Optimal Res-Electrolyser Coupling- A Flexible Technoeconomic Assessment Tool

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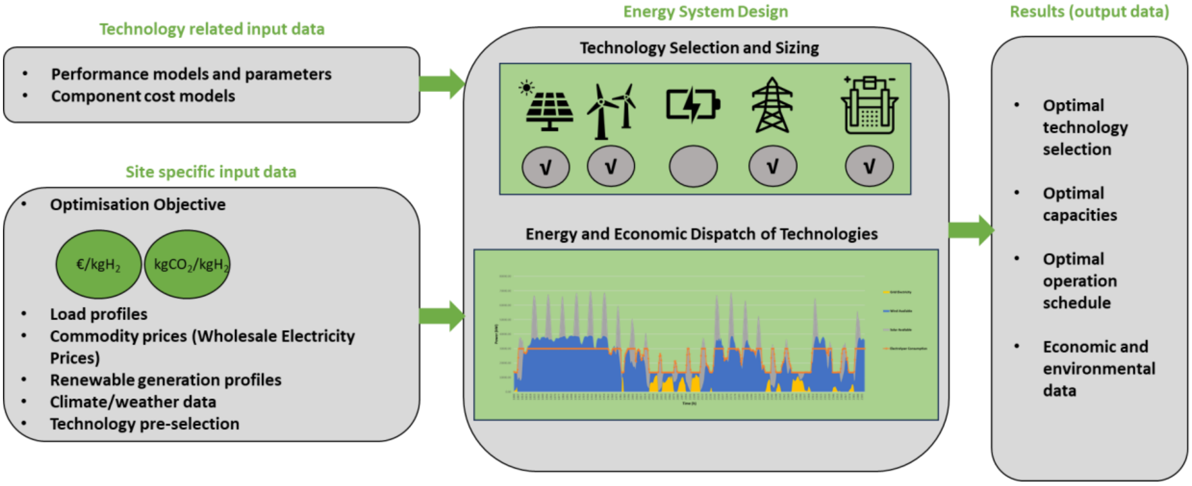

Figure 1: Research Methodology.

The escalating urgency to address climate change has sparked unprecedented interest in green hydrogen as a clean energy carrier. The intermittent nature of Renewable Energy Sources (RES) like wind and solar can introduce unpredictability into the energy supply, potentially causing mismatches in the power grid. To this end, green hydrogen production can provide a solution by enhancing system flexibility, thereby accommodating the fluctuations and stochastic characteristics of RES. Furthermore, green hydrogen could play a pivotal role in decarbonizing hard-to-abate sectors and promoting sector coupling.

This research article endeavors to delve into this subject by developing a dynamic techno-economic analysis tool, capable of flexibly assessing the optimal setup of Alkaline (AEL) electrolysis coupled with Renewable Energy Sources (RES) in a specific region or hub. The focus lies on achieving cost-effectiveness, efficiency, and sustainable production of green hydrogen. The tool leverages a comprehensive dataset covering a full year of hourly data on both renewable electricity production from intermittent RES and wholesale electricity market prices, alongside customizable inputs from users. It can be applied across various scenarios, including direct coupling with dedicated RES plants and hybrid configurations utilizing the electricity grid as a backup source. Moreover, the tool can integrate multiple electricity sources to minimize electricity costs. Extensive analyses are conducted within the context of the Peloponnese region, where TRIERES, the Greek Hydrogen Valley, is taking shape. The model optimizes RES and electrolyzer capacities to minimize the Levelized Cost of Hydrogen (LCOH) and surplus renewable electricity. By incorporating real operating maps of electrolysis systems from industrial manufacturers, the model accounts for factors such as maximum and minimum AEL electrolyzer operating loads, degradation phenomena, and makes hourly decisions regarding the electrolyzer operation load, partial-load efficiency, water consumption, and green hydrogen production. Additionally, the tool calculates the equivalent CO_2 emissions associated with hydrogen production, considering the carbon intensity of the electricity utilized. This enables the assessment of the environmental impact of various hydrogen production scenarios. Overall, the dynamic techno-economic tool scrutinizes operational strategies of the AEL electrolysis system when interfacing with stochastic RES, aiming to optimize economic, technical, and environmental parameters.

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