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Advancement of eco-friendly hydrogen production under the National Green Hydrogen Mission.

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The world's energy demand is rising rapidly due to population growth, industrialization, digital infrastructure, and expanding living standards. However, much of today's energy still comes from fossil fuels such as coal, oil, and natural gas, which significantly contribute to CO_2 emissions and climate change. Therefore, the challenge is twofold: meeting increasing energy needs while reducing environmental impact.

One promising solution is hydrogen.

Hydrogen can be used in many ways:

Energy storage: Hydrogen can be used to store energy from renewable sources like solar or wind power.

Clean energy: Hydrogen is a clean fuel that produces only water vapor when combusted.

Rocket fuel: Hydrogen is used as a propellant in rockets and spacecraft.

Transportation: Hydrogen can be used in fuel cell vehicles, which produce electricity and power the vehicle's electric motor.

Industrial processes: Hydrogen is used in industrial processes.

Hydrogen is the most abundant element in the universe, and it could play an essential role in tomorrow's energy mix — from fueling cars, trains, trucks and ships, to generating electricity and powering industry. The opportunities and challenges of hydrogen emerge from its energy characteristics. Hydrogen's specific energy (i.e. energy content per unit of mass) is higher than most hydrocarbon fuels. But its volumetric energy density is the lowest. That means pressurization or liquefaction is required for hydrogen to be useful as a fuel. These two properties drive the value as well as the applicability of hydrogen for the various possible end-use cases

Although hydrogen is the lightest and most abundant element in the universe, it is rarely found in nature in its elemental form and always must be extracted from other hydrogen-containing compounds. It also means that how well hydrogen contributes decarbonization depends on how clean and green the method of production is. Based on the sources and processes, hydrogen can be classified into various colours:

• Black / Brown / Grey hydrogen is produced via coal or lignite gasification (black or brown), or via a process called Steam Methane Reformation (SMR) of natural gas or methane (grey). These tend to be mostly carbon intensive processes.

• Blue hydrogen is produced via natural gas or coal gasification combined with carbon capture storage (CCS) or carbon capture use (CCU) technologies to reduce carbon emissions.

• Green hydrogen is a clean energy source produced using electrolysis of water with electricity generated by renewable energy sources such as wind, solar, and hydro power. The carbon intensity ultimately depends on the carbon neutrality of the source of electricity (i.e., the more renewable energy there is in the electricity fuel mix, the "greener" the hydrogen produced). It has the potential to become a key player in the transition to a carbon-free economy and can help mitigate climate change

Currently, the majority of the world's industrial hydrogen is derived from natural gas (methane) and is used for fertilizers, as well as in the iron, steel, and space industries. However, the traditional method of extracting hydrogen from natural gas also creates around 10 tonnes of CO_2 for every tonne of hydrogen produced. Therefore, for a better future of this planet, there is no alternative but to relay on Green Hydrogen as fuel.

Central to the green hydrogen production process is the Electrolysis technology. Alkaline and Polymer Electrolyte Membrane (PEM) Electrolysers are two commercially available technologies for green hydrogen production today. Advanced Eectrolyser technologies like solid oxide and anion exchange membrane nearing commercial deployment as well. Another green hydrogen production technology using Plasma-which is the fourth state of matter, (an ionized gas having some criterion, like quasi neutrality, collective behaviour and Debye shielding etc.) is in trend. Plasma-based technologies have gained attention in the field of green hydrogen production as a potential means to enhance the efficiency and reduce the costs associated with electrolysis. Several efforts have been made by researchers in this direction for conversion of methane, ethanol and methanol with the help of the plasma techniques for the effective production of hydrogen gas. Research and development in plasma-based technologies for green hydrogen production are ongoing, and the outcomes may contribute to advancements in the field. It's important to note that the practical implementation and commercial viability of these technologies are still subjects of investigation, and their success will depend on factors such as efficiency, scalability, and economic feasibility.

As per India's commitment in the 2021 UN Climate change conference (COP 26) to increase its non-fossil fuel energy capacity to 500 GW by 2030 and increase the share of renewables in the energy mix to 50% by 2030 and net zero carbon emission by 2070, India is prioritising green hydrogen as a potential solution to decarbonise hard-to abate sectors such as refinery, ammonia, methanol, iron and steel and heavy-duty trucking. “National Green Hydrogen Mission” is launched with the aim of making India the world’s largest hydrogen hub. The National Green Hydrogen Mission aims to provide a comprehensive action plan for establishing a Green Hydrogen ecosystem and catalysing a systemic response to the opportunities and challenges of this sunrise sector.

Addressing the nation on the 75th Independence Day, Prime Minister of India announced the National Hydrogen Mission with an aim of making India a hub for the production and export of green hydrogen. This is geared to make India energy independent before the country completes 100 years of its independence in 2047.

The National Hydrogen Mission is part of India's broader strategy to promote clean and sustainable energy sources. The strategy aims to harness hydrogen as a clean fuel to reduce carbon emissions and promote energy security. Here are some key aspects of the National Hydrogen Mission strategy in India:

Policy Framework:

The mission involves the development of a comprehensive policy framework to support the production, distribution, and consumption of green hydrogen. This framework would likely include regulations, incentives, and guidelines to encourage the adoption of hydrogen as a clean energy source.

Research and Development:

There is a focus on research and development activities to advance technologies related to hydrogen production, storage, and utilization. This involves collaborations between government agencies, research institutions, and industry partners to drive innovation in the hydrogen sector.

Infrastructure Development:

The mission emphasizes the development of infrastructure for the production, storage, and transportation of hydrogen. This includes establishing hydrogen production facilities, building a network of hydrogen refueling stations, and creating the necessary storage infrastructure.

International Collaboration:

India is likely to engage in international collaborations to benefit from global expertise, share best practices, and access cutting-edge technologies in the field of hydrogen production and utilization. Partnerships with other countries and international organizations may be part of the strategy.

Green Hydrogen Production:

The mission is expected to prioritize the production of green hydrogen, which is produced using renewable energy sources such as solar or wind power. This aligns with India's commitment to reducing carbon emissions and transitioning towards a greener and more sustainable energy mix.

Industrial Integration:

Integrating hydrogen into various industrial processes is likely to be a key component. Industries such as steel, chemicals, and transportation may be encouraged to adopt hydrogen as a clean energy source, contributing to the reduction of carbon emissions in these sectors.

Capacity Building:

The mission may include initiatives for skill development and capacity building to ensure that there is a workforce with the necessary expertise in hydrogen technologies. This could involve training programs and educational initiatives.

Financial Support and Incentives:

Financial support and incentives, such as subsidies or tax benefits, may be provided to encourage investment in hydrogen-related projects. This is aimed at making green hydrogen economically viable and attractive to investors.

With proactive collaboration among innovators, entrepreneurs and government sectors, green hydrogen has the potential to drastically reduce CO_2 emissions, fight climate change, and put India on a path towards net-zero energy imports. It will also help India export high-value green products making it one of the first major economies to industrialise without the need to 'carbonise'.

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