Yield Assessment of Off-grid PV Systems in Nigeria

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Abstract:
Off-grid PV systems are providing critical access to energy services for millions of people throughout the globe. However, optimum sizing of these PV systems still poses a challenge, as inadequate system sizing could result in low system reliability and/or high cost of electricity generated. This paper presents a hybrid method of sizing off-grid PV systems for undefined electricity consumption. It then compares this sizing with off-grid PV systems installed in Nigeria - ranked the most populous electricity-deficit country in the world. The yields of the installed off-grid PV systems are also simulated for four major cities in Nigeria. Results show that for the over 1.5MWp of off-grid PV systems installed in the country, there is a potential 1.11 – 3.04 MWh of unutilised surplus electricity, which can supply 2hours of green electricity to at least 2,000 Tier-2 households during peak demand in the dry hot season. Thus, our hybrid model provides design and operational insight to off-grid PV system optimization.

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I. Introduction

Off-grid Solar PV systems are fast paving the way for electricity access in Sub-Saharan Africa (SSA) where approximately 592 million people lack access to electricity. This represents approximately 75 percent of the global population without access to electricity and this figure is likely to increase due to the (electrification) setbacks incurred by the Covid-19 pandemic [1], [2]. In most of these countries, the main technical obstacles to electricity access include aging grid infrastructure requiring extensive reinforcement investment and the limited network coverage of the existing infrastructure [3]–[5]. Thus, off-

grid solar photovoltaic (PV) systems comprising mainly of mini-grids and off-grid solar home systems (SHS) have become increasingly important when considering expediting access within cost constraints for these communities [2]. As of 2018, more than 35 million people gained Tier 1+ electricity service access through standalone home systems or renewable-based mini-grids [1]. Declining costs of small-scale solar PV installations means they are increasingly seen as a practical and cost-effective solution for bridging the electricity-access gap, especially in rural areas which make up approximately 80 percent of the population without access to electricity [2]. However, the optimum sizing of the system components has been one of the major technical challenges regarding the design of off-grid PV systems, especially in rural and developing regions.

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