SIMA
Sponge Iron Manufacturers Association
Indian voice for the ore based metallic & steel industry

DRI UPDATE

Special Seminar Issue

DRI SUMMIT 2022

OCTOBER 2022

Editorial

Dear Industry Friends,

As you all are aware, our Association has recently organized one of the biggest global technical conferences – **"5th India International DRI Summit 2022" held on at Hotel Taj Palace, New Delhi on 30th September 2022.** The focus of this conference was **Decarbonization of Indian DRI & Steel Industry – Way Forward.** Apart from the Inaugural Session, we had four sessions all focusing on how to reduce carbon footprints in DRI & steel making. It was very well attended by Indian and overseas participants.

In the various deliberations it was made very clear that to achieve the targeted level of CO2 emissions by 2030 and 2047, DRI industry must play major role. As a short-term measure, we must ensure as to how to reduce carbon footprints in the coal based DRI production route as major savings will come through this segment of the industry as compared to other areas of iron and steel making. As there appears no immediate solution, we must direct our all resources in the areas of Research and Development. This requires hand holding between Government and DRI industry. SIMA is prepared to play a meaningful role to contribute to reduce carbon footprints.

Another area which requires immediate solution to ensure supply of natural gas to the potential greenfield DRI production capacities. This route which has less than 50% CO2 emissions compared to the conventional route of BF – BOF route. In this direction Government must take action to ensure to supply natural gas on a continuous and affordable basis. We have huge unutilized infrastructure particularly in the Eastern sector which is the hub of Iron and steel making.

We wish you all the best in this festival season.

Deependra Kashiva

Director General

Chairman's Message

It's an exciting time to be in India, we have surpassed China to become the fastest growing economy among the larger emerging economy. I think it will not be an overstretch to call this "**India's decade**". Ministry of Steel is engaged in preparing **Vision 2047** which envisages India's steel production of about **490 million tonnes**. This Grand Vision calls for close interaction and partnership between the Government, industry and other stakeholders for long term sustainability.

The Sustainable Development Scenario requires direct emission intensity of crude steel production in India to fall over 60% by 2050 on the path to net zero in 2070**.** At the current level of steel production, Indian steel sector contributes about 490 million tonnes of CO2 emissions which is about 12% of the total emissions in India.

Direct Reduced Iron and Steel scrap are going to augment the steel production in the country and would also play a critical role in reducing carbon footprint in steel making. DRI production and availability of steel melting scrap to the extent of envisaged 300 million tonnes by 2047 will be a great challenge and we will all have to step up and perform to achieve the targets.

To bring the above issues in focus SIMA recently organized a conference – "5th India International DRI Summit 2022". We were blessed by the presence of Secretary Steel and Additional Secretary Steel and we could have constructive deliberations on the road ahead. There was unanimous decision that we require both short term and long term strategies to sustainably handle the issue. Under the short term measure, we should explore all possibility to reduce specific energy consumption and also to substitute part of thermal coal being used in the rotary kiln during the coal based DRI production route and increasing use of steel scrap in all steel making routes. On a long term measures, there is a need to set up merchant syngas plants in the DRI clusters area, create enough availability of green hydrogen at affordable price and to develop the indigenous technology to use green hydrogen.

I would like to congratulate all the Members and participants for the immense success of DRI Summit 2022. We propose to annually organize such interactive conferences to address the current challenges faced by the industry.

I take this opportunity to wish all our readers a joyous and prosperous festive season!

Rahul Mittal,

Chairman
SIMA

Tenova Technologies on Direct Reduced Iron and Its Future in Steel Making.

The use of Hydrogen for Steel Production – Praveen Chaturvedi, Tenova Technologies

tenova

SIMA Sponge Iron Manufacturers Association

5th India International DRI Summit 2022

Tenova Approach for Green Steelmaking

Tenova Technologies on Direct Reduced Iron and its Future in steel Making: The use of Hydrogen for steel production

Praveen Chaturvedi

Tenova HYL

5th India International DRI Summit 2022, New Delhi, 30th Sept.2022

Agenda

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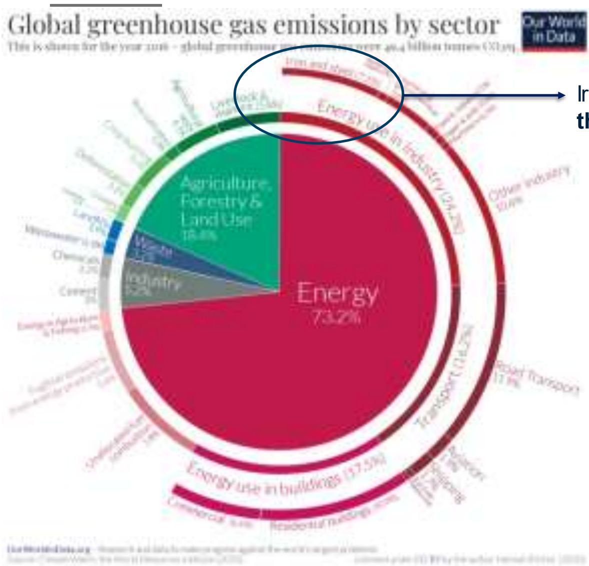
1. **Global Greenhouse Emissions**
2. **The Tenova Approach for Sustainable and Green Steelmaking**
3. **Key Features for the DRI Technology to reach the ultimate goal of net zero carbon**
4. **Routes for Low Carbon Steelmaking**
5. **On-going projects for Green Steelmaking**

The road to Net Zero Carbon

Greenhouse Gases Emissions– by Industry type

tenova



Iron & Steel Industry accounts for **~7% of the total CO_2 Emissions** in the World

The TENOVA Approach to support the industry to reach the carbon footprint reduction:

1. **ENERGIRON DRI Technology**, jointly developed by Tenova and Danieli, for produce high quality reduced iron to be coupled either wiith:
   a) An **Electric Arc Furnace (EAF)** for liquid steel production, and/or,
   b) A **Open Slag Bath Furnace (OSBF)** for hot metal production

Is this transition enough for the long term objective? Yes, but complementing, **Hydrogen** need to be used

DR technology characteristics for Green Steel

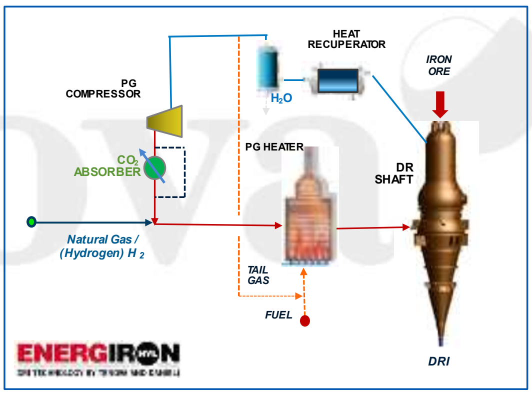
tenova

BASIC REQUIREMENTS FOR DECARBONIZING IRONMAKING/STEELMAKING INDUSTRY

1. **Hydrogen Ready!** Flexibility to operate with NG/H_2 from 0-100%:
   ENERGIRON is the only DR technology available capable to operate from 100%NG - 100%H_2 in **reversible operating mode** at any moment with no need to modify the process configuration.

2. Flexibility for **high %C DRI** for HM production
   ENERGIRON is the only proven technology to produce >4%C DRI with 100%NG. Even with 30%H_2 (energy), %C >3.3% can be achieved.

3. Possibility for inherent **CCU/CCS.**
   ENERGIRON DR technology has an inherent selective CO_2 removal as part of its standard and unique scheme.

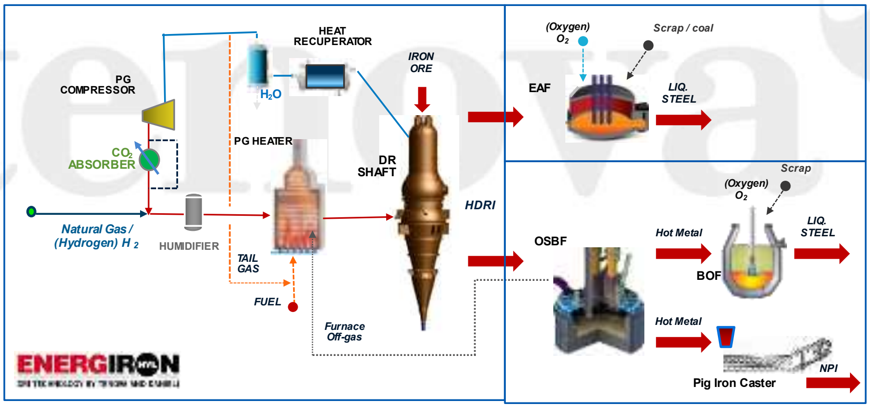


***ENERGIRON** DRI Standard Process Scheme*

Routes for low-C footprint steelmaking

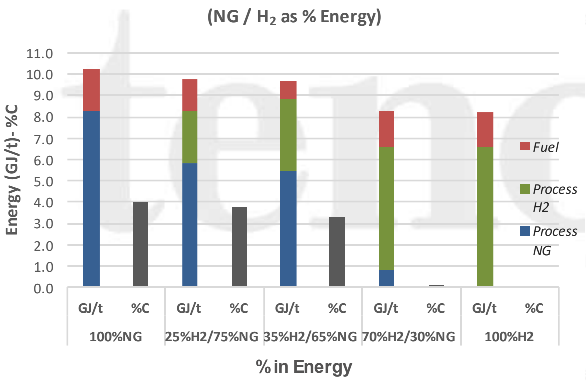
GENERAL APPROACH

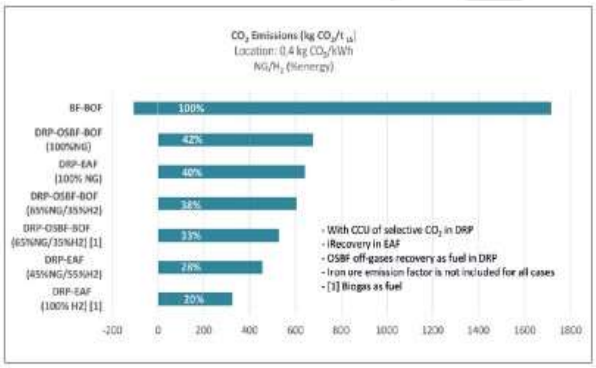
1. Steel production by DRI -EAF
2. Replacement of BF by ENERGIRON DRI -Tenova OSBF for Hot Metal production to existing BOF-downstream facilities
3. Production of PI/NPI by DRI -Tenova OSBF



DR Process efficiency and flexibility

ENERGY CONSUMPTION AND CO₂ EMISSIONS





DR Process efficiency and flexibility

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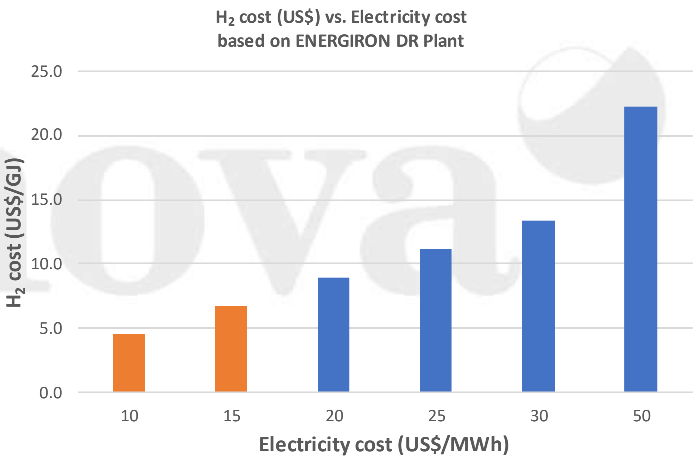
ENERGY CONSUMPTION AND CQ EMISSIONS

As observed from the graph:

- Hydrogen cost, as compared to NG cost scenario, depends on the local electricity cost.
- In general, to be competitive vs. NG, electricity cost for H_2-based DRI production shall be **< $20/MWh**

Basis:
Typical AAElectrolyzers with eff. ~74%
Typical consumption process energy consumption for ENERGIRON process



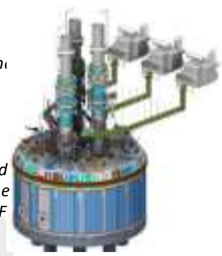
Steelmaking routes characteristics

tenova

ENERGY AND IRON ORES ISSUES TO CONSIDER

- For steel production by DRI -EAF
  - Typically, high quality iron ore pellets for economically EAF high-quality steel production
  - Possibility for intensive use of ~100% H_2 for <1%C. Carbon balance injected directly in EAF.
- Replacement of BF by DRI -Tenova Melter for Hot Metal production to existing BOF -downstream facilities
  - BF type pellets for production of HM
  - Preferably High -C DRI with >4.0% but also ~3.3%C with C balance injected to the Tenova OSBF.
- Production of NPI by DRI -Melter
  - Any iron ore pellet with special attention to Si, S, P, Mn, depending on the NPI grade to be produced
  - Preferably High -C DRI.

Integrated Process Scheme for DRI-EAF

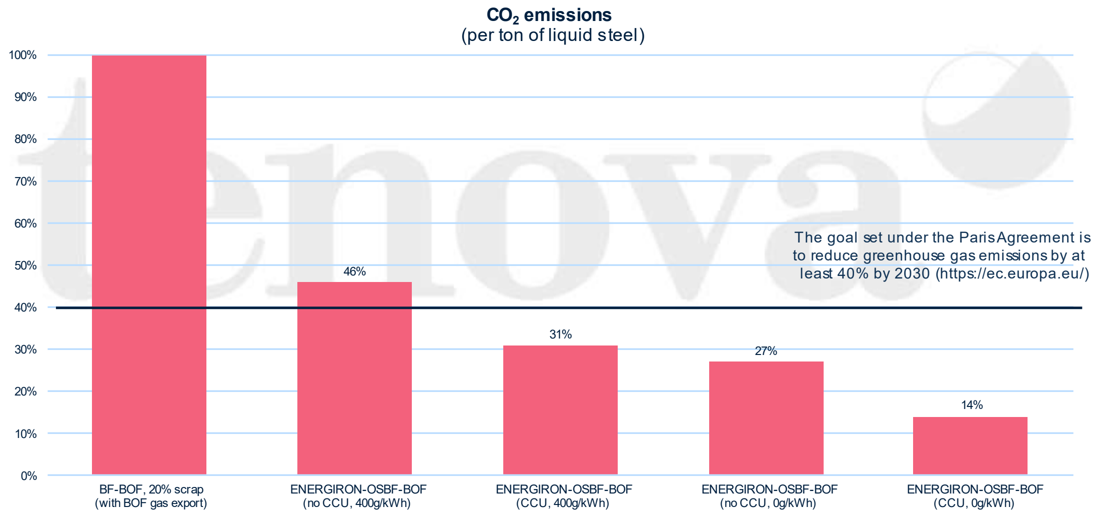


Integrated Process Scheme for DRI-OSBF

Integrated Process Scheme for Production of Hot Metal with Natural Gas: ENERGIRON ZR + Tenova OSBF

DR Process efficiency and flexibility

ENERGY CONSUMPTION AND CQ EMISSIONS



Current Ironmaking/Steelmaking Projects

PROJECTS WITH THE LOWESTC EMISSIONS IRONMAKINGBASED ON ENERGIRON TECHNOLOGY

- **Blackrock Metals, Canada**
  Pelletizing, DRI plant and Smelter to produce hot metal for PI, slag metals recovery
- **PETMIN, OH, USA**
  DRI plant and Smelter for production of NPI

➢ Valuable production of Hot Metal/Pig Iron ONLY possible thanks to the ENERGIRON high -C DRI: C >4.0%

Current Ironmaking/Steelmaking Projects

tenova

PROJECTS WITH THE LOWEST -C EMISSIONS FOR STEELMAKING BASED ON ENERGIRON TECHNOLOGY

HYBRIT
FOSSIL-FREE STEEL
SSAB LKAB VATTENFALL

SALCOS
Steelmaking. Reinvented.

HBIS GROUP 河钢集团 HBIS GROUP

First Hydrogen-based DRI Plant in China

tenova

Praveen Chaturvedi
VP & Head– Sales Upstream India

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TECHINT GROUP

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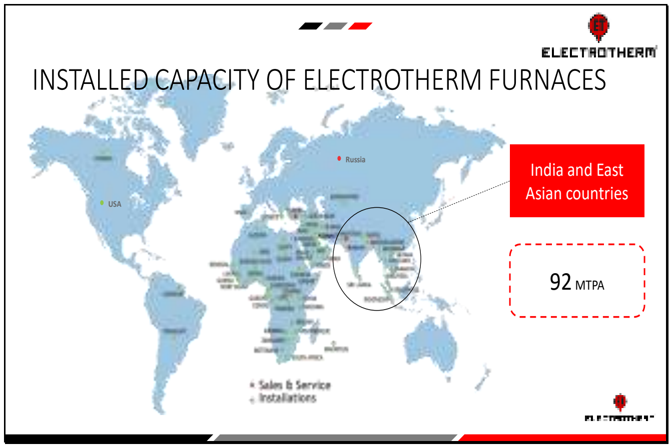
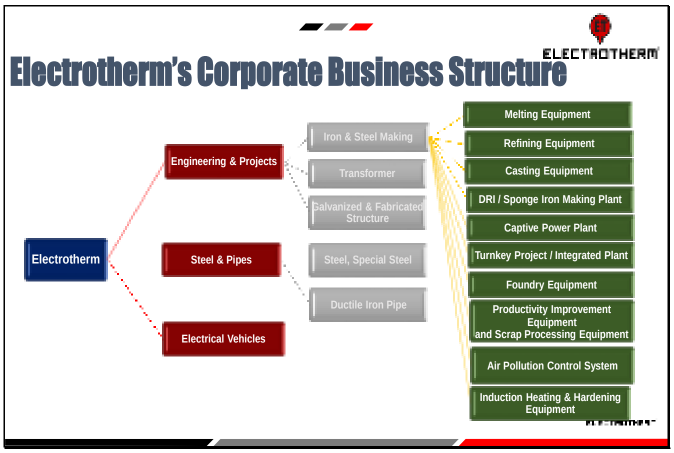
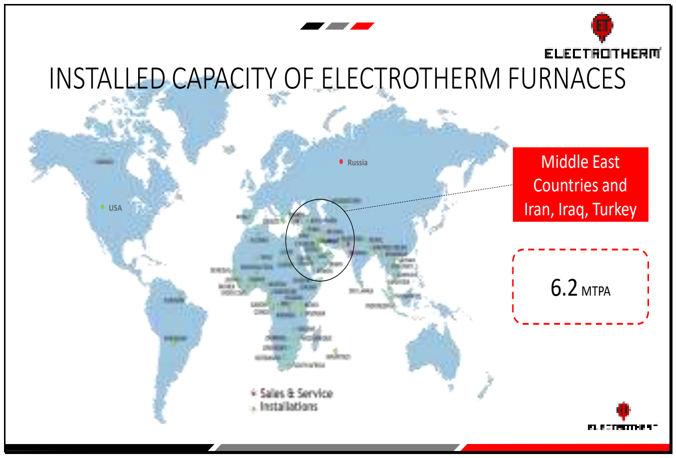
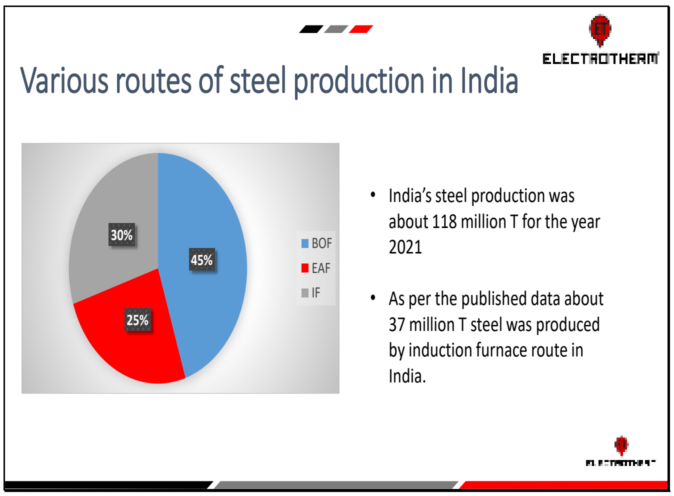
Induction Furnace Route for Steel Making and CO2 emissions

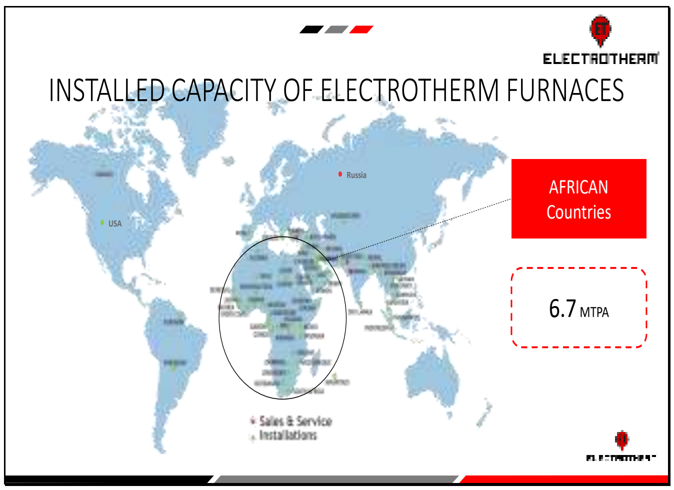
Mukesh Bhandari & Dr. Swaren Bedarkar, Electrotherm India Ltd.



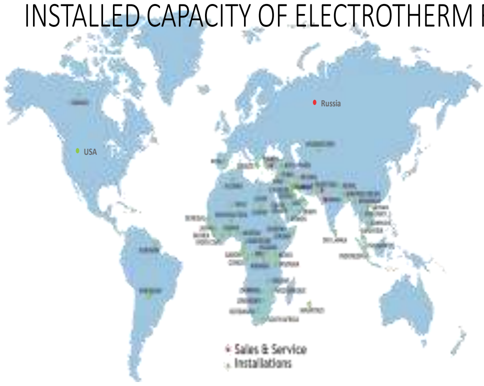






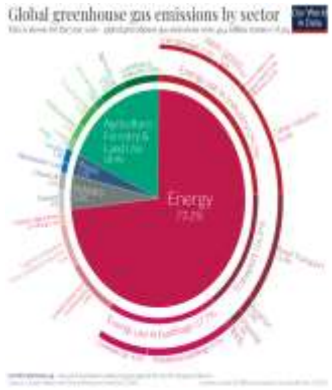


INSTALLED CAPACITY OF ELECTROTHERM FURNACES



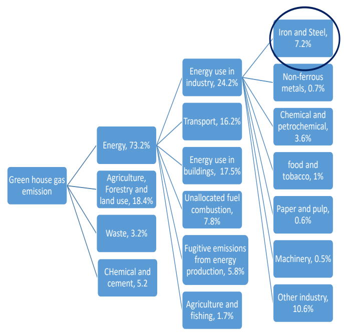
TOTAL

105 MTPA



Various sectors responsible for GHG emission

Estimated IF steel production capacity across the world is about 200 million T, which is approximately 10% of the world's steel production.



Various sectors responsible for green house gas emission and contribution of Iron and Steel Industry

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CO_2 Emission During Steelmaking

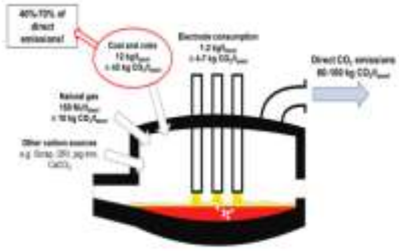
The presentation will encompass .....

- Study of carbon flow diagrams for all steel-making processes
  - BF – BOF steelmaking
  - Electric steelmaking
- CO_2 emission during melting of 100% scrap in IF and EAF steel-making
- Effect of CO_2 emission due to introduction of Gas-Based and Coal-Based DRI
- Effect of direct rolling on CO_2 emission
- Important points about induction furnace steelmaking and CO_2 emission

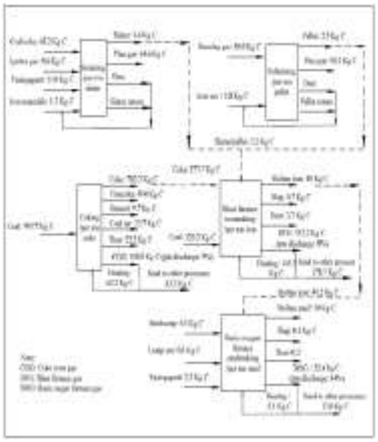
Iron and Steel Industry

- As discussed earlier, Indian steel industry is divided mainly in three parts
  - BF-BOF steelmaking — capacity: 0.75 MTPA and higher
  - Electric steelmaking
    - EAF route — capacity: 0.5 MTPA and higher
    - Induction furnace route — capacity: 0.1 MTPA and 0.5 MTPA
- It is a common practice to study carbon flow diagram of the process to estimate CO_2 emission per ton of steel production

Carbon flow diagram for EAF route



Carbon flow diagram for BF-BOF route



Carbon balance diagram for induction furnace which implies CO2 emission is about 3.2 kg / T steel

Carbon from scrap, 2.08 kg
Carbon from ferro alloys, 0.15kg
Carbon from oily scrap, 0.88 kg
Carbon in flue gas, 0.88 kg

Electric steelmaking CO_2 emission

Electric steelmaking CO2 emission

- **Direct emission** (Gases coming out during steelmaking)
- **Indirect emission** (Gases coming out at thermal power plant)

CO2 emission at thermal power plant

- Electrical furnaces are run on electric power
- Electricity is produced by thermal power plants, hydro power plants or at wind turbines.
- Now, SOLAR POWER is an emerging trend where possibilities of installation and utilization of solar power have been explored.
- Across the world various data have been used for the CO2 emission for the production of 1 electrical unit (i.e. kWh) at thermal power plant. The data ranges from 0.6 kg CO2 to 1.0 kg CO2 / kWh.
- **In the present work 0.9 kg CO2 / kWh emission data has been used.**

Comparison of Electric Steelmaking Routes

- EAF
  - EAF with 100% scrap — 100 kg CO2 / T steel
  - With average electrical energy consumption — 420 kWh / T steel
  - SVC + Pollution control unit — 80 kWh/T steel
  - CO2 emission at thermal power plants due to EAF — 0.9 kg CO2 / kWh
  - CO2 emission at thermal power plant due to EAF — 450 kg / T steel
- Total CO2 emission for EAF — 100 + 450 = 550 kg/T

CO2 emission at DRI plant

- Gas based DRI plant — 1300 kg CO2/t DRI
- Coal based DRI plant with power generation — 1550 kg CO2 /t DRI

Comparison of Electric Steelmaking Routes

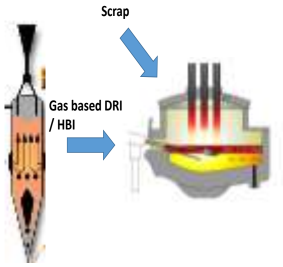
- Induction Furnace
  - Induction Furnace with 100% scrap — 3.2 kg CO2 / T steel
  - With average electrical energy consumption — 510 kWh / T steel
  - Pollution control unit — 25 kWh/T steel
  - CO2 emission at thermal power plants — 0.9 kg CO2 / kWh
  - CO2 emission at thermal power plant — 482 kg / T steel
- Total CO2 emission for induction furnace — 3.2 + 482 = 485 kg/T

Induction Furnace Steelmaking

Induction Furnace Steelmaking

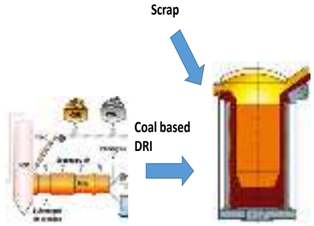
Charge mix	Charge weight		CO_2emission at DRI plant @1550 kgCO2/t DRI, kg	CO_2emission at Furnace , kg	kWh/t steel at furnace with APCS	CO_2 emission at thermal power plant@0.9kg CO2/kWh, kg	Total CO2 emission, kg/T steel
	Scrap (Y 96%), kg	Coal based DRI (Y 84%), kg					
100% scrap	1041.6	0	0	3.2	535	482	485
50% scrap, 50% DRI	555.6	555.6	861.2	3.2	630	567	1432
20% scrap, 80% DRI	231.5	925.9	1435.15	3.3	685	616	2054

EAF Steelmaking



CO2 generation at gas based DRI + CO2 generation EAF

IF steelmaking



CO2 generation at coal based DRI + CO2 generation IF

EAF Steelmaking

Electric Arc Furnace Steelmaking

Charge mix	Charge weight		CO_2emission at HBI plant @1300 kgCO2/t DRI, kg	CO_2emission at Furnace , kg	kWh/t steel at furnace with SVC and APCS	CO_2 emission at thermal power plant@0.9kg CO2/kWh, kg	Total CO2 emission, kg/T steel
	Scrap (Y 92%), kg	HBI (Y 84%), kg					
100% scrap	1087	0	0	100	500	450	550
50% scrap, 50% DRI	564	568	739	100	560	504	1343
20% scrap, 80% DRI	234	935	1216	100	680	612	1930

Comparison of CO2 emission of EAF and IF

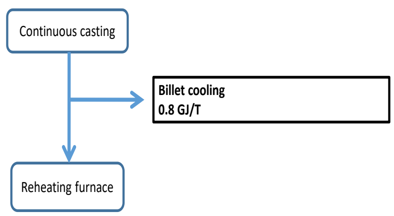
Charge mix	Total CO2 emission, kg/T steel	
	Electric Arc Furnace	Induction Furnace
100% scrap	550	485
50% scrap, 50% DRI	1343	1432
20% scrap, 80% DRI	1930	2054

- For 100% melting of scrap, CO2 emission for EAF is more due to foamy slag practice
- As Coal based DRI is used IF, cumulative CO2 emission for IF increases as coal based DRI units emit more CO2 compared to gas based DRI.

Comparison of CO2 emission of EAF and IF

Charge mix	Total CO2 emission, kg/T steel	
	Electric Arc Furnace	Induction Furnace
100% scrap + rolling	650	485
50% scrap, 50% DRI + rolling	1443	1432
20% scrap, 80% DRI + rolling	2030	2054

Direct rolling in steel plants



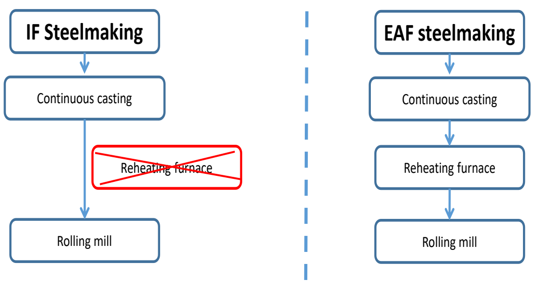
- In reheating furnace steel needs to be heated to 1100 ^{0}C
- It generates about 100 kg CO_2 / T of steel

Comparison of CO2 emission of EAF, IF and BOF with steelmaking and rolling

Charge mix	Total CO2 emission, kg/T steel		
	Electric Arc Furnace	Induction Furnace	BF-BOF
100% scrap	650	485	2000-2200
50% scrap, 50% DRI	1443	1432	
20% scrap, 80% DRI	2030	2054	

- Once can observe that all the steelmaking processes emit almost similar amount of CO2 per ton of steelmaking
- For melting of 100 % scrap, induction furnace is a better option compared to EAF

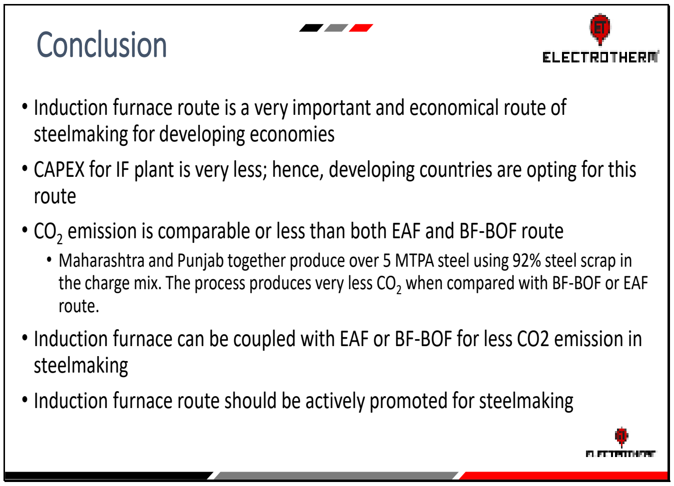
Direct rolling in steel plants

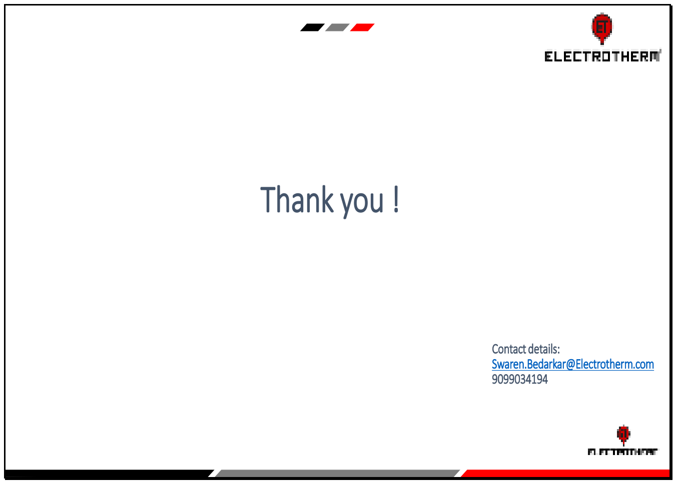


- Direct rolling is a common practice in **induction furnace** based steel plants
- Almost 90 % steel plants follow this

Important points to note

- The countries where iron ore and coal/coke are not available, are making steel using only steel scrap and induction furnaces.
- In terms of CAPEX, IF steelmaking plant is much cheaper compared to BF-BOF or EAF route of steelmaking.
- Induction furnaces are operated with normal electrical grids as compared to EAFs which need stronger electric grids.
- Many countries like Nepal and Congo where hydro power is the major source of electricity, produce steel using induction furnaces. Here, indirect CO2 generation at power plant is negligible.





Authors of this article have estimated that IF steel production capacity is about 200 million tonnes, which is about 10% of the global steel production. They have also opined that total CO2 emissions in induction furnace route is about 0.485 tonne per tonne of crude steel and 0.55 tonne through the EAF route with 100% scrap. With 50% scrap and 50% DRI, these figures would change to 1.34 tonnes and 1.43 tonnes respectively.

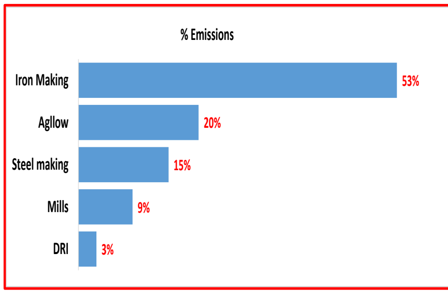
Editor

Low CO2 DRI Making – In Quest to Decarbonize Steel Making

Reddi B.Prasad and Mukesh V. Shah, JSW Steel Ltd.

CO2 baselining | Fuel accounts for ~70% of total emissions

CO2 Emission Contribution at Plant level



CO2 Emission at DRI kg/t DRI

	Total
IBRM	3
Fuel	729
Energy	351
Utilities	4
Output	-59
Total	1029

Scenario : Energy equivalence of electricity taken as 9.8 GJ/MWH (WSA Global value)

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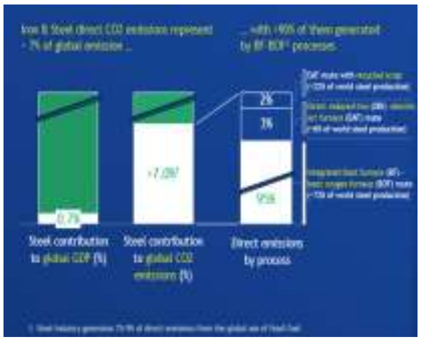
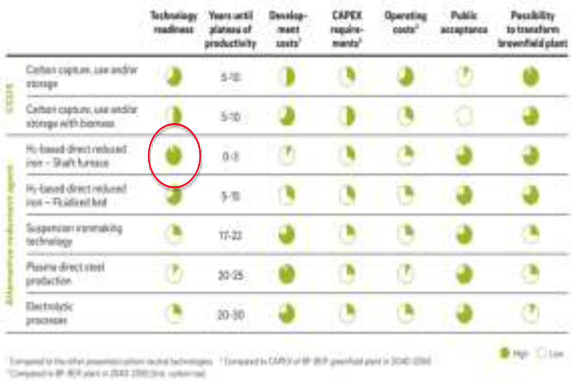
STEELMAKING AND DE-CARBONIZATION



- The production of steel remains a CO2 and energy-intensive activity. However, the steel industry is committed to continuing to reduce the footprint from its operations and the use of its products.
- The Paris Agreement was adopted in 2015. The agreement's central aim is to limit global temperature rise to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.
- Going forward, steel producers need to assess, evaluate, and decide on a technologically and economically viable way to decrease their carbon footprint.
- The optimal steps to decarbonization will differ by location and site, depending on the likes of technical feasibility, existing infrastructure, market demands, operating costs (ie, the price of renewable electricity, the price of scrap), and the regulatory environment.

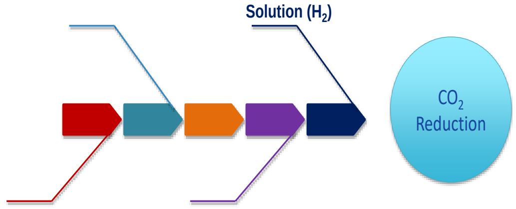
2

TECHNOLOGY READINESS



Source: The future of steelmaking, Roland Berger GmbH, 2020

CO_2 REDUCTION PATHWAY



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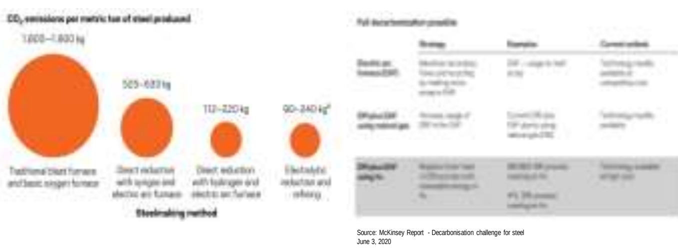
DE-CARBONIZATION PATHWAY



DRI route is going to be the future of steel making

6

The History of JSW DRI/SIP Plants

2014

Location	Vijayanagar
Type of Fuel	Corex Gas
Technology Partner	M/s Midrex/ SVAI/ LINDE
Raw material	Pellets
Product flexibility	HDRI+CDRI
Capacity	1.2 MT

1994

Location	Dolvi
Type of Fuel	Natural Gas
Technology Partner	M/s Midrex
Raw material	Pellets + Lump
Product flexibility	CDRI
Capacity	1.6 MT

1993

Location	Salav
Type of Fuel	Natural Gas
Technology Partner	M/s HYL
Raw material	Pellets + Lump
Product flexibility	HBI+CDRI
Capacity	0.9 MT

7

GOING GREEN IN JSW DRI PLANTS

Process Improvement
- Process Improvements & digitalization
- Reduction in Fuel consumption
- Optimization of process gases

Emissions Control
- Use 10% lump ore in raw material
- Energy Efficient Technologies
- Carbon Capture & Utilization Technologies

Alternative Reductants Usage (H2/COG)
- Use of CO Gas to cut down the Natural gas
- Injecting H2 into bustle gas blend
- Inject reformed COG into bustle blend

100% H2 Replacement
- Build Green Energy/Hydrogen Capacity
- Hydrogen based DRI Plants

8

GOING GREEN

Process Improvements
- Process Improvements & digitalization
- Reduction in Fuel consumption
- Optimization of process gases

	Process Idea
Reduction in Fuel consumption	Reduction control on COG gas usage in bustle and cooling gas circuit (Maintaining the carbon % <1 in Product)
Optimization of process gases	Optimization of Recycle gas addition to reduce the Corex Gas Consumption
Process Improvements	Reduction control of Alternate Rapid cooling agent in Product cooler by maintaining the Uniform distribution

9

GOING GREEN

Emissions Control
- Use 10% lump ore in raw material
- Energy Efficient Technologies
- Carbon Capture & Utilization Technologies

	Process Idea
Optimal IBRM	Use 10% lump ore in raw material
Increase power generation	Install WHRS near the top gas outlet
	Install turbine to capture energy from pressure drop between product gas and reduction gas
With Every 1 KWH/t DRI Power reduction/ generation, , we save 0.79 kg of Co2/t DRI	
Carbon capturing	Install CCU (utilization in Different forms Exa. Beverages, Ethanol etc..)
Waste utilization	Recycle DRI fines from top gas scrubber output into DRI brickets for use in SMS against current use in sinter/pellet

10

GOING GREEN

Alternative Reductants Usage
- Use of CO Gas to cut down the Natural gas
- Inject reformed COG into bustle blend
- Injecting H2 into bustle gas blend

	Process Idea
Reduce CO2 Emissions in process	Inject reformed COG into bustle blend *(Dolvi DRI plant is able to reduce natural gas consumption by @ 15-20% with coke oven gas addition)*
	Injecting H2 into bustle gas blend up to 20%

11

GOING GREEN

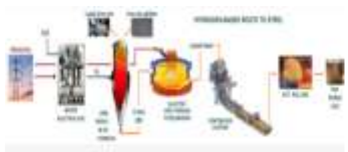
100% H2 Replacement Plan
- DRI making using 100% hydrogen
- Build Green Energy/ Hydrogen Capacity

12

HYDROGEN TECHNOLOGIES

DRI making using Hydrogen

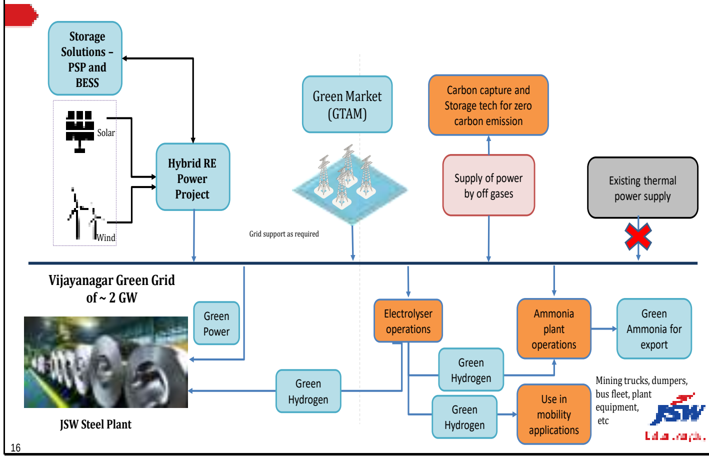
100 % replacement solution



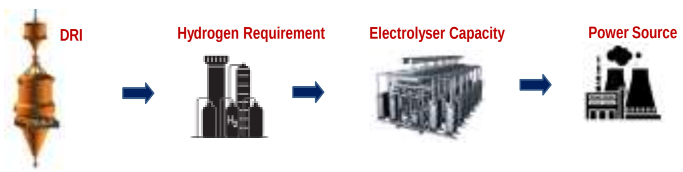
a) Midrex H2 process
b) ULCORED process (Europe)
c) HYBRIT (Sweden)
d) Primetals – HYFOR -Hydrogen-based Fine-Ore Reduction
e) H2FUTURE (Europe)
f) Salzgitter "WindH2" project

Adopting an approach combining scrap, DRI, and EAF using hydrogen is currently considered the most viable option and the long-term solution to achieving carbon-neutral steel production

Vijayanagar JSW Energy – Future Green Tech Park



DRI USING HYDROGEN



@ 340 days Operation
@ 2941 T/day
@ 122.54 T/hr Production

Basis – 1 Mtpa

H_2 requirement → 600 Nm3/T *
H_2 requirement → 73524 Nm3/hr

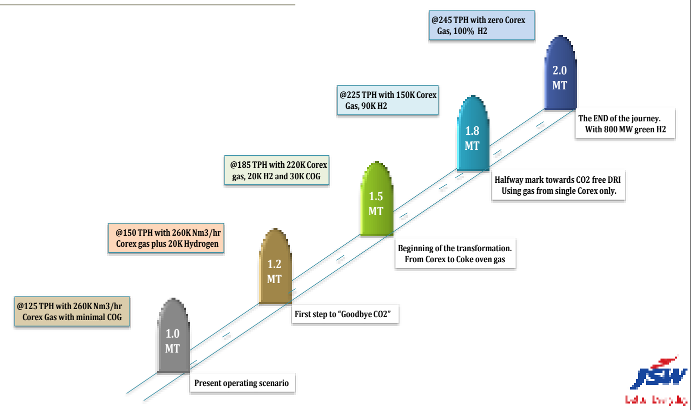
* MIDREX H_2

1MW Electrolyser → 200Nm3/hr
73524 Nm3/hr → 367 MW
@ 90 % Efficiency → 400 MW

Power Source → +400 MW

1 Mtpa DRI → 400 MW Electrolyser

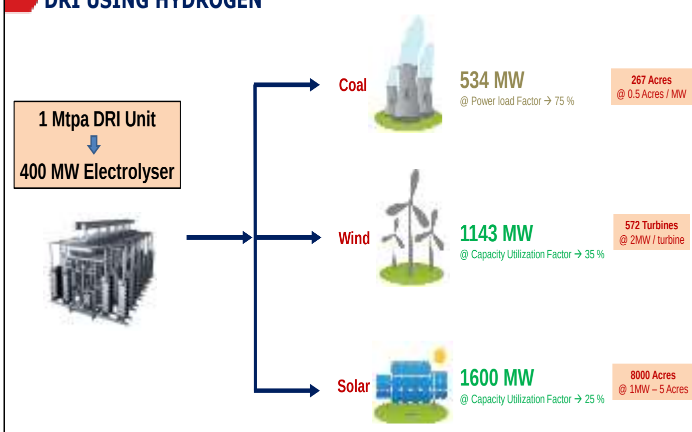
CARBON NEUTRAL GROWTH PLAN @ JSW



DRI USING HYDROGEN

Capacity Requirement

1 Mtpa DRI Unit
↓
400 MW Electrolyser



CONCLUSIONS

- In Dolvi & VJNR there is potential to use 32000 NM3/Hr & 20000 NM3/Hr Hydrogen respectively in process without affecting plant Productivity & Quality with minimum modifications.
- It is feasible to expand VJNR plant up to 2.0 MTPA by further increasing Hydrogen quantity.
- Use of 100% Hydrogen with major modification at Dolvi & VJNR is possible.

Research Trends in Sponge Iron Process: Energy Integration, Hydrogen Utilization and Waste Plastic Utilization- Dr. Shabina Khanam, IIT Roorkee

Research Trends in Sponge Iron Process: Energy Integration, Hydrogen Utilization and Waste Plastic Utilization

Shabina Khanam
Associate Professor
Chemical Engineering Department
IIT Roorkee

5th India International DRI Summit 2022 on 30th September, 2022

Research Trends in Sponge Iron Process: Energy Integration Hydrogen Utilization and Waste Plastic Utilization

- Energy integration ✓
- Hydrogen utilization
- Waste plastic utilization

Sponge Iron

Fe present in iron ore → 63-67%
Fe present in sponge iron → 90-93%

In India most of the sponge iron plants are coal based.

Problems in such plants:

- Non-optimal operation of equipment
- Lack of proper integration of energy
- Fly ash and wet ash generated due to coal combustion
- CO_2 emission

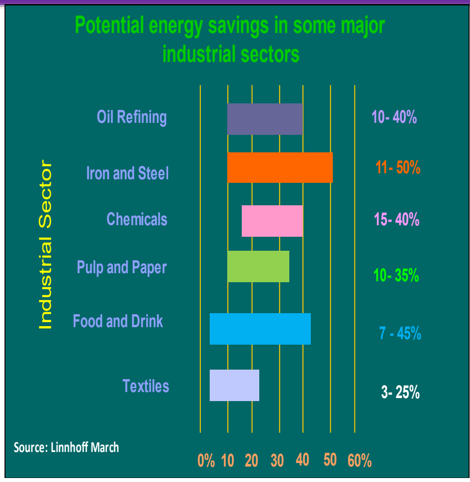
Approach used for Energy Integration

For energy integration the concept of Process Integration (PI) has been used. PI which is a knowledge subset of Process Engineering is an evolving field.

- PI is a holistic approach to process design, retrofitting, and operation of industrial plants, with applications focused on resource conservation, pollution prevention and energy management.
- It enables the process engineer to see "the big picture first, and the details later".

Integration of any process leads to many useful outcomes like saving energy, minimizing environmental effect, better economy, etc.

Real Achievable Targets (Energy) through PI



Facts about PI

IT IS

- Reliable
- Widely accepted and applied
- Matured
- Established

> 300 plants in foreign
> 10 plants in India

for last 40 years

- Practical, efficient and gives achievable targets
- Applicable in a number of areas pertaining to industry

Process Integration in Sponge Iron Plant (SIP)

1 Energy integration in a single plant

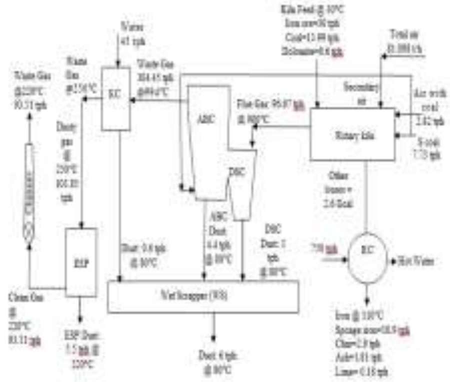
2 Energy integration in a cluster of plants

3 CFD analysis of rotary kiln to improve metallization

Energy integration in a single SIP

Preheating of Feed and Air

Existing PFD of Bihar Sponge Iron Ltd.

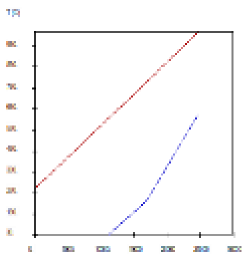


Energy integration in a single SIP

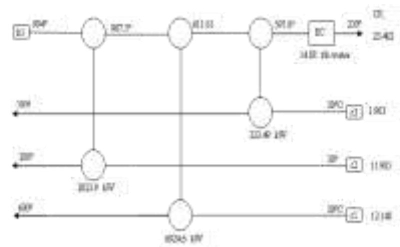
Stream data

Stream	Type	T_s	T_t	Flow (T/hr)	CP (kW/ °C)	Unit
Waste gas	h1	994	250	73.89	23.402	ABC
Kiln air	c1	30	600	42.35	12.148	Rotary kiln
Kiln feed	c2	30	200	39.22	11.905	
S coal	c3	30	200	4.96	1.903	

Preheating of Feed and Air



Composite curve

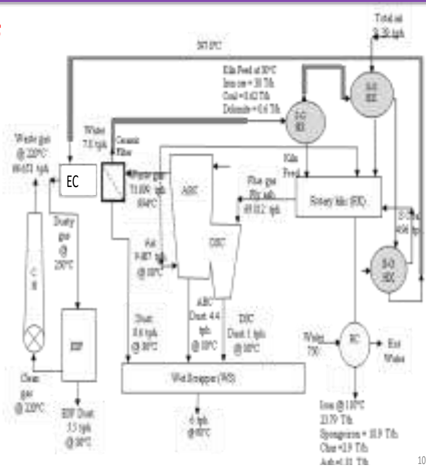


Heat Exchanger Network Diagram

Energy integration in a single SIP

Preheating of Feed and Air

Modified PFD of Bihar Sponge Iron Ltd.



Energy integration in a single plant

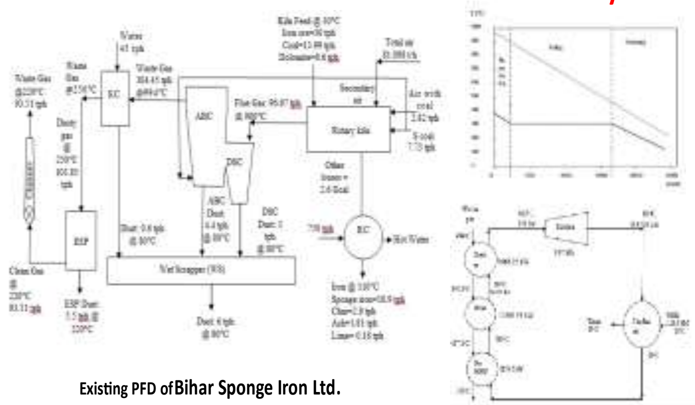
Economic analysis of Preheating of Feed and Air

Operating cost (Lakh/year)			Capital cost (Lakh)		TAC	Profit	Payback
Commodity	Amount	Cost	Item	Cost	(Lakh/year)	(Lakh/year)	period, yr
Coal	13.58	2678.1	G-G HX	50.8	7272.4	1126.8	3.22
Water	757.8	3584.7	G-S HX	142.14			
Ceramic filter		577.5	G-S HX	22.72			
Electricity cost		74.5	Ceramic filter	2941.1			
			Ducts	8.97			
			Insulation	42.79			
			FD fans	367.26			

Saving in coal = 37.6 %

Energy integration in a single SIP

Waste heat recovery Boiler



Existing PFD of Bihar Sponge Iron Ltd.

Energy integration in a single SIP

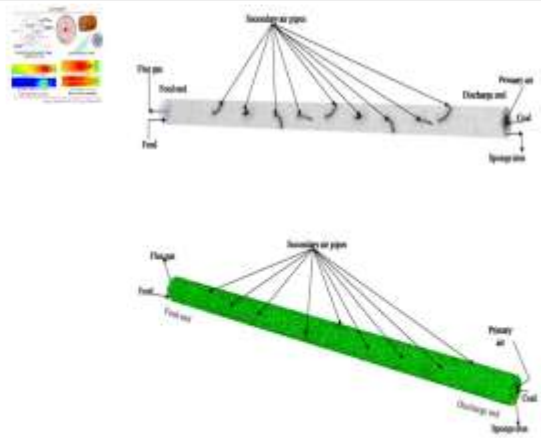
Economic analysis of WHRB

Operating cost (Lakh/year)			Capital cost (Lakh)		Power (MW)	Power Exported (Lakh Rs)	TAC (Lakh/ year)	Profit (Lakh/ year)	Payback period (Years)
Commodity	Amount, t/h	Cost	Item	Cost					
Coal	21.72	4344	Boiler & turbine system	4197.9	8.97	5107.5	12104.3	2029.9	4.17
Water	779.56	5964.9	Ceramic filter	4157.3					
Ceramic filter		816.3							
Maintenance cost of turbine system		143.52							

Total power output through WHRB = 8.97 MW

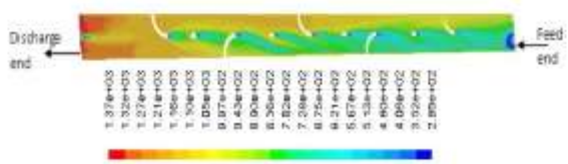
Option	Coal cons., t/h	Water cons, t/h	Operating cost, lakh/year	Electricity cost, lakh/year	Capital investment, Lakh		TAC, lakh/year	Waste gas generated, t/h	Profit, lakh/year	Payback period, Years	Power Generation, MW
Existing System	21.72	795	3866.9	-----	765		4431.3	128.376	728	1.05	-----
WHRB	21.72	1242.7	10308.9	-----	Item	Cost	12104.3	98.358	2029.9	4.17	8.97
					Boiler and turbine system	4197.96					
					Ceramic filter	4157.3					
Preheating of raw material, air and slinger coal	13.587	757.8	6262.8	74.5	G-G HX	50.8	7272.4	82.679	1126.8	3.22	-----
					G-S HX	142.14					
					G-S HX	22.72					
					Ceramic filter	2941.1					
					Ducts	8.97					
					Insulation	42.79					
					FD fan	367.26					
Combination of WHRB and preheating	13.587	917.5	7018.8	74.5	G-G HX	50.8	8086.8	82.679	1897.1	2.62	2.76
					G-S HX	142.14					
					G-S HX	22.72					
					Ceramic filter	2941.1					
					Ducts	9.628					
					Insulation	85.58					
					FD fans	367.26					
					Boiler and turbine system	1290.28					

CFD analysis of rotary kiln to improve metallization



CFD analysis of rotary kiln to improve metallization

Temperature profile contour for 3D model



Parameter	3D model
Inclination	2.6°C
Flow rate of iron ore	8.33 kg/s
Flow rate of feed coal	3.88kg/s
% metallization increased	1.3%

Research Trends in Sponge Iron Process: Energy Integration, Hydrogen Utilization and Waste Plastic Utilization

- Energy Integration
- Hydrogen Utilization ✓
- Waste Plastic Utilization

Hydrogen Utilization

Hydrogen-based reduction

$Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$, $FeO + H_2 \rightarrow Fe + H_2O$

The main advantage of this steelmaking route is the dramatic reduction in CO_2 emissions.

Using just hydrogen as a reductant for ironmaking is not yet an industrial process. However, it could become one soon according to several recent signs.

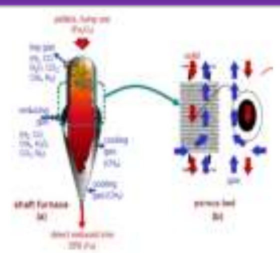
In the iron and steel industry, where hydrogen can be used to reduce iron ore to iron, the use of clean hydrogen will be expected by 2030 and gain momentum by 2035.

Route	Energy needed	CO_2 emissions
Standard BF-BOF route	18.8 GJ/t_{HRC} (mostly coal)	1850 kgCO_2eq/t_{HRC}
Direct reduction + EAF	15.6 GJ/t_{HRC} (gas and electricity)	970 kgCO_2eq/t_{HRC}
Hydrogen-based route	15.4 GJ/t_{HRC} 14.7 GJ/t_{LS} (mostly electricity) 13.3 GJ/t_{LS}	196 kgCO_2eq/t_{HRC} 25 kgCO_2eq/t_{LS} 53 kgCO_2eq/t_{LS}

Fabrice Patisson and Olivier Mirgaux, Hydrogen Ironmaking: How it Works, Metals 2020, 10, 922.

Hydrogen Utilization

DRI using Hydrogen

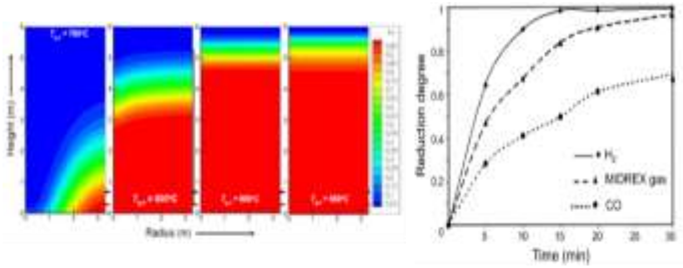


Shaft	Height = 6 m	Radius = 3.3 m	
Pellets	CVRD-DR	Diameter = 14 mm	Porosity = 0.33
Inlet solid	Fe_2O_3	Flowrate = 52 kg/s	Temperature = 25°C
Inlet gas	98% H_2, 2% H_2O	Lateral flowrate = 3634 mol/s Bottom flowrate = 100 mol/s	Temperature = 800°C

Fabrice Patisson and Olivier Mirgaux, Hydrogen Ironmaking: How it Works, Metals 2020, 10, 922.

Hydrogen Utilization

DRI using Hydrogen



Fabrice Patisson and Olivier Mirgaux, Hydrogen Ironmaking: How it Works, Metals 2020, 10, 922.

Hydrogen Utilization

Ground development

A number of steelmakers are taking this approach; key projects include Hybrit (SSAB/LKAB/Vattenfall) and ArcelorMittal's Hamburg pilot project. The IEA views hydrogen reduction as being very important for net-zero emission, and likely to be available from 2030.

Another group of steelmakers are looking at the transitional use of hydrogen by blending it with fossil-based reductants, using it in conventional steelmaking processes to improve greenhouse gas efficiency. Thyssenkrupp is testing the use of hydrogen in a blast furnace; this approach has also been studied in Japan. The approach will be ready for deployment by 2025.

Hydrogen reduction of fine ores in a two-stage fluidized bed process, named CIRCORED, was the only direct reduction process using pure hydrogen as a reductant that had ever been commercially operated. Hydrogen was produced by natural gas steam reforming. This process was decommissioned for economic rather than technical reasons.

Research Trends in Sponge Iron Process: Energy Integration, Hydrogen Utilization and Waste Plastic Utilization

- Energy Integration
- Hydrogen Utilization
- Waste Plastic Utilization ✓

Waste Plastic Utilization

Waste Plastic based reduction

When the waste is polyethylene:

(i) $\frac{1}{2} C_2H_4 + CO_2 = 2CO + H_2$ (ii) $Fe_2O_3 + 2CO + H_2 = 2Fe + 2CO_2 + H_2O$

CO_2 emissions attributed to the iron and steel industry worldwide, 30% of the carbon footprint is reduced using the waste plastics compared to other carbon sources, in addition to energy savings.

Plastics have higher H_2 content, than the coal. Hydrogen evolved from the plastics acts as the reductant along with the CO. Hydrogen reduction of iron ore in presence of plastics increases the reaction rates due to higher diffusion of H_2 compared to CO.

Plastic replacement reduces the process temperature by at least 100–200ºC due to the reducing gases (hydrogen) which enhance the energy efficiency of the process.

Waste Plastic Utilization

DRI using Waste Plastic

The known diameters iron ore pellets were weighed.

PET was taken from post-consumer soft-drink bottles and cut into small pieces (-2mm).

The reduction beds were prepared for each percent-by-weight composition of the coke-plastic reductant (0% PET, 5% PET, 10% PET, and 20% PET).

The prepared crucibles were then placed into the preheated furnace (temperature varies as 850°C, 950°C, 1050°C).

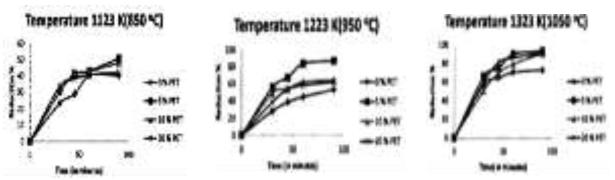
The samples were then preserved at different time intervals (30mins, 45mins, 60mins and 90mins) by withdrawing them from the furnace.

The final weight of pellets was noted, from which weight loss (equal to oxygen removed) was calculated.

Ankit, S. Sethi, G.S. Mahobia and O.P. Sinha, "Reduction behavior of iron ore pellets with addition of plastics along with conventional reducing agents", Journal of Metallurgy and Materials Science, 57, 2015, 161-171.

Waste Plastic Utilization

DRI using Waste Plastic



Improved extent of reduction was observed in all the PET compositions when compared to 100% coke composition.

5% PET and coke system gave the best extent of reduction.

However, accretion and formation of char remain a serious bottleneck in the implementation of process.

Nevertheless, the work showed the capability to use plastics in DRI production.

Ankit, S. Sethi, G.S. Mahobia and O.P. Sinha, "Reduction behavior of iron ore pellets with addition of plastics along with conventional reducing agents", Journal of Metallurgy and Materials Science, 57, 2015, 161-171.

Waste Plastic Utilization

Ground development

Operations to convert industrial plastic waste except for PVC to blast furnace reducing agents were commenced in October 1996.

MIDREX Reformer facilitates the reaction between both CO_2 and H_2O with natural gas and does not require any CO_2 removal system. The syngas produced from plastics can be used in a Midrex DR plant and it is estimated that this alternative route results in 5% CO_2 mitigation.

JFE Engineering, developed electric arc melting furnace ECOARC, which can process press scraps from scrapped automobiles, with high plastics and other combustible content.

Y. Ogaki, K. Tomioka, A. Watanabe, K. Arita, I. Kuriyama, T. Sugayoshi, "Recycling of Waste Plastic Packaging in a Blast Furnace System", NKK TECHNICAL REVIEW No. 84(2001).
S. Devasahayam, G. B. Raju, C. M. Hussain, "Utilization and recycling of end of life plastics for sustainable and clean industrial processes including the iron and steel industry", Materials Science for Energy Technologies 2 (2019) 634-646.

Conclusions

1. Significant amount of energy can be saved in sponge iron process by Energy Integration approach.
2. CFD analysis can be used to optimize the performance of primary equipment of the process.
3. Hydrogen can be a solution for decarbonizing the iron and steel industry.
4. Blend of coal/coke and plastic can be used in DRI.

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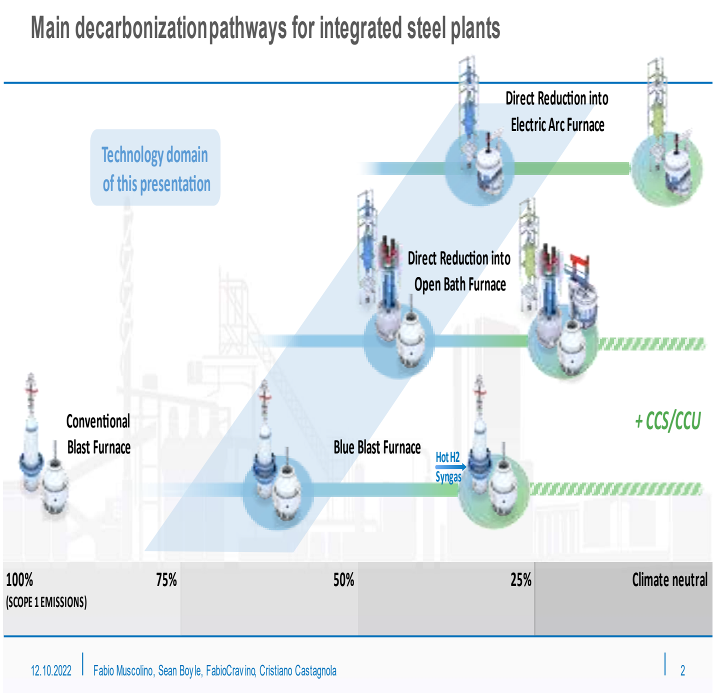
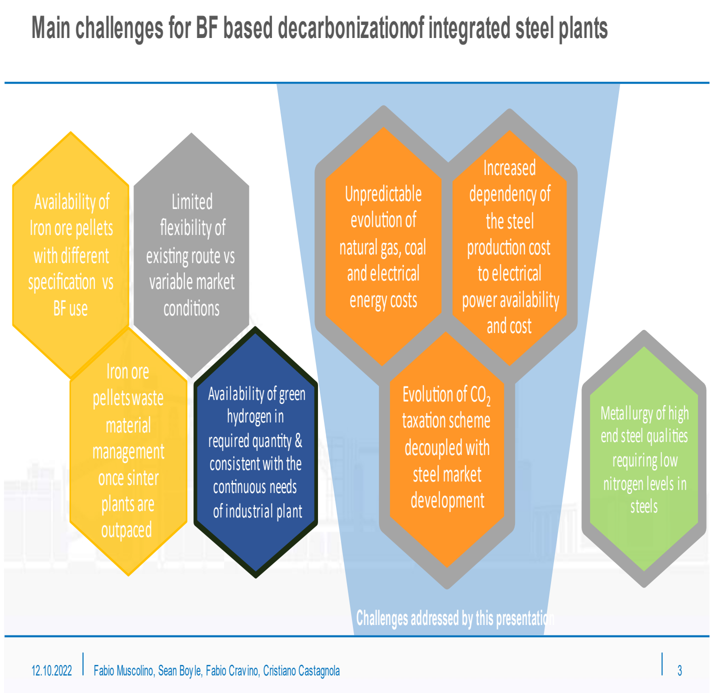
DR Plants in Existing BF based integrated Plant Solutions for Lowering OPEX and CO2 Emissions vs the Stand Alone Approach – F. Muscolino, SMS India P. Ltd.





NG Midrex Direct reduction Technology (NG DRP)

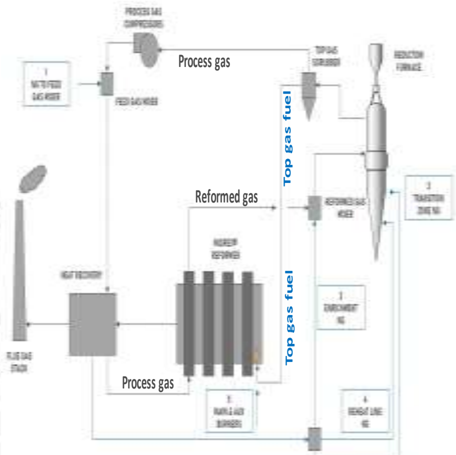
Focus on gas looping

NG Process use

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

NG Thermal use

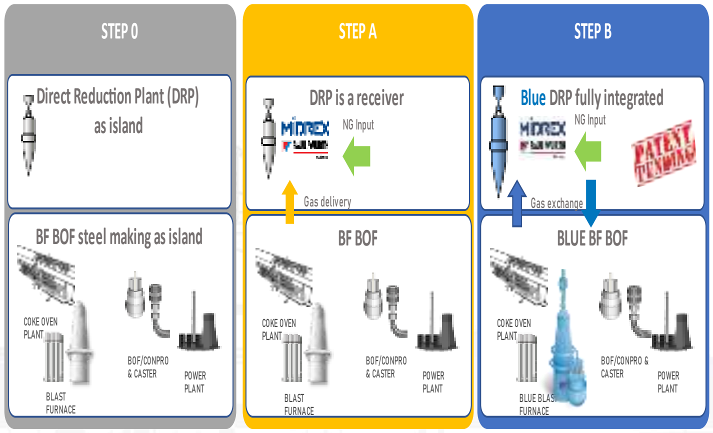
5. Feed to burners of Reformer mixed with top gas fuel



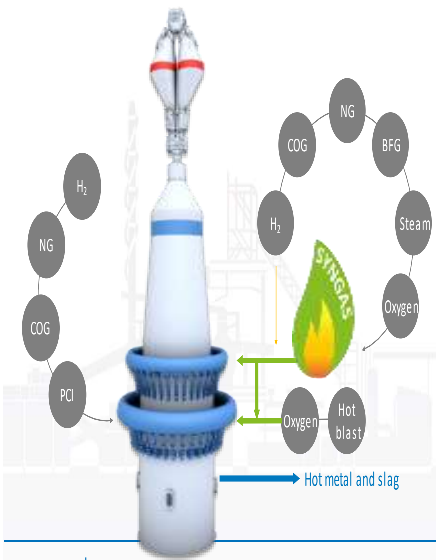
Simplified flow schematic of MIDREX NG DRP

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

how to maximize metallurgical gases valorisation



Blast Furnace (Blue BF) modified to use Syngas for reducing OPEX & CO_2 footprint



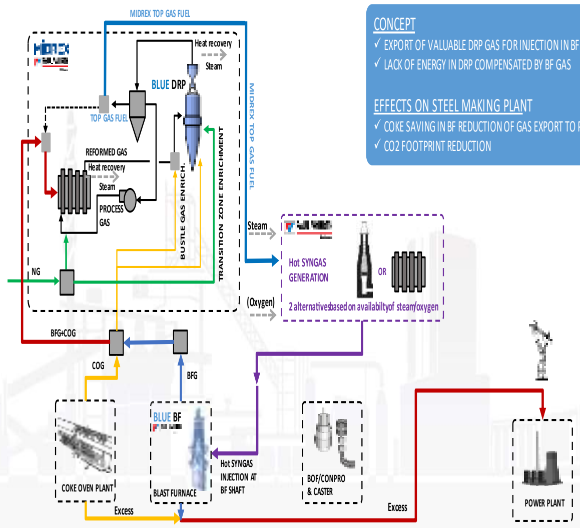
Hot syngas shaft injection

- 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 -69% (with CCU/S up to 88%)
- Reduced OPEX due to coke rate decrease
- Productivity increase due to decreased gas generation at bosh level

BLUE BF in smart combination with DRP through gas exchange



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

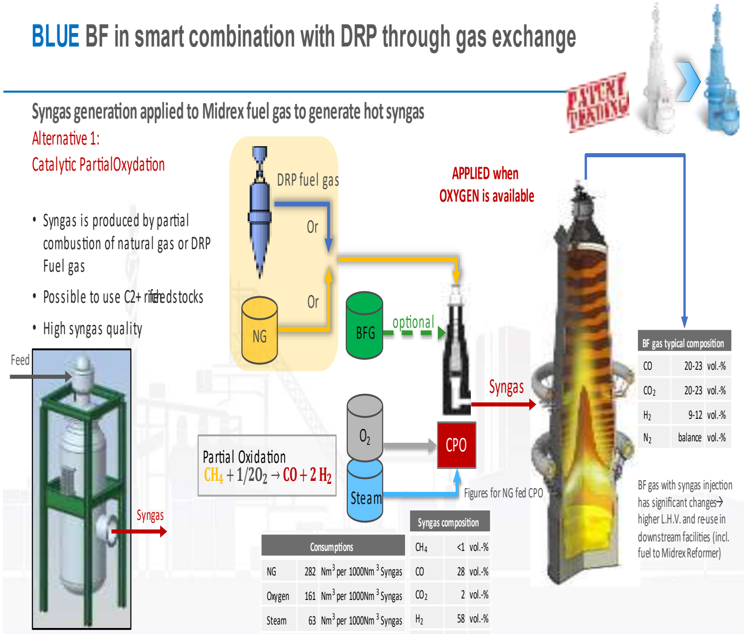
- ✓ COKE SAVING IN BF REDUCTION OF GAS EXPORT TO POWER PLANT
- ✓ CO2 FOOTPRINT REDUCTION

BLUE BF in smart combination with DRP through gas exchange

Syngas generation applied to Midrex fuel gas to generate hot syngas

Alternative 1:
Catalytic PartialOxydation

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



Consumptions		
NG	282	Nm^3 per 1000Nm^3 Syngas
Oxygen	161	Nm^3 per 1000Nm^3 Syngas
Steam	63	Nm^3 per 1000Nm^3 Syngas

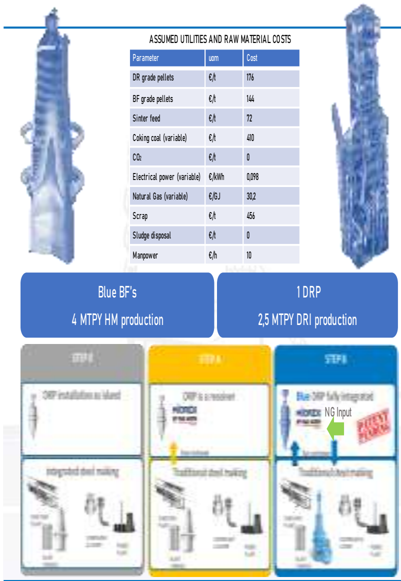
Syngas composition		
CH_4	<1	vol.-%
CO	28	vol.-%
CO_2	2	vol.-%
H_2	58	vol.-%
H_2O	7	vol.-%
N_2	3	vol.-%

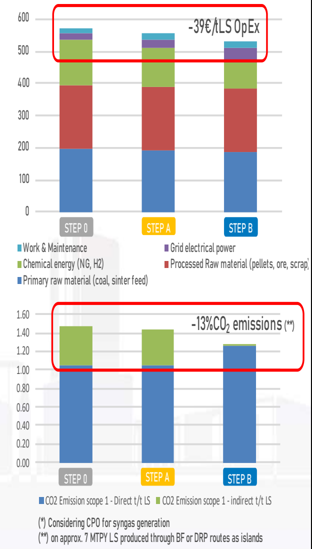
BF gas typical composition		
CO	20-23	vol.-%
CO_2	20-23	vol.-%
H_2	9-12	vol.-%
N_2	balance	vol.-%

BLUE BF in smart combination with DRP through gas exchange: OPEX and CO_2*

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



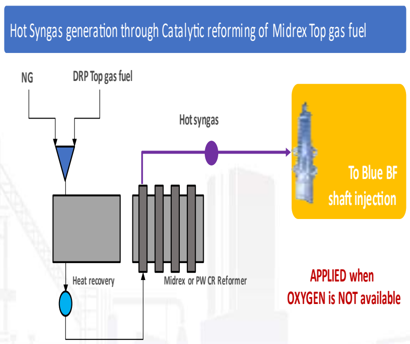


(*) Considering CPO for syngas generation
(**) on approx. 7 MTPY LS produced through BF or DRP routes as islands

BLUE BF in smart combination with DRP through gas exchange

Syngas generation applied to Midrex Top gas to generate hot syngas

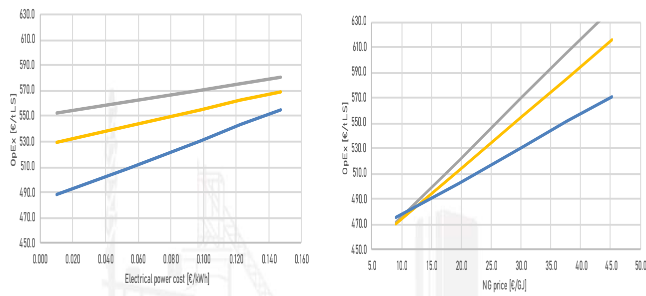
Alternative 2: Midrex or Paul Wurth Combined Reforming additional reformer

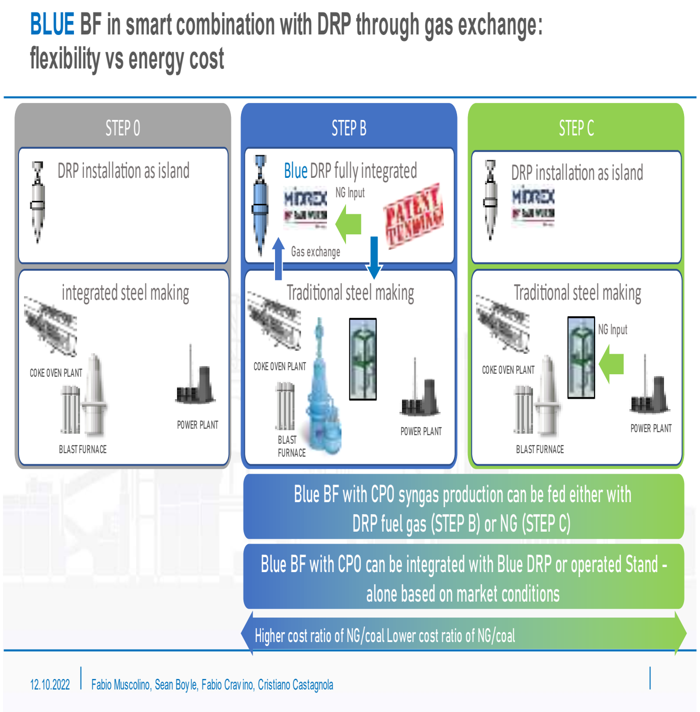


	H_2 [mol %]	CO [mol %]	CO_2 [mol %]	H_2O [mol %]	CH_4 [mol %]	N_2 [mol %]	TEMP
INLET	35	19	15	13	17	1	580°C
OUTLET	55	35	2	6	1	1	950 °C

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

UTILITIES AND RAW MATERIAL COSTS AS PER PREVIOUS SLIDE





This presentation created lot of the interest among the participants as it talks about blue blast furnace and its subsequent modification to use syngas resulting reduction in OPEX and CO2 footprints it also talks about integration of blue blast furnace with gas based DRI plant through gas exchange.

Editor

Recycling Carbon. Creating Value – **Sangeet Jain, Lanzatech**

LanzaTech

The time is now.

Fossil carbon is in nearly everything we use in our daily lives. It is not just in fuels or used to generate power, but fossil carbon is in fibers, coatings, and materials used in our clothes, cosmetics, toys, and household goods. Both fuels and materials originate in refineries fed by petroleum or natural gas. Perpetuating virgin fossil carbon use in these products is not sustainable

given the current understanding of the impact of extracted, emitted, and waste carbon on our environment, climate, and vulnerable populations. If we are to achieve climate goals and avoid catastrophic scale, strong, rapid, and sustained effort to re-tool our entire carbon economy. To align with a “Net Zero Path” economies today are investing in innovative technologies that enable a closed loop, circular carbon economy where carbon is reused rather than wasted. In India, LanzaTech is a prime example of how advanced technologies, such as Carbon Capture and Transformation (CCT), can help achieve decarbonization and biofuel goals by changing the way the world procures, uses, and disposes of carbon. LanzaTech’s commercial gas fermentation platform makes low carbon fuel (ethanol) and chemicals from waste carbon (such as industrial off-gases, agricultural residues, municipal waste, waste plastics) with the intent to displace products made from petroleum. The low carbon ethanol can be transformed into high-value products, including sustainable aviation fuels (SAF), cleaners, fabrics, and packaging used in every facet of our lives.

The 3rd largest energy consumer in the world, India is seeking solutions to diversify its energy basket, reduce reliance on imports, and harness domestic resources to address climate risks. CCT technologies like LanzaTech are expected to increasingly be applied across economic sectors such as agriculture, industrial point sources, and waste management, as an important strategy to reduce greenhouse gas (GHG) emissions and meet the nation’s objective to reduce its reliance on imported oil and natural gas. India’s commitment at COP 21[1] is indeed a laudable step, however, going forward, meeting this commitment will require judicious use of carbon resources in the future.

India is a global leader in biofuels. As we step forward, CCT technologies like LanzaTech’s can address sustainability needs across the country by reducing air pollution, recycling waste, providing clean jobs,

[1] https://moef.gov.in/wp-content/uploads/2018/04/revised-PPT-Press-Conference-INDC-v5.pdf

generating cleaner burning fuels, and producing low-carbon materials. This article provides an overview of LanzaTech's technology and our vision to support India in its transition to a clean energy future.

LanzaTech's Gas Fermentation Process

LanzaTech paves a way towards a sustainable future by recycling and reusing waste carbon**.** Waste carbon is simply carbon that's already seen a primary use, such as the emissions created during the steel making process or the carbon found in solid waste streams.

The LanzaTech gas fermentation platform (Figure 1) is a commercially proven, first-of-a-kind process which uses a biocatalyst (microorganism) to convert gas containing carbon monoxide (CO), hydrogen (H2), and carbon dioxide (CO2) into ethanol, providing industries an economical, sustainable, and flexible means of creating value from residues and off-gas through conversion into products. Gas fermentation is an alternative to sugar fermentation. In this approach, instead of breaking down glucose, microbes build up products from carbon oxides (CO or CO_2), which are found in waste gases from heavy industry (for example, steel mills, processing plants or refineries), or syngas generated from solid wastes (including, for example, unsorted and non-recyclable municipal solid waste, agricultural residue or organic industrial waste or even landfill and manure digester gas)[2]. Capturing and recycling waste carbon streams before they enter the atmosphere or environment offers routes to sustainable domestic fuels, carbon-negative manufacturing, and a circular economy.

The inherent flexibility of biology allows LanzaTech's technology to create value using a variety of different waste streams readily available in India (as shown in Figure 1). Industrial waste gas, biogas/landfill gas, and solid wastes are high volume and point sourced feeds which have low value and can be used for fuel and chemical production without adversely affecting food or land security. LanzaTech's ethanol produced from these wastes can have substantial savings in emissions compared to fossil ethanol and is competitive with plant-based ethanol without impacting land use.

Beyond ethanol, LanzaTech's synthetic biology platform has allowed LanzaTech to produce novel biocatalyst strains capable of producing other chemical intermediates, such as isopropanol and acetone, with more in the pipeline, supporting India's strategic expansion into sustainable chemicals.

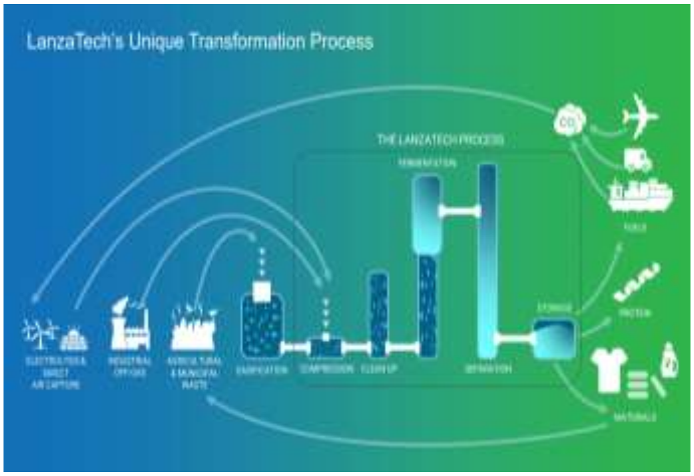


Figure 1: LanzaTech gas fermentation process

Capturing and Transforming Carbon around the World

LanzaTech's first two commercial scale gas fermentation plants are operating in China using industrial off-gases from Steel (Figure 2) and Ferro-Alloy plants. They have produced over 115 million litres of ethanol, avoiding the equivalent of over 180,000 metric tons of CO_2 released into the atmosphere.

In Europe, ArcelorMittal (Ghent, Belgium) is in the advanced stages of construction for a facility that will produce ethanol from blast furnace and basic oxygen furnace emissions. In India, LanzaTech's strategic partner, IndianOil, is building the world's first of its kind refinery off-gases to ethanol plant, which is expected to come online this year. In all, seven facilities implementing LanzaTech's technology are under construction in different parts of world.

[2] Carbon-negative production of acetone and isopropanol by gas fermentation at industrial pilot scale, Nature Biotechnology, Michael Köpke et. al., Vol 40, 335-344, March 2022, https://doi.org/10.1038/s41587-021-01195-w

LanzaTech's extensive network of customers and partners have committed approximately USD800 million to the development of new facilities using LanzaTech's CCT technology. The new facilities are expected to bring on significant new production capacity in the future and serve as a major validation to potential future customers as our roster of these notable partners continues to grow.

Figure 2: The LanzaTech-Shougang 1st commercial scale plant recycling steel mill offgases (China, 2018)

Transforming Emissions, Transforming the Market

The total addressable market for LanzaTech technology is over USD1.0 trillion. The pathway enables India to invest in a sustainable supply-chain solution that will allow companies to advance their own sustainability objectives, as well as efforts to meet decarbonization mandates across the globe.

One exciting market segment created by LanzaTech's process is 'CarbonSmart™ Products'. When choosing paper or plastic bags, Fairtrade coffee, organic milk or recycled paper, consumers are given the choice of what sort of footprint they are leaving on the planet.

LanzaTech envisions a world where a consumer can also choose where the carbon in their products comes from. This is the inspiration behind CarbonSmart.

LanzaTech is finding manufacturers, major brands, consumers, and sustainability-conscious governments like India desire products that are more sustainable than what is currently available in the marketplace. Over the past year, LanzaTech has completed campaigns with several major brands who have partnered with us to bring to market products made from industrial emissions.

LanzaTech ethanol from industrial emissions has been the feedstock for a diverse array of consumer products, most on the shelves today. Ethanol produced from waste carbon can be converted to ethylene, which can be further transformed into biopolymers, surfactants, or polyester fiber. LanzaTech is working with companies like Unilever, Mibelle, L'Oréal, and COTY to make packaging, perfume, laundry detergent and household cleaners from our ethanol. India Glycols Limited has converted LanzaTech ethanol into MEG (monoethylene glycol), a key component of PET plastics.

Figure 4: LanzaTech CarbonSmart products

These products can have reduced GHG emissions by over 70% when compared to equivalent products derived from fresh fossil resources. Around the world, countries including India are developing low carbon growth trajectories to meet the demand for petrochemical products which contribute ~2% of global GHG emissions. Innovative pathways like LanzaTech's that produce sustainable chemicals from waste streams could be game changers, reducing emissions while promoting circularity.

The Future of Flight: Sustainable Aviation Fuel

In October of 2021, the International Air Transport Association (IATA) announced that it had "approved a resolution for the global air transport industry to achieve net-zero carbon emissions by 2050", termed

Fly Net Zero.[3] IATA also urged the International Civil Aviation Organization (ICAO) to adopt a comparable commitment, well beyond that currently codified in the ICAO Carbon Offset and Reduction Scheme for International Aviation (CORSIA) which comes into full effect in 2027. The use of sustainable aviation fuel (SAF) is a key element of Fly Net Zero and IATA laid out a scenario in which the global demand for SAF is 17% of total aviation fuel by 2035 (~91 billion litres). To meet that demand, the capacity for SAF production must grow rapidly.

India recognizes decarbonization is essential, not just for road transport and industry, but also for aviation. As India is the 3rd largest domestic aviation market[4], this creates real urgency in creating a domestic SAF supply using sustainable feedstocks that are available today.

LanzaTech, in partnership with the U.S. Department of Energy (US DOE) Pacific Northwest National Lab and with US DOE support, has developed an innovative Alcohol-to-Jet (ATJ) platform to produce SAF from ethanol. The ethanol can come from any environmentally, economically, and socially sustainable feedstocks. To accelerate global commercialization of this SAF technology, LanzaTech spun out a new company, LanzaJet, in 2020. The ethanol-based ATJ technology is particularly well-suited to the Indian market due to India's strong ethanol industry.

In the LanzaJet™ ATJ process, ethanol is chemically converted to synthetic paraffinic kerosene (SPK) via the four steps defined in ASTM D7566 Annex A5: dehydration, oligomerization, hydrogenation, and fractionation. Key advantages to the LanzaJet ATJ process are its unprecedented product flexibility and selectivity. The process can produce a product slate that is 90% SAF and 10% renewable diesel or 25% SAF and 75% renewable diesel with only operational changes. This flexibility allows the operator to respond to demand swings effectively. The SAF from the process is qualified for use in commercial aviation in blends of up to 50% with conventional jet.

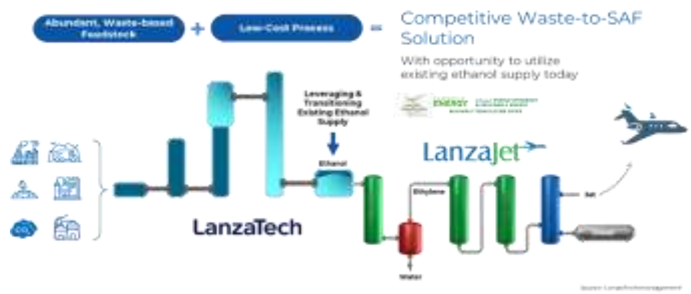


Figure 5: Ethanol-based Alcohol-to-Jet (ATJ) creates flexibility for global deployment

Abundant, available waste carbon-based ethanol coupled with the LanzaJet ATJ process can play a key role in deploying SAF production across India and the world. The combination of LanzaTech's gas fermentation technology with ethanol-based ATJ technology (as shown in Figure 5) enables end-to-end conversion of waste into SAF without impacting the food chain, land use, or water supplies.

India: An Opportunity for Energy Security & Decarbonization & Circular Economy

The Energy Transition Roadmap is at the forefront of policy considerations in India. Sustainable fuels like biofuels are being seen as an important pillar in the Roadmap. While India has made great strides toward blending of 1st generation ethanol into gasoline, advanced biofuels, made from agricultural, municipal and industrial wastes, will be very important to accelerate India's progress toward energy security and decarbonization of both road transport and aviation. Advanced biofuels from CCT pathways offer the opportunity to reduce carbon emissions, improve air quality and provide economic benefits in the sectors where the waste feedstocks originate.

India's 'National Policy on Biofuels' (NPB) 2018 envisioned developing sustainable domestic feedstocks to promote biofuel production. This policy enabled India to reach 9% ethanol blending in gasoline in 2021. Moving ahead, advanced biofuels from waste feedstocks can play a vital role in expanding the ethanol production pool in the country and building circular economy, as part of India's ambitious plan to achieve

[3] https://www.iata.org/en/pressroom/2021-releases/2021-10-04-03/

[4] https://www.ibef.org/news/india-has-become-the-third-largest-domestic-aviation-market-in-the-world-mr-scindia

20% blending by 2023 (requiring about 12 billion litres of ethanol)[5].

The overall ethanol feedstock potential in India from industrial off-gas and other waste resources is estimated at 30 billion litres per year. When used as feedstock for ATJ, this in turn could produce over 17 billion litres per year of hydrocarbon fuels, of which up to 90% can be SAF. This sustainable ethanol can also serve as a building block to produce low carbon chemicals and materials that today are made from petroleum. In addition to carbon benefits, these advanced biofuels, sustainable chemicals, and materials will offer employment and economic benefits for rural economies and urban communities as well as reduce industrial emissions.

Policy: Enabling the change we need

Simply put, CCT technologies like LanzaTech's can increase production of domestic ethanol and create an indigenous SAF manufacturing sector in India. As a time when industry is looking to reduce its carbon footprint, this technology can be leveraged to create jobs and to replace fuels and other products currently made from oil and natural gas with recycled carbon. A supportive policy framework will be central for steel sector and other industries to creating a circular carbon economy with a foundation on CCT technologies.

The future of sustainable fuels and chemicals can only be assured by technology-neutral policies that incentivize the early adoption of innovative technologies. A clear roadmap of supportive policies will be a great enabler to attract investment into the first few plants implementing a new technology. Such intervention is needed to reduce the cost of deploying CCT technologies at a scale that will subsequently bring down production costs in future plants. To fast-track sustainable ethanol and chemicals projects built on abundant available waste feedstocks in the country, industry needs policy interventions such as sustainable feedstock supply chain development, mandates and differential pricing for advanced biofuels and products, subsidies for renewable power used in production, as well as direct financial and fiscal incentives. The role of policies will be central for their continued guidance to advance innovative pathways for production of sustainable fuels as well as chemicals from waste carbon would be of great value; while also enabling decarbonization for steel sector players

Stepping back to look at the bigger picture, it is clear to that India can play a pivotal role in moving the global economy away from fresh fossil carbon and into a circular model that addresses both fuels and products. This should be seen as strategic opportunity for India, in which a pragmatic approach to address decarbonization will cement India's leadership position in a new circular carbon economy.

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[5] https://auto.economictimes.indiatimes.com/news/oil-and-lubes/9-ethanol-blending-in-petrol-achieved-20-target-by-2025-puri/89338676
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Global & Domestic Steel Scrap Scenario – Ritesh Maheshwari, MRAI

5th India International
DRI Summit 2022
By
SIMA

Global & Domestic Steel Scrap Scenario

Ritesh Maheshwari - Director
Material Recycling Association of India

INDEX

WORLD CRUDE STEEL PRODUCTION SUMMARY

(MILLION TONNES)

Region	2019	2020	2021
European Union	150.2	132.2	152.6
Other Europe	45.9	47.1	52.3
North America	119.7	101.0	117.9
South America	41.7	38.7	45.7
Asia	1349.4	1392.3	1404.7

Source: Worldsteel & Ruslom

Steel is highly recyclable, and is the world`s most recycled material

STEEL SCRAP USE FOR STEEL MAKING IN KEY COUNTRIES:

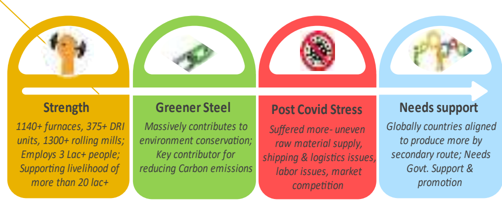
(MILLION TONNES)

Region	2019	2020	2021
European Union28/27	86.473	75.255	87.853
USA	60.7	50.2	59.4
Japan	33.682	29.179	34.727
Russia	30.173	30.030	32.138
Turkey	27.900	30.077	34.813

Source:EUROFER, CAMU, USGS/ISRI-calculations, TCUD Japan Ministry of Economy, RUSMET, KOSA, CARI

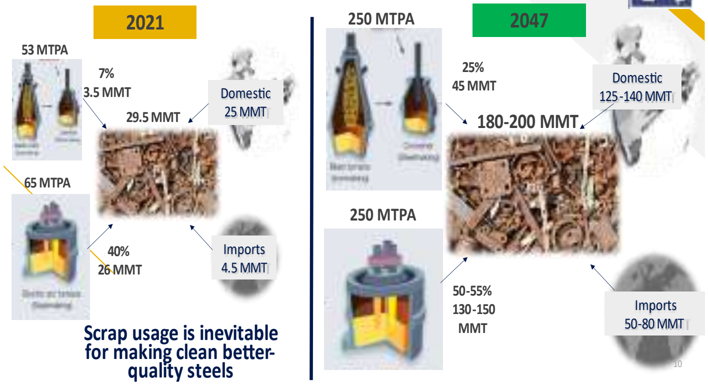
Current Scenario – Steel Production in India

India (MMT)	2019	2020	2021
Crude Steel Production MMT	111.2	100.3	118.2
BOF Route MMT	48.7	44.6	53.0
EAF/IF Route MMT	62.5	55.7	65.2



7

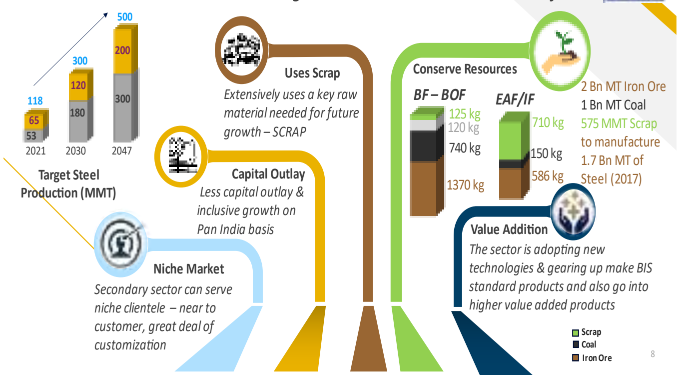
Role of Scrap – Key Enabler for Steel Industry



10

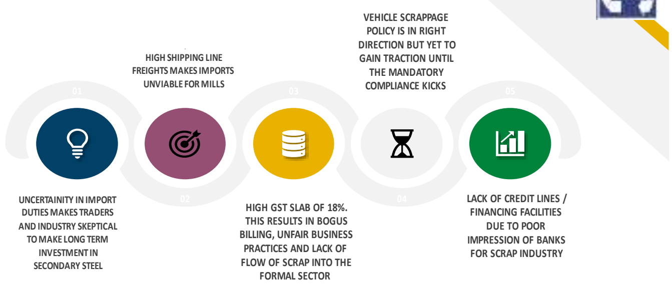
Why Secondary Steel Making?

"Make-in-India to Make-in-Steel : Building New India with Steel as material of choice"



8

Key Hurdles in Scrap Availability



Globally all the countries are recognizing the need to prevent Scrap from leaving their countries

Scrap Availability - Demand In India Going Forward

- India is standing at the threshold of quantum jump in both consumption and production of steel
- One of the key aspects of the Vision 2047, shared by the Ministry of Steel, is to reduce the CO2 emission emissions from 2.6 to 1.3 T CO2 / Tones of Crude Steel
- MRAI in collaboration with Steel mint has done detailed modelling of the Scrap Demand Supply Scenario in the coming years in India and we expect significant increase in scrap consumption albeit their remains significant concerns on the scrap availability
- Currently with 154 MMT Steel capacity, scrap contribution in steel making is around 30 MMT
- Going further steel making capacity is to increase to 500 MMT by 2047 as per Ministry of Steel
  - As per our estimates, Taking modest CAGR numbers, a minimum 183 MMT of scrap will have to be made available to make this Vision 2047a reality.
- Which directly translates into the fact that scrap generation, requirement and consumption in India is going to witness a huge leapwhether through domestic or imported scrap

9

Reduction in CO2 Emissions

Circular Economy
The Recycling industry to contribute responsibly towards resource efficient circular economy. MRAI will signifanctly contribute towards circular economy

Inclusive Growth– Sabka Vikas
Policy framework to make Recycling inclusive and getting the Household Scrap Collector also a part of the formal organized sector

India as a recycling hub
Spurt in recycling zones across the country engaged in recycling of ELVs resulting into various raw materials including Metal Scrap. Processing as per International norms.

Reduction in Co2 emissions for 1 Ton Production through Secondary vs. Primary route
- 58% for Iron & Steel scrap
- 92% for Aluminium scrap
- 65% for Copper scrap
- 99% for Lead scrap
- 90% for Nickel scrap
- 99% for Tin scrap

Conservation of Natural Resources
Recycling & using 1 MT of Steel Scrap saves:
- Avoids 1.5 MT of CO2 emission
- 642 kWh of energy
- 1.8 Barrels (287 Liters) of Oil
- 2.3 cubic meters of landfill

Growth with Co-existence
India's Steel Production to reach 500 MTPA Primary Sector & Secondary sector hand in hand

Cleaner / Greener Steelmaking
Using Technoloy & cleaner raw material- India's aims for being the leader in value added products as well – High Volume – High Quality products

Raw Material Security to Industry
Industry needs secure raw material availability of myriad of products such as Scrap, DRI, Pellets, HBI Hote Metal, etc. to match their production requirement with available resources

We Are..

R	E	C	Y	C	L	E	R	S
Respect the Environment	Enablers of Change	Committed to Perform	Yearning for Success	Care for community	Long-term vision	Efficiently run operations	Responsible Recycling	Securing resources for future

12

Glimpses of 5th India International DRI Summit 2022

Address of Chief Guest, Secretary (Steel)

High Power CEOs Inter Active session

Session on Innovations to substitute carbon

Presentation of Memento to COO,MIdrex Technologies

Inaugural session

Session on Technical advances in Gas Based DRI Production

Session on Raw Materials and their impact on CO2 emission

Address of Guest of Honour, DG, TERI

Statistics

Item	Performance of Indian Steel Industry		
	April-Sept. 2022*(mt)	April-Sept. 2021 (mt)	% Changes*
Crude Steel Production	61.056	57.531	**6.1**
Hot Metal Production	38.757	38.596	**0.4**
Pig Iron Production	2.882	3.058	**-5.8**
Sponge Iron Production	**20.999**	**19.392**	**8.3**
Total Finished Steel (alloy/stainless + non-alloy)			
Production	58.050	53.938	**7.6**
Import	2.558	2.373	**7.8**
Export	3.601	7.754	**-53.6**
Consumption	55.431	49.710	**11.5**
Source: JPC; *provisional; mt=million tones			

All India Coal Demand and Supply -Sector Wise: 2019-2022

Qty. in MT

Year	**NON COKING COAL Sector**	**Demand**	**Supply**
2019-20	Power (Utilities)	682	533.4
	Power (Captive)	102	77.15
	Cement	42	8.6
	Sponge Iron	**48**	**10.44**
2020-21	Power (Utilities)	707	475.93
	Power (Captive)	108	89.62
	Cement	45	6.75
	Sponge Iron	**50**	**9.57**
2021-22	Power (Utilities)	771	671.7
	Power (Captive)	114	38.16
	Cement	49	7.29
	Sponge Iron	**52**	**8.67**

Source: Coal Controller Organization

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