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Safety Risks in Solar-Hydrogen Energy System: Fine Kinney Risk Analysis

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I. Introduction

The installation phase of solar energy systems comes with various risks related to occupational health and safety. These risks involve testing and certifying products, analysing the land and solar energy potential, planning, overseeing installation, checking system efficiency, managing performance, and conducting periodic inspections. Moreover, despite the numerous advantages of producing hydrogen in this system, there are also risks to consider. Ensuring high purity in hydrogen production can be costly. Additionally, factors like the expense of fuel cells, challenges in storage and transportation, the possibility of leaks, and the risk of explosions and fires need to be taken into account.

Safety precautions are crucial when cleaning solar panels. Cleaning panels during production can expose workers or maintenance personnel to high currents and voltages. Therefore, the first step in the process is to disconnect the system from the mains and the electrical connections between the solar panels and the inverter. This ensures the safety of maintenance and repair personnel, allowing maintenance and inspection operations to be conducted safely.

II. Experimental Set-up and Procedure

In this study, the Fine-Kinney risk analysis method is used to assess the risks in a solar-hydrogen hybrid energy system. Compared to other risk analysis methods, the risk scores that are higher in this method are more accurate and lower. Because in the Fine-Kinney method, the frequency of exposure to hazards plays a key role. The Fine-Kinney risk analysis method is a quantitative method based on equipment, work processes and machinery. In the method, calculations are made using the probability, exposure (frequency), and consequence (severity) of occurrence of the hazard when assessing the risks. In this method, the probability of occurrence of accidents/events, the frequency of occurrence, and the severity of the consequences are used to calculate risk scores (R).

$$R = \text{Probability} \times \text{Exposure} \times \text{Consequence} \quad (1)$$

III. Results and discussions

Prior to commencing the study, it is essential to gain an understanding of the general principles underlying the photovoltaic method of electrical energy production. Solar panels are constructed by assembling numerous small photovoltaic cells, comprising silicon crystals. When exposed to sunlight, the surface of these crystals absorbs photons (Fig. 1). This process causes electrons within the crystal to move, generating electric current. The direct current (DC) generated is then converted to alternating current (AC) using an inverter device. This enables the energy to be made suitable for the grid voltage (sinusoidal), which is then offered to industrial facilities and subscribers for consumption. Depending on the type of system, charge controllers, batteries, and other elements may be used.

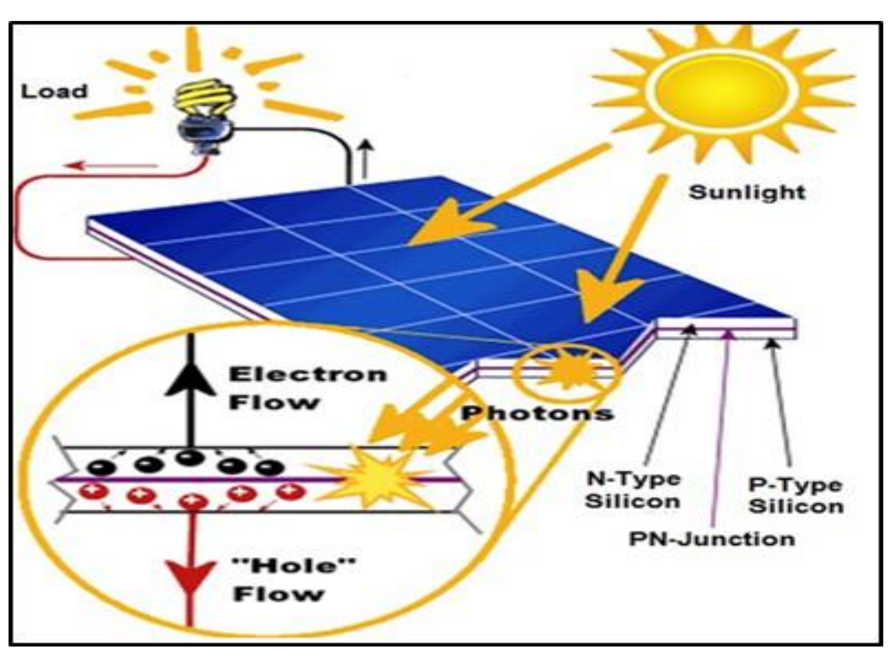

Fig. 1. Basic working principle of the solar cell (URL-2, 2024)

Even today, hydrogen production is mostly realized using fossil fuels. However, due to global warming and the search for alternative energy sources, there is a tendency towards renewable energy sources. At this point, hydrogen, which boasts a number of advantages, stands out. It is more efficient than other fuel types and generates water as waste.

The direct current (DC) electrical energy required for the electrolysis method, which is the simplest method for hydrogen production, is obtained directly from solar panels. The electric current obtained is applied to the electrodes in the electrolysis cell to separate oxygen and hydrogen, which form the basic structure of water.

As technology has advanced, numerous techniques have emerged for generating energy from hydrogen. Steam reforming is the most prevalent hydrogen production method, requiring temperatures between 700°C and 1100°C. In contrast, electrolysis of water can be conducted at temperatures between 50°C and 80°C. The primary difference between these two methods lies in the use of primary energy sources. For electrolysis, the primary energy source is electric current, whereas for steam reforming it is natural gas. One of the key objectives in the field of hydrogen production is to reduce the cost of electrolysis. Additionally, utilizing electrical energy generated from renewable sources in the electrolysis method is a crucial goal (Çiçek and Aliyeva-Ç, 2022). A solar hydrogen hybrid energy system production scheme is given in Fig. 2 (Yılmaz Ulu, 2010).

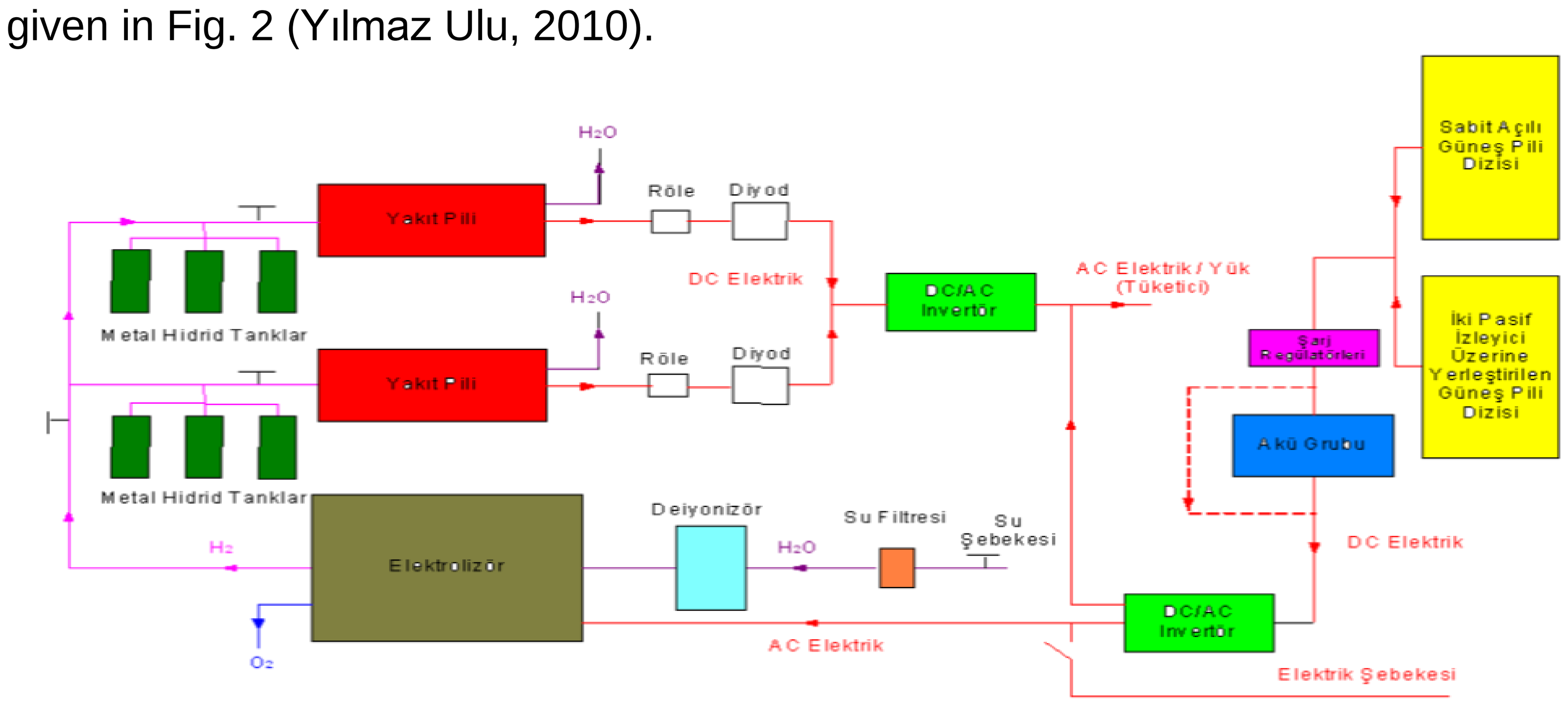

Fig. 2. Solar-Hydrogen Hybrid Energy System (Yılmaz Ulu, 2010)

III. Conclusion

There are always safety risks in power generation systems. These risks should be eliminated with a proactive approach by using an appropriate risk analysis method. Working at heights, occupational accidents during the installation phase or during maintenance and repair, leaks that may occur during the transport and storage of hydrogen, and the risk of explosion of the hydrogen tank are the high risks. Solar-hydrogen system is one of the hydrogen production systems of the future. In parallel with the suitability of the method, it is necessary to carry out the necessary hazard risk analyses in terms of occupational health and safety related to the systems to be used, and to eliminate the safety and occupational accident hazards.

The risk analysis identified several high-risk factors, including falling from roof systems, inverter burning or explosion due to lack of a separator after solar panels, fire hazards, hydrogen tank explosion risk from leakage, and explosion risks from electrical faults in panels and transformers. To mitigate these risks, it's advised to use a separator after solar panels and regularly inspect electrical connections and system faults by qualified individuals to prevent spark formation and fire. Roof systems should be avoided if possible, but if used, appropriate occupational health and safety precautions must be implemented.

Acknowledgements

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