A promising sustainable energy pathway: Bio-hydrogen

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Abstract

Oman's strategic focus on environmental sustainability and reducing the carbon emission of energy sources aligns with the global shift towards net zero. As a clean energy source, green hydrogen is a promising alternative in the energy transition. Green hydrogen production can be achieved through multiple pathways, with desalinated water electrolysis being the most prevalent and widely adopted method. Specifically, water electrolysis is an electrochemical technique that splits water molecules using electricity to generate hydrogen. As technical obstacles and the high Capex cost of electrolysis system, this research focuses on environmentally friendly bio-hydrogen production. In summary, by using Anaerobic digestion of wastewater involves bacteria breaking down organic matter in biosolids in absence of oxygen, producing CH_4 (methane) and other components. The methane is then purified (scrubbing) to separate organic CO_2 and H_2, with the H_2 serving as green hydrogen. The separated CO_2 can further be converted into sustainable aviation fuel (SAF), enhancing the process's overall sustainability. The economic feasibility of using sewage for bio-hydrogen production is enhanced by lower capital costs, as it leverages existing wastewater treatment infrastructure. Operational costs, however, depend on energy prices and scale. Anaerobic digestion (AD) produces biogas with a 55-70% methane, 30-45% CO_2, and trace impurities. Direct hydrogen production is low but can be generated through steam reforming or gas separation processes. Purification methods include Pressure Swing Adsorption, Membrane Separation, and Cryogenic Distillation, achieving up to 99.999% hydrogen purity. Hydrogen production from wastewater is an innovative approach that utilizes organic matter in wastewater as a feedstock. Numerous studies have investigated waste-to-hydrogen generation, with a UK pilot waste-to-biohydrogen plant design achieving 78% gross efficiency at a cost of £71 per MWh. The plant produced 3.1 and 45.3 MW of high purity, grid-quality hydrogen, respectively. This process not only supports sustainable hydrogen generation but also enhances wastewater treatment by reducing organic loads. Moreover, this approach supports circular economy principles and contributes to greenhouse gas reduction, positioning it as a viable option for regions aiming to optimize local resources and minimize environmental impact.

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panelMostafa El-Shafie, Highlights•The state of the art of impure water electrolysis was assessed.•The available water electrolysis systems were compared.•A whole system was investigated to cover pure water and power demand using seawater.•The available electrolyzers should be u and AbstractHydrogen as an energy source has been identified as an optimal pathway for mitigating climate change by combining renewable electricity with water electrolysis systems. Proton exchange membrane (PEM) technology has received a substantial amount of (2023a) *Hydrogen production by water electrolysis technologies: A Review*, *Results in Engineering*. Available at: https://www.sciencedirect.com/science/article/pii/S2590123023005534#bib60 (Accessed: 28 October 2024).