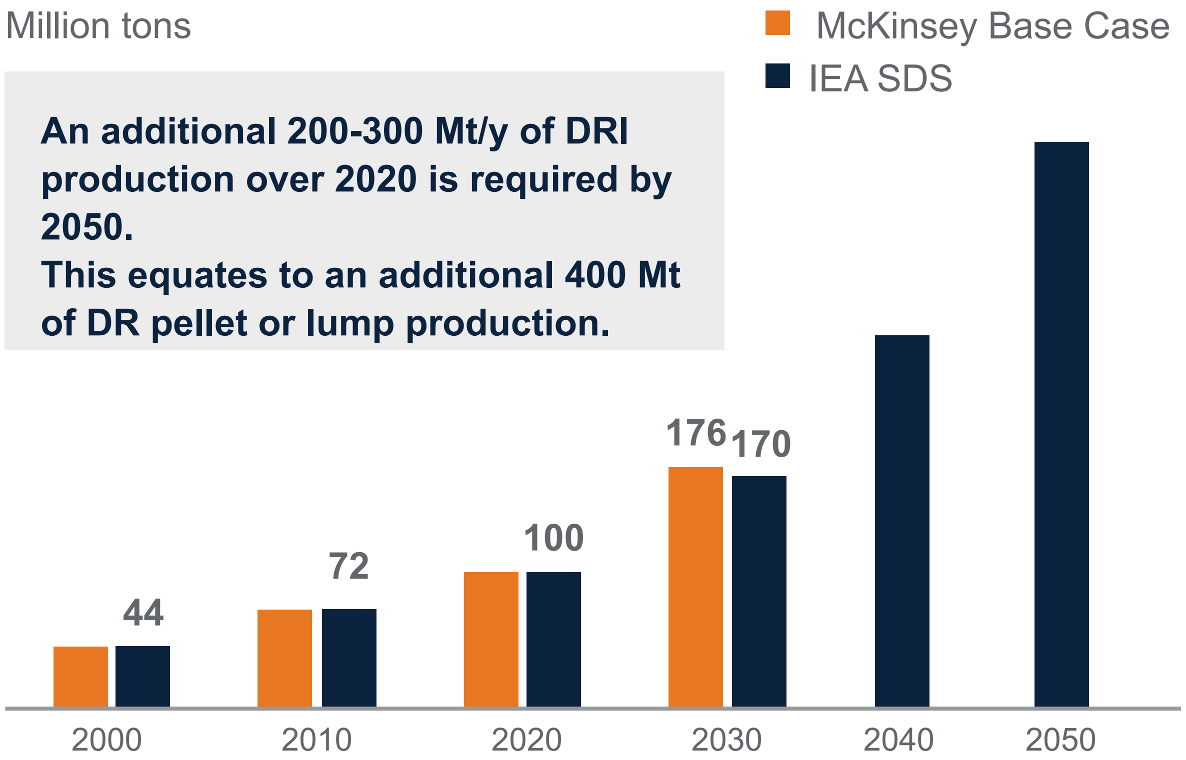
Potential DRI raw materials demand by pellet type[1]



1. Assuming raw materials yield of 1.45:1
2. Using MineSpans base case to 2030 and linear extrapolation forwards

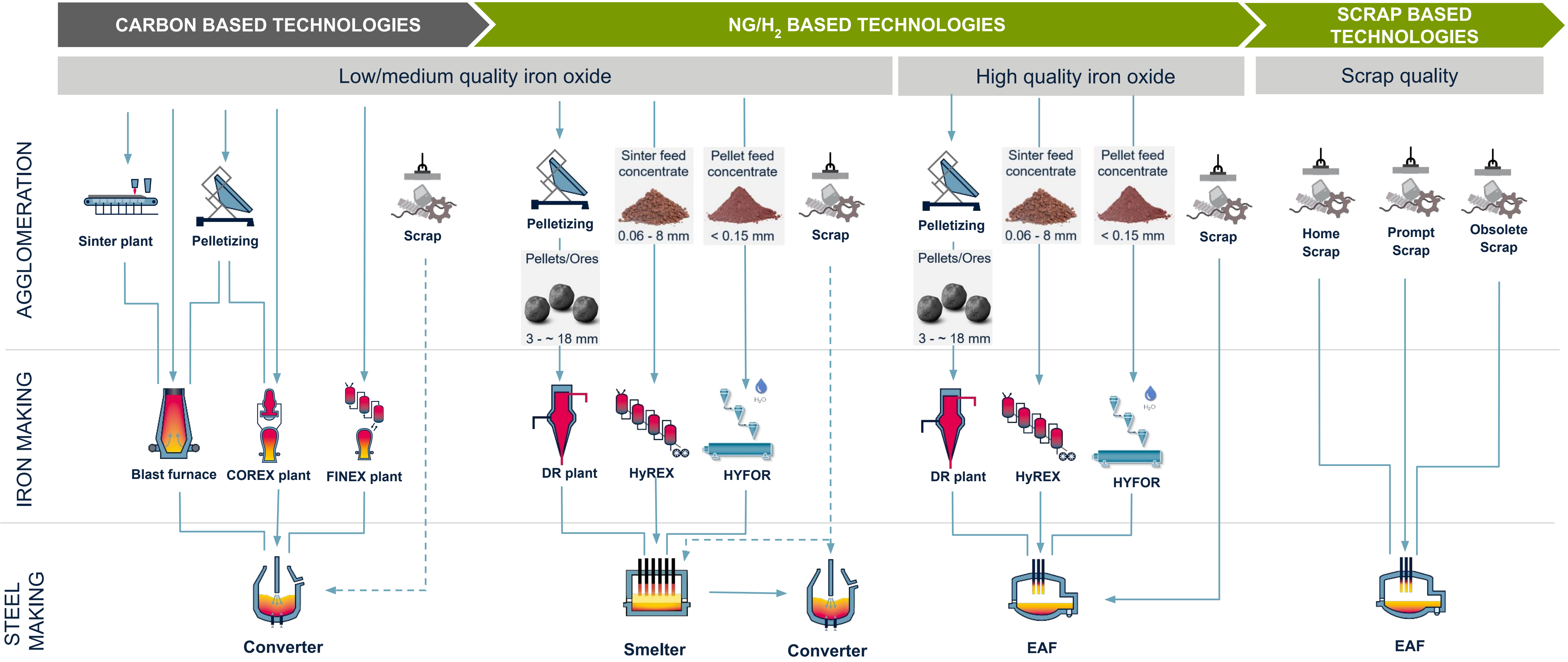
Source: McKinsey analysis, IEA SDS, MineSpans by McKinsey

DRI Production



Source: McKinsey – The DRI Dilemma (November 2021)

Main process routes for decarbonized steel production



HYFOR – Hydrogen based Fine Ore Reduction (pilot plant)

Main input

- Direct use of iron ore concentrate
- Reducing gas: hydrogen

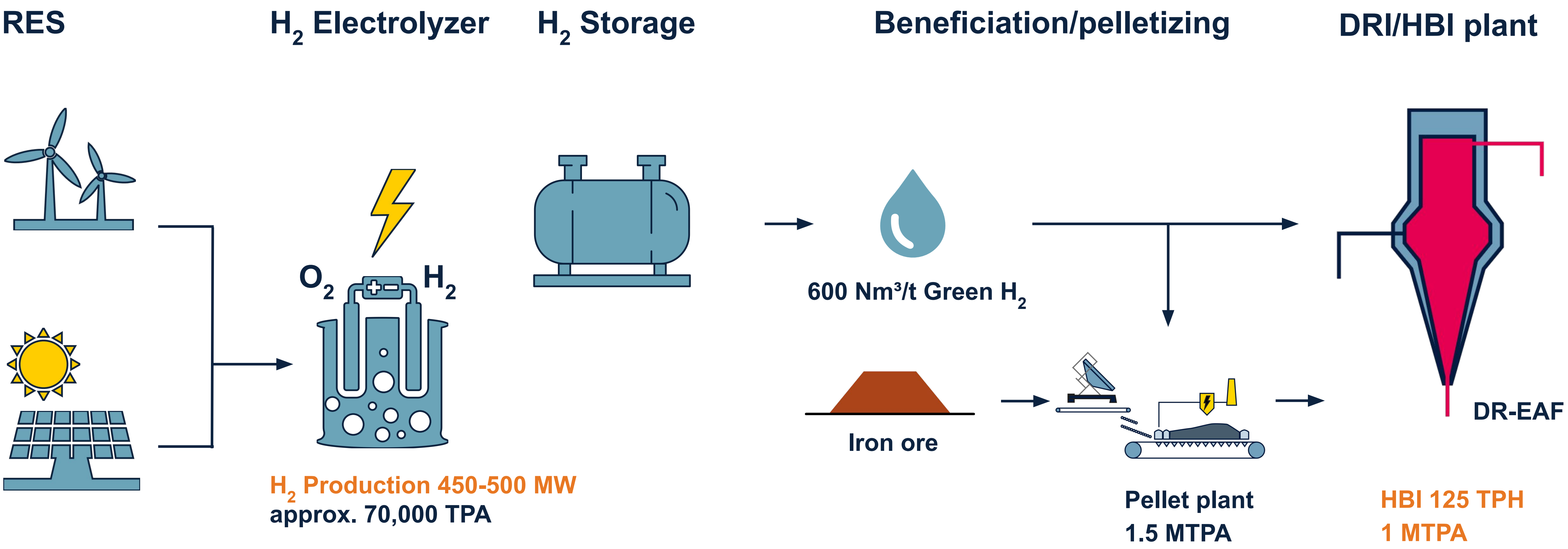
Main benefits

- No pelletizing required
- High oxide yield
- CO_2-free ironmaking
- High reduction rate, Low temp./pressure operation

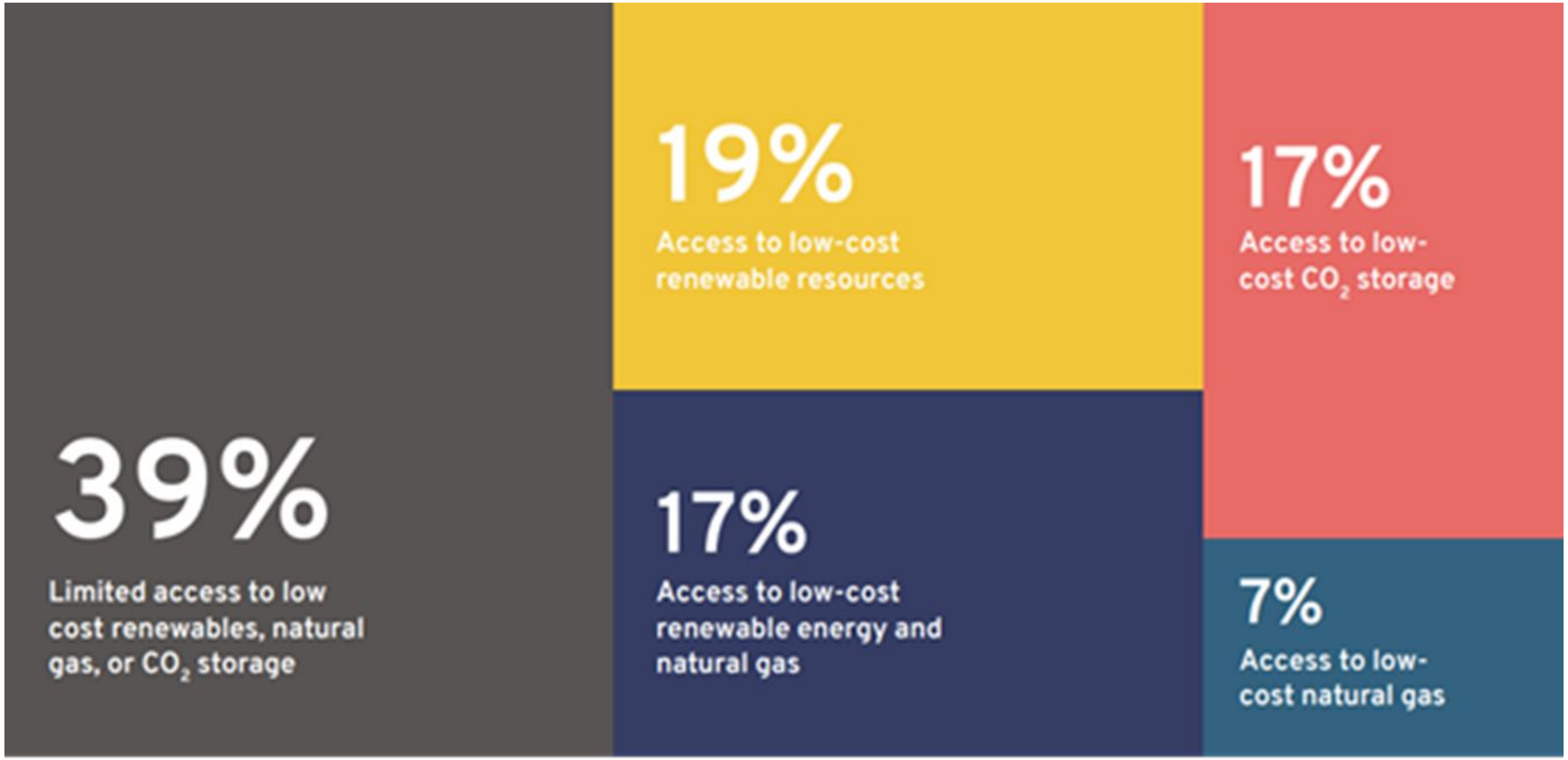
Status

- Digital Showcase (DigiTwin, VR, m.doc,…)
- Plant in stable operation since beginning of 2022
- Multiple campaigns successfully executed
- Continue of tests with various ores
- Evaluate design parameters for next plant size

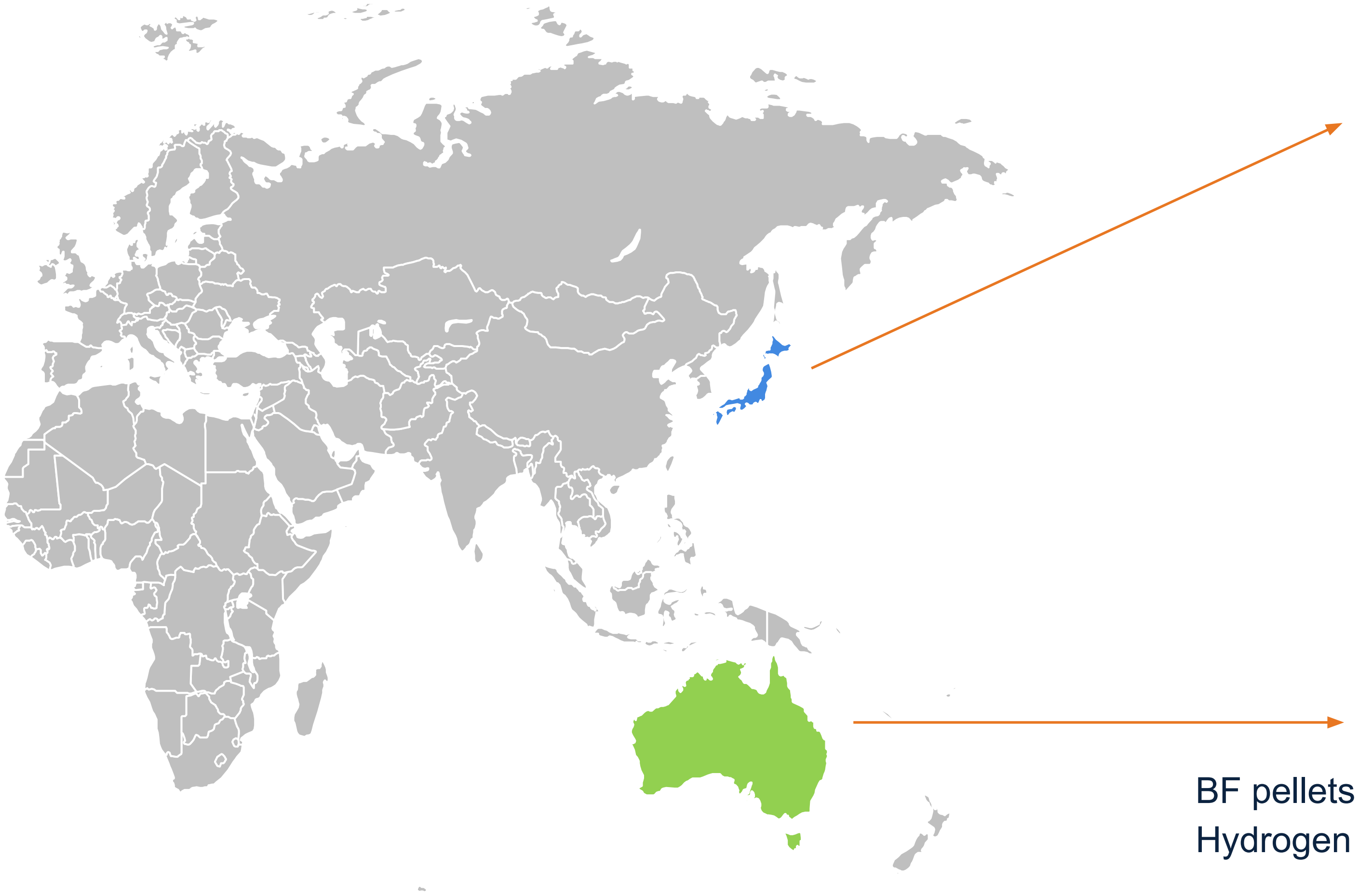
Hydrogen Availability
The Energy Enigma

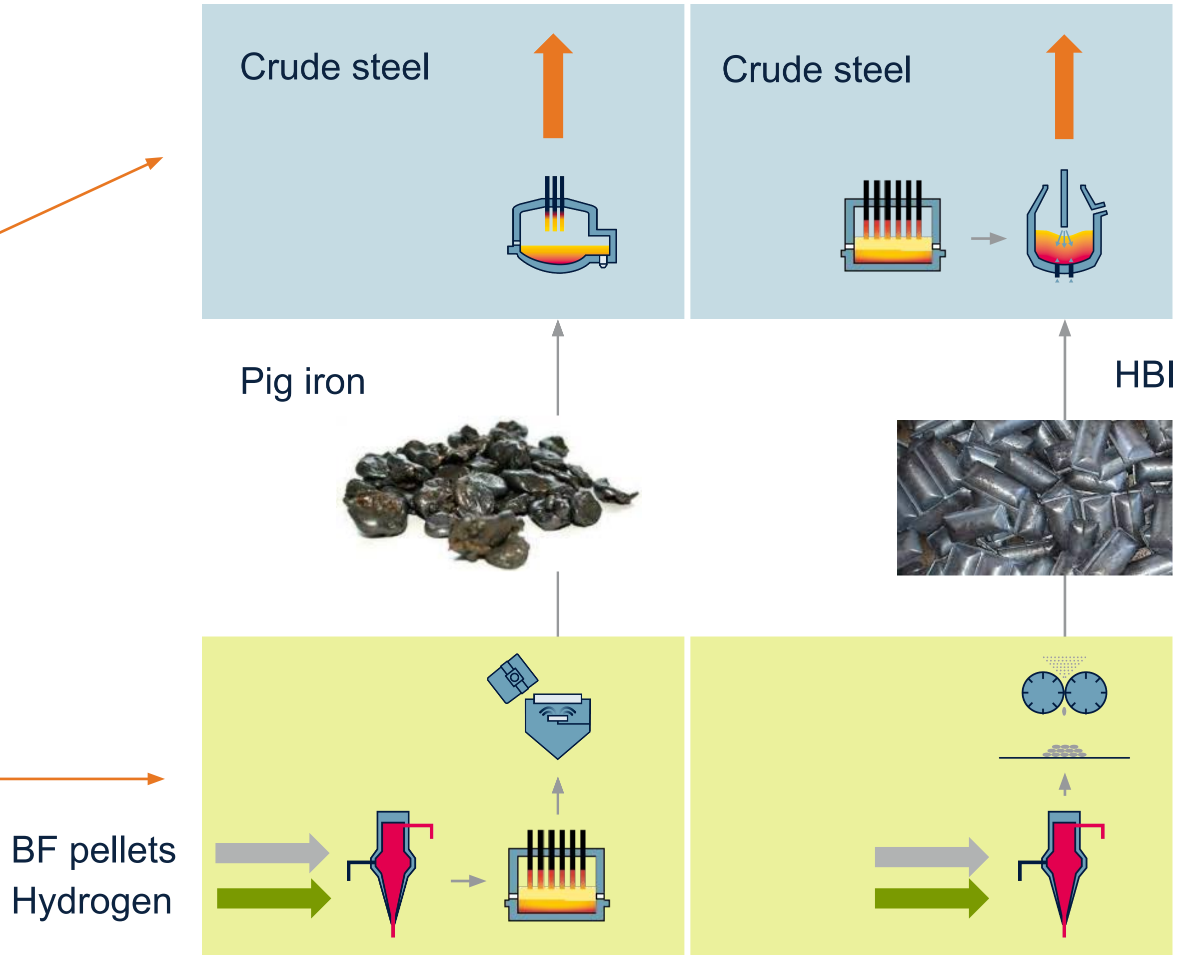


The Location Dilemma



Energy vs. Steel Demand
Location Dilemma





PRIMETALS TECHNOLOGIES

Market Strategy

- 13% **steel supply demand** increase expected in 2050 **(CAGR ~0,5%)**; mainly driven by **growth in India** (CAGR 4-5%) and other developing nations; Europe, US and other developed counties with stable demand, China expected to drop.
- Today we have **>70% high emission steel** in the market (>0.6 t CO_2/t of liquid steel).

Capex Cost

- Transition steel to net-zero requires a **massive global investment** volume of up to 4.4 trillion (~**150 bil. p.a**).
- **Major steel players have started to invest despite the difficult energy market and major uncertainties** (ETS price, carbon tax, free-allocations, CBAM and public support) □ First mover benefit
- Hard-Tech net-zero transition will **increase the price of steel by minimum 30%**, which consumers will have to accept. Till 2030 300-500 US$/t is estimated.
- Steel consumers are setting strong decarb-targets. Low-carb steel demand is less than 1% but quickly growing to >25% in 2040. **Green steel premium will establish** to compensate for higher Opex.

Technology

- **Major transition pathways** are 3-fold: EAF (scrap-HBI), DRI-SMELTER-BOF and CCUS
- In 2050 more than 65% of steel will come from plants with an EAF or SMELTER installed.

Materials

- **Scrap consumption will grow faster** (~1.5-2%) than steel demand, esp. in India & China.
- Mid-term this will lead to a **decline of virgin based metallics**, except in India and other developing countries. China will see a significant decline in BF iron ore demand.
- **DRI capacity will quadruple till 2050** (CAGR 5%). According to our tracking **>25 new DR plants** have been **announced** (>30 MTPA in Europe!)
- **High-grade iron ore will become an undersupply** material before 2030 with an increased premium.

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THANK YOU

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