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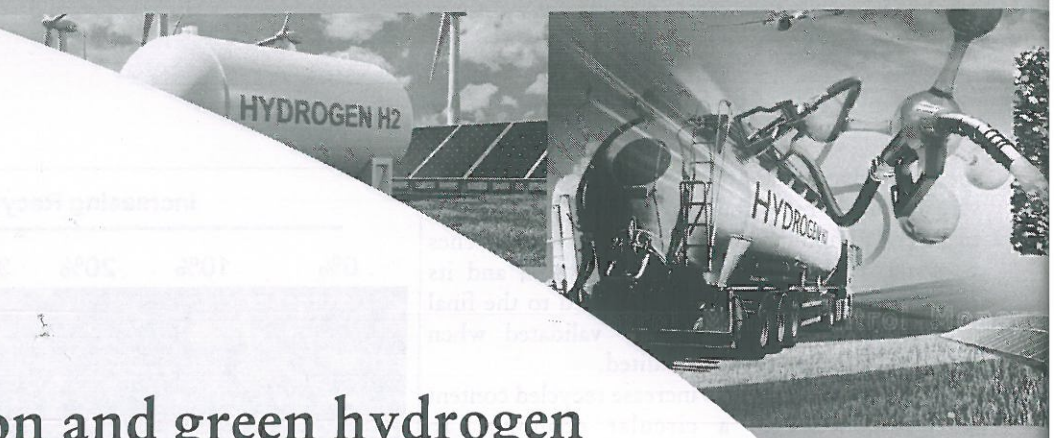


# Decarbonisation and green hydrogen

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DECARBONISING the planet is one of the goals that countries around the world have set for 2050, whereas India has pledged for it by 2070. Decarbonising the production of hydrogen, gives rise to Green Hydrogen. Climate change and net-zero commitments are accelerating the shift from fossil fuels to alternative such as green Hydrogen.

Hydrogen is not a direct substitute for coal, oil and natural gas, but it can help to decarbonize. Hydrogen could account for 12% of global energy by 2050. Green hydrogen could be a huge value adding opportunity for India as it pivots towards renewables and away from imported fossil fuels, which currently meet most of the oil and gas demand.

A novel, green method of generating hydrogen could reduce global warming and GHG generation.

Hydrogen is a key input in fertilizer and refineries, so green hydrogen would help these industries cut aggregate emissions.

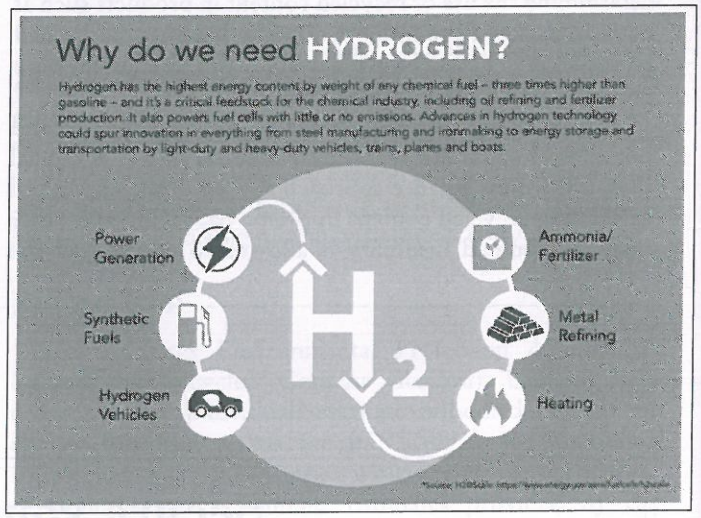
Till now we have been focusing on renewable energy sources for clean energy, but for industry and transport sector to transition to net zero emissions a clean fuel is required. And that clean fuel is green hydrogen.

When we use renewable energy for production of hydrogen there is no carbon or GHG generation. When hydrogen is used as a fuel there is no carbon or GHG generation as it produces only water vapours.

## Why do we need hydrogen?

India's industry – chemical and refining are the largest consumer of Hydrogen in India. India produced 36 M tons of Nitrogen based fertilizers in 2018-19, and imported 9 M tons to full fill the demand gap. Oil refineries in India cover main part of their hydrogen requirement by catalytic reforming, and additional requirements are met by gasification.

The chemical industry requires large amount of hydrogen for production of ammonia and methanol.




Hydrogen as an energy vector or chemical agent is utilized for

- Transportation,
- As a feed stock, or
- For heat and power to building and industry.

## Government policy

Government is encouraging and giving full support for manufacturing green hydrogen and equipment required for.

- Indian government has announced national green hydrogen policy with a target of manufacturing 5 m tonnes per annum by 2030.
- Government is supporting development of green hydrogen generation and ancillary industry required for it like renewable power and electrolysers etc.
- For renewable energy generation for green hydrogen government shall provide land in designated solar parks.
- The energy transportation for 25 years is free subjected to installation by dead line June 2025.
- Producers will be allowed to set up bunkers near ports for

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storage of green hydrogen/ammonia for exports by shipping.

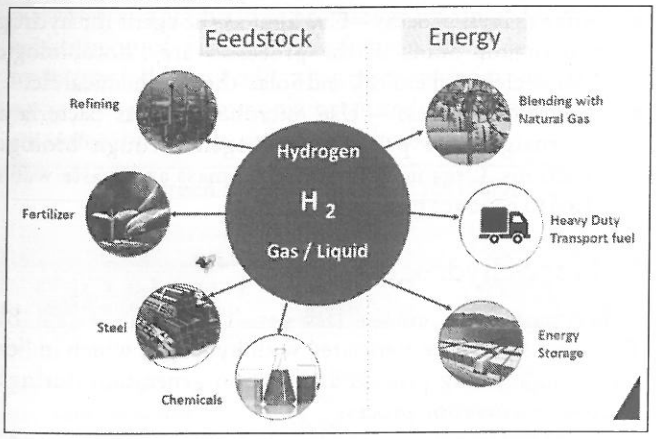
- Manufacturers of green hydrogen are allowed to purchase renewable power from the power exchange or set up renewable energy capacity them self or through any other developer, any where.
- Manufacturer can bank any surplus RE generated with discoms for 30 days and use it as required.
- India has already committed to achieving net zero carbon emissions by 2070
- Government is providing single portal for all clearances required for green hydrogen production.

## Hydrogen – an energy dense fuel

- The specific energy of hydrogen is between 120-140 MJ per kg while that of diesel and gasoline fuel is between 30-45 MJ per kg. Therefore, hydrogen specific energy is around 3X to 4X higher than gasoline and diesel fuels.
- Similarly, the specific energy of hydrogen is around 30X to 90X higher than Lithium batteries.
- Also, Diesel and gasoline emit approx. 75-85 g $CO_2$ per MJ of energy produced along with other harmful substances such as nitrogen oxides, hydrocarbons and particulate matter. Where as hydrogen only emits water vapours as a by-product.
- Hydrogen efficiency to wheel is about 25%, where as fuel cell efficiency is about 60%

Hydrogen offers the greatest potential to decarbonize difficult-to-abate sectors like steel, cement and heavy-duty transport. Green hydrogen has been used in transportation, heating, and in the natural gas industry, and can be used to produce green ammonia.

## Different areas of hydrogen usage for decarbonisation




## Why India is betting big on hydrogen?

- **Energy Security** – The fluctuations in the oil and gas market have disrupted the supply-demand chain and causes variation in fuel cost. India needs to find an alternative to strengthen it's national energy security.
- **Emission targets** – India is the third largest global CO2 emitter (about 7% of global CO2 emission). Our emission levels are well below China and United States of America. India also has committed to reduce it's emission level by 33-35% under the Paris Agreement.
- **Economic dependant & balance of trade** – India is third largest crude oil importer with import dependency of more than 80%. It also imports 54% of natural gas and 24% of coal requirements which greatly affects financial accounts balance. India's oil import bill in 2019 and 2020 was approx. US $ 111.9 Billion and US $ 101.4 billion respectively.
- **Energy subsidies** – India gives away overall energy subsidies of approx. US $ 30 bn/year on oil, gas, and coal transmission and distribution, renewable energy and electric vehicles.

Hence, India can grab this early opportunity to capture the entire value chain of hydrogen and look out for global exports.

**Drivers for green hydrogen moment in India.**

- **Decarbonising targets** – To limit the global warming temperature rise to 1.50 C, large no of renewable energy systems needs to be installed.
- **A complementary solution to renewable energy** – Hydrogen can be a missing piece to complement renewable energy systems to store the excess energy produced during generation hrs.
- **Supporting grid load management via storage solutions** – Hydrogen based energy storage system will help improve the load management.
- **Decarbonization of hard – to – abate sector** – Hydrogen is potential fuel and feedstock to reduce carbon intensities of sectors such as transportation, industrial and residential applications.
- **Technological advancement** – There is a significant improvement in the efficiency of electrolyser and fuel cells technologies.
- **Falling technology cost** – The cost of hydrogen produced from electrolysis has fallen fast and it will go down at a very fast pace in near future.
- **$CO_2$ and energy import savings-** India can abate 3.6 giga tonnes of $CO_2$ emissions cumulatively between 2020 to 2050.

Domestically produced green hydrogen can have energy import savings of $246-$358 billion cumulatively between 2020 and 2050.

## Hydrogen demand outlook

Today the global hydrogen market is about 100 M tonnes per annum, more than 95% of which is produced from fossil fuels, primarily natural gas using the steam methane reforming.

Hydrogen demand in India can potentially grow more than 4 fold between 2022 and 2050, amounting to around 29 m tonnes. Steel and heavy duty trucking will be long term driver for demand in near future. Industrial feed stock–ammonia and

refining, increased consumption in these two sectors can require almost 11 M tonnes of hydrogen by 2030, from current level of 6 m tonnes.

As per the Council on Energy, Environment and Water (CEEW) Green hydrogen demand could be up to 1 Million tonnes in India by 2030. Almost 16% of hydrogen demand in 2030 and 94% in 2050 can be met by green hydrogen.

The cumulative value of green hydrogen market in India could be $ 8 billion by 2030 and $ 340 billion by 2050.Refining and Ammonia are two sectors will foster the demand, whereas steel and heavy duty vehicles will be more prominent drivers of green hydrogen.

Forecast by various agencies see India fuel demand climbing to 400-450 million tonnes by 2040 as against 250 million tonnes now. This gives enough opportunity for all forms of energy to co-exist.

India's total hydrogen demand is expected to touch 11.7 million tonnes by 2029-30 from the current 6.7 mt. Around 54% or 3.6 mt of hydrogen is utilized in petroleum refining and the rest in fertilizer production.

### Immediate market opportunities–

There are 5 market segments where green hydrogen can be used immediately

1. Displacement of existing grey hydrogen.
2. Feed stock for other high value products like ammonia, methanol and other chemical manufacturing.
3. Decarbonisation of some current industrial process as steel manufacturing, refineries and cement industry, etc.
4. Blending in existing natural gas systems, blending at 5-10% by volume is possible by no or minimal modification to existing gas infrastructure.
5. Long term energy shifting in grid connected renewable energy systems.

### Export opportunities

Geographies such as Europe and Asia-Pacific (India, Japan, and China) are expected to be major consumers of green hydrogen. There are likely to be very high chances of export.

Driven by low cost of renewable energy the country can emerge as one of the most competitive sources for green hydrogen in the world.

Disparity in sources and consumption of green hydrogen is bound to create markets for green hydrogen as a tradeable energy commodity in the long term.

Energy importers like Japan, and South Korea are willing to pay the premium prices, and exploring the possibility of importing hydrogen through ocean shipping.

European countries are also welcoming prospects from both intra-region and international hydrogen trade.

Traditionally energy exporting regions like Australia and the Middle East are increasingly positioning themselves for hydrogen exports.

Japan and Australia are currently working on a hydrogen energy supply chain project.

Green hydrogen from India can be competitive at for select geographies by 2030, and it will be r competitive by 2050 from countries like Austral United States.

The requirement of green ammonia and green st run will also act as a big driver for export marke hydrogen from India.

Exports of Green hydrogen –embedded products international alliance will also help increase the expor

## Global scenario

As of 2020, the global hydrogen market was valu million and expected to reach $300 billion by 2050. A analysts at Fitch Solutions, the global hydrogen ma jump to 10% by 2030. The number of investmen hydrogen has risen from almost none in 2020 to 12 across 136 projects in planning and developm totalling over $500 billion in 2021. Companies acros have formed alliances to increase production of the fold in the next six years, the market could be wor trillion a year by 2050 according to Goldman Sachs.

## Hydrogen production

Hydrogen can be produced using different techno sustainable production technologies will crea possibilities of adoption and scale up. Currently h produced mainly from fossil fuel such as coal and r however it can be generated from various feed stocks.

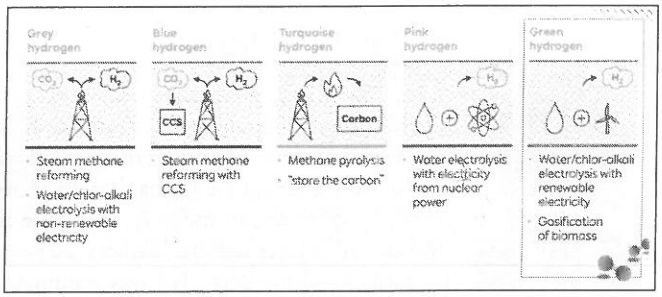
The most common methods for Hydrogen generat

- **Thermal process** – A typical high temperatu where steam reacts with hydrocarbon fuels t hydrogen. Almost 95% of all hydrogen is prod steam reforming of natural gas.
- **Electrolytic process** – Water is separated in to and Oxygen through a process called electro equipment for converting water in to Hydrogen a with electrolysis is call an Electrolyser.
- **Solar driven process** – Use light as the agent for production. Some of the processes are Photo Photo-electrochemical, and Solar-thermochemic
- **Biological process** – Use microbes such as ba microalgae and produce hydrogen through reactions. Organic matter like biomass and was used to produce hydrogen.

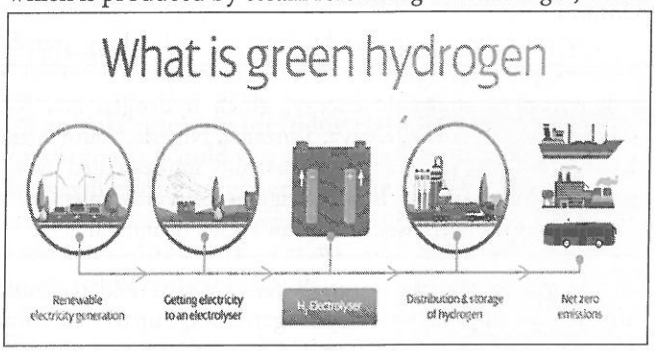
## Colour of hydrogen

Hydrogen is a colour less gas. The colour G Torquish, Green are associated with hydrogen whic the manufacturing process and carbon generation hydrogen generation process.

Green hydrogen is made by electrolysis of wat energy used for electrolysis is supplied by renewal Since the water is split in to Hydrogen and Oxygen, carbon emission in the process and as such it is term hydrogen.



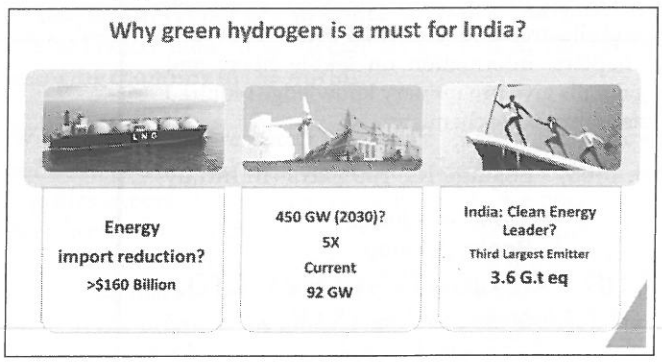

Green hydrogen is hydrogen generated by renewable energy or from low-carbon power. Green hydrogen has significantly lower carbon emissions than grey hydrogen, which is produced by steam reforming of natural gas, which




makes up the bulk of the hydrogen market. Green hydrogen produced by the electrolysis of water is less than 0.1% of total hydrogen production. It may be used to decarbonize sectors which are hard to electrify, such as steel and cement production, and thus help to limit climate change.

The high cost of production is the main factor behind the low use of green hydrogen. Nonetheless, the hydrogen market is expected to grow, with some forecasts of the cost of hydrogen production falling from $6/kg in 2015 to around $2/kg by 2025. In 2020, major European companies announced plans to switch their truck fleets to hydrogen power.

Green hydrogen can be blended into existing natural gas pipelines, and also used to produce green ammonia, the main constituent of fertilizer production. It is suggested by hydrogen industry bodies that green ammonia will be cost-competitive with ammonia produced conventionally (gray ammonia) by 2030.In order to minimize




In order to minimize the ever-increasing energy import bills of $ 160 Billion currently Green hydrogen is must.

To increase the 92 GW renewable power generation from current level of 92 GW to 450 GW by 2030, green hydrogen generation is must.

In order to become the clean energy leader by decarbonising 3.6 GT equivalent of carbon, from the current third largest emitter green hydrogen is must.

### What India intends to do to achieve the target production of green hydrogen

- The world's largest green hydrogen generation capacity of over 5 M tonnes by 2030 for domestic consumption.
- The world's largest green steel production at 15-20 m tonnes by 2030.
- The world's largest electrolyser manufacturing capacity annually at 28 GW by 2028 delivering affordable ones for India and the world.
- The world's largest green ammonia production for exports by 2030 helping India's allies to decarbonise.

The government is well determined and taking necessary steps to achieve the ambitious target set for green hydrogen production, to be a global leader and exporter.

### Hydrogen storage and distribution

Storage and transportation of hydrogen have traditionally been difficult due to the unique characteristics of the gas flammability, low density, and ease of dispersion.

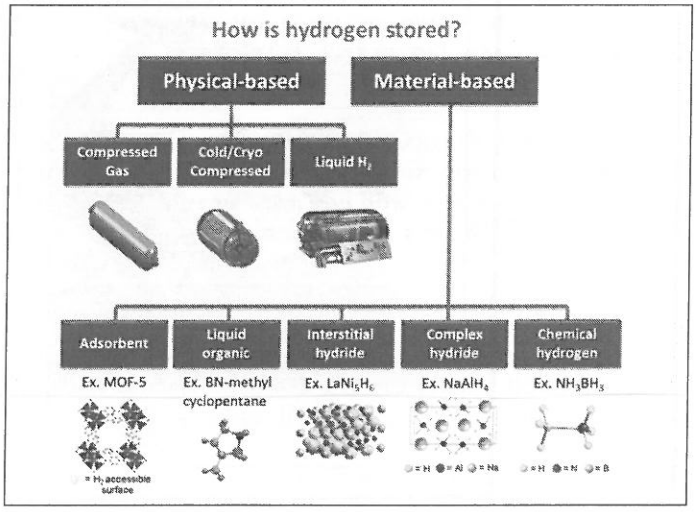
Under normal temperature and pressure, 1 kg of Hydrogen occupies a volume of 12.15 m3 and an energy of 33.5 kwh.

Hydrogen have three main avenues for storage –

- **Hydrogen storage in gas form** – Hydrogen is compressed to 700 bar for storage purpose and it weighs 40 kg/m3
- **Hydrogen storage in liquid form** (cryogenic hydrogen storage), Hydrogen boils at a temperature of -2530C, so the liquid storage has to be below this temperature. Maintaining this low temperature is difficult, and costly. It weighs 70kg/$m^3$

### Hydrogen storage and distribution

There are three approaches to hydrogen transportation and

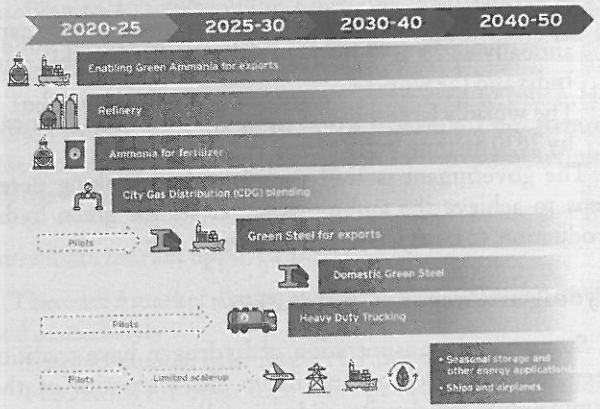


distribution

- Hydrogen distribution with pipe lines – Hydrogen can be transported using existing natural gas pipe lines or new pipe lines for hydrogen. Hydrogen can be mixed in a fixed proportion for transportation purpose and separated from natural gas on arrival at destination.
- Hydrogen transportation by using trucks, trailers and ships.
- Hydrogen storage in tanks.

INOX has recently built and supplied world's largest storage system with 283 m3 to south Korea.

**Governments mandate for creating green hydrogen demand**




**About the author**

Mr. Sarolkar is Mechanical engineer, backed up with double post-graduation in Management, marketing management & Production Management, having over 44 years of experience in industry of repute in local as well as international markets (20 years + international markets). He was nominated member of Kenya Bureau of Standard for Plastics & Rubber technical committee.

Mr. Sarolkar was managing director & CEO of Bericap India Pvt Ltd, a German MNC, renowned name in Plastics caps and closures.

Currently he is in the business of technology transfer, turnkey projects, product development from concept to commercials, renewable energy, green hydrogen etc, with customer base in India, Kenya, Tanzania, Nigeria, South Africa, Kuwait, etc. Mr. Sarolkar has successfully implemented over 25 projects. Mr. Sarolkar is a managing committee member of Technology transfer association, and Tech-Forum, Pune.

Carbon composite materials tanks a patented technology offers low weight tanks for hydrogen storage up to 9 Nl volume, 300 bar pressure, weighing only 4.5 kg, stored energy 8.3 kwh. The lowest one with 2 ltr volume with energy storage 1.9 kwh is the lowest one. ■