Green hydrogen microgrid for residential applications

Simulation and economic assessment of a hydrogen-based microgrid on dwellings in Spain and Switzerland

Graduate

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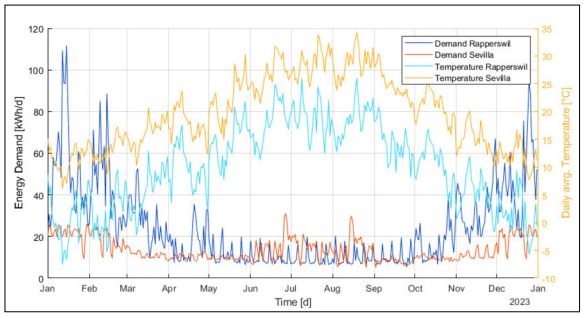
Definition of Task: When implementing a Solar Power system in residential areas, utilizing the generated power directly on-site is an ideal objective. However, this is impossible because the power demand doesn't align with the production schedule. Consequently, the need for energy storage arises. Batteries are commonly employed for storing energy on a residential scale. Nonetheless, despite their usefulness, batteries are not always the optimal solution.
The objective of this thesis is to analyse residential hydrogen storage systems; including an electrolyser, a fuel cell, hydrogen storage, and a solar power system. To achieve this, the goal is to develop a simulation environment capable of simulating a hydrogen storage microgrid. The simulated system should undergo analysis and be subject to parametric or economic comparisons with other systems.

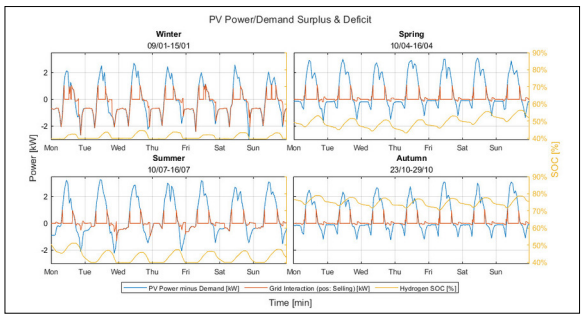
Approach: The hydrogen microgrid was simulated in a MATLAB Simulink program. While it was initially obtained from the University of Sevilla, it necessitated adjustments to align with the requirements of this thesis. This simulation effectively assesses the behavior of microgrid components over a year, precisely determining when and how much power each component consumes or generates. The simulation process required gathering both measurement and simulated data to obtain energy demand information from a flat in Sevilla and Rapperswil. Subsequently, these datasets were transformed to become appropriate input data for the microgrid simulation. A MATLAB code was developed to embed the Simulink Simulation. All crucial calculations were performed within this code, enabling swift modifications to system conditions and facilitating the generation of numerous simulations and corresponding results. The simulation's output data was then exported for examination and utilization in economic and parametric analyses. This simulation platform is designed to facilitate rapid alterations to system conditions, thus enabling a thorough examination of the strengths and limitations of hydrogen storage systems. A search for suitable components uncovered only a few results and with a substantial price difference among the components. This indicates that the market for these components is not yet fully developed. Pricing details had to be obtained through direct inquiries.

Conclusion: The analyses conducted in this study demonstrated the potential of a hydrogen storage system; however, from an economic standpoint, its installation is not feasible. The data suggests that even within the next decade, electricity prices would need to rise more than threefold to become an economically viable hydrogen storage system. Seasonal storage or off-grid systems are found to be impractical due to the substantial storage capacity required to meet the demand. Moreover, the size of the required solar power system greatly exceeds the limitations of an average roof, particularly when considering the applied energy demands of two-person apartments.
Future work should focus on utilizing the developed simulation environment to conduct more comprehensive analyses and optimizations. Exploring the relations between system components is critical for optimizing their respective sizes. Additionally, it is worthwhile to compare the residential-scale simulation with battery storage solutions and larger hydrogen system configurations.

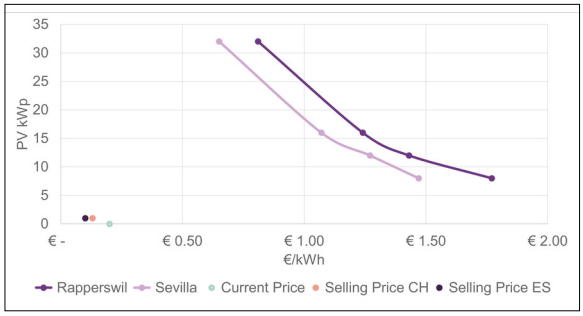
Daily Energy Demand of a two-person flat in Rapperswil and Sevilla over one year, including temperatures
Own presentment



Seasonal diagram with the difference between produced and used power, interaction with electricity grid and hydrogen SOC
Own presentment



Price necessary for electricity for an economically feasible hydrogen microgrid
Own presentment



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Subject Area
Electric solar technology, General energy technology