Abstract

According to the World Bank's classification of countries by income, a low-income country refers to a nation with a per capita gross national income (GNI) of less than $1,026. This largely encompass developing countries especially in sub-Saharan Africa and developing Asia, with less developed industrial base and low Human Development Index (HDI) relative to other countries. It is well-established that the availability and adequate supply of energy is needed to drive development, yet roughly 20% of the world's population do not have access to electricity. Electricity is also viewed as the type of energy most valued and needed for economic development.

There is a consensus that decentralized renewable energy may be most appropriate for the electrification of rural areas as it enables countries to leapfrog the development of conventional electric grids. Indeed, this sort of energy-based economic development holds great promise. However, there are still unanswered questions of how best to move rural areas to adequate renewable energy and how to tackle the incessant challenge of lack of systematic planning as regards improving rural energy access.

Therefore, this thesis primarily presents and illustrates an integrated rural renewable and sustainable energy planning framework for low-income countries. This framework provides a unified road map for energy planning, system design, and operation with renewable energy integration geared towards improving localized energy access in rural areas.

The integrated rural renewable and sustainable energy planning framework has emerged as a standardized and holistic integrated framework for rural energy planning to foster locating, planning and operating decentralized renewable hybrid energy systems. The entire framework is geared towards improving localized energy access in low-income countries.The framework embodies a comprehensive methodology encompassing three methodical action steps which have been illustrated based on case study applications adopted at varying scopes. The first step which entails site identification and selection is performed for Nigeria which presents an archetype for the developing world especially countries in sub-Saharan Africa. The second step encompassing robust energy demand and supply estimation and third step focused on detailed energy system planning, design and configuration are streamlined to two target communities from the first step.

This framework has been immensely facilitated by a compendium of methodologies and the application of a multi-tool approach drawing insights from existing literature as well as providing insights that can inform the trajectory for future research endeavours in this field. The apparent synergies of the action steps have been extensively discussed to expatiate the softlink between the different modules of the framework. This buttressed the bi-directional flow of information between the different steps of the framework and attests to the interoperability, and interconnectedness of the different approached and models utilized.

Overal, the IR^{2}SEP framework is poised to completely change the narrative of rural areas and the findings here can be regarded as a proverbial "springboard" to spur sustainable development in rural areas of low-income countries. It could also standardise rural energy planning and set the precedence for future energy access studies in the developing world. Therefore, this framework finds applicability across areas with similar energy access and rural development issues especially sub-Saharan Africa and developing Asia. Given the prevalence of the rural population in many developing countries, these insights are useful in these regions to further the realization of the United Nations' goal of affordable and clean energy (SDG7) by enabling the provision of sustainable, reliable and productive energy for all**.**