Value Realization through NetZero Implementation

EY Discussion Document

January 2024

Strategy realized

TATA STEEL

IIM
Metallurgy
Materials Engineering

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Imperative for Decarbonization in Iron & Steel sector

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Key imperative for Iron & steel companies in India to decarbonize while also achieving cost efficiency & stakeholder value

Key Statistics

8% …Iron & Steel sector's contribution to global GHG emissions [3]

2X …Growth in India's Iron & Steel capacity by 2030[4]

40% …higher emission intensity of Indian companies compared to global average[5]

Iron & Steel Decarbonization Imperatives

1 Regulatory & Compliance
- Perform, Achieve, Trade (PAT Scheme)
- India & UK's Industrial Deep Decarbonization Initiative (IDDI)
- USA FAIR transition & competition act
- Carbon Border Adjustment Mechanism (CBAM)

2 Technology Advancement
- Low carbon solutions (LCS) in production process and energy emissions
- Material circularity/ Resource efficiency
- Electrification of Heat

3 Market & Shareholder Pressure
- 4x access to Green financing
- 30-40 bps lower CoC for green investments*

4 Cost Savings via
- Renewable energy adoption
- Increased usage of scrap
- Waste heat recovery
- Energy efficient technologies

5 Green Product Premium
- Green Steel Demand is Rising Faster Than Production Can Ramp Up. By 2030, 30% of EU steel market will be green [1][2]
- Green premium of 30%-40% over unabated steel in the short term primarily from the automotive sector[1][2]

"CEO's Speak"

"We are undertaking a host of initiatives to reduce our GHG emissions, aligned with India's net zero targets and are planning an investment of ₹10,000 cr

Sajjan Jindal,
Chairman JSW Steel

"Steel companies believe that government incentives for low carbon tech. state funding of green pilots and a market for green steel would enable a low carbon footprint

T.V. Narendran,
CEO & MD TATA Steel Ltd

"Jindal Stainless is in the process of decarbonising, as it continues to focus on transitioning to renewable energy and becoming carbon neutral by 2050

Abhyuday Jindal,
Managing Director Jindal Stainless Ltd.

EY Analysis - *

Iron & Steel decarbonization has the potential to bring about organizational improvement affecting the top and bottom-line, cost of capital as well as market valuation

Illustrative

Companies with robust net-zero/decarbonization agenda typically exhibit…

… superior top- and bottom-line performance

Revenue Enhancement

- Positive effect of employee engagement on revenues
- 5 %-pts. improvement in shareholder value
- 3 %-pts. increase in sales

~2% — **Additional revenue growth** vs. firms with high carbon emission (Supplier preference for low carbon Steel)

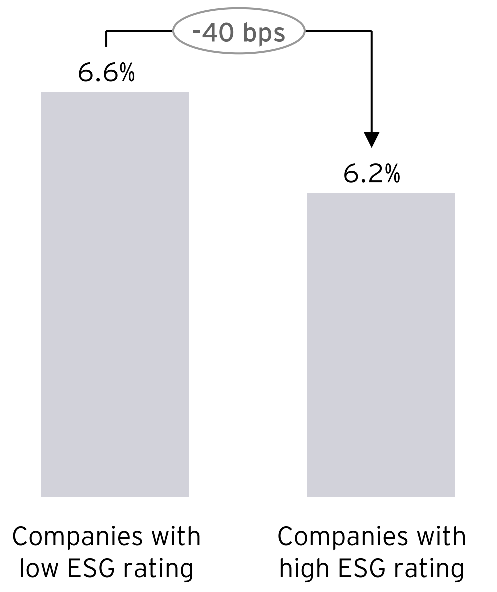
Cost Optimization

~15%
- Emission Reduction
- Reduced operating cost by 15-20% due to adoption of low-carbon & efficient technologies

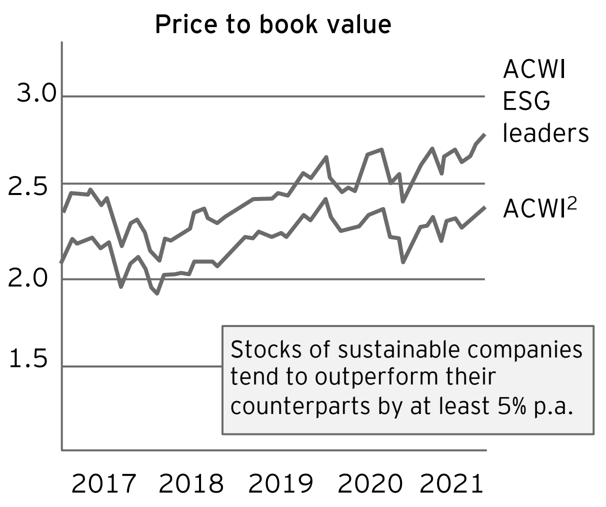
… and lower cost of capital[1]

Improved ESG Rating

Lower Cost of Capital (Green Funding)



… leading to above-market valuation



Seven in 10 have achieved higher than expected financial value

1.Applies both to debt and equity; superior access to capital, largely driven through reduction of ESG-related business risks
2.All Country World-Index (MSCI ACWI)

Sources: Oxford university; Arabesque Partners; Deutsche Bank; Hamburg University; MSCI; Harvard Business Review; Aon Hewitt; BNB Paribas; EY-Parthenon analysis; : EY 2022 Sustainable Value study

Global Iron & Steel sector: Decarbonization initiatives in short- and long-term perspective from the top Iron & Steel manufacturers globally

Top 10 Steel Producers (2022), MT

Key Players

Key Player	% of global production	Emission intensity	Interim goals	Long term net zero target	Key Initiatives
ArcelorMittal	3.6%	2.1	30% emission reduction by 2030 vs. 2019	Net zero by 2050	▸ Launched XCarb™, designed to bring together all of their reduced, low and zero-carbon products and steelmaking activities. ▸ Investing 40 billion euros ($48.4 billion) for low-emission steelmaking methods
BAOWU	7.0%	1.8	30% emission reduction by 2025	Net zero by 2050	▸ Has signed agreements with BHP and Rio Tinto to invest US$45m in low-carbon steel projects.
NIPPON STEEL	2.35%	1.8	>30% reduction in t CO2 emissions by 2030 vs. 2013	Carbon neutral by 2050	▸ Exploring new steelmaking routes using H2 which can reduce 80% C emissions compared to conventional methods of production. ▸ Exploring carbon capture & storage technologies to ensure it meets its environmental target.
posco	2.04%	1.5	10% emission reduction by 2030 and 50% by 2040 vs. 2019	Net zero by 2050	▸ Green Steel' that adopts green hydrogen and renewable energy (HyREX process)
TATA STEEL	1.6%	2.4	<2.0tCO2/tcs by 2025; <1.8 tCO2 /tcs by 2030	Net zero carbon by 2045	▸ Started trails for continuous injection of coal bed methane in one of its blast furnaces (E blast furnace) at Jamshedpur
thyssenkrupp	0.52%	1.3	Production & Purchase energy cut by 30% in 2030	Net zero by 2050	▸ Started building a new steel mill that uses the hydrogen steelmaking method in August and will complete most of the construction by 2025.

Private Iron & Steel manufacturers in Indian market (with >40% market share) have long term net zero targets with planned activities to realize their goals

Key Player	% of Indian steel production, 2023	Emission intensity, 2021-22	Short term targets (till 2025)	Medium term targets (2025- 30)	Long term targets (2030 -50)	Initiatives
JSW Steel	18%	2.5	• Adoption of BAT • Renewable energy • Increasing PCI and NG in BF	• <1.95 t CO_2/ tcs of crude steel by 2030 • Increased use of scrap • Creation of carbon sinks	• Carbon neutral by 2050 • Scaled deployment of CCUS • Usage of H_2	• CCU pilot at JSW plant, Salav. • RE-RTC • Green hydrogen
TATA STEEL	16%	2.43	• Scrap recycling & high charge • BAT • Renewable energy • Internal carbon pricing	• Scrap based EAF • Shift to NG from Met. Coal • Upscaling pilot of CCS and H_2	• Net zero carbon emissions by 2045 • Hisarna technology • Usage of H_2 across steel value chain	• Coal bed methane injection in Blast furnace • 5 TPD CCS pilot plant • Use of biomass in BF route
AM/NS INDIA	8%	-	• Acquire major port infrastructure and assets	• Invest in renewable energy power project and secure 250MW of RE power annually for the next 25 years for Hazira steel plant	• Further vision to build a new integrated steel mill in East India	• Energy conservation measures across Hazira integrated steel plant
JINDAL STEEL & POWER	6%	2.6	• Adoption of BAT • RE – RTC plant installation	• <2.0 t CO_2/tcs by 2030 • Modification of Electric Arc furnace to New-oxy furnace	• Net carbon zero by 2035	• Plans for 1 GW RE-RTC (with Greenko) • Green Hydrogen • CCU at Angul plant
सेल SAIL	5%	2.51	• Modernisation program & Energy efficiency	• Phasing out old energy intensive units & raw material quality improvement	• Deep decarbonization through usage of H_2, renewable electricity & CCUS	• Installing coke dry quenching units.

Source: IRADe, Sustainability reports 2022-23, Company websites, news articles, EY analysis

2

Pathways for emission reduction for an integrated iron & steel plant

Tata steel Capacity Expansion Overview: Looking at opportunities/constraints and how it would tie-in with Green Iron - making initiatives

Illustrative

2023 | 2026 | 2030

Current capacity : ~22 MTPA

TATA steel India capacity Build-up

Current fixed technology plans :

5 MTPA at Kalinganagar

Future expansion plans :

13 MTPA of which 5 MTPA through EAF steelmaking

Different ways of decarbonization need to be followed for:

A Alternate Ironmaking delivery pathways

Short term (up to 2026)

Blast Furnace Ironmaking route locked

(5 MTPA till 2026)

Since the technological route is locked for 5 MTPA expansion with the conventional BF-BOF process, it is important to take steps towards decarbonization by considering:

- Usage of COG with H2 enrichment in Blast Furnace or Coke oven
- Increased scrap feed in the BOF charge mix.
- Usage of HBI in BOF steelmaking process.

Long-term (2026 & beyond)

Future expansion route

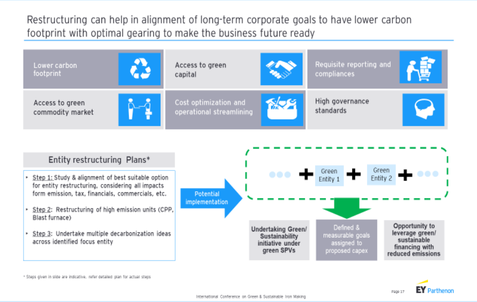
(13 MTPA beyond 2026)

For the future expansion plan, TATA Steel would like to explore global supply options for Green DRI/HBI. It is necessary to analyse different factors like resources availability , policy support , cost, infrastructure to decide between two models of future expansion that are given as follows:

1. Co-location
2. Geo split

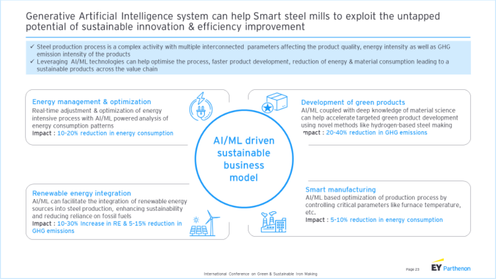
B Entity Restructuring

Carving out units with high emission intensity like CPP can help reduce scope 1 & 2 emissions



C Focused Decarb. activities

- Improvement in the current system via various decarbonization levers
- AI / ML tools to optimize processes & decarbonize operations



Injection of Coke Oven Gas with H2 enrichment in Blast Furnace is one of the effective ways to achieve low carbon intensity Ironmaking; Scrap & HBI in BOF can further reduce the footprint

Illustrative

COG production within the plant is typically used in various applications ranging from heating to being used as process gas across the value chain

Coke oven

COG

Iron making
- Sinter Plant
- Pellet Plant
- Blast Furnace

Steel making
- SMS
- HSM (RHF)

Downstream
- Annealing & Pickling
- Coating

COG Enrichment with H2 (Blue/Green)

- COG gas inherently contains 55+% of H2 along with CH4, CO and higher alkanes
- Existing network is an ideal delivery mechanism for injected hydrogen
- H2 capable lines already exist for H2 distribution to various units
- Green/blue H2 injection into the system will reduce overall emission load

Dependencies

- Quality of gas requirement in different processes and impurity requirement
- Generation of other gasses with heat value ex. BFG, BoFG etc. needs to be assessed for creating usable gas mixtures
- Assessment of delivery pipeline for higher levels of hydrogen
- Pipeline adequacy for increased volumetric flow from hydrogen injection

Scrap feed in the BOF has several functions, such as: coolant to the steel bath, high steel production rate, and reduced emissions.

Higher scrap feed in BOF can be attained through:

1. Process & Energy Optimization Models
2. Post Combustion Blowing
3. Scrap Preheating
4. Combined blowing: Top & Bottom blowing practice

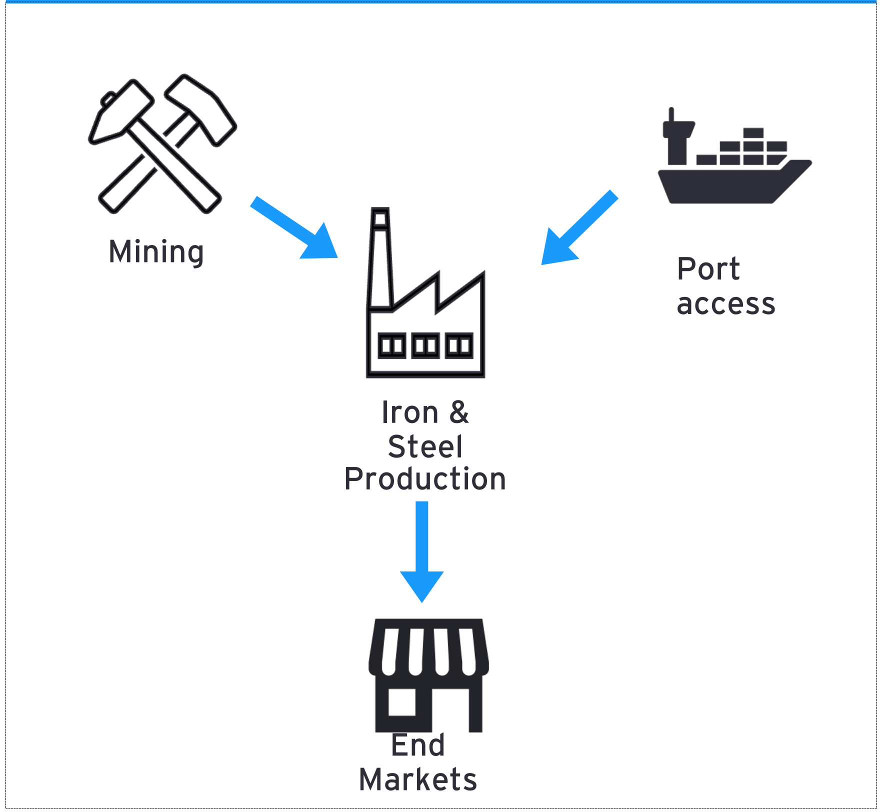
Despite few advantages over scrap, HBI is not a substitute to steel scrap, but another virgin source of Iron. On the other hand, HBI at source should have lesser footprint than scrap, as a part of decarbonization goal.

Benefits of HBI in BOF Process
- Lower tramp elements than scrap
- Heat & Mass balance is accurate
- Higher Bulk Density ~2.8 t/m3
- ~10% greater cooling effect than scrap.
- Metallic Yield similar to Hot Metal

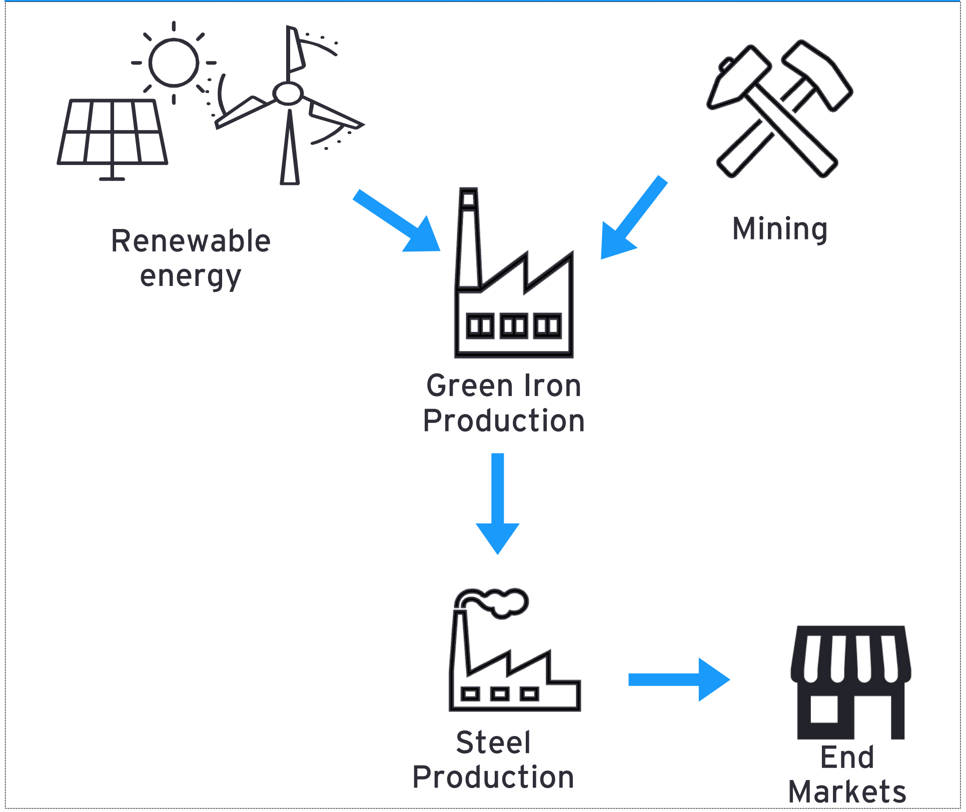
Alternative Ironmaking delivery pathways : Proximity to low-cost renewable power, Green H_2 and high-grade iron ore will be future critical conditions for Green Iron production

Illustrative

Historical conditions



Future conditions



A geo-split model could be a solution – with potential iron(ore) shipping in order to decarbonise Iron & Steel sector

Comparing low emission pathways: Cost competitiveness is driven by multiple factors, many of which are geographic, and at times site specific

Illustrative

- ✓ Mill efficiency has been a dominant cost driver in the historic & current pathways leading to focus on integrated manufacturing of iron & steel.
- ✓ However, going forward as new production pathways emerge, the cost drivers will diversify amongst renewable cost, availability of high-quality ore, availability of natural gas, etc.
- ✓ A detailed analysis of these pathways is required for developing most cost-efficient low carbon emission steel delivery methodology

Approach		Example locations	Cost drivers					Key advantage
			CFR iron ore cost	Iron ore quality	Natural gas cost	Firmed renewables	Mill efficiency	
Mine-adjacent hematite-based HBI	A	Country 1	$	XX%	$	Solar / wind	—	Freight, gas, renewables
	B	Country 2	$	XX%	$$	Hydropower	—	Iron grade
Natural-gas adjacent hematite/magnetite DRI	C	Country 3	$$	XX%	$	Solar / wind	—	Gas, renewables
	D	Country 4	$$	XX%	$	Solar / wind	—	Gas, renewables
Mine-adjacent magnetite-based DRI	E	Country 5	$$$	XX%	$$	Hydropower	—	Iron grade
	F	Country 6	$$$	XX%	$$$	Hydropower	—	Iron grade
Integrated steel mill DRI-EAF	G	Country 7	$$$	XX%	$$$	Solar / wind	✓	Integrated mill efficiency
	H	Country 8	$$$	XX%	$$$	Solar / wind	✓	Integrated mill efficiency

Indicate Most Preferable option for individual factor

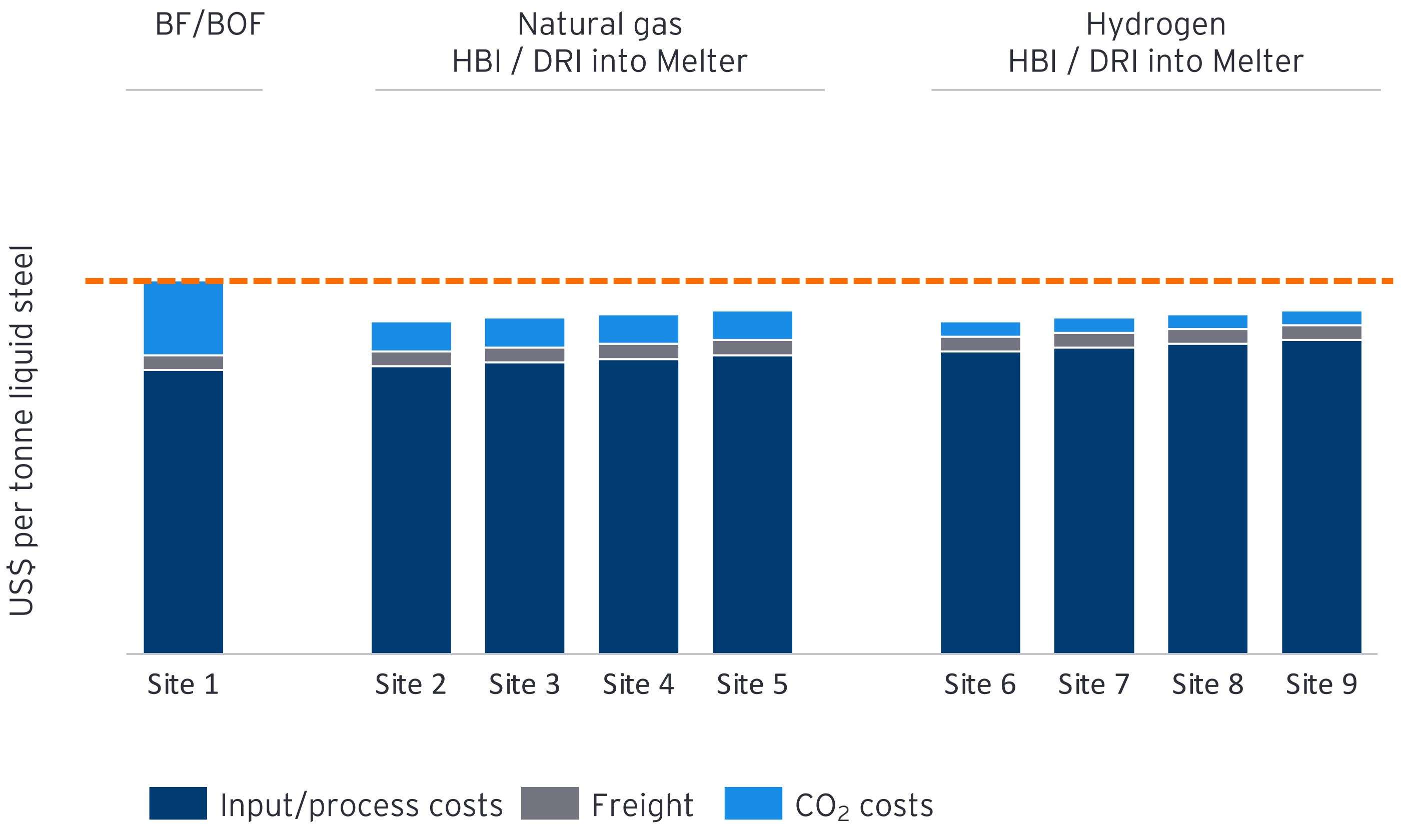
Source : EY analysis

EY Parthenon

Carbon prices will create a competitive market for low emission steelmaking pathways based on imported green iron metallics into EU

Illustrative

Ironmaking pathway economics for EU market, 2030



- ✓ Going forward as the technologies mature, cost of production methodologies via greener routes will be competitive & with BF/BOF route
- ✓ If cost of carbon is taken into consideration, cost of new routes is lower than BF/BOF route

However, there are some differences across the new technology pathways

- ✓ In case of NG route, the cost of process will be less however cost of carbon capture will increase
- ✓ In case of green H_2, cost of process will be higher, but the cost of carbon capture will be lower
- ✓ Overall, the total cost across pathways will be almost equal

Source: Incremental steel decarbonisation economics model between Australia / Europe / Korea

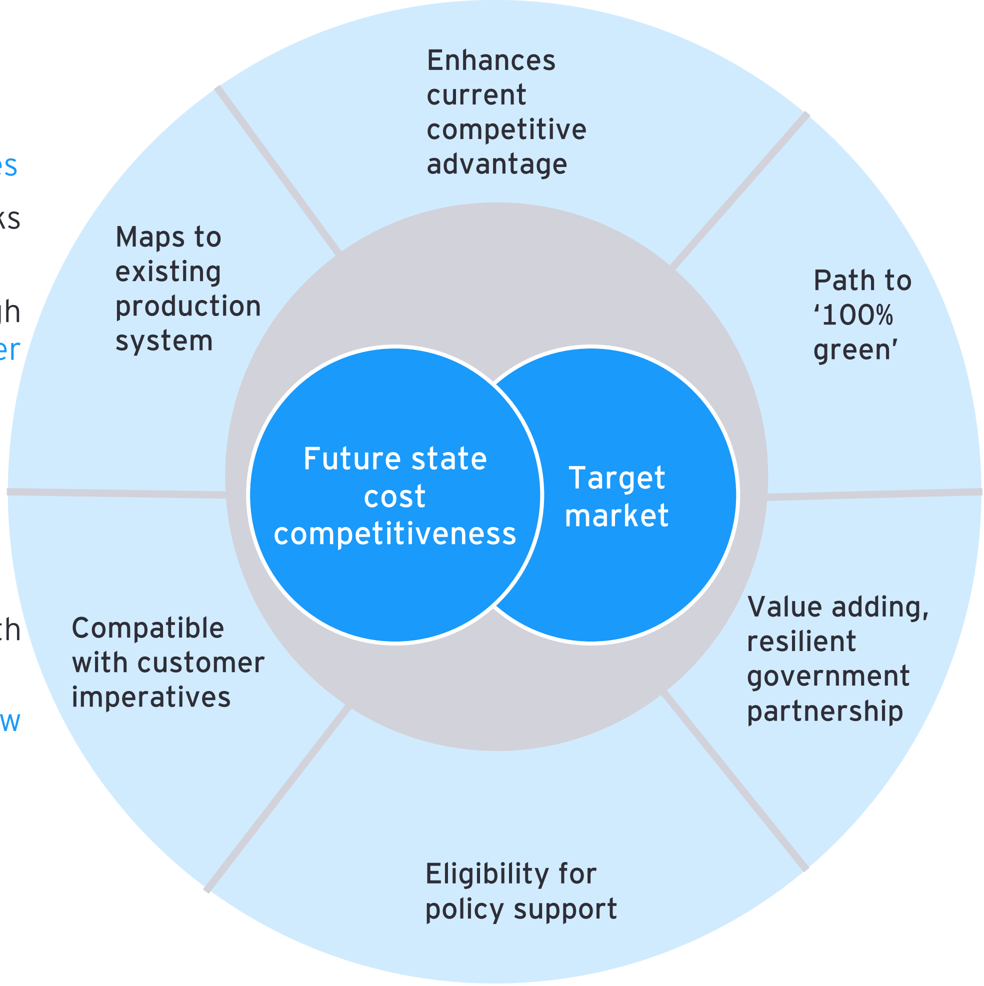
Cost of CO_2e = US $ 80 / tonne CO_2e

Other factors must compliment competitiveness and market access for the best proposition. This framework ranks locations for likely business success

Illustrative

Elements of a investment proposition

- Commercial and/or business model for DRI activity reinforces or extents current resource, capability, reputational or market position advantages



- Potential for operational synergies
- Stakeholder support through links to existing locations
- Ability to use product through existing distribution or customer relationships

- Ample potential for 100% renewable power at competitive prices…
- … with a path to this point that accommodates some 'blue' production, or below market green energy…
- … in a way that contributes to initial market development

- Geopolitical compatibility with destination market preferences
- Sustainability through in low carbon energy and other issues
- Traceability of product

- Local policy support
- Workable project development and related agreements
- Opportunities to productively co-invest and/or create meaningful industry coalitions (e.g. for technology sharing)

- Fit with regulatory tests for local and increasingly international assistance

Restructuring can help in alignment of long-term corporate goals to have lower carbon footprint with optimal gearing to make the business future ready

Lower carbon footprint	Access to green capital	Requisite reporting and compliances
Access to green commodity market	Cost optimization and operational streamlining	High governance standards

Entity restructuring Plans*

- Step 1: Study & alignment of best suitable option for entity restructuring, considering all impacts form emission, tax, financials, commercials, etc.
- Step 2: Restructuring of high emission units (CPP)
- Step 3: Undertake multiple decarbonization ideas across identified focus entity

Potential implementation

… + Green Entity 1 + Green Entity 2 + …

- Undertaking Green/ Sustainability initiative under green SPVs
- Defined & measurable goals assigned to proposed capex
- Opportunity to leverage green/ sustainable financing with reduced emissions

* Steps given in slide are indicative, refer detailed plan for actual steps

Entity restructuring is a complex exercise & will affect company's business in multiple fronts which must be kept into considerations while finalizing the restructuring plans

Key considerations

Financial

- The current financial structure as well as upcoming financing considerations must be reflected to study impact of the restructuring on the business
- Working capital, equity structure, debt conditions all need to be examined thoroughly to minimize negative impact of restructuring on the business

Tax & Legal implications

- A well-executed restructuring plan will avoid unnecessary tax burdens that the company may bear
- Regulatory clearance, stakeholder approvals & legal hurdles must be inspected along with their mitigation strategies before finalizing the restructuring plan

Entity restructuring

Commercial & Operational

- Commercial & daily operations like contract terms, employee compensation, etc. will be significantly impacted by the entity restructuring
- Studying these impact & developing strategies as well as system for smooth transformation towards new entity structure

ESG impact

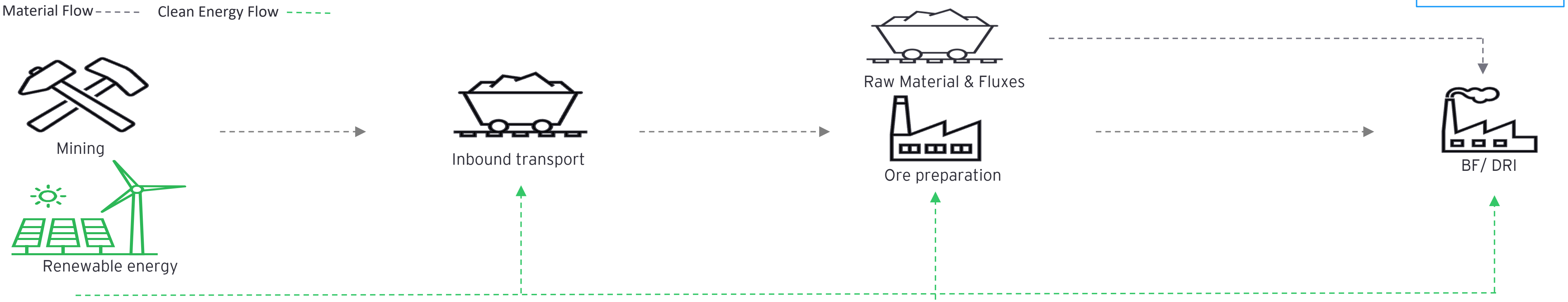
- GHG Emission, other harmful emissions (NOx, SOx) & waste produced are reduced considerably by carving out a unit with damaging environment impacts as separate entity
- The entity restricting will also impact ESG reporting under various regulatory frameworks (E.g., BRSR)

➢ Entity restructuring is a complex process with **implications across the business unit**

➢ At **EY Parthenon** we have **sectorial expertise** across to strategically deal with every considerations to help company with **successful implementation** of the process

Interventions across the Ironmaking value chain of the production process are necessary to operationalise a sustainable downstream plant operations

Illustrative



Value chain step	Ore mining & preparation	Iron Making via Blast Furnace	Iron Making via DRI (Gas Based Shaft DRP)
Emission footprint of finished steel	-	2.33* tCO_2/tcs	1.37** tCO_2/tcs
Decarbonization Levers at individual value chain components	✓ Carbon capture & utilization ✓ Sustainable sourcing ✓ Energy Substitution • Biofuel for Heat ✓ Circularity & feed mix optimization • Use of Scrap to reduce emission	✓ Carbon Capture & Utilization ✓ Energy Substitution • Biochar/Bio coal ✓ Process reconfiguration • CBM, Hydrogen Injection • New ferrous materials ✓ Cross cutting innovation • Heat Recovery • Carbon cycle analysis	✓ CCUS integration with Natural Gas based DRI ✓ Process reconfiguration • Shift to H2 based DRI process ✓ Cross cutting innovation • Deploying DRI Melter for conversion to liquid hot metal, and retaining downstream facilities
Decarbonization levers applicable across value chain	✓ Energy Substitution • Increase renewable % in electricity mix	✓ Digitization • Digitization of the value chain can help identify & optimize process to reduce emission & save costs	✓ Green finance & restructuring • Green financing assist execution of decarbonization projects • Restructuring can be a short term lever

* World average
** World average, Natural Gas based DRI

Decarbonization Levers

EY-P has developed a 11 lever framework to solve for Industrial decarbonization of clients

Key possible decarb levers Identified

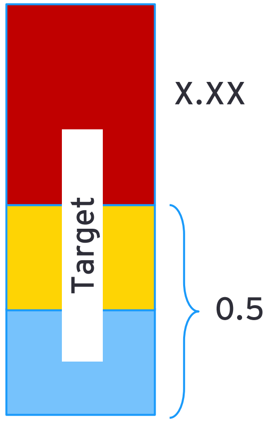
tCO2/
ton of product

FY'23

1. Feed stock Optimization & Green Feedstock Substitution (Scope 1, Scope 2, Scope 3)
2. Process Reconfiguration (Scope 1, Scope 2)
3. Circularity in Raw material and Process (Scope 1, Scope 2, Scope 3)
4. Clean Energy Substitution *(Electricity + Heat)* (Scope 1, Scope 2)
5. Carbon Capture Utilization & Storage (CCUS) (Scope 1)
6. Logistics Decarbonization (Scope 2, Scope 3)
7. Sustainable supply-chain/ Procurement (Scope 3)
8. Carbon credits
9. Green Finance
10. Decarbonization journey enabled Digitally (Scope 1, Scope 2, Scope 3)
11. Green Marketing & Communication

Scope 1
Scope 2
Scope 3

tCO2/
ton of product



Target Green steel

*Including the expansion

EY Parthenon

Generative Artificial Intelligence system coupled with material science knowledge can help Smart Iron & steel mills to tap the potential of sustainable innovation & efficiency improvement

- ✓ Steel production process is a complex activity with multiple interconnected parameters affecting the product quality, energy intensity as well as GHG emission intensity of the products
- ✓ Leveraging AI/ML technologies can help optimise the process, faster product development, reduction of energy & material consumption leading to a sustainable products across the value chain

AI/ML driven sustainable business model

Energy management & optimization

Real-time adjustment & optimization of energy intensive process with AI/ML powered analysis of energy consumption patterns

Impact : 10-20% reduction in energy consumption

Development of green products

AI/ML coupled with deep knowledge of material science can help accelerate targeted green product development using novel methods like hydrogen-based steel making

Impact : 20-40% reduction in GHG emissions

Renewable energy integration

AI/ML can facilitate the integration of renewable energy sources into steel production, enhancing sustainability and reducing reliance on fossil fuels

Impact : 10-30% Increase in RE & 5-15% reduction in GHG emissions

Smart manufacturing

AI/ML based optimization of production process by controlling critical parameters like furnace temperature, etc.

Impact : 5-10% reduction in energy consumption

Global Steel manufactures have started adopting AI/ML in their business model improving operations & thus shareholder value

Steel manufacturing Company	AI/ML related initiatives
ArcelorMittal	ArcelorMittal, one of the world's leading steel companies, implemented AI/ML and material science to **optimize energy consumption** in their blast furnace operations, resulting in a **15% reduction in energy usage** and significant cost savings (Source: MIT Technology Review, 2020).
NUCOR	Nucor, a major mini-mill operator in the United States, utilized **AI/ML technologies to minimize their carbon footprint**, achieving a **10% reduction in CO_2** emissions and a 20% improvement in resource efficiency (Source: GreenBiz, 2021).
SSAB	SSAB, a leading Nordic steel producer, employed AI/ML and material science to **develop HYBRIT**, a novel low-carbon steelmaking process that uses hydrogen instead of coal, **reducing their CO2 emissions by 35%** compared to traditional steelmaking processes (Source: SSAB, 2021).
posco	POSCO, a South Korean steel giant, utilized AI/ML in their **research and development** process to discover and develop target alloys with specific properties, resulting in faster development times, **increased product quality, and better customization** to meet customer requirements (Source: Business Korea, 2020).

Case study 1 : Energy optimization of integrated steel mill operations to reduce cost & process emissions using generative AI (1/2)

Blast Furnace Net Fuel Rate Optimization

- ✓ Streamlining of workflow along with data integration & analysis to deliver optimal operational ranges of parameters for initial analysis
- ✓ The metallurgical domain expertise coupled with analytical ability of AI/ML offered valuable insights into the relationships among the critical parameters of the plant operations
- ✓ The resultant model led to cutting down the fuel consumption by 10-15% without impacting other production parameters

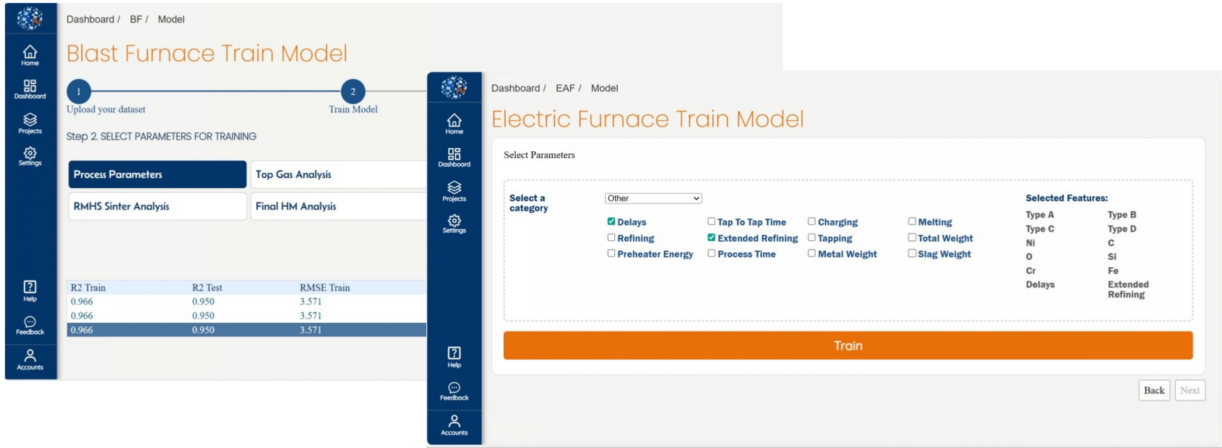
Electric Arc Furnace Power Consumption Optimization

- ✓ A material science driven AI/ML based optimization framework to optimize the total scrap cost and EAF energy consumption per ton of scrap
- ✓ The model considered parameters like types of scrap, cost, and additives to arrive at the optimal operational parameters.
- ✓ The resultant model had potential to reduce the energy consumption and scrap cost by 1.5-8% and 2-5% form business as usual cases respectively .

Case study 1 : Energy optimization of integrated steel mill operations to reduce cost & process emissions using generative AI (2/2)

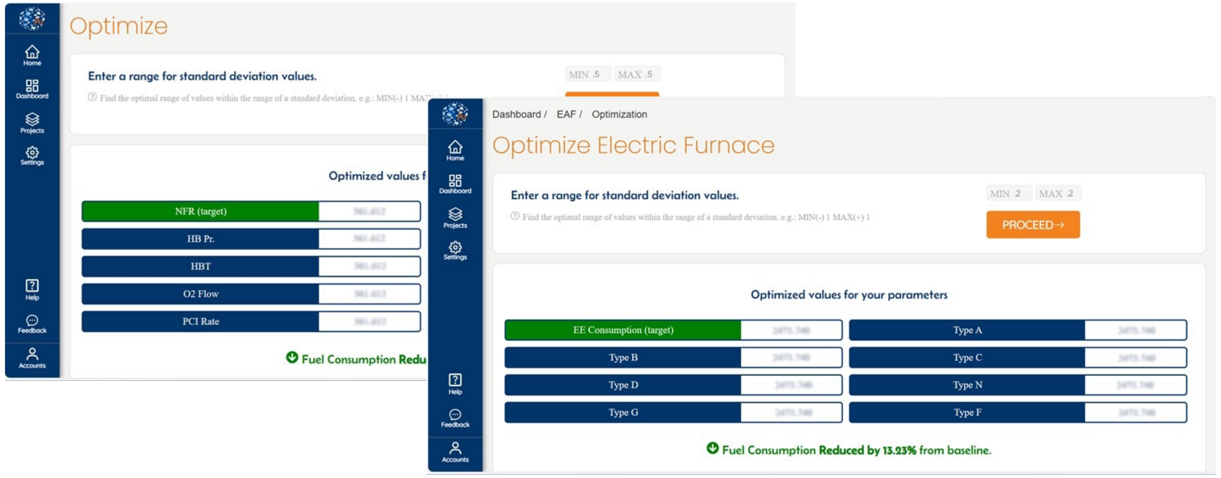
Step 1 : Building a precise process model as per tailored need of the client

- ✓ With the customization prevalent in industry, building a tailored model for each furnace is a critical task
- ✓ With the advance algorithm used in the modelmaking we ensured precise predictions with actionable insights
- ✓ Finetuning of process model was carried out using the hyperparameters from the top metrics



Step 2 : Precise optimization for fuel & power savings

- ✓ The state-of-the-art optimization tool powered by the data input received from the plant gives optimal solution of utilization of power
- ✓ With the ability to set custom constrains based on customer preference, multiple conditions can be simulated multiple scenarios to arrive at optimal operating point.
- ✓ Thus, leading to increasing operational efficiency with reduction in fuel consumption & cost savings



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