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APPLYING THE ARTIFICIAL BEE COLONY ALGORITHM: ENHANCING THE EFFICIENCY OF A HYDROGEN-BASED HYBRID RENEWABLE ENERGY SYSTEM

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ABSTRACT

Hydrogen, as a clean energy resource, has the potential to alleviate impending energy shortages and environmental issues. Owing to its plentiful renewable energy resources, Turkey is advantageously positioned to fulfill its electricity requirements. In rural locations where the energy grid is either unavailable or excessively costly, Hybrid Energy Systems (HRES) integrating multiple energy sources are employed. While HRES offer an economical solution custom-fit to distinct power needs and techno-economic circumstances, the aspects of their management, sizing, and component selection present notable difficulties. This study aims to develop, simulate, and evaluate a hybrid system composed of wind, solar, biomass gasifier, and fuel cell components. It also addresses optimization algorithms related to the management of energy flow and optimal sizing of renewable energy sources. In HRES, the surplus energy undergoes conversion into hydrogen, which is then stored and harnessed in fuel cells during instances of overproduction. The primary objective in the optimization process is to minimize the Annual Total Cost (ACS). The decision variables include the power output of solar panels and wind turbines, as well as the quantity of hydrogen tanks. A hybrid optimization method, based on the Artificial Bee Colony (ABC) algorithm, is implemented to determine the optimal dimensions of the HRES components. Consumption and weather data from 2022 are employed to design a hybrid system capable of fulfilling all energy demands at the lowest possible cost. Simulations suggest that the proposed off-grid hybrid energy system is the most cost-effective choice for the selected location. The ABC algorithm identifies the optimal system configuration, which incorporates a 358.08 kW wind turbine, a 2551.69 kW solar panel, and 636 hydrogen storage tanks. The system's annual total cost is $\$3.1189 \times 10^6$, its net present cost is also $\$3.1189 \times 10^6$, and its levelized cost of energy is 1.2300 $/kWh. The energy produced by the system is entirely renewable, with 53.53% from solar, 0.57% from wind, 12.23% from fuel cells, and 33.67% from a biomass generator. The optimization algorithm was implemented using the MATLAB 2022b simulation software.

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