Performance Analysis of Header & Raiser Solar Module With Silica Sand

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Abstract- *The main aim of this paper is to create an innovative integrated system that harnesses renewable energy, specifically solar and wind sources, to generate four valuable outputs simultaneously. Electricity, hydrogen, freshwater, and cooling, tailored to meet community needs. Additionally, the system incorporates a thermal energy storage solution based on silica sand, enhancing its efficiency, cost-effectiveness, and environmental sustainability. The unique aspect of this multigeneration system lies in its exclusive reliance on renewable energy sources for all outputs, distinguishing it from existing designs and providing a sustainable approach to achieving net-zero carbon emissions. A comprehensive analysis of the system is conducted, employing both energy and energy principles, to assess its performance through the evaluation of energy and energy efficiencies.*

Keywords- Eco-friendly, carbon free, sustainability, green energy, environmental protection, smart technology.

I. INTRODUCTION

As the repercussions of fossil fuel consumption affect communities, governments are striving to implement ambitious initiatives focused on energy efficiency, decarbonization, and energy storage, all of which are vital to the expanding energy economy. [1] The efficiency of wafer-based crystalline as well as Thin-film Solar photovoltaic cells get reduced with increase of panel temperature. It is noted that the efficiency drops by about 0.5% for increase of 1°C of panel temperature. Given the varying energy needs of different communities, integrated systems that provide multiple outputs are essential for the effective utilization of renewable energy sources. Consequently, significant efforts have been dedicated to modeling and analyzing these systems. Globally, there are incentives aimed at transitioning to electric vehicles and buildings by 2040. [2] The performance of photovoltaic (PV) panels relies on the surrounding working temperature". The majority of incident solar radiation dissipates as heat accumulation on PV panels in hot climates, which negatively affects PV performance because of elevated temperatures. PV modules must be cooled effectively in order for their performance to remain at a respectable level.

Additionally, numerous countries have established diverse energy policies targeting a reduction of carbon emissions to net-zero by 2060. [3] The experimental investigations of different cooling methods used for photovoltaic (PV) panels. Phase change material (PCM), thermoelectric (TE) and aluminum fins were chosen as the cooling methods". Policies targeting a reduction of carbon emissions to net-zero by 2060.

Silica sand serves as a reliable and cost-effective medium for thermal energy storage, capable of holding up to 5,000 MWh with minimal environmental repercussions during both extraction and disposal. This translates to a storage cost of approximately \$2 to \$4 per kWh of thermal energy, achieved with a temperature variation of 900 °C. Additionally, the economic advantages of silica sand, priced between \$35 and \$45 per ton, further enhance its appeal as an ideal storage solution. [4] An alternative cooling technique for photovoltaic (PV) panels that includes a water spray application over panel surfaces. An alternative cooling technique in the sense that both sides of the PV panel were cooled simultaneously, to investigate the total water spray cooling effect on the PV panel performance in circumstances of peak solar irradiation levels. [6] describe this study investigates a solar thermal integrated system combining a supercritical-CO_2 (sCO_2) gas turbine cycle, a four-step Mg-Cl cycle, and a five-stage hydrogen compression plant. To maintain continuous operation, a molten salt storage system is employed. [5] The water-based cooling methods increase the output power of photovoltaic (PV) panels. In contrast to other energy storage options, such as lithium-ion batteries, silica sand not only offers a more affordable alternative but also presents a cleaner option that avoids the global hazards associated with battery disposal. To maintain continuous operation, a molten salt storage system is employed. The specific heat capacity of silica sand varies with temperature; for this analysis, it is assumed to be 1.5 J/gK at 1500 °C. To reduce heat loss, the heated sand particles are stored in concrete silos.

Sand thermal energy storage systems are not limited by geographical constraints. The sand particles involved in the process are transported via a conveyor system. The main aim of this paper is to create an innovative integrated system that harnesses renewable energy, specifically solar and wind sources, to generate four valuable outputs simultaneously: electricity, hydrogen, freshwater, and cooling, tailored to meet community needs. Additionally, the system incorporates a thermal energy storage solution based on silica sand, enhancing its efficiency, cost effectiveness, and environmental sustainability. The unique aspect of this multigeneration system lies in its exclusive reliance on renewable energy sources for all outputs, distinguishing it from existing designs and providing a sustainable approach to achieving net-zero carbon emissions. A comprehensive analysis of the system is conducted, employing both energy and energy principles, to assess its performance through the evaluation of energy and energy efficiencies.

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II. METHODOLOGY

Water electrolysis is a process that uses electrical energy to break down water (H_2O) into its basic components: hydrogen (H_2) and oxygen (O_2). This occurs in an electrolyzer, which consists of two electrodes the anode and cathode submerged in water. When an electric current is passed through the water, hydrogen gas forms at the cathode, while oxygen gas is produced at the anode. Electrolysis is an important method for producing hydrogen, which can be used as a clean fuel source. The process requires pure water and an electrolyte to improve conductivity and efficiency.

III. EXPERIMENTAL SETUP

An experimental setup for hydrogen production through water electrolysis involves several key components that work together to break down water (H_2O) into its constituent gases—hydrogen (H_2) and oxygen (O_2). This process is powered by electrical energy and is facilitated by the electrolysis of water, typically performed in a controlled laboratory or small-scale industrial setup. The main components include the electrolyzer, power supply, electrodes, electrolyte, gas collection system, water tank, and monitoring tools. Below is a detailed description of each component involved in the experimental setup.

The electrolyzer is the central unit in the setup where electrolysis occurs. It consists of a chamber that holds the electrolyte solution and houses the electrodes. The electrodes-typically made of conductive materials like platinum, stainless steel, or graphite are strategically placed in the electrolyte solution. Flow chat shown in the figure 1. The electrolyzer is designed to ensure that the electrodes remain submerged in the solution, allowing for efficient electrolysis. The two electrodes are connected to an external circuit that provides the necessary electrical current to facilitate the reaction.

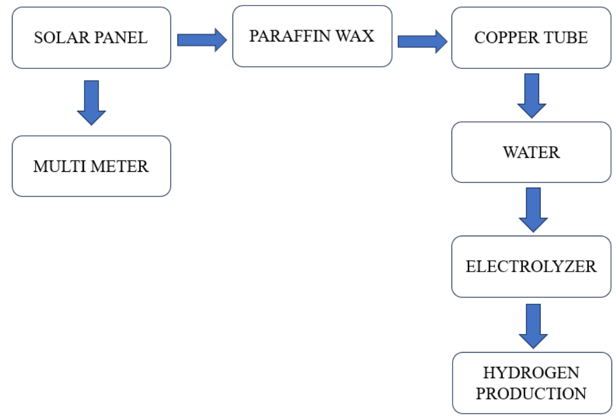

Figure. 1 Flow Chat

There are two electrodes in the electrolyzer: the anode (positive electrode) and the cathode (negative electrode). The anode is where oxygen (O_2) is produced, and the cathode is where hydrogen (H_2) is generated. The materials used for the electrodes are chosen for their ability to conduct electricity effectively and resist corrosion under the electrolytic conditions. Platinum is often used for its high efficiency and durability, although less expensive materials like stainless steel are also common in experimental setups.

A constant DC (direct current) power supply is essential for water electrolysis. The power supply provides the voltage and current necessary to break the bonds between hydrogen and oxygen atoms in the water molecules. The voltage typically used for water electrolysis is in the range of 1.8 to 2.2 volts, although the actual voltage may vary depending on the electrolyte concentration and electrode material.

The current is adjusted to control the rate of electrolysis and, subsequently, the volume of hydrogen and oxygen gases produced. The electrolyte is a solution that enhances the conductivity of water, allowing the electric current to flow more efficiently. Power reading shown in the figure 2. Pure water has low conductivity, so a small amount of an electrolyte such as potassium hydroxide (KOH), sodium hydroxide (NaOH), or sulfuric acid (H_2SO_4) is added to improve the ionization of water. The electrolyte helps facilitate the splitting of water molecules into hydrogen and oxygen gases at the electrodes.

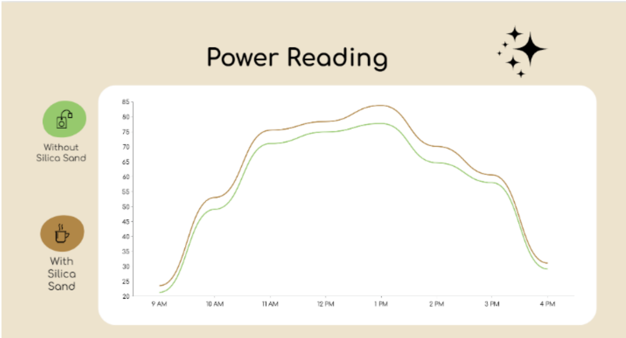

Figure. 2 Power Reading

The concentration of the electrolyte affects the efficiency of the electrolysis process, and its temperature can also play a role in the reaction rate. The gases produced during electrolysis hydrogen at the cathode and oxygen at the anode must be collected and stored separately. This is achieved using a gas collection system that typically consists of inverted graduated cylinders or gas burettes connected to the electrodes. The gases are captured in these containers as they bubble up from the electrodes, and the volume of gas produced can be measured. This system ensures that the hydrogen and oxygen gases do not mix, maintaining safety and allowing for accurate quantification of the gases. The water tank holds the electrolyte solution and provides the medium through which electrolysis occurs. It is typically a container filled with purified or distilled water to avoid impurities that could interfere with the electrolysis process. The tank is large enough to ensure the electrodes are fully submerged and that there is a continuous supply of water for electrolysis.

The water must be replenished periodically, depending on the scale of the experiment. Hydrogen is a highly flammable gas, so a pressure regulator is an important safety feature in the setup. The regulator ensures that the collected gases are stored at safe pressures, which is especially critical when dealing with hydrogen. To monitor the efficiency of the electrolysis process, flow meters are used to measure the volume of gases produced. These devices provide real-time data on the amount of hydrogen and oxygen being generated, allowing researchers to calculate the efficiency of the system. Other measurement tools may include thermometers to monitor the temperature of the electrolyte, voltmeters to ensure the proper voltage is applied, and ammeters to measure the current flowing through the system.

Hydrogen gas is highly flammable and can be explosive when mixed with oxygen, so safety measures are crucial in the experimental setup. Aside from the pressure regulator, the setup should be placed in a well-ventilated area to allow the gases to dissipate safely. Additionally, non-sparking tools should be used for any handling or maintenance of the equipment, and fire extinguishers should be readily available.

IV. CONCLUSION

The commercialization of hydrogen production processes utilizing renewable energy, along with the development of markets and infrastructure, necessitates further investigation. For remote areas that lack grid access, water electrolysis systems powered by off-grid solar photovoltaic or wind energy can be employed. Additionally, hydrogen has the potential to significantly contribute to the decarbonization of the maritime sector by utilizing offshore wind energy to generate clean fuel. Blue hydrogen can be transported globally in the form of ammonia, which can be easily converted back to hydrogen on-site. The commercial implementation of carbon dioxide removal technologies can also support the achievement of net-zero CO_2 emissions and help mitigate global warming by 1.5 °C. Beyond its traditional role as an industrial feedstock for ammonia and methanol production, hydrogen is being explored as a new energy carrier. This study addresses the technologies for hydrogen production from both conventional and renewable energy sources, as well as the key challenges faced in the practical application of these systems. Various renewable energy sources, including solar, wind, geothermal, hydro, and biomass, are considered for hydrogen production. Given that intermittent renewable sources like solar and wind are among the most promising, hydrogen emerges as an optimal choice for fuel, energy transport, and storage. Due to its advantages and the availability of carbon-free alternatives, hydrogen is increasingly recognized as a viable fuel and a distinctive energy carrier on a global scale. This review article offers a concise overview of different hydrogen production methods based on conventional and renewable energy sources, detailing each method while highlighting the progress made to date. The selection of hydrogen energy for various applications can be advantageous due to its low emissions.

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