Maximizing the Potential of an Hybrid Renewable Energy System including hydrogen : A Multi-Criteria Approach

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1 Introduction

The main goal of this work is to precisely delineate the hydrogen ecosystem, covering all aspects of production, storage, and application, [1] while also simulating and optimizing these aspects based on technical, economic, and environmental parameters. As part of the hydrogen ecosystem, a hybrid renewable energy system is proposed. This system comprises solar photovoltaic panels, wind turbines, an electrolyzer, hydrogen storage tanks, fuel cells, and a grid to fulfill the electricity demand of the city and hydrogen demand of the vehicles. We propose a mathematical model involving multi-objectives to minimize the carbon emission, grid dependency and total annual costs of this system.

2 Implementation Steps

2.1 Data collection

Dijon, France was chosen as the case study location from the Bourgogne Franche Comté region. The first step of this study commenced with data mining activities to gather information on the electricity and hydrogen demand in Dijon, as well as wind speed and solar irradiance data. The study case consider high peak demand of about 395 MW of electricity taken from the "Open Data Réseaux Énergies (ODRÉ)" and peak hydrogen demand of about 85 kg for 50 vehicles. The economic and technical parameters of all the components were extracted. Power profiles for solar PV and wind were generated using the PVLib [4] and Windpowerlib [3] platforms available in Python.

2.2 Optimization Model

The need for an optimization model capable of handling multi-objective functions and various energy management was identified. In the context of our model, our primary sources of renewable energy are photovoltaic (PV) panels and wind turbines (WT). Their numbers are decision variables, respectively N_{pv} and N_{wt}. The numbers of electrolyzers and the capacity of the tank are decision variables as well. To ensure a reliable energy supply, we have implemented a grid system (where $P_{grid}(t)$ denote the grid power at time period t) in our model as shown in the proposed architecture in Figure 1, treating it as an ultimate power source. This approach allows us to supply and extract power to and from the grid as needed, ensuring that electricity and hydrogen demand are met at all times, regardless of fluctuations in pv and wind power output. The key to achieving this dual fulfillment lies in the dynamic allocation decision variables $\alpha(t)$, $\beta(t)$ allowing a flexible distribution of available power.

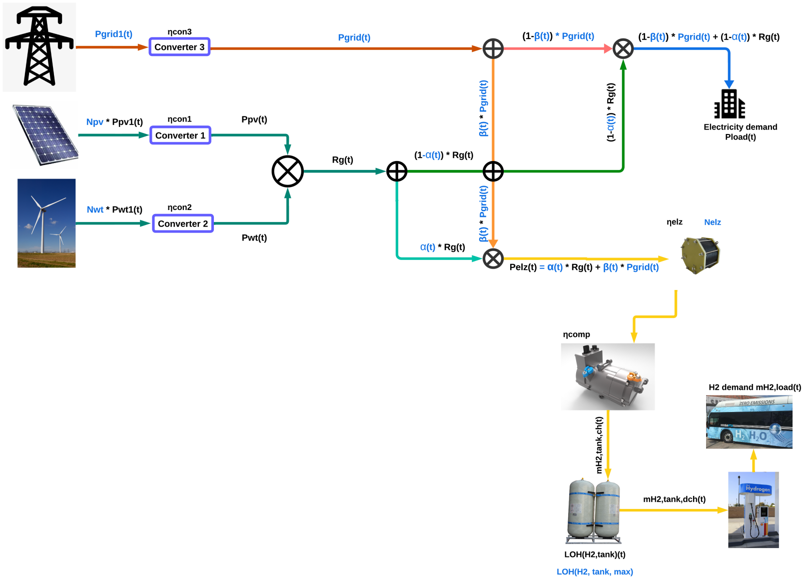

FIG. 1 – Flow Chart of the renewable energy system

All equations and constraints related to the various components of the architecture have been formulated. Several objective functions have been proposed, those related to the total cost of operating the architecture, the one linked to minimal reliance on the grid, and the one focused on grid consumption stability.

2.3 Resolution Method

The optimization problem and its resolution have been implemented using the DEAP framework [2] which allow to test different types of evolutionary algorithms present in the literature.

3 Conclusions and perspectives

The upcoming goals for this work include extracting carbon emission data for the various components from different sources. Additionally, the smooth functioning of the simulation and optimization tool, particularly in handling multi-objective functions, is a priority. Finally, the results obtained from the tool will be validated.

Références

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