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Hybrid Renewable Energy Systems for Electricity and Hydrogen Production in an Urban Environment

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Abstract : Renewable energy micro-grids, such as those powered by solar or wind energy, are often intermittent in nature. This means that the amount of energy generated by these systems can vary depending on weather conditions or other factors, which can make it difficult to ensure a steady supply of power. To address this issue, energy storage systems have been developed to increase the reliability of renewable energy micro-grids. Battery systems have been the dominant energy storage technology for renewable energy micro-grids. Batteries can store large amounts of energy in a relatively small and compact package, making them easy to install and maintain in a micro-grid setting. Additionally, batteries can be quickly charged and discharged, allowing them to respond quickly to changes in energy demand. However, the process involved in recycling batteries is quite costly and difficult. An alternative energy storage system that is gaining popularity is hydrogen storage. Hydrogen is a versatile energy carrier that can be produced from renewable energy sources such as solar or wind. It can be stored in large quantities at low cost, making it suitable for long-distance mass storage. Unlike batteries, hydrogen does not degrade over time, so it can be stored for extended periods without the need for frequent maintenance or replacement, allowing it to be used as a backup power source when the micro-grid is not generating enough energy to meet demand. When hydrogen is needed, it can be converted back into electricity through a fuel cell. Energy consumption data is got from a particular residential area in Daegu, South Korea, and the data is processed and analyzed. From the analysis, the total energy demand is calculated, and different hybrid energy system configurations are designed using HOMER Pro (Hybrid Optimization for Multiple Energy Resources) and MATLAB software. A techno-economic and environmental comparison and life cycle assessment (LCA) of the different configurations using battery and hydrogen as storage systems are carried out. The various scenarios included PV-hydrogen-grid system, PV-hydrogen-grid-wind, PV-hydrogen-grid-biomass, PV-hydrogen-wind, PV-hydrogen-biomass, biomass-hydrogen, wind-hydrogen, PV-battery-grid-wind, PV- battery -grid-biomass, PV- battery -wind, PV-battery -biomass, and biomass- battery. From the analysis, the least cost system for the location was the PV-hydrogen-grid system, with a net present cost of about USD 9,529,161. Even though all scenarios were environmentally friendly, taking into account the recycling cost and pollution involved in battery systems, all systems with hydrogen as a storage system produced better results. In conclusion, hydrogen is becoming a very prominent energy storage solution for renewable energy micro-grids. It is easier to store compared with electric power, so it is suitable for long-distance mass storage. Hydrogen storage systems have several advantages over battery systems, including flexibility, long-term stability, and low environmental impact. The cost of hydrogen storage is still relatively high, but it is expected to decrease as more hydrogen production, and storage infrastructure is built. With the growing focus on renewable energy and the need to reduce greenhouse gas emissions, hydrogen is expected to play an increasingly important role in the energy storage landscape.

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