

CHALLENGES AND OPPORTUNITIES IN THE GREEN TRANSFORMATION OF THE EU STEEL INDUSTRY

Ramping-up EU H2 Economy

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SMS group - Leading partner in the world of metals



Thomas Hansmann

Chief Technology Officer

Jochen Burg

Chief Executive Officer

Fabíola Fernandez

Chief Financial Officer

Michael Rzepczyk

Chief Operating Officer

“ Built on family tradition and firm values, we prioritize our customers' interests, trust our talented team, drive technological innovation, and embrace a global perspective.

We are
your partner to shape
the future of the
metals industry ”

SMS group – Shaping the future of the metals industry



... as your **lifecycle partner**.

With holistic, integrated cyber-physical solutions, we enhance your plant's performance throughout its lifecycle, delivering unmatched efficiency.

#integratedsolutions



... by **leading the decarbonization** of the metals industry.

Our goal: a sustainable, near-zero carbon emissions metals industry. As the sole provider of technology for metal production and recycling along the entire process chain, we are a key player in this historical transformation.

#turningmetalsgreen

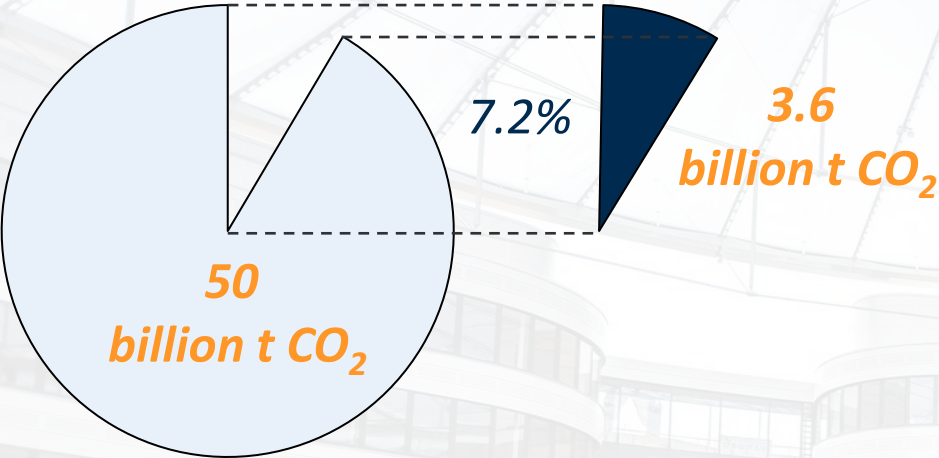


... by **driving innovation**.

Innovation has always defined us. We pioneer advancements in the metals industry and continuously develop solutions that not only benefit our customers in the long term but also differentiate us from the competition.

#leadinginnovation

Iron & steelmaking is one of the major emitters of our time



Global
CO₂ Emission

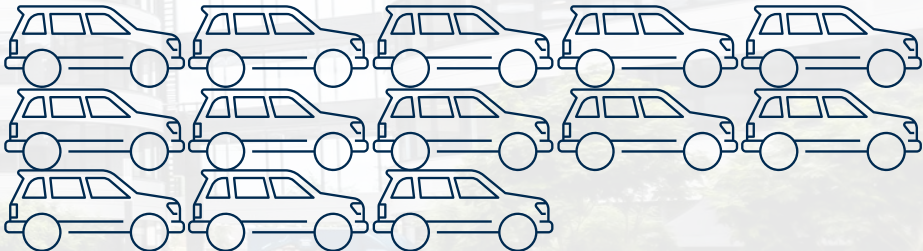
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Steel
CO₂ Emission

450 million
human beings
per year



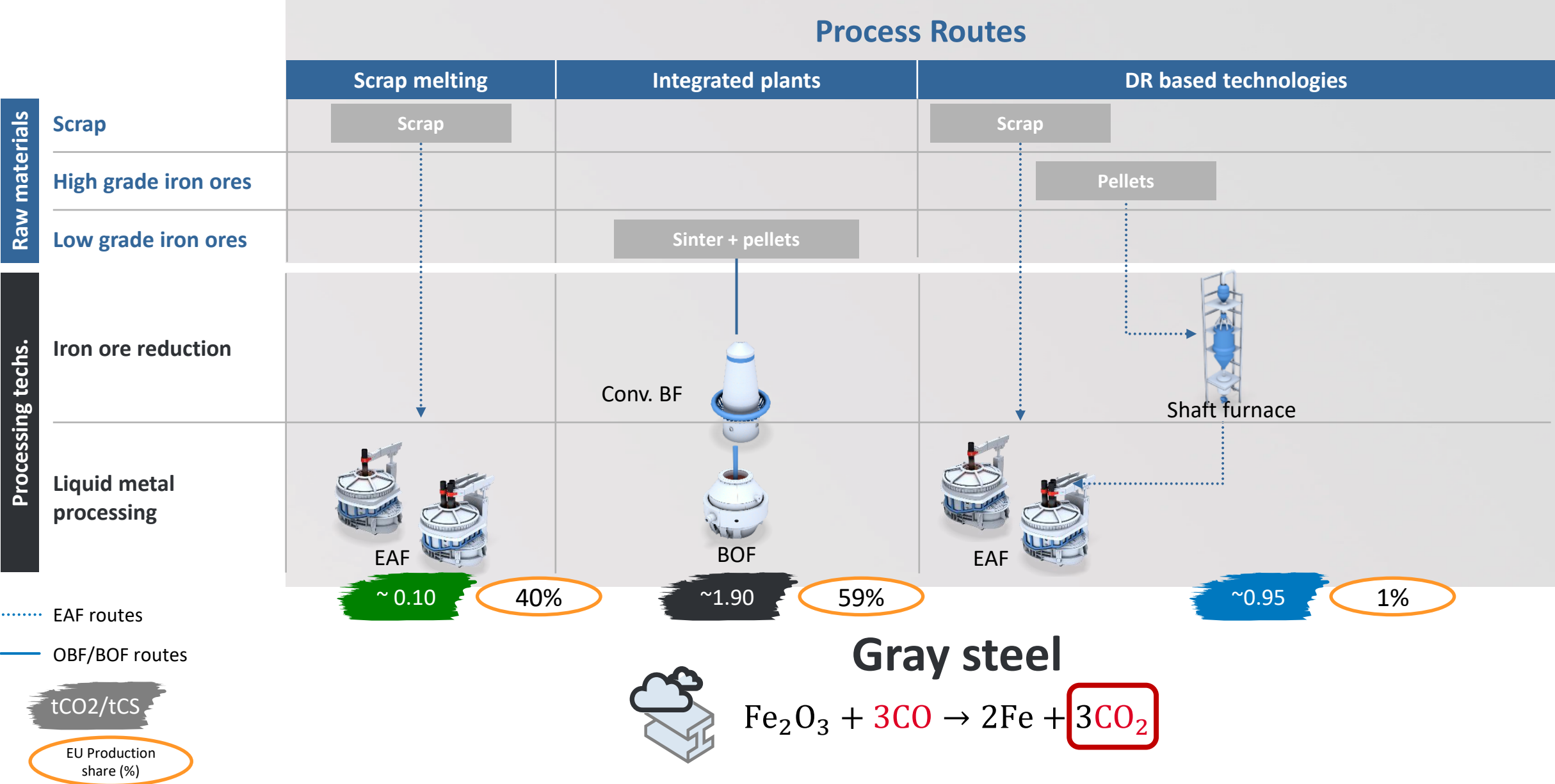
2.5 billion
middle class
cars per year



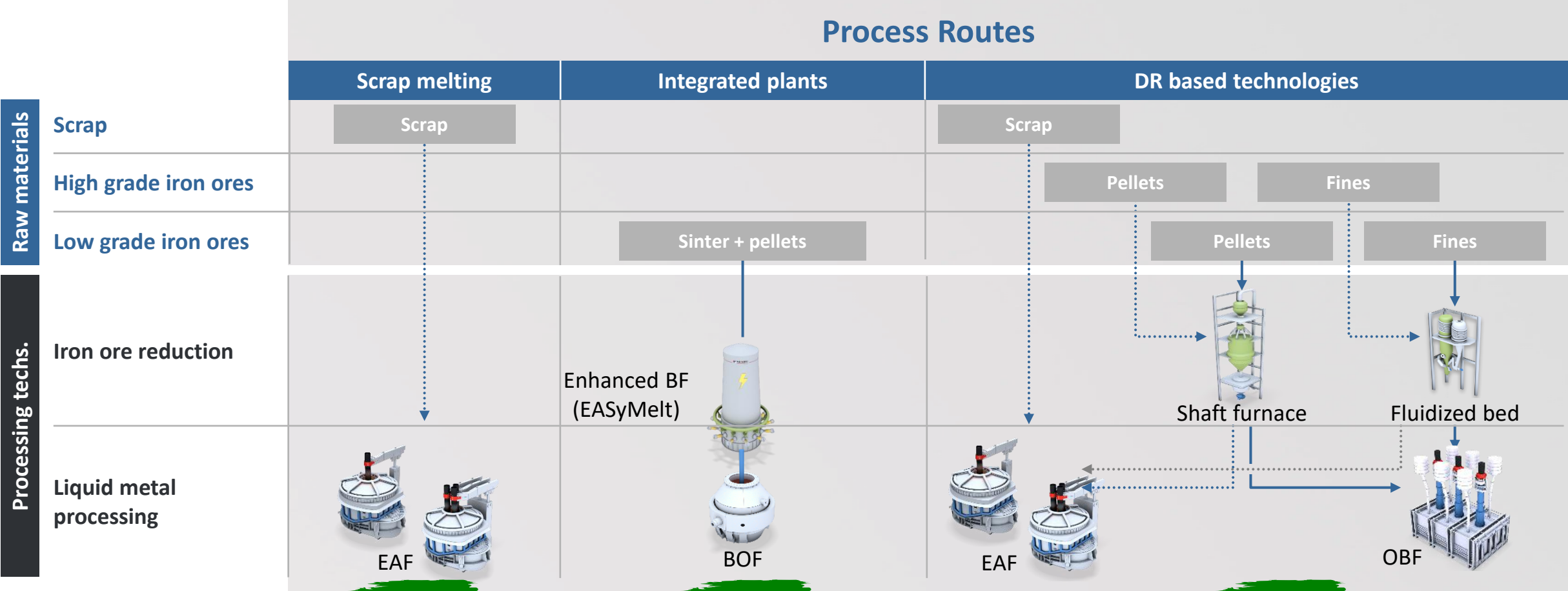
Emitting as much as

The potential for emission reduction is high and technologically possible – yet there are considerable questions and restraints that need to be answered

3 major process routes are available to realize decarbonization



3 major process routes are available to realize decarbonization



..... EAF routes
— OBF/BOF routes

tCO2/tCS



Region Europe: The slow growth is backed by scrap-based steelmaking and DRI routes

Scrap-EAF

100% scrap based steelmaking

An illustration of an electric arc furnace (EAF) used in steelmaking.

DRI-EAF/ DRI-OBF

Iron and steelmaking based on H₂ or NG as reductant

An illustration of a direct reduced iron (DRI) process, showing a vertical shaft reactor.

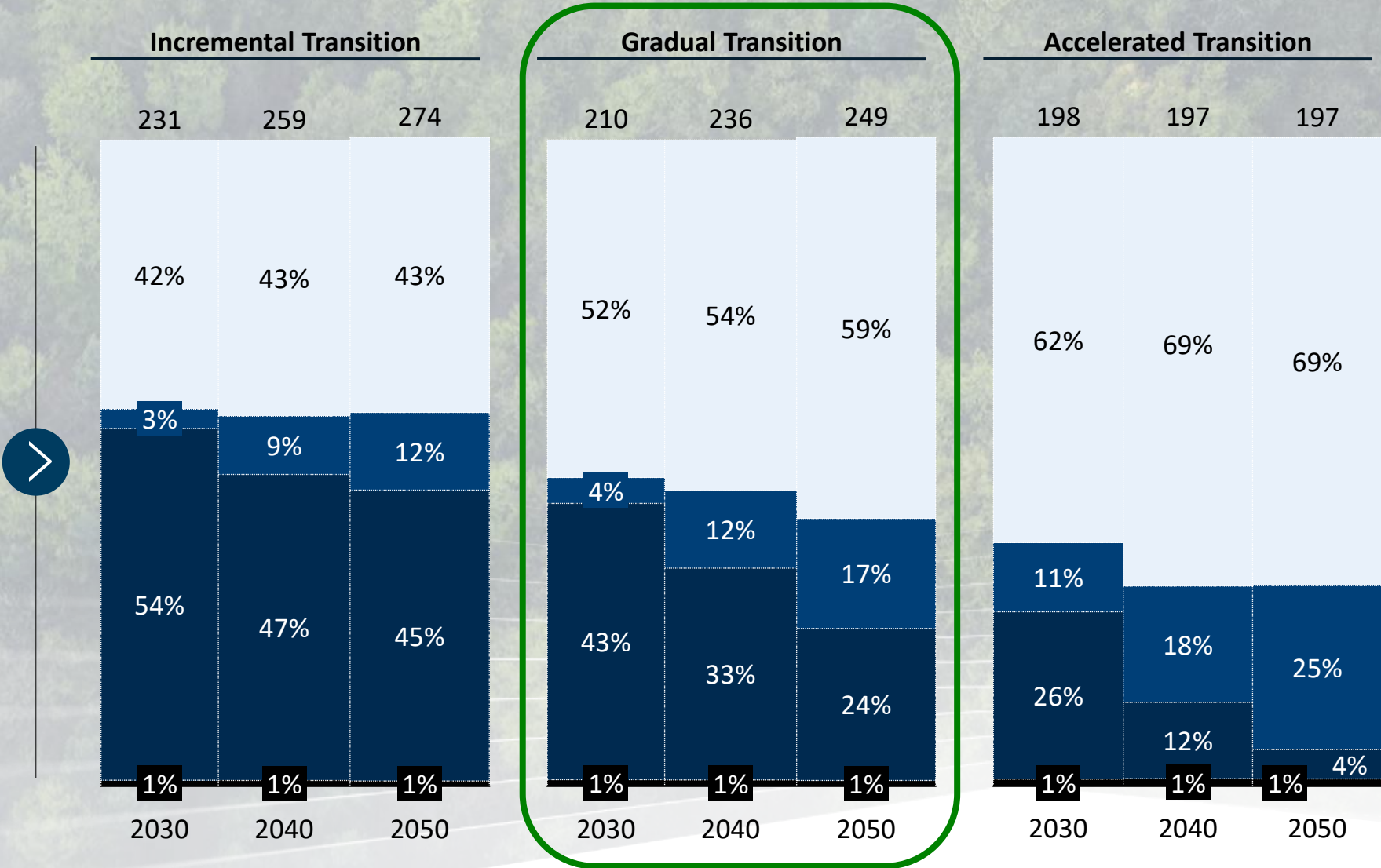
BF-BOF

Integrated steel plant or decarbonized retrofit

An illustration of a basic oxygen furnace (BOF) used in integrated steelmaking.

Others

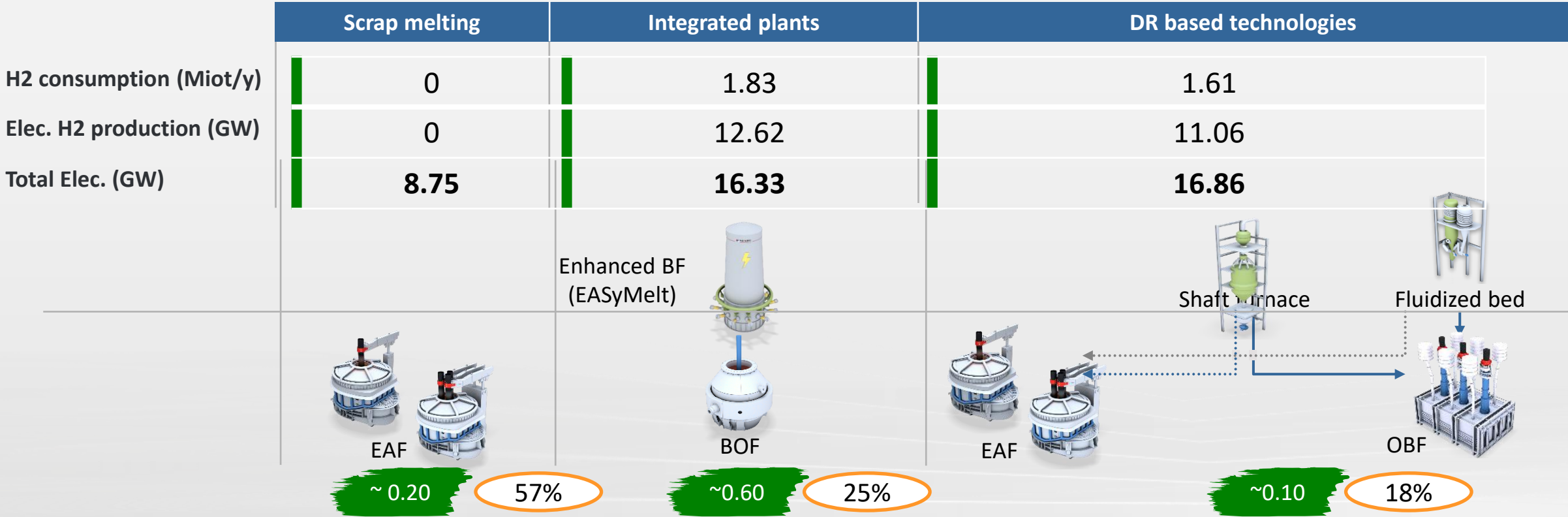
Siemens Martin, Open hearth, Rotary Kiln, etc.



3 major process routes are available to realize decarbonization

Basis: 250 Miot Crude Steel production by 2050

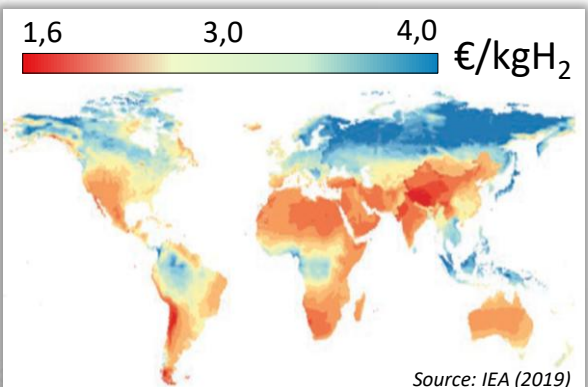
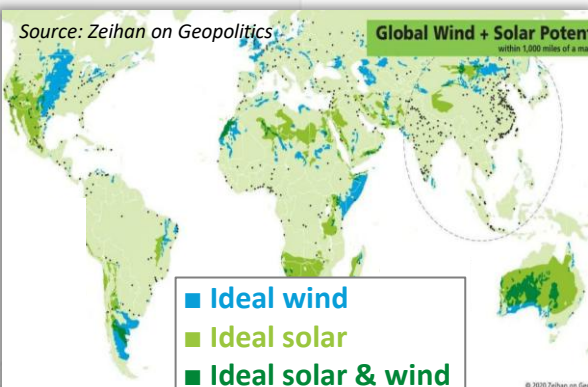
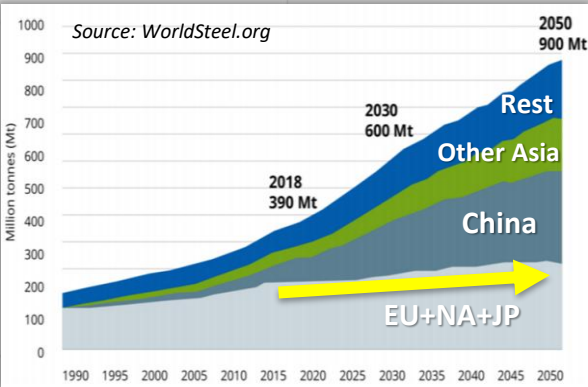
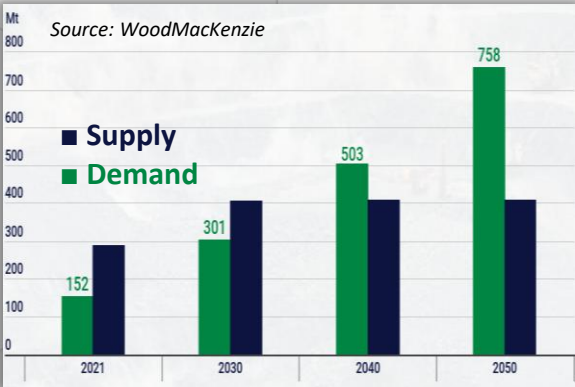
Process Routes



- ❑ 3.3 times of today's electricity consumption of EU steel plants (*renewable energy*)
- ❑ ~ 30 Nuclear power plants (*with 1 GW capacity*)
- ❑ ~ 6000 windmills (*with the capacity of 5MW*)

Future feedstock challenges of green steel

1 | 5 | 0 YEARS
of shaping
the future



DR pellet availability

- Limited availability
- Growing demand
- High premium

Need for
FLEXIBLE ORE SOLUTION

End-of-life scrap availability

- Limited availability
- Growth in demand
- Contaminated scrap (Cu)

Need for
PRIMARY STEELMAKING

Green electricity availability

- Unequal availability of sun, wind & free usable land
- High cost & scope 2 emissions in some regions

Need for
POWER AUTONOMY

Hydrogen availability

- Unequal green hydrogen production cost
- Immature supply chain
- Small volumes, high costs

Need for
FLEXIBLE H2 USAGE

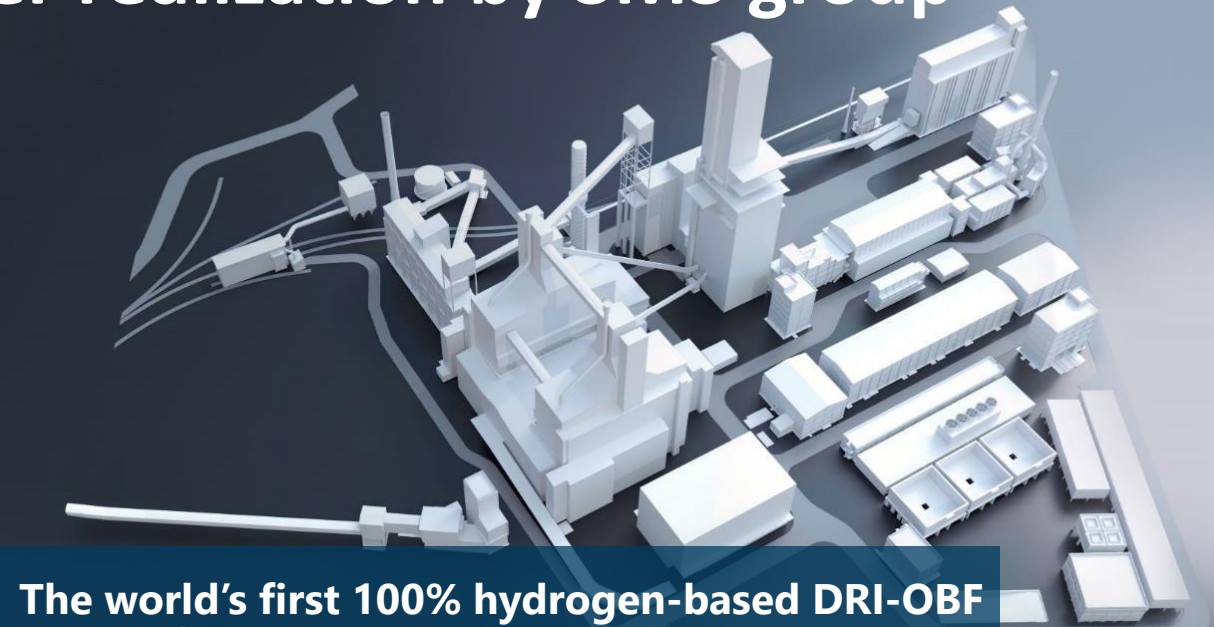
Influencing factors of successful transition – opportunities

Reduce risks – Act smart and flexible



A basket of solutions are required to be tailored based on the influencing factors.

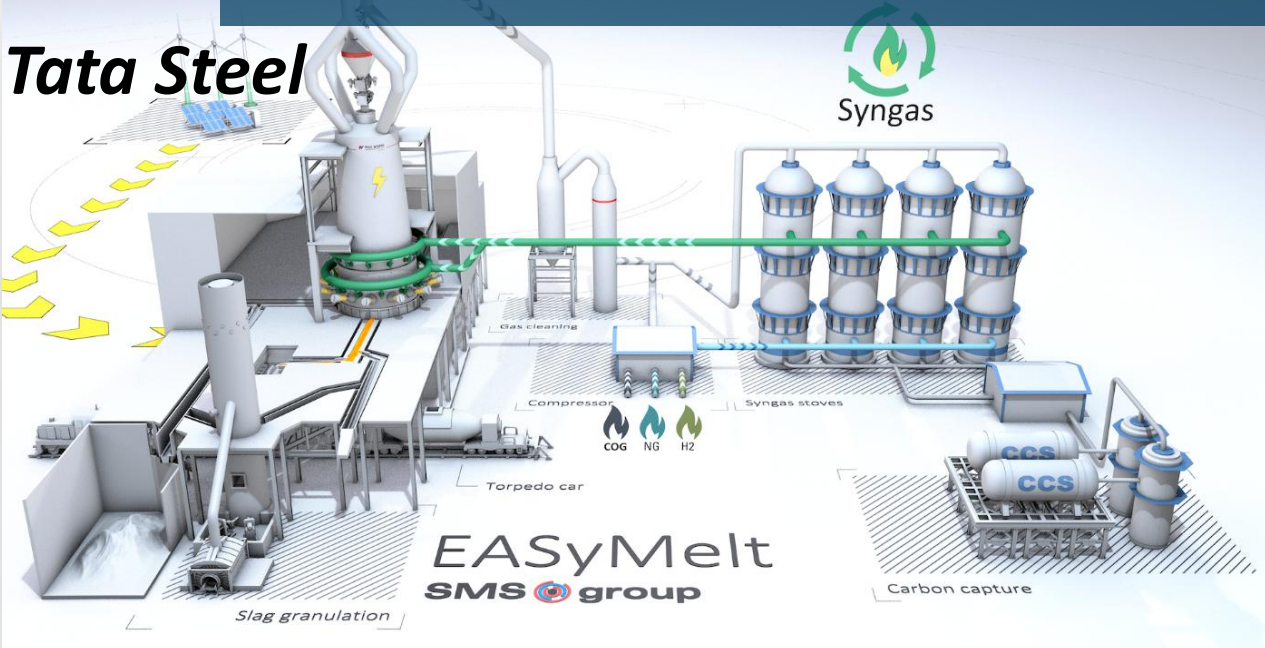




The world's first 100% hydrogen-based DRI-EAF
The world's first >70% CO2 emission reduction BF

The world's first 100% hydrogen-based DRI-OBF
One of the world's biggest and flexible AC EAF

Tata Steel



Saarstahl



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PAT is the appropriate tool for making the right decision



Plant

Assessment

Tool



Use of Plant Assessment Tool to define a decarbonization strategy

PAT main inputs & outputs



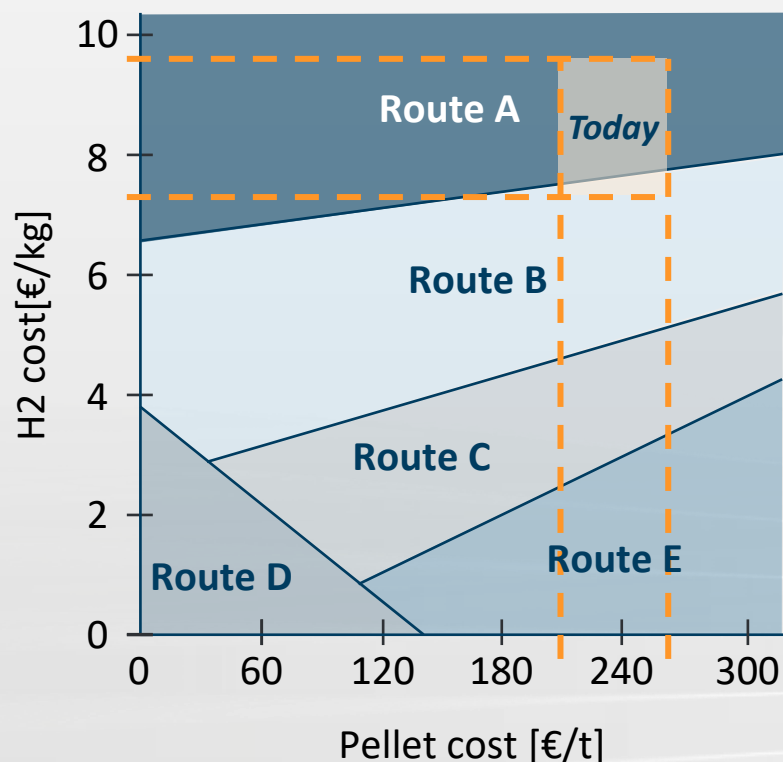
Combining metallurgical process calculations with economics allows realistic business scenarios estimation



Opex Analysis – There are multiple decarbonization pathways going forward



Based on heat and mass balance models

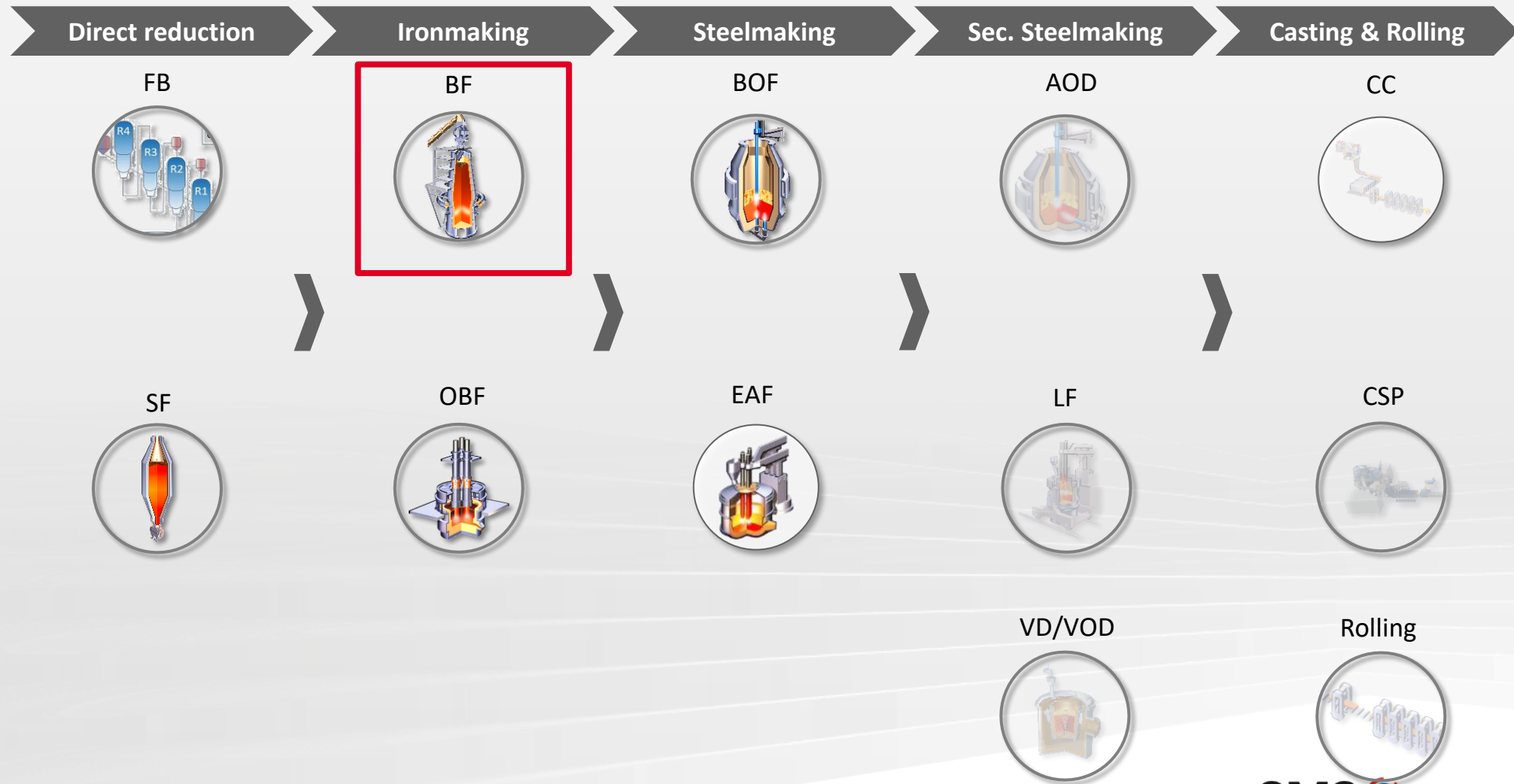


PAT enables the **identification of routes feasibility** via:

- › The **selection of relevant routes** for the customer situation and regional preconditions
- › The display of the **minimum OPEX areas** depending on the chosen drivers

Sensitivity
Analysis

HSC Process Simulation models in PAT



An aerial photograph of a dense, lush green forest. A semi-transparent road with white lane markings is overlaid on the image, starting from the bottom left and curving towards the right. The text 'CASE STUDY' and 'BLAST FURNACE ROUTE IN HSC' is written in a bold, white, italicized sans-serif font in the upper right quadrant.

CASE STUDY
BLAST FURNACE ROUTE IN HSC

Why model the whole route in one tool?



One tool including all units

In the integrated steel plant, there are several mass and energy interlinks → The impact of a change in one unit can be directly followed in the other units



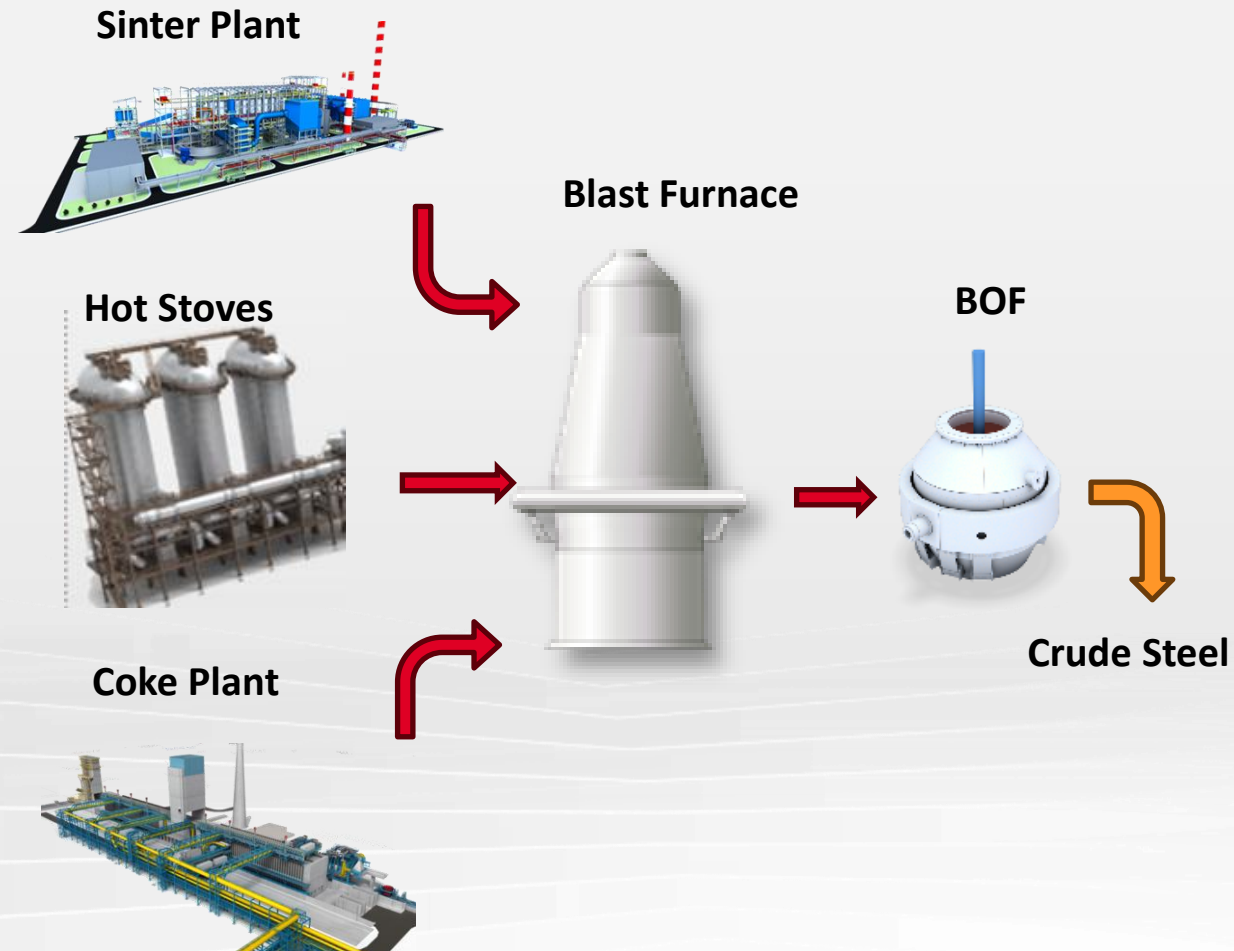
Operational Expenditure (OPEX)

OPEX calculation of different scenarios including the impact of electricity, hydrogen, raw materials in OPEX



CO2 emission calculation

Calculating CO2 emission for different scenarios



Blast furnace model description and HSC as the simulation tool



Thermodynamic core

HSC Chemistry tool:

- More than 28,000 species
- Thermophysical properties as a function of temperature
- Including large temperature range for data



Iterative, steady-state

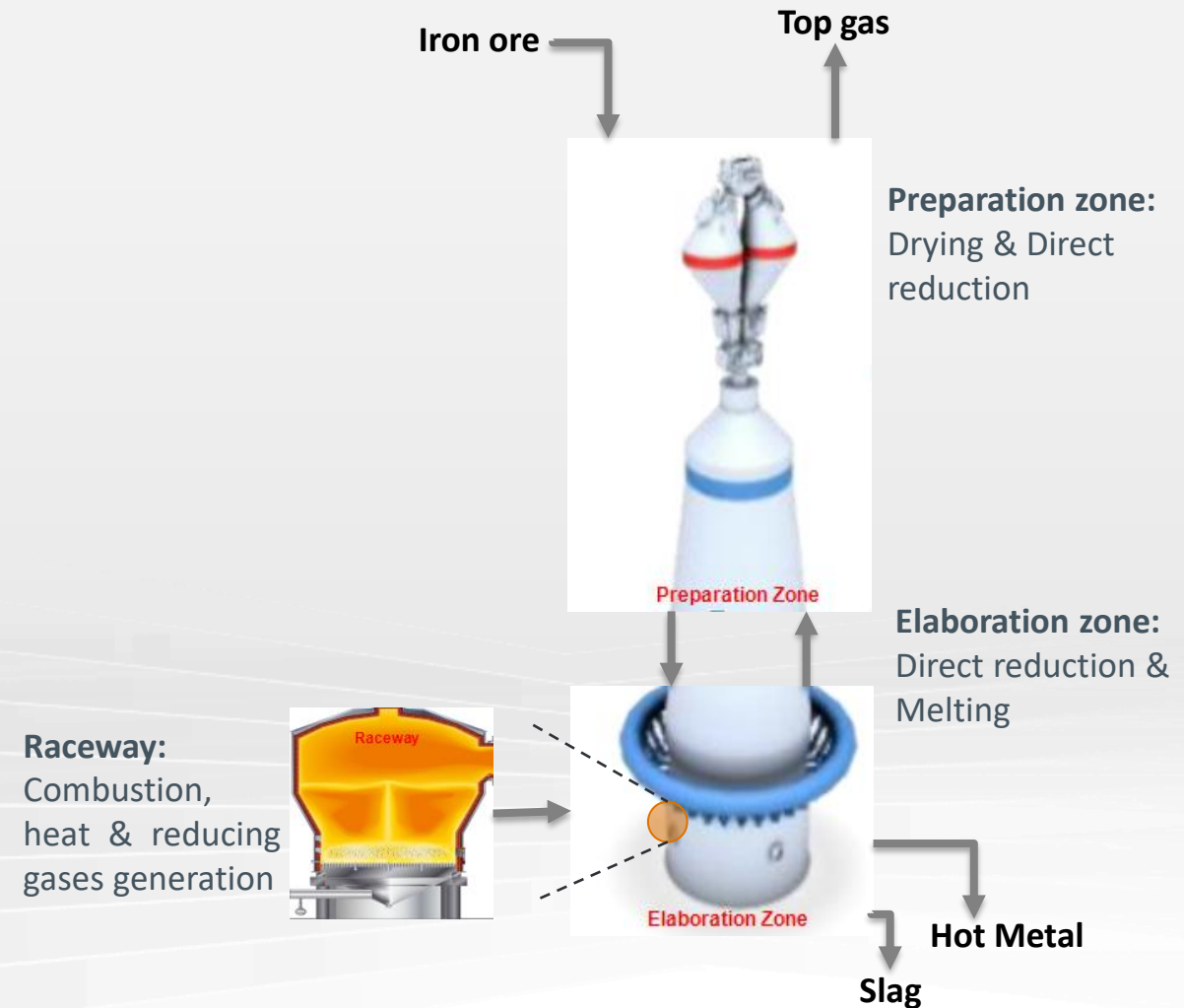
Solver converges compositions, flows, temperature and enthalpies of all units

Every zone, every unit will satisfy mass and energy balances:

$$\Sigma \dot{m}_{out} = \Sigma \dot{m}_{in}$$

$$\Sigma \dot{m}_{out} \cdot h(T) - \Sigma \dot{m}_{in} \cdot h(T) + Q_{loss} = 0$$

Main elements: Fe, C, O₂, N₂, H, Ca, Si, Al, Mg, ...

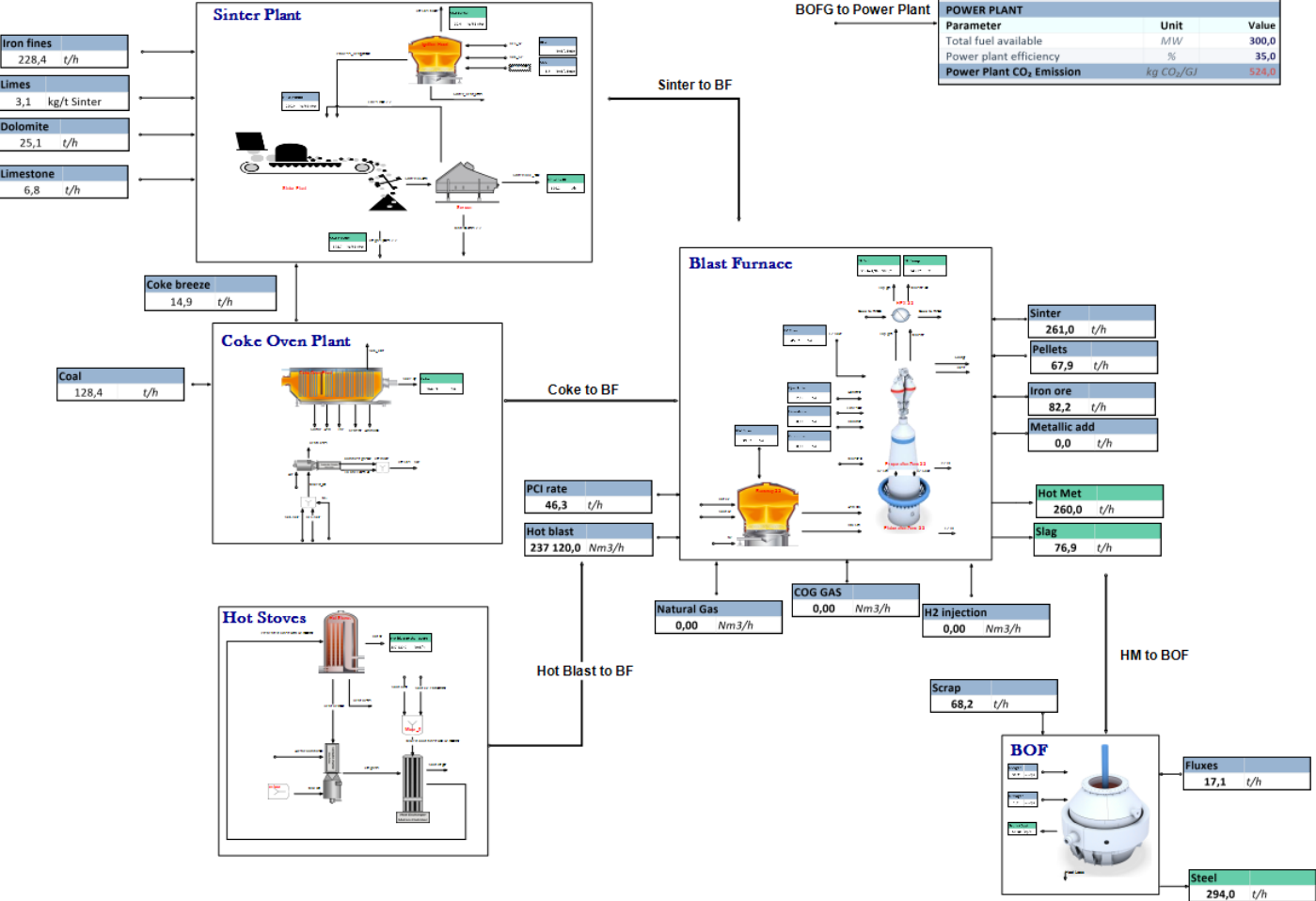


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Schematic of the Blast Furnace – Basic Oxygen route in HSC

Project Number	XXXXXXXX
Project Title	General
Client	N/A
Revision	0
Date	18/07/1905

Client Logo
SMS group



HSC CHEMISTRY — SIMULATION RESULTS			
Production	ILS/d	7102	
Total CO ₂	kgCO ₂ /ILS	1739	
SINTER PLANT			
PRODUCTION & INPUTS			
Parameter	Unit	Value	
Production rate	t/HM	1,0	
IBRM	kg/t sinter	875,0	
Return fines	kg/t sinter	250,0	
CO ₂ FOOTPRINT			
Component	Unit	Value	
CO ₂ Total	kgCO ₂ /t sinter	289,0	
COKE OVEN PLANT			
PRODUCTION & YIELDS			
Parameter	Unit	Value	
Total coke production	t/HM	0,4	
COG yield	Nm ³ /t coke db	509,9	
COKE QUALITY (wt-%)			
Fixed Carbon	%	87,5	
Ash	%	11,3	
Sulfur	%	1,2	
COG COMPOSITION (vol-%) & LHV			
CH ₄	vol-%	23,4	
H ₂	vol-%	53,0	
N ₂	vol-%	5,3	
CO	vol-%	8,4	
CO ₂	vol-%	2,8	
O ₂	vol-%	0,0	
C ₂ H ₆	vol-%	0,0	
LHV (dry)	MJ/Nm ³	16,3	
CO ₂ FOOTPRINT			
CO ₂ emissions	kg CO ₂ /t coke	762,0	
HOT STOVES			
CO ₂ FOOTPRINT			
Parameter	Unit	Value	
CO ₂ emissions	kg CO ₂ /tHM	485,0	
BLAST FURNACE			
BURDENS & FLUXES (kg/tHM)			
Item	Unit	Value	
Sinter	kg/tHM	1 004,0	
Pellets	kg/tHM	261,0	
Ore	kg/tHM	316,0	
Metallic additions	kg/tHM	0,0	
Limestone	kg/tHM	0,0	
Quartzite	kg/tHM	5,0	
Dolomite	kg/tHM	25,0	
REDUCTANTS & INJECTANTS (kg/tHM)			
Coke	kg/tHM	329,0	
PCI	kg/tHM	178,0	
COG injection	kg/tHM	0,0	
NG injection	kg/tHM	0,0	
BLAST CONDITIONS			
Dry blast volume	Nm ³ /tHM	912,0	
O ₂ content (dry)	%	26,0	
O ₂ enrichment	Nm ³ /tHM	61,6	
Blast humidity	g/Nm ³	5,8	
Blast temperature	°C	1 100,0	
RAFT	°C	2 231,0	
Tuyere gas volume	Nm ³ /tHM	1 345,0	
TOP GAS (DRY)			
CO	%	25,4	
CO ₂	%	22,6	
H ₂	%	4,0	
N ₂	%	48,0	
Temperature	°C	140,0	
Volume (dry)	Nm ³ /tHM	1 507,0	
LHV (dry)	kJ/Nm ³	3 632,0	
η _{CO}	%	47,1%	
η _{H₂}	%	35,2%	
HOT METAL COMPOSITION			
Carbon	%	4,5	
Silicon	%	0,6	
Manganese	%	0,2	
Phosphorus	%	0,1	
Sulphur	%	0,1	
Temperature	°C	1 489,0	
SLAG COMPOSITION & BASICITY			
Slag rate	kg/tHM	295,6	
CaO	%	41,1	
SiO ₂	%	38,9	
MgO	%	7,1	
Al ₂ O ₃	%	11,4	
Basicity B ₂	—	1,1	
THERMAL LOSSES			
Total heat losses	MJ/tHM	412,0	
Ideality defect ω	—	0,02	

 Material consumption rate

 Electrical consumption

 CO₂ Footprint

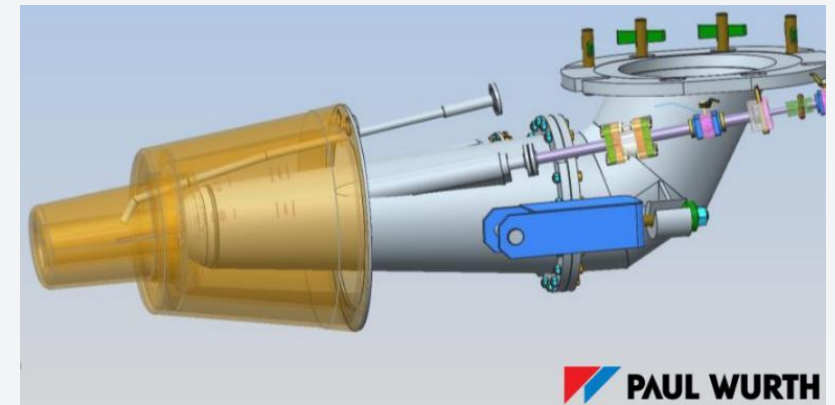
Case study with Coke Oven Gas Injection (COG)

	Reference	Max COG
COG injection (kg/tHM)	0	77
PCI (kg/tHM)	178	165
O ₂ enrichment (%)	5	14
Flame temp. RAFT (°C)	2300	2055
Top gas H ₂ (vol %)	3.9	13.5
Coke (kg/tHM)	326	290

From fuel to reductant: 1 kg COG replaces $\approx$ 0.65 kg coke

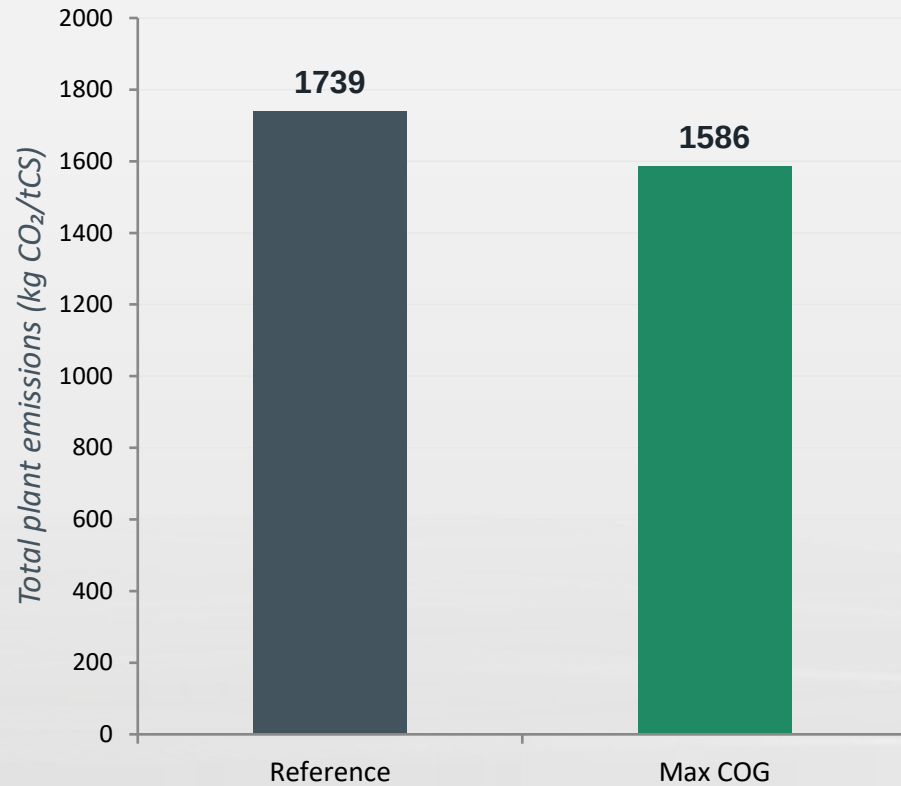
Reference: A BF with 6250 tHM/day production

Burden 64% sinter · 16% pellets · 20% lump



Existing hardware: gas-port injection tuyere + PCI lance

Results with Coke Oven Gas Injection (COG)



-8.7%
CO₂ per ton of crude steel



And it pays

ROI ≈ 4.5 year

With no CO₂ Certificate in place

ROI < 1 year

With a CO₂ Certificate of 100€ /tCO₂

**Let's shape a better tomorrow together
For our regions and for the world**

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