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Decarbonizing Indian Steel

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Abstract

India is the second largest steel producer in the world around 120 MT of crude steel in 2021-2022. The National Steel Policy envisages increasing crude steel capacity to 300 MT by 2030-2031. Steel is an essential sector for developing economy like India. On the other hand, this is one of the most energy intensive and polluting sectors. Steel production consumes around 20% of global industrial energy and contributes 7% CHG (2.6 Gt CO_2/yr.). India is signatory to the UNFCCC Paris agreement whose goal is to keep the rise in mean global temperature well below 2°C above pre-industrial level. India Intended Nationally Determined Contribution (INDC) is pledged to (a) to reduce emission intensity to its GDP by 33-35 % by 2030 from the 2005 level and (b) to achieve about 40% cumulative electric power installed capacity from renewable source. The high level of energy consumption and CHG emission of steel production is largely driven by primary BF-BOF route which uses carbon as the iron ore reductant and accounts for approximately 70% of total production and only 5% is produced by Directly Reducing Iron (DRI) followed by refinement in Electric Arc Furnace (EAF). Switching to 100% H_2 will mitigate CO_2 emission.

Keywords: *Decarbonizing, National Steel Policy, Steel, Sustainable Development Goal*

1.0 Introduction

India has 2.4% of world surface and home of around 17.5% of the world population. The annual energy consumption in 2011 was 0.6 tonnes of oil equivalent (toe) per capita as compared to the global average 1.88 tonnes per capita. To achieve Human Development (HDI) of 0.9 or more, the minimum energy requirement is 4 tonnes per capita. The per capita energy consumption is 917 KWH which is barely one third of global average more, sumption. India has lot to do to provide a dignified life to its population and meet their rightful aspiration. India INDC is fair an ambitious considering the challenges country face today. Indian steel sector has multiplier effect on both GDP and employment. At the same time 1.9 tonnes of CO_2 is produced for every tone of steel. Decarbonizing the industry in accordance with the Paris agreement to reduce net emission to zero by 2050.

2.0 National Steel Policy and Coal

National steel policy 2017 vision is to achieve 300 million tonnes per annum capacity by 2030-31. With significant increase in exports steel consumption is expected to reach 206 million tonnes. India is endowed with high quality iron ore, but it has low reserve of coking coal. NSP vision of 300mt of capacity will be achieved through blast furnace route mainly. Additional capacity of 200 million tonnes of steel requires at least 180 million tonnes of coking coal. India mainly depends on import for coking coal from Australia and America. Due to geopolitical condition and fluctuations in weather

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cost of coking coal is unpredictable. Use of coking coal has higher emission level and large amount of carbon dioxide increases the global warming. The use of green hydrogen as reducing has also cost effectiveness in India case.

3.0 India's Sustainable Development Goal (SDG) and Employment

India is a developing country with a per capita GDP in USD 1408 per annum. In India around 363 million people (30% of population) live in poverty and 4.9% of population (aged 15 years and above) are unemployed. The 17 SDGS and 169 targets are part of 2030 agenda part of sustainable development goal adopted by 193 members' state at the US general assembly Summit in September 2015, and which came into effect on 1st January 2016. The SDG goals are like no poverty, zero hunger, good health, sustainable cities affordable clean energy. Unemployment rate in India is 7.18 in April 2022 according to CMPI. To escape the middle-income trap and to reap the demographic window, productive employment should be generating. Indian steel industry is the India's core industries contributing more than 2% of GDP. NSP envisage producing 300 metric ton per annum steel by 2030-31. Steel industry provides employment to more than 20 lakh individuals through direct and indirect position. It is expected to grow 36 lakh employments by 2031 broadly adding the country economic success.

4.0 National Hydrogen Mission

National hydrogen Mission was launched by honourable Prime Minister on India's 75th Independence Day (15th August 2021). The mission and government are meeting its climate target and making India's a green hydrogen lab. The mission envisages production of 5 million tonnes of green hydrogen by 2030. Hydrogen is emerging as an important energy source. It has zero carbon content and is non-polluting source of energy. Current global production of hydrogen is around 80 million metric tons are produced through fossil fuels. Green hydrogen is produced by splitting water into hydrogen and oxygen using electrolyser powered by electricity from green energy sources such as wind and solar energy. NTPC renewable energy is setting up India's largest solar Park of 4.75GW in Gujarat which plans to make green hydrogen on a commercial scale. Reliance Industries Limited has recently announced plans to build large scale low cost and high efficiency electrolysers as a part of its $10 billion renewable plan.

5.0 Hydrogen Source and Production

Overuse of fossil fuels has adverse effect on global climate condition. Developing the hydrogen economy tend to be a new competitive field. Hydrogen production process can be classified in two major categories (i) fossil fuel and (ii) renewable source. One of the main processes is electrolysis of water and this is one of the promising processes where water is split directly into hydrogen and oxygen with the help of electricity and electrolysis equipment. This process accounts around 5% of world's hydrogen production. Process produces 99.99% pure hydrogen. Two common electrolyser (a) one is alkaline electrolysis system of taking potassium hydroxide or sodium hydroxide aqueous solution as electrolyte. (b) Proton Exchange Membrane (PEM) employs a solid polymer electrolyte. Cost and energy demands are the two major drawback of the system. However, switching to renewables such as wind and solar energy is a solution.

6.0 Hydrogen as Reducing Agent

There are three viable technological approaches to produce iron using hydrogen as reducing agent:

a. **Direct Injections:** Direct injections of hydrogen into existing blast furnace with coke. This method has the highest Technology e-readiness level. But this still requires coke as energy supply and porous solid support to permit gas percolation. This method can only serve as short term transition technology of limited effectiveness.
b. **Direct reduction:** In this method in shaft furnaces or bad reactors when ore is exposed to hydrogen

Table 1. Recent green steelmaking initiatives

Company	Project/ technology	Location	Target
ArcelorMittal	Hydrogen reduction with grey hydrogen derived from natural gas	Hamburg, Germany	Fossil free by 2050
	Blast furnace + electrolysis for hydrogen production	Bremen, Germany	
	Hybrid blast furnace with direct reduced iron (DRI) gas injection	Dunkirk, Germany	
	Coke oven gas with grey hydrogen; hydrogen in DRI-EAF	Asturias, Spain	
HYBRIT (SSAB, LKAB and Vattenfall)	Replacing coking coal with hydrogen and fossil-free electricity	Sweden	Fossil free by 2045
Rogesa	Hydrogen in coke gas as reducing agent	Dillingen, Germany	Started operations in 2020

containing gas subsequently melted in electric Arc furnace.

c. **Hydrogen plasma-based reaction**: In this method ores get melted reduced simultaneously. The HPR process is more thermodynamically efficient as it allows simultaneous reduction and melting of the ores. This process is still in the exploratory stage. However, many technical features required for HPR are similar to existing electric furnaces. This slight modification in existence electric Arc furnace can be used for HPR process.

7.0 Conclusion and Recommendation

India is developing country with around 30% of population live in poverty. Per capita emission in India was only 1.56 metric tonnes in 2010 while in developed countries it varies between 7 and 15 metric tonnes. India is striving to improve its Human Developed Index (HDI) and to achieve SDG by 2030. India's INDC to reduce the emission of its GDP by 33 to 35% by 2030 from 2005 level while facing development challenges is ambitious. Indian steel sector industry has an advantage of abundant availability of raw material. It is expected to provide 36 lakh employments by 2030. However steel industry is energy intensive and polluting industry. Using the green hydrogen can reduce of emission and energy requirement. Green steel can aid in economic success of India.

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