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Green Hydrogen - Energy Fuel for the Future in India

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ABSTRACT

Hydrogen has an important potential role in a net zero economy as it has no carbon emissions at the point of use. Hydrogen fuels are versatile, capable of being produced and used in many ways, including production from renewable sources and applications to decarbonize challenging areas, such as heavy transport, industry, and heat, as well as the storage and transport of energy. It is already widely used in industry and agriculture, but their current production carries a high greenhouse gas footprint. Significant greenhouse gas emission reductions could be achieved through decarbonization of production for both existing and new applications. However, it currently faces challenges that require technological advances, including in their generation, storage, and use, particularly the costs involved in achieving net zero life cycle emissions. Further research, development, demonstration, and deployment are required to identify the areas where hydrogen can make a critical difference in practice.

KEYWORDS: *Greenhouse gas, Green hydrogen, Renewable sources, Fuel Cell, Net zero, Clean Hydrogen & water electrolysis*

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INTRODUCTION

Hydrogen can be used to facilitate the introduction of renewable energy resources since it can be used as both an energy carrier and a storage medium to compensate for the intermittency of many renewable resources. Using renewable resources and hydrogen we can serve both the electric sector and the transportation sector. It has been suggested there may be a synergy between the transportation and electric sectors when renewable resources are used. This section investigates the possibility of such a synergy.

Renewable sources of energy can produce hydrogen, like water, solar photovoltaic (PV), waste, wind, small sustainable hydropower, geothermal, and even wave power among others. These ‘‘green’’ resources, along with environmentally sound technologies that are available today, are increasingly being used to produce electricity. This electricity in turn can be used through the electrolysis process to split water into hydrogen and oxygen.

The efficiency of electrolysis is around 80%, which means that nearly all the energy values of the electricity can be stored as hydrogen. Clearly this is a positive factor given the importance of finding a way to store electricity, since it must be used later or at peak hours once it is created.

Sustainable energy conversion requires zero emissions of greenhouse gases and criteria pollutants using primary energy sources that the earth naturally replenishes quickly, like renewable resources. Solar and wind power conversion technologies have become cost effective recently, but challenges remain to manage electrical grid dynamics and to meet end-use requirements for energy dense fuels and chemicals. Renewable hydrogen provides the best opportunity for a zero emissions fuel and is the best feedstock for production of zero emission liquid fuels and some chemical and heat end-uses. Renewable hydrogen can be made at very high efficiency using electrolysis systems that are dynamically operated to complement renewable wind and solar power dynamics (IRENA, 2019). Hydrogen can be stored within the existing natural gas system to provide low-cost massive storage capacity that could be sufficient to enable a 100% zero emissions grid, has sufficient energy density for end-uses including heavy duty transport, it is a building block for zero emissions fertilizer & chemicals, and it also enables sustainable primary energy in all sectors of the economy.

Greenhouse gas emissions from the production of Gray hydrogen can be separated into two parts: (a) the SMR process in which methane is converted to carbon dioxide and hydrogen; and (b) the energy used to generate the heat and high pressure needed for the SMR process. For blue hydrogen, which we discuss later in this paper, emissions from the generation of electricity needed to run the carbon dioxide capture equipment must also be included. In this analysis, we consider emissions of only carbon dioxide and methane, and not of other greenhouse gases such as nitrous oxide that are likely to be much smaller. For methane, we consider the major components of its lifecycle emissions associated with the mining, transport, storage, and use of the natural gas needed to produce the hydrogen and power carbon capture. Emissions are expressed per unit energy produced when combusting the hydrogen, to aid in comparing the greenhouse gas footprint with other fuels.

The world is confronting the significant test of environmental change. In 2015 the worldwide local area focused on making a move to keep worldwide temperature rise this century well underneath 2°C above pre-modern levels. A developing number of nations are swearing to arrive at net-zero carbon dioxide (CO2) outflows by mid-century determined to restrict temperature ascend to 1.5°C. Accomplishing the profound or full decarbonisation of economies will require deliberate and wide-going activity across every single financial area.

We have scarcely started such outflow emissions. It has been assessed that 8.8% less CO2 was transmitted in the initial a half year of 2020 than in a similar period in 2019, following the COVID-19 pandemic and the subsequent lockdowns. Yet, for proceeded with long haul decrease, the requirement for primary and ground-breaking changes in our worldwide energy creation, utilization and basic financial frameworks can't be put into words.

Air pollution is a serious public health problem throughout the world, especially in industrialized and developing countries. In industrialized and developing countries, motor vehicle emissions are major contributors to urban air quality. Hydrogen is one of the clean fuel options for reducing motor vehicle emissions. Hydrogen is not an energy source. It is not a primary energy existing freely in nature. Hydrogen is a secondary form of energy that must be manufactured like electricity. It is an energy carrier. Hydrogen has a strategic importance in the pursuit of a low-emission, environment-benign, cleaner, and more sustainable energy system. Combustion product of hydrogen is clean, which consists of water and a little amount of nitrogen oxides.

Hydrogen has very special properties as a transportation fuel, including a rapid burning speed, a high effective octane number, and no toxicity or ozone-forming potential. It has much wider limits of flammability in air than methane and gasoline. Hydrogen has become the dominant transport fuel and is produced centrally from a mixture of clean coal and fossil fuels (with C-sequestration), nuclear power, and large-scale renewables. Large-scale hydrogen production is probable on the longer time scale. In the current and medium term, the production options for hydrogen are first based on distributed hydrogen production from electrolysis of water and reforming of natural gas and coal. Each of centralized hydrogen production methods scenarios could produce 40 million tons per year of hydrogen. Hydrogen production using steam reforming of methane – Steam Methane Reforming (SMR) is the most economical method among the current commercial processes. In this method, natural gas feedstock ` contribute approximately 52–68% to the final hydrogen price for larger plants, and 40% for smaller plants, with remaining expenses composed of capital charges.

The energy change requires a significant change in power age from petroleum products to sustainable sources like sunlight based and wind, more prominent energy proficiency and the broad charge of energy utilizes from vehicles to warming and cooling in structures. In any case, not all areas or businesses can undoubtedly change from petroleum products to power. Difficult to-energize (and in this way difficult to-lessen) areas incorporate steel, concrete, synthetic compounds, long stretch street transport, oceanic delivery and aeronautics.

Green hydrogen a give a connection among developing and manageable sustainable power age and the difficult to-energize areas. Hydrogen overall is a reasonable energy transporter for applications remote from power networks or that require a high energy thickness, and it can fill in as a feedstock for substance responses to deliver a scope of engineered powers and feedstocks. Extra advantages of green hydrogen include: the potential for extra framework adaptability and capacity, which backing further organization of variable renewable energy (VRE); commitment to energy security; decreased air contamination; and other financial advantages like monetary development and occupation creation, and modern seriousness. All things considered; green hydrogen should defeat a few boundaries to live up to its maximum capacity. Boss among those obstructions is cost. Defeating the hindrances and changing green hydrogen from a specialty player to an inescapable energy transporter will require committed arrangement in every one of the phases of innovation status, market infiltration and market development.

Hydrogen Value Chain

Green hydrogen is a reasonable answer for decreasing ozone harming substance discharges and changing away from petroleum derivatives for "difficult to-subside" areas. The production network for hydrogen isn't yet completely created. A few boundaries, for example, the significant expense of green hydrogen contrasted with non-sustainable other options and the absence of committed foundation, are yet blocking hydrogen's full commitment to the energy progress.

Types of Hydrogen

Gray Hydrogen

The most widely recognized type of hydrogen, it's made from non-renewable energy sources (fossil fuels) and the cycle discharges carbon dioxide which isn't caught. The interaction used to make hydrogen from petroleum gas is called steam methane changing (SMR) where high-temperature steam (700°C-1,000°C) is utilized to create hydrogen from a methane source, like flammable gas. In steam methane changing, methane responds with steam under 3-25 bar tension (1 bar = 14.5 pounds per square inch) within the sight of an impetus to create hydrogen, carbon monoxide, and a moderately limited quantity of carbon dioxide. Steam improving is endothermic - that is, heat should be provided to the interaction for the response to continue (Clark & Rifkin, 2006). There is additionally a gasification interaction which utilizations coal as a feedstock, making earthy coloured hydrogen, which likewise delivers carbon dioxide and can be placed in a similar class as dim. The head of the business advancement at the sustainable power goliath Enel has portrayed hydrogen as an "environment executioner" the way things are correct now due to practically every bit of it being dim: "98% of it is delivered from steam transforming and gasification, which likens to yearly fossil fuel by-products tantamount to that of Indonesia and the UK consolidated," he said. "Simply 2% is created from electrolysis." Clearly then, at that point, dark hydrogen is anything but a drawn-out arrangement.

Black and Brown Hydrogen

Gray hydrogen is the most well-known structure and is created from gaseous petrol, or methane, through a cycle called "steam re-forming". This cycle produces simply fewer emanations than dark or earthy coloured hydrogen, which utilizations dark (bituminous) or brown (lignite) coal in the hydrogen-production process. Dark or earthy coloured hydrogen is the most ecologically harming as both the CO2 and carbon monoxide created during the interaction are not recovered.

Blue Hydrogen

Blue hydrogen involves a similar interaction as Gray hydrogen, aside from this time the carbon is caught and put away. This makes it significantly more harmless to the ecosystem yet accompanies added specialized difficulties and a major expansion in cost. Carbon catch and capacity (CCS) has been around some time, with the innovation being utilized by weighty industry and power age organizations consuming petroleum products. The innovation can catch up to 90% of the CO2 created, so it is more than a little flawed yet obviously a monstrous improvement. Often, this CO2 is then shipped by a pipeline and put away profound underground, frequently in salt sinkholes or exhausted oil and gas supplies. Nations that don't approach such underground choices will observe it extremely testing to lay out a blue hydrogen industry, and it could be more practical to foster green hydrogen as their essential arrangement. Some ground-breaking associations in the UK have been consolidating CCS with biomass fills, planning to become carbon negative - eliminating more carbon dioxide from the climate than it produces. With regards to hydrogen creation, blue hydrogen is frequently considered a venturing stone from dim to green, and it's demonstrated to be troublesome among industry experts. On one hand, it is somewhat simple to increase from existing dim hydrogen creation and requires less power. It is likewise not reliant upon the fast and persistent development in sustainable power sources like seaward wind and sun oriented. On the other, think tanks and green hydrogen advocates contend that blue hydrogen conflicts with the objectives and standards of net-zero, as well as being more costly than green in the medium term.

Green Hydrogen

The idealistic vision of things to come is a net-zero reality where all our power and fuel are created by emanation free sources. With regards to this piece, which implies a completely scaled green hydrogen industry on a worldwide scale. "So, what exactly is green hydrogen?" It can possibly be a significant part in addressing the irregular creating limit of most environmentally friendly power sources. Overabundance power can be utilized to make hydrogen, which is then put away as a gas or fluid until required. It faces many difficulties, however, the energy behind it is developing with state-run administrations all over the planet perceiving the likely advantages and creating arrangements to assist with driving turn of events and reception. Rather than utilizing petroleum products, green hydrogen is made by utilizing an interaction called electrolysis to part water into hydrogen and oxygen. Assuming that interaction is controlled by a sustainable power source, for example, wind or solar based power, then, at that point, the hydrogen is alluded to as being green.

Other source

Among the various shades of hydrogen, GREEN HYDROGEN - meaning hydrogen created from environmentally friendly power - is the most appropriate one for a completely maintainable energy change. The most settled innovation choices for creating green hydrogen are water electrolysis fuelled by sustainable power. This innovation is the focal point of this report. Notwithstanding, aside from SMR with biogases, these are not developed innovations at a business scale yet. Green hydrogen creation through electrolysis is predictable with the net-zero course, permits the double-dealing of cooperative energies from area coupling, accordingly, diminishing innovation costs and giving adaptability to the power framework. Low VRE costs and mechanical improvement are diminishing the expense of the creation of green hydrogen. Therefore, green hydrogen from water electrolysis has been acquiring expanded interest.

Turquoise Hydrogen

It joins the utilization of gaseous petrol as feedstock with no CO2 creation. Through the course of pyrolysis, the carbon in the methane becomes strong carbon dark. A business opportunity for carbon dark as of now exists, which gives an extra income stream. Carbon dark can be more effectively put away than vaporous CO2. Presently, turquoise hydrogen is currently at the pilot stage.

Production of hydrogen

Hydrogen can be created from assorted, homegrown resources, including petroleum products, biomass, and water electrolysis with power. The ecological effect and energy productivity of hydrogen relies upon how it is delivered. A few tasks are in progress to diminish costs related to hydrogen creation.

Natural Gas Reforming/Gasification

Synthesis gas-a a combination of hydrogen, carbon monoxide and a modest quantity of carbon dioxide is made by responding flammable gas with high-temperature steam. The carbon monoxide is responded with water to deliver extra hydrogen. This strategy is the least expensive, generally productive, and generally normal. Petroleum gas changing utilizing steam represents a large portion of the hydrogen created in the United States every year. A combination gas can likewise be made by responding coal or biomass with high-temperature steam and oxygen in a compressed gasifier. This changes over the coal or biomass into vaporous parts an interaction called gasification. The subsequent blend gas contains hydrogen and carbon monoxide, which is responded with steam to isolate the hydrogen.

Electrolysis

An electric flow parts water into hydrogen and oxygen. Assuming that the power is delivered by sustainable sources, for example, solar based or wind, the subsequent hydrogen will be viewed as inexhaustible also and has various emanations benefits. Power-to-hydrogen projects are taking off, utilizing abundance sustainable power, when accessible, to make hydrogen through electrolysis

Renewable Liquid Reforming

Renewable liquid fuels, like ethanol, are responded with high-temperature steam to create hydrogen close to the place of end use.

Currently, hydrogen is delivered in three ways:

Pipeline

This is the most cost-effective technique for transporting large amounts of hydrogen, but the limit is set by the fact that only around 1,600 miles of hydrogen-transport pipes are now available in the United States (Administration, 2007). In Illinois, California, and the Gulf Coast, these pipelines are near to large oil treatment facilities and substance factories see Table 5.

High-Pressure Tube Trailers

Moving packed hydrogen gas in high-pressure tube trailers by truck, railway, boat, or barge is expensive and only used for distances of 200 miles

Liquefied Hydrogen Tankers

The process of chilling hydrogen to the point where it becomes a fluid is known as cryogenic liquefaction. The liquefaction cycle, despite its high cost, allows hydrogen to be carried more efficiently (contrasted and high-pressure tube trailers) over longer distances by truck, railway, boat, or barge. It bubbles off (or vanishes) from its regulating vessels if the condensed hydrogen is not consumed at a sufficiently high rate at the site of usage. As a result, hydrogen transportation and consumption rates must be carefully synchronised.

Developing a framework for hydrogen distribution and supply to many future individual fuelling stations is fraught with difficulties. Because hydrogen has less energy per unit volume than any other fuel, it is more expensive to ship, store, and carry to the place of consumption for each fuel gallon comparable premise. The expense of constructing a new hydrogen pipeline network is high up front, and the properties of hydrogen present unique issues for pipeline materials and blower designs. Local or even nearby hydrogen production, on the other hand, can boost the utilisation of local resources while lowering appropriation difficulties because hydrogen can be created from a variety of sources.

Between unified and scattered creation, there are trade-offs to be made. Midstream hydrogen generation in huge plants reduces both production and transportation costs. The cost of creating local creation capabilities boosts creation costs. Creating hydrogen at the point of use-at gas stations, for example-reduces dissemination costs but enhances creation costs.

Is Hydrogen a Safe Fuel?

The safety aspects of hydrogen are systematically examined and compared with those of methane and gasoline. Physical and chemical property data for all three fuels are compiled and used to provide a basis for comparing their various safety features. Each fuel is examined to evaluate its fire hazard, fire damage, explosive hazard and explosive damage characteristics. The fire characteristics of hydrogen, methane and gasoline, while different, do not largely favour the preferred use of any one of the three fuels; however, the threat of fuel-air explosions in confined spaces is greatest for hydrogen. Safety criteria for the storage of liquid hydrogen, liquefied. natural gas (LNG) and gasoline are compiled and presented. Gasoline is believed to be the easiest and perhaps the safest fuel to store because of its lower volatility and narrower flammable and detonable limits. It is concluded that all three fuels can be safely stored and used; however, the comparative safety and level of risk for each fuel will vary from one application to another. Generalized safety comparisons are made herein but detailed safety analyses will be required to establish the relative safety of different fuels for each specific fuel application and stipulated accident.

Industrial Applications Of Hydrogen

Hydrogen is currently being used in many industries, from chemical and refining to metallurgical, glass and electronics. Due to the increased use of heavier crude oils, containing higher amounts of sulphur and nitrogen and to meet stringent emission standards, need for hydrogen is experiencing a very rapid growth in the petroleum refining industry. For decades, hydrogen has been used primarily by the chemical and refining industries. End applications include:

Agricultural/Chemical Industry: Hydrogen is a fundamental raw material needed to produce ammonia (NH_3), also known as azane, an important part of fertilizers used in agricultural industries around the world. Ammonia can also be used as an affordable, environmentally friendly refrigerant (R-717). Petroleum Refining Industry: Hydrogen is commonly used in hydrocracking to create petroleum products, including gasoline and diesel. It is also used to remove contaminants like Sulphur and to create methanol.

Energy Losses

At every stage of the value chain, green hydrogen causes massive energy losses. Around 30-35 percent of the energy utilised to produce hydrogen via electrolysis is wasted. Similarly, converting hydrogen to various transporters (such as alkali) can result in a 13-25 percent energy loss, and shipping hydrogen necessitates additional energy inputs that are typically equivalent to 10-12 percent of the energy of the real hydrogen. Hydrogen in power modules can result in a 40 percent increase in half-energy misfortune. The total energy loss will be determined by the final use of hydrogen. The greater the energy misfortunes, the greener hydrogen is projected to be delivered by a more sustainable power limit.

In any event, the main point of dispute isn't the required all-out limit, because the global sustainable potential is just a few degrees higher than hydrogen interest, and green hydrogen designers are likely to prioritise locations with abundant environmentally friendly power assets. The main point of contention is whether the annual rate of improvement of solar and wind potential will be fast enough to meet the requirements for both the charging of end-uses and the advancement of a global inventory network in green hydrogen, as well as the additional cost that this additional limit will entail

Conclusion

Green hydrogen can be a fuel for the future. The main investors are going to be its wide scale adoption, its economic and commercial viability and how it can be used as just option and how the project liability can be ascertained in terms of commerciality. So green hydrogen is going to be the fuel soon as countries move towards you can say accelerated decarbonization initiatives. The aim of the companies and the aim of the various countries will be to reduce pollution across the entire value chain. Big scope one, scope two, scope three and green hydrogen is going to be going to play a key role in that.

The national hydrogen policy so national hydrogen policy is a welcome step in the adoption of hydrogen economy in India the government is providing various incentives for setting up a hydrogen. Green hydrogen infrastructure in the country and what feel that it is a welcome step but additional we can say support is required in the form of a more robust policy. So, to say with even greater source of greater source of end use industry adoption for example producing hydrogen is not going to be now but it's economic viability and adoption in user industries like Fertilizers and electricity is going to be the key going forward.

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