

Design and Implementation of a Low-Speed Vertical Wind Generator Charge Controller for Sustainable Energy Generation in Bangladesh

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Abstract— Integrating renewable energy is a great solution to mitigate the global energy demand. The wind-based energy system has added a new dimension to the renewable energy system. In Bangladesh, solar-based energy generation systems are increasing rapidly. Large-scale wind-based energy installation is still under research due to low wind speed. The available wind speed in Bangladesh is 5m/s on average in the coastal area. However, a 100W vertical axis wind generator starts working with 2m/s wind speed, while the rated speed is 11m/s. Therefore, a vertical-axis wind generator will be feasible for Bangladesh if the turbine can be designed with a low-speed range. In this work, a charge controller is designed and practically developed for a 100W vertical-axis wind generator. The availability of the wind-based charge controller is very scanty in the market in Bangladesh. Besides the online charge controller price is comparatively high. Hence a cost-effective and efficient charge controller design is one of the main objectives of this work. In this work, a microcontroller-based wind charge controller is designed using Proteus professional software. The digital display system is integrated here to display the voltage and current reading. Finally, the developed charge controller is tested in the laboratory. The experimental results show the validity of the charge controller, which can convert the three-phase input signals to a DC signal to charge a battery and operate the DC loads successfully.

Keywords— Vertical axis wind generator, charge controller, microcontroller-based converter, sustainable energy.

I. INTRODUCTION

Wind energy is essential for addressing global energy challenges due to its renewable and sustainable nature. It significantly reduces greenhouse gas emissions, aiding in climate change mitigation. Wind power fosters energy independence by reducing reliance on volatile fossil fuels and has created numerous jobs worldwide, driving economic growth. Moreover, it diversifies energy sources, enhancing resilience during supply disruptions. Wind energy's scalability and accessibility make it suitable for various users, including rural communities and developing nations [1]. Technological advancements have boosted efficiency and reduced costs, increasing its competitiveness. Compared to fossil fuels, wind power has a lower environmental impact. Many countries, including China, the US, Germany, India, and Brazil, have invested

heavily in wind infrastructure, contributing to substantial electricity generation. In sum, wind energy is crucial for a sustainable, low-carbon future, offering environmental benefits alongside economic growth and energy security. As technology evolves, its global significance in the energy landscape continues to grow. Bangladesh holds substantial potential for harnessing wind energy, offering a promising avenue for addressing its energy needs and sustainability goals. The country's geographical features, including coastal areas, hill tracts, and river basins, provide a diverse range of wind resources. This proximity to the Bay of Bengal and the Indian Ocean ensures a steady and dependable source of wind, particularly during the monsoon season [2].

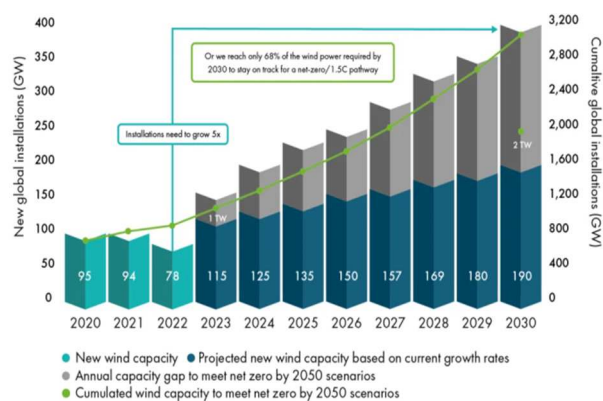


Fig. 1. Global wind installation capacity present and future prospect [6]

Wind energy represents an environmentally friendly and sustainable power source, contributing to reduced greenhouse gas emissions and improved air quality. Moreover, it enhances energy security by reducing reliance on volatile fossil fuels, which are susceptible to price fluctuations and supply disruptions. The development of wind energy infrastructure, including wind farms and associated supply chains, creates employment opportunities and stimulates economic growth by attracting investments and fostering local industries. Furthermore, wind power can play a pivotal role in rural electrification, extending electricity access to remote and off-grid areas.