DESIGN AND OPTIMIZATION OF HYBRID RENEWABLE ENERGY SYSTEM FOR RURAL ELECTRIFICATION OF AN OFF-GRID COMMUNITY

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ABSTRACT

This study focuses on the technical feasibility and economic viability of an optimal hybrid renewable energy system, designed for the rural electrification of an off-grid community of Edem Urua, a remote village located in the southern part of Nigeria. Mathematical modelling method was used for modelling; energy resources such as solar, wind, and diesel-generator with battery storage were combined for the design and optimal sizing of system components using Ampere-Hour optimal design method. The simulation and optimization were carried out using the Hybrid Optimization of Multiple Electric Renewables (HOMER or Homer Pro) Microgrid Analysis Tool. System performance and techno-economics were determined using some objective functions such as cost of energy, net present cost, renewable penetration fraction (RPF), CO_2 emission, payback years and returns on investment (ROI). The various system configurations were compared and analyzed for technical feasibility and economic viability. Findings showed that three optimal system configurations, Solar-PV/Diesel-Generator/Battery-Bank (SDB), Solar-PV/wind/Diesel-Generator/Battery-Bank (SWDB) and Solar-PV/Wind/Battery-Bank (SWB) had little or no CO_2 emission and were the most cost effective and technically preferred solutions. The SDB had a net present cost of $233,867.86, cost of energy of $0.062/kWh, RPF of 95.219% and CO_2 emission of 8,231 kg/yr. The SWDB had a total NPC of $227,082, COE of $0.063/kWh, RPF of 97.34%, and CO_2 emission of 4,621 kg/yr while the SWB had a total NPC of $264,046.10, COE of $0.073/kWh, RPF of 100% and zero CO_2 emission. The result of this research was found to be in alignment with the recent "Race to Zero" global campaign/climate action by the United Nations Framework Convention on Climate Change (UNFCCC) to keep global temperature rise to 1.5°C through cutting of global CO_2 emissions by 45% by the year 2030 and to net-zero CO_2 emissions by the year 2050.

Keywords: Hybrid Renewable Energy System, Off-grid, Cost of Energy, CO_2 emission, HOMER Pro.