TATA STEEL
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THE INDIAN INSTITUTE OF METALS
भारतीय धातु संस्थान
IIM
Metallurgy
Materials Engineering

Presents

International Conference on

GREEN & SUSTAINABLE IRON MAKING

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Title of Paper: Smart combination of new Midrex DR plants in existing BF based integrated plant solutions for lowering OPEX and CO2 emissions vs the stand alone approach

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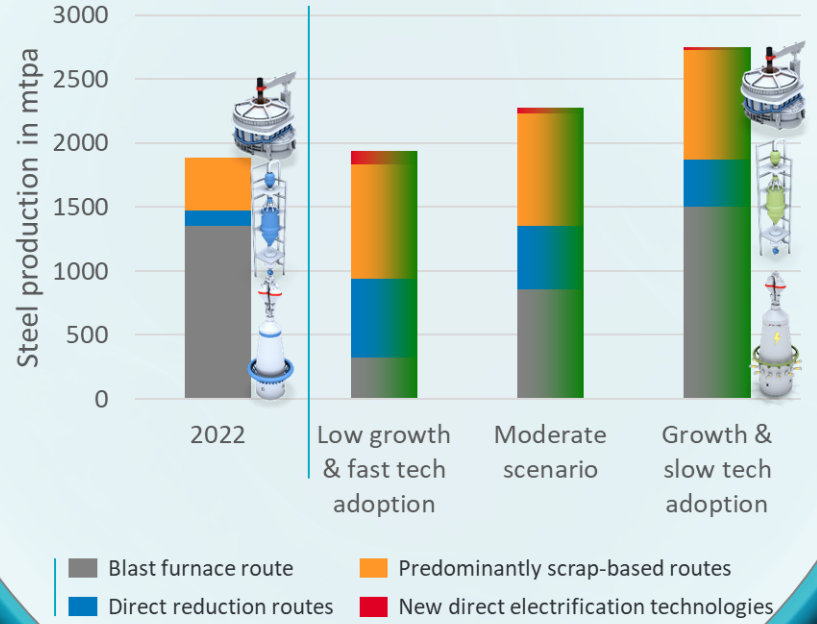
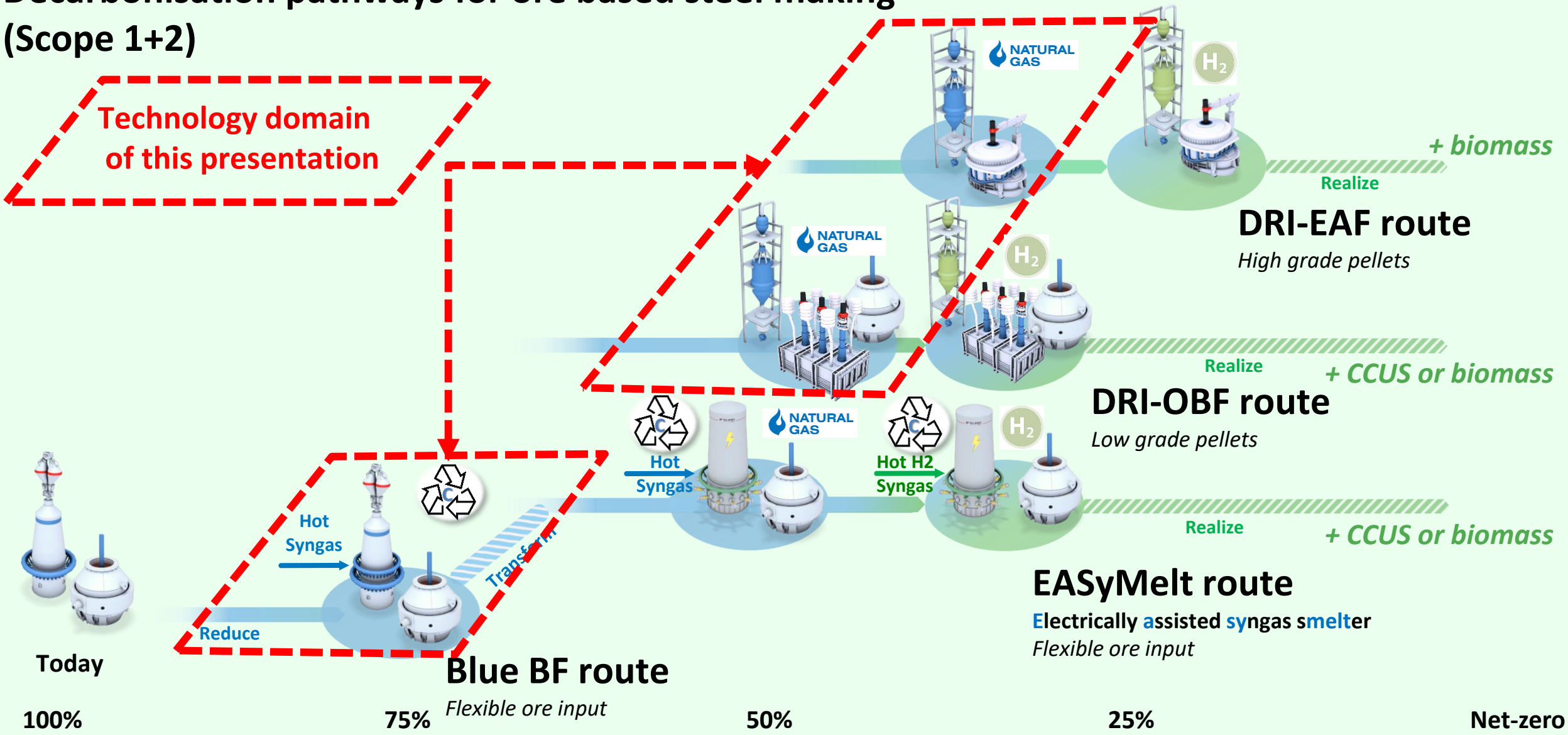
2050

Global Steel Demand & Production Technology Mix

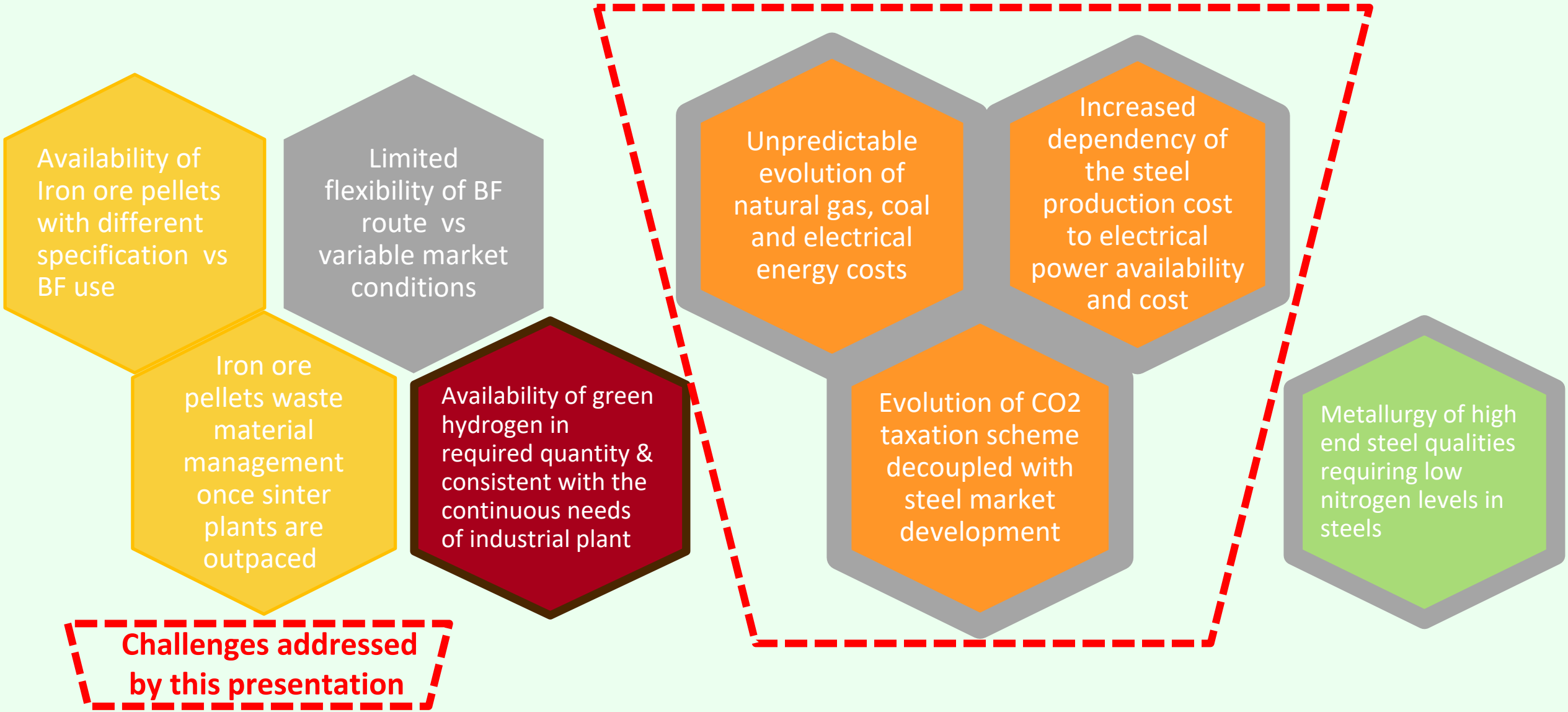


Decarbonisation pathways for ore based steel making (Scope 1+2)



SCOPE 1+2 EMISSIONS **Scope 2 calculated with Ele. Power emission factor of 80kg CO2/MWh (target 2050)**

Main challenges for BF based decarbonization of integrated steel plants



NG Midrex Direct reduction Technology (NG DRP)

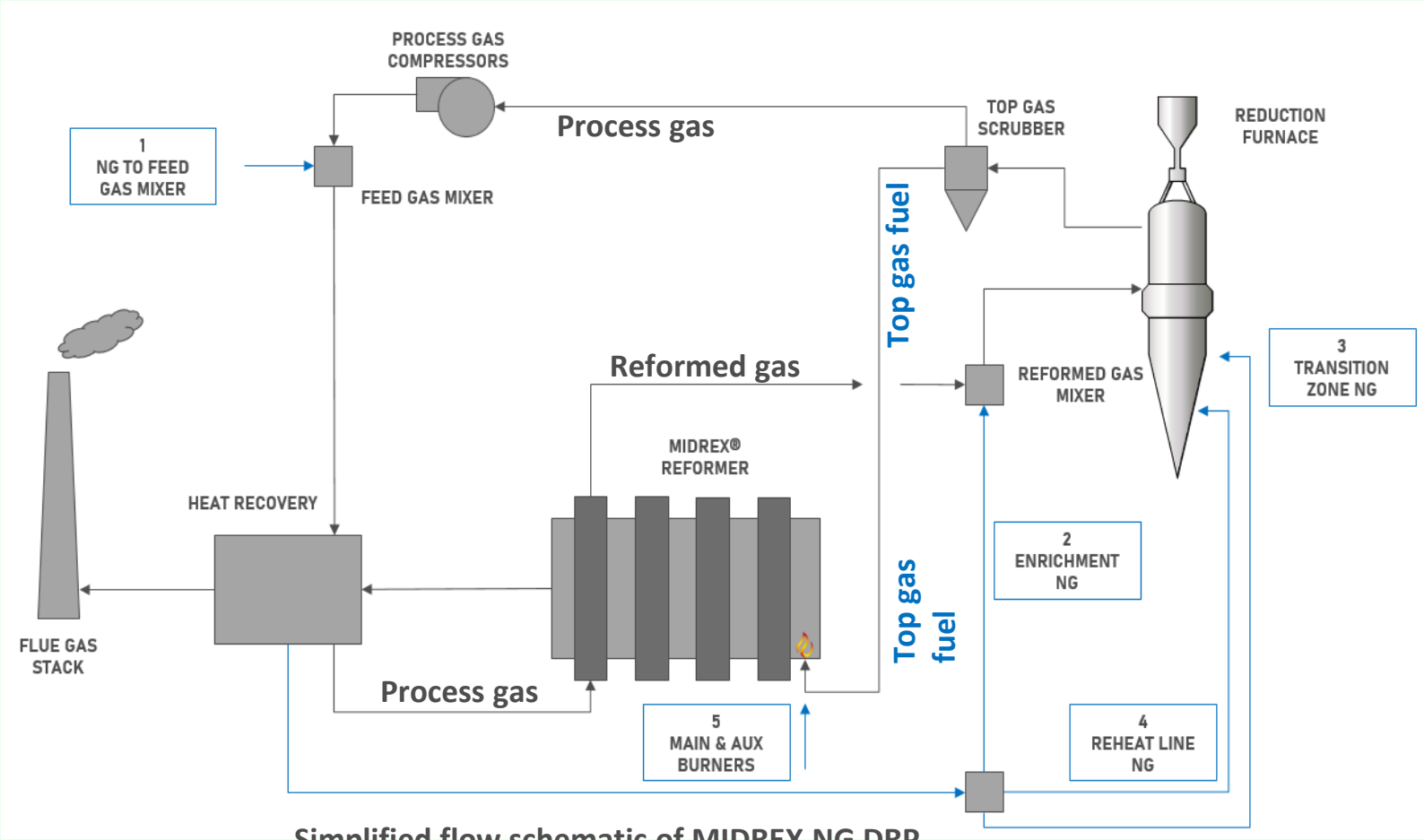
Focus on gas looping

NG Process use

1. Feed gas mixer (NG make up)
2. Enrichment at reformed gas
3. Transition zone
4. Reheat line

NG Thermal use

5. Feed to burners of Reformer mixed with top gas fuel



Simplified flow schematic of MIDREX NG DRP

Blast Furnace (Blue BF) modified to use Syngas for reducing OPEX & CO2 footprint

Hot syngas shaft injection

- Enabler for higher top gas temperature
- Allows higher amounts of auxiliary fuel injection at tuyère level (e.g. COG, NG, H_2, syngas)

Main effect of hot syngas injected at BF shaft

- CO_2 emission reduction up to 28 % (only syngas)
- Reduced OPEX due to coke rate decrease
- Productivity increase due to decreased gas generation at bosh level

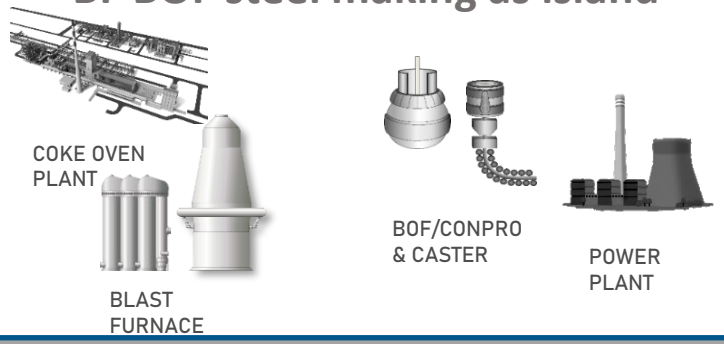
The way to smartly integrate a Midrex DRP into traditional BF BOF steelmaking

how to maximize metallurgical gases valorisation

STEP 0

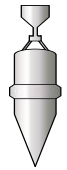
Direct Reduction Plant (DRP) as island

BF BOF steel making as island



STEP A

DRP is a receiver

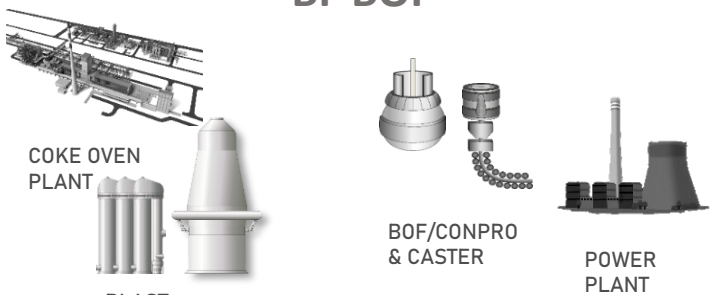


MIDREX PAUL WURTH

NG Input

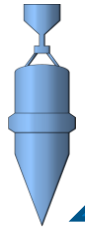
Gas delivery

BF BOF



STEP B

Blue DRP fully integrated



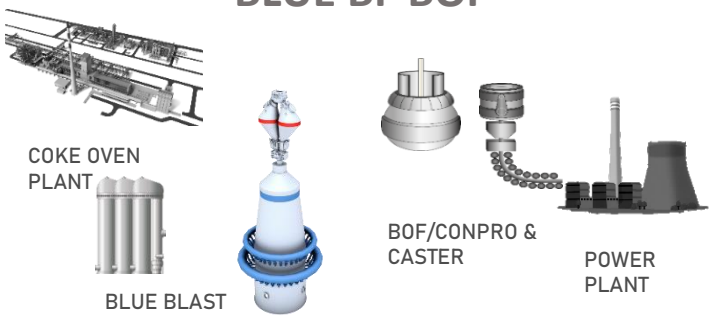
MIDREX PAUL WURTH

NG Input

PATENT PENDING

Gas exchange

BLUE BF BOF



BLUE BF in smart combination with DRP through gas exchange

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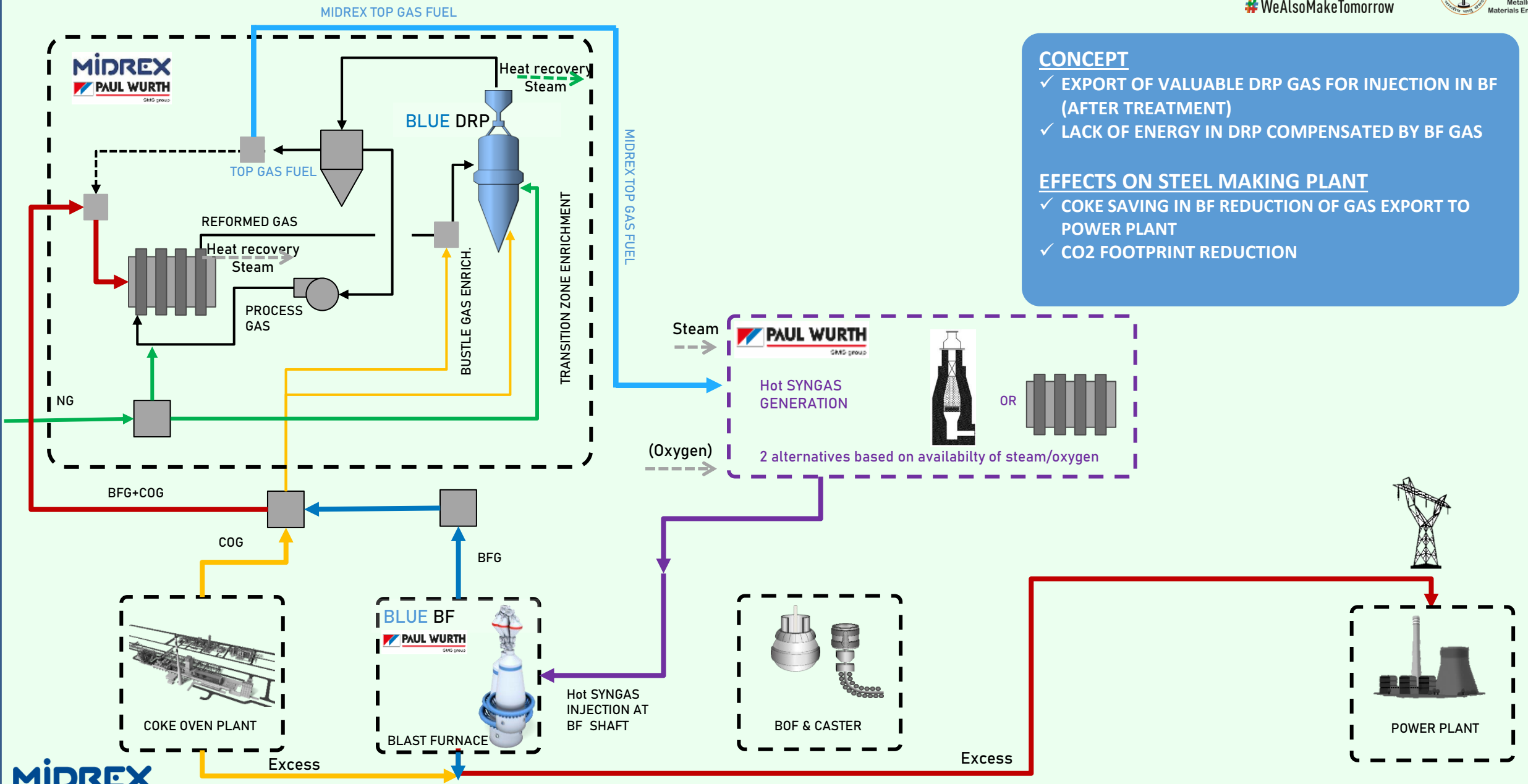


CONCEPT

- ✓ EXPORT OF VALUABLE DRP GAS FOR INJECTION IN BF (AFTER TREATMENT)
- ✓ LACK OF ENERGY IN DRP COMPENSATED BY BF GAS

EFFECTS ON STEEL MAKING PLANT

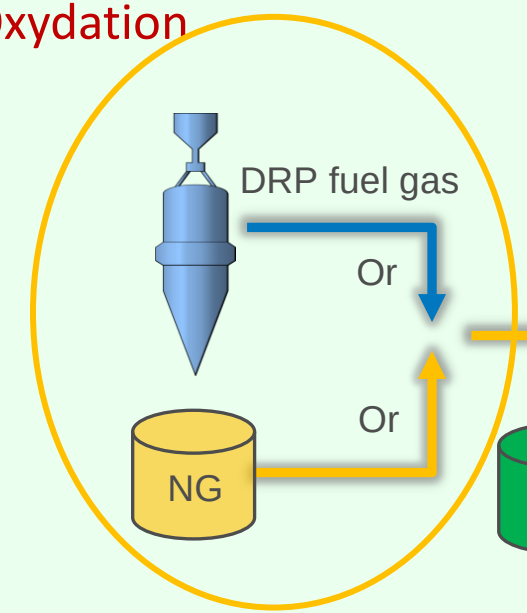
- ✓ COKE SAVING IN BF REDUCTION OF GAS EXPORT TO POWER PLANT
- ✓ CO2 FOOTPRINT REDUCTION

BLUE BF in smart combination with DRP through gas exchange

Syngas generation applied to Midrex fuel gas to generate hot syngas

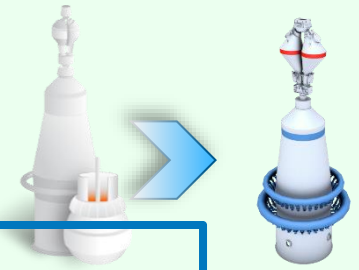
Alternative 1: Catalytic Partial Oxydation

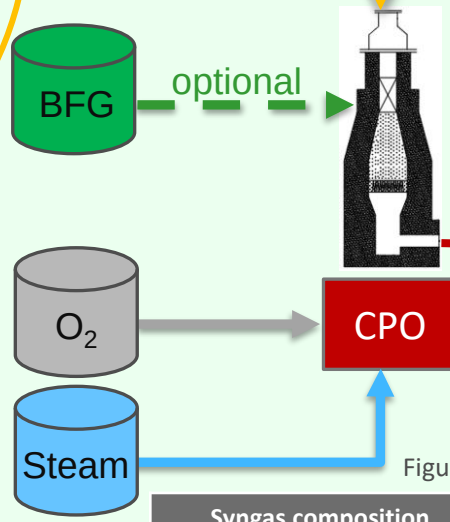
- Syngas is produced by partial combustion of natural gas or DRP Fuel gas
- Possible to use C2+ rich feedstocks
- High syngas quality



APPLIED when OXYGEN is available

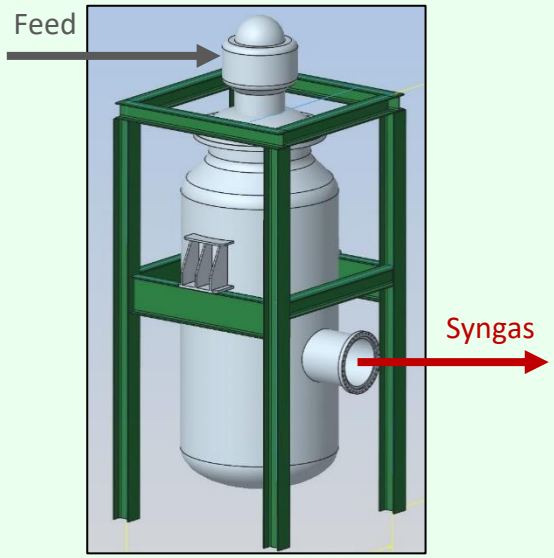
PATENT PENDING





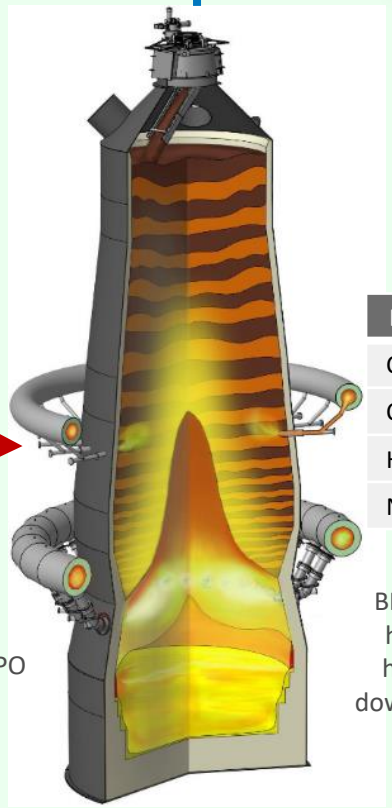
Partial Oxidation

$$CH_4 + 1/2O_2 \rightarrow CO + 2\,H_2$$



Figures for NG fed CPO

Syngas composition		
CH_4	<1	vol.-%
CO	28	vol.-%
CO_2	2	vol.-%
H_2	58	vol.-%
H_2O	7	vol.-%
N_2	3	vol.-%



BF gas typical composition		
CO	20-23	vol.-%
CO_2	20-23	vol.-%
H_2	9-12	vol.-%
N_2	balance	vol.-%

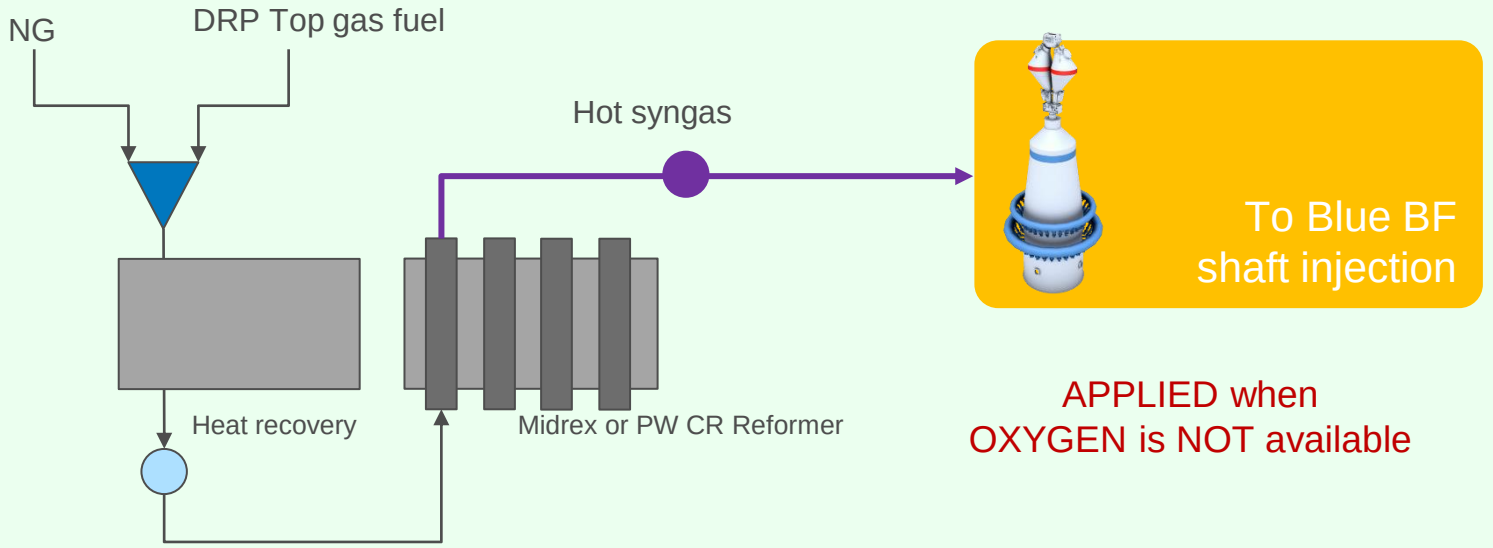
BF gas with syngas injection has significant changes → higher L.H.V. and re-use in downstream facilities (incl. fuel to Midrex Reformer)

BLUE BF in smart combination with DRP through gas exchange

Syngas generation applied to Midrex Top gas fuel to generate hot syngas

Alternative 2: Midrex or PW Combined Reforming additional reformer

Hot Syngas generation through Catalytic reforming of Midrex Top gas fuel



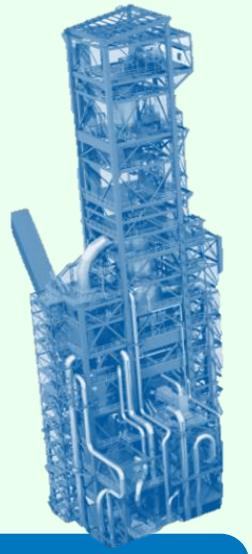
APPLIED when
OXYGEN is NOT available

	H_2 [mol %]	CO [mol %]	CO_2 [mol %]	H_2O [mol %]	CH_4 [mol %]	N_2 [mol %]	TEMP
INLET	35	19	15	13	17	1	580°C
OUTLET	55	35	2	6	1	1	950 °C

BLUE BF in smart combination with DRP through gas exchange: OPEX and CO2 (*)

ASSUMED UTILITIES AND RAW MATERIAL COSTS

Parameter	uom	Cost
DR grade pellets	€/t	176
BF grade pellets	€/t	144
Sinter feed	€/t	72
Coking coal (variable)	€/t	410
CO_2	€/t	0
Electrical power (variable)	€/kWh	0,098
Natural Gas (variable)	€/GJ	30,2
Scrap	€/t	456
Sludge disposal	€/t	0
Manpower	€/h	10

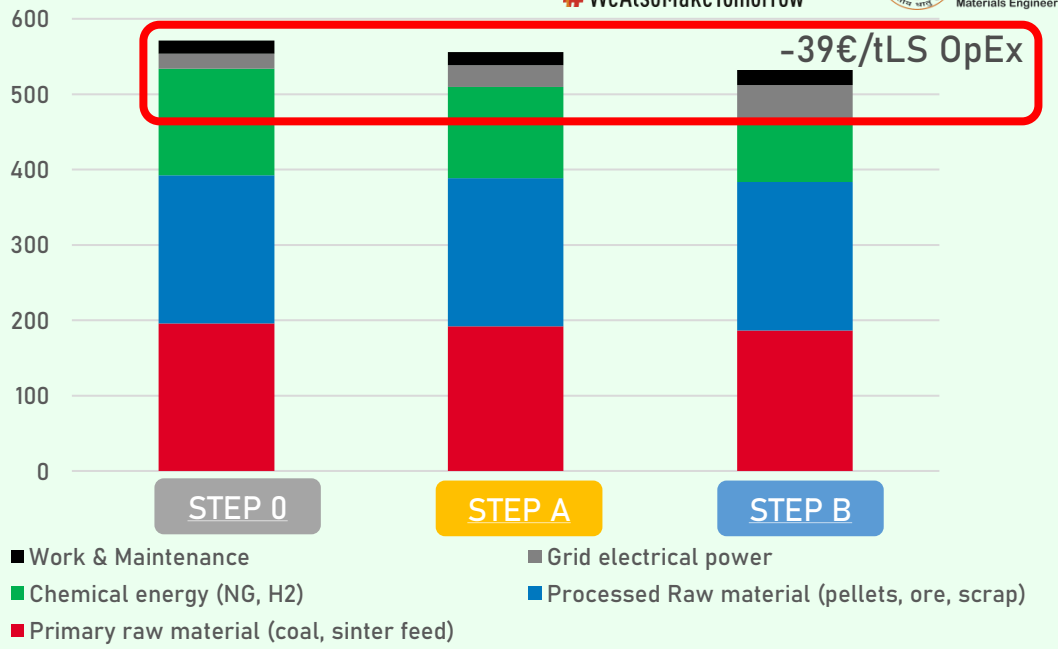


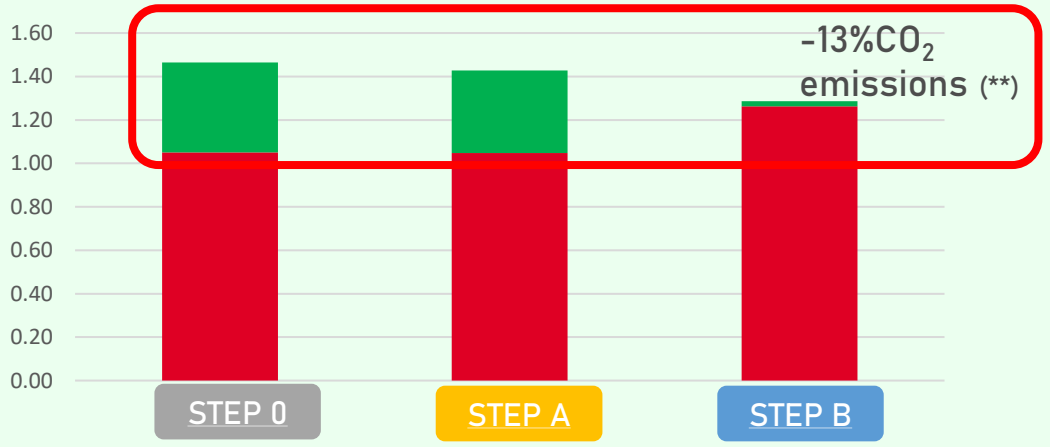
Blue BF's

4 MTPY HM production

1 DRP

2,5 MTPY DRI production



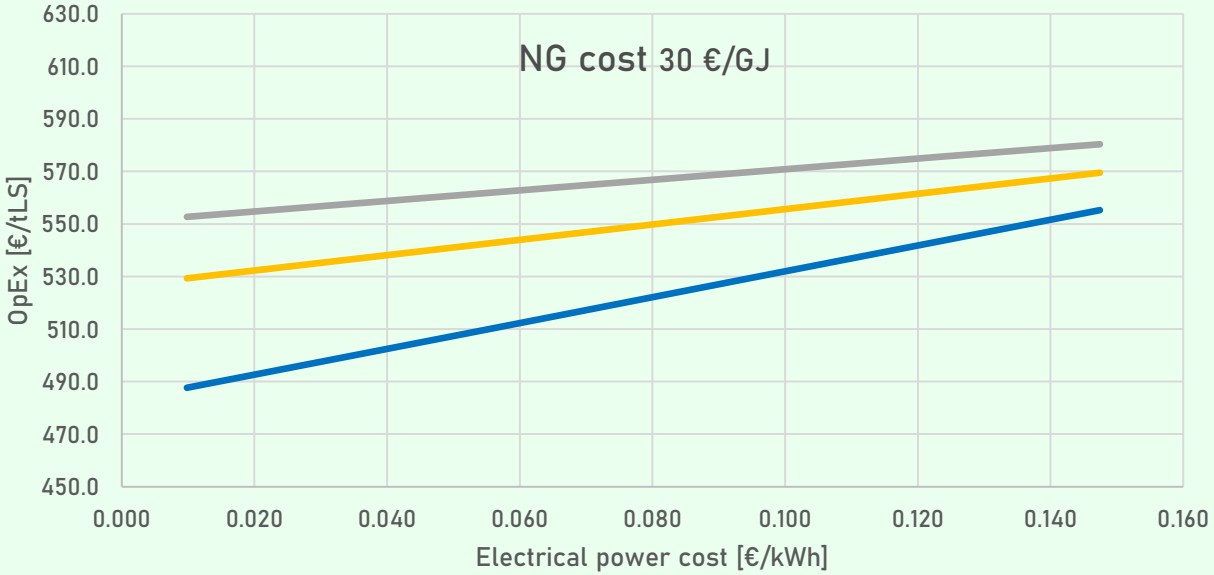


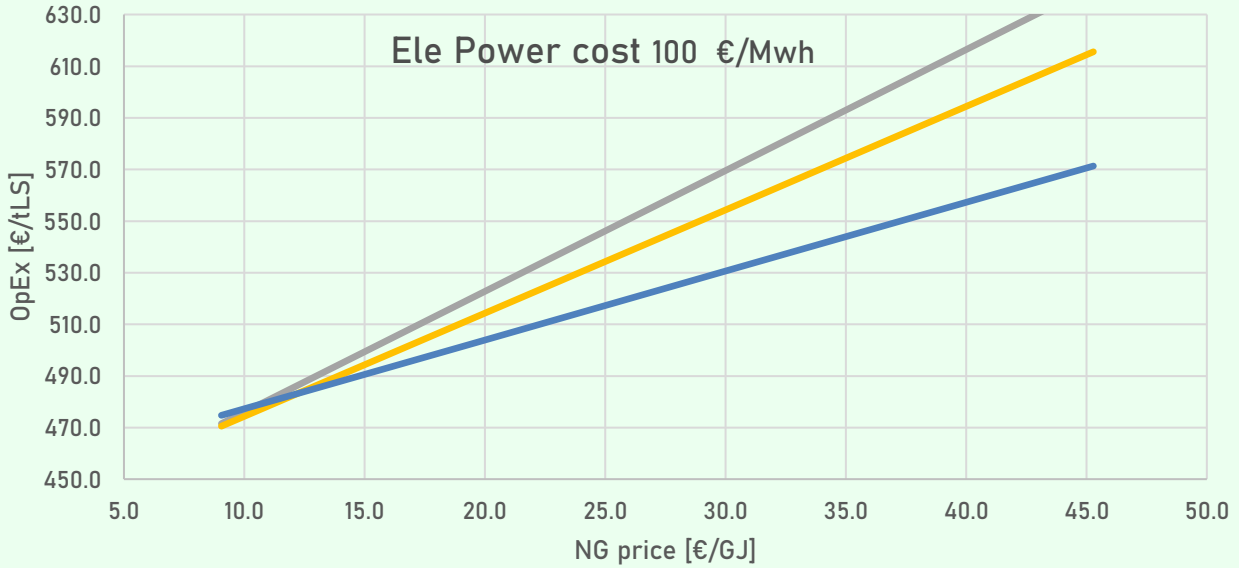
(*) Considering CPO for syngas generation

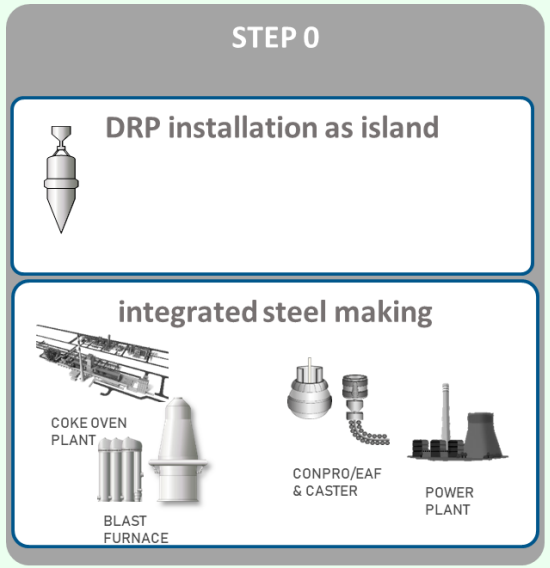
(**) on approx. 7 MTPY LS produced through BF or DRP routes as islands

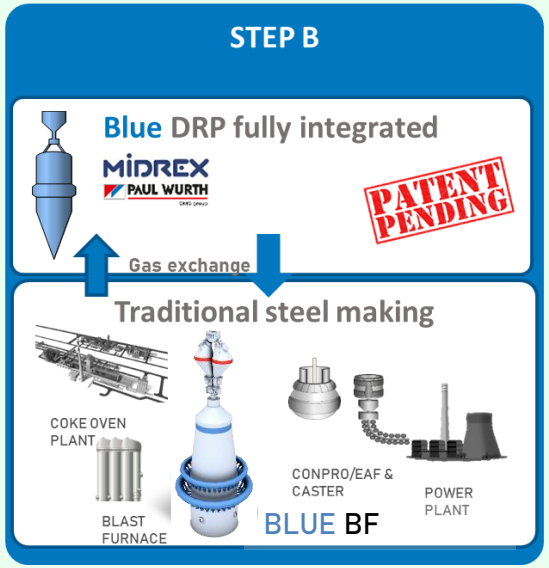
BLUE BF in smart combination with DRP through gas exchange: OPEX sensitivity

UTILITIES AND RAW MATERIAL COSTS AS PER PREVIOUS SLIDE









BLUE BF in smart combination with DRP through gas exchange: flexibility vs energy cost

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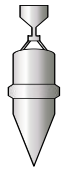
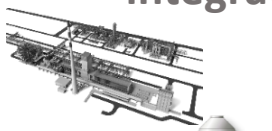
STEP 0

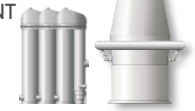
DRP installation as island



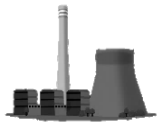
integrated steel making



COKE OVEN PLANT



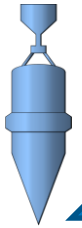
BLAST FURNACE



POWER PLANT

STEP B

Blue DRP fully integrated



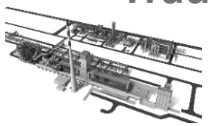
MIDREX
PAUL WURTH

NG Input

PATENT PENDING

Gas exchange

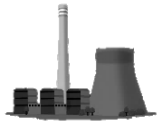
Traditional steel making



COKE OVEN PLANT

BLAST FURNACE

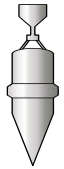
CPO



POWER PLANT

STEP C

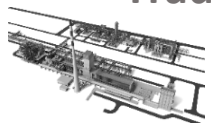
DRP installation as island



MIDREX
PAUL WURTH

NG Input

Traditional steel making

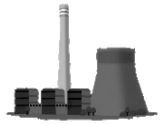


COKE OVEN PLANT

BLAST FURNACE

CPO

NG Input



POWER PLANT

Blue BF with CPO syngas production can be fed either with DRP fuel gas (STEP B) or NG (STEP C)

Blue BF with CPO can be integrated with Blue DRP or operated Stand-alone based on market conditions

Higher cost ratio of NG/coal ⟷ Lower cost ratio of NG/coal

Main takeways

The use of NG as a needed transition reductant in place of green hydrogen can be optimized when a Midrex DRP is installed in an existing BF based integrated plant

The proposed solution of bi-directional gas exchange between Blue BF and Midrex DRP is beneficial in terms of OPEX and CO2 emissions

The needed technologies to smartly integrate an NG based Midrex DRP in a BF based steel plant are proven and readily available

The proposed solution is best placed to ensure the OPEX competiveness in case the relative costs of reducing agents (NG , coal and H2) change

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