

# Hydrogen Energy as Advance Renewable Resource

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**Abstract** Reducing the demand on fossil resources remains a significant concern for many nations. Renewable-based processes like solar- or wind-driven electrolysis and photo biological water splitting hold great promise for clean hydrogen production; however, advances must still be made before these technologies can be economically competitive. Approximately 95% of the hydrogen produced today comes from carbonaceous raw material, primarily fossil in origin. Only a fraction of this hydrogen is currently used for energy purposes; the bulk serves as a chemical feedstock for petrochemical, food, electronics and metallurgical processing industries. However, hydrogen's share in the energy market is increasing with the implementation of fuel cell systems and the growing demand for zero-emission fuels. Hydrogen production will need to keep pace with this growing market. In this regard's an effort has been made to study of hydrogen as new renewable energy resources.

**Keywords:** biomass, carbon dioxide, Methane, process, utilization

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## 1. Introduction

Energy is an essential factor in development since it stimulates, and supports economic growth, and development. Fossil fuels, especially oil and natural gas, are finite in extent, and should be regarded as depleting assets, and efforts are oriented to search for new sources of energy. The clamour all over the world for the need to conserve energy and the environment has intensified as traditional energy resources continue to dwindle whilst the environment becomes increasingly degraded. The basic form of biomass comes mainly from firewood, charcoal and crop residues. Out of the total fuel wood and charcoal supplies 92% was consumed in the household sector with most of firewood consumption in rural areas.

The term biomass is generally applied to plant materials grown for non-food use, including that grown as a source of fuel. However, the economics of production are such that purpose-grown crops are not competitive with fossil-fuel alternatives under many circumstances in industrial countries, unless subsidies and/or tax concessions are applied. For this reason, much of the plant materials used as a source of energy at present is in the form of crop and forest residues, animal manure, and the organic fraction of municipal solid waste and agro-industrial processing by-products, such as bagasse, oil-palm residues, sawdust and wood off-cuts. The economics of use of such materials are improved since they are collected in one place and often have associated disposal costs [1] The technology is shrinking day-by-day in today's world and the prefix "nano" implies one of the dimension sizes in this cutting-edge era. Nano is of the order of  $10^{-9}$ . The demand for energy is increasing at a high rate these days. Each and every thing requires energy to carry out its functions. So conservation of energy becomes an important issue. First

of all, let me define what is Energy? The rate of doing work is termed as energy. Energy can be in various forms (light, heat, work, etc). There are two major sources of energy being used in today's world, Renewable and Non-renewable sources. Let me define the non-renewable source first [2]. These are the sources which cannot be renewed after a period of time and becomes exhausted e.g., coal, fossil fuels, natural gas, etc. Such sources release harmful gases to the environment thereby polluting the atmosphere. The alternative to such sources is the renewable source of energy. These sources are clean or say, non-polluting or it reduces the effect of harmful gases to a considerable amount. Such sources can never be exhausted and hence called non-conventional sources of energy [3]. Renewable sources include solar energy, biomass, wind, etc. In today's economy, reliable, efficient, pollution free, abundant energy requirement is the major challenge. Our major economy needs, in terms of energy comprises of transportation sector, residential and commercial sectors. We are heavily dependent on the non-renewable sources for our energy needs. Not only these resources will deplete over time, they are also the major source of pollution, which is another key issue in front of the economy. To face these challenges there's needed to come up with the new technology that helps in reducing the problems and also improves our economy [4].

## 2. History of Renewable Sources of Energy

Several developments have been made and are in progress to harness the renewable source of energy. The increasing popularity of the use of solar energy, wind energy and bio-mass fuels provide the evidence that the

work has been in progress to accomplish the task and improves the economy. The Energy Efficiency and Renewable Energy branch of the US Department of Energy Office [6] heads the research, development, and deployment efforts in renewable sources of energy. It develops energy efficiency technologies to provide reliable and affordable supply of energy using the solar, biomass and wind. Due to their efforts, tremendous progress has been made in bringing renewable energy technologies to the marketplace. While the efforts of DOE have started giving results but a lot more has to be done to meet current energy challenges [7].

## 2.1. Solar Energy

Solar Energy is the energy obtained from the sun. It's the most efficient and clean source of energy to drive the latest trends in the market. Solar energy in the form of photovoltaic cells has been extensively used in electricity and the related areas. It is the permanent and reliable source of non-conventional form of energy. Solar energy is a non-exhaustible, non-pollutant, readily available source of energy [8]. The sun is being used for many purposes in our daily life routine. It is used for several

household activities like cooking, drying clothes, generating electricity and so on and so forth. The solar energy can be used through photovoltaic cells to generate the electricity that can either be stored in the form of battery or used for many applications such as [9]:

- Desalination of salty water,
- Railway signals,
- Electrification,
- Telecommunication, etc.

The modern technology is full of electronic gadgets that utilize solar energy like solar cookers, solar cells, solar heating and cooling systems, solar timber kilns, and power towers.

## 2.2. Biomass

It is defined as the conversion of biodegradable waste obtained from the organic and inorganic substances into fuel or power. It is an important source of energy used in domestic as well in industrial applications. All such kind of energy sources are used to produce the pollution free atmosphere and healthy and clean surroundings. Several researches show the new trends in the use of biomass productions [10].

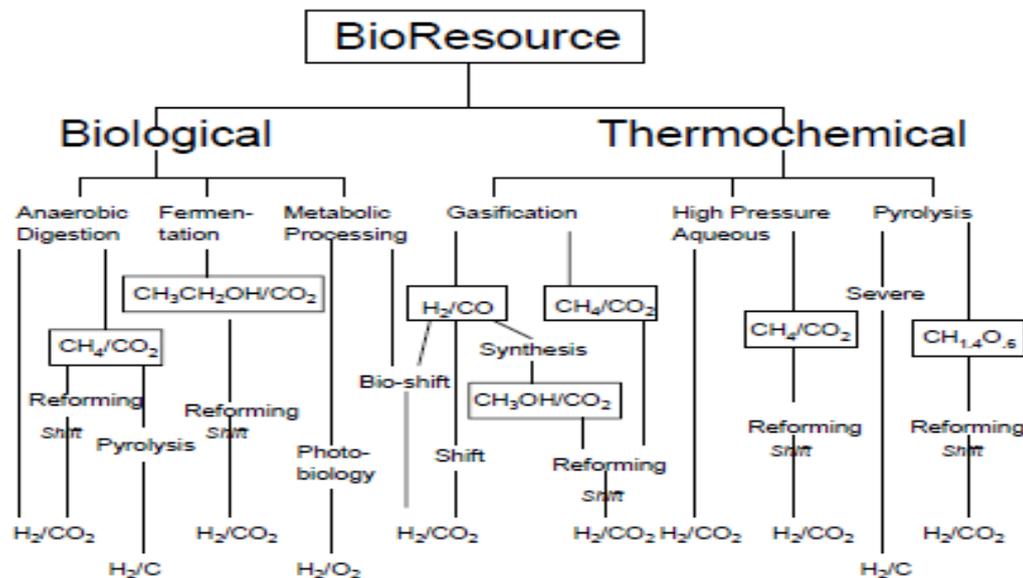


Figure 1. Pathway from biomass for production of hydrogen

## 2.3. Wind Energy

The air in our environment moves in many directions. The movement is caused by the temperature difference. Hot air rises while cool air comes down. The air from hot tropical region moves towards the cold polar region [11]. The wind energy can be converted into electricity by using a windmill. The wind rotates the fan on the mill which is connected to a dynamo that generates electricity. This wind electricity can also be utilized to produce hydrogen which is the most important element in Hydrogen economy [12].

## 3. Emerging Technology (Hydrogen)

To conserve and establish the new renewable sources, many countries are trying hard to develop new projects and harness the new renewable forms of energy. These

countries are trying to tap the energy from relatively unexplored sectors. Nanomaterials and Hydrogen fuel cell have the advantage of being smaller and portable. Therefore they have many more applications. The world has already begun the transition to cleaner fossil fuels containing less carbon and more hydrogen. As the world's supply of fossil fuels decreases, the shift to renewable energy sources will continue with a move to resources such as hydrogen, which human beings previously were unable to harness. There are five key policy reasons why this shift is necessary [13]:

(1)The environment. Emissions from vehicles are the largest source of air pollution.

(2)Human health. More than 50,000 people per year may die prematurely from exposure to fine particulates emitted by trucks and buses, power plants and factories.

(3)Economics. The costs of producing oil continue to increase, as deeper wells are drilled farther and farther from markets in harsh climates.

(4)Energy Security. Military and political costs of maintaining energy security internationally are becoming untenable.

(5)Supply. World oil supplies are finite, and are expected to reach their peak as early as 2010. (Cannon, 1998)

To say that hydrogen is an energy “source” is actually a misnomer. That is, hydrogen is not a primary energy like natural gas or oil, existing freely in nature. Instead, hydrogen is an energy “carrier,” which means it is a secondary form of energy that has to be manufactured. Although hydrogen is the most abundant element in the universe, practically all of it is found in combination with other elements, for example, water (H<sub>2</sub>O), or fossil fuels such as natural gas (CH<sub>4</sub>) [14].

Hydrogen can be generated from many primary sources. Today, hydrogen is mainly extracted from fossil fuels through a process known as “steam reforming” (Thomas, 2001). However, most supporters of fuel cells and renewable energy are uncomfortable with the idea of making hydrogen through steam reforming because carbon dioxide (CO<sub>2</sub>) is a byproduct of the process. To truly reap the benefits of the environmentally friendly characteristics, environmentalists argue, hydrogen should be made from clean water and clean solar energy, as well as “cleaner” nuclear energy, including fusion. Others disagree, citing that hydrogen produced from natural gas would nonetheless cut greenhouse emissions by up to 40 percent. This, natural gas supporters argue, proves that society does not have to wait for purely renewable hydrogen energy to make significant cuts in greenhouse emissions [15]. Furthermore, proponents of natural gas argue that it may serve as the bridge to a hydrogen and renewable energy society

### 3.1. Hydrogen Fuel Cell

Hydrogen can be used in a fuel cell which basically operates like a battery. The fuel cell consists of two electrodes and an electrolyte. Hydrogen and Oxygen are passed over the electrodes to generate electricity and Water. Hydrogen cells are used in Auto industry. Compressed hydrogen tanks are used to supply the Hydrogen and Oxygen is used from the air directly. There is no pollution caused by hydrogen fuel cell autos and the only emission is water [16]. If the hydrogen fuel cell autos become main stream instead of exception, we can eliminate autos from the global pollution problem. By the middle of the 21st century, the global community will be dependent on alternative fuels as energy sources. Alternative fuels, those that are not derived from oil, will have taken the place of fossil fuels in powering everything from automobiles, office buildings, and power plants to everyday household items such as vacuum cleaners and flashlights. Driven by environmental, health, economic and political concerns, the global community has been forced to begin developing technology and infrastructure to support the revolution fossil fuels to alternative fuels such as hydrogen [17]. In particular, the world’s leaders have targeted the automotive fleet and the internal combustion engine. By replacing the internal combustion engine in automobiles with the hydrogen fuel cell, we could achieve zero emissions of pollutants into the environment [18]. The transformation of the existing

transportation system is key to solving many of the world’s environmental problems and significantly improving the quality of the air that we breathe. This paper will focus on the role that the Polymer Electrolyte Membrane (PEM) Fuel Cell, widely considered the most practical fuel cell, will play in the switch to alternative fuels [19].

### 3.2. Hydrogen Economy

The hydrogen economy is an energy system of the coming generations in the near future. The hydrogen can be generated using the renewable energy sources which are readily available. One of such sources is the wind energy that is playing the major role in the generation of hydrogen. The hydrogen economy is capable of fulfilling the human needs of the coming generations [20]. The hydrogen being in the most demand needs the technologies for their production, storage, distribution, and utilization.

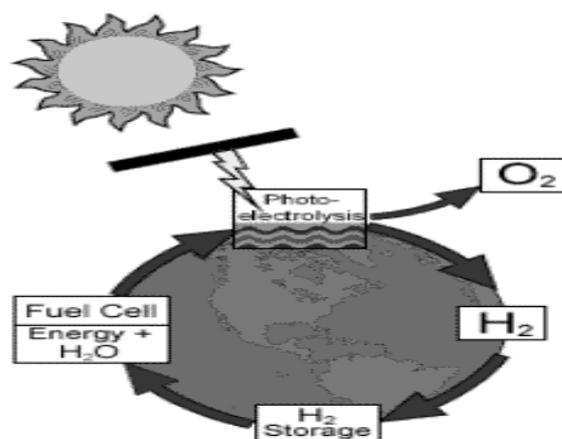


Figure 2. Generation of Hydrogen-clean, cyclic process

There’s always the need for clean, efficient, convenient forms of energy which the user can easily access. Hydrogen is one of the many other convenient forms of energy which forms an energy system and satisfies the human energy needs [21].

Hydrogen in chemistry has the following properties:

- Available in huge quantity.
- Can be stored in solid, liquid or gas form.
- Can be converted into other forms of energy efficiently.
- Renewable source as made from the product of water or water vapor.
- Easily transportable.
- Hydrogen as an energy carrier is environmentally compatible.

### 3.3. Hydrogen Production

Several technologies have been developed to produce hydrogen. Some of the ways have been attempted to describe regarding the hydrogen production. Hydrogen is mainly being produced from fossil fuels in refineries or in industries. The fossil fuels which are used for hydrogen production are in the form of coal, crude oil or natural gas. These fuels produce carbon-dioxide gas during their production process. The processes involved are hydro-treating and hydro- cracking. To avoid the emission of carbon-dioxide gas many other technologies are coming

up to produce cost effective hydrogen. Water electrolysis is one of the efficient methods to produce hydrogen but it needs electricity which is expensive [22]. If the method of water electrolysis is being used with photovoltaic (PVs) then that would be more suitable as well an effective method. But photovoltaic cells are costly to produce and install so even though highly efficient but not a good alternative. Wind energy is the other way to produce hydrogen at a low cost but this energy can be utilized in the areas where the wind energy is easily available. The energy required to produce hydrogen is more than what it releases during its utilization [23].

### 3.4. Hydrogen Storage

After production storage becomes an important issue which needs to be taken care of. Hydrogen can be stored as solid, liquid or gas in the form of glass micro-spheres, chemical hydrides, metal hydrides or cryo-adsorbers. Hydrogen storage in caverns, aquifers are costly and cause loss of gas and pressurized gas storage systems are similar as conventional gas storage systems. Liquid hydrogen storage is being used only in the condition of high need of hydrogen. Metal hydride storage system has an advantage of storing hydrogen in terms of safety aspect. This process requires system set up and the release of heat during the process is another important factor to make this storage system more popular [24].

### 3.5. Hydrogen Transport and Distribution

Hydrogen transportation by pipeline is up to 200 km from production to utilization sites but for effective transportation high capacity reciprocating compressors are used. The pipelines used for hydrogen transportation requires large diameter and more compression power. Due to low volume of hydrogen and lower pressure losses, less recompression stations are required and that too placed far apart. It has been estimated that transportation of hydrogen is cheaper comparative to electricity transport [25].

### 3.6. Hydrogen Utilization

The use of hydrogen as a fuel in the internal combustion engines has been found to a great extent. The hydrogen is more efficiently used by 20% in the internal combustion engines. The greater advantage is its more clean that is the use of hydrogen causes less amount of pollution compare to other gasoline engines. Hydrogen use in jet engines and turbines produces the only pollutant nitrogen oxides. Use of hydrogen in biomedical technology is becoming popular in the form of micro steam generator. Catalytic burners in household appliances are coming up with the use of combustion of hydrogen only [26].

### 3.7. Hydrogen Safety

Every process has its own risks and benefits. Similarly hydrogen can be a risk-full factor if the proper care is not done starting from the process of production until the process of utilization. Hydrogen has the smallest molecule so high tendency to leak through the smaller openings. Also due to low ignition energy of hydrogen the flame

becomes nearly invisible and that could be a dangerous issue as it becomes hard to detect if there is a fire [27]. Liquid hydrogen also causes the risk of cold burns. In spite of all the safety hazards hydrogen is still has a very good safety record and is actually a safer fuel than any other gas. Although the transition to a hydrogen society must happen at a relatively rapid pace in order to answer to the demands of the global community, safety considerations should not be overlooked. Although hydrogen is considered to be a safe form of energy, like gasoline or any form of fuel, it does have the potential to be dangerous under certain circumstances [28]. Regardless of whether hydrogen has the potential to be dangerous, government and industry leaders have to be proactive in shaping public perception when attempting to market the new fuel. Unfortunately, many people associate hydrogen with the hydrogen bomb of World War II and the Hindenburg disaster of the 1930s, even though neither incident relates to hydrogen fuel cell technology.

### 3.8. Benefit

There is an unmistakable link between energy and sustainable human development. Energy is not an end in itself, but an essential tool to facilitate social and economic activities. Thus, the lack of available energy services correlates closely with many challenges of sustainable development, such as poverty alleviation, the advancement of women, protection of the environment, and jobs creation. Emphasis on institution-building and enhanced policy dialogue is necessary to create the social, economic, and politically enabling conditions for a transition to a more sustainable future. On the other hand, biomass energy technologies are a promising option, with a potentially large impact for Sudan as with other developing countries, where the current levels of energy services are low. Hydrogen accounts for about one third of all energy in developing countries as a whole, and nearly 96% in some of least developed countries [29,30].

Climate change is a growing concern around the world, and stakeholders are aggressively seeking energy sources and technologies that can mitigate the impact of global warming. This global concern is manifest in the 1997 Kyoto Protocol, which imposes an imperative on developed nations to identify feasible options by the next Conference of the Parties to the Convention (COP) meeting later in 2001. Possible actions range from basic increases in energy efficiency and conservation, to sophisticated methods of carbon sequestration to capture the most common greenhouse gases (GHGs) emission (CO<sub>2</sub>). On the other hand, renewable energies have always been identified as a prime source of clean energies that emit little or no net GHGs into the atmosphere. Forest ecosystems cause effects on the balance of carbon mainly by the assimilation of CO<sub>2</sub> by the aboveground biomass of the forest vegetation. The annual emissions of greenhouse gases from fossil fuel combustion and land use change are approximately 33 x 10<sup>5</sup> and 38 x 10<sup>5</sup> tons respectively [31]. Vegetation and in particular forests, can be managed to sequester carbon. Management options have been identified to conserve and sequester up to 90 Pg C in the forest sector in the next century, through global afforestation [32,33]. This option may become a necessity (as recommended at the Framework Convention on

Climate Change meeting held in Kyoto), but a preventative approach could be taken, reducing total GHGs emissions by substituting biomass for fossil fuels in electricity production.

Simply sequestering carbon in new forests is problematic because trees cease sequestering once they reach maturity, and as available land is used up the cost of further afforestation will grow. Indeed the cost of reducing the build-up of GHGs in the atmosphere is already lower for fossil fuel substitution than for sequestration, since fast growing energy crops are more efficient at carbon removal, and because revenue is generated by the scale of electricity. Some biomass fuel cycles can also provide the additional benefits of enhanced carbon storage [34]. The relative merits of sequestration versus fossil fuel substitution are still debated. The flow of carbon during the life cycle of the biomass should determine whether it is better left standing, used as fuel or used as long-lived timber products [35]. Where there are existing forests in good condition there is general agreement that they should not be cut for fuel and replanted [36]. This principle also concurs with the guidelines for nature protection, i.e., energy crops should never displace land uses of high ecological value. Where afforestation is undertaken, however, fossil fuel substitution, both by using wood fuel and using timber as a renewable raw material, should be more sustainable and less costly approach than sequestration could also be used to displace the harvest of more ecologically valuable forests. For efficient use of Bioenergy resources, it is essential to take account of the intrinsic energy potential. Despite the availability of basic statistics, many differences have been observed between the previous assessments of Bioenergy potential [37]. These were probably due to different assumptions or incomplete estimations of the availability, accessibility and use of by products

## 4. Conclusion

Hydrogen technology can not only provide fuel, but is also important for comprehensive utilization of biomass forestry, animal husbandry, fishery, evaluating the agricultural economy, protecting the environment, realizing agricultural recycling, as well as improving the sanitary conditions, in rural areas. The hydrogen energy, one of the important options, which might gradually replace the oil in facing the increased demand for oil and may be an advanced period in this century. Any country can depend on the biomass energy to satisfy part of local consumption. Development of Hydrogen technology is a vital component of alternative rural energy programme, whose potential is yet to be exploited. A concerted effect is required by all if this is to be realised. The technology will find ready use in domestic, farming, and small-scale industrial applications. Support hydrogen research and exchange experiences with countries that are advanced in this field. In the meantime, the biomass energy can help to save exhausting the oil wealth. The diminishing agricultural land may hamper Hydrogen energy development but appropriate technological and resource management techniques will offset the effects. The conclusion obtained from the above topic is that we should increase the use of renewable sources of energy

and decrease the use of non renewable resources. Existing renewable resources are well established and proven. It has been seen through the various articles that available renewable energy resources are helping in the production of the other forms of energy which makes our energy system more strong and economical. Likewise the production of hydrogen, from the available wind energy, and its usage is more clean, safe and efficient. They are commercially available and are being utilized. The new upcoming technologies in renewable resources are very promising but a lot more research and infrastructure is required before it can be adapted.

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