AIST MENA

Member Chapter Webinar

Steel Industry Transformation: From Carbon to Green

Revolutionizing Ironmaking: An Overview of Stegra’s Direct Reduction Plant

Organized by AIST Association for Iron & Steel Technology MENA

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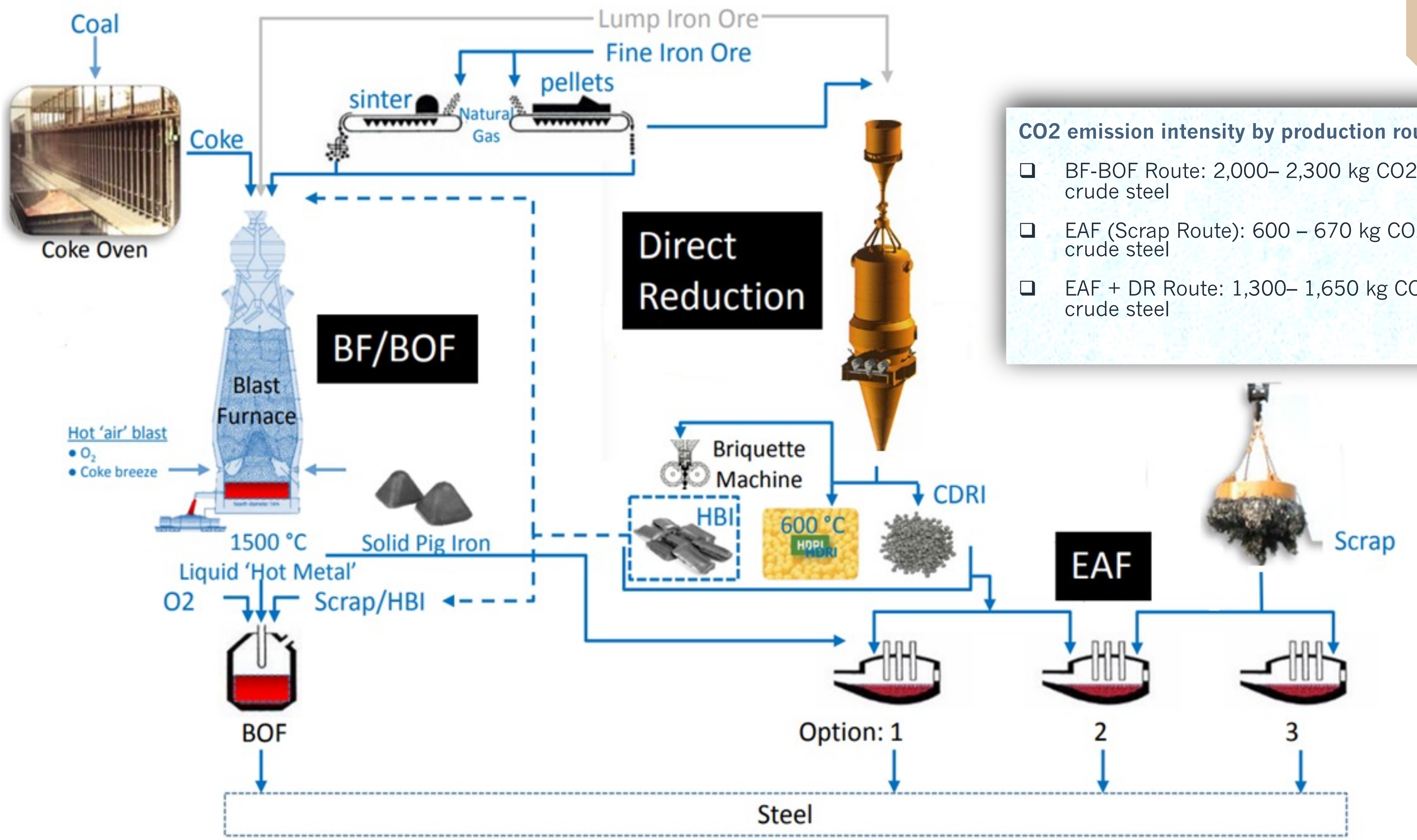
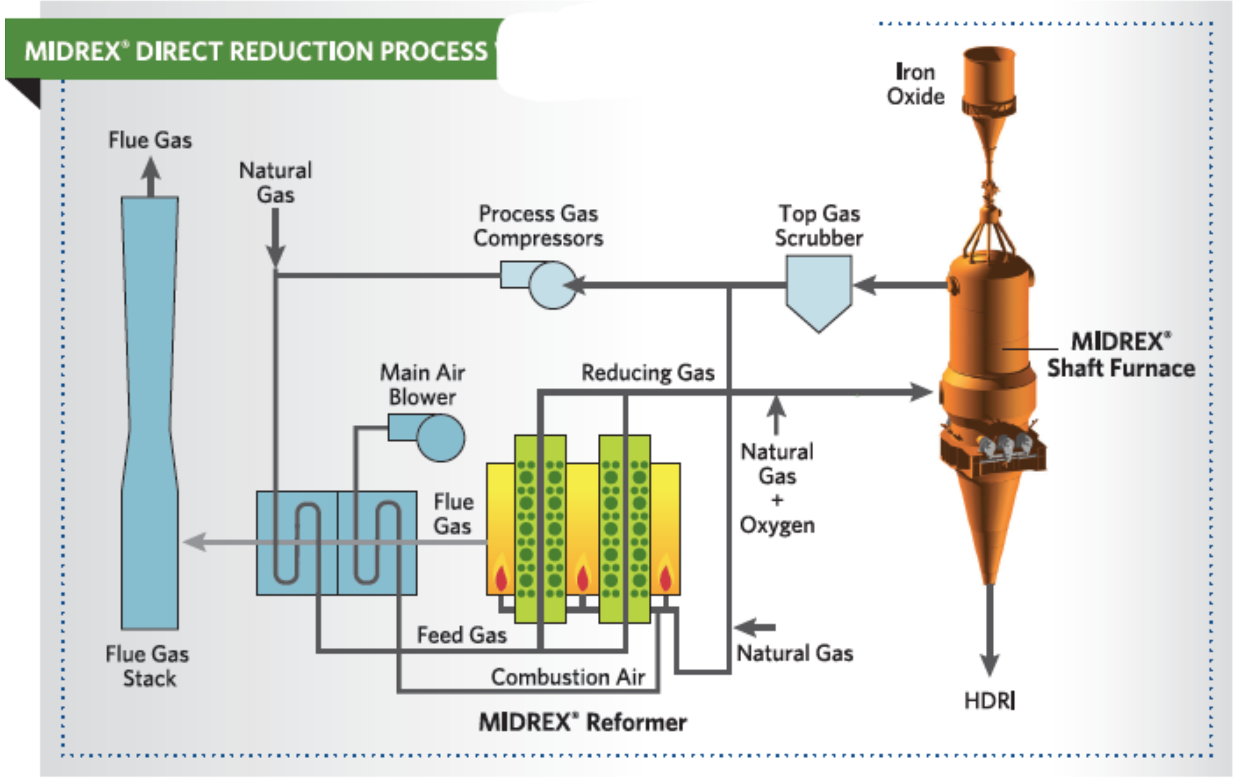


CO_2 emission intensity by production route

- BF-BOF Route: 2,000– 2,300 kg CO_2/ton of crude steel
- EAF (Scrap Route): 600 – 670 kg CO_2 / ton of crude steel
- EAF + DR Route: 1,300– 1,650 kg CO_2/ton of crude steel

Overview of Steel Making Process



Standard DRI plants based on Natural Gas

Over 100 Midrex DRI plants worldwide based on natural gas.

Reformer Process:

- Generates reducing gas from natural gas, recycled CO_2, and H_2O.
- Composition: 55% H_2, 36% CO (H_2/CO ratio ~1.5).

Syngas Options: Operates with H_2/CO ratios from 0.4 to 3.5.

Reduction Furnace:

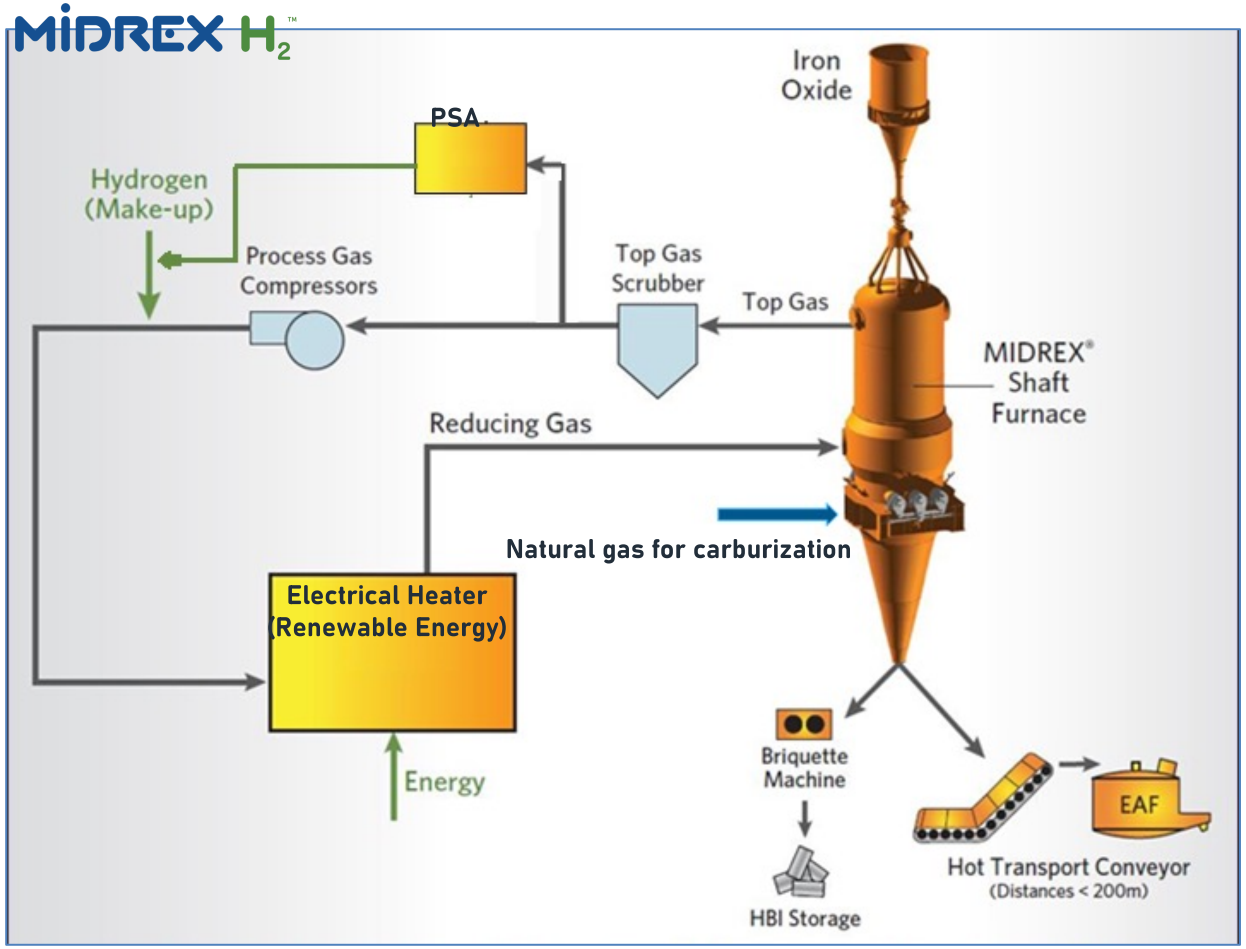
- Gases enter from bottom, pellets from top.
- Gas inlet temperature: 900-980°C.

Emissions:

- CO_2 emissions: ~600 kg/ton.

Challenges:

- High hydrogen costs prevent large-scale hydrogen-based DRI facilities.



Key Features of Stegra's DRI Plant:

Innovation: First of its kind using green H2 for reduction.

Capacity: 2.1 MTPA.

Product Types:

- Hot DRI + Green Merchant HBI.
- HDRI continuously charged to the EAF via a hot transport conveyor.
- Green HBI for sale and in-house consumption.

Furnace Design: Established Shaft Furnace design.
7.15m Hot Discharge Furnace

Gas Composition:

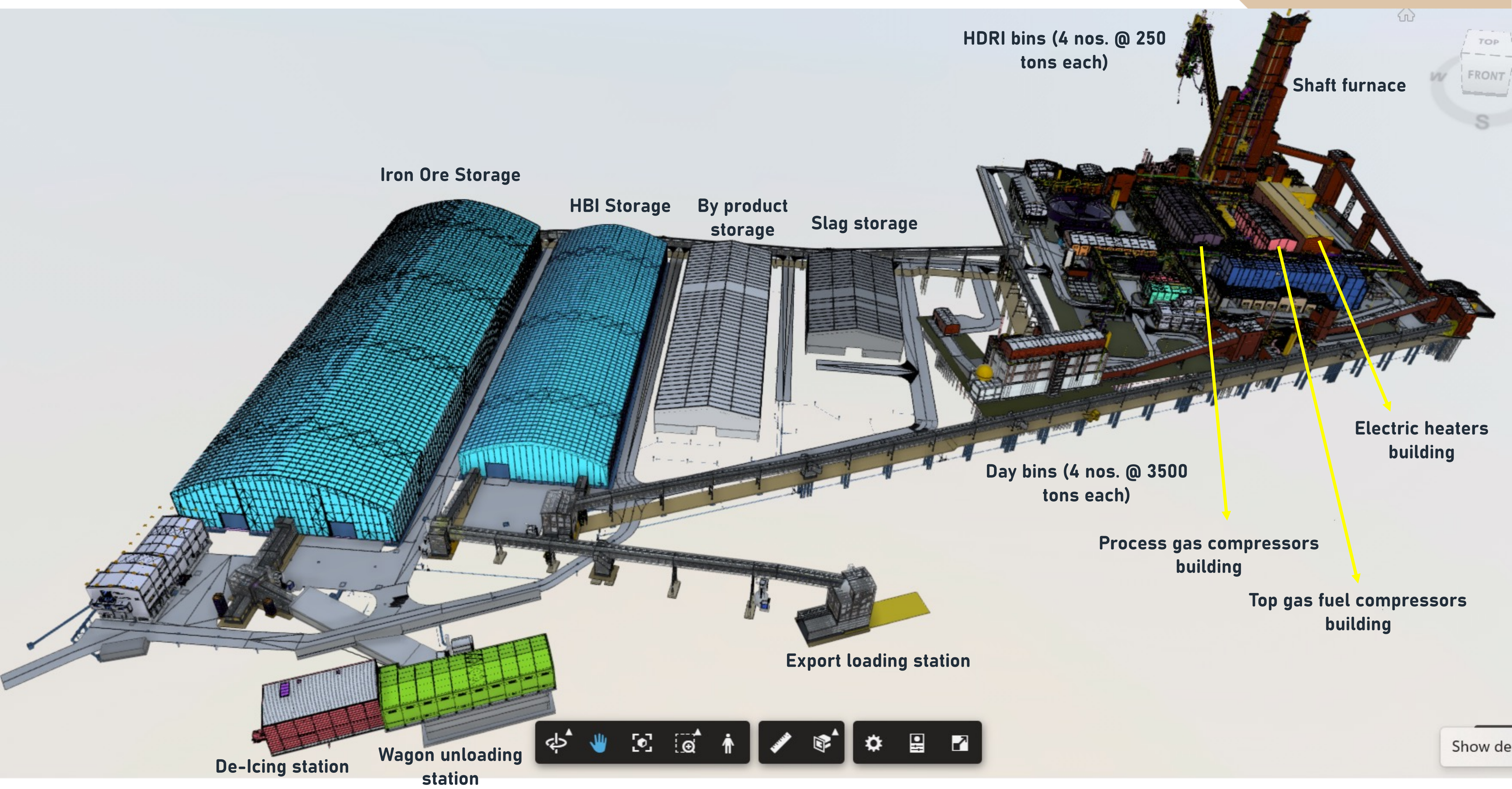
- For 1.3% carbon in DRI: ~85% hydrogen, balance CO, CO2, H2O, CH4, N2.
- 100% hydrogen usage possible; carbon in DRI optimized with the melt shop.

Electrical Heating: Uses fossil-free electricity for heating.
15 Midrex (Tutco) Electric Heaters

Hydrogen Recovery: PSA unit.

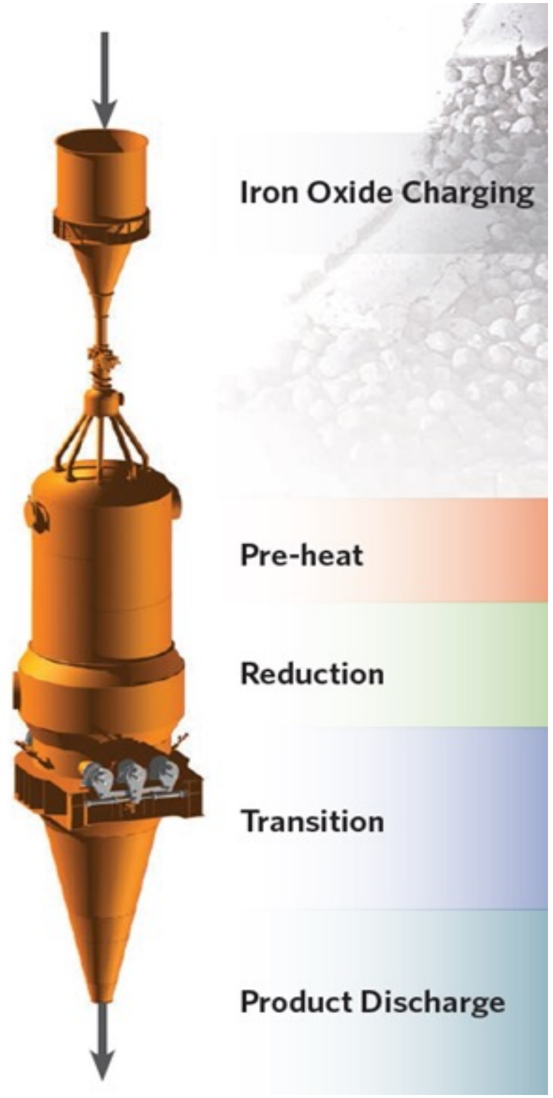
CO2 Emissions:

- 50 Kg CO2/t DRI (carburized DRI case).
- 90% or greater CO2 emissions reduction.


HDRI bins (4 nos. @ 250 tons each)
Shaft furnace
Iron Ore Storage
HBI Storage
By product storage
Slag storage
Electric heaters building
Day bins (4 nos. @ 3500 tons each)
Process gas compressors building
Top gas fuel compressors building
Export loading station
De-Icing station
Wagon unloading station
TOP
FRONT
Show de

May 2026

Furnace Design Aspects Using Hydrogen



Adaptability:

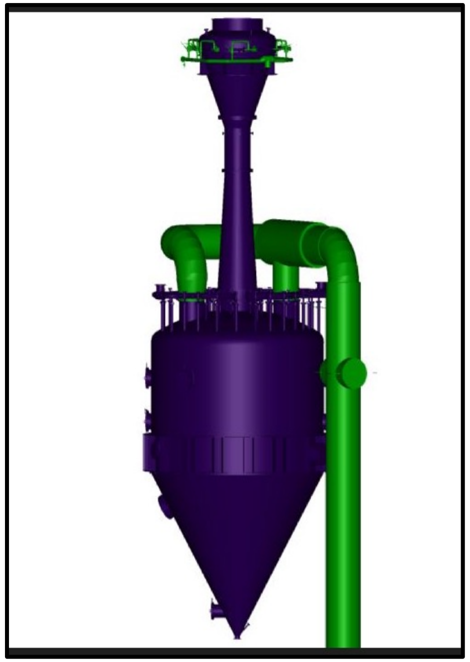
- Existing shaft furnaces require no fundamental changes for full range hydrogen addition.
- Reduction kinetics improve with higher hydrogen levels.

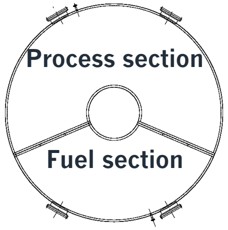
Thermal Considerations:

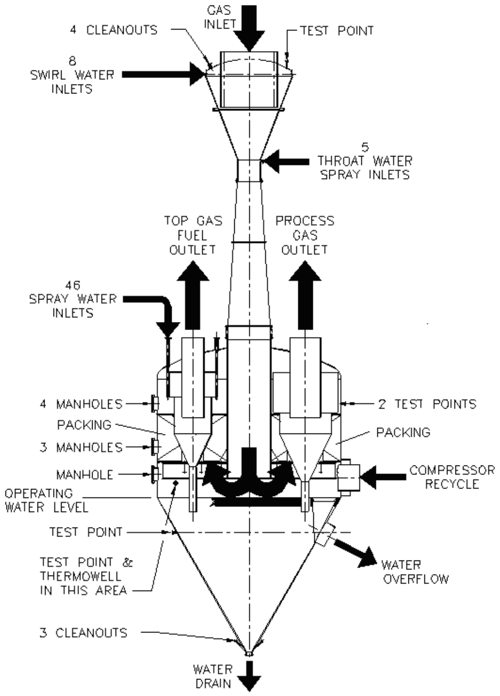
- Increasing hydrogen increases the endothermic load in the furnace.
- The reduction furnace operates as an adiabatic reactor, requiring more heat input to sustain the reduction process.

Heat Input Methods:

- **Raise Reducing Gas Temperature:**
  - Increase the sensible energy entering the reduction furnace.
- **Increase Reducing Gas Flow:**
  - Raise the total energy (or thermal mass) entering the furnace by increasing the reducing gas flow per ton at any given temperature.







Design Changes for Top Gas Scrubber with H2-DRI

Increased Water Vapor:

- Higher hydrogen levels in reducing gas increase water vapor in the top gas.
- Results in higher condensation heat load in the scrubber.

Water Flow Requirements:

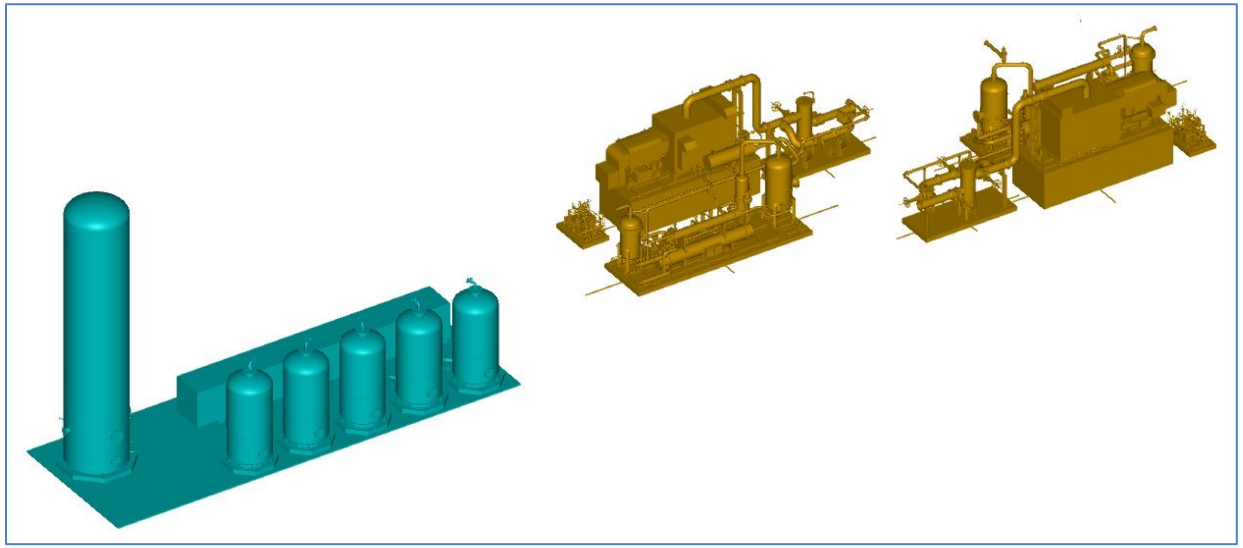
- Increased water flow needed for the packing.
- Generates more water for the system to handle.

Process Water Demand:

- **Cold Process Water:** Demand increases due to higher condensation heat load.
- **Hot Process Water:** Demand decreases as exit gas temperature from the scrubber decreases with more hydrogen addition.

Top Gas Fuel (TGF) Flowrate:

- Even in carburizing cases with high TGF generation, TGF flowrate is less than 10% of the gas stream exiting the scrubber.
- With 0% DRI carbon condition, very little TGF is generated, further reducing flowrate.



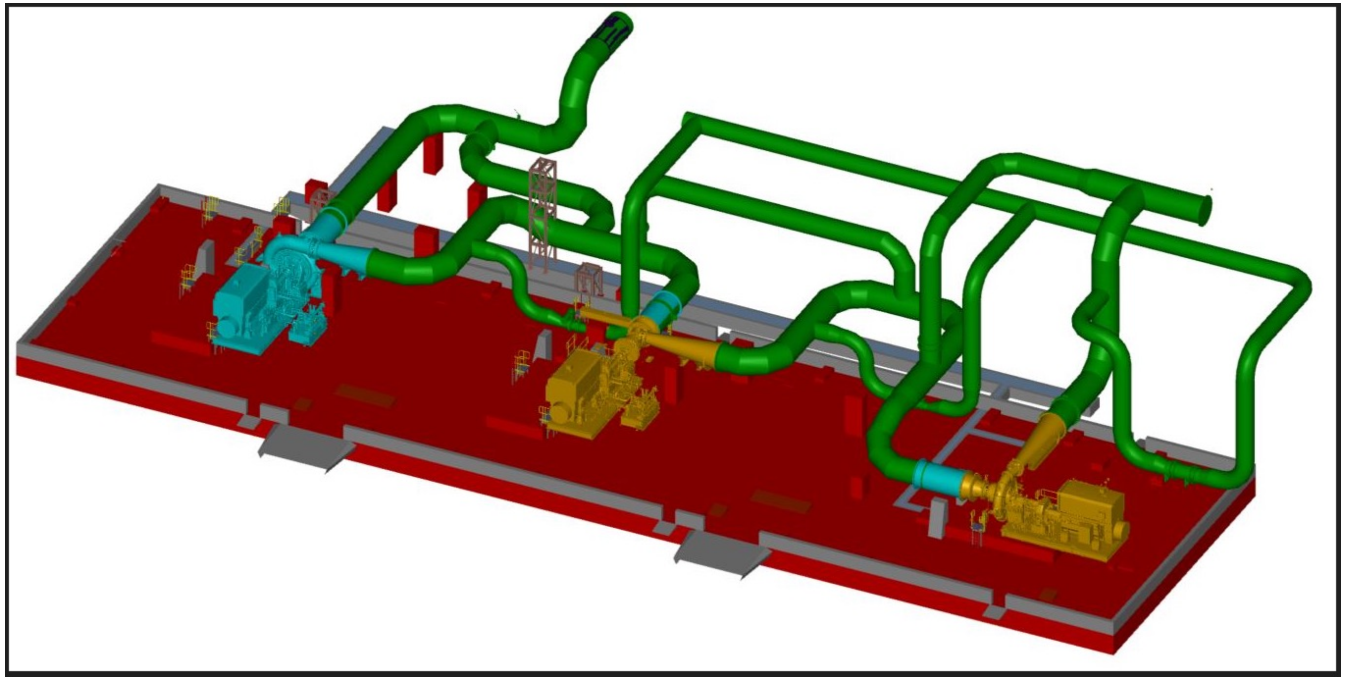
Hydrogen Recovery with Pressure Swing Adsorbers

Components:
- **Top Gas Fuel Compressors**
- **Pressure Swing Adsorption (PSA)**

Hydrogen Recovery:
- Produces high purity PSA product stream (99.5% H_2).
- Reduces overall make-up H_2 consumption.

Utilization of PSA Tail Gas:
- PSA tail gas can be utilized elsewhere in the process or within the steel complex.

Operational Flexibility:
- Turndown capability to adjust based on DRI product carbon requirements.



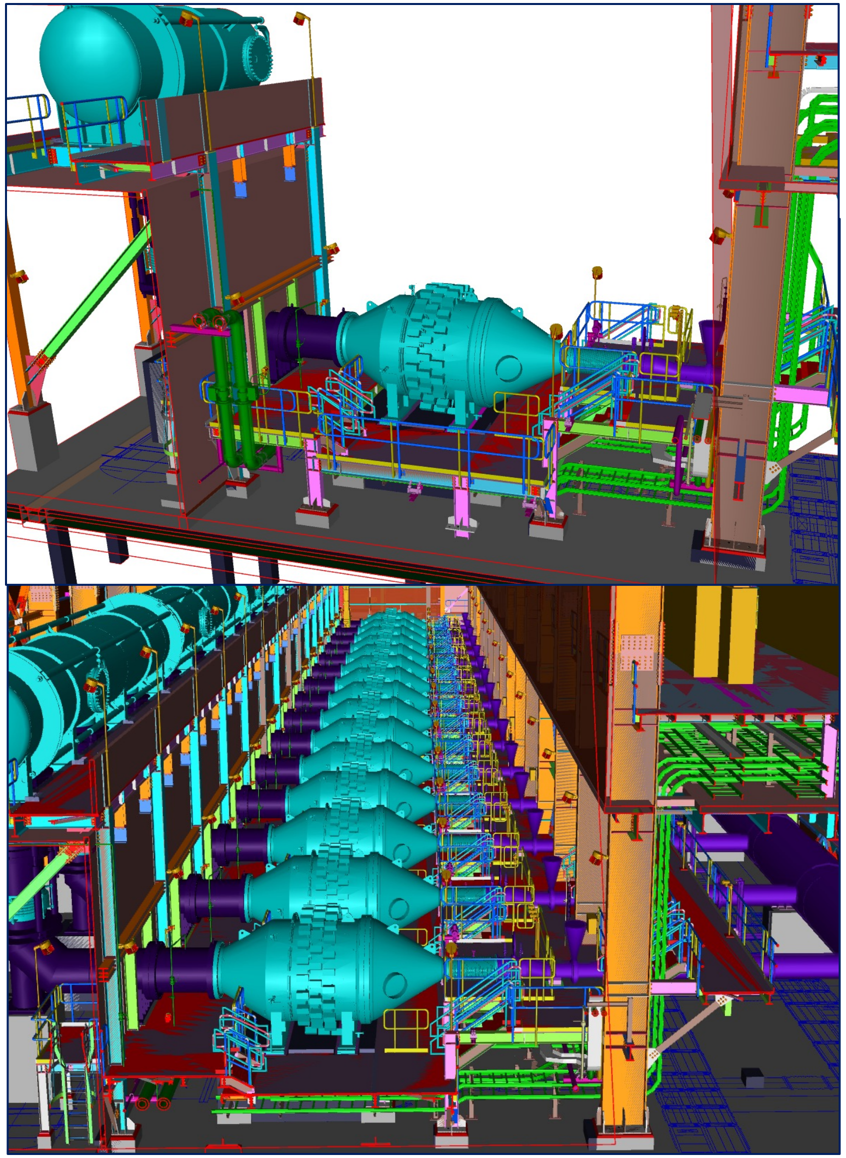
Process Gas Compressor Design Changes for H2-DRI Module

Increased Flow Requirements:

- Utilizing 100% H2 as the reductant increases the total recirculating Process Gas flowrate.
- Hydrogen reduction is more endothermic than reduction by carbon monoxide, necessitating higher Process Gas flowrate to maintain the energy balance (thermal mass) in the shaft furnace.

Compression Stages:

- The increased PGC flowrate, coupled with the lower molecular weight (MW) of the circulating gases, requires the addition of a 3rd compression stage in the PGC arrangement on the MIDREX H2 flowsheet.



Electrical Heaters for H2-DRI Setup

Efficiency and Sustainability:

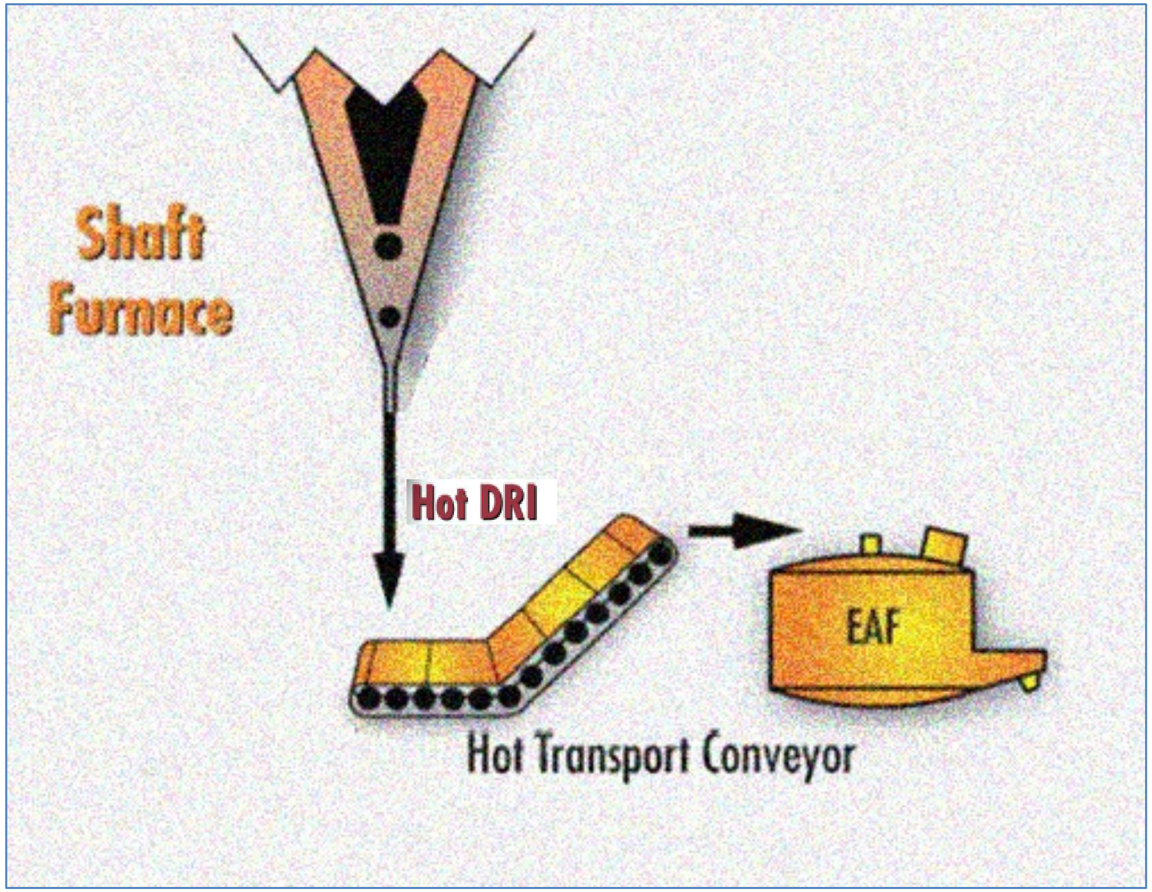
- Provides sensible heat energy for reducing gas via direct electrical heating, offering increased efficiency compared to the gas-fired route.
- Eliminates the need for fossil fuels, significantly reducing CO2 footprint.

Design Features:

- **Modular Design:** Consists of 15 electric heating vessels.
- **Control:** Equipped with dedicated control panels.
- **Safety:** Over Temperature Protection ensures heater element safety.

Performance:

- Capable of providing reducing gas temperatures in excess of 900°C.
- No heat recovery system required.



Get it While It's HOT: Benefits of HDRI Charging

Enhanced Efficiency:

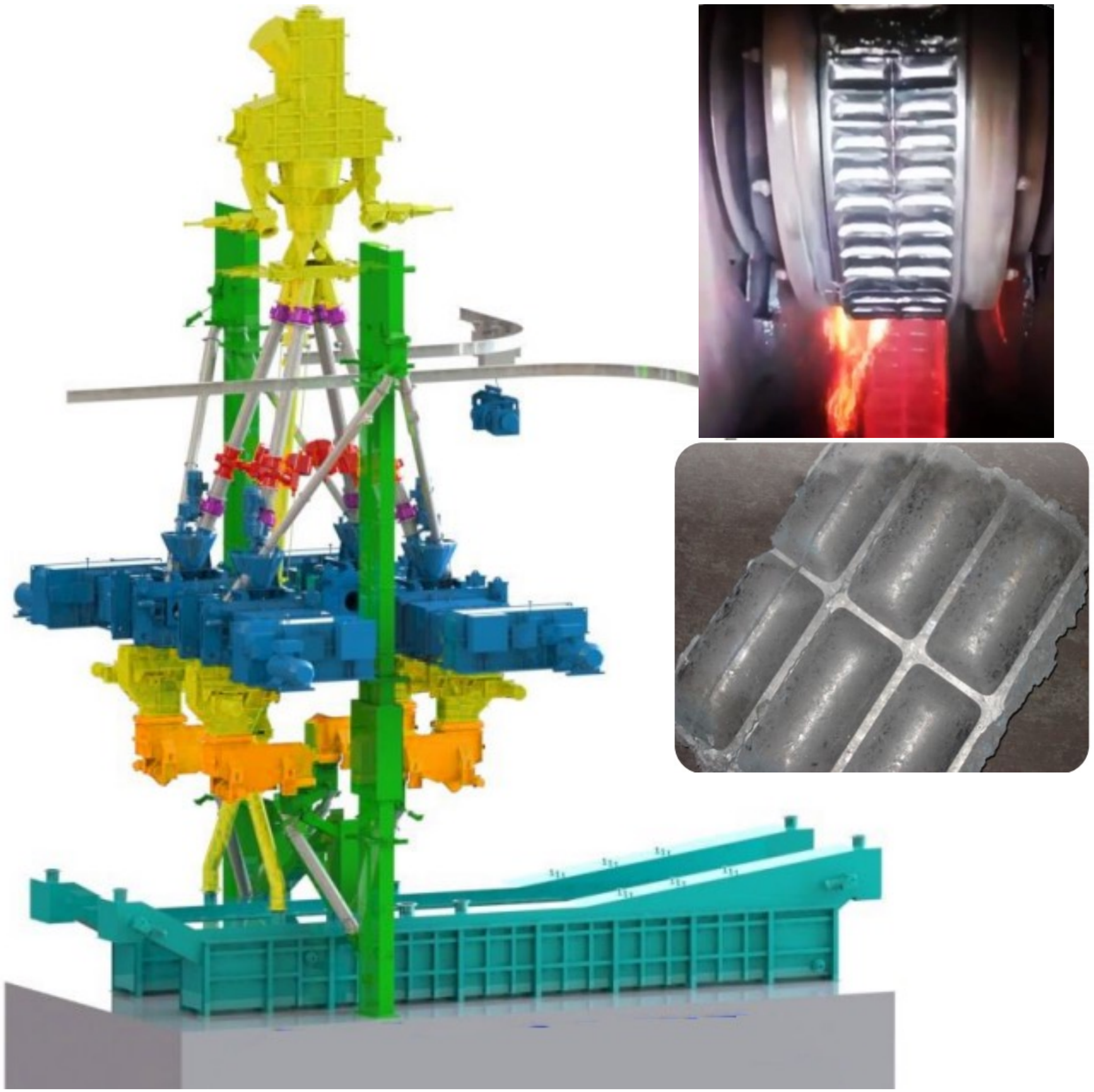
- **High Temperature:** HDRI supplied at 600°C+ directly to the steelmaking plant.
- **Energy Savings:** Reduces specific energy consumption by 130-150 kWh/ton of liquid steel.
- **Electrode Savings:** Reduces electrode consumption by 0.5-0.6 kg/ton of liquid steel.
- **Refractory Savings:** Decreases EAF refractory consumption by 1.8-2 kg/ton of liquid steel.

Increased Productivity:

- **Faster Processes:** Reduces tap-to-tap time, boosting productivity by up to 20% compared to ambient temperature DRI charging.

Environmental Impact:

- **Lower Carbon Emissions:** Further reduces carbon emissions by hot charging DRI to the EAF.



PHYSICAL ANALYSIS	
Bulk Density (Ton/M3)	2.4 ~ 2.7
Apparent Density (Ton/M3)	5.0 Min
Average Size (mm)	106 x 48 x 32
Size Under 1/4 Inch at Loading Port	5.0% Max
CHEMICAL COMPOSITION	
Total Iron (T. Fe)	91.37 – 92.48%
Metallic Iron (M.Fe)	85.89 – 86.93%
Metallization	94%
Carbon (C)	Max 1.3%
Phosphorous (P)	0.033 – 0.052%
Sulphur (S)	0.01 – 0.02%
Total Gangue (CaO+Al2O3+MgO+SiO2)	4.51 – 5.61%
Very low levels (0.02%) of residual elements like Cu, Sn, Ni, Cr	

Green HBI Quality Specification


Stegra
This is the end of an era,
and the beginning of a new one.