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Potential Assessment and Techno-Economic Evaluation of Photovoltaic Energy Conversion System: A Case of Ethiopia Light Rail Transit System

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Abstract : The Earth and its inhabitants have faced an existential threat as a result of severe manmade actions. Global warming and climate change have been the most apparent manifestations of this threat throughout the world, with increasingly intense heat waves, temperature rises, flooding, sea-level rise, ice sheet melting, and so on. One of the major contributors to this disaster is the ever-increasing production and consumption of energy, which is still primarily fossil-based and emits billions of tons of hazardous GHG. The transportation industry is recognized as the biggest actor in terms of emissions, accounting for 24% of direct CO2 emissions and being one of the few worldwide sectors where CO2 emissions are still growing. Rail transportation, which includes all from light rail transit to high-speed rail services, is regarded as one of the most efficient modes of transportation, accounting for 9% of total passenger travel and 7% of total freight transit. Nonetheless, there is still room for improvement in the transportation sector, which might be done by incorporating alternative and/or renewable energy sources. As a result of these rapidly changing global energy situations and rapidly dwindling fossil fuel supplies, we were driven to analyze the possibility of renewable energy sources for traction applications. Even a small achievement in energy conservation or harnessing might significantly influence the total railway system and have the potential to transform the railway sector like never before. As a result, the paper begins by assessing the potential for photovoltaic (PV) power generation on train rooftops and existing infrastructure such as railway depots, passenger stations, traction substation rooftops, and accessible land along rail lines. As a result, a method based on a Google Earth system (using Helioscopes software) is developed to assess the PV potential along rail lines and on train station roofs. As an example, the Addis Ababa light rail transit system (AA-LRTS) is utilized. The case study examines the electricity-generating potential and economic performance of photovoltaics installed on AALRTS. As a consequence, the overall capacity of solar systems on all stations, including train rooftops, reaches 72.6 MWh per day, with an annual power output of 10.6 GWh. Throughout a 25-year lifespan, the overall CO2 emission reduction and total profit from PV-AA-LRTS can reach 180,000 tons and 892 million Ethiopian birrs, respectively. The PV-AA-LRTS has a 200% return on investment. All PV stations have a payback time of less than 13 years, and the price of solar-generated power is less than $0.08/kWh, which can compete with the benchmark price of coal-fired electricity. Our findings indicate that PV-AA-LRTS has tremendous potential, with both energy and economic advantages.

Keywords : sustainable development, global warming, energy crisis, photovoltaic energy conversion, techno-economic analysis, transportation system, light rail transit
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