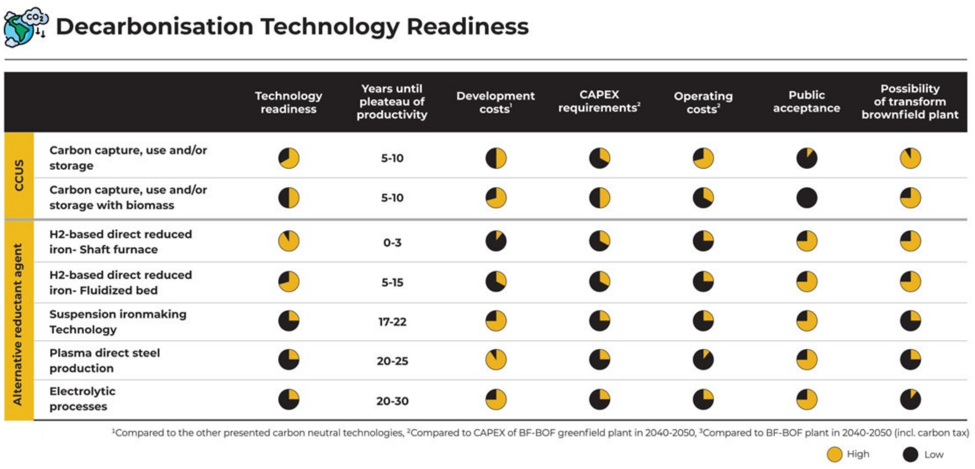
Huge investments needed for low-carbon transition of Indian steel industry - Expert



Carbon dioxide (CO2) concentration in the atmosphere today is at the highest level in the last 8,000 years and annual global CO2 emissions is nearly 40 gigatonnes (GT).

The share of the steel industry is total emissions is 9%. Renewables, hydrogen fuel and battery technologies are moving at a fast pace in decarbonising the power and mobility sectors. However, in a business-as-usual scenario, the steel industry's share in global man-made emissions may reach 40% in the next 20-25 years, said Debashish Bhattacharjee, VP, Technology & R&D, Tata Steel.

Replacing coke

"For decarbonisation of the steel sector the focus should primarily be on the BF-BOF process, as it is the predominant route of steel production today. Emissions in the integrated process is due to usage of coke in the BF, which plays the role of a reductant, produces heat, and provides the physical structure of the BF," said Bhattacharjee.

Replacing coke as a reductant in the BF is possible through hydrogen and heating can be provided through plasma torches powered by green electricity, but coke does not have a replacement when it comes to providing the physical structure of the BF. Hydrogen use can only reduce about 15-20% of coke use in the BF.

Makeshift technologies

"Replacing coke with hydrogen, coke oven gas (COG) and biochar in the BF are all makeshift decarbonisation strategies for which we do not need to change the set up much. We just need to change the gas or reductant composition through usage of scrap in the BF, increasing the use of scrap in the BOF, introducing biochar in the BF instead of PCI, as it has a negative C02 footprint. These technologies are ready for implementation in live BFs but their CO2 reduction potential is just about 20%," he informed.

In fact, deeper decarbonisation technologies either necessitate retrofits or are transformational in nature. Naturally, the readiness level of these technologies is lower compared to makeshift technologies. For example, molten oxide electrolysis, electrowinning or even hydrogen-based DRI are transformational technologies with low readiness level.

Outlook to 2030

So, with makeshift technologies steelmakers have to rely on CCUS to control emissions. In eastern India, a major steelmaking hub, there are no proven geologic sites for sequestration of captured CO2. So, steelmakers need to rely on CO2 utilisation, the easiest way of fixing the CO2 in is methanol. Roughly, a 10 mnt/year steel plant emits 22 mnt of CO2. So, CCUS will need to be adopted to abate that 22 mnt in the absence of makeshift technologies.

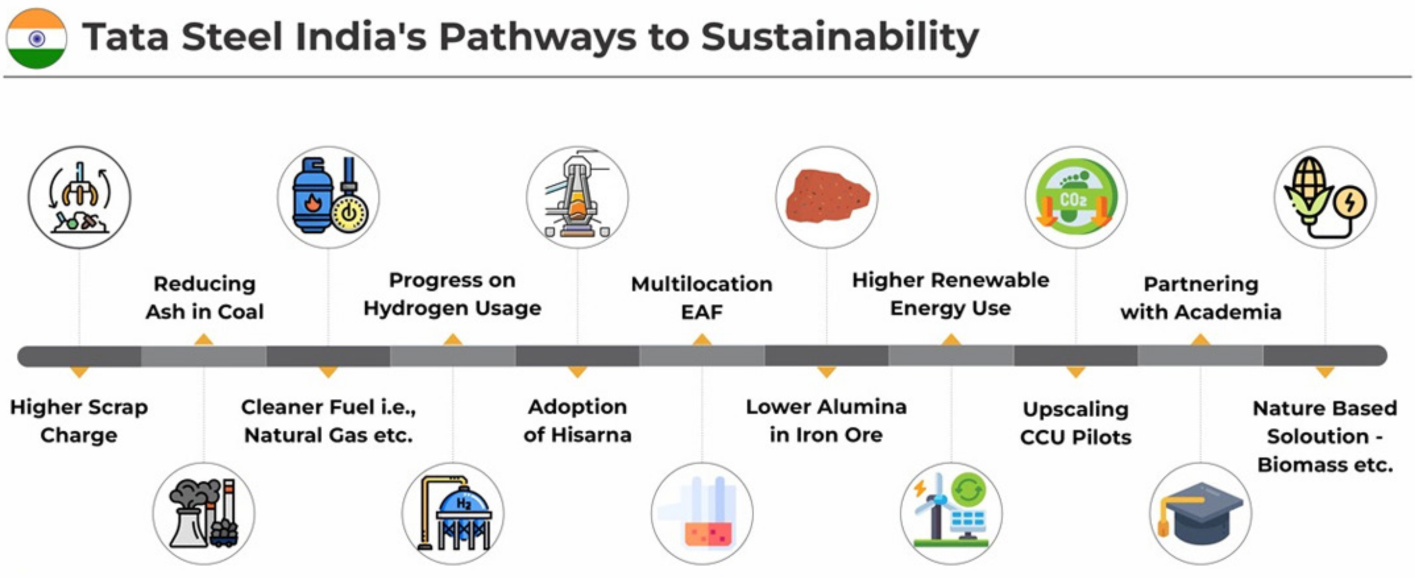
"Say, in 2030, India produces 175 mnt of crude steel and the emissions intensity is reduced to 2.3 tCO2/tcs then 400 mnt of CO2 will need to be sequestered," contended Bhattacharjee. "If makeshift technologies are implemented and the emissions intensity falls to 1.8 tCO2/tcs, still we would need to capture 315 mnt of CO2. The additional cost of reducing emissions intensity to 1.8 tCO2/tcs is $200/tcs provided green hydrogen is available at $4/kg," he said. However, Deependra Kashiva, DG, SIMA feels that above estimated production of 175 mnt of crude steel is on the conservative side in view of the production of 144mnt in F.Y. 24 and the current growth rate.

For achieving 1.8 tCO2/tcs by 2030 India would need 60 CCU units, additional cost will be around INR 45,000 crore, additional cost for hydrogen (pegging industry requirement at 9 mnt in view of 175 mnt of steel production) will be INR 4.5 lakh crore, and power requirement will be around 60 GW.

Tata Steel has generated enough data at the mill level with its 5 tpd CCUS pilot and is planning to scale it up to 15 tpd, he informed.

Transition tasks

The key levers are using more scrap and natural gas, supplies of which are constrained. Hydrogen DRI needs green hydrogen and iron ore of high grade which, going forward, will not be Australian much less Indian ore, but South American and West African ore. Use of hydrogen, NG, and scrap through a remelter, which can use low-grade ore, is possible. However, it is not ideal due to the sheer scale of the iron and steel industry. Biomass is limited in supply and competes with agricultural land, which is a big challenge.



Currently, the key tasks are:

* High-efficiency electrolysis for hydrogen production from around 50% efficiency levels at present
* Non-electrolytic processes of hydrogen production
* Cheap and safe hydrogen storage options

Net-zero challenge

To achieve net-zero, wind energy capacity has to go up by 15%, solar by 25%, and global grid capacity almost three times that of the current level, Bhattacharjee said. Total number of EVs must rise at least 60 times. The material requirement for this is huge. Copper and nickel demand will go up by 50-70%, cobalt by 150%, lithium and graphite demand will rise 6-7 times. More than 5 billion tonnes (bnt) of steel will be required and over 9 bnt of aluminium.

"Mining these materials will be impossible and so urban mining will hold the key," he said. The government needs to prioritise green procurement policies, offer incentives for low-carbon steel, introduce carbon taxes, and facilitate urban mining.

Prospects of using Electric Smelting Furnace to overcome the raw material quality challenge for steel decarbonisation?

There is a growing concern about the depletion of high grade iron ore and consequently production of low grade DRI leading to high energy consumption which would be impediment to the steel producers to mitigate carbon footprints.

With a view to facilitating the use of generally below-DR grade iron ore for production of DRI and its subsequent melting and refinement, the electric smelting furnace (ESF) retains the potential to lower steelmaking emissions, although adoption of renewable electricity is a must.

"It is a fact universally accepted that there is simply not enough high-quality iron ore suitable for efficient DRI/EAF production to meet global steel demand," a steel mill spokesperson informed BigMint.

"DRI production must use the very highest quality iron ore, with average iron content in the range of 67% Fe. Such deposits, worldwide, are scarce," he said.

As per experts, the ESF technology has the promise to emerge as a significant low-carbon alternative, among a host of other smelting reduction technologies, amid general tightness in availability of DR-grade iron ore globally.

Transition pathways
The decarbonisation of the global steel industry will depend on companies switching to low-emissions steelmaking through a) aligning existing BF-BOF processes with state-of-the-art technologies such as top gas recycling and carbon capture utilization and storage (CCUS); b) DRI-EAF technologies with lower CO2 footprint, including a host of smelting reduction technologies; and c) direct electrolysis of iron ore.

It is an accepted fact that direct electrolysis – such as processes pioneered by Boston Metal which have raked in considerable investments – still has a long way to go.

DRI potential
After 2030, gas based DRI capacity expansion will need to accelerate to maintain a net-zero pathway. Bloomberg New Energy Finance anticipates 56% of primary steel production coming from DRI-EAF processes using hydrogen and 3% from DRI-EAF processes based on natural gas by 2050 under a net-zero steel sector scenario.

This would mean 840 mnt of steel production from DRI-EAF-hydrogen processes and 49 mnt from DRI-EAF-natural gas processes by 2050, requiring a tenfold rise in DR-grade supply unless technology innovations allow DRI processes to use lower-grade ore. Incidentally, as per the WSA, route wise production of crude steel in 2023 was BOF – 71.1 %, EAF – 28.6%, Others – 0.39.

The electric furnace routes that use DRI are appealing for deep greenhouse gas (GHG) emissions abatement as, unlike the BF, the DRI plant does not require carbon-containing coke to operate and instead may use hydrogen-containing gas mixtures to chemically convert iron ore into iron, which will greatly lower the CO2 emissions intensity, experts from BHP note.

Presently, these process gas mixtures are derived from fossil fuels, but in the future there is the potential to transition DRI process gas toward 100% hydrogen. Therein lies the potential of DRI.

EAF challenges
* The EAF was originally designed and optimised for rapidly melting scrap in small batches particularly for making alloy and special steel.

*When EAFs are operated with high levels of DRI, higher slag volumes are generated from the gangue impurities and iron is easily lost to this slag. Losing iron in the process is expensive and inefficient

* To limit iron losses in the EAF, the DRI unit is also configured to metallise as much of the iron ore as possible and the DRI that is produced is usually mixed with at least 50% scrap.

ESF features
*Unlike EAFs, the ESF can work on any sort of physical DRI and a metallization level much lower than required for EAF processes (<85% Fe)

*The ESF operates continuously, with reducing conditions maintained by adding small amounts of carbon. DRI is continuously fed to the furnace to maintain a layer of gradually reducing and melting solid material

*The furnace operating environment also allows the slag chemistry to be controlled in a way that resembles BF slag rather than EAF slag.

*Molten metal and slag are periodically drained from the furnace through tap holes without stopping the furnace operation

Outlook
The ability of the ESF to produce a molten metal and slag that are similar to what a BF produces also offers upstream synergies, by relaxing the stringent DRI quality thresholds that apply to the EAF. Iron losses to slag are lower and phosphorus from the ore feed can be managed by the downstream refining processes.

However, scale is always a challenge, as with all smelting reduction technologies – especially in the Indian context. Also, the costs of incorporating an extra smelting process before transfer of hot metal to BOF will surely add extra cost burden on steelmakers in case it is decided to bypass existing BOF.

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