

Blast Furnace Decarbonization by using Metallics

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Introduction

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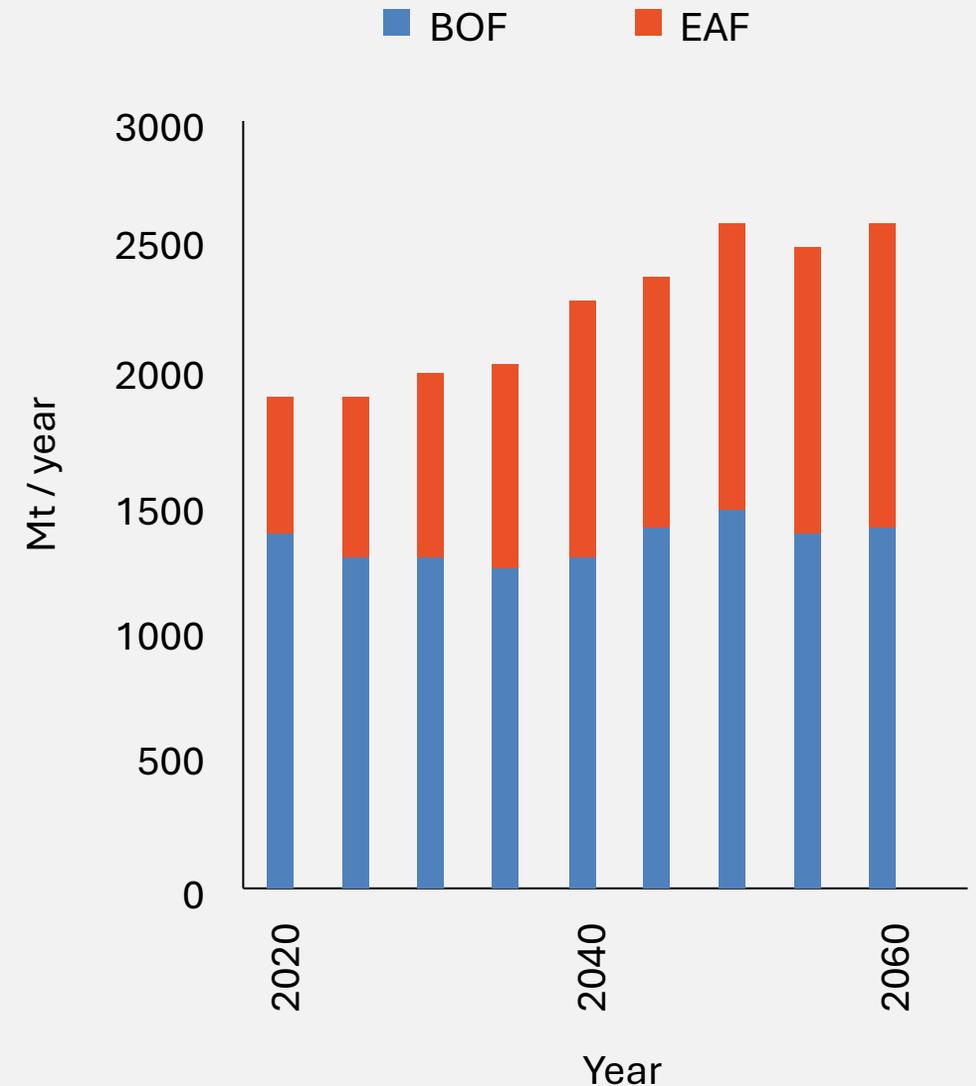
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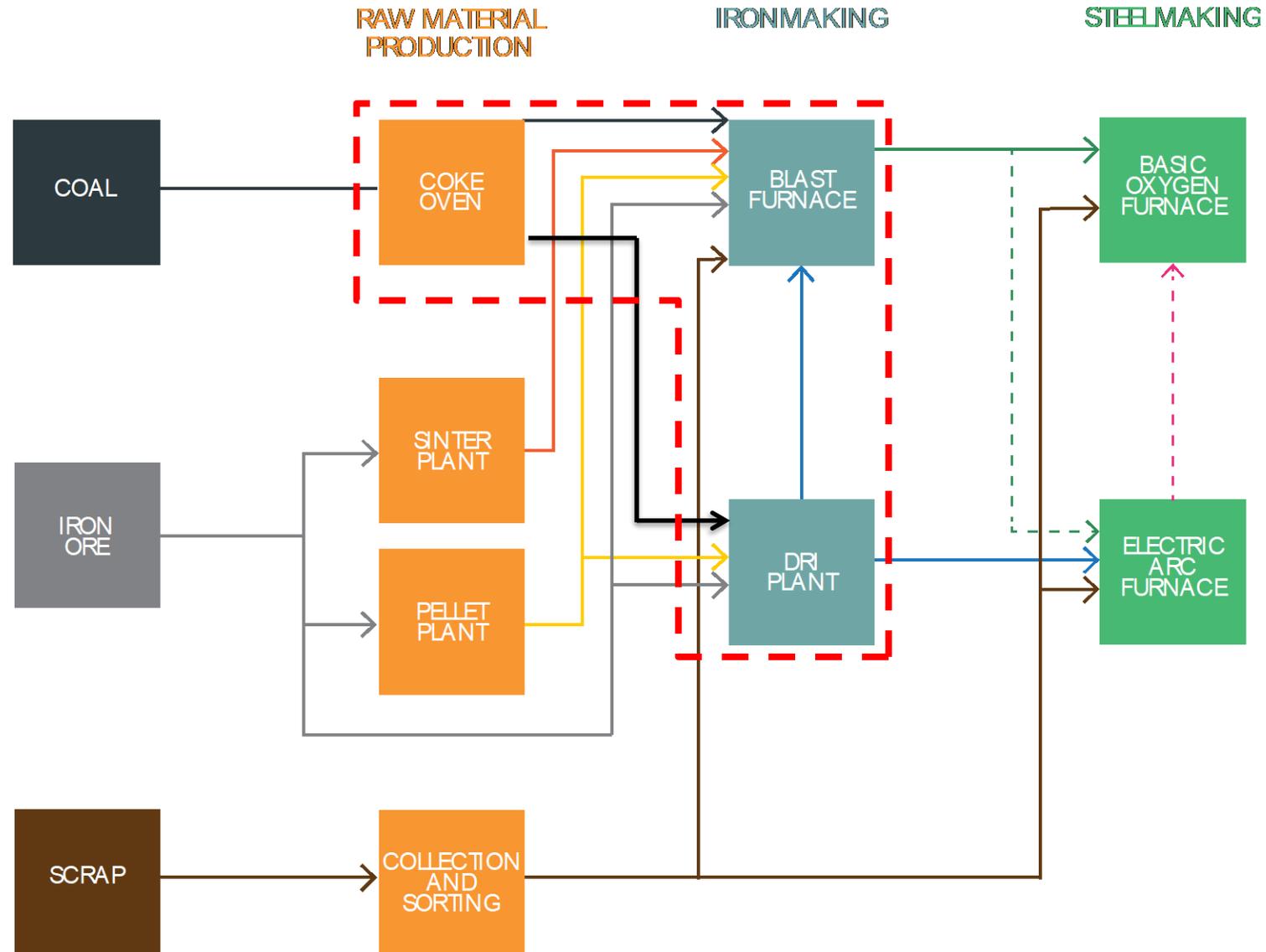
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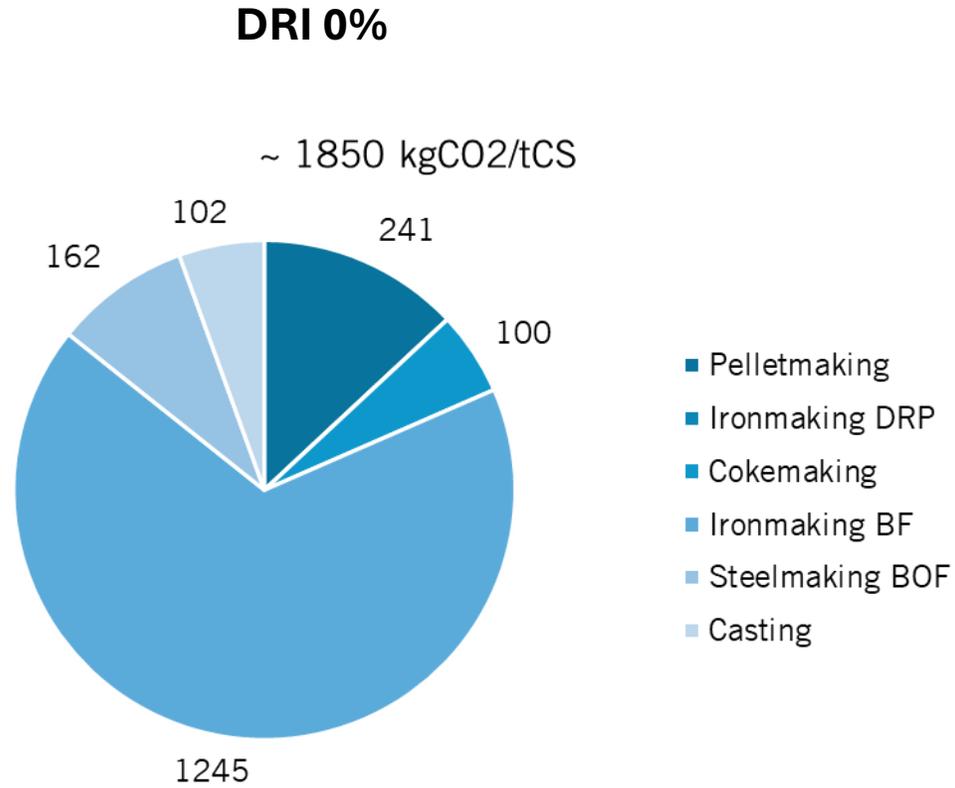
CO₂ emissions reductions requirements will have a significant effect on our industry due to its **challenges**.

- > Green electricity
- > Availability of high-grade ores
- > Hydrogen infrastructure
- > Scale-up of new technologies
- > CAPEX and OPEX
- > Green steel premium
- > Time

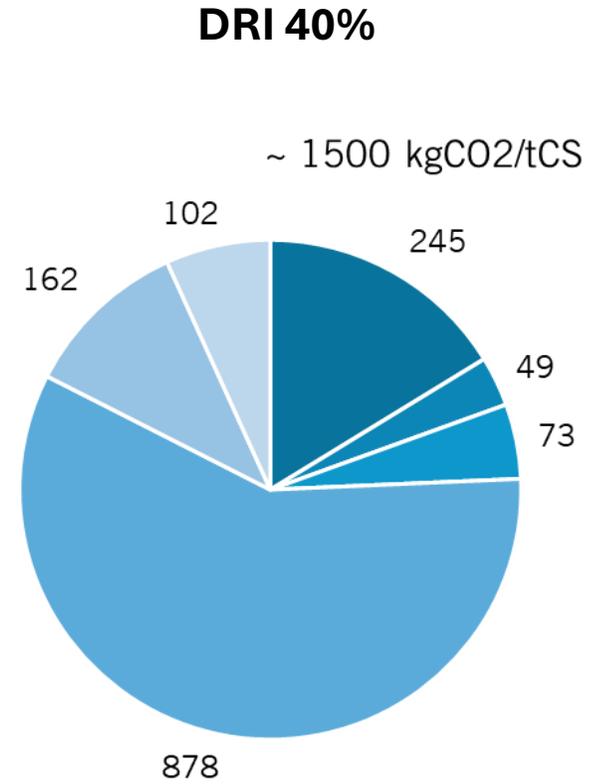
It also drives **innovation** and **development** of new technologies.







Electricity Balance -/- 137 kWh/tCS



Electricity Balance +/+ 377 kWh/tCS

DRI made by using COG and BFG

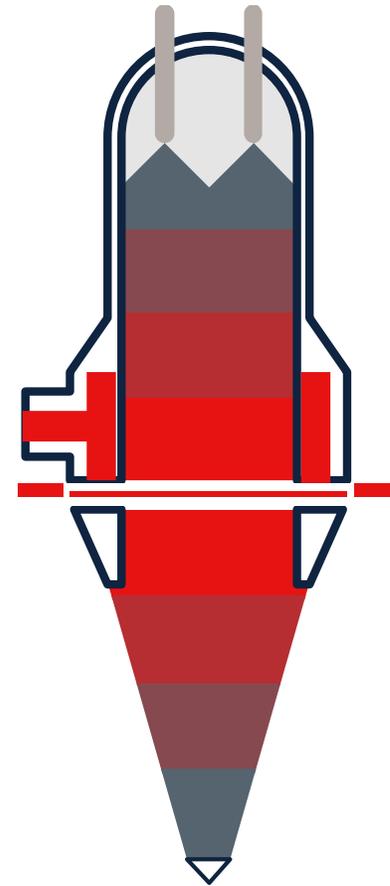
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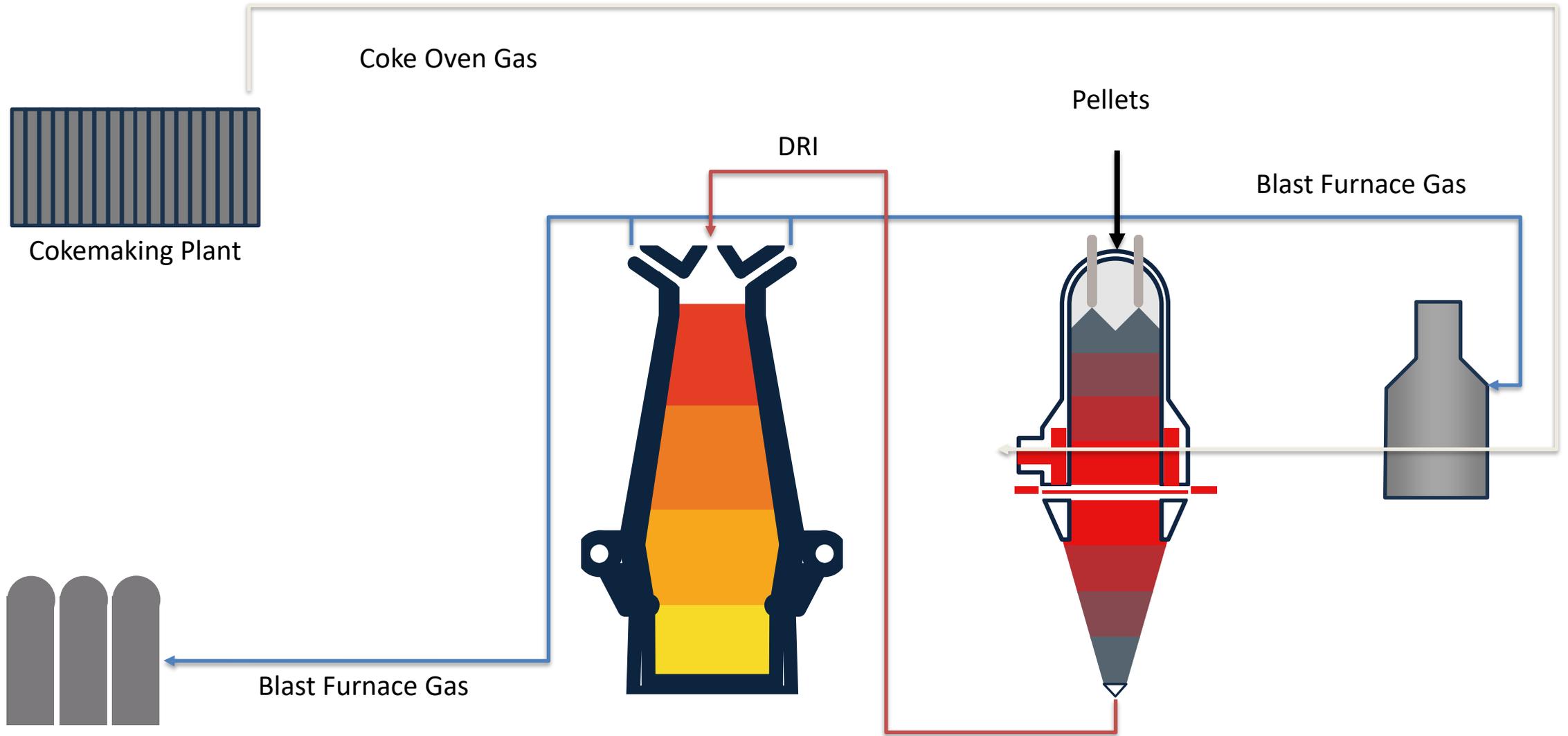
COG

	LHV kWh/Nm3	5.0
	LHV kJ/Nm3	18000
CO	Vol %	5.3%
CO2	Vol %	1.2%
CH4	Vol %	24.5%
H2	Vol %	59.7%
H2O	Vol %	2.9%
N2	Vol %	3.6%
C2H6	Vol %	2.4%
C3H8	Vol %	0.2%
C4H10	Vol %	0.2%
Production	Nm3/tCoke	500

BFG

	LHV kWh/Nm3	0.8 - 1.0
	LHV kJ/Nm3	3000 - 3500
CO	Vol %	23.7%
CO2	Vol %	23.2%
CH4	Vol %	0.0%
H2	Vol %	5.1%
H2O	Vol %	7.2%
N2	Vol %	40.8%
C2H6	Vol %	0.0%
C3H8	Vol %	0.0%
C4H10	Vol %	0.0%
Production	Nm3/tHM	1200 - 1600

COG/BFG in typical integrated contemporary steelmaking plants are used for cokemaking, hot blast stoves, reheating furnace(s) and generation of electricity. These gases could also be used as reducing gas to produce DRI and fuel for the associated PGH. COG also includes naphthalene, tar and BTX

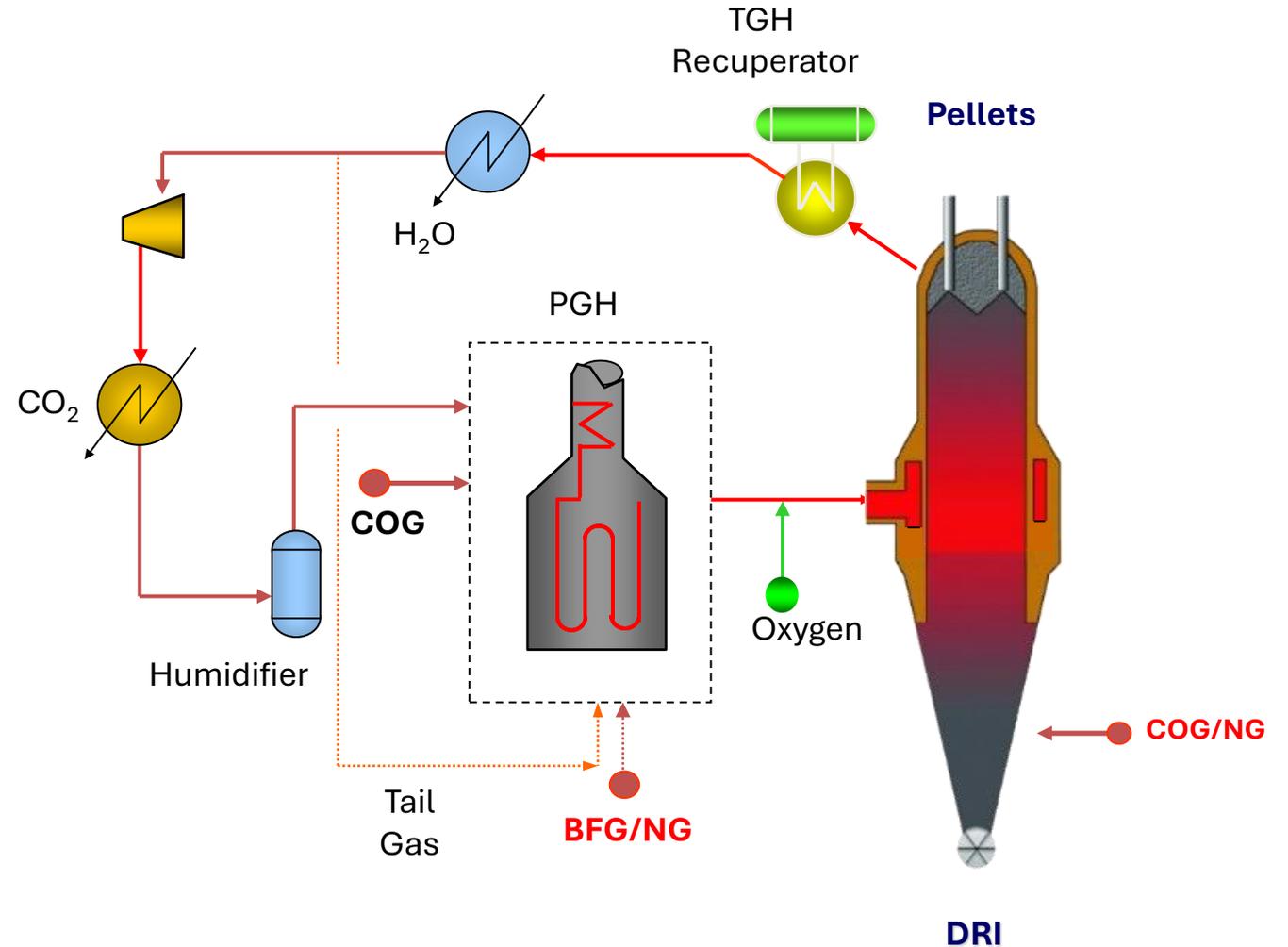


Depending on the impurities (heavy hydrocarbons, BTX) in COG, the make-up can be fed either to Reduction circuit and/or to Cooling zone of the DR reactor, where these compounds are destroyed.

COG BTX, naphthalene, heavy hydrocarbons can be processed (and destroyed) in the ENERGIRON process through a patented scheme configuration.

The patented scheme has been tested under the following scenarios:

- > Pilot plant tests; 1978-1982, 1997
- > Laboratory tests at AHMSA to prove destruction of BTX with hot DRI; 1980's
- > Tests were carried out in 2008 in Poland in a joint effort with ArcelorMittal to confirm the above.





HBIS 0,5MTPY



Baowu 1.0 MTPY

DRI Quality

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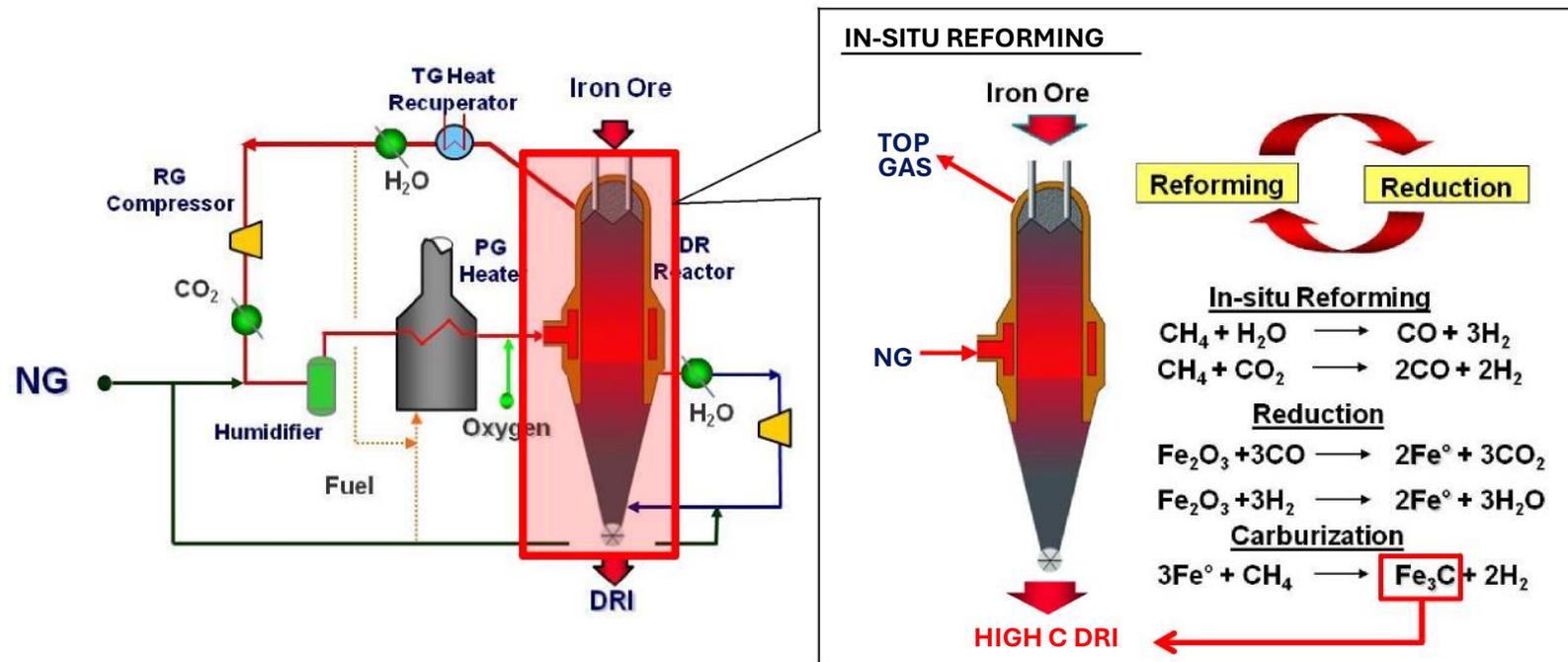
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- > ENERGIIRON-ZR process is the most advanced and flexible DR process proven at industrial scale due to the absence of an external Reformer
- > ENERGIIRON-ZR can produce High C DRI because of “In-situ Reforming” that allows the gas reforming, the iron ore reduction and the carburization of DRI to take place inside the reactor simultaneously.



- > DRI has C content in the form of Fe_3C that prevents re-oxidation
- > DRI has higher reduction rate because of its porosity
- > DRI size is same as iron ore pellet which makes the handling to be easy
- > HBI size challenges melting time in the BF cohesive zone and process stability
- > High C DRI is more suitable for DRI charging to BF

		DRI	HBI
Apparent Density	(g/cm^3)	3.4 - 3.6	5.0 - 5.5
Porosity	(%)	50 - 54	26 - 33
Typical Size	(mm)	4 - 20 (diameter)	30 x 50 x 110

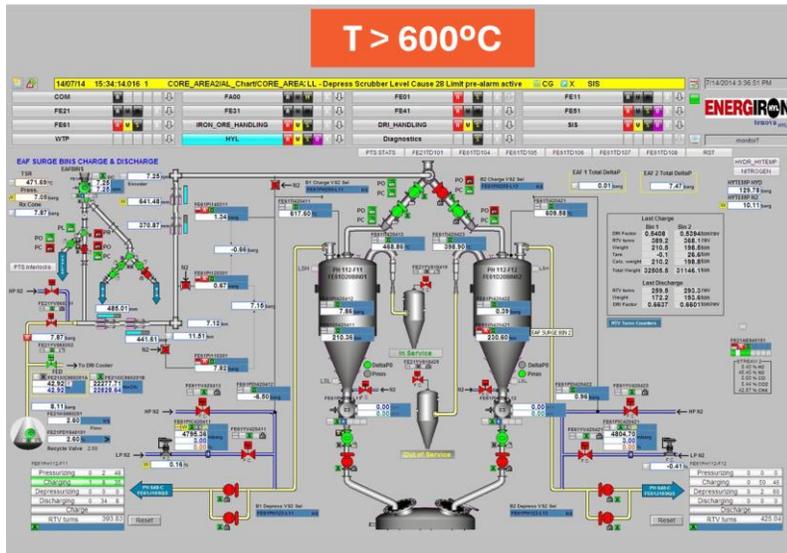
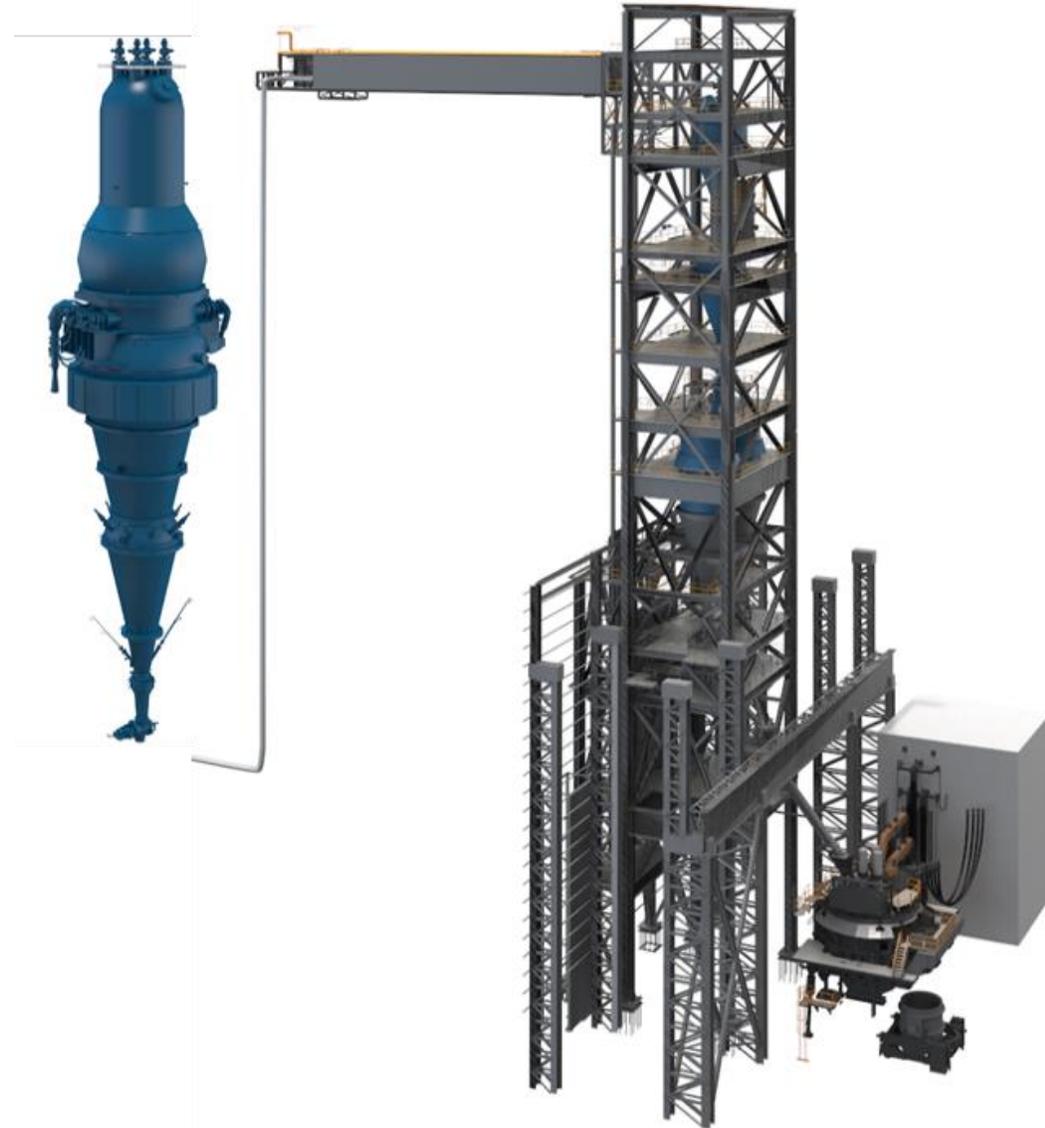


	BF-Grade Pellets	DRI (Fe 82%)
Fe total	62.0%	82.0%
Fe₂O₃	88.6%	
FeO		6.2%
Metallization		95.0%
Carbon		1.5%
SiO₂	4.5%	6.0%
Al₂O₃	0.9%	1.2%
CaO	5.5%	7.3%
MgO	0.3%	0.4%

Blast Furnace Decarbonization by using Metallics

- > Pneumatic transport system
- > Outstanding reliability and availability
- > Negligible maintenance requirements
- > Zero material/dust emissions
- > Minimum DRI temperature losses
- > Fully automated and integrated
- > Compliance with all safety regulations

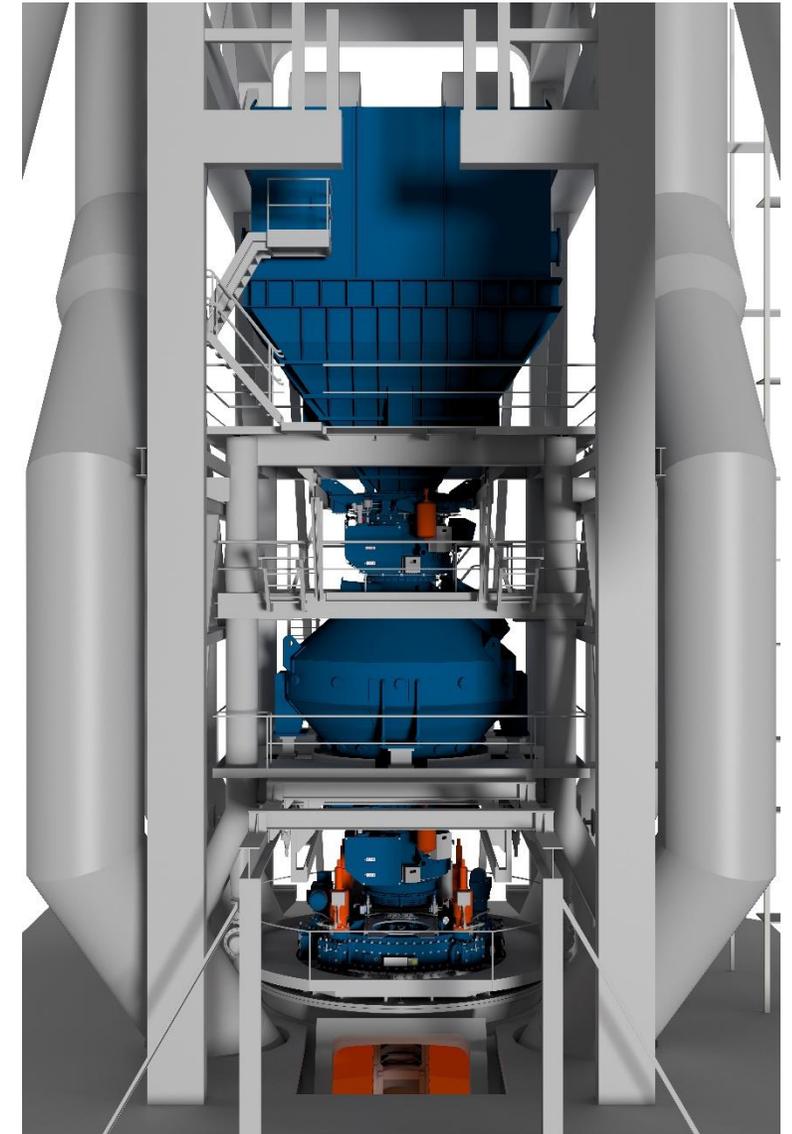
Hot DRI: HYTEMP System



- > Receiving Hopper
- > Upper Material Gate Valve and Seal Valve
- > Material Bins
- > Lower Material Gate Valve and Seal Valve
- > DANCU Distributor
- > Chute



Designed for raw material temperatures up to 700 °C



DRI in BF

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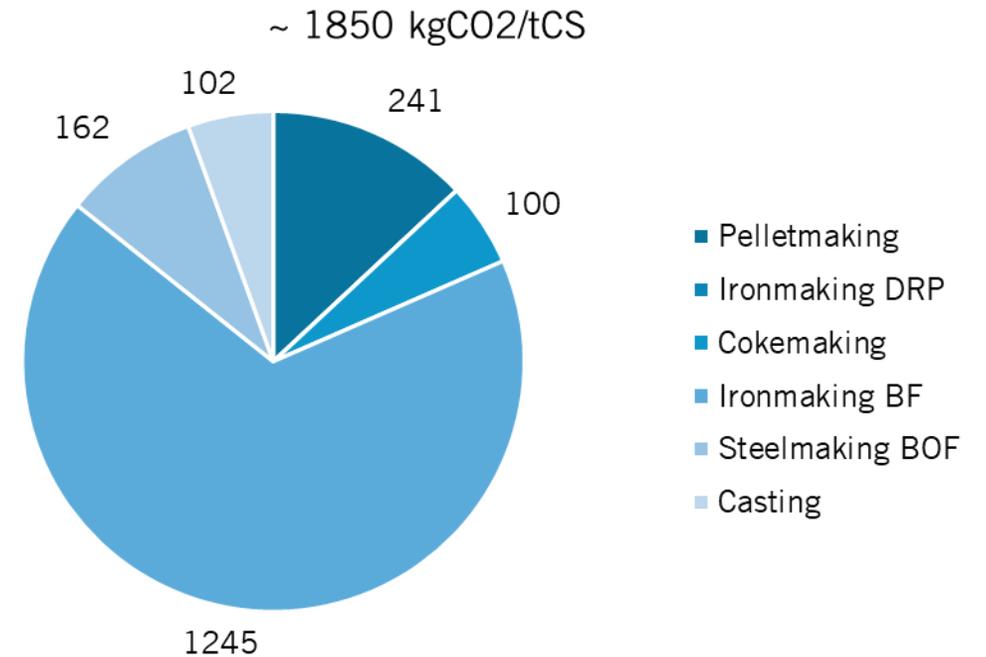
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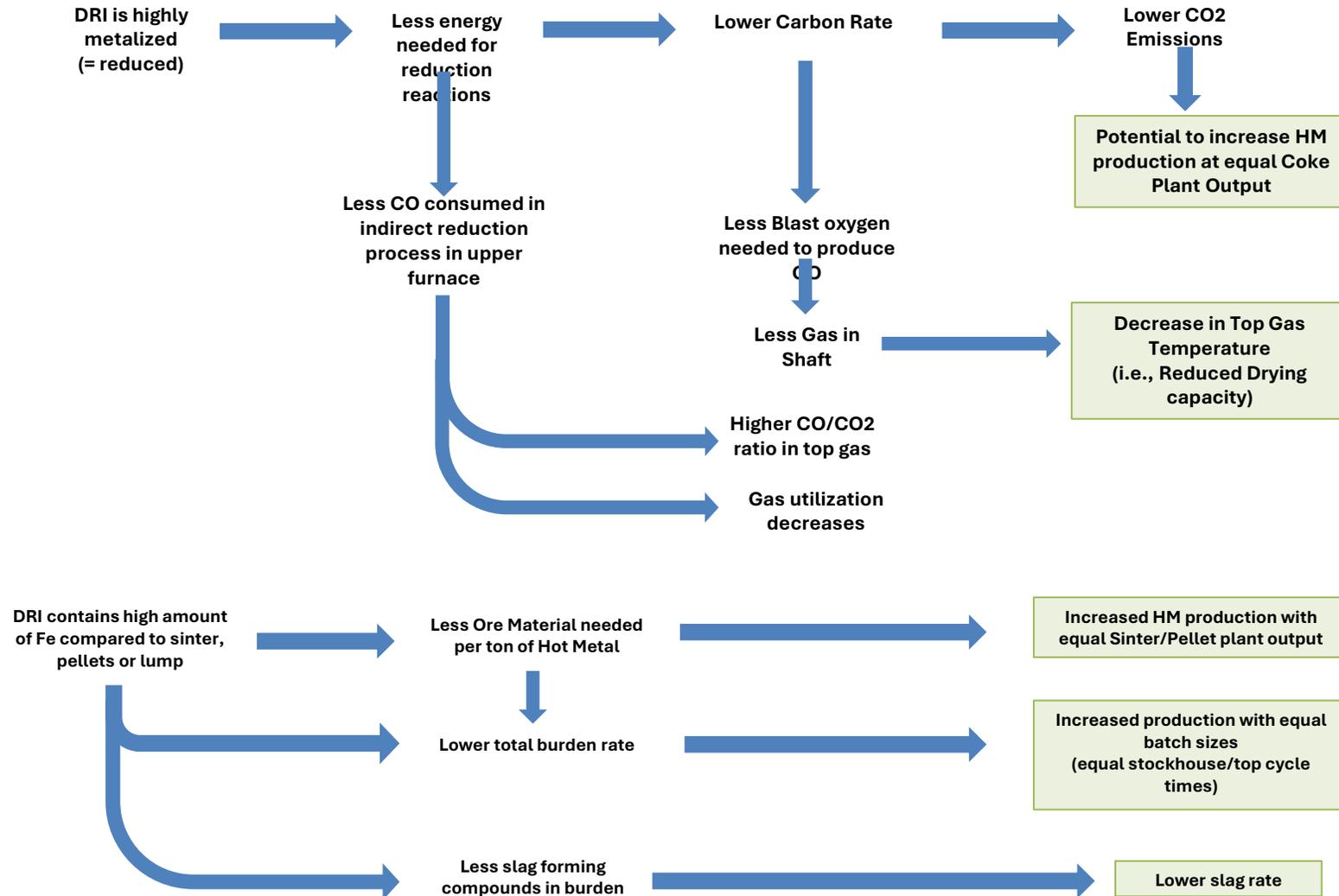
Pellets/Lump/DRI	%/%/%	95/5/0
Hearth Diameter	m	14
Production	tHM/d	11500
Productivity	tHM/m³WV.d	3.03
Coke Rate	kg/tHM	476
Coal Injection Rate	kg/tHM	-
RAFT	°C	2253
Top Gas Temperature	°C	122



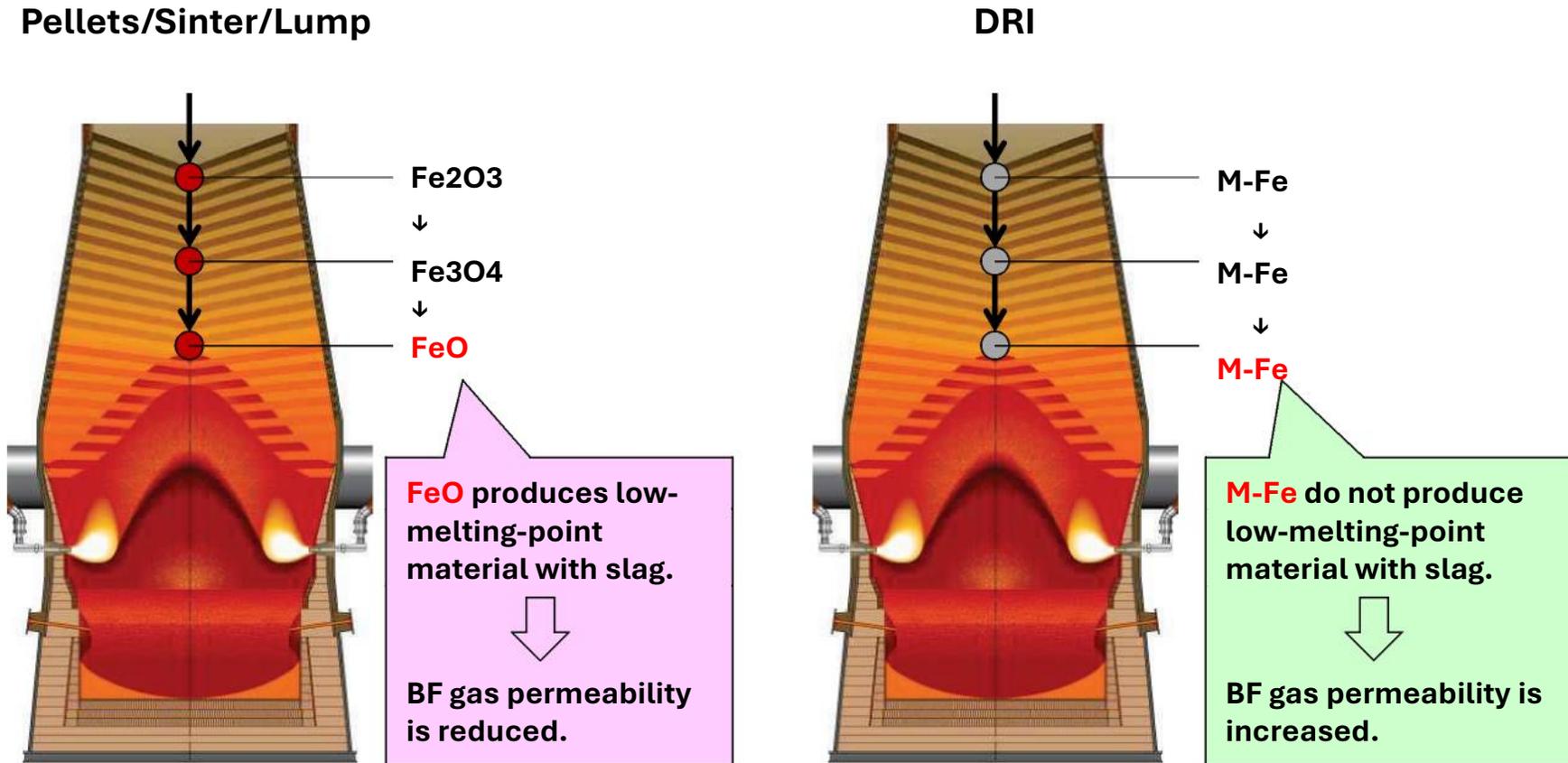
Blast Furnace Decarbonization by using Metallics

- > Carbon Rate
- > Top Gas Temperature
- > Gas Efficiency / Gas Utilization
- > Permeability, DP
- > Cohesive Zone / Melting
- > Productivity, Stability
- > Slag Rate / Composition
- > $[Si]_{\text{Hot Metal}}$

Effects of DRI in BF

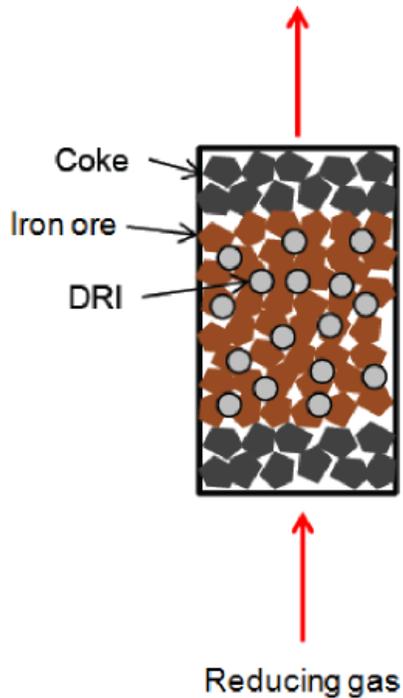


- > DRI charging operation increases the gas permeability of the cohesive zone because M-Fe in DRI reduces the amount of low-melting-point material. ΔP is decreased.
- > DRI particle size is superior to HBI and minimizes melting instabilities.



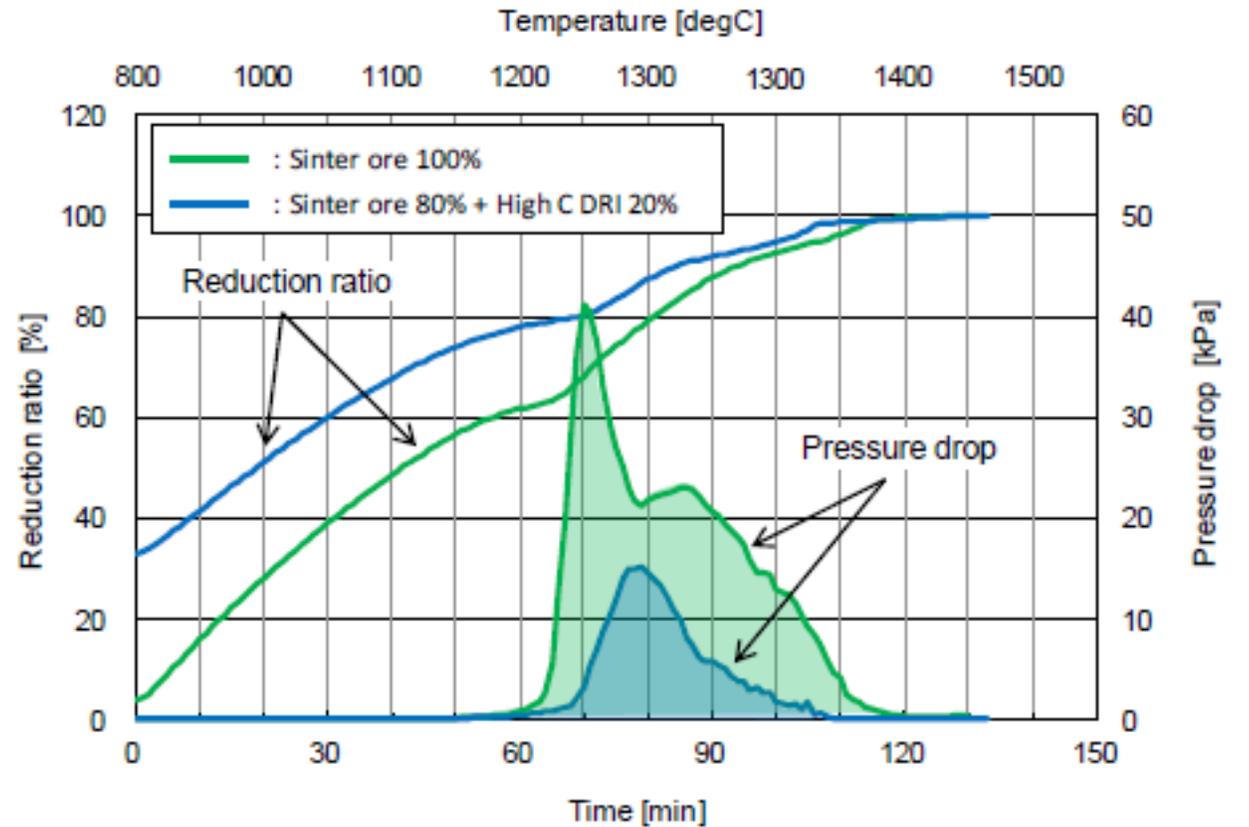
Pellets/Sinter/Lump

Melting Trajectory due to high FeO primary slag liquidus of 1300°C and solid iron liquidus of 1500°C as C does not dissolve in iron until all FeO is removed.

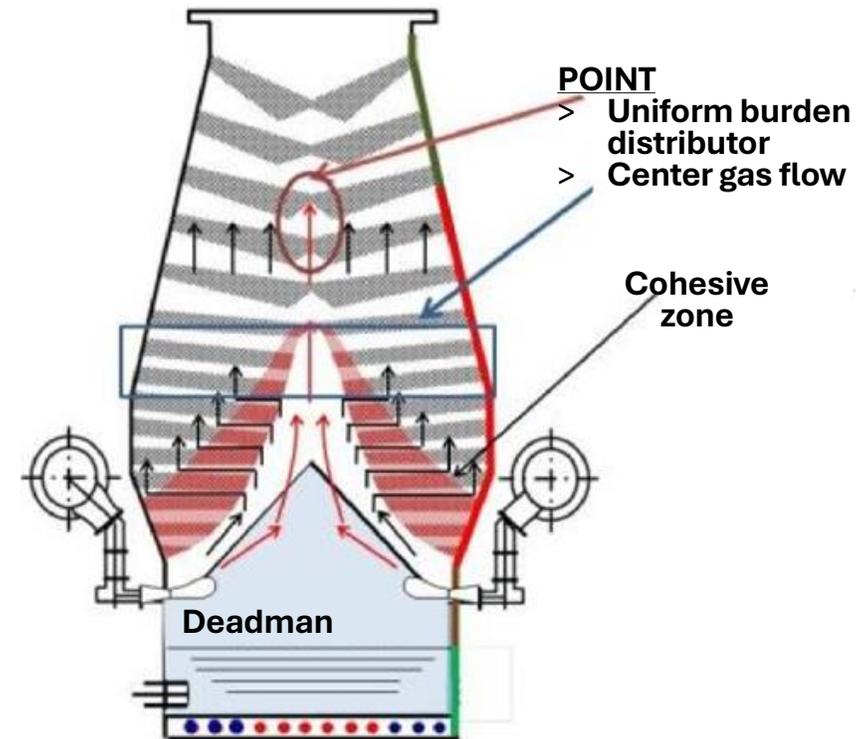


DRI

Melting Point around 1400°C at 2% C in DRI



- > Critical drivers for low carbon rate and high efficiency include burden and gas distribution
- > DRI easier to distribute in ferrous layer and Less damage in logistics
- > To make the gas flow uniform, the following two points should be necessary
 1. Make a uniform burden distribution in radial direction
 2. Provide a proper center gas flow



Conclusions

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DRI in BF using COG

No usage of Hydrogen
No Scale-up Risks

+

BF-Grade Pellets
High-Grade Steel

=

Realistic Solutions to
Reduce BF-BOF CO₂
Emissions

Blast Furnace Decarbonization by using Metallics

Outlook



40% metallics in BF



40% metallics in BOF



40% CO₂ emissions reduction

Thank you