



Decarbonisation of Steelmaking

For Prelims: [Hydrogen, greenhouse gas emissions](#), Direct Reduction using Hydrogen (DR-H), [Greenhouse Gas Emissions](#).

For Mains: Significance of the Direct Reduction by Hydrogen in Steel Making.

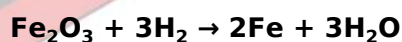
Why in News?

[Hydrogen](#) is a crucial part of the world's plans to **greenify** its manufacturing and **automobile industries** as a fuel whose production and use **needn't emit carbon**.

- **Hydrogen** can also be used as a reducing agent instead of **carbon monoxide (CO)**, which would result in **much lower greenhouse gas emissions**.

What is the Direct Reduction Process by Hydrogen in Steel Making?

- **Procedure:**
 - **Direct reduction by hydrogen (DR-H)** in steel making is a process that uses **hydrogen gas** to reduce **iron oxide (Fe₂O₃)** into **metallic iron (Fe)** without the use of a **blast furnace**.
 - This method is also known as the "**green route**" for steel production, as it significantly reduces the **carbon emissions** associated with traditional **steelmaking processes**.
 - The **Direct Reduction process** typically involves **mixing iron ore pellets or lumps with hydrogen gas** in a reactor vessel at temperatures ranging from **600 to 800°C**.
 - The **hydrogen reacts** with the **iron oxide** to form **metallic iron** and **water vapor**, as shown in the following chemical equation:



- **Significance:**
 - **Lower Carbon Emissions:** Using Hydrogen as a reducing agent produces only water vapor as a byproduct making it a much cleaner alternative to **coal/coke**.
 - This process has the potential to reduce **carbon emissions** by up to **97%**.
 - **Energy Efficiency:** The process is more efficient because it eliminates the need for heating and melting large quantities of iron ore in a **blast furnace**.
 - **Higher Quality Steel:** The direct reduction process produces **high-quality iron** that is purer and has lower levels of impurities, resulting in **higher-quality steel**.
 - **Flexibility:** Direct reduction by hydrogen can be used to produce steel from a wide range of iron ores, including those with **lower iron content**.
 - **Cost-Effectiveness:** The direct reduction process can be more **cost-effective** than traditional steelmaking methods, especially when **natural gas prices are high**.

What is the Use of Hydrogen in Industries other than Steel Making?

- **Energy Production:** Hydrogen can be used as a fuel for power generation, either through combustion or fuel cells. In fact, [hydrogen fuel cells](#) are already used in some vehicles and are being explored as a [renewable energy](#) source for buildings.
- **Chemical Production:** Hydrogen is used as a **feedstock for the production of chemicals** like ammonia, methanol, and other hydrocarbons which are used in various industries (agriculture, transportation, and construction).
- **Electronics:** Hydrogen is used in the **manufacturing of electronic components, such as [semiconductors](#)**, and in the production of flat panel displays and [light-emitting diodes \(LEDs\)](#).
- **Food Processing:** Hydrogen is used in the food processing industry **as a reducing agent to preserve the quality and appearance** of food products.
- **Medical Applications:** Hydrogen is being **investigated as a potential medical gas with anti-inflammatory and antioxidant properties**. It is also used as a tracer gas in medical diagnostics.

Note:

- The [National Green Hydrogen Mission](#) is a program to incentivise the commercial production of green hydrogen and make India a net exporter of the fuel.
- The [National Hydrogen Energy Mission \(NHEM\)](#) was announced in [Union Budget 2021-22](#) for promoting the **development and deployment of hydrogen energy technologies** in the country.

What is the Status of Steel Production in India?

- **Production and Consumption:** India is **currently the world's 2nd largest producer** of crude steel (as of 2021) and also the **2nd largest consumer of finished steel in 2021** (preceded in both cases by China).
- **Important Steel-Producing Centers in India:** Bhilai (Chhattisgarh), Durgapur (West Bengal), Burnpur (West Bengal), Jamshedpur (Jharkhand), Rourkela (Odisha) and Bokaro (Jharkhand).
- **Export:** India is a **significant exporter of steel products**, with major export destinations including the US, the UAE, and Nepal.
- **Government Policies:** The [National Steel policy](#) was launched in 2017 which projects **crude steel capacity of 300 million tonnes (MT)**, production of **255 MT** and a robust finished steel per capita consumption of **158 Kgs by 2030-31**.
- **Steel Industry and GHG Emissions:**
 - According to the **International Energy Agency (IEA)**, the **steel industry** is responsible for around **7% of global CO₂ emissions**, making it one of the largest industrial emitters of [greenhouse gases](#).
- **Pollutants from Steel Industries:**
 - [Particulate Matter \(PM_{2.5} and PM₁₀\)](#)
 - [Oxides of Sulphur](#)
 - [Oxides of Nitrogen](#)
 - [Carbon Monoxide \(CO\)](#)
 - [Carbon Dioxide \(CO₂\)](#)
 - [Solid Waste](#)
- **Green Steel:**
 - The Ministry of Steel seeks to reduce CO₂ in steel industry through promotion of [Green Steel \(manufacturing steel without using fossil fuels\)](#).
 - This can be done by using **low-carbon energy sources** such as **hydrogen, coal gasification, or electricity** instead of the traditional **carbon-intensive manufacturing route of coal-fired plants**.
 - It eventually lowers GHG emissions, cuts cost and improves the quality of steel.

What are the Challenges Associated with Using Hydrogen in Steel Production?

- **High Capital Costs:** The initial capital costs of building and operating a direct reduction plant are typically higher than traditional steel making methods. This can be a barrier to entry for smaller steel producers.
- **Availability of Hydrogen:** The availability and cost of hydrogen can be a challenge, especially if it is produced using fossil fuels. The development of low-cost, [green hydrogen production technologies](#) will be critical for the widespread adoption of this process.
- **Scale-up Challenges:** Scaling up the direct reduction process can be challenging, especially **when producing large volumes of steel** as it requires careful management of the reactor and the supply of hydrogen gas.
 - Also, it **requires a high degree of technical expertise** and process control to ensure the quality and consistency of the iron product.
- **Infrastructure Requirements:** The process requires specialized infrastructure, including storage and handling facilities for hydrogen gas. The development of this infrastructure can be costly and time-consuming.

Way Forward

- **Better Investment:** Governments and the private sector should increase investment in R&D of green hydrogen production technologies to reduce the cost and increase the availability of hydrogen.
- **Encourage Collaboration:** Collaboration between steel producers, hydrogen producers, and other stakeholders can **help address technical challenges and promote the development of necessary infrastructure.**
- **Policy Support:** Governments can provide policy support through incentives such as **tax credits, grants, and loan guarantees** to encourage the adoption of this technology.
 - Also, **developing standards for the production/use of green hydrogen** can help **ensure the quality and consistency of the product, reduce costs, and promote market acceptance.**

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims:

Q. In the 'Index of Eight Core Industries', which one of the following is given the highest weight? (2015)

- (a) Coal production
- (b) Electricity generation
- (c) Fertilizer production
- (d) Steel production

Ans: (b)

Q. In India, the steel production industry requires the import of (2015)

- (a) saltpetre
- (b) rock phosphate
- (c) coking coal
- (d) All of the above

Ans: (c)

Q. Which of the following are some important pollutants released by steel industry in India? (2014)

1. Oxides of sulphur
2. Oxides of nitrogen

3. Carbon monoxide

4. Carbon dioxide

Select the correct answer using the code given below:

- (a) 1, 3 and 4 only
- (b) 2 and 3 only
- (c) 1 and 4 only
- (d) 1, 2, 3 and 4

Ans: (d)

Q. Steel slag can be the material for which of the following? (2020)

- 1. Construction of base road
- 2. Improvement of agricultural soil
- 3. Production of cement

Select the correct answer using the code given below:

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Ans: (d)

Mains:

Q. Account for the present location of iron and steel industries away from the source of raw material, by giving examples. **(2020)**

Q. Account for the change in the spatial pattern of the Iron and Steel industry in the world. **(2014)**

Source: TH

PDF Refernece URL: <https://www.drishtias.com/printpdf/decarbonisation-of-steelmaking>