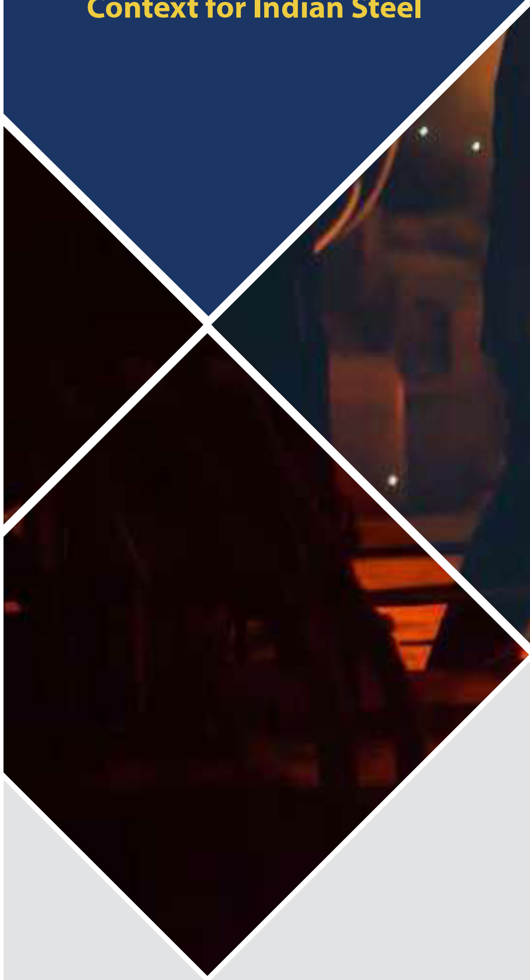
Towards a Low Carbon Steel Sector

Overview of the Changing Market, Technology, and Policy Context for Indian Steel



Consultation Document

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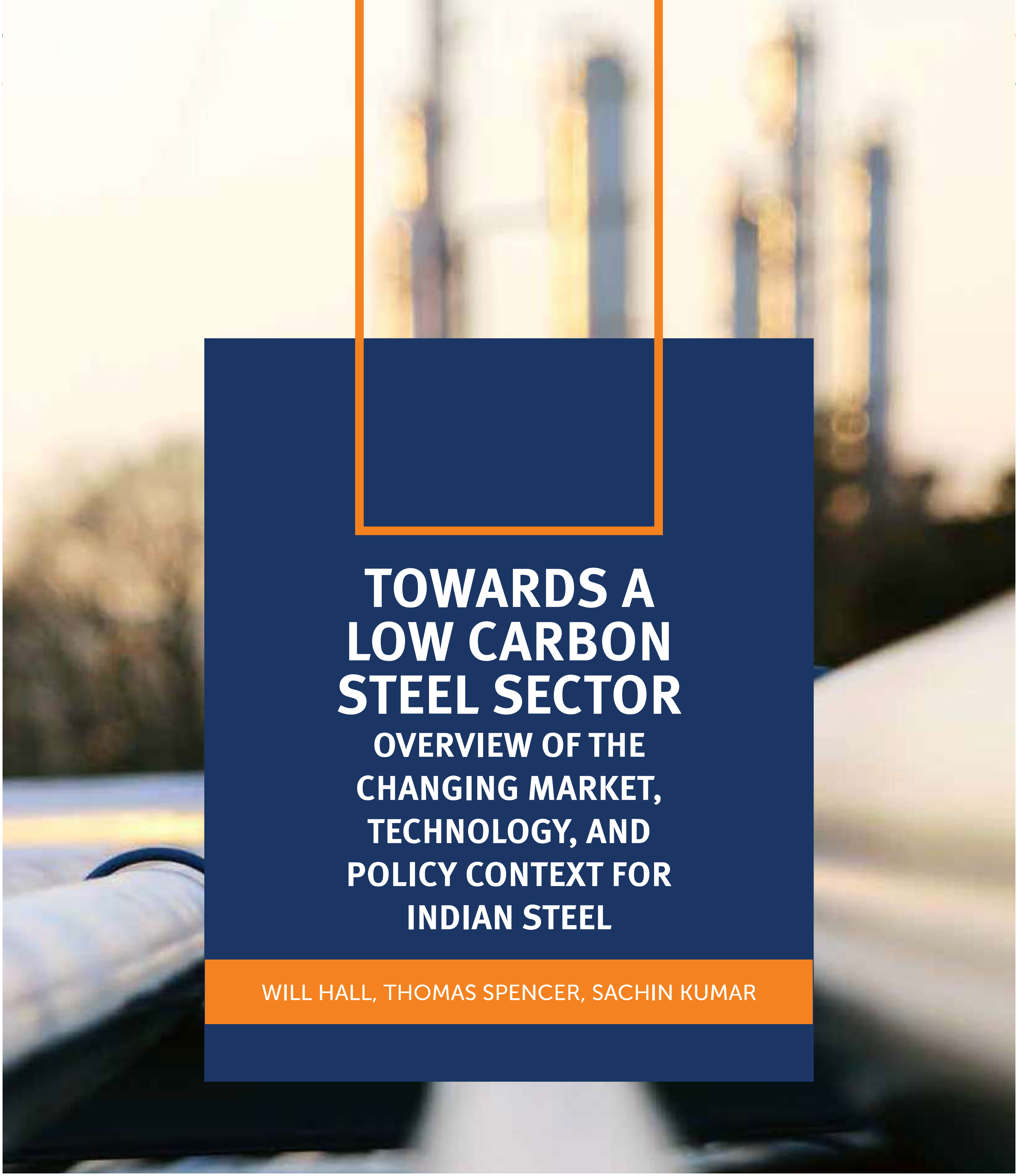

TOWARDS A LOW CARBON STEEL SECTOR

OVERVIEW OF THE CHANGING MARKET, TECHNOLOGY, AND POLICY CONTEXT FOR INDIAN STEEL

WILL HALL, THOMAS SPENCER, SACHIN KUMAR

THE ENERGY AND RESOURCES INSTITUTE
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ENERGY TRANSITIONS COMMISSION INDIA

Energy Transitions Commission (ETC) India is a research platform based in The Energy and Resources Institute (TERI) in Delhi. ETC India is the Indian chapter of the global Energy Transitions Commission, which is co-chaired by Lord Adair Turner and Dr Ajay Mathur.

In 2018, ETC launched its 'Mission Possible' report, which detailed decarbonisation pathways for the 'hard-to-abate' sectors. This included a sectoral focus on steel, which provided the impetus to start work on the same in India.

ETC India initiated activities in 2017-18 with a focus on the decarbonization of India's power sector. Whilst that work is still continuing, ETC India has also started to work on industry transformation, particularly in the 'harder-to-abate' sectors including iron & steel, cement, and other industry sub-sectors.

Learn more at: https://www.teriin.org/energy-transitions

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FOREWORD

Dr Ajay Mathur
Director General, TERI

Steel is a material of vital importance to the Indian economy, as with all economies. If the living standards of Indian citizens are to increase, then the use of steel will also need to increase substantially. With this increase in steel demand comes a myriad of challenges and opportunities, not least amongst them the impact this would have on the environment.

At TERI, we have developed a robust understanding of the factors that drive the transition towards cleaner technologies through our Energy Transitions Commission India work programme. Whilst much work has been carried out in the power sector, we are just beginning to understand what such a transition might look like for the highest energy consuming sectors of the Indian economy; the heavy industry sectors, chief amongst them being steel.

This report presents an initial overview of the Indian steel sector and the options to mitigate its impact on the environment, through reducing emissions. We view this report as the first step in a consultation process with the steel sector, government, research community and civil society, which will ultimately lead towards a comprehensive roadmap to decarbonisation for the steel sector.

From this work, it is clear that there is more that can be done in the near-term to mitigate emission increases from the steel sector, including driving forward with cost-effective energy efficiency measures and maximising the efficient use of resources. Beyond efficiency, India will also need to start exploring deep decarbonisation alternatives, including hydrogen, electrification and carbon capture, use and storage (CCUS). India is set to be a major beneficiary from advancements in these key technologies and should be proactive in pushing ahead with collaborative projects and pilot plants.

We look forward to working hand-in-hand with the sector over the coming year, expanding on this work to produce a roadmap which can simultaneously satisfy India's growing demand for steel, whilst minimising the impact of the sector on the environment.

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EXECUTIVE SUMMARY

Steel Is Essential to the Development of the Indian Economy and the Welfare of Its Citizens

Steel is the foundation of a developed economy. It supports the infrastructure that facilitates growth, the housing that drives urbanization, and the machinery and tools that power industrialization. No country has achieved high levels of income per capita without substantially raising steel consumption per capita. India's steel consumption per capita is still very low at only about 64 kg per year, consistent with India's low GDP per capita. This is only 27% of the world average, a clear indication of the large growth in steel consumption required to raise Indian GDP per capita and improve the welfare of its citizens.[1]

As India's Economy Grows, Its Steel Demand Will Grow Substantially

India's GDP per capita, even when measured at Purchasing Power Parity (PPP), is only around 6900 USD, just 43% of the world average. A significant portion of the population still lives below the poverty line: as of 2011, the year of the last Census, 20% of the population lived below the minimum international poverty benchmark of 1.90 USD per day of consumption expenditure. Clearly, India must grow its economy to provide for higher incomes per capita and improved welfare for its citizens. This raises the question of the impact of India's economic growth on its steel demand. In this report, we have made projections for the Indian economy out to 2050, and from these economic scenarios derived projections for India's steel demand. In our Baseline Scenario, India's GDP per capita grows from the current level to about 25,000 USD by 2050, measured in constant 2011 PPP. This is an ambitious but feasible long-term growth scenario, which would bring India into the ranks of the high-income countries. In this *Baseline* scenario, India's steel demand grows by more than a factor of 5 between now and 2050- from about 94 million tonnes (Mt) to 489 Mt. Indeed, we do not project that India's steel demand would saturate by 2050, but would instead continue to grow beyond this point.

There Is Substantial Uncertainty in These Projections, Even Before We Consider More Disruptive Factors

There is clearly a lot of uncertainty in projecting both the Indian economy and steel demand out to 2050. Both the rate of economic growth, as well as its key drivers, are uncertain. Will India follow a more service-based economy? Or will its rate of infrastructure investment and industrialization pick up, following a path more similar to that charted by China and other East Asian industrial powerhouses like Taiwan and South Korea? Indeed, in our analysis of the historical experiences of a large number of countries, we find that the most significant determinants of steel demand are the rate of investment and industrialization in the economy, not the absolute level of GDP per capita.

In order to analyse the full range of possible pathways for Indian steel demand, we constructed sensitivities on our Baseline economic scenario out to 2050. In the High Scenario, the rate of investment, industrialization and overall growth is higher than in our Baseline Scenario, consistent with a 'Make in India' style development scenario. In the Low Scenario, investment, industrialization and aggregate growth are lower than in the Baseline, consistent with a more services-led and potentially more unequal development trajectory.

1 The above figures are based on data from the World Steel Association and take true steel consumption per capita as the metric. The figure quoted for the world is the value for a panel of 74 countries for which the World Steel Association provides data on true steel consumption per capita.

These different economic scenarios have a huge impact on our projection of Indian steel demand out to 2050. The High Scenario sees steel demand become almost 40% higher than in the Baseline Scenario (at 755 Mt by 2050), which is close to but still below China's level of steel demand in 2017. On the other hand, in the Low Scenario, steel consumption is almost 40% lower than the Baseline Scenario (at 289 Mt by 2050). In this report, we use the Baseline Scenario as our central scenario. However, the large spread between the High and Low Scenarios indicates a wide band of possible outcomes, dependent on the development trajectory of the Indian economy. Figure E1 shows the results of these scenarios.

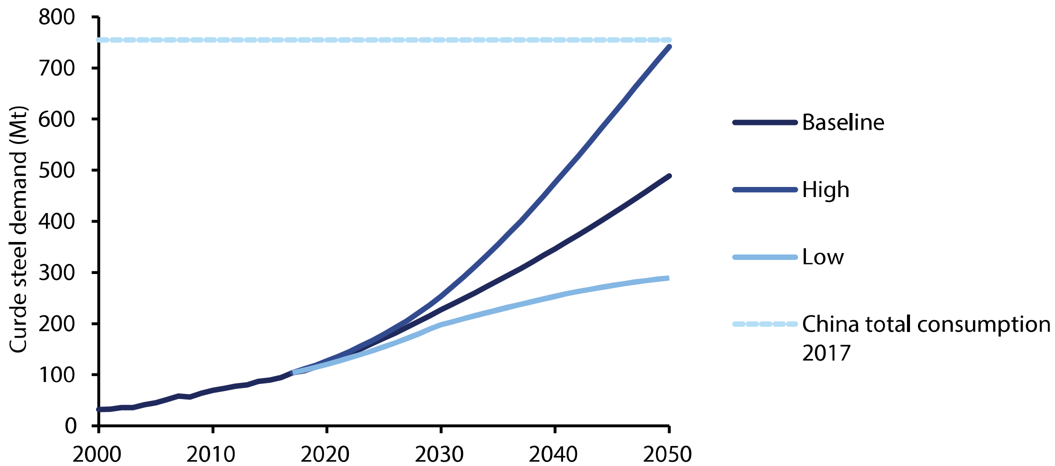

Figure E1: Range of Projections for Indian Steel Demand Out to 2050

Source: *TERI modelling and analysis*

The Level of Steel Demand Growth Projected in the Baseline Would Have Significant Economic and Environmental Externalities

Although critical for economic growth, the iron and steel sector is energy- and resource-intensive. Rapid growth of Indian steel demand cannot but have significant environmental and economic consequences. Today, the iron and steel sector is already the largest industrial sector in terms of energy consumption. In addition, it accounts for a significant share of India's manufacturing goods trade deficit- at about 7.4% if we include both the net import of coking coal and iron and steel products.

In our Baseline Scenario, by 2050 energy demand from the iron and steel sector would grow by a factor 4, from about 59 million tonnes of oil equivalent (Mtoe) in 2016 to about 235 Mtoe. This is substantially slower than the growth in total steel demand (a factor 5 increase), indicating that we expect substantial improvements in energy efficiency to occur even in our Baseline Scenario. Coking coal requirements could grow from 60 Mt to 218 Mt, implying an increase in the import bill from 10 billion USD today to 33-40 billion USD by 2050. Emissions of CO_2 would grow from today's level of 242 Mt to about 837 Mt by 2050 in our Baseline Scenario. This is equivalent to 35% of India's total current emissions of CO_2 from fossil fuel combustion and industry. The growth in emissions by a factor of 3.45 is lower than our projected growth of energy demand (factor 4), indicating that we consider some decarbonization of iron and steel production even in our Baseline Scenario.

Clearly, this level of resource consumption, energy consumption and GHG emissions is a concern. Incremental measures to improve energy and carbon efficiency in the iron and steel sector are not enough to place it on a trajectory consistent with limiting warming to less than 2°C.

The Iron and Steel Sector Can No Longer Be Excluded from International or Indian Climate Policy Focus

In 2015, the iron and steel sector accounted for about 6.2% of global emissions from fossil fuel combustion. If the sector were a country, it would be the fifth largest emitter, after China, the United States, the European Union and India. Despite its large emissions footprint, the iron and steel sector has largely been exempt from stringent climate policy measures. It is economically significant and exposed to international competition, and countries have long been concerned about the impact of unilateral measures on the domestic industry's international competitiveness. At the same time, coordinated international approaches have not been developed. In addition, the level of technical and commercial readiness of mitigation technologies has been lower in the iron and steel sector compared to other sectors like electricity production. Thus, policy-makers and corporations have implemented strategies to incrementally improve energy efficiency, but shied away from more profound decarbonization of the iron and steel sector.

However, this cannot continue. By 2050, in scenarios consistent with limiting warming to less than 2°C, the carbon intensity of steel production needs to be reduced by at least 70% globally. In 2050, India will be one of the few world regions (alongside Africa) still expecting further growth in iron and steel demand: China's steel demand will have peaked (indeed may already have peaked), and will following the trajectory of plateau and decline charted by developed countries before it.

Thus, in order for India's long-term development to be consistent with a global scenario limiting warming to 2°C, it is essential that the world innovates a pathway towards zero carbon steel and that India transitions towards this pathway too.

Strategies Toward Iron and Steel Sector Transition Need Not Be 'All or Nothing'

Because of the large facilities, huge investments and long plant lifetimes, it may seem that a pathway towards zero carbon steel is 'all or nothing'. If this were so, it is understandable that policy-makers and business strategists would shy away from such a proposition, particularly while decarbonization technology in the iron and steel sector is still far from commercially available. However, we argue that this is an incorrect framing. It is possible to envisage a feasible, cost-effective, step-wise pathway for Indian iron and steel that would allow the sector to contribute to a global effort to limit warming to less than 2°C. We argue that this pathway is firmly in India's interest: it would innovate a much less resource-, import-, and energy-intensive pattern of industrialization for India. In the following sections, we outline the three key pillars of this pathway.

Pillar 1: Improve Energy Efficiency, Resource Efficiency and Material Circularity

Due to the heavy reliance on coal-based Direct Reduction (DR), and the presence of many older, relatively inefficient blast furnace units, the Indian iron and steel sector is relatively energy intensive compared to international benchmarks. However, on reviewing a large number of possible energy efficiency measures, we have shown that the average plant could lower energy consumption per unit output by between 24-38%, depending on the production route. This would have important benefits in lowering aggregate energy consumption and CO_2 emissions, where adoption of best available energy efficiency technologies could reduce overall emissions by up to 15% by 2050, versus the Baseline (where some energy efficiency measures are adopted).

Reducing steel consumption through resource efficiency can have a substantial benefit in terms of more efficient aggregate resource use across the Indian economy. Indeed, certain structural trends like the emergence of ride-sharing (Uber/Ola), the emergence of the gig economy, teleworking and coworking suggests that the future Indian economy, even in the absence of further policy measures, may in fact be less steel intensive than the Baseline Scenario presented above. If we also consider policies to actively promote resource efficiency, steel demand could be 25% lower by 2050, compared to our Baseline Scenario. Production of energy intensive primary steel can be avoided by increasing the collection and use of domestic scrap steel, which is 85% less emissions intensive than primary steel today. In addition, India already imports substantial quantities of scrap and there may not be much scope for increasing scrap imports. In a low carbon future, demand for scrap in developed countries is likely to increase, given the reduced emissions through the secondary production route. A scenario combining resource efficiency and increased circularity could further reduce emissions by 20% by 2050.

Pillar 2: Implement Transition Strategies by the 2030s and Deep Decarbonization Options by the 2040s

Even with the above-described energy and resource efficiency measures, the iron and steel sector would still emit around 500 Mt of CO_2 by 2050. Theoretically, substituting natural gas for coal could further lower emissions, but this option must be discounted given the lack of domestic gas and the expense of imported gas in India. A more promising transition option would be the HIsarna process, which can reduce emissions by 20%, compared to the traditional Blast-Furnace Basic Oxygen Furnace route (BF-BOF). If the resulting pure stream of CO_2 from the blast furnace route is captured using the Carbon Capture Use and Storage (CCUS) route, then emissions could be reduced by up to 80%. This technology is already being trialled in Europe by Tata Steel, the owner of the technology.

By the 2040s, it is expected that more radical decarbonization technologies, which are currently being demonstrated, would be commercially available. Of particular interest is the hydrogen route, which involves the substitution of coal or natural gas as a reducing agent with hydrogen. If hydrogen is produced from emissions free electricity, total iron and steel emissions can be reduced by 94%. According to the analysis developed in this report, if hydrogen can be delivered at a cost of 2.5-3.5 USD/kg, the hydrogen route can be cost competitive with the BF-BOF route. This would require electrolyser costs to fall to around 400 USD/kW and renewable electricity to be priced in the range of 20–30 USD/MWh. Both of these assumptions are perfectly feasible by 2050 (renewable electricity is already in the range of 35 USD/MWh in India).

Assuming that new facilities after 2040 are based on the hydrogen route and hydrogen is increasingly blended in existing facilities to substitute coal; emissions can be reduced by a further 8% by 2050. More importantly, the sector would be on a pathway to fully decarbonize thereafter. India would be the first ever country to industrialize while decarbonizing its steel production. The cumulative effects of these measures are shown in Figure E2.

Pillar 3: Promote International Collaboration, Innovation and Technology Diffusion and Develop a Domestic Low Carbon Steel Strategy

India is faced with a paradox. Between now and 2050, it will be one of the major sources of growth of global steel demand. By 2050, India will be one of the few world regions whose steel demand will still be growing, even while the pressure to reduce global CO_2 emissions will only increase. It is thus in India's interest that global efforts to innovate a zero-carbon pathway for iron and steel succeed. In addition, Indian firms, notably Tata Steel, are active in the global market and own a number of key low carbon technologies. India doesn't have cost-effective reserves

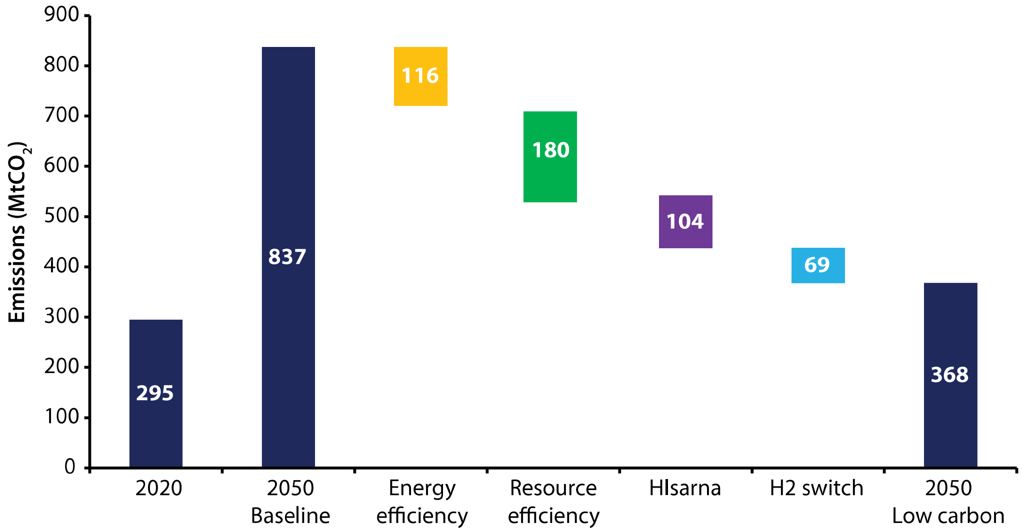

Figure E2: Cumulative Impacts of the Proposed Measures

Source: *TERI modelling and analysis*

of natural gas or coking coal and so the development of a renewables plus hydrogen economy is in its interest. India should therefore actively promote international innovation, technology learning and diffusion, and become a major driver of the push to zero-carbon steel: it stands to be the major beneficiary.

Secondly, India should develop a domestic pathway towards a low-emissions iron and steel sector by 2050, and zero emissions sector shortly thereafter. The long-term low emissions development strategy that India will submit to the UNFCCC provides an opportunity to do so, as does the India 2047 vision being developed by NITI Aayog. Domestic policy frameworks to promote energy and resource efficiency already exist in the form of the Perform Achieve and Trade Scheme, the Steel Scrap Recycling Policy and the Draft National Resource Efficiency Policy. These can be implemented and strengthened over time. They should also be complemented with policies to promote innovation and technology demonstration for crucial technologies such as HIsarna, CCUS and hydrogen-based steel production. This could include proactively pushing for international collaborative research, development and demonstration (RD&D) programs, engaging in international consortia, and seeking funding and technology from international donors. In this regard, developed countries also need to realize that the climate policy agenda has to shift towards promoting industry decarbonization and supporting India in its endeavours to deploy low carbon technologies out to 2050.

Moreover, in combination with various supply-side policies, it will be important to complement these with measures to stimulate demand for low carbon steel. This can be in the form of buyers' clubs, whereby groups of businesses who use steel in their products (e.g. automotive manufacturers) agree to buy low carbon steel at a premium, so that they can then market their products as environmentally friendly alternatives. This can be supported by standard setting systems, such as the ResponsibleSteel™ standard. The government can also play an important role here, buying up large quantities of low carbon steel to help scale up production, as has been done so effectively with LEDs under the UJALA scheme.

Finally, India should engage in the sensitive topic of international trade and potential measures to protect domestic industry in a world of uneven carbon prices and climate policy efforts. Carbon border adjustments are already being actively considered by the European Union, and appear inevitable in a world of ever growing, but unevenly shared, concern about climate change. The iron and steel sector is likely to be the first to be targeted by such measures; Europe is one of India's major destinations for its steel exports. By engaging in global efforts to transition in the iron and steel sector, India can hedge against the risk of the imposition of climate related trade measures.