BUDGET 2021: GREEN ENERGY HIGHLIGHTS

CONTEXT: The usage of clean and renewable energy will bring India one step closer to growth and sustainability. With that in mind, Budget 2021 announced renewable energy initiatives during the Budget 2021 presentation.

ANNOUNCEMENTS:

- The finance minister highlighted the **National Hydrogen Energy Mission** has been set up in 2021-22 for generating hydrogen from green power sources.
- Additional capital infusion of **Rs 1,000 crore to Solar Energy Corporation of India and Rs 1,500 crore to Indian Renewable Energy Development Agency** has been provided.
- To build up domestic capacity, a **phased manufacturing plan for solar cells and solar panels** will be notified.
- To encourage domestic production, **duty on solar inverters has been raised from five percent to 20 percent, and on solar lanterns from five percent to 15 percent**.
- **A framework will be put in place to give consumers alternatives to choose from among more than one electricity distribution company.**
- **A revamped reforms-based result-linked power distribution sector scheme** will be launched with an outlay of Rs 3,05,984 crore over five year. Moreover, the scheme will provide assistance to DISCOMS for infrastructure creation, including pre-paid smart metering and feeder separation, upgradation of systems, etc., tied to financial improvements.
- Centre's clean air programme also got a shot in the arm with Finance Minister announcing **a fund of ₹2,217 crore for air pollution control** in 42 cities with a million plus population.
- Finance Minister also announced a **voluntary vehicle scrapping policy** to phase out old and unfit vehicles.
- The **PLI scheme has also been extended to the Advanced Chemistry Cells**-the new generation advanced storage technologies that can store electric energy either as electrochemical or as chemical energy and convert it back to electric energy as and when required.
- For the first time there is **private financing of ₹18,000 crore for 20,000 buses** and innovative financing with PPPs which would revolutionise the way public transport systems and buses function in India.

VEHICLE SCRAPPAGE POLICY:

- This will help in encouraging fuel-efficient, environment friendly vehicles, thereby reducing vehicular pollution and oil import bill.
- **Vehicles would undergo fitness tests in automated fitness centres after 20 years in case of personal vehicles, and after 15 years in case of commercial vehicles.**
- Automobile industry forms the backbone of the country's manufacturing sector, comprising 40 per cent of the sector's share of the gross domestic product (GDP).
- Of this, about half is contributed by the car industry.
- Government expects over one crore old vehicles (more than 15 years old) to go to scrap, increase turnover of automobile industry from 4.5 lakh crore at present to Rs 10 lakh crore in a few years and kick start new investments of approximately Rs 10,000 crore which will help create around 50,000 jobs.
- Old vehicles will have to pay **'Green Tax'** too which would be in range of 10-25 per cent of road tax (up to 50 per cent in cities with high level of pollution).
- The government will provide **monetary incentive** to those who send their vehicles to the scrap heap.

- **Target of the scheme is 51 lakh light motor vehicles (LMV) that are above 20 years of age, 34 lakh LMVs above 15 years and 17 lakh medium and heavy motor vehicles above 15 years.**
- It's more important to take old commercial vehicles off the road because though they constitute about 5 per cent of the total vehicle fleet, they contribute around 65-70 per cent of total vehicular pollution.
- And vehicles older than 20 years constitute 1 per cent of the present fleet but contribute to 15 per cent of total vehicular pollution, as per a release by the government of India.

Analysis:

- Centre should focus on making it a one-time initiative (like the highly successful 'cash for clunkers' initiative in the United States) rather than a continuing one.
- There is no point in allowing old vehicles to keep plying on roads for such a long period and there should be a complete ban on them.
- The scrappage of or trading in old vehicles for cash rebate kind of policies (carrots) should be aimed at vehicles which are still relatively newer. This is in line with practices in advanced Western economies where vehicles start qualifying for trade-in or scrap after 10 years.
- While it may appear to be too much of a burden, it's only one-fifth of the amount that the government gets as GST revenue from sales of automobiles in the country.
- Plus, the extra revenue that the government will get in the form of higher GST due to sale of more cars (by those who will sell their old ones for a rebate).
- Then there are environmental benefits in addition to jobs created in the manufacturing sector.
- Additionally, given how important automobile sector is to manufacturing part of the economy, positive benefits to the economy and growth in general should also be kept in mind.
- In fact, this will be no less than a production-linked incentive scheme that the government is contemplating.
- It will be a win-win for economy, jobs, environment and health of the people.

GREEN ENERGY AND INDIA:

- India ranks at the **fifth position among the countries of the world when it comes to the size of its energy economy.**
- India is the **fourth largest solar installed capacity country in the world and third largest renewable energy installed capacity country in the world.**
- The Government of India had set a target of **175 GW renewable power** installed capacity by the end of 2022. This includes 60 GW from wind power, 100 GW from solar power, 10 GW from biomass power and 5 GW from small hydro power.
- The renewable energy capacity in India is **currently 136 Giga Watts**, which is about 36% of its total energy capacity.
- In 2018 the GoI announced an increased ambition of **227 GW renewable capacity by 2022 and 275 GW by 2027.**
- At the United Nations' Climate Summit in New York on 23 September 2019, the Prime Minister of India announced a new target of 450 GW of renewable electricity capacity, without specifying a date.
- **At the end of November 2019 grid-connected renewable electricity capacity reached 84 GW, with 32 GW coming from solar photovoltaic (PV), around 37 GW from onshore wind and the remainder from small hydro.**
- **India's total solar power capacity alone has increased by more than 11 times since 2014 to June 2020, from 2.6 GW to 38 GW.**

POLICY AND REGULATION

- **Electricity:** The government has a target to achieve 175 GW of grid-connected renewable electricity by March 2022: 100 GW solar, 60 GW wind, 10 GW biomass and 5 GW of small hydropower. In addition, the MNRE is targeting 1 GW of geothermal capacity by 2022. The 2018 National Electricity Plan sets out ambitions to achieve 275 GW of renewables by 2027, which would increase their share to an estimated 44% of installed capacity and 24% in electricity generation.
- **Utility-scale renewables:** For utility-scale renewables India relies on renewable purchase obligations (RPOs), renewable electricity certificates (RECs), accelerated depreciation of renewable energy assets for commercial and industrial users, and most recently on competitive tenders.
- **Rooftop solar PV:** For residential and commercial solar PV applications, the GoI has set an ambitious target of 40 GW of rooftop solar by 2022 within the 100 GW solar target.
- **Offshore wind:** The GoI estimates the potential of offshore wind to be in the region of 10-20 GW.
- **Off-grid solar PV:** Various schemes are available at both national and state level to support the uptake of off grid electrification, mainly through solar technologies.
  - In 2015 the *Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)* scheme was launched to support the adoption of decentralised distributed electricity in rural India via off-grid installations, mainly mini-grids.
  - In 2017 the *Off-Grid and Decentralised Solar PV Programme* was put in place to facilitate uptake of various solar PV applications for lighting and water pumping in rural areas by providing financial means to the implementing agencies.
  - In December 2018 the *Atal Jyoti Yojana (AJAY) Phase II programme* was initiated to finance the installation of over 3 million solar street lights in selected regions.
  - Initiated by the GoI in February 2019 (and followed by guidelines in July 2019), the *KUSUM scheme* will support farmers to replace existing diesel pumps with solar PV pumps (with both on-grid and off-grid features). The scheme aims to add solar and other renewable capacity of 28 GW by 2022.
- **Bioenergy and waste:** India is close to meeting its 2022 target for 10 GW of bioenergy capacity. The principal contributor is the use of bagasse in sugar mill co-generation plants. India's 2016 waste management rules provide the basis for stimulating greater exploitation of EfW.

NATIONAL HYDROGEN ENERGY ROAD MAP 2006:

- It is an **industry driven planning process** that offers to identify the paths which will lead to a gradual introduction of Hydrogen Energy in the country, accelerate commercialization efforts and facilitate the creation of the Hydrogen Energy Infrastructure in the country.
- The Road Map has **identified technology gaps and challenges** to be overcome for a large-scale introduction of hydrogen as an energy carrier in a phased manner.
- The Road Map has **suggested suitable pathways** that will help the Industry, Government, Research Organizations, Academia, NGO's and other stakeholders to achieve the national goals for sustainable energy development.
- It will lead to the implementation of the **National Hydrogen Energy Programme**.
- The Road Map has called for the **adoption of a total systems approach for developing hydrogen energy technologies though public private partnership**.
- The Road Map has **highlighted hydrogen production, hydrogen storage, proposed setting up of demonstration projects, demonstration of technologies for power generation and automobile applications.**

- Road Map has identified two major initiatives; namely **Green Initiatives for Future Transport (GIFT) and Green Initiative for Power Generation (GIP).**
- GIFT aims to develop/demonstrate hydrogen powered IC engine and fuel cell based vehicles ranging from small two/three wheelers to heavy vehicles.
- GIP envisages developing and demonstrating hydrogen powered IC engine/turbine and fuel cell based decentralized power generating systems ranging from small watt capacity to MW size systems through different phases of technology development and demonstration.
- Road Map, set a **target of one million vehicles based on hydrogen energy and 1000 MW of power generating capacity based on hydrogen energy by 2020.**

HYDROGEN AS A FUEL:

- Hydrogen is a clean fuel and an efficient energy carrier.
- Hydrogen is **found in water, organic compounds and hydrocarbons such as petrol, natural gas, methanol and propane.**
- Hydrogen is **high in energy content** as it contains 120.7 MJ/kg, which is the **highest for any known fuel**. However, its **energy content compared to volume is rather low**. This poses challenges with regard to its storage for civilian applications, when compared to storage of liquid fossil fuels.
- **When burnt, hydrogen produces water as a by-product and is, therefore, environmentally benign.**
- Although no CO_2, etc. are produced if hydrogen is burnt in air, yet NO_X will be formed at high temperatures.
- One of the advantages of hydrogen as a fuel is that it **can be used directly in the existing internal combustion engines and turbines.**
- It can also be used as a fuel in fuel cells for electricity generation. Hydrogen applications, besides industrial application, cover power generation, transport applications and heat.
- However, when compared to other alternatives, **use of hydrogen in transport sector appears to be more beneficial as it is possible to store hydrogen on-board.**

Hydrogen properties:

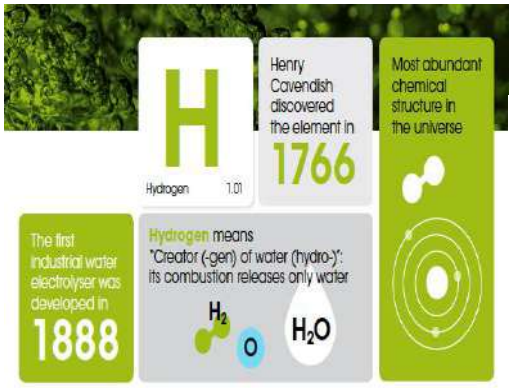


Table 1.1: Properties of Hydrogen vs. other conventional fuels

Fuel/property	Hydrogen	Natural Gas	Petrol	LPG
Lower heating value (MJ/kg)	120.7	49.54	41.87 - 44.19	46.05
Higher heating value (MJ/kg)	141.89	54.89	43.73 - 47.45	50.24
Density at standard conditions (kg/m^3)	0.08	0.6	720 – 780	510
Phase at standard conditions	Gas	Gas	Liquid	Liquid
Auto-Ignition temperature[1] in air (°C)	566 – 582	540	257	454 – 510
Ignition limit[2] in air (Vol%)	4.1 – 74	5.3 – 15	1.4 – 7.6	2.2 – 9.5
Diffusion coefficient[3] in air (cm^2/s)	0.61	0.16	0.05	0.11

1. Auto-ignition temperature is the lowest temperature at which a fuel will ignite when an external source of ignition is present
2. Ignition limit is the range of concentration within which the fuel will ignite, if an ignition source is present
3. Diffusion coefficient is used to determine the rate at which the fuel disperses (the higher the co-efficient, the faster the rate)

Shades of Hydrogen:

GREY HYDROGEN is produced with fossil fuels (i.e. hydrogen produced from methane using steam methane reforming (SMR) or coal gasification). The use of grey hydrogen entails substantial CO_2 emissions, which makes these hydrogen technologies unsuitable for a route toward net-zero emissions.

During early stages of the energy transition, the use of **BLUE HYDROGEN** (i.e. grey hydrogen with carbon capture and storage (CCS)) could facilitate the growth of a hydrogen market. Around three-quarters of hydrogen is currently produced from natural gas. Retrofitting with CCS would allow the continued use of existing assets while still achieving lower GHG emissions. The main option is to produce hydrogen with lower GHG emissions while reducing pressure on the renewable energy capacity installation rate to produce green hydrogen. Notably, industrial processes like steel production may require a continuous flow of hydrogen; blue hydrogen could be an initial solution while green hydrogen ramps up production and storage capacity to meet the continuous flow requirement.

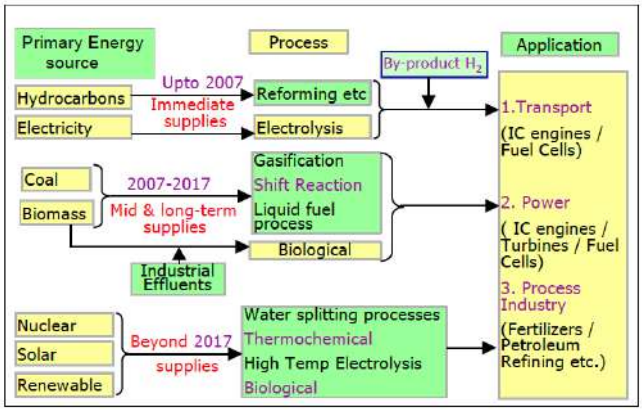
However, blue hydrogen has limitations that have so far restricted its deployment: it uses finite resources, is exposed to fossil fuel price fluctuations and does not support the goals of energy security. Moreover, blue hydrogen faces social acceptance issues, as it is associated with additional costs for CO_2 transport and storage and requires monitoring of stored CO_2. In addition, CCS capture efficiencies are expected to reach 85-95% at best,[1] which means that 5-15% of the CO_2 will still be emitted. And these high capture rates have yet to be achieved.

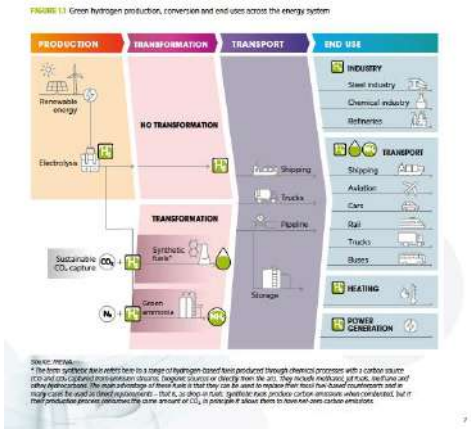
In sum, the carbon emissions from hydrogen generation could be reduced by CCS but not eliminated. Moreover, these processes use methane, which brings leakages upstream, and methane is a much more potent GHG per molecule than CO_2. This means that while blue hydrogen could reduce CO_2 emissions, it does not meet the requirements of a net-zero future. For these reasons, blue hydrogen should be seen only as a short-term transition to facilitate the uptake of green hydrogen on the path to net-zero emissions.

TURQUOISE HYDROGEN combines the use of natural gas as feedstock with no CO_2 production. Through the process of pyrolysis, the carbon in the methane becomes solid carbon black. A market for carbon black already exists, which provides an additional revenue stream. Carbon black can be more easily stored than gaseous CO_2. At the moment, turquoise hydrogen is still at the pilot stage. (Philibert, 2020; Monolith, 2020).

Among the different shades of hydrogen, **GREEN HYDROGEN** – meaning hydrogen produced from renewable energy – is the most suitable one for a fully sustainable energy transition. The most established technology options for producing green hydrogen is water electrolysis fuelled by renewable electricity. This technology is the focus of this report. Other renewables-based solutions to produce hydrogen exist.[2] However, except for SMR with biogases, these are not mature technologies at commercial scale yet (IRENA, 2018). Green hydrogen production through electrolysis is consistent with the net-zero route, allows the exploitation of synergies from sector coupling, thus decreasing technology costs and providing flexibility to the power system. Low VRE costs and technological improvement are decreasing the cost of production of green hydrogen. For these reasons, green hydrogen from water electrolysis has been gaining increased interest.

Hydrogen production:





Hydrogen storage:

Hydrogen Storage Options

1. High pressure gaseous storage
2. Storage as liquid hydrogen
3. Solid State Storage
   - Intermetallic hydrides
   - Complex hydrides
   - Carbon Nanotubes and Nanofibres
   - Metal Organic Complexes,
   - Clatherate Hydrates H_2-(H_2O) etc.
   - Glass microspheres
   - Liquid hydride (e.g. cyclohexane).
   - Zeolities and Aerogels.
4. Storage in Chemicals
   - Ammonia
   - Methanol
5. Bulk Storage
   - Underground storage
   - Gas pipelines

Issues in Hydrogen Storage

- Cost
- Weight &Volume
- Efficiency
- Life
- Refuelling Time
- Compatability
- Safety

Hydrogen in India:

- According to a report titled "The Potential Role of Hydrogen in India – Harnessing the Hype" by The Energy and Resources Institute (TERI) released in December last year, **demand for hydrogen could increase by at least 5-fold by 2050, continuing to grow in the second half of the century in India.**
- **Demand for hydrogen is at around 6 metric tonne (MT) per annum**, mainly from industry sectors, such as fertilizers and refineries.
- This can increase to around 28 MT by 2050 mainly due to cost reductions in key technologies and a push to reduce carbon footprint.
- Demand will mainly grow in steel and road transport, shipping and aviation sectors.
- The report also projected that **India would require 40 MT of green hydrogen to achieve net zero carbon emissions by 2060.**

An emerging virtuous circle for hydrogen deployment:

- Demand will continue to be largely focused in industry sectors, either expanding in existing sectors, such as fertilizers and refineries, or growing into new sectors, such as steel.
- Hydrogen will play some role in the transport sector in heavy-duty and long-distance segments, and a minor role in the power sector as a long-term storage vector.
- Beyond 2050, one can expect demand for green hydrogen to continue to grow, particularly in the steel and road transport sectors, as well as in shipping and aviation.

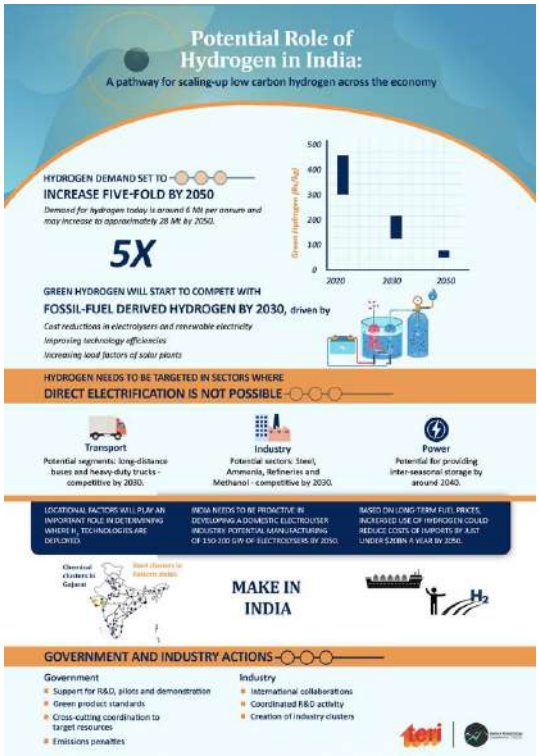


Table 1: The role of hydrogen across key sectors

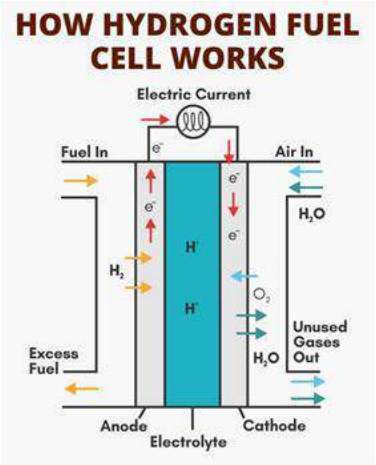
Sector	Use-Case	2020s	2030s	2040s
Transport	Light-duty passenger and freight transport	BEVs competitive with both FCEVs and ICEs	BEVs competitive with both FCEVs and ICEs	BEVs competitive with both FCEVs and ICEs.
	Short-distance, regular-route heavy-duty transport	BEVs becoming competitive with ICEs. FCEVs not competitive.	BEVs competitive with both FCEVs and ICEs.	BEVs competitive with both FCEVs and ICEs.
	Very long-distance heavy-duty freight transport	ICEs competitive.	FCEVs and BEVs becoming competitive with ICE.	FCEVs likely to be competitive with ICE. BEVs partly competitive.
Industry	Ammonia production	Fossil fuels competitive. H_2 becoming competitive.	H_2 competitive (ammonia and refineries) and partly competitive (steel).	H_2 from renewables competitive.
	Steel production			
	Refineries hydrogen demand			
	Methanol production	Fossil fuels competitive.	Fossil fuels competitive. H_2 partially competitive.	Fossil fuels competitive. H_2 partially competitive.
	Industrial heat	Fossil fuels competitive. Direct electrification partly competitive.	Fossil fuels competitive. Electrification increasingly competitive.	Fossil fuels likely to be competitive. H_2 and direct electrification may be partly competitive.
Electricity storage	Short-term (daily) storage	Li-ion batteries competitive.	Li-ion batteries competitive.	Li-ion batteries competitive.
	Short-term (weekly/monthly/seasonal) storage	Long-term balancing from fossil and hydro. Long-term storage needs minimal.	H_2 becoming competitive but minimal need as wind and solar still below 60-80%.	H_2 competitive. Long-term storage required in a high wind and solar system.

HCNG:

- **Delhi became the first city in India to operate buses with hydrogen-enriched CNG (HCNG).**
- Several companies like Indian Oil Corporation and NTPC are working towards operating more hydrogen-run buses in the country.
- MNRE allotted Rs 25 crore for research and development (R&D) in hydrogen.
- HCNG is a hydrogen-enriched compressed natural gas (CNG).
- It is cleaner and more economical. Power output of HCNG is also better than CNG ones.
- HCNG **means four per cent more fuel economy than CNG.**
- It **reduces the emission of carbon dioxide by 70% and increases the fuel efficiency by up to 3% resulting in overall fuel savings of around 5%.**
- Switch to HCNG fuel requires minimum modifications to the existing buses.
- It **requires only a small hydrogen storage and a column for the mixing of hydrogen with natural gas at existing CNG stations**. Safety components are similar to the CNG.
- HCNG is **easier and safer to use than hydrogen as it contains very low energy content from hydrogen i.e., up to 30% by volume.**
- HCNG reduces the engine's unburned hydrocarbon emissions and speeds up the process of combustion.
- The engine's fuel efficiency is improved by blending the CNG from hydrogen which lowers the fuel consumption of the vehicle.
- The thermal efficiency and fuel economy is also increased by HCNG.
- The Supreme Court had suggested looking at hydrogen-run vehicles as a solution for Delhi NCR's poor air quality and believed that the HCNG could be a step in that direction.

Hydrogen Fuel Cells:

- Germany has rolled out world's first hydrogen fuel cell powered trains called **Coradia iLint.**
- It is a fuel cell that **combines hydrogen and oxygen** to produce electricity with water and steam as the only biproducts.
- The excess energy can be stored on board in ion lithium batteries.
- It is a climate friendly fuel as it **does not emit carbon dioxide or particulate matter** as the case with conventional fuels like diesel, coal etc.
- A fuel cell works by passing **hydrogen through the anode** of a fuel cell and **oxygen through the cathode**.
- At the anode, the hydrogen molecules are split into electrons and protons.
- The **protons pass through the electrolyte membrane**, while **the electrons are forced through a circuit, generating an electric current and excess heat**.
- At the cathode, the protons, electrons, and oxygen combine to produce water molecules.
- Unlike **traditional combustion technologies that burn fuel**, **fuel cells undergo a chemical process** to convert hydrogen-rich fuel into electricity.



BARRIERS TO THE UPTAKE OF GREEN HYDROGEN:

Barriers include those that apply to all shades of hydrogen, such as the lack of dedicated infrastructure (*e.g.* transport and storage infrastructure), and those mainly related to the production stage of electrolysis, faced only by green hydrogen (*e.g.* energy losses, lack of value recognition, challenges ensuring sustainability and high production costs).

- **HIGH PRODUCTION COSTS** Green hydrogen produced would be two to three times more expensive than grey hydrogen. In addition, adopting green hydrogen technologies for end uses can be expensive. Vehicles with fuel cells and hydrogen tanks cost at least 1.5 to 2 times more than their fossil fuel counterparts.
- **LACK OF DEDICATED INFRASTRUCTURE.** Hydrogen has to date been produced close to where it is used, with limited dedicated transport infrastructure.
- **ENERGY LOSSES.** Green hydrogen incurs significant energy losses at each stage of the value chain. About 30-35% of the energy used to produce hydrogen through electrolysis is lost.
- **LACK OF VALUE RECOGNITION.** There is no green hydrogen market, no green steel, no green shipping fuel and basically no valuation of the lower GHG emissions that green hydrogen can deliver.

WAY FORWARD

- **Pilot initiatives:** India needs a strategy in place to launch such a big mission, such as a few pilot initiatives.
- **Efforts at all levels:** The budget perspective presses that a lot more needs to be done not only in order to push them into using green energy, they must be made aware of the benefits of the energy they are consuming. Also, there can be extensive marketing and awareness campaigns.
- **Capacity building:** It should not only be about awareness but also about building the capacity of the industries.
- **Exclusive expenditure on R&D:** There should be a good spending on R&D and technology adoption in hydrogen energy..

- The Government of India should:
  - **Develop a holistic strategy on renewable energy**, encompassing both supply and use, for electricity, heating and cooling as well as transport to fully harness India's large untapped potential.
  - **Adapt the design of competitive auctions by SECI** to ensure India can meet the 2022 renewable electricity targets.

- **Adopt a medium- to long-term target for renewable electricity** for the period beyond 2022 to give investors certainty.
- **Support further growth of distributed renewable energy** – notably the solar PV rooftop market – by strengthening and clarifying incentives to implement business models that offer customers standardized solar PV rooftop systems, based on international and national best practice experience.
- Ensure **compliance with RPOs** imposed by state regulators.
- **Strengthen the financial viability of DISCOMs** by ensuring the full implementation of the UDAY scheme.
- Maximize India's significant potential for **sustainable bioenergy**, comprising implementation of the policy on transport biofuels to scale up conventional and advanced biofuel production while ensuring sustainability criteria are met, realizing the potential to scale up bioenergy in the sugar and cement industries, and scaling up EfW, using best practice throughout the supply chain.

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