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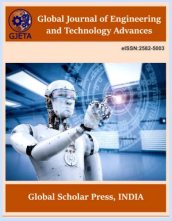

(RESEARCH ARTICLE)

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Integrating localised energy systems into the Nigerian power network

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Abstract

The ever-increasing population and growing demand for electricity in Nigeria has put great pressure on the existing conventional generations and there is urgent need for other alternative energy resources. Localised energy systems which have been prevalent in the UK and Europe remain the most viable solution to tackle the pressing challenges of lack of reliable, environmentally friendly and sustainable electricity supply in Nigeria. However, the implementation of localised energy system might face some challenges and barriers that could hamper the development. In this paper, these challenges were analysed and possible solutions were suggested, in order to facilitate the growth of localised energy systems in Nigeria. Aside solving electricity related problems integration of localised energy systems will also help to provide jobs for the youth and create new investment opportunities for the people.

Keywords: Localised energy system; Nigeria power system; Renewable Energy; Solar Photovoltaics; Wind Energy

1. Introduction

Access to sustainable, quality and reliable energy is essential to promote human and economic development. Currently, around 16% of the world population, lack access to electricity. In fact, majority of this population are located in Africa, where less than 40% of homes have access to the national grid[1]. For instance, in Nigeria, less than 40% of the citizen are connected to the grid while the remaining population lack access to reliable electricity[2]. Therefore, there is an urgent need to address this horrible situation.

Currently, the price of renewable energy generation is gradually reducing and thus will help to achieve better energy access [3]. Power sector in Nigeria is poorly funded and grid infrastructure are not well maintained leading to inadequate grid capacity to meet current energy demands [4]. The rate of integration of renewable energy sources into the energy mix is slow and cannot meet the expected target time frame due to poor funding [5]. Efforts are ongoing to upgrade the existing grid infrastructure, it is obvious that population growth will always be greater than the existing generation and distribution capacity[6] Therefore, renewable generation and storage remains the most viable option [7]. Nigeria has high solar radiation intensity for the most part of the year. Therefore, the power sector in Nigeria can be sustained by solar energy [5]. Renewable energy sources must be integrated into the national energy mix to expand electricity access[4]. Localised energy system is a medium-sized electricity generation system of capacity not larger than 50MW connected to a local distribution network [8]. Localised generations are connected close to the load which is responsible for losses reduction in the network. This paper discusses the prospect and challenges of localised energy system for rural electrification in developing countries such as Nigeria. The paper is organised as follows section 2 discuss the Nigerian energy systems and its power needs as well as renewable energy potential in Nigeria, section 3 addresses overview of localised energy systems, localised energy models, barriers and benefits to localised energy system. Section 4 gives the conclusion and recommendation.

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2. Nigerian energy systems and its power needs

In March 2005, the federal government signed the power sector reform bill into law to encourage private participation in power generation and supply [9][10],[11]. The aim of the power sector reform is to enable drastic expansion of the power grid. However, this deregulation process was unable to transform the power sector.

Power infrastructure in Nigeria is inadequate, outdated and poorly maintained which lead to low revenues, high transmission and distribution losses, power theft and poor tariffs [12], [13], [14]. In Nigeria, the total installed generation capacity is 12,522 MW [15], while the available generation capacity of 4,500MW. This is inadequate for the population of around 190 million people [16]. The demand for electricity in Nigeria is greater than the available generation and is estimated to be 12,800 MW [15]. According to [16], Nigeria power sector has one of the highest transmission and distribution losses in the world. Majority of the rural population rely on diesel generator leading to environmental pollution and inflation in the prices of goods and services [17]. This poor electricity supply has been a barrier to private investment in the country [18].

Currently, Government is considering power generation from renewable energy sources and to increase its power generation to 30,000MW by 2030 with 30% of its energy from renewable [19]. The present power challenges facing Nigeria will persist unless the government diversifies the energy sources and adopts new technologies such as localised energy system [20].

2.1. Renewable energy potential in Nigeria

Nigeria is endowed with abundant renewable energy resources such as solar energy, hydro-power, biomass, wind etc. Unlike the developed countries such as USA, UK and Europe these renewable resources are underutilised in Nigeria [21], [22]. Aside from biomass and waste, the current state of exploitation and utilization of renewable energy resources is low [23] as shown in Table 1.

Table 1 Renewable energy potential and utilisation in Nigeria [23].

Resource type	Reserves	Domestic utilization
Small hydropower	3500 MW	30 MW
Large hydropower	11,250 MW	1938 MW
Wind	2-4 m/s at 10m height (mainland)	-
Solar radiation	3.5 - 7.0 kWh/m2/day	6 MWh/day
Fuel wood	11 million hectares of forest and wood	0.120 million tonne/day
Animal waste	211 million assorted animals	None
Energy crop and agricultural residue	28.2 million hectares of arable land	None

2.1.1. Hydropower

Hydropower is one of the key sources of electricity supply in Nigeria with about 30% of total installed electricity generation in the country [24]. Nigeria is endowed with rivers, dams and waterfalls. Hydropower is derived from the potential energy present in water due to height in reservoirs, dams or lakes [25]. Hydropower is renewable and therefore, is a reliable source of electric power.

The grid-connected hydropower in Nigeria is about 1,977MW [26]. There are over 278 unexploited Small Hydro Power (SHP) sites in Nigeria [27]. Hydropower contributed about 0.4% to the total energy consumption in the country [28], while it currently contributes approximately 30% of the total installed grid-connected generated electricity [28].

2.1.2. Wind

Wind energy generation is popular in North America, Europe and Asia. Wind speed in Nigeria is about 2.0m/s at the coastal region and 4.0 m/s at the far northern region of the country [23]. This technology has been tested in the Northern

parts of the country, mainly for water pumping in secondary colleges in Sokoto state, Kano states, Katsina, Bauchi and Plateau state. According to Energy commission of Nigeria (ECN), the total exploitable wind energy reserve at 10m height is between 8MWh/yr in Yola to 51MWh/yr in Jos.

2.1.3. Solar

Nigeria is endowed with abundance solar energy resources [29]. The country solar energy generation is high with direct sun rays and high temperature. According to [30], solar radiation in Nigeria is estimated to be approximately $3.8x10^{23}$ kW. The solar radiation varies from 3.5 kW m^{-2} day^{-1} in the south to 7 kW m^{-2} day^{-1} in the far North of Nigeria. The country solar radiation is about 3.55 kWh m^{-2} day^{-1} in Katsina in January and 3.4 kWh m^{-2} day^{-1} for Calabar in August [31].

Solar energy can be used for rural electrification to provide power supply to remote villages not connected to the national grid. Solar power can also be grid-connected, that is, to generate power for feeding into the national grid. Solar electricity can also be used for water pumping, rural electrification, schools power supply and traffic lighting etc. Several research projects and studies have been conducted by agencies such as Sokoto Energy Research Centre (SERC) and the National Centre for Energy Research and Development (NCERD) [4].

2.2. Biomass

Biomass resources in the country include fuel wood, crop residue, agricultural waste, saw dust, animal dung etc. [32]. Figure 1 shows the estimated biomass resources in Nigeria.

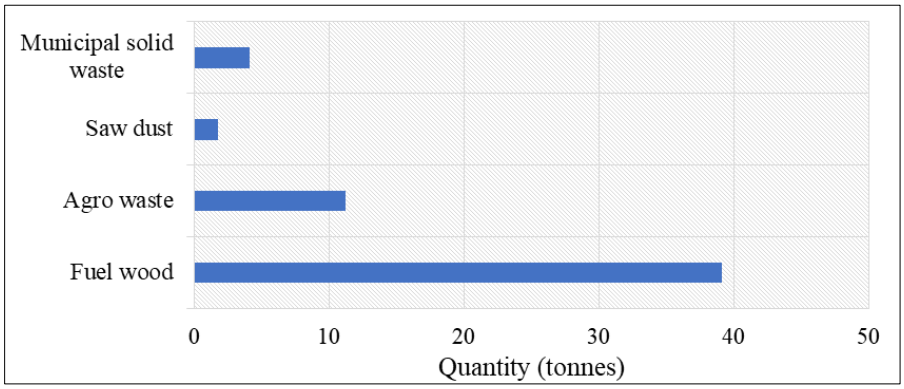

Figure 1 Biomass resources and the estimated quantities in Nigeria [32]

Fuel wood is the most common form of biomass energy in Nigeria. Fuel wood can be used for both commercial and energy purposes. The energy purposes include plywood, sawn-wood, paper products and electric poles. The energy purposes include cooking and other domestic purposes.

2.3. Policy on renewable energy generation

A robust and effective energy policy is essential for efficient utilization of renewable energy in any country. The Nigerian National Energy policy was established in 2003 for effective use of renewable and fossil energy in Nigeria. The renewable energy sources, such as wind, solar, hydro, biomass etc. The policy is to assist in the integration of renewable generation into the country's energy mix [30]. Renewable Energy Feed-in-Tariff (REFiTS) was introduced by the Nigeria Electricity Regulation Commission (NERC) to encourage investments in the renewable energy. This was included in the Multi-Year Tariff Order (MYTO) II issued in June 2012 [30]. Also, five-year tax-free period for renewable investments was introduced as well as 30% target for renewable energy for the year 2030.

The Road map for steady power supply was introduced in 2016 which shows the government commitment to renewable energy development and to increase generation capacity in the country [33]. In addition, National Energy Efficiency Action Plan was set up with the aim of attaining 30,000MW of electric power by the year 2030 using at least 30 per cent renewable energy in the electricity mix. If well implemented by the government and relevant agencies, the renewable energy market in Nigeria will experience radical growth [33].

3. Overview of Localised Energy Integration

The needs for affordable, reliable and sustainable energy have led to transformation in the way energy is generated, transmitted and distributed. It has change from a passive one-directional system to an active, multi-directional system. In this transformation consumers can now produce, manage and own generation assets. Many households now have solar photovoltaic on their rooftops and some are owners of off-site generators such as wind turbines. The distribution systems are now own by cooperatives that are accountable to their customers.

Localised energy system is growing rapidly both in developed and developing nations as alternative sources of electric power supply. It is much larger in capacity than microgrid and can provide electricity for both urban and rural villages. They have the potential to increase the penetration of renewable energy and enhance smart grid development [34].

The concept of LES [8] represents a transformation in electricity generation, transmission and distribution and is now popular in the UK and Europe. Localised energy system (LES) is a medium-sized electricity generation system of capacity not larger than 50MW connected to a local distribution network[8]. Local energy systems provide electricity for different categories of customers for domestic purposes, commercial use and for electric vehicle charging. It is now assisted traditional generation to meet the demand that previously been met by a centralized system. Most electricity systems worldwide are yet to adopt renewable local generation but in the nearest future localised energy system could dominate centralised generation. For instance, Germany have successfully integrated large amounts of distributed renewable technologies into their national energy mix. In Denmark. a large proportion of the wind energy generation are owned by local wind cooperatives. Localised energy systems encourage full utilization of smart meters features such as demand side management [24]. They could facilitate faster decarbonization than conventional centralised power systems [35], [36].

3.1. Barriers

This paper has identified a number of barriers that could hinder the implementation of localised energy systems. These includes

- The existing regulatory frame work must be updated and modified to accommodate local energy integration [36].
- It is expensive and difficult to obtain a grid connection for local energy project.
- Initial cost of local energy project is very high, dependent upon location.
- The existing grid must be reinforced to accommodate local energy at significantly increasing costs [37].

3.2. Local energy models

The available localised energy systems models are discussed in Table 2. They are categorised into a set of archetypes.

Table 2 Local energy archetypes [24]

Archetype	Description	Example projects
Local generation	Projects can be financed, managed and owned by community.	Brixton energy, Awel group
Local supply	Model aimed at providing affordable low carbon energy to communities.	Robin hood energy
Micro-grid	They are either grid connected or off-grid	Knoydart, Isles Scilly
Virtual private networks	They are not widespread and operate on the public distribution network.	Fintry smart meter

3.3. Benefits of local energy

The benefits of local energy system are:

- To boost energy reliability and security and to complement conventional generation.

- To provide greater flexibility within the system, which could be particularly beneficial with increasing penetration of renewable energy.
- To help in achieving renewable energy target as well as carbon reduction targets.
- To open up investment opportunities for independent generators, farmers, schools, hospitals, and community groups.
- To reduce costs of electricity for consumers in some ways. [38].
- To raise awareness on energy security, decarbonisation and energy efficiency.

4. Conclusion

This paper discusses localised energy systems as alternatives source of electricity for rural villages and towns in Nigeria. Localised energy systems are one of the most efficient methods of electrical energy generation in a developing economy likes Nigeria, that rely on conventional generation. From the discussion in this paper, it is clear that the country's power sector is suffering from under funding, leading to inadequate generation capacity. Localised energy system will encourage different groups in the society to come together and invest in energy sectors. Nigeria has sufficient amount of sunshine and good solar isolation that favours localised energy systems preferably from solar, wind and small hydro technology. Localised energy systems should be encouraged as the merits include: pollution free environment, free renewable and energy source, high reliability and low maintenance costs. It is our opinion for the above merits of localised energy system technology to be achieved; the following recommendations must be adhered to:

- Government should fund research in the area of renewable energy technology.
- Training of manpower in the areas of renewable energy technology.
- The government should set up independent policy makers on renewable energy to monitor and to encourage the Energy Commission of Nigeria.
- A favourable and robust feed in tariff should be introduced to assist investment in renewable energy.
- The nation's electricity grid connection should be made flexible to accommodate renewable localised energy systems.

Compliance with ethical standards

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Disclosure of conflict of interest

We hereby declared there is no conflict of interest.

References

[1] International Energy Agency (IEA), "Energy and Climate Change," World Energy Outlook Special Report, OECD/IEA PARIS, 2015.

[2] Fasina ET, Adebanji B. and Adewale A. Impact of distributed generation on the Nigerian power network. Indonesia Journal of Electrical Engineering and computer science. 2020; 21(3): 1263-1270.

[3] REN21. Renewables 2017 Global Status Report (Paris: REN21 secretariat), 2017.

[4] Oyedokun JA, Fasina ET, Adebanji B, Abe A. Electricity challenges in Nigeria: Renewable energy a way forward. Global Journal of engineering technology Advances (GJETA), 2022; 11(03): 016-023.

[5] Pandey R. Reinforcing energy grid in developing Countries and role of energy storage. Journal of Undergraduate Research, University of Illinois, Chicago. 2017; 10(1)

[6] EIA. Energy implications of higher economic growth in Africa. 2018.

[7] Greenpeace, "Decentralising power: an energy revolution for the 21st century," 2005.\

[8] Fasina ET., Hassan AS, Cipcigan LM. Impact of localised energy resources on electric power distribution systems. 50th International University Power Engineering Conference. 2015; 1–5.

[9] Sambo A., Garba B, Zarma IH, Gaji MM. Electricity Generation and the Present Challenges in the Nigerian Power Sector, Energy Commission of Nigeria. 2016.

[10] Sambo AS, Garba B, I. H. Zarma, and M. M. Gaji, "Electricity Generation and the Present Challenges in the Nigerian Power Sector," 2012.

[11] Nesistats, "Nigerian Power Baseline Report," Office of the Vice President of Nigeria, 2015.

[12] NESP, "Nigerian Electricity Supply Industry," Nigeria Electricity Regulatory Commission. [Online]. Available: http://www.nercng.org/index.php/home/nesi. [Accessed: 01-Jul-2018].

[13] Adebanji B, Ojo A, Fasina ET, Adeleye SA, Abere J. Integration of Renewable energy with smart grid Application into the Nigeria Power Network: Issues, challenges and opportunities European Journal of Engineering and Technology Research (EJETR). 2022:7(3); 18-24

[14] Samuel I, Katende J, Ibikunle F, "Voltage Collapse and the Nigerian National Grid. EIE's 2nd International Conference on Computer Energy Networks Robotics and Telecommunication. 2012; 128-131.

[15] PwC. Powering Nigeria for the future. The Power Sector in Nigeria. 2016.

[16] NESISTAT. Nigeria Power Baseline Report. Office of the Vice President. Federal Republic of Nigeria, 2016.

[17] Fasina ET, Oliyide RO, and Cipcigan LM. Localised energy systems in Nigerian power network, in Proceedings - IEEE 15th International Conference on Industrial Informatics, INDIN 2017, 456–461, doi: 10.1109/INDIN.2017.8104815.

[18] Sambo AS, Matching Electricity Supply with Demand in Nigeria. 2008; 32–36.

[19] SE4ALL, "Sustainable energy for all: action agenda & investment prospectus implementation," in Presented At the 3rd Annual Workshop on Advancing SE4All Country Action in Africa Abidjan – Cote D'Ivoire 9th -12th February 2016, 2016.

[20] Oyedepo SO, "Towards achieving energy for sustainable development in Nigeria," Renewable and Sustainable Energy Review. 2014; 4(1): 255–272.

[21] Osueke CO, Ezugwu CAK. Study of Nigeria Energy Resources and Its Consumption. International journal of Science and Engineering Reviews. 2011; 2(1): 2229–5518.

[22] Sambo AS, Strategic Developments in Renewable Energy in Nigeria. International Association of Energy Economics. 2009; 15–19,.

[23] John EA, Tariilanyo A. Proper Energy Mix: A Solution to Stable Power Supply in Nigeria. Academic Journal of Interdisciplinary Studies, MCSER, 2013; 2(13): 93–102, 2013.

[24] Hall S, and Roelich K. Local Electricity Supply: Opportunities, archetypes and outcomes. 2015.

[25] Oyedepo SO. Towards achieving energy for sustainable development in Nigeria," Renewable Substantiable Energy Reviews. 34(1).

[26] UNIDO. Baseline Report on Small-Scale Hydropower Systems in the ECOWAS region ECOWAS Regulation Work on Small-Scale Hydropower, 2012.

[27] NESP, The Nigerian Energy Sector: An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification, 2nd Edition, GOPA, 2015.

[28] C. Newsom, "Renewable Energy Potential in Nigeria," International Institute for Environmental Development, 2012.

[29] M. Shaaban and J. O. Petinrin, "Renewable energy potentials in Nigeria: Meeting rural energy needs," Renewable and Sustainable Energy Review, vol. 29, pp. 72–84, 2014.

[30] Fasina E.T. "Localised energy system in the Nigeria power Network" Ph.D thesis submitted to Cardiff University, June, 2019 .

[31] A.S. Sambo, "Renewable Energy for Rural Development: the Nigeria Perspective," ISESCO Science and Technology Vision, vol. 1, pp. 12–22, May 2005.

[32] SE4ALL, "Sustainable energy for all: action agenda & investment prospectus implementation," in Presented At the 3rd Annual Workshop on Advancing SE4All Country Action in Africa Abidjan – Cote D'Ivoire 9th -12th February 2016, 2016.

[33] Oyedepo SO, Towards achieving energy for sustainable development in Nigeria," Renewable and Sustainable Energy Review. 2014; 34, (1) 255–272.

[34] [Kukoyi D, Adeyemi E. Renewable Energy Law Review, Law Business Research Limited. 2018.

[35] Siemens. Local Energy Systems, Siemens UK. [Online]. Available: https://www.siemens.com/content/dam/webassetpool/mam/tag-siemens-com/smdb/regions/united-kingdom/energy-management/local-energy-systems-uk-brochure.pdf. [Accessed: 25-Jun-2018].

[36] House of Commons. Local Energy, Sixth Report of Session 2013–14, Energy Climate Change, 2013; 1(1).

[37] Simonds V, and Hall B. Overcoming grid connection issues for community energy projects for Co-operatives UK and The Co-operative Group. Cornwall energy, 2013.

[38] Tingey M, Webb J, and Hawkey D. Local Authority Engagement in UK Energy Systems: Highlights from Early Findings. A Report by Energy Technology Institute, UKERC, London ETI, Loughborough, 2017