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Research Papers

Building integrated photovoltaics powered electric vehicle charging with energy storage for residential building: Design, simulation, and assessment

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ABSTRACT

Global warming poses a serious danger to the environment, animals, and the livelihoods of humans. The residential building sector & transportation sector has received significant attention in recent years due to GHG emissions. Electric vehicles (EVs) are poised to play an essential function in reducing dependency on non-renewable fuels and the transportation sector's environmental implications. On the other hand, the sustainability of EVs depends on their method of charging. This paper investigates the feasibility and design of a BIPV (building-integrated photovoltaic) powered EV charging system in a typical Malaysian house using solar energy to meet residential and EV charging demand. Three BIPV systems: Grid integrated with no battery, grid integrated with 75 % battery storage and grid integrated with 100 % battery storage have been designed, simulated, and assessed for the performance parameters. BIPV plant capacity of 5.6 kWp, roof inclination of 10°, and roof facing southeast and northwest have been sized for the proposed system. The annual energy output was 8.05MWh, 7.21MWh and 7.19MWh for the three scenarios. LCOE of the grid-connected system with no batteries showed the lowest value of 0.16RM/kwh, whereas a system with batteries had higher LCOE of 0.51RM/kWh and 0.65RM/kWh. The grid-connected system without batteries showed the highest GHG emission savings of 137,321,924 kgCO_2e.

1. Introduction

Rising energy usage, dwindling resources, and growing energy costs substantially influence future generations' level of life. Buildings are a significant contributor to the use of fossil fuels and greenhouse gas emissions; thus, it is crucial to design integrated sustainable energy solutions that cover everything from energy production to storage and distribution. In this perspective, solutions for achieving green urban spaces and greener transport are solar homes, sustainable transportation, and electric storage systems. The development of innovative, energy-efficient sources for residential and non-residential structures and the transportation sector, particularly private vehicles, must be prioritized. According to IEA, under stated policies, global building energy consumption in the residential sector is expected to rise by 83 % between 2018 and 2040, from 6008TWh to 11,000TWh [1,2]. Building-related CO_2 emissions rose to their greatest level in 2019, accounting for roughly 10 GtCO_2, or 28 % of total world energy-related CO_2 emissions [3]. Globally, gasoline and other carbon-based fuels, the principal supplier of the transportation sector [4], account for 24 % of direct CO_2 emissions [5]. The number of vehicles on the planet is predicted to double by 2050, with low and middle-income economies responsible for >90 % of the rise [6]. This paper focuses on BIPV power generation for building energy use and EV charging using solar energy toward net zero energy building (NZEB) and net zero energy transportation (nZET) targets.

1.1. Literature review

The motivation for nZEB is more urgent and comprehensive when seen from the standpoint of reducing energy use and combating climate change [7]. The notion behind an nZEB is that it can fulfill all of its energy needs using cheap, nearby, environmentally friendly, renewable

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