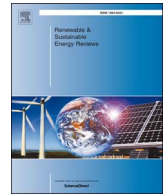




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Economic feasibility of solar PV system for rural electrification in Sub-Saharan Africa

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ABSTRACT

The future of solar photovoltaic (PV) systems as a viable alternative to conventional fossil fuel-based resources seem promising with the rapid decline in the cost over the last decade. Notwithstanding, PV technology is yet to make a meaningful contribution in Sub-Saharan Africa (SSA) where the need for energy is deemed critical. The reason being that the technology is perceived by policymakers in SSA not to be capable of functioning profitably as an independent economic unit that requires project financing. Regrettably, the widely utilized levelized cost of energy (LCOE) in the literature for PV economic assessment only provides a benchmark to assess grid parity. A detailed economic assessment that includes risks and actual capital financing method is urgently needed to encourage potential investors and foster adoption. In this paper, a generalized economic model is developed to assess the cost-benefit of off-grid PV system. The developed method is demonstrated on a case study of rural Gusau, Nigeria. The results show that the feasibility of the proposed system is highly location dependent. Overall, conclusion is drawn that PV technology is eligible for project financing as it can repay its loan within the stipulated time considering the current infrastructure and energy policies in Nigeria.

1. Introduction

Global energy crises continue with the increasing human population. Without additional dedicated energy policies, Kaygusuz [1] mentioned that about 1.2 billion people around the world will not have access to electricity by 2030. The situation is more pronounced in Sub-Saharan Africa (SSA) where the need for energy is so critical i.e. approximately 68% of the 915 million population do not have access to electricity [2]. Moreover, available evidence reveals a wide gap in electricity access between the urban and rural areas in SSA [3,4]. Adequate attention is usually given to the urban areas relative to the rural communities. For this reason, most people living in the rural communities are technologically, socially and economically backward. The electricity access rate of African region is depicted in Table 1 which shows the shortfall of SSA relative to North Africa and other developing countries [3]. Till date, fossil fuel-based resources account for 80% of the global energy supply [5] notwithstanding their environmental impact of global warming, acid rain formation, and ozone depletion. Due to low per capita income, there are speculations that Africa would be more vulnerable to extreme weather conditions associated with the environmental impact of fossil fuels. For emphasis, Wesseh and Lin [6] explained that unlike rich nations, it would be difficult for Africa to import food from abroad, build dams to prevent rising sea water and pay

for air conditioning. Moreover, the Africa contribution to the global carbon dioxide emissions are low compared to the other regions. The regional aggregates presented in Table 2 depicts that the carbon dioxide contribution of Africa is less than 4% of the global emissions [7,8]. Conversely, the recent upsurge in the price trend of fossil fuel-based resources is encouraging the consideration and development of renewable energy sector. Sustainable development which can be achieved using renewable energy technologies (RET) have been the main focus of recent policies and development plan of many countries. Most countries now do not only set renewable energy target but also defines the proportion of each RET alternative in the forecasted energy generation mix. In general, the decision on which RET to adopt is not trivial due to trade-offs of economic costs, supplies reliability, environmental concern, and social aspect [9]. The prospect of achieving a sustainable endogenous development via the use of these renewable energy systems was emphasized by Delrio and Burguillo [10]. An endogenous development implies using the available local resources to achieve a localized change which is capable of not only improving the cultural but also spiritual well-being of the community. Moreover, there have been some other studies focusing on various decision frameworks and operational strategies with the aim of minimizing the total energy costs [11–13].

Solar photovoltaic (PV) technology has been accepted as a

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