SOLAR POWERED GREEN HYDROGEN GAS PRODUCTION AND QR CODE SCANNING FOR UTILIZATION

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Abstract

With the increasing trend of energy demand, it has brought a huge burden to the environment. Since sustainable development is a dominant agenda or top priority for nearly every country, there is a pressing need to find clean and sustainable alternatives to replace existing non-renewable sources (e.g., fossil fuels). Hydrogen, as a clean, safe, and efficient energy source has a wide range of applications, in which it can meet energy demands while eliminating greenhouse gas emissions. In the past decades, there was a rapid development of hydrogen-related technologies, especially hydrogen energy storage technology. Therefore, this paper will mainly examine hydrogen storage in geological formations as well as its related hydrogen production process in order to explore how it helps solve energy-related environmental issues. Besides, this paper will also employ qualitative and quantitative studies to analyze and compare different hydrogen storage methods in order to determine a feasible approach that can be widely used in the industrial sector. Overall, the results will shed light on guiding future research of underground hydrogen storage (UHS) that will be contributed to the way of sustainability. This research focuses on the integration of solar-based hydrogen gas production with QR code scanning for efficient utilization. Hydrogen gas is a promising alternative to traditional fossil fuels due to its high energy density and environmental friendliness. Solar-based hydrogen production systems utilize renewable energy sources, such as solar power, to generate hydrogen gas through electrolysis. To enhance the utilization of hydrogen gas, this project proposes the use of QR code scanning technology, enabled by Internet of Things (IoT) devices.

Introduction

The integration of photovoltaic energy systems with electrolysis has led to interesting developments in the production of hydrogen gas. Electrolysis of water using electricity from photovoltaic energy enables the storage, transportation, and reuse of energy without causing pollution. Previous research on water electrolysis for hydrogen production has primarily focused on alkaline electrolysis systems and proton exchange membrane (PEM) electrolysis. PEM electrolysis offers several advantages over conventional alkaline electrolysis systems, including ecological cleanliness, simplicity, high efficiency, and easy scalability. Optimization and modelling of the various components of photovoltaic-electrolysis systems have attracted the attention of scientists and researchers aiming to achieve optimal hydrogen production. Approaches such as maximum power point tracking and output current control have been employed to optimize the overall system, including photovoltaic electrolysis and DC/DC converters. Additionally, empirical models have been developed to simulate regenerative electrolysis. These models adapt the voltage and maximum power of the photovoltaic system to match the voltage requirements of PEM electrolysis, resulting in improved hydrogen production. New catalysts for PEM electrolysis have also been developed to enhance hydrogen production. However, most research studies have not taken into account the impact of water flow control on the performance of hydrogen production and the overall photovoltaic-electrolysis system. This article focuses on the importance of controlling the water flow injected into the electrolysis process to maximize hydrogen production while considering the power transferred by the photovoltaic system.

The article presents a comprehensive and simplified model of the photovoltaic generator and PEM electrolysis, analysing the results of the modeling process. It also describes the control system in detail. Furthermore, simulation results are provided to illustrate the effectiveness of the proposed strategies. The conclusions drawn from the study contribute to advancing the understanding of hydrogen gas production through electrolysis processes and their integration with photovoltaic systems.

Photovoltaics

Photovoltaic (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics and photochemistry. Photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process takes place involving crystallized atoms being ionized in a series, generating an electric current. Power generation from solar PV has long been seen as a clean sustainable. Energy technology which draws upon the planet’s most plentiful and widely distributed renewable energy source - the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. It is well proven, as photovoltaic systems have now been used for fifty years in specialized applications, and grid-connected PV systems have been in use for over twenty years. Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic has declined steadily since the first solar cells were manufactured, and the liveliest cost of electricity from PV is competitive with conventional electricity sources in an expanding list of geographic regions. Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity; have supported solar PV installations in many countries. With current technology, photovoltaic recoups the energy needed to manufacture them in 1.5 to 2.5 years in Southern and Northern Europe, respectively.

Solar Cells

Photovoltaic are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current.

The photovoltaic effect was first observed by Alexandre-Edmond Becquerel in 1839. The term photovoltaic denotes the unbiased operating mode of a photo diode in which current through the device is entirely due to the transuded light energy. Virtually all photovoltaic devices are some type of photodiode.

Modelling of Solar Cell

Solar energy directly converts sun light in to electrical energy. so solar is direct set of energy .Solar irradiation are used to generate electricity. Now a day's solar system is available or used worldwide in private sector, government sector and also in residential house. solar circuit consist current source which is connected in parallel with respect to diode. For figure The current source is used to measure current produce due to photons and temperature and light which is incident on solar panel. Solar panel is developed with number of solar cell in series and parallel connection. One solar cell developed using combination of series and parallel resistance with respect to diode and current source

Electrical characteristics of PV module of solar cell are determine by current and voltage characteristics which is plot by connecting variable resistive load to solar cell which is as shown in fig. The short circuit current is most important in case of solar cell with respect to open circuit voltage i.e. Voc. The maximum power attain by PV system is calculated as Pmax=Imp * Vmp

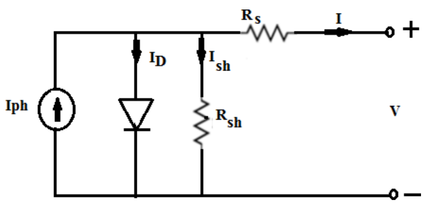

Figure 1 Open Circuit

P-V Characteristic of a Solar Panel

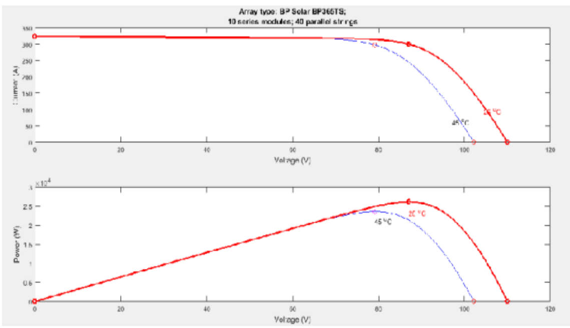

Figure 2 I-V Characteristics of PV Module

From fig. shows I-V characteristics of PV module which is equivalent to characteristics of solar cell .When we connect different resistive load in PV module with different irradiation condition the combination of current and voltage is recorded which result in I-V curve. Multiplication of I-V pairs tends to output power which reaches to its maximum value which is consider as "Maximum Power Point" to obtain this standard condition we consider air mass index 1.5 ,irradiance 250 W/^{m2} to 1000 W/m2and cell operating temperature is set up to 25 ^{o}C .from Fig 1.4 when irradiance is less then voltage decrease automatically because Ish is proportional to E (Ish=short circuit current,E=irradiance) fig. indicates maximum power attain at 1000W/m^{2} at 25^{o}C.

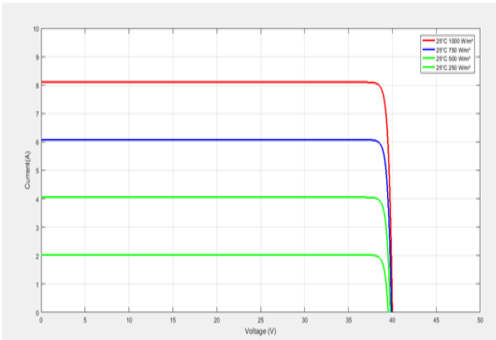

Figure 3 I-V Characteristics of Multi-Crystalline Silicon PV Module at Different Irradiance

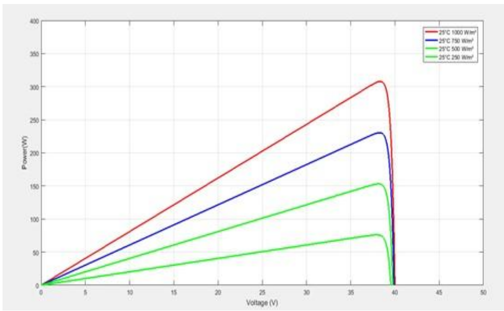

Figure 4 PV Characteristics of Different Irradiance

Boost Converter

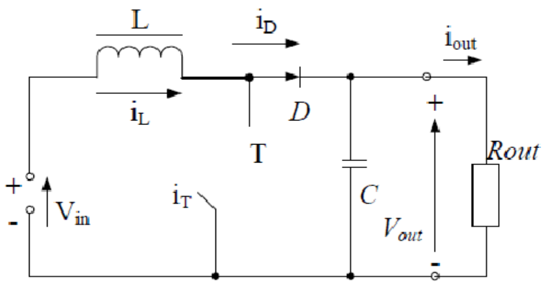

Figure 5 Boost Convertor Circuit

The boost converter is used to controlled level of voltage from output of PV system through MPPT. When voltage measured by MPPT is higher than set point (i.e. 450V) controller controls operate. Vin= V Input Voltage. Vout=V Output Voltage. D = Duty Cycle.

Growth of Solar Cell Implementation

Solar photovoltaic is growing rapidly and worldwide installed capacity reached at least 177 gig watts (GW) by the end of 2014. The total power output of the world's PV capacity in a calendar year is now beyond 200 TWh of electricity. This represents 1% of worldwide electricity demand. More than 100countries use solar PV. China, followed by Japan and the United States is now the fastest growing market, while Germany remains the world's largest producer (Fig), contributing more than 7% to its national electricity demands. Photovoltaic is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity.

Roof-Top Solar Panel Arrangements

Figure 6 Roof-Top Solar Panel

Several market research and financial companies foresee record-breaking global installation of more than 50 GW in 2015. China is predicted to take the lead from Germany and to become the world's largest producer of PV power by installing another targeted 17.8 GW in 2015.India is expected to install 1.8 GW, doubling its annual installations. By 2018, worldwide photovoltaic capacity is projected to doubled or even triple to 430 GW. Solar Power Europe (formerly known as EPIA) also estimates that photovoltaic will meet 10% to 15% of Europe's energy demand in 2030.The EPIA/Greenpeace Solar Generation Paradigm Shift Scenario (formerly called Advanced Scenario) from 2010 shows that by the year 2030, 1,845 GW of PV systems could be generating approximately 2,646 TWh/year of electricity around the world. Combined with energy use efficiency improvements, this would represent the electricity needs of more than 9% of the world's population. By 2050, over 20% of all electricity could be provided by photovoltaic. Michael Liebreich, from Bloomberg New Energy Finance, anticipates a tipping point for solar energy. The costs of power from wind and solar are already below those of conventional electricity generation in some parts of the world, as they have fallen sharply and will continue to do so. He also asserts that the electrical grid has been greatly expanded worldwide, and is ready to receive and distribute electricity from renewable sources. In addition, worldwide electricity prices came under strong pressure from renewable energy sources that are, in part, enthusiastically embraced by consumers.

Solar cells produce direct current electricity from sun light which can be used to power equipment or to recharge a battery. The first practical application of photovoltaic was to power orbiting satellites and other spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation. In this case an inverter is required to convert the DC to AC. There is a smaller market for off-grid power for remote dwellings, boats, recreational vehicles, electric cars, roadside emergency telephones, remote sensing, and cathodic protection of pipelines.

Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaic include mono crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Copper solar cables connect modules (module cable), arrays (array cable), and sub-fields. Because of the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years. Solar photovoltaic power generation has long been seen as a clean energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source – the sun. The technology is Cells require protection from the environment and are usually packaged tightly behind a glass sheet. When more power is required than a single cell can deliver, cells are electrically connected together to form photovoltaic modules, or solar panels. A single module is enough to power an emergency telephone, but for a house or a power plant the modules must be arranged in multiples as arrays.

Electrolysis

Electrolysis is a chemical process that uses an electric current to drive a non-spontaneous chemical reaction. It involves the decomposition of a compound into its constituent elements or ions through the passage of electric current.

The general formula for the electrolysis process can be represented as follows:

Compound (in electrolyte) → Cations (positive ions) + Anions (negative ions)

During electrolysis, the positive ions migrate towards the negative electrode (cathode), where reduction occurs, while the negative ions migrate towards the positive electrode (anode), where oxidation takes place.

The overall electrolysis reaction can be summarized as:

Cations (at cathode) + n electrons → Reduced product

Anions (at anode) - n electrons → Oxidized product

The specific reactions and products depend on the electrolyte used in the process. For example, in the electrolysis of water (H_2O), the equation can be written as:

$2H_2O$ (liquid) → $2H_2$ (gas) + O_2 (gas)

Here, water molecules are broken down into hydrogen gas (at cathode) and oxygen gas (at anode) through the application of an electric current. It's important to note that the actual reactions and stoichiometry may vary depending on the electrolyte, concentration, and conditions of the electrolysis process.

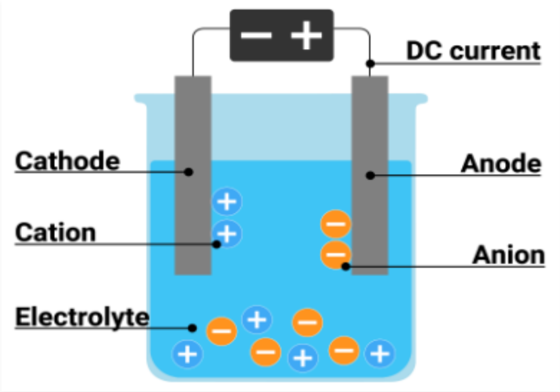

Figure 7 Electrolysis

Conclusion

The integration of solar-powered green hydrogen gas production system with QR code scanning for efficient utilization holds significant promise for the transition to a sustainable energy future. Hydrogen gas, produced through electrolysis powered by solar energy, offers numerous advantages as a clean and renewable energy source. It has a high energy density, emits no greenhouse gases during usage, and can be stored and distributed for various applications. By incorporating QR code scanning technology, enabled by Internet of Things (IoT) devices, the utilization of hydrogen gas can be enhanced. QR codes provide a convenient and secure method for tracking, monitoring, and controlling the distribution and usage of hydrogen gas. This ensures efficient management of the supply chain and enables seamless integration with various industries and applications.

The solar-powered green hydrogen gas production system, coupled with QR code scanning, enables the generation of hydrogen gas using renewable energy sources and ensures traceability and accountability throughout the entire value chain. This combination contributes to reducing reliance on fossil fuels, mitigating environmental impacts, and promoting a sustainable and cleaner energy ecosystem. Furthermore, the utilization of hydrogen gas derived from solar power and facilitated by QR code scanning opens up a wide range of possibilities. It can be used for transportation, electricity generation, heating, and various industrial processes, thereby diversifying the energy mix and driving the transition towards a carbon-neutral economy. In conclusion, the integration of solar-powered green hydrogen gas production system with QR code scanning technology offers a compelling solution for the efficient and sustainable utilization of hydrogen gas. It represents a significant step towards achieving a cleaner, greener, and more energy-independent future.

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