GREEN TECHNOLOGY OPTIONS FOR AUSTRALIA

A CONSIDERATION OF OPTIONS THAT ARE AVAILABLE

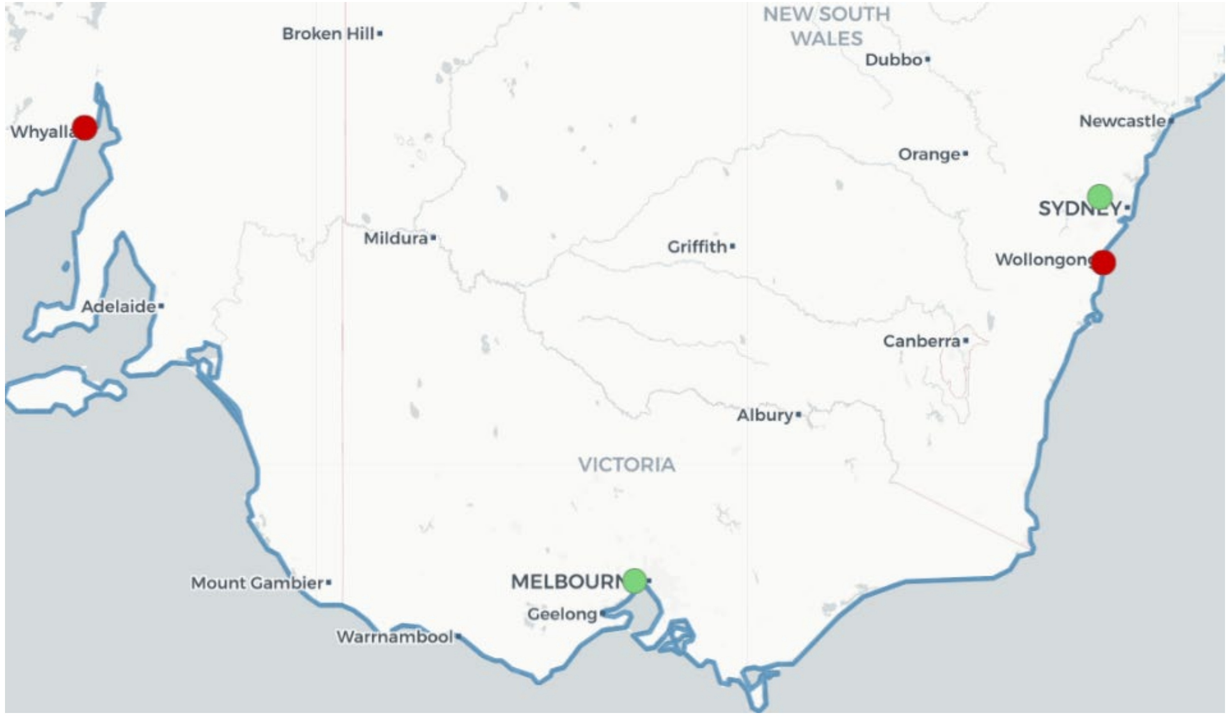
Martin Paul Smith, Business Development Director

Agenda

The Market – the market for making iron and/or steel in Australia

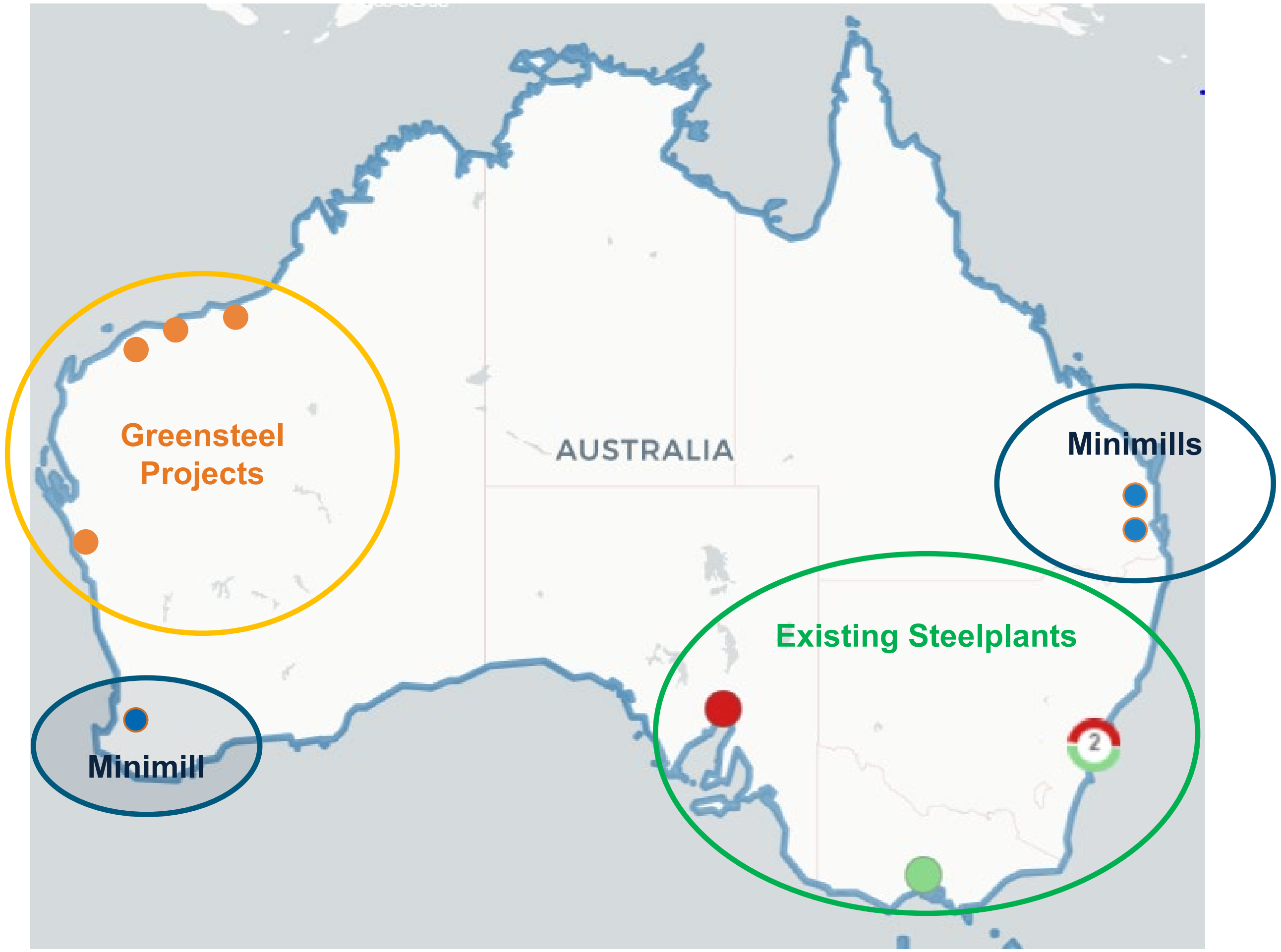
- Overview of Market as it is now
- Consideration of how the Market could look
- Consideration of technologies that could facilitate the market now
- Consideration of technologies that could facilitate the new look market now and in the future

Existing Steel Making Facilities



- Electric
- Electric, Oxygen
- Integrated (BF and DRI)
- Integrated (BF)

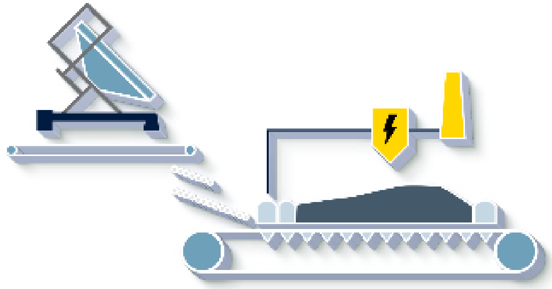
Image of the Future Today



- **BF Production:**
  - Bluescope Port Kembla
  - Whyalla
- **EAF Production:**
  - GFG Sydney
  - GFG Melbourne
- **Greensteelprojects announced:**
  - Athena / Warradarge
  - PGS
  - Revera
  - Greensteel WA
- **Minimills announced:**
  - Future Furgeworks
  - Westview / Alter
  - Greensteel WA - Collie

Decarbonizing/Optimizing Existing Integrated Plants

AGGLOMERATION



-25%

CO_2 equivalents

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

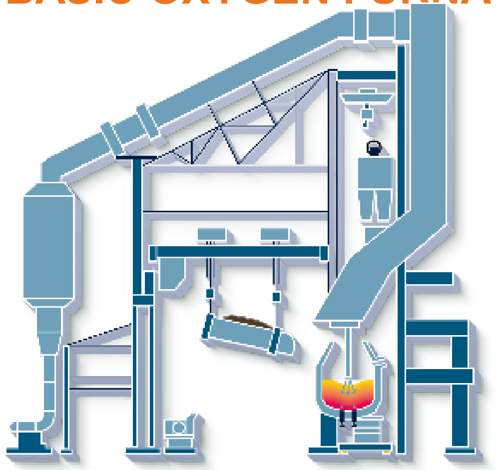
BLAST FURNACE

-40%

CO_2 equivalents

H_2 injection, HBI feed, advanced stove system, MERIM dry dedusting incl. TRT & dry slag granulation

BASIC OXYGEN FURNACE



-25%

CO_2 equivalents

Process optimization, scrap pre-heating, DFPC lance and KOBM without hot blast (Jet), gas recovery, MERCON & cooling stack extension

Tata Jamshedpur ‘E’ Blast Furnace Hydrogen Injection System

Demonstrating the feasibility of hydrogen injection for the overall reduction of Blast Furnace carbon emissions

- Objective:- Demonstrate feasibility of hydrogen injection into the E-BF at Jamshedpur.
- Scope:- PT provided: the system design; operating and safety philosophies including HAZOP; procurement and construction guidance; and commissioning / operational support.
- Contract Award:- July 2022
- System was installed on 4 of the 12 tuyeres and ran for a series of 12-hour injection periods during April 2023.

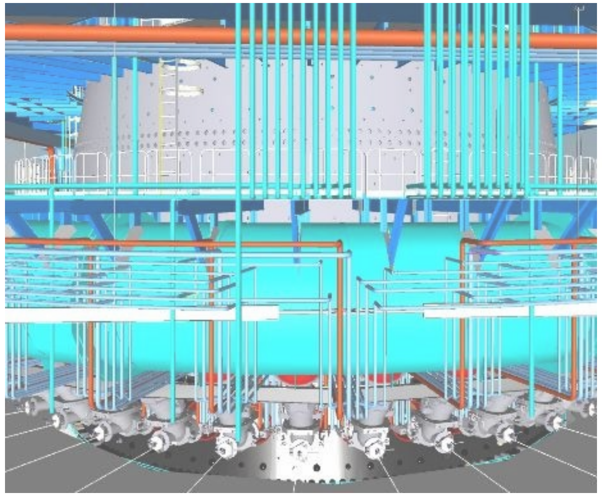
https://www.youtube.com/watch?v=C0fIJ-U2aGE&list=PLiOeSkJ1KgFvgypVfZ1R5SxSuF5LoakYW&index=4

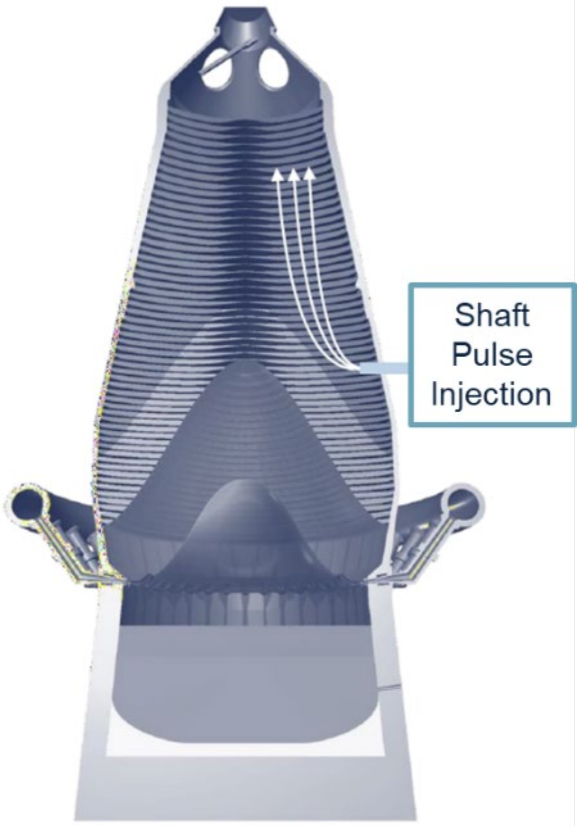
But what is the limitation? – Hydrogen Availability

Hydrogen Gas Injection Development

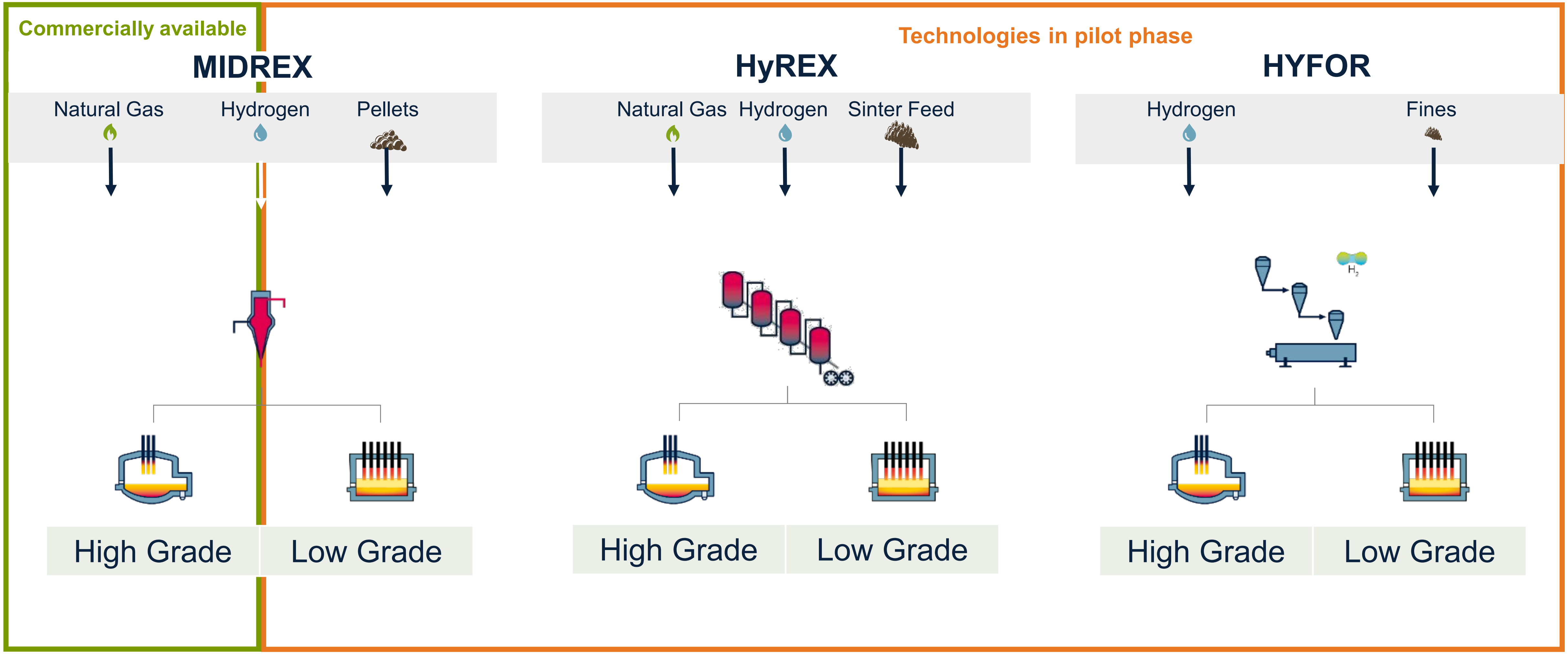
- Gas injection at the tuyeres can replace coke and coal and reduce CO_2 emissions.
- Primetals Technologies have designed systems for hydrogen and Syngas injection for blast furnaces.
- After commissioning later this year the Syngas system will be able to reduce CO_2 emissions by up to 2%.

- 3-year European research project with industrial partners to investigate **H_2 injection in the shaft**
- Utilises high kinetic energy and penetration depths provided by SIP – to reduce wall-working of the injected hydrogen.





Direct Reduction Technologies

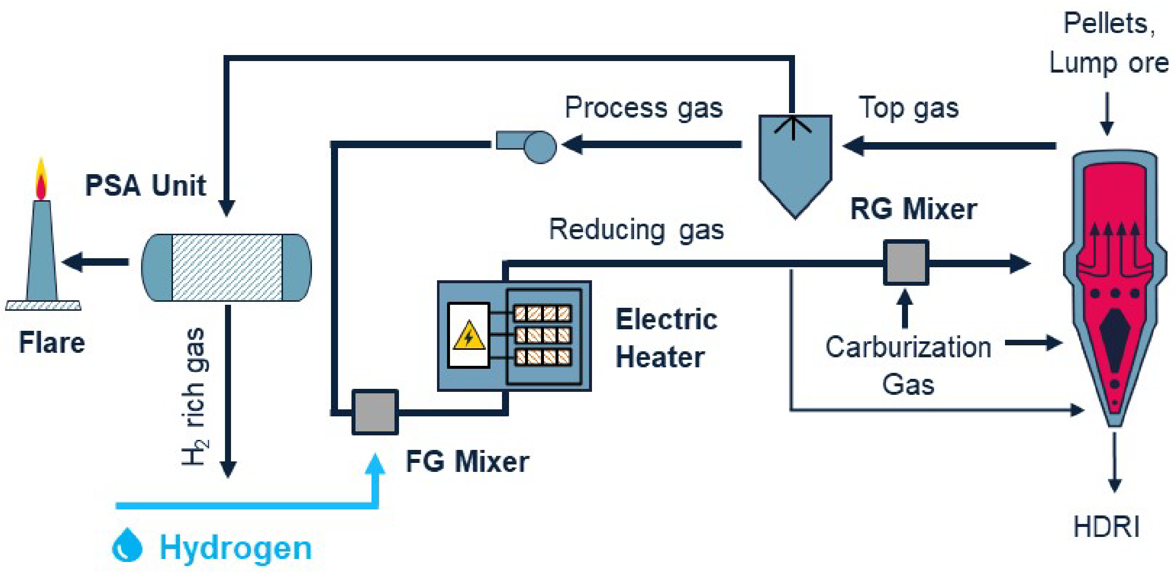


High-grade ores: Electric arc furnaces (EAF)

Low-grade ores: “Smelter” for DRI melting and final reduction

MIDREX H_2™ – The future today

- Optimized for 100% H2
- Electric heater
- Top Gas Fuel hydrogen recovery to improve efficiency
- No fossil fuel input required
  flexibility to add carburizing gas for DRI carbon adjustment
- Adapt to market demand and feedstock availability (e.g. use of pellets with different Fe content)



EAF Quantum WHR System

Minimized power off times less than 4 minutes per heat.

Metallic yield advantage 2% or more comparing to conventional EAF.

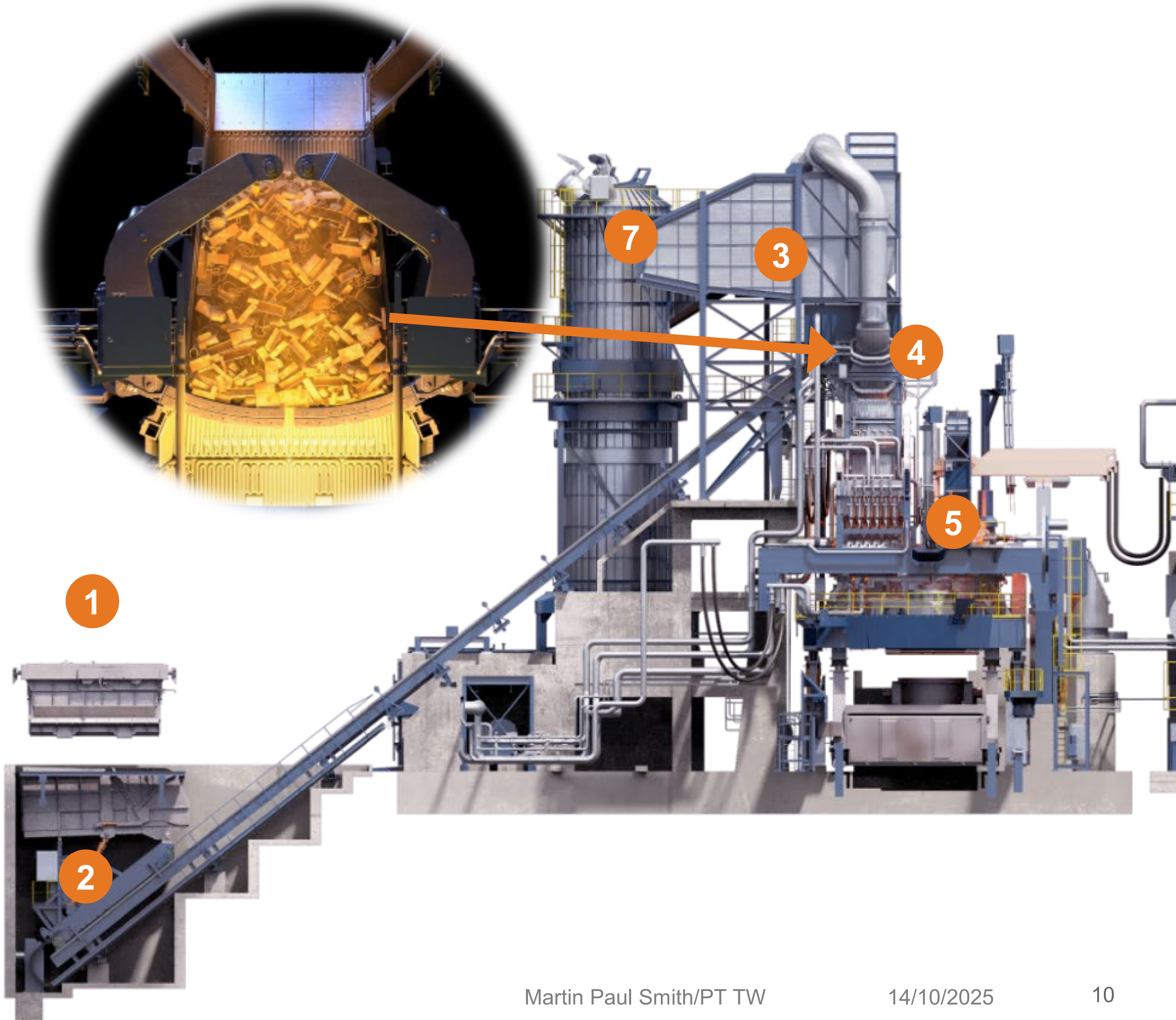
EAF Dust rich with Zinc and around 5 kg/t steel produced.

Refractory consumption less than 1,5 kg/t.

No Charging crane and operator.

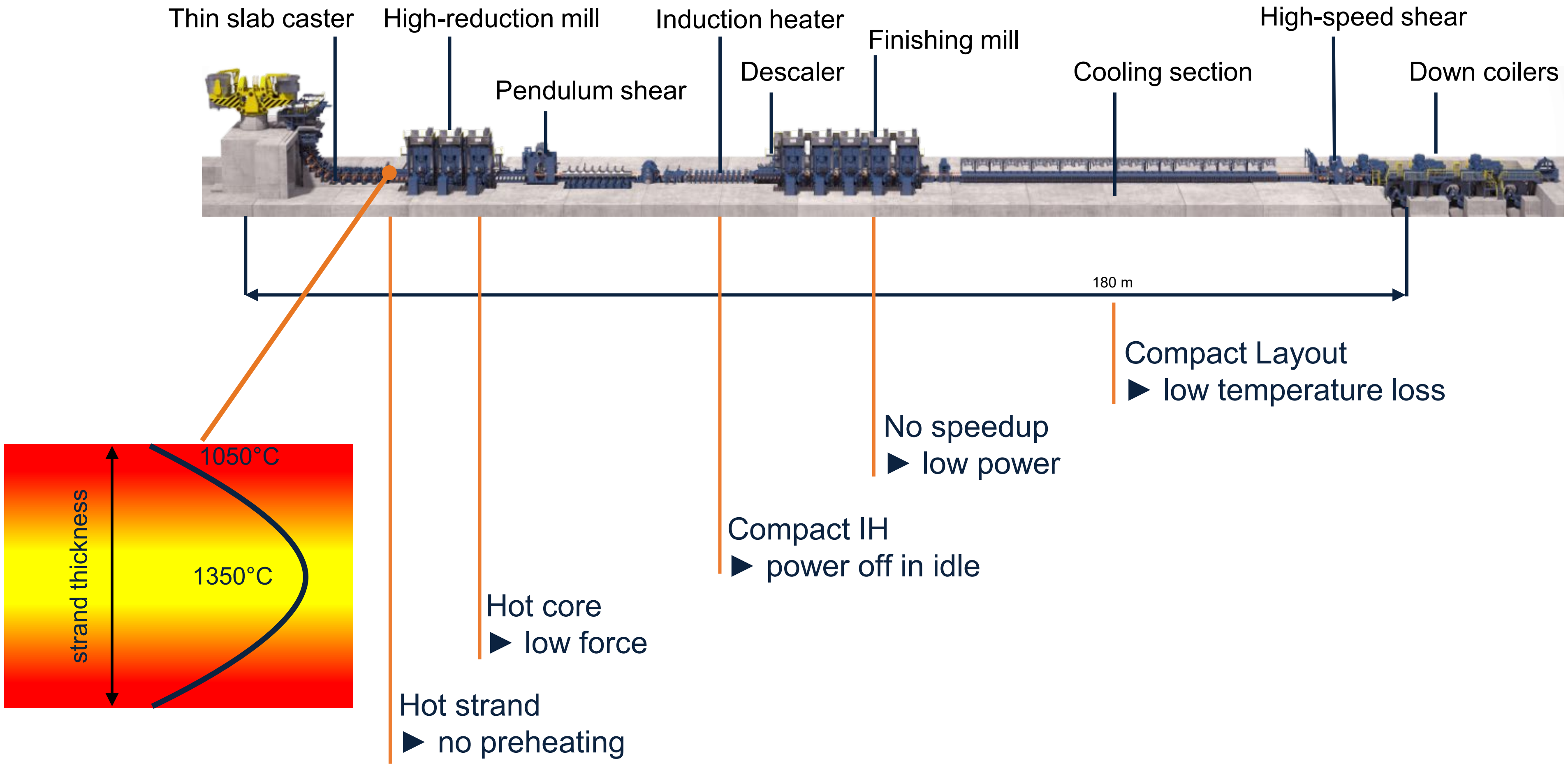
Electrical energy consumption down to 280 kWh/t and less

Electrode consumption like a DC furnace (less than 0.8 kg/t)

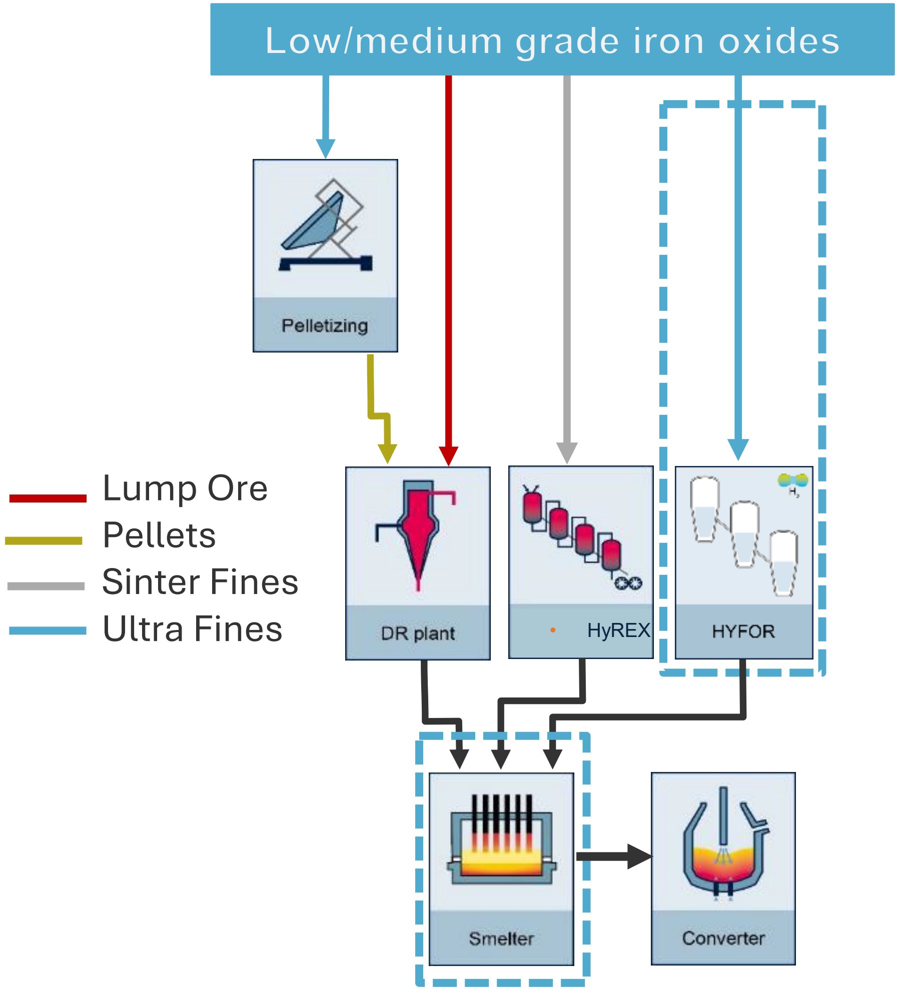


What's behind the GREEN ESP concept?
The endless principle

Rolling with the heat of the liquid steel



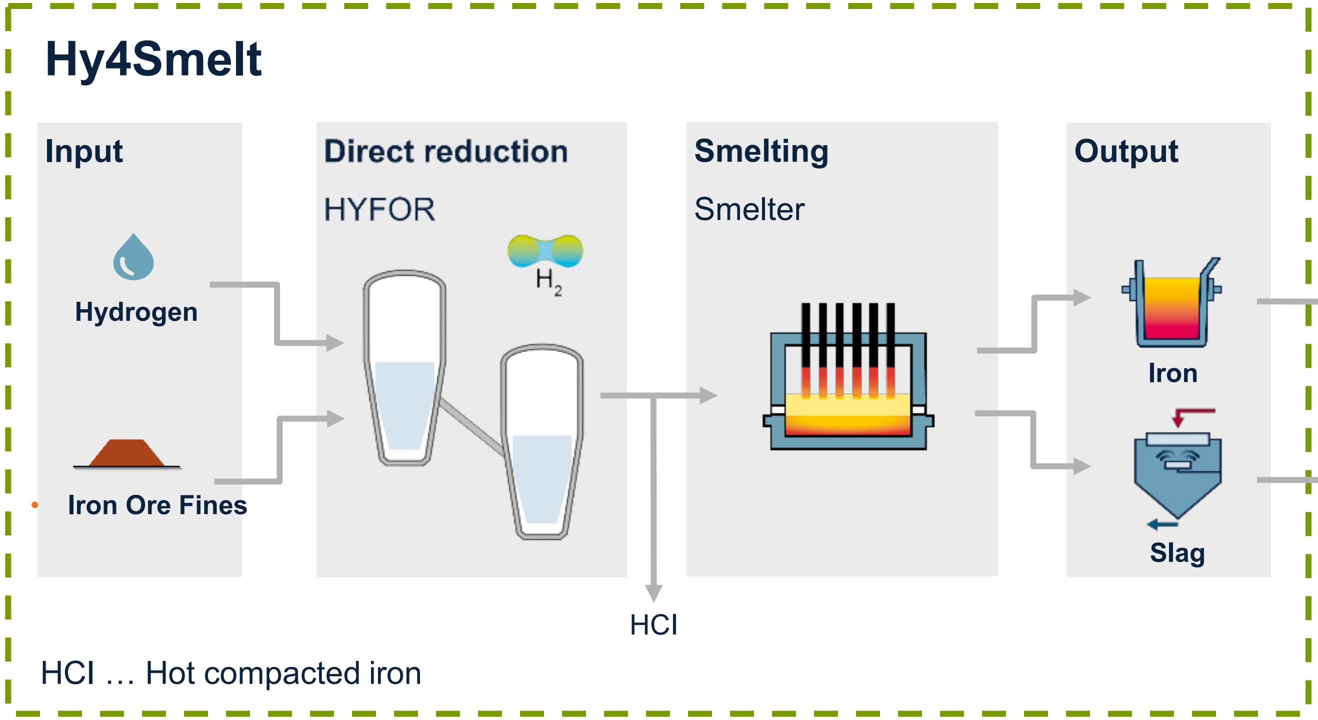
Process Routes for Green Hot Metal



- **HYFOR (Hydrogen-based fine ore reduction)**
- **HYFOR** technology owned by Primetals Technologies Austria is an alternative **direct reduction process** for **ultrafine iron ores** that will not require any agglomeration steps
- A combination with the **Smelter technology** (owned by Primetals Technologies Austria) is used for melting and final reduction of direct reduced iron (DRI) based on low and medium grade iron ores with Fe < 65 %
- In that way, **green hot metal** is produced with **hydrogen** for BOF or EAF steelmaking

General Information Hy4Smelt Process

- Hy4Smelt is a **groundbreaking new process** combining direct reduction (HYFOR) and electrified smelting under reducing conditions (Smelter)
  - In the **direct reduction step** the iron oxide in the fine iron ore is reduced to metallic iron using only green hydrogen
  - In the **smelting step** the direct reduced iron is smelted using green electricity, the melt is adjusted, hot metal (HM) and slag are tapped separately from the furnace
- The Hy4Smelt plant is capable to process a **wide range of iron ore fines** coming from different mines worldwide



Iron is sent to steel plant for refining, replacing hot metal coming from BF.

Slag is granulated and used in cement industry as a clinker substitute.

Basic Design for Hy4Smelt demonstration plant

- **Iron ore** 2-3 t/h
- **Hydrogen** 1 500 m³/h
- **Hot metal** 2-3 t/h
- **Slag** < 1 t/h

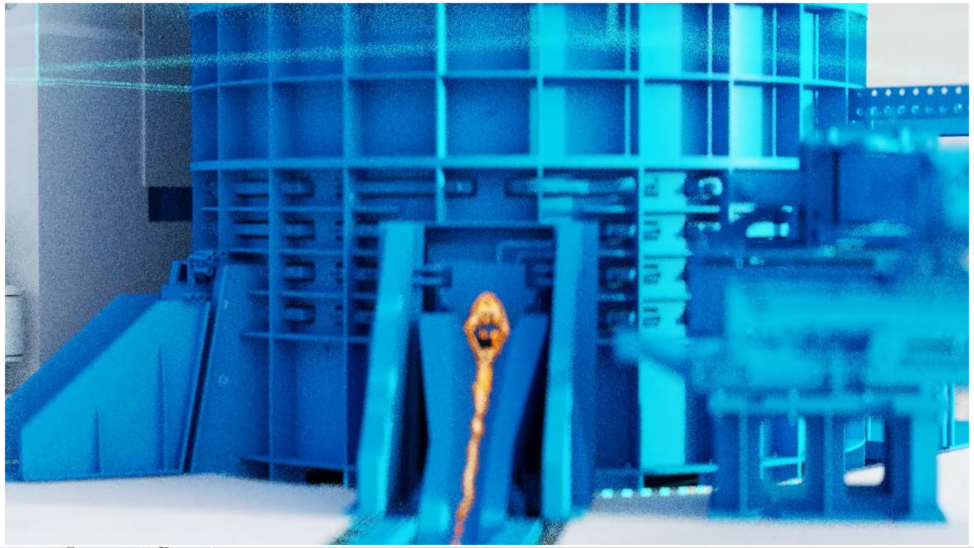
- **TRL** 8
- **Location** voestalpine Stahl Linz site

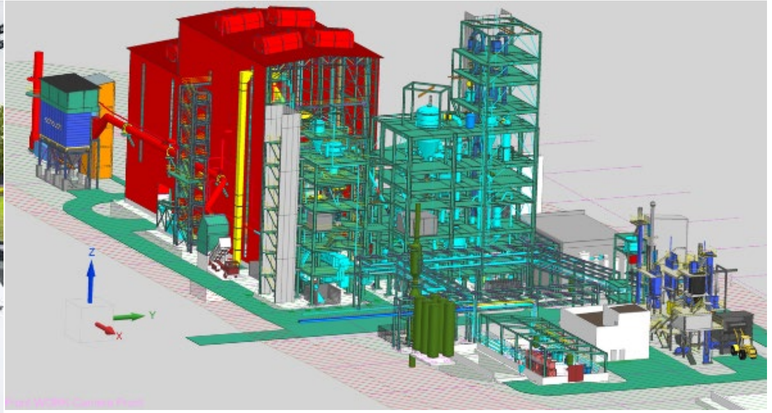
- **Final Investment Decision** 04/2025
- **Start of Operation** - 07/2027

RioTinto voestalpine ONE STEP AHEAD. PRIMETALS TECHNOLOGIES

Hy4smelt Industrial Demonstration Plant for Hyfor and Smelter

- testing a continuous hydrogen-based pig iron production
- 1500 Nm³/h H_2, 3 t/h iron ore, 2 t/h hot metal
- Start up autumn 2027
- Smelter:
  - Closed round AC furnace, dia 3m, 3,5MW, 5MVA,
  - 3 x graphite electrodes allowing for resistance or arc-operation
  - Option for fines and compacted DRI feeding





[Net-Zero CO2-Emissionen bis 2050 - greentec steel]

[Hy4Smelt – www.hy4smelt-project.eu]

https://primetals.sharepoint.com/sites/Intranet/SitePages/Construction-Begins-on-Hydrogen-Based-Ironmaking-Plant-in-Linz%2C-Austria.aspx

Overall flowsheet demonstration plant

Main Process data

Productivity: 2 – 3 t/h Iron ore feed

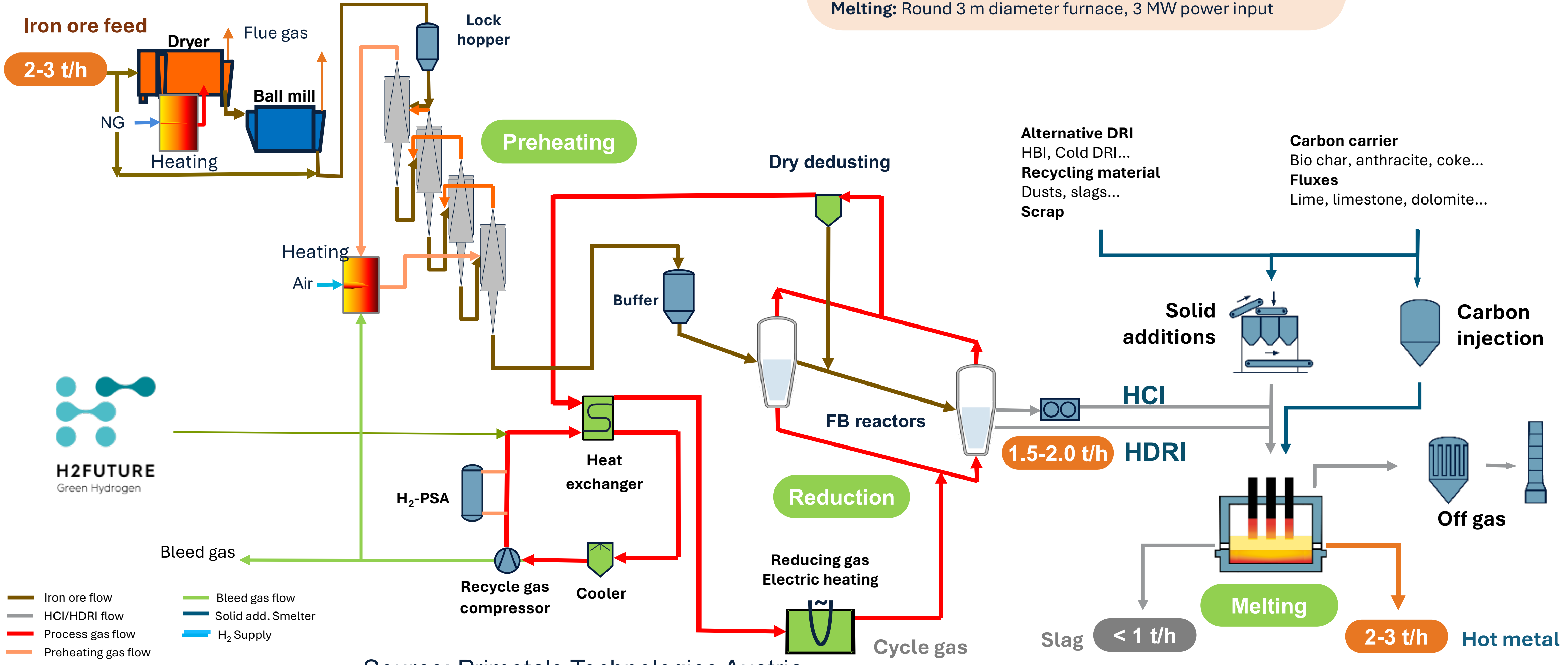
1.5 – 2 t/h DRI (HYFOR)

2 – 3 t/h Hot metal (Smelter)

Preheating: 4 cyclones in series, up to 900 °C, up to 3,5 bar(g)

Reduction: 2 reactors in series, circular shape, up to 3,5 bar(g)

Melting: Round 3 m diameter furnace, 3 MW power input

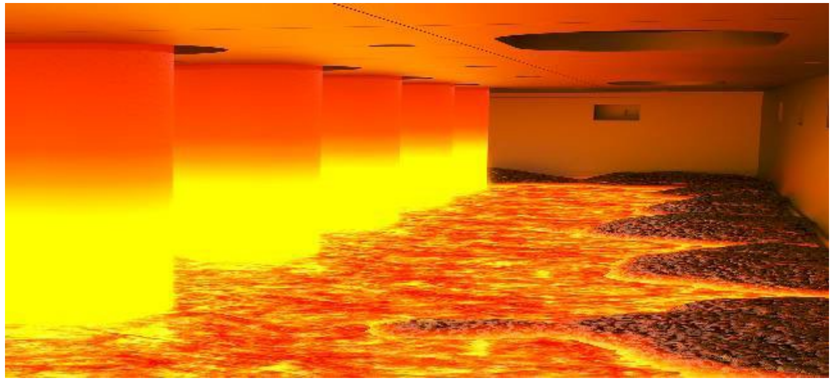


- Source: Primetals Technologies Austria

Smelter (Electric Smelting Furnace)

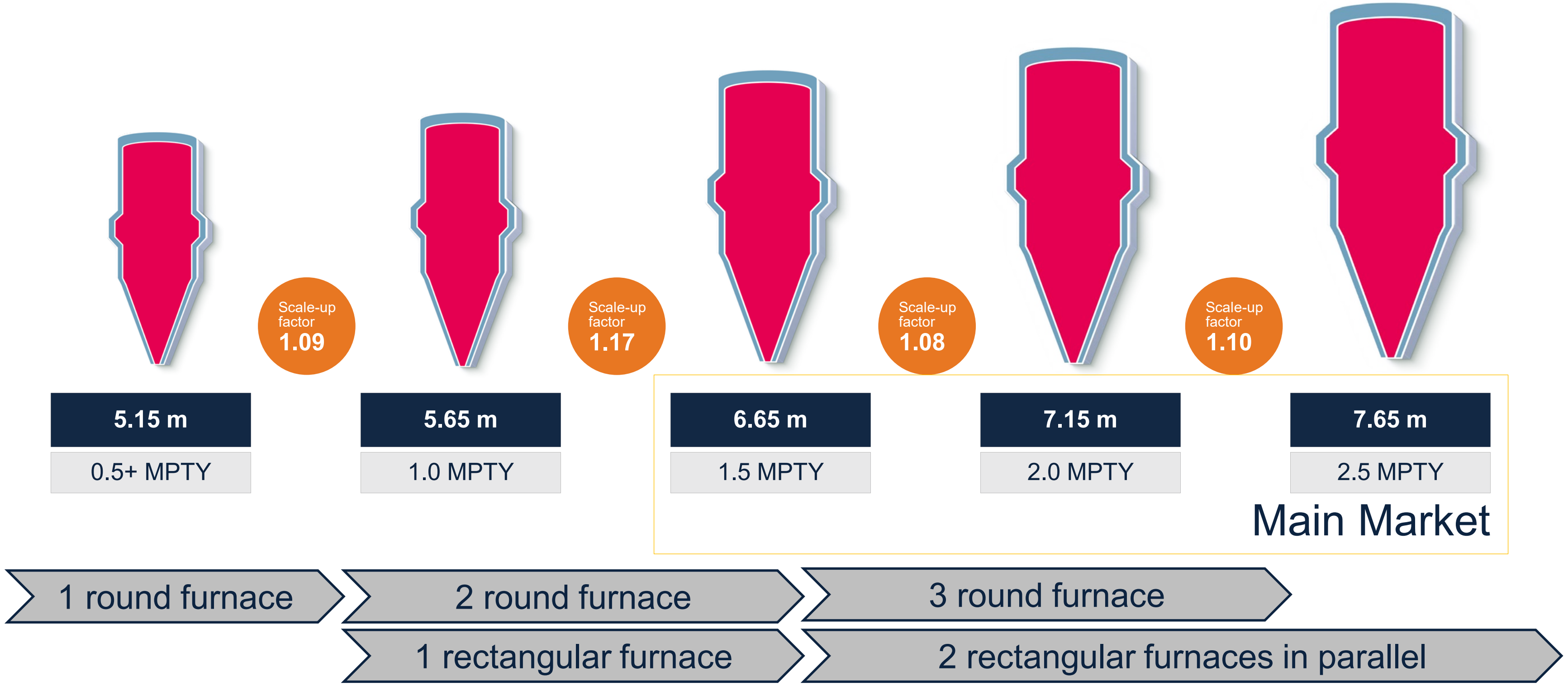
- **DRI is molten, final reduction takes place** and an adjustment of the iron (carbon level) and slag (basicity, MgO-level)
  - Iron from the Smelter goes the steel plant
  - Slag is granulated and used in cement industry
  - High calorific off-gas as substitute for natural gas
- Due to the **reducing atmosphere inside the Smelter**, the Smelter is well designed to **process other iron oxide containing materials from steel production**, such as dusts, mill scale or slags to improve the **circularity of the production process**
- For the **Smelter** in large scale ironmaking, **no reference plants exists yet**; however, principles were tested and verified by simulations, in the laboratory and on a modified furnace in the hundred kg scale

Cross section of a Smelter



Inside a Smelter

Required SMELTER Size



- Target capacity for rectangular furnace is 1,5MPTY or 190t/h (based on 8000h annual operation time)
- For 2,5MPTY two furnaces working in parallel required
- Max. possible furnace capacity might increase in future (electrodes, specific bath power ratio)

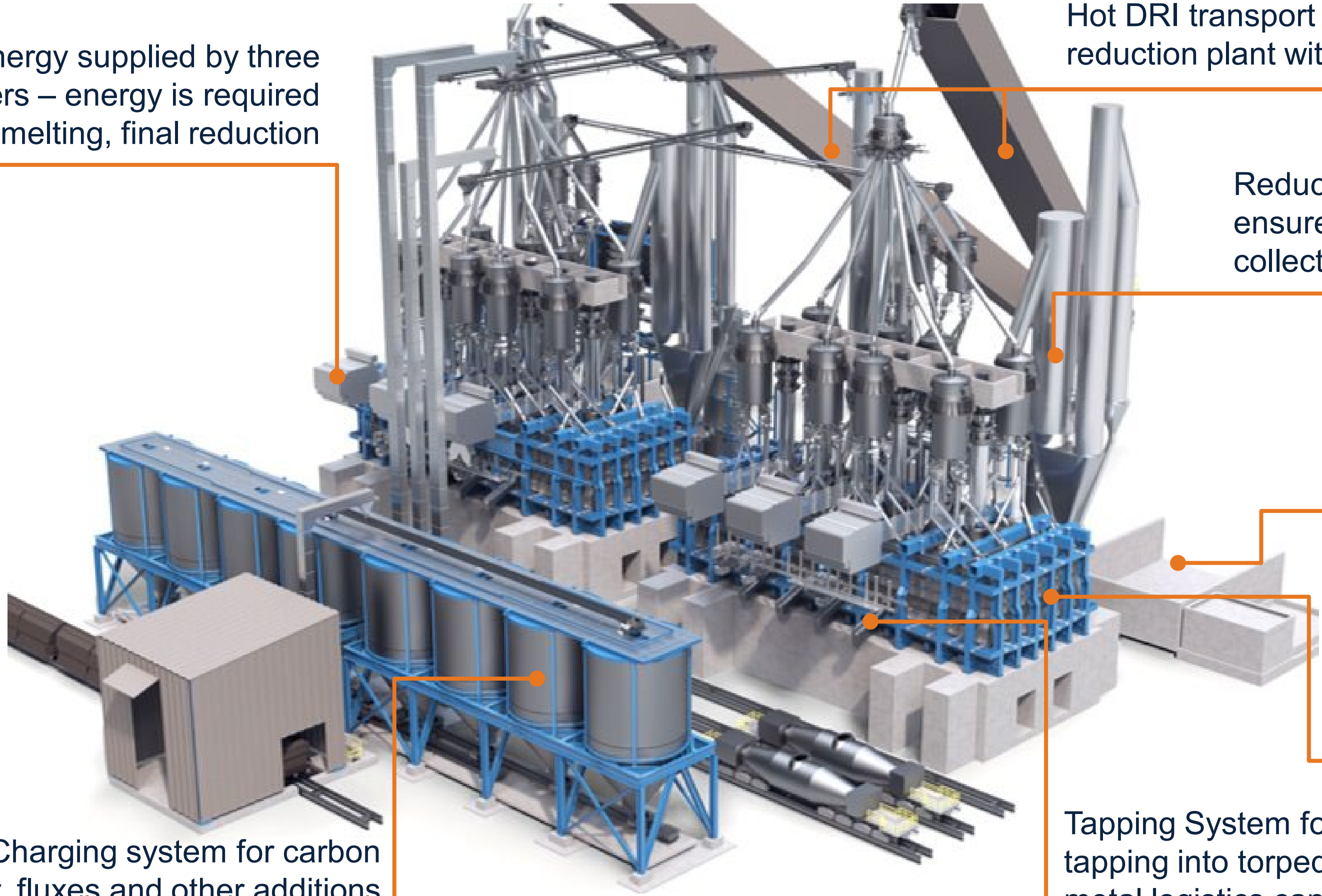
2,5mta Plant => 2x 90MW SMELTER

Electrical energy supplied by three transformers – energy is required for melting, final reduction

Hot DRI transport connects direct reduction plant with Smelters

Reducing atmosphere in the furnace ensures CO rich off gas – off gas is collected and prepared for further usage.

Slag is adjusted to fit for application in cement industry. Slag is tapped on one side and granulated right after tapping.

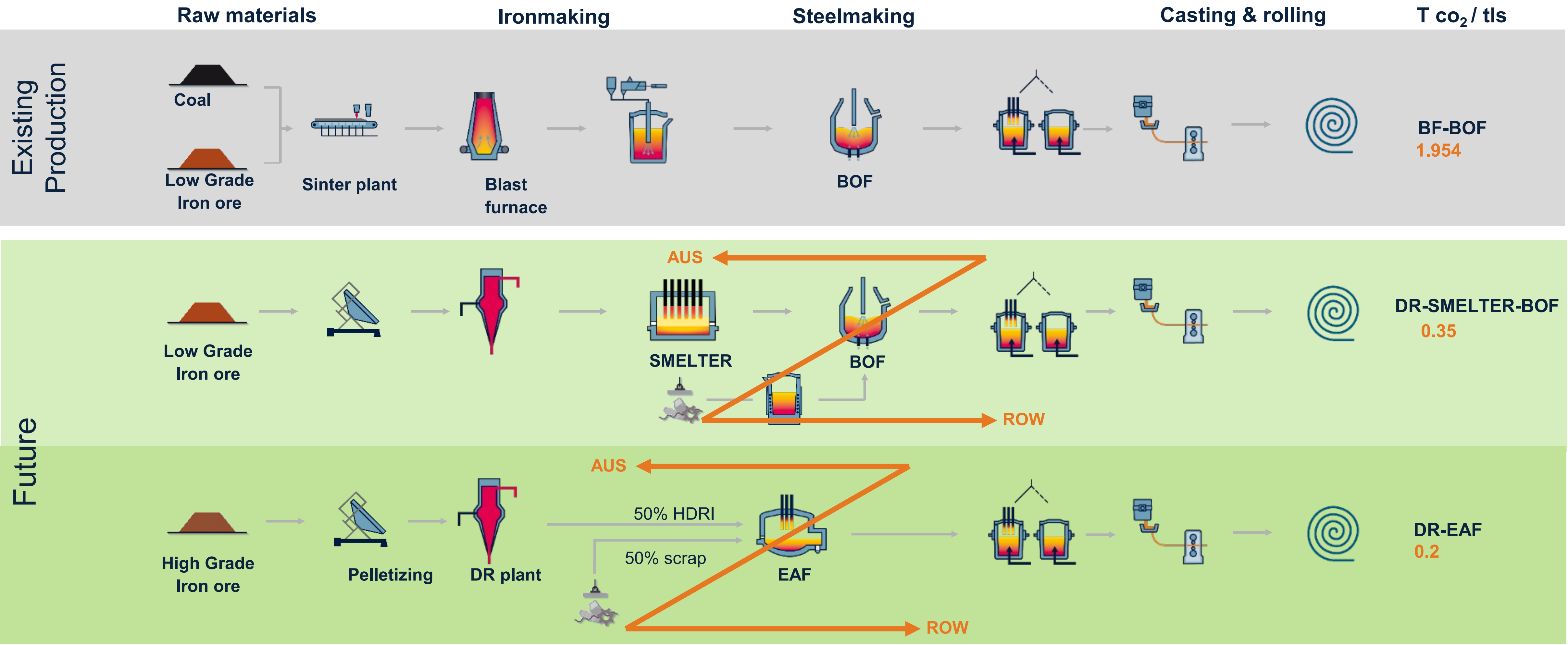


Large furnace ensure big surface between slag and metal and good slag reduction, big hot heel to buffer hot metal before tapping as well as long refractory lifetime

Charging system for carbon carrier, fluxes and other additions (e.g. recycling materials, scrap)

Tapping System for hot metal tapping into torpedo car. Existing hot metal logistics can be reused

Australia Scenarios



Contact

Martin Smith

T +886 7 5361750
E martin.p.smith@primetals.com

Primetals Technologies Austria GmbH Taiwan
Representative Office
No. 7, Siwei 4th Rd., Lingya Dist.
80247 Kaohsiung
Taiwan

primetals.com

THANK YOU