

Green Hydrogen

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Scientists and technocrats have for years been engaged in the quest of discovering alternative fuels to fossil fuels. In order to achieve the goal of an alternative source of energy, governments are placing large bets in the hope of adopting a multi-faceted practical approach to utilise 'Green hydrogen' as a driving source to power our industries and light our homes with the 'zero emission' of carbon dioxide.

In news: Green hydrogen, a new ally for a zero carbon future

Placing it in syllabus: Science & Technology

Dimensions

- Energy problem in India
- Green Hydrogen
- Importance for India
- Hurdles
- Suggestions

Content:

Energy problem in India:

According to the ***The India Energy Outlook 2021*** – a special report in the **IEA's World Energy Outlook series**:

Energy Demand Projections:

- **India is the world's fourth largest energy consuming country** (behind China, the United States and the European Union), according to the International Energy Agency's (IEA) forecast.
- It **will overtake the European Union to become the world's third energy consumer** by the year 2030.
- India is set to see the **largest increase in energy demand of any country over next 20 years**

- India's ability to ensure affordable, clean and reliable energy for its growing population will be vital for the future development of its economy

Sustainable Development Challenge:

- The combination of a growing and industrialising economy and an expanding and increasingly urban population will drive energy use higher
- This reality raises the question of how best to meet that swelling demand without exacerbating issues like costly energy imports, air pollution and greenhouse gas emissions.
- Based on India's current policy settings, nearly 60% of its CO2 emissions in the late 2030s will be coming from infrastructure and machines that do not exist today.
- This represents a huge opening for policies to steer India onto a more secure and sustainable course.

Evolving Energy Security challenges:

- India's **combined import bill for fossil fuels is projected to triple over the next two decades**, with oil by far the largest component.
- Domestic production of oil and gas continues to fall behind consumption trends and net **dependence on imported oil rises above 90% by 2040, up from 75% today.**
- This continued reliance on **imported fuels creates vulnerabilities to price cycles and volatility, as well as possible disruptions to supply.**
- Energy security hazards could arise in India's domestic market as well, notably in the electricity sector in the absence of significant increases in system flexibility, improvements to the financial health of many electricity distribution companies, and other reform efforts.

Green Hydrogen:

- 'Green hydrogen', the emerging novel concept, is a **zero-**

carbon fuel made by electrolysis using renewable power from wind and solar to **split water into hydrogen and oxygen.**

- With **electrolysis**, all you need to produce large amounts of hydrogen is water, a big electrolyzer and plentiful supplies of electricity.
- If the electricity comes from renewable sources such as wind, solar or hydro, then the hydrogen is effectively green; the only carbon emissions are from those embodied in the generation infrastructure.
- This 'Green hydrogen' can be utilised for the generation of power from natural sources – wind or solar systems – and will be a major step forward in achieving the target of 'net zero' emission.

Hydrogen as a Fuel:

- Hydrogen is the **most abundant element on the planet**, but **rarely in its pure form** which is how we need it.
- It has an **energy density almost three times that of diesel**. This phenomenon makes it a **rich source of energy**.
- But the challenge is to compress or **liquify the LH2 (liquid hydrogen)**- it needs to be kept at a stable minus 253° C (far below the temperature of minus 163° C at which Liquified Natural Gas (LNG) is stored; entailing its 'prior to use exorbitant cost'.
- In electrical terms, the energy density of hydrogen is 33.6 kilowatt hour (kWh) of usable energy/kg, compared to diesel's 12-14 kWh/kg, which despite having significantly lesser energy density emits severely high levels of CO₂, CO, particulate matter and NO₂.
- **Green hydrogen could meet up to 25% of the energy needs of the world by the end of 2050** and become a **\$10 trillion recognisable market**.

Types of Hydrogen Fuels:

- The production techniques of Hydrogen vary depending upon its applications – designated with different colours such as black hydrogen, brown hydrogen, blue hydrogen, green hydrogen, etc.
- **Black hydrogen** is produced by use of fossil fuel
- **Brown Hydrogen** is made through the gasification of coal or lignite
- **Gray Hydrogen** is made through steam methane reformation, which typically uses natural gas as the feedstock.
- **Pink hydrogen** is produced through electrolysis, but using energy from nuclear power sources.
- **Blue hydrogen** is produced by steam methane reformation but the emissions are curtailed using carbon capture and storage. This process could roughly halve the amount of carbon produced, but it's still far from emissions-free.

Turquoise hydrogen is produced by breaking methane down into hydrogen and solid carbon using a process called pyrolysis.

Importance for India:

- Green hydrogen could well play an important role in India's future.
- The potential of green hydrogen in India was highlighted by a recent report from **The Energy and Resources Institute (TERI)** called "**The Potential Role of Hydrogen in India.**"

Energy Self-Reliance:

- In this global context, it is crucial for India to get ahead in the race of new and upcoming green technologies and become self-reliant.
- Being an early adopter of hydrogen energy technology will pay off in the long-term, given hydrogen's cross-sectoral sustainability.

Meeting NDC Targets:

- Considering India's 175 GW target of **Renewable Energy (RE) capacity** by 2022 and 450 GW by 2030, it is imperative that our energy grid involves other green technologies on a medium-to-long term basis.
- This will help India lower its emission intensity by 33-35% from the 2005 levels by 2030, another **Nationally Determined Contributions (NDC)** target under the **Paris Agreement**.

Energy Diversification:

- Hydrogen power, with its **versatility in production methods and cross-sectoral applications**, could be an important solution for the future
- It allows a **steady diversification of the energy system** and creates additional demand for the Renewable Energy sector.

Grid-Scale Power Storage:

- The application of Hydrogen for power storage, however, is perhaps the most intriguing for India.
- Large and relatively inexpensive **renewable energy capacity is inherently intermittent and needs large power storage solutions** to address peaking demand and reduce reliance on fossil fuel-based power generation.
- These **green hydrogen plants would assist in the provision of grid-scale storage solutions**, as well as the resolution of electricity transmission and evacuation issues for renewable energy projects.

Reducing Energy Imports:

- There is a wide variety of primary and secondary energy sources of hydrogen that can help to accommodate the local context in different parts of India.
- This eventually helps to **cut the country's dependence on imports and move towards improved energy security**.

India and Hydrogen Energy:

- India is already keen on developing a hydrogen economy.
- It is a participant, one among 16 nations or groupings, in the **Mission Innovation Renewable and Clean Hydrogen Challenge**.
- In November 2020, Prime Minister announced plans to launch a **National Hydrogen Energy Mission (NHEM)**, buttressing India's green energy credentials with the carbon emission-free next-generation fuel.
- **The Indian Railways** have announced the country's **first experiment of a hydrogen-fuel cell technology-based train** by retrofitting an existing diesel engine.
- This will run under Northern Railway on the 89 km stretch between Sonipat and Jind. The project will not only ensure diesel savings to the tune of several lakhs annually but will also prevent the emission of 0.72 kilo tons of particulate matter and 11.12 kilo tons of carbon per annum.
- Nasdaq-listed **Fusion Fuel Green** – which has offices in Ireland and Portugal – said it had **signed an agreement with BGR Energy Systems**, whose headquarters are in Chennai for the development of green hydrogen projects in India. The facility set to be built in Tamil Nadu will use proprietary technology from Fusion Fuel Green which produces hydrogen using solar energy.
- A report titled **'India Country Status Report on Hydrogen and Fuel Cells'**, launched by the Department of Science and Technology in mid-October last year, outlines the benefits of hydrogen in comparison to conventional fuels and with respect to tackling challenges in the energy sector.
- The report says that Hydrogen with its abundance, high energy density, better combustion characteristics, non-polluting nature etc, have vast advantages over the conventional fuels.
- It also says that the use of hydrogen can reduce the CO₂

related emissions significantly at the point of use and if green hydrogen is used then there is capability to decarbonize the entire value chain, enabling reduced emissions and climate change threats. It can even decarbonize the sectors where it is difficult to reduce emissions

Hurdles:

High Production Cost:

- The '**production cost**' of '**Green hydrogen**' has been considered to be a prime obstacle.
- The challenge right now is that **big electrolyzers are in short supply**, and plentiful supplies of renewable electricity still come at a significant price.
- Compared to more established production processes, **electrolysis is very expensive**, so the market for electrolyzers has been small.
- According to studies by the **International Renewable Energy Agency (IREA)**, the production cost of this 'green source of energy' is expected to be around \$1.5 per kilogram (for nations having perpetual sunshine and vast unused land), by the year 2030; by adopting various conservative measures.

Safety Concerns:

- Admittedly, hydrogen is far from ideal as a fuel. Its low density makes it hard to store and move around.
- And its flammability can be a problem, as a Norwegian hydrogen filling station blast highlighted in June 2019.

Issues of Safe Storage and Transportation:

- The main problem with satisfying all these potential markets is in getting green hydrogen to where it is needed.
- Storing and transporting the highly flammable gas is not

easy; it takes up a lot of space and has a habit of making steel pipes and welds brittle and prone to failure.

- Because of this, the bulk transport of hydrogen will require dedicated pipelines, which would be costly to build, pressurizing the gas, or cooling it to a liquid.
- Those last two processes are energy-intensive and would further dent green hydrogen's already underwhelming round-trip efficiency.

Suggestions:

- A shift towards clean energy with green hydrogen is only possible if India remains ahead of the curve in **technological development, invests early in research and ramps up manufacturing capability** to maximise domestic needs.
- A strong policy and financial support in the following three key areas will help India's hydrogen mission:
 - **Hydrogen for domestic market;**
 - **manufacturing electrolysers** – devices that split water into hydrogen and oxygen using electrical energy – especially in the area of managing power intermittencies for P2G applications;
- **powering freight vehicles.**
- For India to become a global champion in RE, it is crucial to **encourage production of green hydrogen at scale.**
- Additionally, exploring energy storage using hydrogen and 'piloting' hydrogen-powered vehicles along industrial corridors, could be the way ahead for the NHEM.
- Further, hydrogen strategies of global leaders like Australia, Canada, Germany and Norway make it clear that

green hydrogen production requires ample public and private investments.

- Being an early adopter of **hydrogen energy technology will pay off in the long-term**, given hydrogen's cross-sectoral sustainability.

Mould your thought: Explore the potential of Green Hydrogen as a fuel of future for India.

Approach to the answer:

- Introduction
- Define Green Hydrogen
- Briefly mention India's Energy Problem
- Discuss potential of green Hydrogen to meet this need
- Suggest way forward for India
- Conclusion