Indian Steel Association

STEEL: SHAPING THE SUSTAINABLE FUTURE

November 2023

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Acknowledgements

The Indian Steel Association (ISA) is proud to publish this report on the occasion of ISA's 4th Steel Conclave, held in New Delhi in November 2023.

The report offers a perspective on the shifting outlook for steel demand in India, and how it compares to the global steel trade. We outline the changing dynamics and their impact on the demand for green steel, by region and sector, as well as how hydrogen production in India could evolve. The report culminates with a set of implications for Indian steelmakers on the path to decarbonization, the benefits of accelerated adoption of green hydrogen, and the enablers for cost-effective hydrogen-based steelmaking capacities.

The ISA is grateful for the efforts and contributions of the people who have made this report possible. We thank our member companies for their support. We extend our gratitude especially to our knowledge partner, McKinsey and Company, for providing the analytical fact base, led by Rajat Gupta, Kunwar Singh, Praveen Krishnan, Amit Aggarwal and other global McKinsey experts who shared valuable perspectives and insights.

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The shifting outlook for steel demand

A large part of India's 2070, or even 2050 vision, is still a blueprint or an aspiration – either under construction or yet to be built. Steel, durable and adaptable, will be at the heart of most of this development. India's steel demand is expected to exceed 370 to 400 million tons per annum by 2050 – a six-fold growth from current levels.

This push for steel from India (and other developing countries) is expected to sustain global demand for steel. Over the next decade, steel demand in India is likely to grow at 6 percent per annum, compared to a growth rate of under 1 percent for the global steel industry.[1]

An expected regional rebalancing of demand, as well as shifts in steel usage and environmental concerns prompting a greater call for "green" or low emission carbon steel are all underlying factors for this decline in growth of steel demand.

The construction and infrastructure sectors could continue to account for the majority of global steel demand, but the automotive sector may drive a shift in steel demand with the gradual transition from manufacturing traditional, internal combustion engine (ICE) vehicles to electric vehicles or EVs. With massive electrification and a growing share of renewables, steel could be in high demand for power/electricity generation and transmission purposes.

The increasing urgency of environmental concerns is expected to drive demand for more green steel, with a growing emphasis on decarbonization and circularity putting the demand spotlight on (mostly flat) green steel.

[1] Unless otherwise specified, the numbers in this chapter are drawn from the World Steel Association

Three themes define the nature of steel demand over the next decade

1
A rebalancing of regional demand for steel

2
A rebalancing of products and applications

3
Growth in demand for green steel

A rebalancing of regional demand for steel

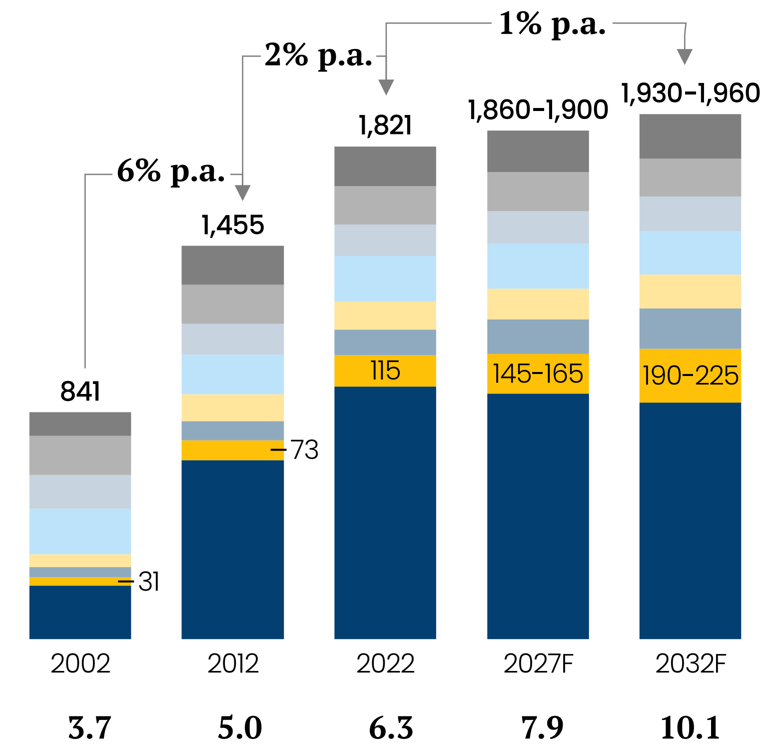
China – the country that historically contributed to over 75 percent of global steel demand growth at a CAGR of more than 8 percent for the past two decades, is likely to see steel demand decline by 1 percent CAGR in the coming decade. This will happen as the country shifts from infrastructure-led growth to a more consumer-driven economy, moving from an approach of aggressive investment in steel towards stock replenishment mode (Exhibit 1).

Exhibit 1

2023 Q1

Global steel demand by region

Apparent finished steel demand, million tons



	CAGR, % 2002-22	2022-32
Global	**4%**	**1%**
Other developing[1]	3%	1%
Other developed[2]	0%	0%
North America	0%	1%
Europe	0%	0%
MENA[3]	4%	2%
SEA[4]	5%	5%
India	**7%**	**6%**
China	8%	-1%

Share of India, %

1. Sub-Saharan Africa, Latin America, CIS
2. Japan, South Korea, Taiwan, Australia and New Zealand
3. Including Turkey
4. Bangladesh, Indonesia, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand, Vietnam, Rest of region
Source: World Steel Association

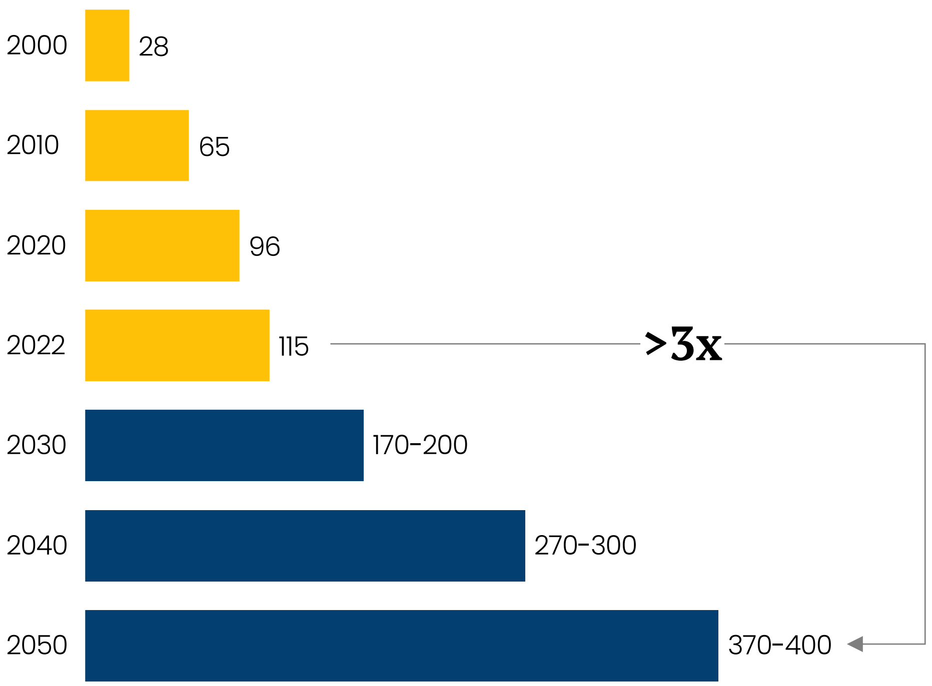
On the other hand, India and South-East Asia could drive global demand for steel, with their rising populations and their governments investing to develop infrastructure. MENA and Ukraine may undertake "mega projects" (that demand 10 to 15 million tons of steel) and restoration and rebuilding activities that could also prompt one-off spikes in steel demand.

Steel demand from India could grow at around 6 percent by 2032, driven by public investment in construction and infrastructure, with multiple projects across roads, bridges, India's steel demand is likely to grow more than three-fold by 2050 (Exhibit 2).

Exhibit 2

Projected steel demand growth for India

Million tons per year



	Crude steel production[1] (million tons)	**Consumption per capita** (kg)
2000	31	26
2010	72	53
2020	100	70
2022	~120	81
2030	185-220	~115
2040	295-330	~170
2050	405-440	~240

1. Crude steel production calculated as 1.1x finished steel demand, for forecast data or data not available
Source: Analysis by McKinsey Basic Materials Insights (BMI) team, United Nations population division. World Steel Association

A rebalancing of products and applications

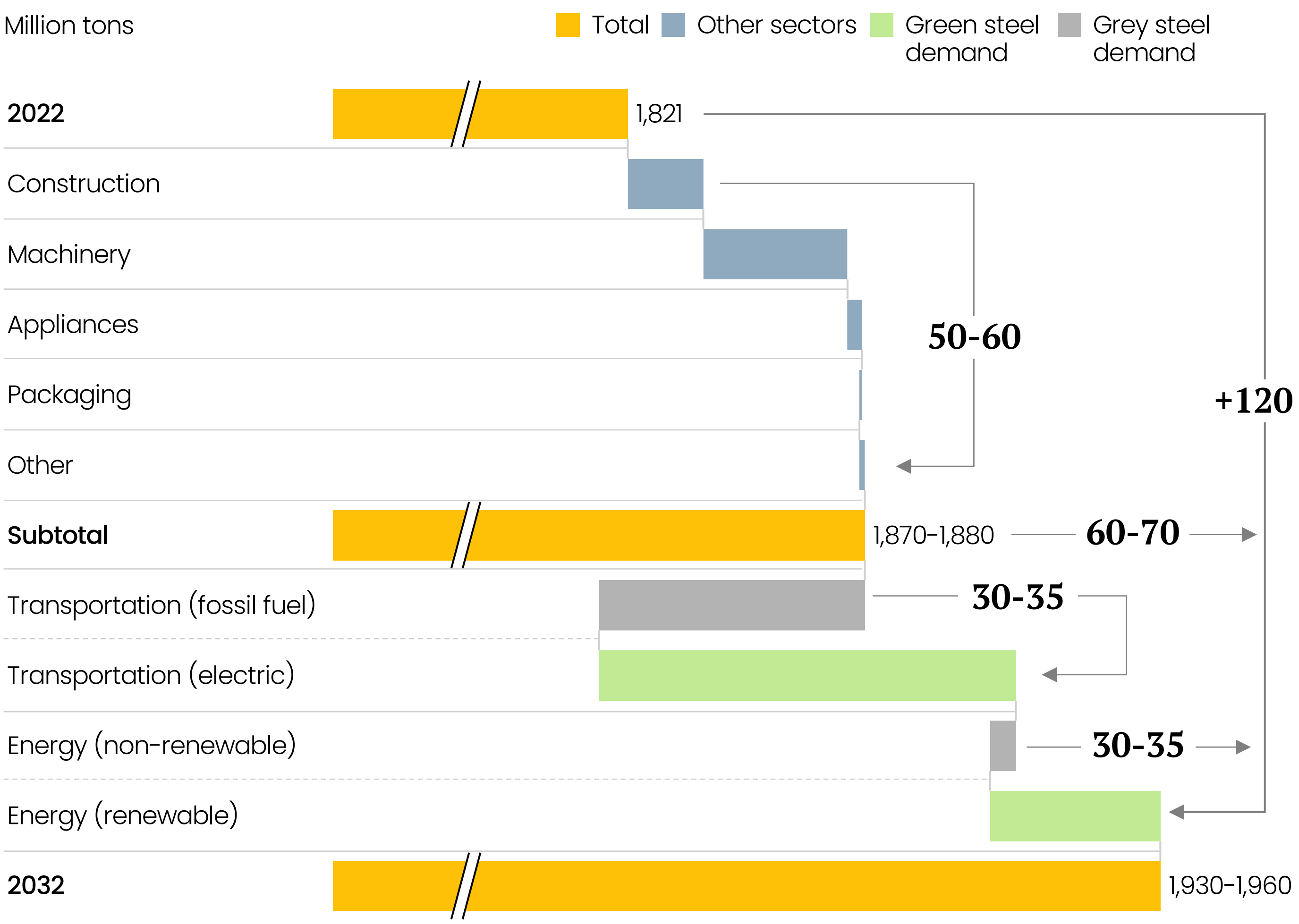
The global push towards energy transition is likely to impact demand growth patterns in steel. Shifting transport and mobility trends from ICE vehicles to EVs, the deepening of shared mobility, and the growth of aluminium giga casting could impact how much and what type of steel is required in the automotive sector. Global steel demand could also increase to address greater power generation and transmission requirements due to massive electrification and the growing share of renewables.

Of the projected 120 million tons increase in global steel demand between 2022 and 2032, the demand increase from sectors not directly linked to the green transformation (construction, machinery, appliances and packaging) could contribute to 50 to 60 million tons of overall growth, mostly from emerging regions. The remaining 60 to 70 million tons is expected to stem from the green transition of the transportation and energy sectors (30 to 35 million tons) each. Electrification of the transportation sector could lead to 90 to 100 million tons of demand, partially offset by the phasing out of traditional transportation of fossil fuels. The renewable energy transformation could deploy 35 to 40 million tons of steel for net capacity additions, while non-renewables are expected to decline by 5 to 10 million tons (Exhibit 3).

Exhibit 3

Sector wise global steel demand growth

Contribution of green transformation to global steel demand[1]



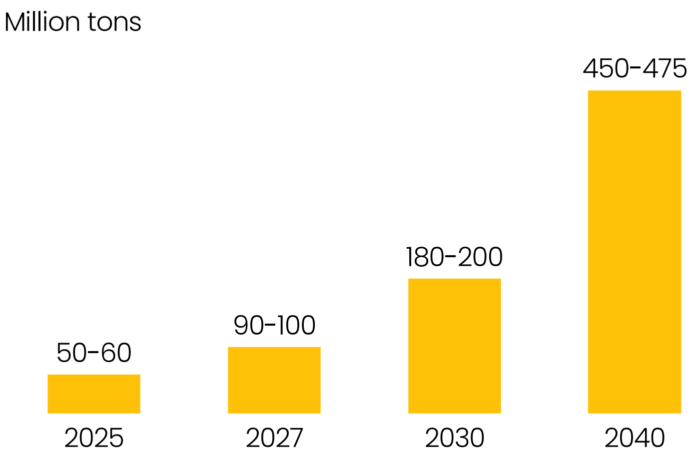
1. Differences might be due to rounding
Source: Analysis by McKinsey Basic Materials Insights (BMI) team

Growth in demand for green steel

The global demand for green or low emission carbon steel is expected to increase to about 180 to 200 million tons in 2030 (around 10 percent of total steel demand), and more than double to 450 to 475 million tons by 2040 (around 20 percent of total steel demand) (Exhibit 4).

Exhibit 4

Global low emission carbon steel demand forecast[1]



1. For the purpose of calculating this demand, low emission carbon or green steel is taken as steel produced at a threshold of 0.6 tons CO_2 per ton of finished steel (across Scope 1-3)

Global green steel demand by region
A few specific regions are expected to lead the demand for green steel. For example, the European Union and the United States will represent nearly half of all global demand for green steel. European steelmakers in particular are subject to greater regulatory scrutiny on decarbonization, with a net zero target for 2050.

In Europe, the share of green steel demand could be in the range of 30 to 35 percent, driven by voluntary commitments in the near term with the withdrawal of free allowances of the EU Emissions Trading System (ETS) in the mid-2030s. North America could represent substantial green steel demand of around 25 to 30 percent by 2030, especially due to the ambitious targets of automotive firms pushing for more low emission carbon flat steel. Subsidies on offer, such as the Inflation Reduction Act with its package of USD 369 billion, could incentivize the push for clean energy.

In developed Asia, domestic companies are likely to drive a demand for green steel through setting high decarbonization targets, even before policy measures come into effect. In developing Asia, foreign corporates could be the early drivers of green steel demand as they decarbonize their overseas sales. In the longer term, domestic companies and national governments could emerge as relevant drivers for green steel demand.

Global green steel demand by sector
In addition to stronger regulations, the demand for green steel is driven by the ambitious Scope 3 emission reduction targets of steel consumers. For example, in Europe, companies in the automotive, construction, and electrical and electronics industries have Scope 3 targets where steel customers demand green steel from their suppliers to decarbonize their supply chains. Several leading automotive companies have set a target to reduce Scope 3 emissions by 100 percent by 2030, and many construction companies have set Scope 3 reduction targets in the range of 30 to 50 percent by 2030.[2]

The transportation (34 percent of all green steel demand till 2030) and construction (32 percent) sectors are likely to lead the global demand for green steel. As the installed base of renewables increases, the energy sector will also call for more green materials across the value chain.

2 Company websites

Green steel demand in India

India's need for green steel is expected to grow as the country aims for net zero by 2070, and steel consumers are already committing to net-zero targets. A few Indian companies which are part of the World Economic Forum's First Mover Coalition,[3] have committed to ensuring that least 10 percent of their steel purchases will have near-zero emissions (less than 0.4t (0 percent scrap inputs) to less than 0.1t CO_2e (100 percent scrap inputs) per ton of crude steel produced) by 2030.

India's demand for green steel could be shaped by the risk to direct steel exports to developed countries, e.g., the EU which is implementing carbon border adjustment mechanism or CBAM (this does not yet extend to indirect steel exports). Domestic factors and the growing likelihood of carbon prices in India could also boost demand for green steel in the country.

Initial domestic demand for green steel is likely to come from the automobile sector as global automakers, who see India as a large consumer market, have global net-zero targets. These companies would require green steel for their automobiles and are likely to prefer to source steel locally.

Steel procurement by the government could provide further impetus to the development of the domestic green steel market. Steel procurement related to government-funded infrastructure projects represents 90 percent of total infrastructure-related steel demand, whereas the government-funded building construction projects represents about 8 to 10 percent of total steel consumed for building construction.[4] The government could encourage green steel demand by initiating the procurement of green steel via policies such as GPP (Green Public Procurement), and GPC (Green Corporate Procurement) recommended by Task Force 4 of G20.[5]

The carbon price mechanism can also be used as a policy tool to change business practices or shift investment decisions and expedite the decarbonization of the steel sector. Linking of emission systems can promote economic efficiency by allowing abatement where it is cheapest to undertake it. Carbon price mechanisms could be developed in line with other developed countries (e.g., ETS), facilitating and incentivizing carbon reduction.

Against the backdrop of these shifts, and with varying trade restrictions around the world, global steel trade flows could transform, shaping the evolution of the steel trade over the coming decade.

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3 WEF -White Paper - Surfacing Supply of Near-Zero Emission Fuels and Materials in India
4 Global efficiency intelligence: Report - Green Public Procurement of Steel in India, Japan, and South Korea
5 Task force 4 - Report - "A G20 Compact to Accelerate Green Public and Private Procurement of Net-Zero Steel"

02

How the global steel trade could evolve

The number of trade restrictions related to steel imports worldwide has been growing in recent years as countries try to safeguard their domestic markets. Environmental considerations could lead to more trade barriers emerging over time. Such restrictions could impact steel trade flows, and spur steel producers to adapt to the shifting landscape for business continuity.

Trade barriers around the world

Around 11,000 trade restrictions are in force today, compared to barely 1,000 in 2009.[6] The number of restrictions rose sharply in 2018, e.g., the US's introduction of Section 232 and the EU's quota-based safeguards for several countries and products. Overcapacity and varying paces of decarbonization could result in more restrictions in the future.

Most steel-producing countries have some form of trade barrier to protect their local industry.[7] For example, the US imposes 25 percent tariffs globally, excluding Australia, Canada and Mexico.[8] The EU will continue global quotas for some products, while steel safeguard measures apply until 2024.[9]

Regional imbalances in supply versus demand could impact global steel trade flows (Exhibit 5). For example, China is projected to see a drop in local demand, prompting greater exports.[10]

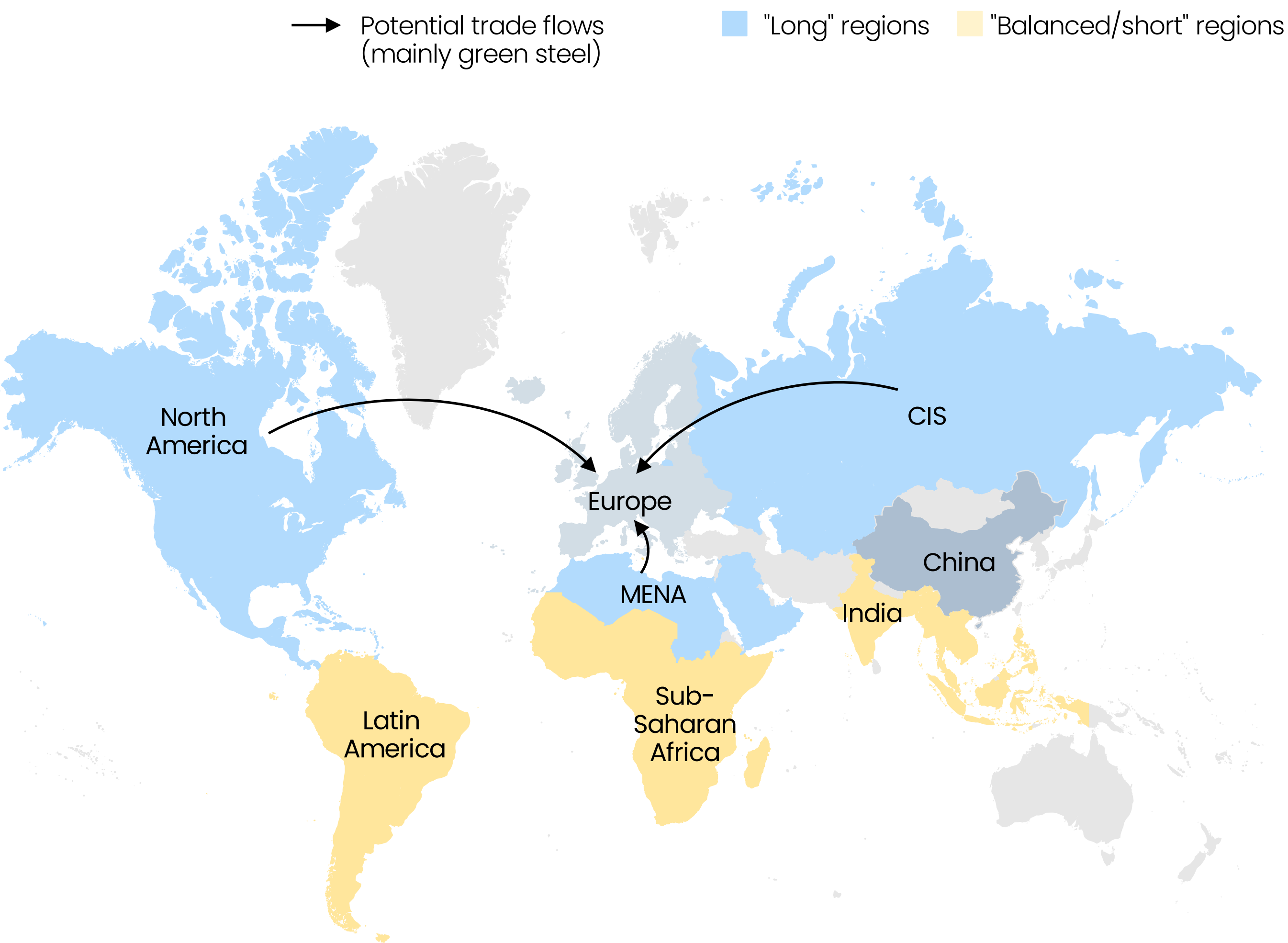
The availability of cheaper renewable energy and green hydrogen could effect a shift in the locations for new steelmaking capacity or parts of the steelmaking process (upstream metallics) – which have traditionally been situated closer to sources of coal and iron ore. Countries such as Brazil, Sweden and Spain, and a region like MENA, could emerge as cost-effective locations for green hot briquetted iron (HBI) production, driven largely by the cost of green hydrogen.

6 Global Trade Alert
7 Platts, Press search
8 PBS Article: "Steel tariffs hurt manufacturers downstream, data shows"
9 European commission: Article – "No early termination of EU steel safeguard, review concludes
10 World Steel Association, Basic Materials Insights

Exhibit 5

Crude steel supply/demand by region

2025



North America

Excessive capacity (~20 to 40 million tons), mainly in low emission carbon EAF route

Europe

Excessive capacity might remain for basic grades

Increasing deficit in low emission carbon and specialized grades

MENA

Overcapacity in low emission carbon flat segment on the back of cheap energy (~20 to 40 million tons)

China

Declining demand in China, but rapidly growing regional demand in South and South-East Asia

CIS

Maintaining overcapacity (~30 to 50 million tons) to secure iron ore monetization

Increasing share of green steel thanks to competitive low emission carbon energy access

India

Capacity growth to match rapidly growing local demand

Source: World Steel Association, Basic Materials Insights

An advantage for green steel products

Over and above the many trade barriers, more countries are introducing carbon penalties, a move that lends an edge to green steel products. Globally, 73 carbon-pricing initiatives are either already implemented or scheduled, covering 23 percent of all GHG emissions. Most include iron and steel among other sectors.[11]

The European Union's ETS or Emission Trading Scheme is the most elaborate carbon program in the world. Other regions such as the US and China have also launched their own forms of carbon-related taxation mechanisms. For example, in the US, California launched a cap-and-trade program in 2013,[12] and China has launched a national ETS for power generation that will gradually grow to include steel as well.[13]

The Carbon Border Adjustment Mechanism or CBAM is a carbon tariff introduced by the EU in 2023. It pushes importers to the EU to stipulate lower emissions from their suppliers elsewhere in the world. Policies such as CBAM and ETS can create a number of possibilities for EU and non-EU or Indian companies to explore.

The costs of manufacturing green steel are likely to push up overall costs by around 20 percent on existing costs. Manufacturers who are ahead of the curve with cost-effective manufacturing technologies could gain a competitive edge.

11 World Bank: Carbon pricing dashboard
12 California Air Resource Board – cap and trade program
13 ICAP, World Bank, Press search

How Indian companies could respond to shifting trade flows

Focus on mitigation measures and compliance with new policies: Indian companies could proactively seek ways to reduce their emissions, establish cleaner production processes, and over time shift products to a lower carbon footprint. It will be important to also start measuring and reporting emission levels in line with EU standards in preparation for important moves such as CBAM. In addition, given the big growth in steel production in India, it is important to ensure that the new investments consider future needs for low emissions.

Promote their low emission carbon products: Developing and promoting low emission carbon products could help make inroads into EU markets and establish a strong presence at a high-demand juncture. They could also gain a cost-competitive edge over existing EU-based suppliers.

Co-invest in EU green steel plants and adjacent industries and co-develop new technologies: These could broaden their business prospects.

Explore the opportunity in indirect steel: For example, the trade of steel-intensive products like cars could tap newer markets.

Companies seeking success and growth in an environment of change could benefit from anticipating and adapting to the new realities of trade in a decarbonizing world. This pursuit of decarbonization in steel also requires understanding the outlook for major input materials for steelmaking.

03

Trends in major steelmaking raw materials

The growing emphasis on decarbonization and the regional rebalancing in steel demand worldwide is likely to prompt changes in the global metallics mix. The global steel industry today is focused on raw material quality to reduce energy consumption and carbon emissions and to increase the efficiency and yield of steel plants. The short-term objective is to increase material and process efficiencies in current steelmaking processes while gradually transitioning to processes that could reduce the industry's carbon footprint.[14]

A changing global metallics mix

Scrap, which is a valuable raw material for decarbonizing steel, is expected to increase its share from 34 percent in 2022 to an estimated 42 percent by 2033. The share of direct reduced iron (DRI), which requires DR pellets made from high grade iron ore, is likely to grow from 6 to 10 percent over the same time period. This will shrink the share of pig iron or hot metal in global metallic mix from 60 to 48 percent (Exhibit 6).

[14] Less CO_2-intensive scrap based and green direct reduced iron (DRI) based electric arc furnace (EAF) processes

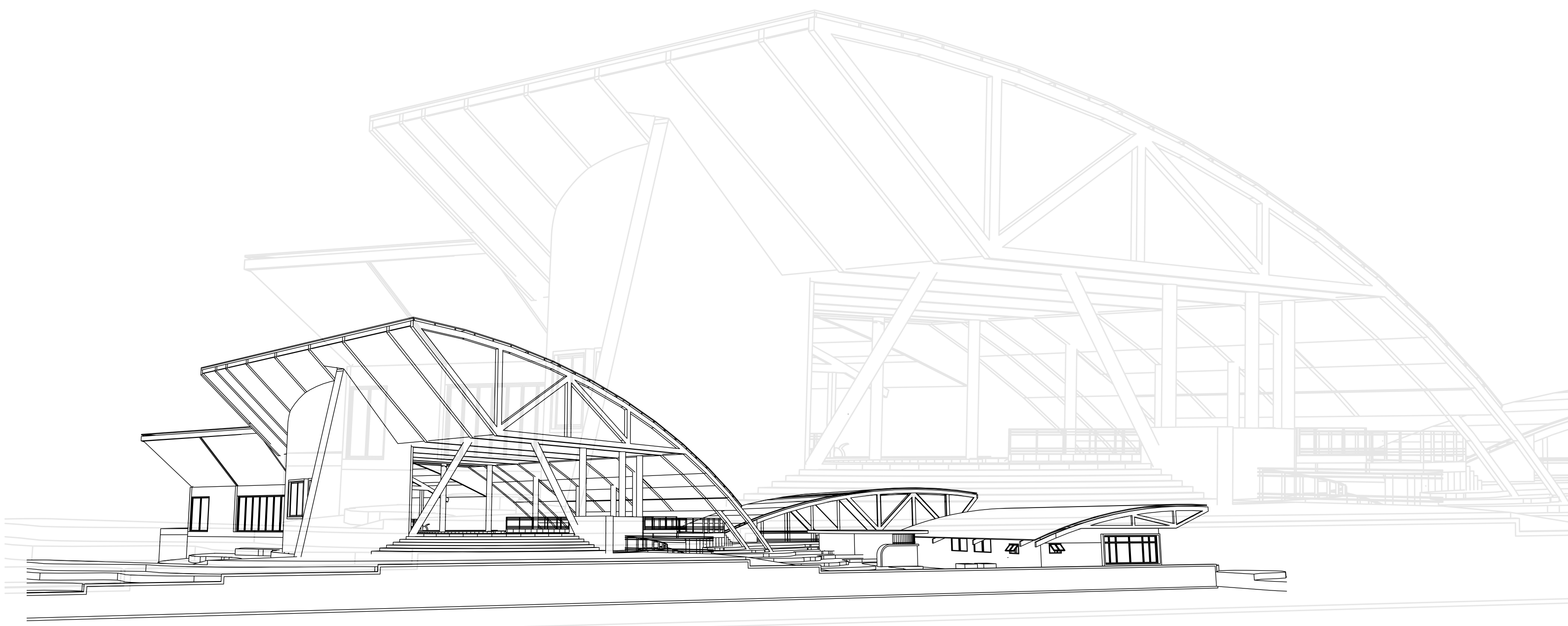
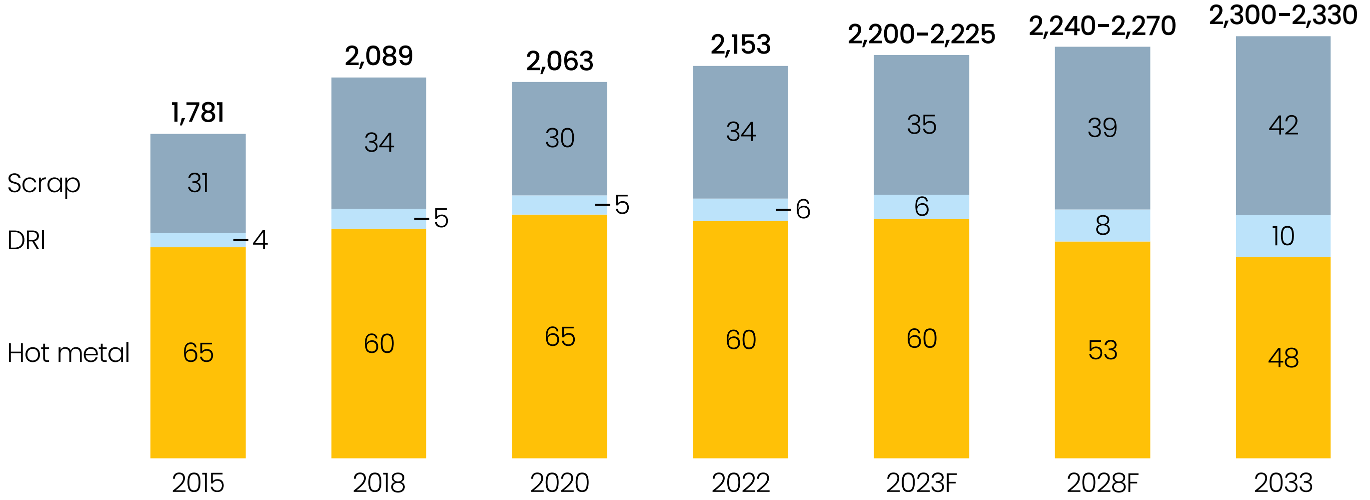


Exhibit 6

Global metallics demand forecast



Source: McKinsey Basic Materials Insights (BMI) team, McKinsey MineSpans, Word Steel Association, Bloomberg

However, metallics mix changes could differ by region, dependent on factors such as the availability of steelmaking raw materials (especially scrap) and renewable energy, the technology mix of the steel industry and domestic decarbonization goals (Exhibit 7). For example, while the global share of hot metal is expected to decline, the share of hot metal is expected to increase in India and South-East Asia where steelmaking capacity could grow by 90 to 100 million tons per annum by 2030.[15] Most of this capacity expansion is slated to be BF-BOF based (hot metal), requiring iron ore and metallurgical coal.

Despite high demand, scrap availability is limited as it is linked to historic steel consumption, and this might result in other ore-based metallic production such as DRI, and breakthroughs in other technologies, such as carbon capture, utilization and storage (CCUS), in the journey to decarbonize the steel industry.

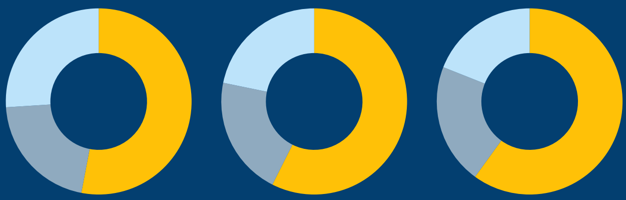
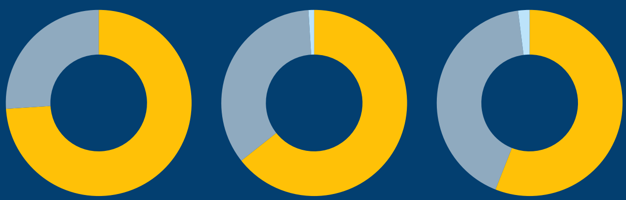
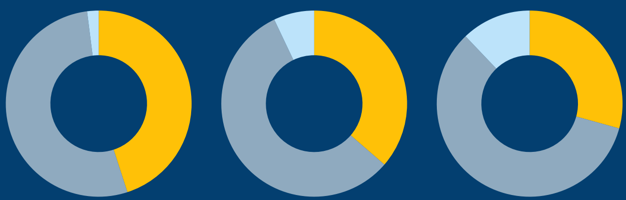
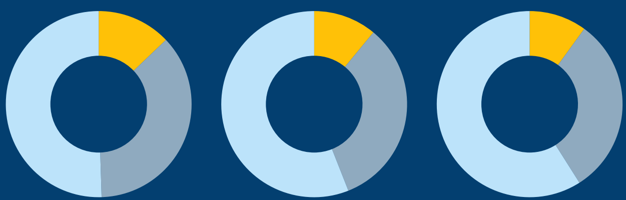
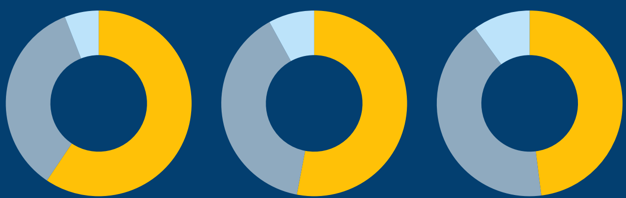
[15] McKinsey Basic Materials Insights (BMI) team, McKinsey MineSpans, Word Steel Association, Bloomberg

Exhibit 7

Shifting global metallic mix by region

The share of hot metal could remain high in developed Asia, China and India; DRI usage could grow in Europe

Hot metal | Scrap | DRI

Metallic trend & market segment	Metallic share 2023, %	Metallic share 2028F, %	Metallic share 2033F, %	Possible drivers
Hot metal up India				India has **cheap energy/coal** which supports the stable **hot metal** share
Stable metallics share Developed Asia				Both limited access to high quality iron ore and high natural gas prices impede further development of DRI based EAF route
Scrap up China				**Growing scrap availability & environment policy are promoting scrap consumption & EAF steel-making route**
Scrap up, DRI up W+E Europe				Demand for **green steel** in Europe could push the change in metallics mix towards pig iron share decline. There is strong upside potential to DRI share given capacity announcements
Scrap down, DRI up MENA				Abundant natural gas supply & cheap electricity are supporting DRI/scrap-based EAF route growth Currently more DRI plants are being built for an increased demand
Global				**Hot metal share could decline due to** the increase of usage of scrap and DRI driven by China, MENA, and Europe

Source: Worldsteel.org, McKinsey Basic Materials Insights (BMI) team, McKinsey MineSpans

Scrap

Scrap is a core decarbonization lever in steelmaking (Exhibit 8). Compared to the BF-BOF route, scrap-based EAF has 70 percent lower emissions[16] as it only requires melting and some refining to produce new steel products, whereas iron ore based production processes require a chemical reduction reaction.

High-quality scrap is particularly in great demand, especially from flat steel producers, who have higher quality requirements than long steel producers. They produce steel using ore-based metallics which can be substituted by high quality scrap.

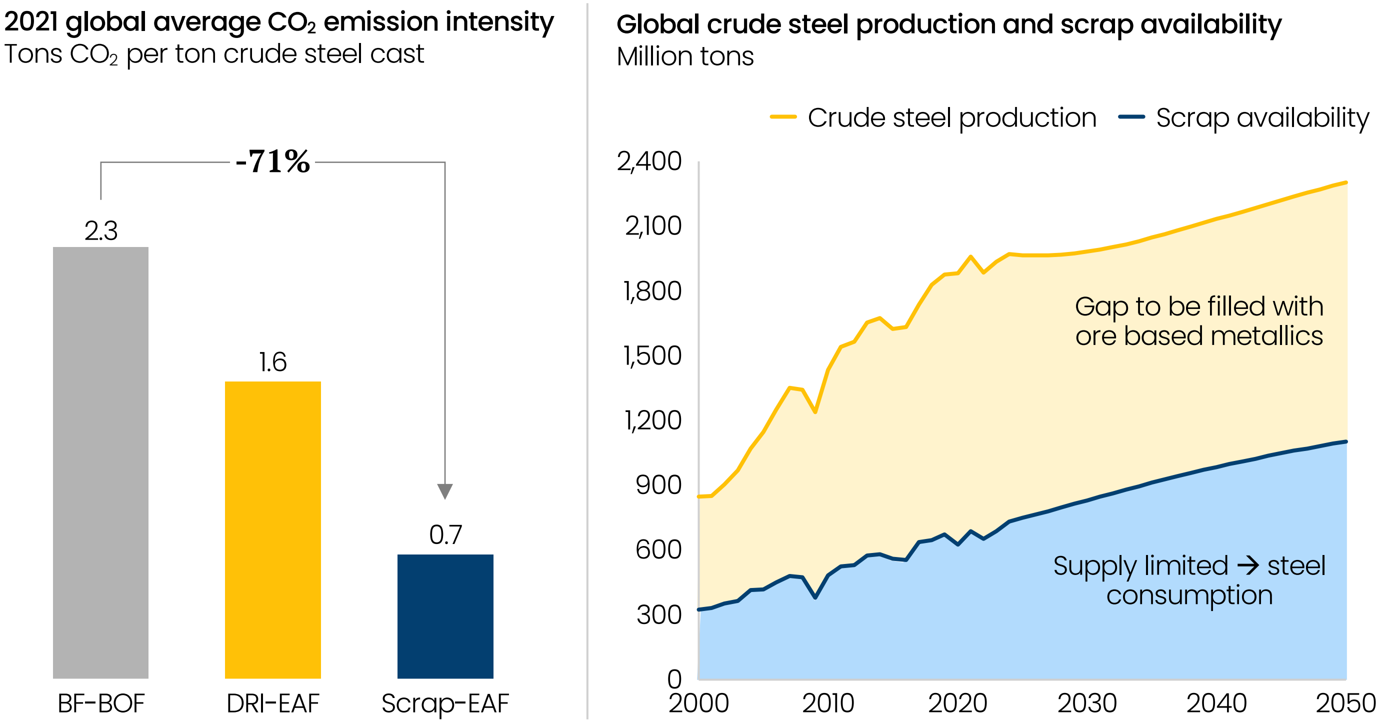
Securing and maximizing scrap availability as the steel industry attempts to decarbonize will be paramount. This could include exploring new and improved techniques for recycling and ensuring that end-of-life steel products re-enter the value chain.

Three types of scrap exist – home scrap is material collected at the steel mill when producing steel products (yield losses); prompt scrap is waste generated by steel customers who use or produce goods with it, e.g., car manufacturing or construction sites; and obsolete scrap or end-of-life scrap, which is typically highest in volume. Its availability is heavily linked to historic steel consumption and its recycling rate. As the scrap industry itself, at the beginning of its value chain, is very fragmented and often relies on smaller companies or one-man businesses, good practices and quality standards are required to maximize the recycling rate.

[16] As reported by World Steel for 2021

Exhibit 8

Scrap is a core decarbonization lever for steel



Source: Worldsteel.org; McKinsey Basic Materials Insights (BMI) team; McKinsey MineSpans; Bloomberg

There is only as much scrap available as end-of-life goods/assets being replaced/demolished. So a maturing/developing economy that is still seeing a rise in steel consumption is likely to face scrap shortage, and rely on ore-based steel production. Learning from more mature economies (such as North America or EU) that have had decades of stable steel consumption and scrap recycling, maturing economies can maximize the scrap supply through organizing the scrap industry value chain, introducing best practices in recycling and KPIs, and setting clear standards with respect to quality. This would allow capturing maximum volume and optimal value through higher quality. Avoiding contamination in the form of copper (and other chemical elements) is critical throughout the recycling process, and better sorting practices and technologies are important to ensure higher quality scrap in the system.

As a country still building out much of its infrastructure, India can develop a professional, transparent and profitable scrap industry by setting out the right guidelines and incentive mechanisms.

Direct reduced iron (DRI)

Today, DRI accounts for about 6 percent[17] of the metallics used in the steelmaking process globally. It is mainly produced by using natural gas for direct reduction of iron ore, but emerging technology is enabling the production of DRI using hydrogen as well. Depending on the source of the hydrogen, this offers the potential for truly green steel. Green hydrogen-based DRI is, therefore, expected to be a major decarbonization lever for steelmakers, particularly in Europe, where companies have announced around 60 to 70 million tons[18] of mostly DRI-based green steelmaking capacity by 2030.[19]

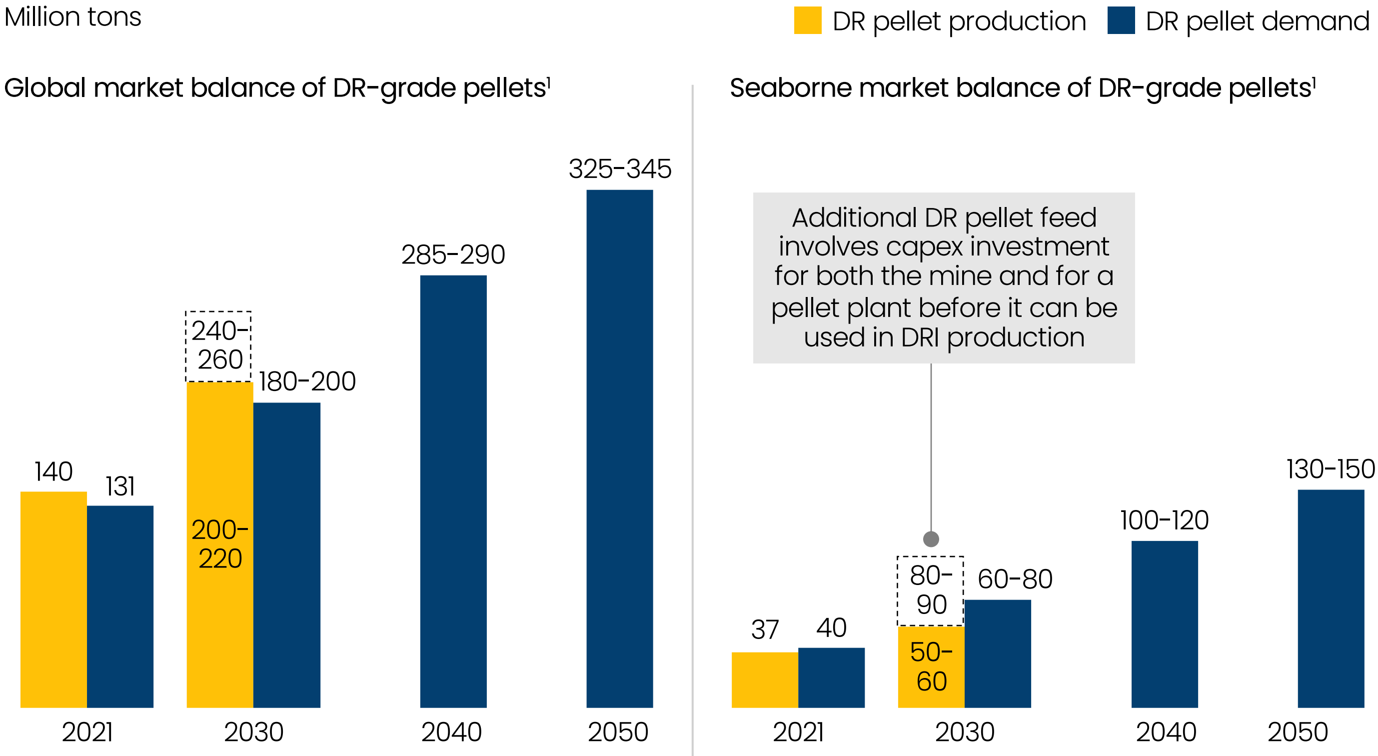
Currently, DRI is mostly made from high-quality raw materials, which can be produced at only a limited number of mines. A significant expansion of the DRI industry will likely lead to a shortage of raw materials within the next decade. Given this potential deficit (Exhibit 9), growth in the DRI industry will have to be accompanied by innovative steelmaking processes, which can use lower-quality iron ore. Several global players are trialling technology to use low-quality iron ore that can be further processed to produce green metallic. This has important implications for steelmakers with wider plant configurations.

In the case of Indian iron ore, a typically high alumina and silica content and medium Fe grade has made the ore unsuitable for making DR grade pellets. High levels of alumina and silica also limit the amount of BF pellets that can be used to make hot metal to prevent the build-up of excessive slag in the furnace. Mills need to add more sinter which enable adding fluxes to remove slag from the BF.

[17] McKinsey Basic Materials Insights (BMI) team, McKinsey MineSpans, Word Steel Association, Bloomberg
[18] Ibid.
[19] The outlook for hydrogen is discussed in Chapter 4

Exhibit 9

Supply & demand balance of direct reduction grade pellets



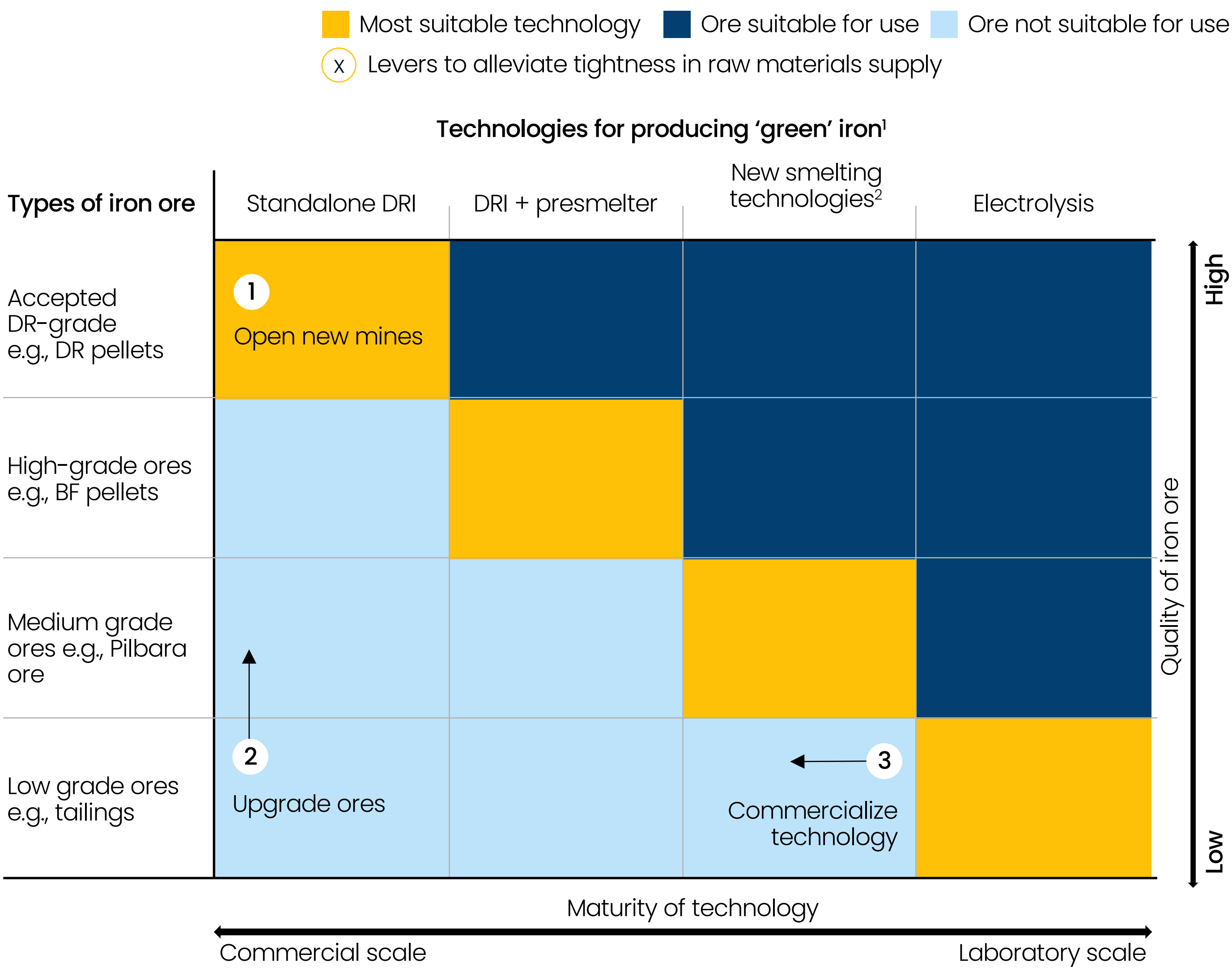
1. If all the DR pellet feed gets pelletized
Source: MineSpans

It could be beneficial to improve the quality of domestic low-grade ore to utilize the ore available in India and to support the expansion of steelmaking capacity. High grade iron ore is also important as more players look to lower their emissions in the near term and invest in gas-based DRI capacity in the medium to long term. Exhibit 10 shows how the maturity of current green steelmaking technology limits the usage of different grades of iron ore. To fully realize the potential of existing iron ore, either the iron ore would need to be beneficiated to a higher grade (the more likely solution) or various steelmaking technologies would need to reach commercial stage (a distant solution).

Exhibit 10

Non exhaustive Illustrative

'Green' iron technology maturity and raw material suitability for each technology



1. Considering routes with carbon direct avoidance i.e.CDA, not CCUS
2. E.g. direct fines reduction or electric smelting
Source: McKinsey Basic Materials Insights (BMI) team; McKinsey MineSpans

Iron ore

Globally, iron ore demand is likely to decline at around 0.9 percent per annum over the next 10 years, from around 2257 MMT in 2023 to 2060-2080 MMT in 2033.[20] This is in line with the modest global steel demand growth and an increase of scrap availability, especially in China. With new mine projects in the pipeline, the iron ore market as a whole could face a potential oversupply situation by 2033 (Exhibit 11).

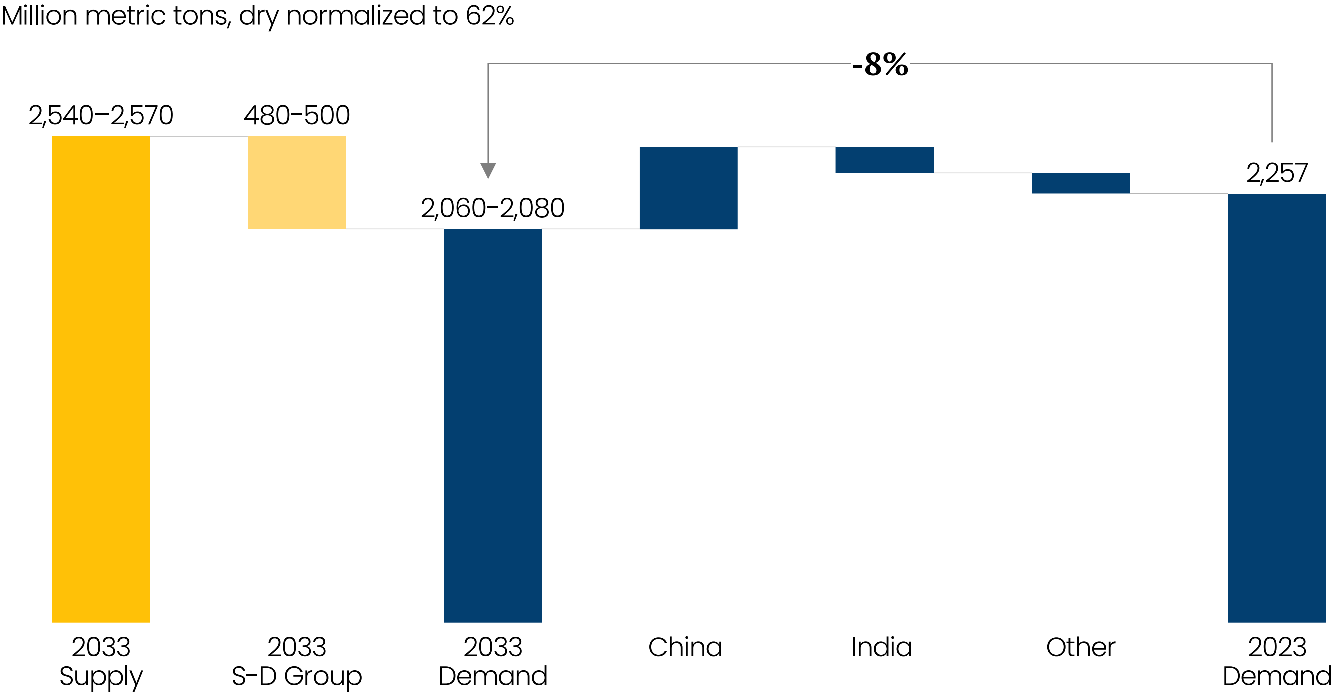
A major contributor to this demand drop is the expected decline in China's domestic steel production and greater use of scrap in steelmaking, driving down China's total iron ore demand at around 4 percent CAGR, from approximately 1.36 billion tons in 2023 to around 1 billion tons by 2030 and seaborne iron ore demand to decline at the same rate, from around 1 billion tons in 2023 to around 790 million tons by 2030.[21]

20 McKinsey Basic Materials Insights (BMI) team; McKinsey MineSpans; Word Steel Association; Bloomberg
21 Ibid.

Exhibit 11

Iron ore global supply and demand projection

Iron ore supply and demand balance, 2023-2033



Source: McKinsey Basic Materials Insights(BMI) team, McKinsey MineSpans, Word Steel Association, Bloomberg

The quality of the iron ore will also be in sharp focus as an important differentiator in the market since DRI production requires high-quality iron ore (with minimal impurities) for lower emissions. The quality of iron ore from two major exporting countries has dropped in recent times – Brazil and Australia have seen a decline in their average iron-ore grade.[22] Both countries are also seeing reduced output, affecting global supply volumes.

To address the issue of iron ore quality, global iron ore makers are entering into MoUs with steelmakers, developing HBI hubs and exploring new iron ore technologies such as green briquette and cold pelletization.

Metallurgical coal

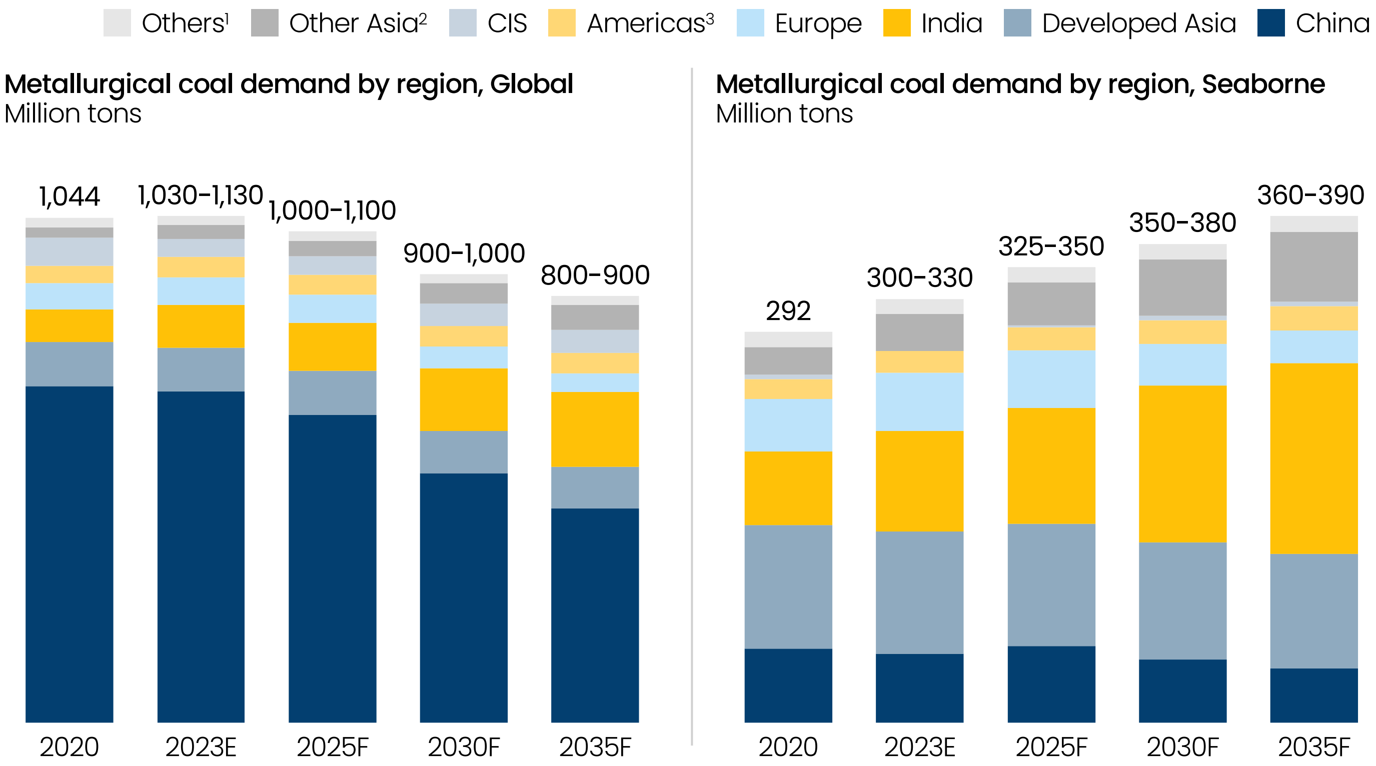
Metallurgical (or "met") coal, transformed into coke is used as a reductant in the blast furnace to produce hot metal/pig iron for steelmaking. However, there is a gradual shift away from coal-based reduction towards more gas-based reduction of iron ore as countries aim to decarbonize their steel industry. The availability and cost of natural gas and "green" hydrogen will determine how much steel will continue to rely on coal-based blast furnace production.

While the overall demand for met coal is expected to decline at around 1.5 percent CAGR in this decade due to the decline in demand from China (at around 4 percent CAGR), demand from India and South-East Asia is expected to grow at around 6 percent CAGR as these countries continue to invest in BF-BOF based capacity expansions (Exhibit 12). Demand from India and South-East Asia might also boost seaborne met coal trade from around 300 to 330 million tons in 2023 to almost 350 to 380 million tons in 2030 (approximately a 2 percent CAGR).

[22] McKinsey Basic Materials Insights(BMI) team, McKinsey MineSpans, Word Steel Association, Bloomberg

Exhibit 12

Region wise global overall metallurgical coal and seaborne metallurgical coal demand projections



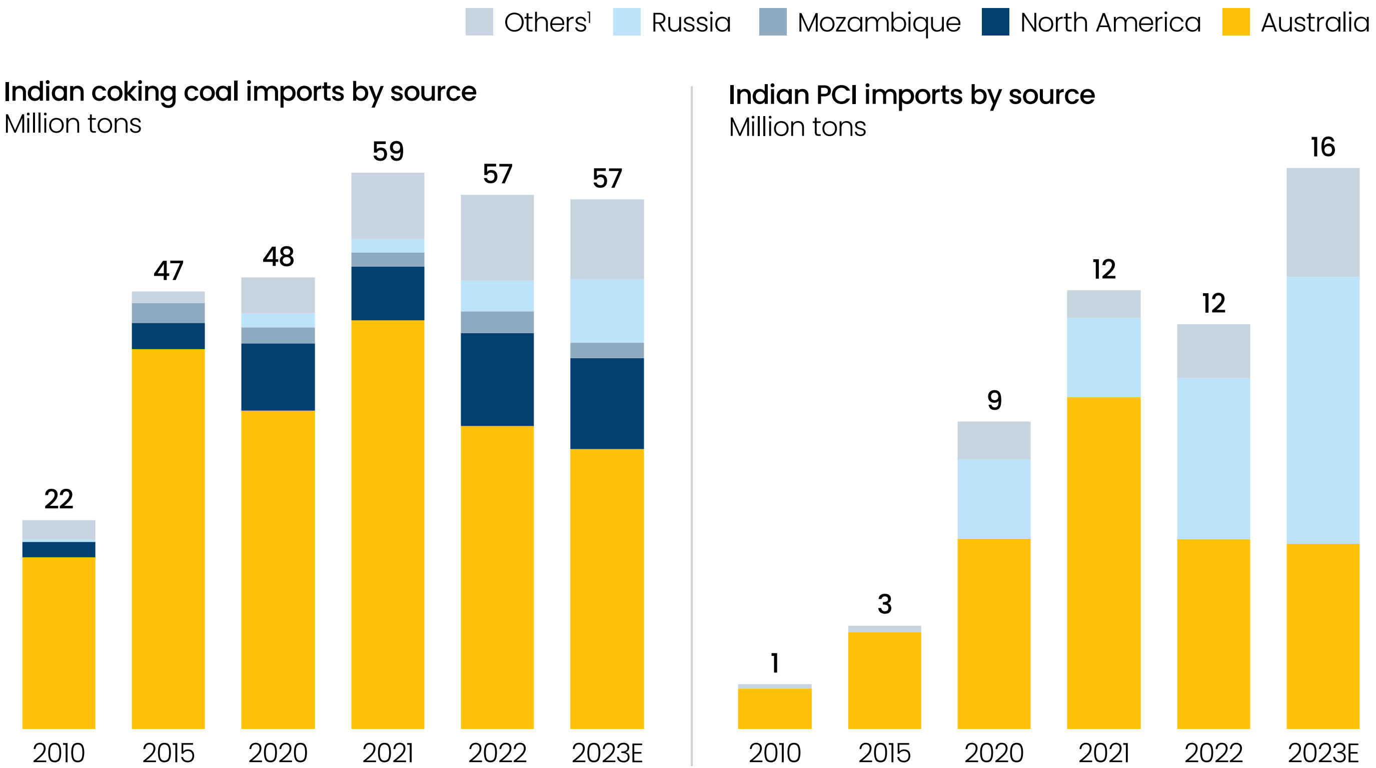
1. Others include MENA, Sub-Saharan Africa and Oceania (no seaborne demand)
2. Other Asia includes Indonesia, Malaysia, the Philippines, Thailand and Vietnam
3. Only South America as North America has no seaborne demand Source: McKinsey GMI

India depends largely on imported met coal (around 80 to 90 percent[23] of domestic met coal requirement is imported), historically from Australia. However, the country has recently been diversifying to import from the US, Russia, and Mozambique (where India has invested in upstream investments in new mines). Despite this diversification, Australia is expected to remain India's foremost supplier of metallurgical coal (Exhibit 13).[24]

23 Ministry of Steel, Government of India
24 Ministry of Commerce and Industry, Government of India

Exhibit 13

Indian coking coal and PCI imports by source



1. Others includes China, Indonesia, New Zealand, South Africa, etc..
Source: Indian Ministry of Commerce and Industry

Given India would remain dependent on met coking coal requirements, global met coal prices could continue to affect the Indian steelmaker's cost of steel production and profitability. This effect could be further pronounced due to the low quality of Indian domestic iron ore as lower-quality iron ores require more energy to reduce, raising coke rates in the blast furnace.

Conversely, higher met coal prices (and higher cost of hot metal production) could also make other green steelmaking technologies more attractive.

Going beyond these input materials, green hydrogen has scope to cut down the iron component in steel production and help produce greener steel. How hydrogen production could shape up in India is the subject of the next chapter.


H2
HYDROGEN

04

How hydrogen production will shape up in India

Renewably sourced green hydrogen could be the fuel of choice in producing green steel as India pursues decarbonization and net zero by 2070.[25] Derived from water through electrolysis (using electricity from renewable sources), green hydrogen could constitute a substantial 15 to 20 percent of India's primary energy mix by 2070, helping to abate 12 to 18 $GtCO_2e$ of cumulative emissions.

Substituting grey hydrogen in existing applications like crude-oil refining, methanol production, fertilizer, and city-gas blending could fuel initial demand for green hydrogen. Replacing the current fuel in hard-to-abate sectors such as long-haul trucking, steel production and power storage with hydrogen could further boost demand. For widespread adoption, green hydrogen must become competitive against conventional fuel or feedstocks such as grey hydrogen, met coal, natural gas or diesel. Currently, all of India's hydrogen production (approximately 5 to 6 million tons) is in the form of grey hydrogen, primarily used for fertilizers, refining, and chemicals. India also imports roughly 2 million tons of grey hydrogen embedded in fertilizers.

Scaling up the use of green hydrogen is one of the key levers for an 80 percent emissions abatement between the line of sight (LoS) and accelerated scenarios of decarbonization in India.[26] New investment in steel production could consider this future trend while assessing the optimal production route and its future adaptability to make greener steel.

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[25] Unless otherwise specified, all numbers and analyses in this chapter are taken from Decarbonising India: Charting a pathway for sustainable growth, McKinsey & Company, March 2023

[26] The two scenarios are presented in Chapter 5

The outlook for green hydrogen in India

Most downstream processes such as refineries and ammonia production use on-site steam methane reformer (SMR)-based grey hydrogen, with a production cost of USD 1.90 per kg. This cost could increase with rising natural gas prices. In contrast, the production of green hydrogen could become cost competitive after 2030. Cost to produce green hydrogen could decline to around USD 2 per kg, a drop of 50 to 55 percent due to the declining cost of electrolyser and renewables electricity, and the government's PLI scheme.

The National Green Hydrogen Mission (approved in January 2023)[27] provides multiple incentives to bring down the levelized cost of hydrogen (LCOH) by incentivizing domestic electrolyser manufacturing through PLI schemes and subsidies. In addition to this the interstate transmission (ISTS) charges have also been waived for 25 years and these manufacturers can bank unconsumed RE power for up to 30 days.

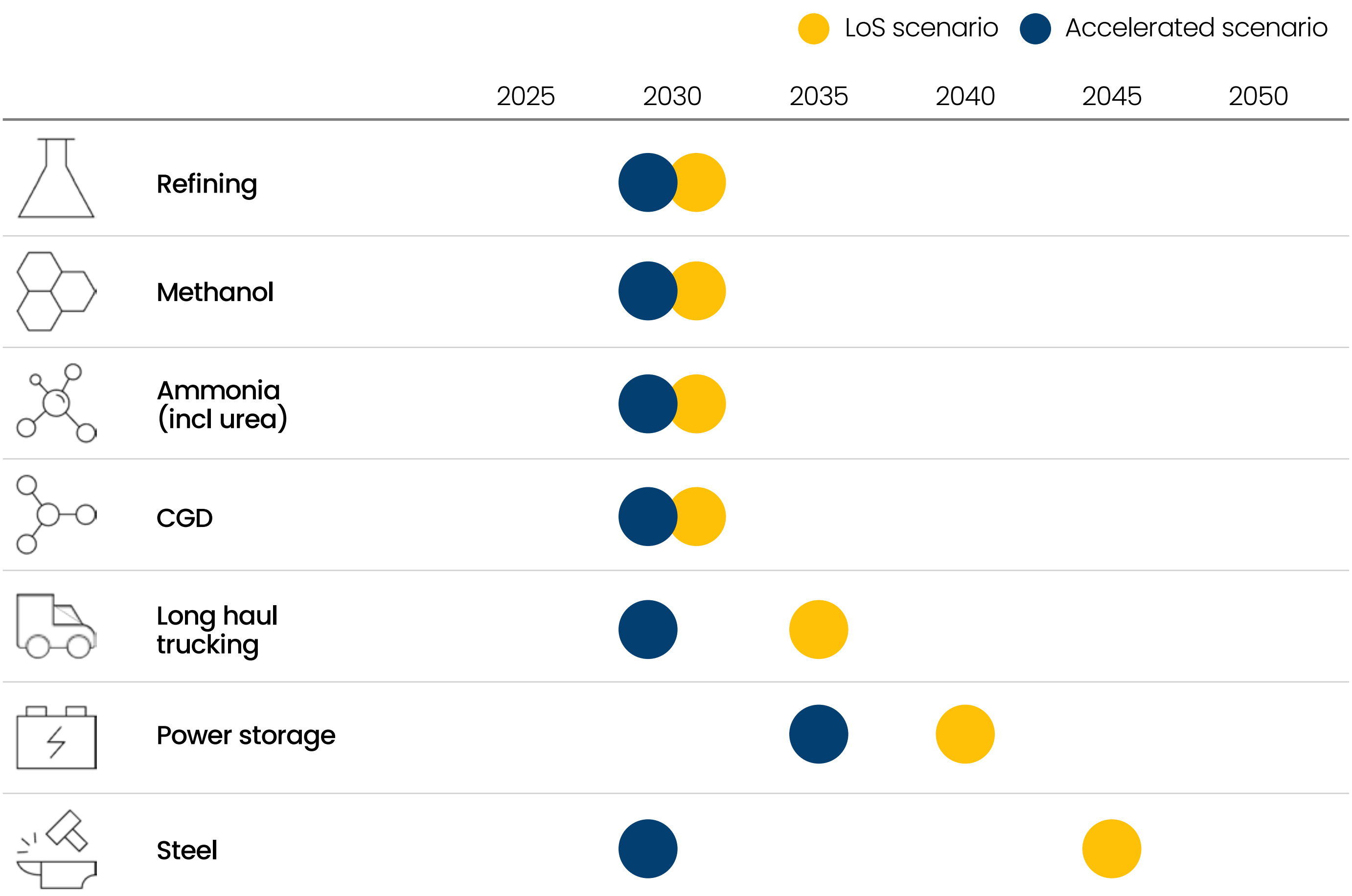
Green hydrogen could see growing demand as it becomes a cost-competitive replacement for grey hydrogen between 2030 and 2035 in an accelerated scenario (Exhibit 14). As the cost of production for green hydrogen falls, existing grey hydrogen use cases in refinery, methanol production, and fertilizers manufacturing are likely to be early adopters of green hydrogen. In addition, blending mandates like in city gas could increase demand for green hydrogen in India.

[27] National Green Hydrogen Mission, Government of India

Exhibit 14

Industry wise tentative timeline for hydrogen cost competitiveness

Competitiveness of green hydrogen in different use-cases



1. Includes ammonia production, refining, methanol production and natural gas blending
Source: Decarbonising India: Charting a pathway for sustainable growth, McKinsey & Company, March 2023

In the LoS scenario, with implementation of current policies, the cost of green hydrogen is likely to fall to around USD 2 per kg by around 2030, making it progressively competitive against alternatives – around 2030 for chemicals and refinery, around 2035 for long-haul trucking, around 2040 for power storage applications, and another five years later, for steel.

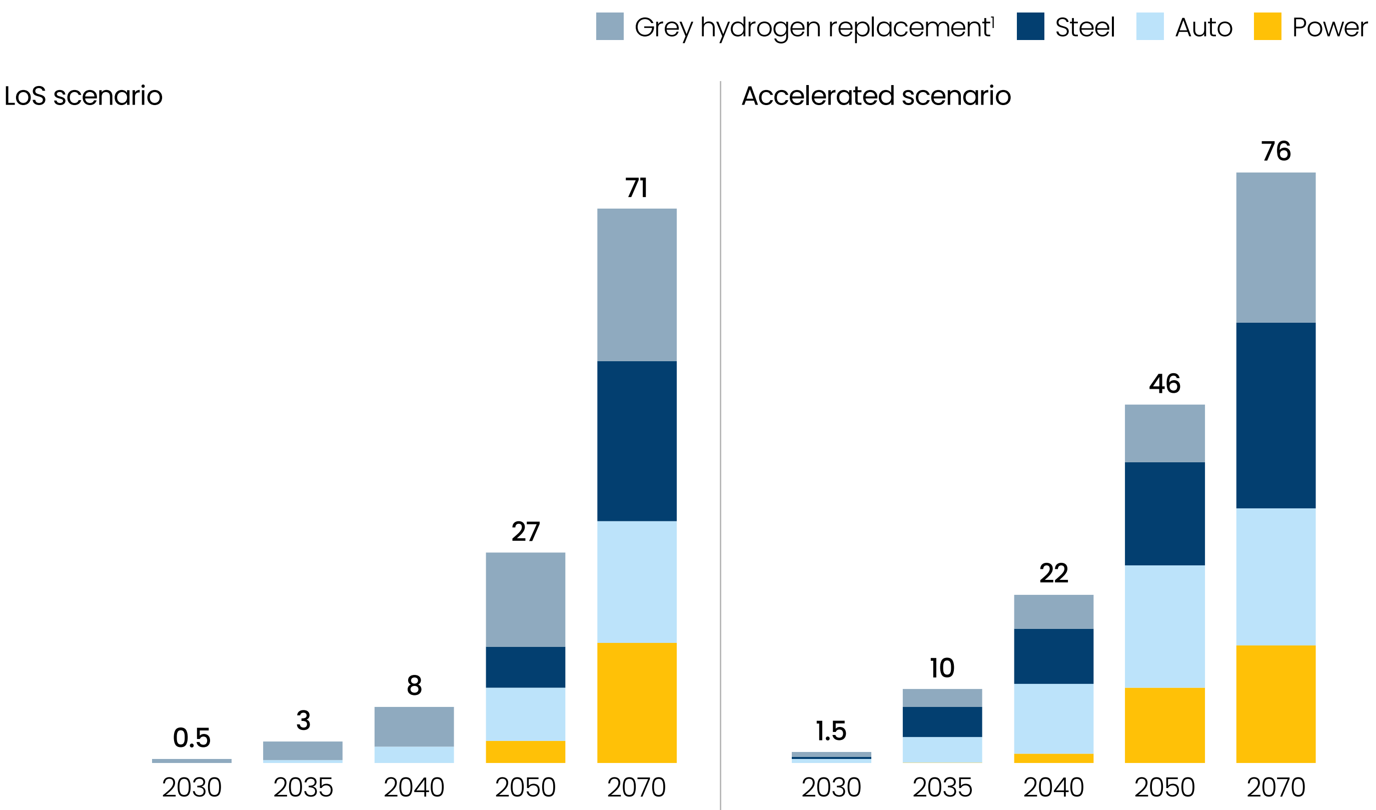
In the accelerated scenario, with a carbon price of USD 50 per ton, green hydrogen becomes competitive for all major use cases in the 2030s, and its use could be triple that of LoS levels in the hard-to-abate sectors (i.e., steel, automotive and power) by 2040, prompting accelerated investment in low-carbon assets (Exhibit 15).

Steel could be one of the largest consumers of green hydrogen from around 2030 onwards, as even a relatively low carbon price makes hydrogen-based steelmaking much more competitive than the blast furnace-coking coal route. In the automotive sector, hydrogen fuel cell–based long-haul trucking is expected to become progressively more cost competitive in lifecycle value terms versus the ICE as well as battery EVs. The last to adopt green hydrogen among the hard-to-abate sectors is likely to be the power sector, since the cost of current power storage solution alternatives could be 40 to 50 percent lower. Even so, as India moves toward firm renewable sources, hydrogen would play a key role in grid balancing and energy storage.

Exhibit 15

Industry wise domestic hydrogen demand in LoS & accelerated scenarios

Green H2 Demand, million tons per annum; bottom-up sector wise projections



	LoS 2030	LoS 2035	LoS 2040	LoS 2050	LoS 2070	Accelerated 2030	Accelerated 2035	Accelerated 2040	Accelerated 2050	Accelerated 2070
CO_2 abated (million tons per annum)	5	27	71	302	810	20	155	310	535	903
USD billion	1.2	4.8	10.6	33.0	64.1	3.1	16.2	31.5	56.0	68.3

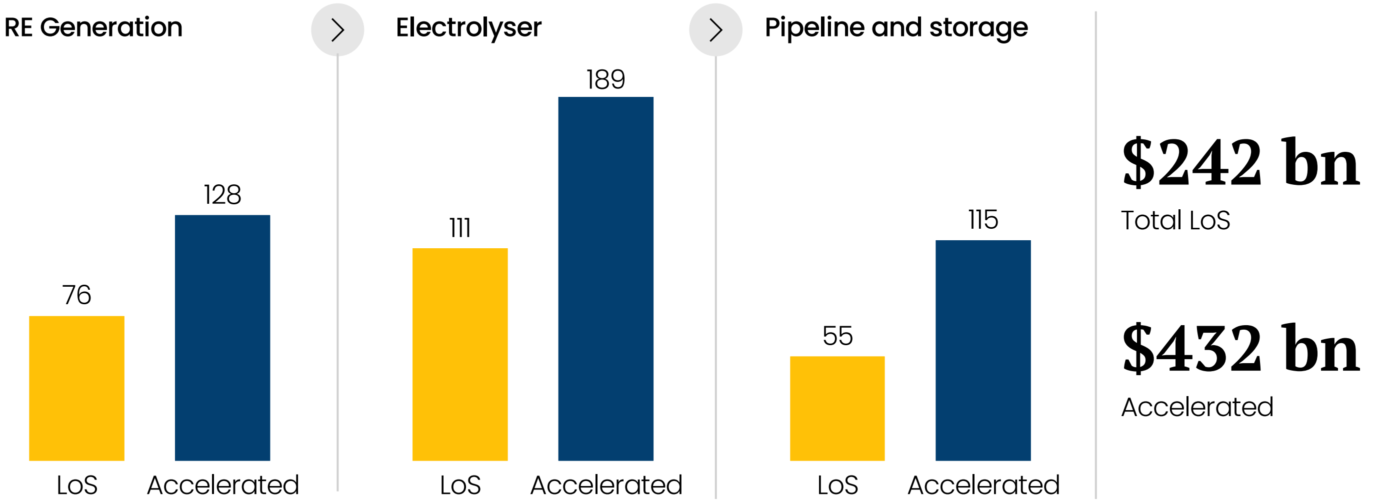
1. Includes refineries, methanol production, fertilizer production and city gas blending

The accelerated scenario is expected to require an investment of around USD 430 billion in green hydrogen by 2050 – around double what is needed for the LoS scenario (Exhibit 16).

Exhibit 16

Cumulative investment requirement across scenarios till 2050

USD billion



The benefits of accelerated adoption of green hydrogen

A rapid ramp up of green hydrogen use could lead to the emergence of greener steel infrastructure, more carbon spaces and greater forex savings. The export of green hydrogen derivatives to energy-short markets with high decarbonization targets (such as South Korea, Japan and the EU) could also represent a USD 5 to 6 billion opportunity.[28]

Building green steel capacity

The growing demand for steel could prompt an additional coal based BF-BOF capacity expansion of approximately 250 million tons over the next 25 years in the LoS scenario. In the accelerated scenario, this figure is significantly lower – around 15 million tons, with the remainder being dedicated to hydrogen-based green steel, enabled by the availability of green hydrogen and other factors. Given that steel assets typically have a lifespan of 40 to 50 years or more, prolonged commitment to high-carbon assets in the LoS scenario risks potential stranding of these assets as India has net-zero commitment by 2070. Companies could hesitate to invest in new assets for fear of getting their assets stranded later. This would affect domestic steel supply and might result in India substantially increasing steel imports.

Creation of carbon space

In the LoS scenario, the steel industry could drive an overall abatement of 5.8 $GtCO_2e$. This increases to 10.3 $GtCO_2e$ in the accelerated scenario (Exhibit 17).

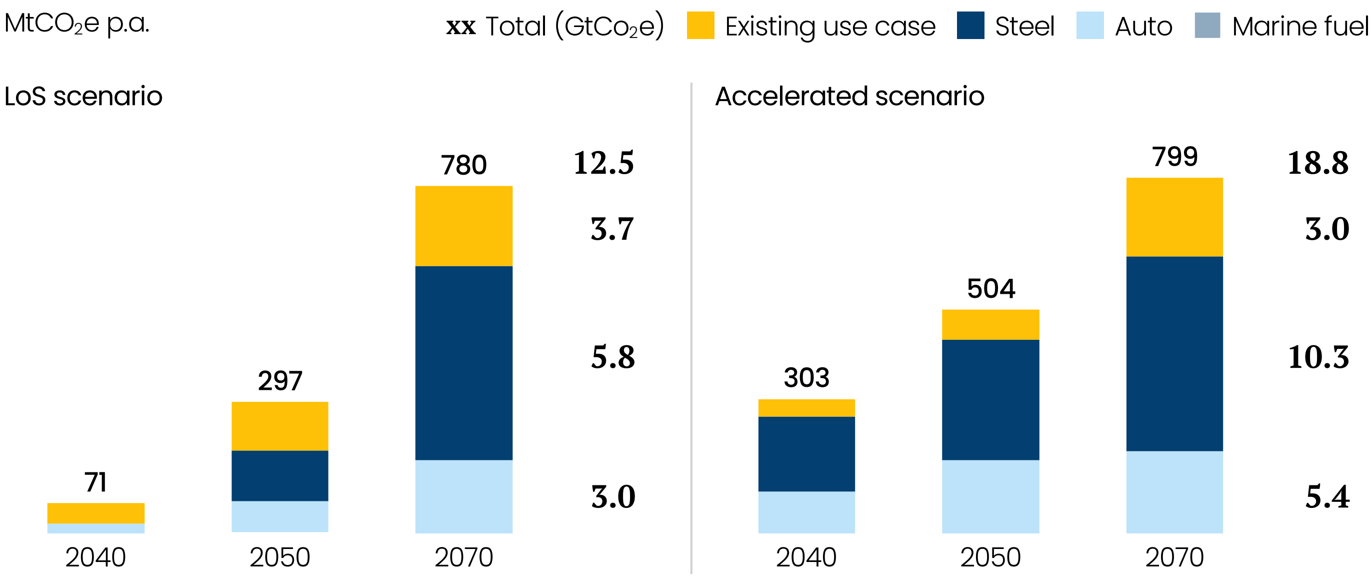
Greater savings on forex

By 2050, India's steel industry is expected to reduce its energy import reliance by USD 11 billion annually in the LoS scenario. In the accelerated scenario, forex savings by the steel industry could be as much as USD 26 billion (Exhibit 18).[29]

28 Decarbonising India: Charting a pathway for sustainable growth, McKinsey & Company, March 2023
29 Ibid.

Exhibit 17

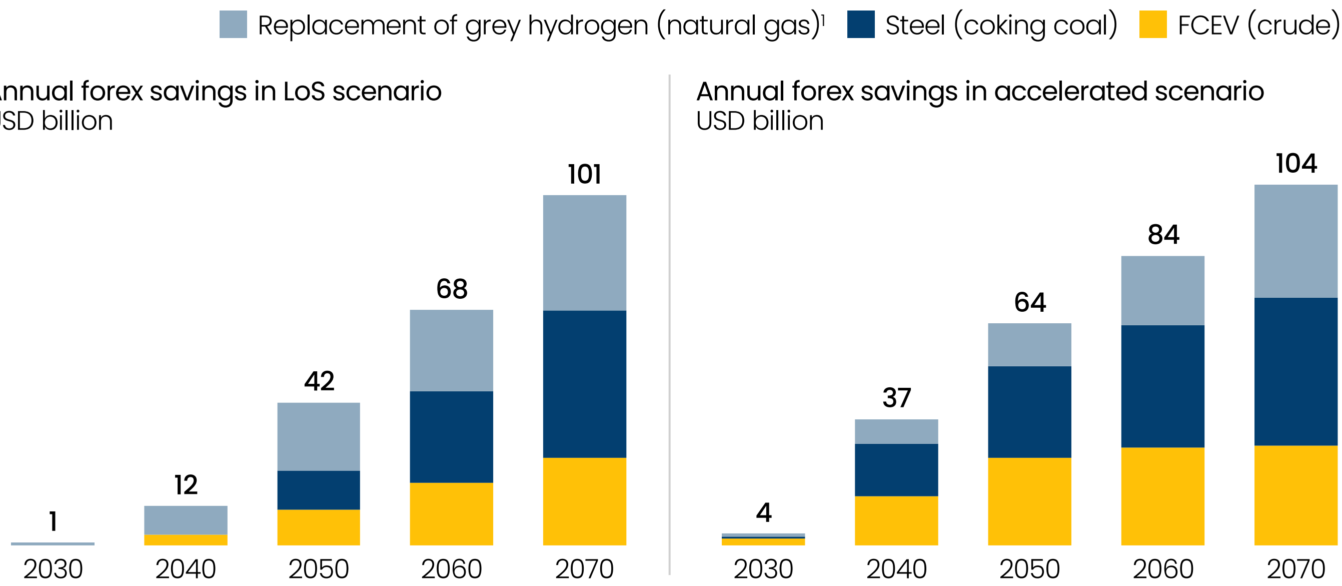
Annual CO_2e abatement potential from green hydrogen



1. Includes ammonia production, refining, methanol production and natural gas blending

Exhibit 18

Forex savings on account of green hydrogen



1. Includes ammonia production, refining, methanol production and natural gas blending

Ramping up hydrogen could contribute to the decarbonization of India's steel industry. With the net zero target urging on the industry's initiatives, various stakeholders could contribute to accelerating this journey.

05

The path ahead for India

With India's steel demand projected to reach nearly 400 million tons per annum by 2050, steel sector emissions (already around 11 to 12 percent of India's total), could grow to 620 million tons per annum carbon emissions by 2045. A journey to decarbonize existing assets could help curb these figures in India.[30]

As steelmakers pursue decarbonization on priority, multiple levers and options are available to them, especially to cut down Scope 1 emissions in their traditional BF-BOF complexes (Exhibit 19). While it will be important to shift to low-emission technologies over time, for now there is scope to reduce around 3 to 5 percent of emissions from the integrated BF-BOF plants through NPV-positive levers, largely related to energy efficiency. Depending on the plant's asset configuration, abatement could be as high as 25 percent through the application of other opex and capex-intensive levers, such as scrap charging and the use of biomass.

[30] A version of this chapter appeared in Decarbonising India: Charting a pathway for sustainable growth, McKinsey & Company, March 2023. All numbers and analyses in this chapter, unless specified otherwise, are taken from the report.

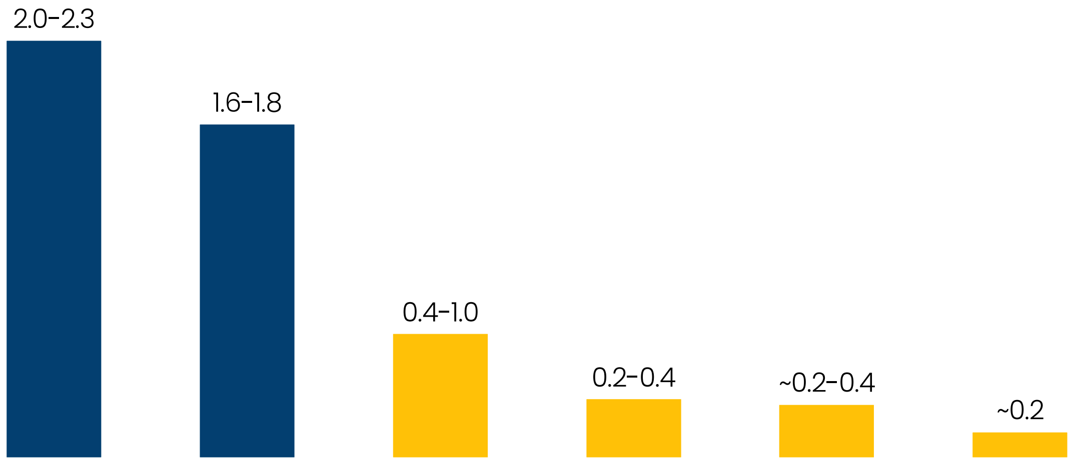
Exhibit 19

Not exhaustive, varying technology maturity

Overview of steelmaking technologies

Green steelmaking capabilities | Maturity: Low – High

	BF-BOF	BF-BOF with efficiency	BF-BOF + CCS	DRI-EAF w. Natural gas + CCS	DRI-SAF-BOF w/green hydrogen	Scrap EAF
Approach	Reduce iron ore by coking coal in BF converted to steel in BOF	Pursue energy efficiency and process improvements, e.g., feedstock quality, digitization	Add carbon capture technology to existing BF-BOF plants	Natural gas-based DRI with an EAF, and capture CO_2 emissions	Combine green hydrogen-based DRI, arc furnace and BOF	Melt high quality scrap in EAF
Emissions tCO_2/t liquid steel[1]	2.0-2.3	1.6-1.8	0.4-1.0	0.2-0.4	~0.2-0.4	~0.2
Max. decarbonization potential using RES[2]**, %**	Baseline	~20-25%	-50-80%	-80-90%	-85-90%	-85-95%
Logic/limitation	Abatement limited by availability/ cost of scrap/ biomass	No step change decar-bonization of the plant	Lack of regulatory clarity; Significant capex requirements	Will apply selectively in India	Requires cheap H2 (~1-2$/Kg) to be cost competitive	Limited by scrap supply
Maturity			No CCS cases, minor CCU	Emirates Steel	Industrial demo plants and large announced projects	



1. Across Scope 1-2
2. % vs. BF-BOF; RES – Renewable Energy Source
Source: Decarbonising India: Charting a pathway for sustainable growth, McKinsey & Company, March 2023

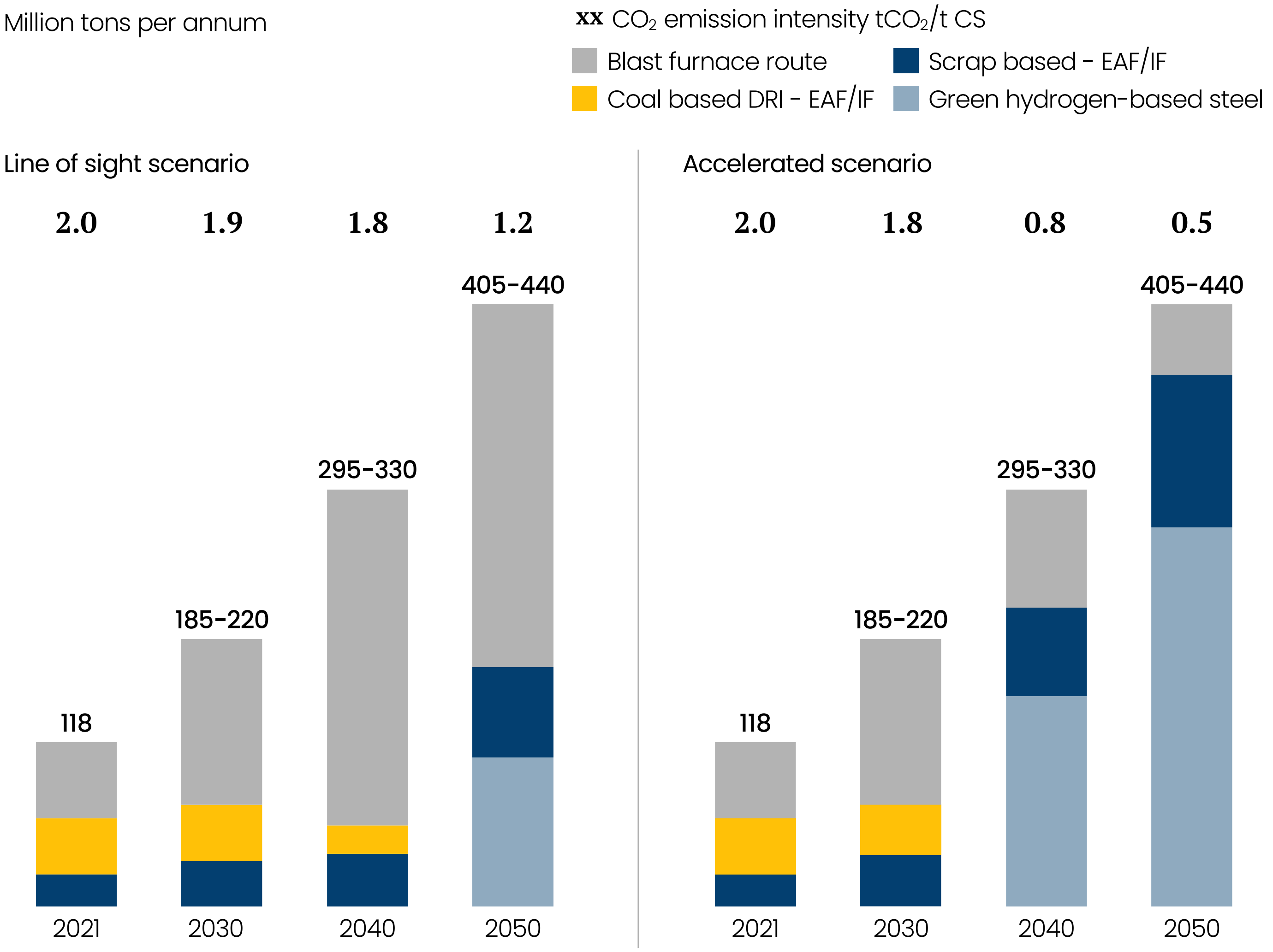
The LoS and accelerated scenarios for decarbonization

In the energy outlook for India, two scenarios could be projected - the line of sight (LoS) scenario with current (and announced) policies and foreseeable technology adoption, and the accelerated scenario with further reaching polices like carbon prices and accelerated technology adoption, including those of technologies like CCUS.

An outlook for 2050 indicates that in an accelerated scenario, the emissions intensity of India's steel industry could drop by around 75 percent by 2050, with a much greater volume of steel being made with green hydrogen, thus easing the transition to net zero (Exhibit 20).

Exhibit 20

Projected crude steel production by various steel-making routes



Source: Decarbonising India: Charting a pathway for sustainable growth, McKinsey & Company, March 2023

Enablers to achieve the accelerated scenario

Collaborative and complementary efforts by the steel industry and the government could help to make the accelerated decarbonization scenario possible for India. The suggestions below call for a mix of public and private initiatives.

Increased domestic scrap-based steelmaking capacity

India depends on imported scrap to the tune of 5 to 6 million tons per annum.[31] As quality scrap becomes a more valuable commodity, sourcing it could become a challenge. India would benefit from a value chain that supports a six- to seven-fold increase in indigenous scrap availability to around 120 to 130 million tons per annum by 2050.[32]

In addition, policies incentivizing scrap collection and recycling could motivate dismantling, collection, and processing centres, thereby boosting scrap availability.

Industrial power price would need to be reduced from its current INR 8 per kWh[33] to make it competitive versus coal-based steelmaking. A greener grid or direct access to stable renewable power will be an important factor here.

Cost-effective hydrogen-based steelmaking capacity

Hydrogen is a key decarbonization lever for the steel industry, prompting the need for cost-effective hydrogen-based steelmaking capacities. These could initially use natural gas as a transition fuel (until hydrogen firing becomes economical). Given the short supply of natural gas in India, the industry will rely on mechanisms that make competitively priced natural gas available. To ramp up natural gas-based steel to 5 percent of India's net steel production by 2030, the steel industry would need 100 MMBTU gas annually[34] – this is projected to be 1 to 2 percent of India's total gas demand by 2030.[35] The industry could benefit from a thrust on natural gas availability and infrastructure[36] at competitive prices, especially in the eastern part of India, which is likely to see a major part of the new steel capacity setup.

Natural gas could over time be largely replaced by green hydrogen, further reducing emissions and ensuring installation of the right type of capacity. The industry would need around 5 million tons per annum in case of LoS scenario and 13 million tons per annum in case of the accelerated scenario of hydrogen adoption, and proportionate transportation infrastructure by 2050.

This would also entail reducing hydrogen costs to be competitive versus coal-based steelmaking. The hydrogen supply cost would need to be within USD 10 per MBTU, with green hydrogen priced below USD 2 per kg. This could be achieved through capital subsidies – for example, a USD 60 to 80/kW subsidy from 2025 might lower electrolyser costs to USD 250/kW by 2030). It might also be possible to cut renewable energy costs by 40 to 50 percent through a drop in technology costs, transmission and distribution waivers, reduced project financing costs, and higher plant utilization.

Carbon tax and pricing at the right levels

There may be a need for border adjustment mechanisms to make the industry competitive against imports that do not have a carbon price. It will be important to set the carbon price at the right levels sooner (over the next few years) rather than later to accelerate the decarbonization journey.

Abatement in coal-based steelmaking

With blast furnace production still the primary steelmaking mode in India, it will be important to pursue abatement in coal-based steelmaking through a thrust on energy efficiency and process improvement measures, infusion of alternate fuels – these could abate emissions by as much as 25 percent.[37]

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[31] Press Information Bureau- Scrapped Steel Market, Ministry of Steel, 2023
[32] India net-zero Steel Demand Outlook Report, Jan 2023
[33] Maharashtra Electricity Regulatory Commission (MERC), Mid-Term Review Order for MSEDCL, 2023
[34] Article "Natural gas and its Usage in Iron and Steel Industry", ISPAT Guru, October 2018
[35] Article "India's gas consumption to jump more than 3 times by 2030: GAIL Director, Business Standard, November 2021
[36] Article "Natural gas and its Usage in Iron and Steel Industry", ISPAT Guru, October 2018
[37] Driving Energy Efficiency in Heavy Industries, IEA, March 2021

Focus on R&D for efficient CCS deployment at scale
Effective carbon capture and storage could further abate emissions, but can be an expensive lever. R&D efforts and technological advancements could make it more cost-effective. Identifying carbon sinks in key steel-producing centres in eastern India could also support this endeavour. It will be important to deploy CCS at scale through improving capture technologies, building a network of pipelines to transport CO_2, and exploring large carbon sinks.

Accelerated consumption of green steel in end-use sectors
The government could promote the use of green steel, with carbon targets for public and private construction as well as in automotive uses. This would support the emergence of a green steel market for domestic steelmakers, who could also sell it in the export market for green premia.

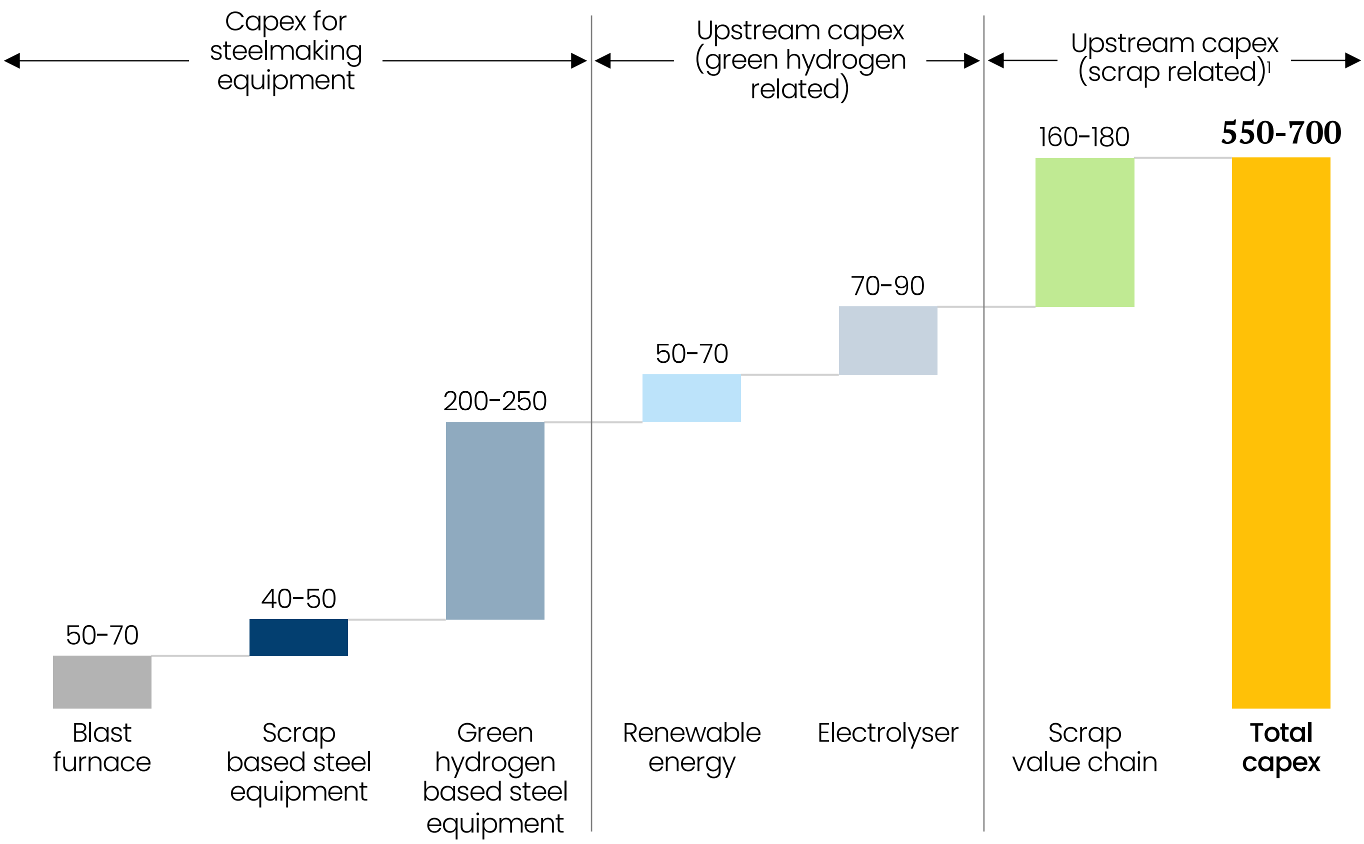
Supply of renewable power at competitive rates
To drive the increased green steelmaking capacity, the industry would need a reliable supply of renewable power (up to 30 to 40 TWh by 2030) at competitive rates. This could be achieved through the reduction of cross-subsidies, largely for scrap and hydrogen based steelmaking.

To finance the green steel transition through the above priorities, India would require a cumulative capex of USD 550 to 700 billion between now and 2050 (Exhibit 21). India and advanced economies could collaborate to direct private and public funding to specific projects.

Exhibit 21

Full chain capex for steel decarbonization in India

Accelerated scenario till 2050, USD billion



1. Beyond steel, including construction and demolition waste
Source: Decarbonising India: Charting a pathway for sustainable growth, McKinsey & Company, March 2023

As the steel sector pursues a decarbonized, sustainable future, historic trade flows, usage patterns and production technologies could all see major shifts. Anticipating these changes and adapting to the new realities could accelerate the decarbonization of steel and speed up India's journey to net zero.

Notes

About the Indian Steel Association

The Indian Steel Association (ISA) is the voice of India's robust and growing steel industry. ISA came to life to create a conducive environment for steel production in the country and has since worked towards representing the interests of the Indian steel ecosystem both nationally and at international forums. As a not-for-profit society, ISA proudly shoulders the responsibility of communicating the views of its constituents to all stakeholders in the steel production supply chain. It remains at the forefront of all policy deliberations and contributes to decision-making in public and regulatory policy, raw material sourcing, global trade, technology, environmental concerns, and the entire gamut of issues related to steel making, steel consumption and steel usage.

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