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Power sector renewable energy integration for expanding access to electricity in sub-Saharan Africa



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ABSTRACT

A looming energy supply crisis in sub-Saharan Africa (SSA) raises concerns about a long-lasting energy shortage. This energy crisis is expected to persist for an indefinite period in the region unless immediate actions are taken to reverse the trend. Although global aspiration to reduce greenhouse gas (GHG) emissions into the atmosphere is high, such desire is low in SSA. Regional stakeholders are more worried about increasing power generation capacity to enhance better access to different sorts of development. To progress in line with advanced patterns of energy development globally, to increase the availability of electrical energy and to sustain emissions reductions, exploitation of local renewable energy (RE) resources is inevitable. Consequently, this paper presents a comprehensive review of RE integration for expanding access to electricity in SSA. The review covers the sustainability of RE resources in SSA, the regional status of RE applications and the necessity of RE power generation integration planning from a management aspect. Finally, the benefits of RE integration into the power sector of SSA and some conceptual challenges affecting its integration in the region are highlighted.

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Contents

1. Introduction	631
2. Review of related literature on power sector renewable energy integration	633
3. Renewable energy resources in sub-Saharan Africa	633
3.1. Solar power	633
3.2. Biomass power	634
3.3. Wind power	634
3.4. Hydropower	635
3.5. Geothermal energy	635
4. Financial constraints on renewable energy development in sub-Saharan Africa	635
5. A methodology for renewable energy integration and a renewable energy planning and management system	636
5.1. A suggested methodology for power sector renewable energy integration in sub-Saharan Africa	636
5.2. Renewable energy planning and management system	637
5.2.1. Merits of power sector renewable energy integration planning	638
6. Major challenges affecting renewable energy power sector integration in SSA	638
6.1. Lack of political will	638
6.2. Poor financial capital investment	639
6.3. Insufficient research and development guides	639
6.4. Inadequate training and poor capacity building	639
6.5. Lack of renewable energy promotion strategies and poor public awareness	639

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7. Conclusions 640
 Acknowledgement. 640
 References 640

1. Introduction

Most developing countries envision increased development in the future. However, the attainment of such status requires an enormous level of energy consumption. Modern conventional power generation infrastructures and some energy consumption processes release greenhouse gas (GHG) emissions unaltered into the surrounding atmosphere. GHGs are principally dispensed from fossil-based energy resources commonly used for large-scale electricity generation. Environmentalists have cultivated a close relationship between RE and sustainable development [1–4]. Most developing countries cannot afford to depend entirely on oil and gas for their electricity demands, especially today with fluctuating fossil fuel prices in the global market. With ongoing regular energy shortages in developing countries, a rethink of integrated energy resource planning to increase access to electrical energy, especially for social, environmental and economic growth, is unavoidable. Today, before a resource can be considered for electrical energy production, some specific requirements must be satisfied. These include cost, environmental pollution, technological robustness, fuel supply stability and energy supply efficiency. In this respect, it can be concluded that renewable energy sources (RESs) meet all the basic requirements for both current and future sustainable energy supply scenarios as revealed in Fig. 1.

The integration of RE into the power sector is not a new concept in any part of the world. It has been a continuously and progressively changing idea, with RE regarded as having a substantial positive role to play, especially in expanding access to energy in regions of energy shortages. The integration of RE into the power sector could be considered more worthwhile in regions where there is a large quantity of sustainable and renewable resources available and where there is a proper understanding of the utilisation technologies. The use of RE to supplement or to replace fossil fuels provides many benefits to developing countries [6–9]. SSA has many isolated rural settlements and promoting RE technologies in these less densely populated areas could facilitate increased energy access to households [10–15], with resulting impacts on economic, environmental and social status [16]. As economic development depends on the energy systems of a country [17], there is a social and moral justification for enhancing the energy resources of all countries. On the one hand, in developing countries, there is a need to increase the level of the available amount of energy supply, whereas on the other hand,

there is global interest in carbon emission reduction. To strategically realise the current demand to sustain a low carbon electricity sector in developing countries, many researchers and international energy stakeholders anticipate the integration of RE into the power sector.

Power sector RE integration could be achieved through integrated green energy resource planning (IGERP), with potential impacts on energy delivery and consumption systems. IGERP is a synchronised planning mechanism for different RE resources. An integrated resource planning (IRP) approach involves a change in the mix of end-use electricity using equipment at the demand side and a change in the total electricity generation, installed capacity, fuel mix, technology mix and environmental emissions at the supply side [18]. Power sector reform is an ongoing phenomenon in some developing countries, especially in SSA, because several reform strategies introduced in the past have yet to exhibit some expected positive impacts. In addition, adequate planning of energy resources incorporating RES have not been translated into effective measures in a regional framework for energy in SSA. Realistically, modern RE exploitation and development in SSA is lagging behind many any other regions in the world due to the following reasons:

- Limited capital investment
- Lack of technological knowledge on RE development
- Constricted power generation planning
- Deficient electricity supply resulting from frequent power systems failure and unreliable equipment
- Low rate of electrification in the region
- High cost of electrical energy generation
- High transmission losses

These constricting factors have adversely affected any effort to expand access to electricity in the region. Approximately 31% of people have access to electricity in SSA, with about a 14% electrification rate in the rural areas [19]. Table 1 shows the electrification status of different countries in SSA and in the northern axis of Africa. Apart from Ghana and Mauritius, the electrification rate by percentage in other countries is quite low, below 50% on average. In Fig. 2, two possible scenarios are shown regarding the electricity generation capacity of SSA. In the first case, it is obvious that electricity generation in SSA (excluding South Africa) has the lowest electricity generation capacity among the developing regions of the world. The trend in capacity has been frozen at a point close to 50 MW per million people for more than 18 years. When South Africa is included in the analysis, the potential of the region increases, and the capacity is slightly better than that in South Asia between 1990 and 1997. In 2008, South Africa alone had a share of 56.1% of the 92.3 MW per million people of the total installed capacity of the region [20]. The prevailing trend changed from 2002 to 2008, with the capacity of SSA falling below that of South Asia, even with the addition of South Africa.

A review of the current use of RE in SSA is necessary to examine the possibility of integrating RE into the power sector of the countries in the region. Section 1 provided an introduction to the subject. In Section 2, a short review on power sector RE integration is presented. Section 3 discusses the various types of renewable resources available in SSA. Section 4 presents a brief discussion of the current status of RE exploitation in the region. RE generation planning and management strategies are briefly highlighted in

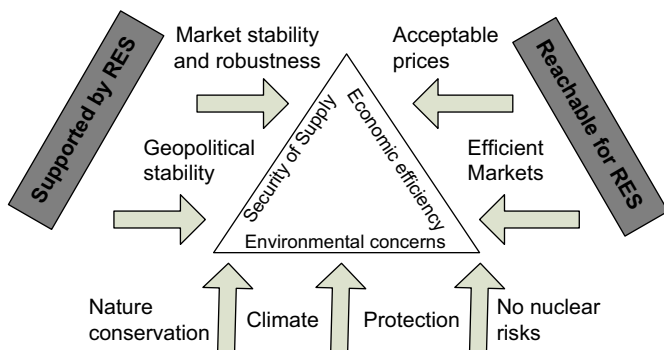


Fig. 1. An energy triangle showing all essential requirements of a sustainable energy supply system can be fulfilled by RES at present and in the future [5].

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