Business Case, Design and Simulation of Solar Powered Hydrogen Refuelling Stations

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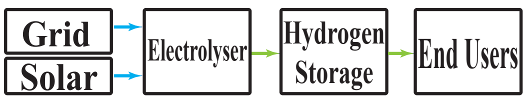
Hydrogen has shown potential to be viable as a sustainable alternative for transportation in the future, however the challenge for today is to establish the infrastructure required to produce and distribute hydrogen in a sustainable way. Solar powered hydrogen refuelling stations (Solar-HRS) are a potential means for this. The thesis investigates how the functionality and economics of such Solar-HRS can be further improved and optimized.

A Solar-HRS has three main functional components. Solar panels, an electrolyser and a hydrogen storage. The solar panels provide the station with electric power. The electrolyser is able to turn electricity and water into hydrogen and oxygen. The storage stores hydrogen produced by the electrolyser for later usage. By producing hydrogen with electricity from solar power the overall carbon footprint of the fuel is reduced compared to conventional means of producing hydrogen (Steam Methane Reforming). The question that remains is, **how to design the system so that the hydrogen is produced as cheaply as possible?**



To answer this question and also to gain further understanding of the functionality of the Solar-HRS system, a mathematical simulation model of the system was developed in MATLAB/Simulink. The model allows quick and simple investigate of how changing the parameters of the system (such as storage size etc.) affects the overall performance of the system (such as capacity to produce hydrogen and more)

The thesis explores two hypothetical applications of a Solar-HRS. The first case is a "Commercial-HRS". This HRS uses grid power but also has its own solar panels. The HRS serves commercial traffic that behaves in a semi-predictable manner. The second case is an "Off-Grid-HRS", this HRS is entirely solar powered. The HRS serves buses for public transport that always refuel at set times.

For the commercial HRS the thesis found that an increase in storage size would allow the HRS to consume more solar power and less grid power, saving some electrical cost. However the investment cost for increased storage was far to large to justify the savings, yielding payback times of hundreds of years. It was also found that a lithium battery can be a beneficial addition for the station.

For the off-grid station it was found that due to the unreliability of solar power the station required a very large storage. Due to the expense of this storage and its inefficient usage, the off-grid station was a much costlier option than its grid based counterpart.

As a conclusion the thesis found that solar power can indeed be a cost effective method of supplementing the power demand of an electrolyser. However relying on solar power to much as the primary source of power is not very practical for the operation of a fuel station.

The thesis also investigated if it is possible for a Solar-HRS to participate in other business opportunities, such as selling electricity from the solar panels to the grid or providing local industry with hydrogen. In general most of these options were often limited in both technical feasibility and economic viability. Selling electricity is potentially useful if the local conditions allow for it.