Solar Extracted Hydrogen Fuel for Benefits of Society

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***Abstract*—One of the reasons why we put hydrogen in internal combustion engines is to lessen the pollution and our reliance on fossil fuels. In contrast to petrol or diesel, hydrogen mostly creates water vapor when it is burnt, hence carbon emissions are significantly reduced. Because of that, hydrogen vehicles are considered as less harmful to the environment. Hydrogen has also high energy value and the combustion of it is very rapid and quite over a broad range of temperatures. It can be used with different air–fuel mixtures, which will lead to the overall engine efficiency to be higher. Just one more good thing about hydrogen is that it can be made with renewable energy sources and that makes it a nice choice for the energy of tomorrow. Right now, lots of countries are dealing with energy problems in energy demand and supply. As an illustration, India had an energy shortage of about 4.3 percent in the year 2020. Traditional energy sources such as coal and natural gas come with a lot of problems. Their sources are not renewables, so after they are used, they cannot be replaced within our lifetime. Moreover, their availability is limited, and their price is going up gradually. On top of that, a major problem is that the burning of these fuels releases some harmful gases to the environment, which will causes pollution and global warming. To lower their growing energy demand, several countries are gradually switching to renewable energy sources, which are cleaner and more sustainable. In our experiment, hydrogen is generated through an HHO generator which is then used as a supplementary fuel for vehicles. The engine gets the mixture of hydrogen and petrol, therefore the vehicle's fuel consumption and performance improve.**

***Index Terms*—Green Hydrogen, Solar Electrolysis, Renewable Energy, Hydrogen Fuel Production, Sustainable Energy, Energy Transition, Clean Fuel Technology, Societal Benefit Solar Hydrogen Generation**

I. INTRODUCTION

AIM OF THE PROJECT

Our primary objective with this project is to operate a car via a hybrid fuel system that derives energy from the sun. This particular system utilizes hydrogen and petrol as fuel together. To generate the hydrogen gas, the solar panel is coupled with the wet HHO generator. This not only makes the vehicle more fuel-efficient but also helps in lessening the air pollution. One of the best energy solutions is the generation of hydrogen fuel with solar energy. Green hydrogen is a trending new concept that is slowly gaining popularity in many sectors due to the world's transition to cleaner energy sources. This method involves the use of solar energy to split water into hydrogen and oxygen. In the context of the global energy transition towards sustainable and decarbonized solutions, green hydrogen has emerged as a vital component across the transportation, energy, industry, and heating sectors [1]. The resulting hydrogen is then used as a clean fuel. Most of the time, this process is performed using electrolysis, which is a renewable energy method and can be instrumental in conservation of fossil fuels. The hydrogen so produced may be used in fuel cells or combustion engines. Technological Approaches Photovoltaic-Electrolysis (PV-EL) use here. Basically, a panel array is the source of power which is eventually used to energize a unit called an electrolyzer, that will separate water into hydrogen and oxygen. A group of scientists researches new ways of utilizing solar energy for the direct splitting of water, thus making hydrogen and releasing almost no pollutants into the environment. Solar Thermochemical Hydrogen Production: This method uses solar energy to produce the heat necessary for the water separation process; therefore, it can generate hydrogen at a very high level of efficiency and in large quantities. Scope of the Project. The increasing demand for hydrogen, specifically green hydrogen, has led to an increasing demand for electrolyzers [5]. By swapping fossil fuels for clean hydrogen, this system aids in the lessening of carbon emissions and, in addition, it decreases air pollution which is a great advantage for public health. It is powered by renewable solar energy; therefore, the environmental impact is minimal. The project is about

building a highly efficient solar-powered system for hydrogen production. It also researches new materials to enhance the electrolysis process. The hydrogen generated can be combined with fuel cells to store energy and release electricity when needed. Technology for solar hydrogen should work with solar energy as the main source for fuel production. Photovoltaic cells or solar panels are elements responsible for changing the solar radiation in electrical energy. This electricity is used to break water molecules apart creating hydrogen and oxygen. The former can later be used as fuel source in cars, industries, and other energy applications, without giving off any kind of pollutant. Besides solar panels, an electrolyzer and a hydrogen reservoir are some of the other necessary devices to a proper system. Such innovation is becoming better with time and thus, it contributes to the decrease of pollutant emissions and fossil fuel consumption. Reducing the use of fossil fuels helps in improving energy security and can create new jobs in the renewable energy sector. Over time, it can reduce fuel costs and provide a long-term energy solution, especially for rural and developing areas. Better energy access can also be given to remote regions. The main aim is to lower dependence on fossil fuels and reduce energy expenses. Promoting hydrogen fuel for transport, industries, and homes supports clean energy goals like SDG 7, which focuses on affordable and clean energy. Hydrogen production on a massive scale to meet the needs of transport, industries, and power generation is definitely feasible. Some of the best minds in the world are on the job finding improved ways to store and distribute hydrogen in a safe manner. In addition, hydrogen can be used along with smart grids to ease energy management. As a matter of fact, this entire endeavor is about making hydrogen a viable and environmentally friendly source of energy.

II. LITERATURE SURVEY

1 Hydrogen fuel can be produced in a renewable way using solar energy. Building a global hydrogen economy is considered an important step toward sustainable energy and reducing carbon emissions. The development of a global hydrogen economy is widely regarded as a critical pathway toward achieving energy sustainability and decar bonization, offering solutions to energy security, environmental degradation, and industrial decarbonization [2]. This method uses sunlight to split water into hydrogen and oxygen, using techniques like photocatalysis, electrolysis, and solar thermochemical reactions. Overall, it supports worldwide efforts to lower carbon emissions and transition to cleaner energy.

2 Research on producing hydrogen fuel from solar energy highlights many societal benefits. The adoption of green hydrogen offers substantial environ mental and socio-economic benefits [1]. advantages, such as enhancing energy security, lowering greenhouse gas emissions, and supporting economic growth through technological innovation. Researchers are exploring ways to increase hydrogen production, focusing on improving photocatalysts, making electrolyzers more efficient, and integrating these systems with renewable energy storage.

3 This analysis examines current research on technologies that produce hydrogen from solar energy. China was followed by Germany and the United States, with a significant difference of 33% and 37%, respectively, in terms of hydrogen exports [9]. The technology of green hydrogen can play a vital role in energy storage. Electrolysis can be utilized for producing hydrogen by using a surplus of renewable energy produced when demand is low [4]. The study focuses on the efficiency, challenges, and applications of solar-derived hydrogen in transportation, industry, and household energy. It also considers the social, economic, and environmental impacts of large-scale hydrogen use. Researchers aim to tackle issues such as cost, infrastructure, and storage, demonstrating that hydrogen fuel can be a practical solution for global energy needs.

4 As our research Other researchers took several approaches. Some built solar hydrogen systems, collected real sunlight and cost data, ran simulations to find the best setup, and then compared costs, efficiency, and potential future benefits. A few studies examined how green hydrogen fits into national strategies, such as Algeria's plans to export hydrogen to Europe. Others conducted review studies to evaluate global research and advancements in the field.

5 Many studies focus on producing hydrogen from water using renewable energy sources like wind and solar power. Water electrolysis is a recognized method for generating oxygen and hydrogen gas [10]. The electrolysis of water using surplus renewable energy is considered an important development [11]. In this process, electricity is used to break water molecules into hydrogen and oxygen. Researchers have tested different types of electrolyzers and found that combining solar panels with an alkaline electrolyzer is more efficient and produces hydrogen at a lower cost. Everyone agrees that this method can help reduce pollution and decrease reliance on fossil fuels.

6. The project utilized solar panels, various types of electrolyzer machines, and tanks and compressors for storing hydrogen. It used clean water or purified seawater for the process. Additionally, software tools were employed: HOMER to estimate the system's cost and performance, and VOSviewer to analyze research trends. All of the resources were chosen to keep hydrogen clean and safe for future use.

7 What researchers found exactly? Solar thermal or collectors are another form of exploitation of solar energy [6]. The intriguing findings include the potential for more affordable green hydrogen production in the future. PTC and STC technologies have the ability to reduce the CO2 emission during H2 production [7]. Hydrogen produced by one system configuration was reasonably priced at roughly 2.12 USD per kilogram. By replacing dangerous fuels in sectors like energy, manufacturing, and transportation, hydrogen could aid in the fight against climate change. It can also assist nations like Algeria and South Africa in creating new jobs and exporting renewable energy.

8 One of the biggest challenges is the high cost of hydrogen production [12]. The idea is great, but there are a few issues. The initial cost is high pipes for storage and transportation are not yet finished solar power and water supply are affected by the weather and some modern electrolysers still need to be improved. Another challenge is the lack of hydrogen infrastructure [12]. Also, a lot of countries still don't have strong rules or help for hydrogen.

9 Germany's "National Hydrogen Strategy" focuses on using green hydrogen to decarbonize industrial sectors and reduce emissions in transportation.[8] The scenarios are for predicting the hydrogen trade outlook towards 2050 in which hydrogen production and costs of transportation are accessible [4]. If possible, we should Reduce the cost of electrolysers. Develop new materials to improve technology. Build hydrogen storage and transportation infrastructure. Use more renewable energy. Green hydrogen will then become common.

III. METHODOLOGY

OBJECTIVES

The objectives of the Hydrogen Fuel Project are as follows: The primary objective of this project is to develop a sustainable and efficient hydrogen fuel production system using solar energy. The specific objectives include:

1. Environmental Sustainability

Decreasing greenhouse gas emissions by substituting fossil fuels with clean hydrogen. Harnessing solar energy as a sustainable and environmentally-friendly method for hydrogen production. Minimizing ecological impact while advancing green energy alternatives. Constructing and managing a solar-powered electrolysis system to derive hydrogen from water. Enhancing the efficiency and affordability of the electrolysis process. Investigating new materials and technologies to boost hydrogen production rates.

2. Efficient Hydrogen Production

Develop a solar-powered electrolysis system to produce hydrogen from water. A 250 kg/day hydrogen load is incorporated into the simulation model for hydrogen production end use for remote areas. The fixed hydrogen load profile is used to evaluate system performance and cost under uniform conditions [3]. Improve the process's effectiveness and economy. to look into cutting-edge technologies and materials to boost the production of hydrogen. supplying rural and undeveloped areas with sustainable, clean energy. increasing knowledge of the benefits of using hydrogen as fuel. to back policies and initiatives of the government that advance renewable energy

3. Storage and Utilization

To create effective ways to transport and store hydrogen fuel to produce clean energy by combining fuel cells and hydrogen fuel. to investigate hybrid

energy systems that combine other renewable energy sources with solar hydrogen.

4. Future Scalability and Research
To look into new developments and trends in solar hydrogen technology to assess the viability of producing and distributing hydrogen widely to help achieve global sustainability goals, especially in clean energy.

IV. COMPONENT

Hardware
1. Solar plate
2. Charge controller
3. Voltage regulator
4. HHO generator
5. Filters
6. valves
7. battery
8. Housings
9. Ms frame
10. Carburetor fuel ratio mixture valve
11. Led indicator

HARDWARE REQUIREMENTS
Solar Plate:
Charge Controller:
Voltage Regulator:
HHO Generator
Filters
Battery

V. BLOCK DIGRAM

Electricity powers an electrolyzer.
* The electrolyzer splits water (H_2O) into hydrogen (H_2) and oxygen (O_2) using electrolysis.

* The chemical reaction:
2H2O→2H2+O22H_2O \right arrow 2H_2 + O_22H2O→2H2+O2Hydrogen Collection & Storage

* The separated hydrogen gas (H_2) is collected.
4.

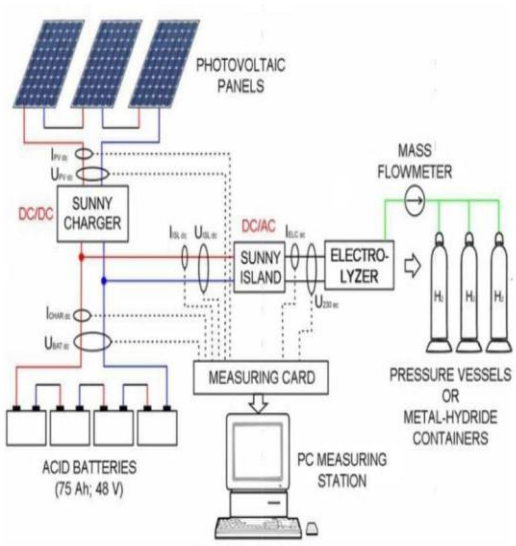

Fig.3.5 No. Block Diagram

VI. WORKING

Hydrogen is regarded as a relatively clean fuel and is predicted to play a significant role in the future. When we use solar energy to manufacture hydrogen, we create a truly sustainable and environmentally beneficial fuel source. Solar panels create power from sunlight, which helps split water into hydrogen and oxygen. This procedure is known as electrolysis. We can then store the hydrogen gas and utilize it to power automobiles, create energy, or power other machinery all without polluting the environment or emitting dangerous gases. As a result, solar-extracted hydrogen fuel is seen as a wise and sustainable way to fulfill our future energy demands
1. Solar Energy Capture
* Solar panels (Photovoltaic) or Concentrated Solar Power (CSP) systems capture sunlight.
* This energy is converted into electricity.

2. Electricity Generation
* Photovoltaic (PV) cells generate DC electricity.
* If CSP is used, heat energy is converted into electricity via steam turbines.

3. Water Electrolysis
* It is compressed or liquefied for efficient storage.
* Storage methods include compressed gas cylinders, metal hydrides, or cryogenic tanks.

VII. RESULT

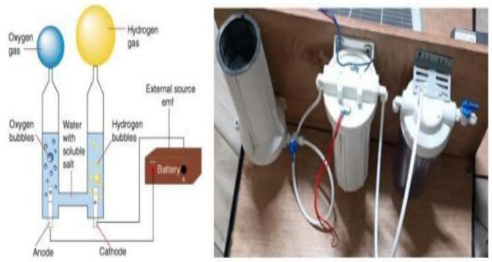

Fig 1.4:-HHO Generator

CONCLUSION

In this study, a solar-powered electrolyser system was analysed to check how much hydrogen fuel can be produced daily and how cost-effective it is. A 1 kW solar panel setup was considered, which typically produces around 5 kWh of electrical energy per day in most regions of India. Using a standard electrolysis requirement of 50 kWh of electricity for producing 1 kg of hydrogen, the hydrogen production rate is calculated as: Hydrogen production = 5 kWh ÷ 50 kWh/kg = 0.1 kg/day. This shows that even a small rooftop solar system can generate a measurable amount of clean fuel every day.

Parameter	Value	Unit
Solar system rating	1.0	kW
Average daily sunlight	5	hours
Daily solar energy	5	kWh/day
Electrolysis energy requirement	50	kWh/kg
Hydrogen output per day	0.1	kg/day
Hydrogen output per year	36.5	kg/year

Electricity cost from solar is lower compared to grid supply. The average generation cost of solar energy is assumed around:
₹4 per kWh common estimate in India
So, cost of hydrogen becomes:
Cost/kg = 50 kWh × ₹4/kWh = ₹200 per kg
This cost is much cleaner and future-wise cheaper compared to petrol.
To understand the replacement value:

- 1 kg Hydrogen = energy of 3.5 liters petrol
- Petrol price = ₹100/liter Equivalent petrol cost = ₹350 per day Hydrogen cost = ₹200 per kg So savings per kg = ₹150 cheaper than petrol.

These results clearly show that solar-based hydrogen fuel production is practical for small-scale use and is already cost-competitive. If the system size is increased, the hydrogen production and cost savings will improve even more. Along with economic benefit, this method reduces oil usage and helps protect the environment, making it useful for society in the long term.

VIII. CONCLUSION

So we got final conclusion that Solar energy extraction offers an entirely renewable and environmentally benign method of producing hydrogen, which is regarded as a clean and sustainable fuel of the future. Sun extracted hydrogen fuel is created when water molecules are broken down into hydrogen and oxygen using solar energy. Electrolysis is one technique that utilizes energy produced by solar panels or concentrated solar power (CSP) systems. The produced hydrogen gas can be stored until being used as fuel for a range of purposes, such as industrial, transportation, and energy production. Solar-extracted hydrogen fuel has enormous, diverse, and revolutionary potential to improve civilization. It addresses some of the most significant global concerns, such as public health, energy security, economic inequality, and climate change, via innovative and sustainable solutions. Solar hydrogen is an excellent example of environmental stewardship as it produces and uses no greenhouse emissions. An increasingly important part of the world's shift from fossil fuels to sustainable energy is solar-powered hydrogen extraction. Solar-powered electrolysis is a scalable and sustainable method of producing hydrogen that may be used for both personal mobility and large-scale industrial applications powered electrolysis is a scalable and sustainable way to produce hydrogen. Solar hydrogen is essential for reducing climate change and preserving natural ecosystems for future generations because it drastically reduces the carbon footprint of energy production and consumption. Additionally, this technology is essential for improving resilience and energy independence. Investing in the production of solar hydrogen can help nations become less

dependent on imported fossil fuels. This invention lowers countries' risk from shifts in the global energy market and political influences by allowing them to manage their own energy future. Hydrogen plays a key role in energy transport. It efficiently distributes and stores energy, working well with renewable sources such as solar and wind. By storing surplus energy generated during peak times and releasing it when demand rises or when sunlight and wind are insufficient, hydrogen provides a practical answer to the challenges posed by renewable energy's variability. Solar hydrogen has many benefits for humanity.

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