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Multi-microgrid optimization and energy management under boost voltage converter with Markov prediction chain and dynamic decision algorithm

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ABSTRACT

Knowledge on operational energy consumption and embodied energy, replacing embodied greenhouse gas (GHG) emissions in building materials, and national energy resources have become a necessity. In this study, the importance of investigating the stochastic nature of weather-dependent renewable energies is well documented. The management of the hybrid renewable energy system (HRES) was built and assessed, utilizing a decision-making algorithm and 13 case studies. When the proportion of renewable energy is at 24% and the average daily fossil fuel usage is 1.11 L per year, the HRES generates 1697 kWh per year with a net present value (NPV) of 553,68 USD, with a rate of return (IRR) of 21.4%, and a payback period (PP) of 15.7 years. With a renewable energy share of 54%, fossil fuel consumption dropped to 0.69 L per year, while yearly energy output was comparable to 1652 kWh per year, with an IRR of 19.5% and a PP of 17.6 years. To achieve zero greenhouse gas emissions, HRES Management employs 100% renewable energy sources to generate 1933 kWh per year at a net present value of −372.09 USD. This scenario is economically possible if the renewable energy feed-in tariff exceeds 0.06 USD.

1. Introduction

Due to limited resources, traditional energy systems cannot keep up with population expansion and industrialization. According to the world energy organization, fossil fuel reserves, which provide 79% of the world's basic energy, are swiftly diminishing with 57% of them used in transportation [1]. As energy demand grows and supply falls due to environmental concerns, the economies of countries will become unstable. Therefore, local and sustainable energy sources are crucial [2].

Renewable energy fluctuates geographically. Photovoltaic and wind energy systems do not work at night. Design and integration of photovoltaic-wind hybrid systems as well as efficient storage and backup systems can boost the willingness to employ renewable systems and control the energy cycle. This technique supports local or household renewable energy consumption while building the basis for large-scale power generation [3]. Investing in solar and wind systems is expensive compared to fossil fuels [4]. Combining conventional and renewable energy sources improves cost-effectiveness and reliability [5]. A small-grid renewable energy management solution incorporates multiple yet complimentary methods [6]. With the rising usage of hybrid renewable energy systems, especially in distant power supplies, a cost effective and reliable design is crucial. Energy researchers have spent decades trying to control renewable systems [7]. Compared to stand-alone systems, integrated renewable energy systems are powerful. Hourly electricity demand is from 2000 Swedish houses [8]. The P-GA-PSO method was used in the research for energy management and efficiency. The result was the use of an innovative method in energy price estimation [9]. Positive feedback between central power generation and house investments in a hybrid solar system and batteries have changed the market to single-family dwellings [10]. A 2022 study advocated the intelligent control of a solar energy utilizing fuzzy logic [11]. In 2021, another study suggested an intelligent control approach for a direct-connected, tracking photovoltaic solar power plant [12]. Recent research focuses on hybrid networks and real-time algorithms [13]. Lee et al. (2018) explored a grid-connected system for regulating consumption and peak correction in Japanese homes [14]. In another study, real-time optimization was done based on dynamic programming

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