Investigate the use of renewable electricity to produce hydrogen

Sean O'Neill – K00249300

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Aim of the Project

To conduct an in-depth analysis of green hydrogen, a critical element towards a sustainable and carbon-neutral energy landscape.

Background

Green hydrogen is a promising technology that can help reduce greenhouse gas emissions. It's produced by the electrolysis of water using renewable energy sources and can decarbonize various sectors, from industry to transport and power generation. The European Union has outlined its intentions to reduce non-renewable energy sources and achieve net-zero emissions of greenhouse gases by 2050, where green hydrogen could play a significant role.

Hydrogen can be produced through different processes, including coal gasification, steam reforming of natural gas, or electrolysis. Each process has different sources and associated greenhouse gas emissions. Hydrogen can be denoted by shades such as Green, blue, grey, and turquoise.

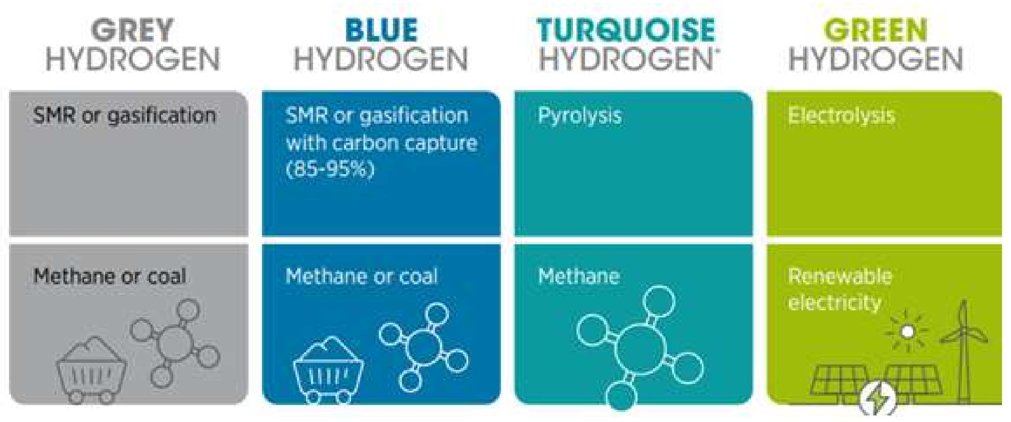
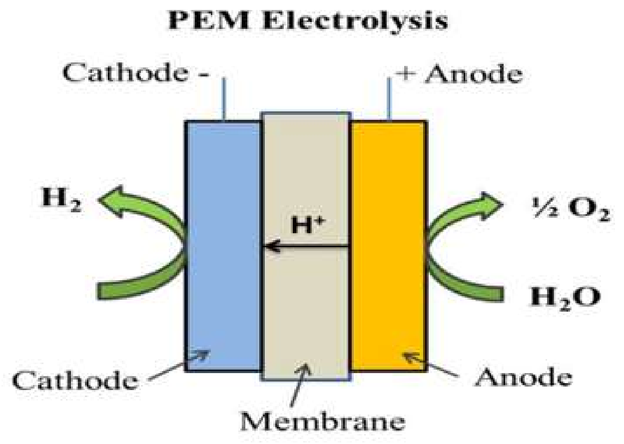


Figure 1:Different Shades of Hydrogen

A method of hydrogen production is the electrolysis of water. There are several different kinds of water electrolysis, and they all start from the same common concept. In a water electrolysis cell, two electrodes are put in the electrolyte solution and connected to the power supply to conduct current. When a sufficiently high voltage is applied between the electrodes, water is decomposed to produce hydrogen on the cathode and oxygen on the anode. Adding an electrolyte increases water conductivity, aiding continuous electricity flow. Figure 2 displays a popular electrolysis process PEM electrolysis.



Anode: $H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$

Cathode: $2H^+ + 2e^- \rightarrow H_2$

Overall cell: $2H_2O \rightarrow H_2 + \frac{1}{2}O_2$

Figure 2: PEM Electrolysis

Objectives

1. Conduct a literature review to analyse existing literature on green hydrogen.
2. To survey individuals who study or work as engineers regarding their knowledge of green hydrogen as renewable energy
3. Research case studies on using green hydrogen to store renewable energy.
4. Determine a life cycle assessment for rechargeable Lithium-ion batteries compared to hydrogen storage for renewable energy storage for PV panels.
5. Determine a cost evaluation of current Renewable energy creators and green hydrogen production comparison.

Adaptions of Hydrogen

From the research conducted, four cases of hydrogen storage were found, two current and two future projects.

- Current: Rijnstate Elst Hospital – uses solar – electrolysis – storage – hydrogen fuel cell. Figure 3
- Current: Viamed San Jose Hospital – uses solar – electrolysis – storage – hydrogen boiler.
- Future: The ACES Delta Hub – excess renewable energy sources – electrolysis - Storage in a salt cavern
- Future: The Kestrel Project – excess renewable energy – electrolysis – storage in depleted Kinsale head gas field . Figure 4

Life Cycle Assessment

This chapter compares the environmental impact of two key energy storage technologies: rechargeable lithium-ion batteries and hydrogen storage systems. The assessment aims to provide an aligned environmental perspective to achieve sustainable development goals. By evaluating the ecological impacts of each stage of their life cycles, this study aims to uncover the trade-offs and environmental implications, contributing to a better understanding of their roles in sustainable energy

Eco properties	Green Hydrogen System	Solar Li-ion Battery System
Total embodied energy for primary production	1.92e+06 - 2.15e+06 MJ/kg	8.92e+03 - 9.87e+03 MJ/kg
Total co2 footprint for primary production	7.29e+04 - 8.14e+04 kg/kg	4.81e+02 - 5.32e+02 kg/kg
Total water usage for the pure element	5.68e+05 - 6.29e+05 l/kg	9.56e+03 - 1.09e+04 l/kg

Figure 5:Extraction Eco Properties

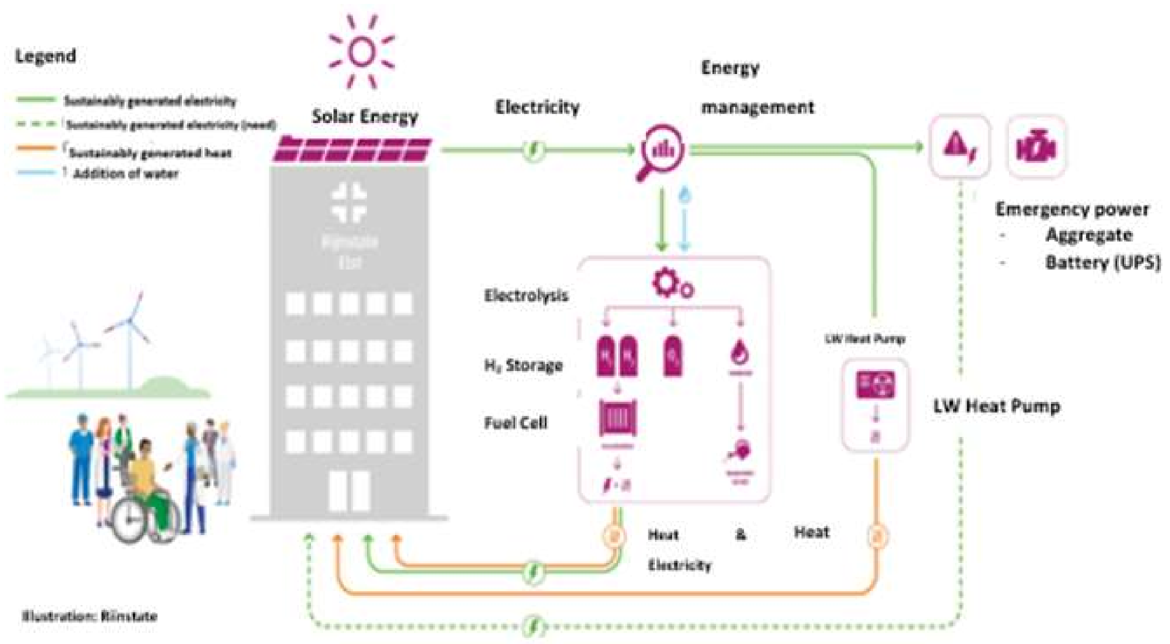


Figure 3: Rijnstate Elst – Energy system

Figure 4:The Kestrel Project

Green hydrogen systems and solar energy systems, including Li-ion batteries and solar panels, exhibit a complex interplay of recyclability, energy use, and environmental impact. While both systems leverage recyclable materials to support sustainability, they also encounter challenges with non-recyclable materials, the energy intensity of recycling processes, emissions, and the potential for downcycling and landfill waste. Addressing these challenges is crucial for enhancing the environmental sustainability of both green hydrogen and solar energy systems, aligning with broader goals of reducing ecological footprints and advancing towards a more sustainable and circular energy economy

Conclusion

The literature review conducted benefitted the researcher's understanding of the project. The gained knowledge perused the research to find the current and future use of hydrogen to store excess renewable energy. Conducting the LCA with the use of Granta EduPack helped to gain an understanding of the emissions created from the extraction and the recycling of the materials used in a current solar li-ion battery system and a green hydrogen system, which involved an AEM electrolyser, PEM stationary fuel cell, PV panels and storage tank. A cost breakdown was to be conducted between a solar system and a green hydrogen system, but due to a lack of information from academic sources and corporations. The objective could not be completed.

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