

Methodology Article

Potentials for Sustainable Power Supply in Nigeria: An Overview of Energy Resources in Western Nigeria

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Abstract: Availability of affordable energy is essential for the improvement of living standard and economic growth in any country. This study examined available energy resources in Western Nigeria and analyzed how they can be harnessed for sustainable energy supply. The study approach used involved literature survey, observation tour of some locations across the region and analysis of the observed scenario. The development of the proposed sustainable solution is based the study of countries in similar situation and how they were able to surmount their energy supply problems as well as personal understanding of the necessary adjustments for differences in locational factors and culture. The framework recommends integration of small number of abundantly available renewable energy sources at a scale manageable by locally available hands and in collaboration with all the stakeholders. It is believed that the proposed sustainable energy technology would ameliorate the persistent energy problems in the region. The proposed energy supply system is also expected to be economically affordable, environmentally friendly and culturally compatible.

Keywords: Affordable Energy, Energy Management, Hybrid Energy, Western Nigeria

1. Introduction

Energy is required for virtually anything we do in our daily lives. Energy is needed for preparing the food that we eat, for various types of self-propelled transport devices, for water treatment and distribution, for wastewater treatment, for manufacturing, for communication and various entertainment and leisure activities. Most energy needs are required in the form of electricity. However, a number of developing countries like Nigeria and businesses operating in their domain have been suffering from epileptic supply of electric energy over a very long period of time. The situation has badly impacted potable water supply, waste management, and health care delivery. It has also weakened industrialization in the country. Furthermore, unstable electric power supply has significantly undermined various efforts aimed at achieving sustained economic growth, increased competitiveness of indigenous industries in domestic, regional and global markets as well as employment generation. This study is aimed at reviewing the current state of energy production and supply in

Nigeria, examining the root causes of the problems and propose sustainable solution to them [1-5].

2. Current State and Approach to Electric Energy Supply in Nigeria

According to KPMG [4], there are currently 23 grid-connected generating plants in operation in the Nigerian Electricity Supply Industry (NESI) with a total installed capacity of 10,396.0 MW and available capacity of 6,056 MW. Most generation is thermal based, with an installed capacity of 8,457.6 MW (81% of the total) and an available capacity of 4,996 MW (83% of the total). Hydropower from three major plants accounts for 1,938.4 MW of total installed capacity (and an available capacity of 1,060 MW).

There are also alternative electric energy supply by corporate organisations and private individuals. Majority of them are from petrol or diesel powered generating sets. In addition, there are also some solar power and small hydro based electric power systems, especially in the rural areas. A

number of individuals and government agencies are also making some effort in developing other alternative sources of electric energy. The Federal government is also pursuing embedded power supply avenue whereby private and corporate generators sell power directly to specific distribution company. But most of these energy facilities are designed for large scale power supply.

3. Causes of Energy Production and Supply Problems in Nigeria

Majority of the current energy supply facilities in Nigeria require steady supply of fossil fuel that does not only pollute our environment but are also not available at crucial times due to infrastructure breakdown from vandalism and inadequate maintenance.

History of electric power development in Nigeria showed that it started small, but it later evolved to regional power supply facilities. The regional energy facilities were later merged to become a monopoly. Meanwhile the ever increasing population growth and expanding economy resulted in increased energy demand. However, the demand outgrew the supply to the point where the demand progression outpaced the increase in energy investment and supply. For instance, it has been estimated Nigeria's immediate electricity requirement stands at 40,000MW for it to achieve a near regular power supply to domestic and industrial users in the country, but the country currently generates a meagre 4500MW on average, out of which about 4000MW is distributed to the approximately 50 per cent of her population that has access to grid electricity [4, 6-8].

Similarly, the increased responsibility of the energy monopoly seems to be beyond the capability of its managers in surmounting the daily emerging new problems. In addition, the energy organization was largely managed like government bureaucracy which further compounded its problem of being able to meet the needs of its clients. Furthermore, government attitude, bad top management attitude, contractors' attitude, poor maintenance planning, spare parts' availability problem, lack of continuity in policy resulting from changes in government and lack of competitiveness exacerbated the problems. Moreover, incessant equipment vandalization and theft, lack of manpower proactiveness, inadequate manpower training/education, equipment vandalization, drought, inadequate gas supply, wrong location, lack of policy continuity, limited automation, lack of energy mix technology, and competitiveness crippled the activities of the energy supply organization. Efforts have been made by various levels of government and private organizations at solving the problems. Dismemberment of the monopoly in recent past and a number of policy changes are among the efforts but unfortunately they are yet to yield any positive result [2, 3, 9].

In view of the undertaken study, the author believed that sustainable solution to the problem would require a shift from the current approach to regional or district based energy generation and supply system that focuses on harnessing

locally abundantly available renewable energy resources at a manageable scale and in an integrative manner. This belief informed the focus of this study on the Western region of Nigeria.

4. Western Nigeria's Renewable Energy Resources Endowment

Nigeria as an entity is blessed with abundant varieties of energy resources both renewable and non-renewable. The abundance of each of these energy resources varies from one location to another. In view of the ongoing global trend, this study is focused on locally available energy resources in Western region of Nigeria. Among the abundantly available energy resources in the region include solar, hydro, biomass, and wind (offshore).

4.1. Solar Energy Resource

The location of Nigeria just above the equator placed it in a vantage position for abundant sunshine all year round and thus endowed it with enormous solar energy potential. Nigeria receives approximately 12 hours of non-stop intensive sunshine throughout the year. According to Iwayemi [3], Nigeria receives about 3.5-7.0 KW/m² per day of solar radiation. Although the solar intensity in the Western Nigeria is not the same as the Northern part, an estimated 500 MW of energy can be generated in Western Nigeria from solar sources. However, the region is yet to tap this abundantly available resource for its energy supply.

4.2. Water Resources

According to USAID [10], Nigeria has potential for 11,500 MW in large hydro power plants as well as up to 730 MW in small hydro-power projects. Western region is particularly blessed with many fast flowing rivers and large streams that run across the region. Among such rivers and big streams with many municipalities near them are Oshun, Owena, Oshin, Erinle (Otan), Ogun (Yelwa), Oyi, Ogunpa, Oba, Ogbesse, Shasha, Ominta, Tesi, Wuru, Asa, Ase, Osiomo, Mim, and Atakpo (Figures 1 and 2). Many of these rivers and streams have sites along their courses where the head (fall) of water is two or more metres. Thus, micro-, mini- and small hydro categories of electric energy (i.e. 5 kW to 10 MW power output) can be generated from those sites (Table 1). Exploring such small scale renewable energy source that has little or no ecological footprint would go a long way in helping to solve the energy deficit in the region [3, 11-12].

4.3. Biomass Resources

Quoting Simonyan and Fasina [9], "biomass consists of organic materials that are plant or animal based, including but not limited to dedicated energy crops, agricultural crops and trees, food and fiber crop residues, aquatic plants, forestry and wood residues, agricultural wastes, biobased segments of industrial and municipal wastes, processing by-products and

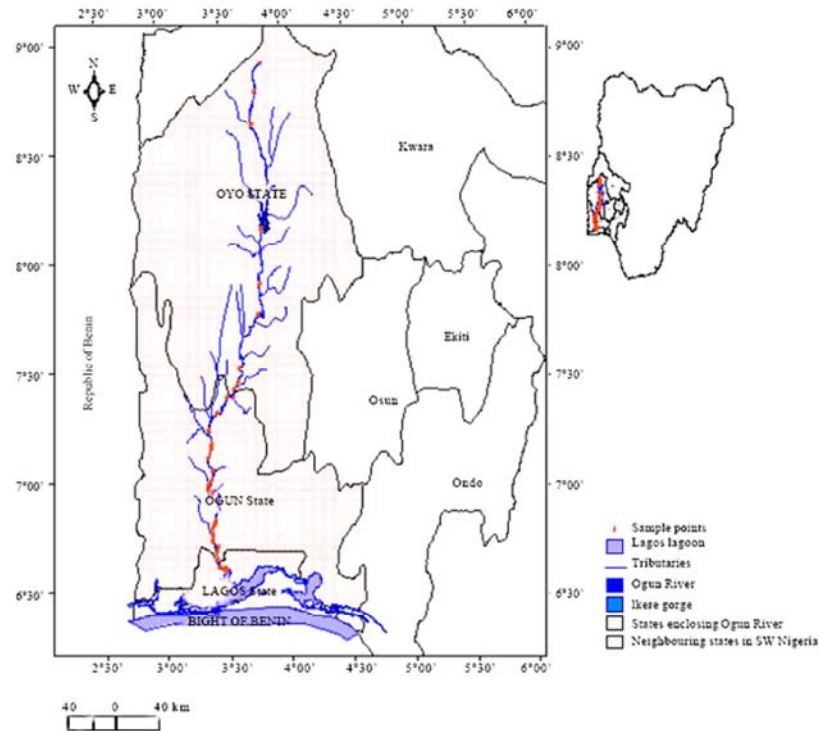
other non-fossil organic materials.”

Western Nigeria's regional vegetation range from being swampy forest in the south to Guinea savanna vegetation in the north. An estimate of about 7% of the region is in the mangrove forest zone, 40% is under forest vegetation while the rest 53% is under Guinea savanna vegetation. Iwayemi [3] also reported that Nigerian biomass endowment stands at 144 million tonnes per year. About 43.3 million tonnes of woody biomass could be harnessed for energy supply from the region.

In addition to woody biomass, there are other significant sources of bioenergy. There are many big municipalities like

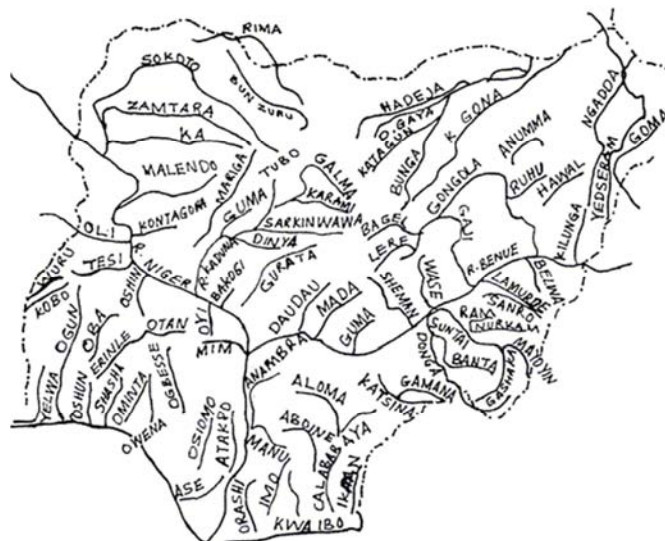
Lagos, Ibadan, Benin City, Akure, Ilorin, Oshogbo, Abeokuta, Oyo, Benin, Asaba, and Sapele where large quantity of municipal solid wastes are produced daily. Electric energy can also be generated from these solid wastes. Energy can also be generated from human and livestock poops in this region.

Utilizing the huge quantities of agricultural residues and other wastes for energy production would increase available energy supply and reduce air pollution from burning fossil fuel. It will also prevent surface and groundwater contamination from dumping. In addition, it will increase the energy mix and balance in Nigeria's Western region.



[Source: <http://scialert.net/fulltext/?doi=rjp.2013.1.8&org=10>]

Figure 1. Map of South Western Nigeria showing the study area and the three states the river traversed.



[Source: <http://www.fao.org/docrep/008/ad793b/AD793B01.htm>]

Figure 2. Major Rivers in Nigeria.

Table 1. Categories of hydro energy.

Hydro Category	Power Range	No. of Homes Powered
Pico	0 kW – 5 kW	0 – 5
Micro	5 kW – 100 kW	5 – 100
Mini	100 kW – 1 MW	100 – 1,000
Small	1 MW – 10 MW	1,000 – 10,000
Medium	10 MW – 100 MW	10,000 – 100,000
Large	100 MW+	100,000+

[Source: Renewables First (2016)]

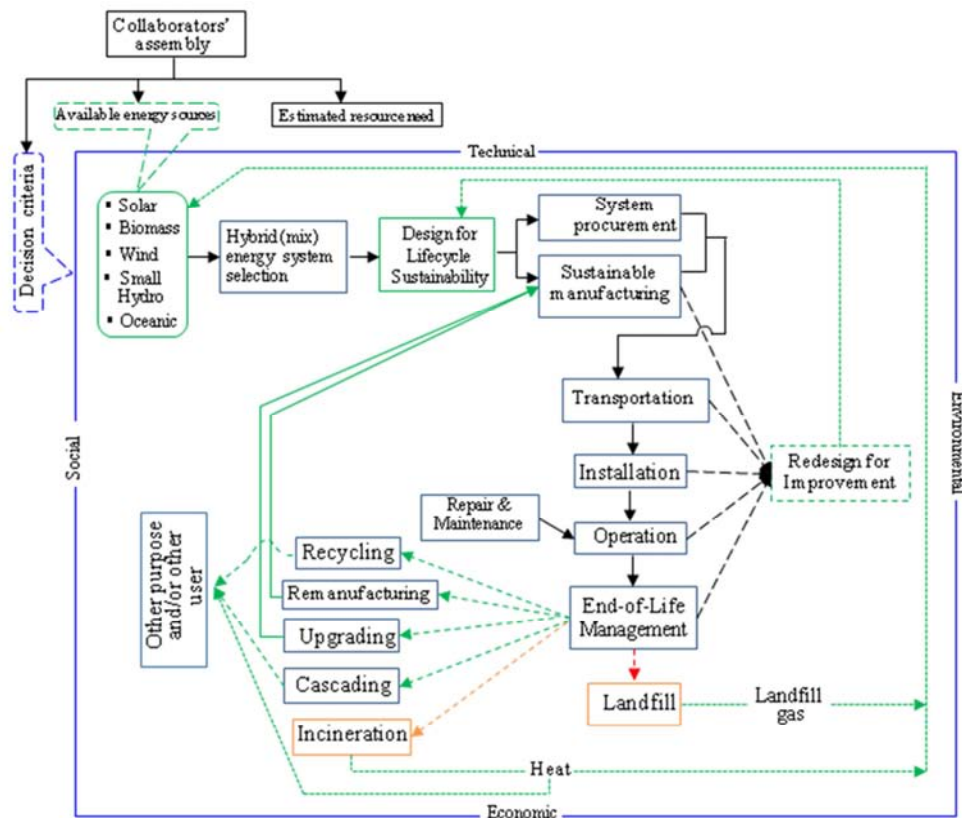
5. A Sustainable Approach to Solving Electricity Supply Problem in Western Nigeria from a Lifecycle Perspective

Although western region of Nigeria have abundant sources of energy resources, they are yet to be adequately harnessed for public utilization. In view of the protracted and seemingly unsurmountable problems of large electric energy supply in Nigeria, this research is proposing a new approach to solving the energy supply problem. The proposed approach is a municipal (or a group of small number of municipalities) scale integrated energy supply system that is based on collaborative lifecycle sustainability design and management (Figure 3).

5.1. Principles of Collaborative Lifecycle Sustainability Energy Supply System Design and Management

A reliable electric energy supply system that is suitable for

Western Nigeria would need to be an integrated sustainable energy system developed and managed at local level in a collaborative manner and from a lifecycle perspective. Integration of various energy sources is necessary because it has been recognized that no single energy source can provide all the energy required by any country or region. A mix of technologies and sources of energy, especially renewable sources, that are abundantly available and/or well suited for a municipality or a region would have to be employed. Such a “sustainable energy paradigm would need to establish and maintain multiple linkages among energy production, energy consumption, human well-being, and environmental quality” [13-17]. Establishment and maintenance of the multiple linkages would require involvement of all the stakeholders throughout the entire spectrum in a collaborative manner. This is necessary because genuine collaboration triggers a sense of responsibility for and ownership of what is created. Although collaboration takes time and require commitment, however when stakeholders are involved from the beginning of a project on an equal status footing, it engenders rapport and reduces the tendency of a party to jeopardize its success. Moreover, it is a win-win approach that enables the stakeholders to table their interests and how they could be accommodated. In addition, collaboration enables the team to identify potential sources of problems in the project and thereby provide opportunities to prevent them or make adequate preparation on how to minimize the risk.

**Figure 3.** Steps for establishing a Hybrid Energy Plant that is Collaboratively Designed for Lifecycle Sustainability.

Approaching energy supply from a lifecycle perspective facilitates identifying and quantifying various issues that could affect the system at each stage of its lifecycle from cradle to grave. So, the lifecycle sustainability concept evaluates the economic, ecological, social and institutional impacts of the system in addition to the technical aspects at each stage of the system's lifecycle [11, 14].

Locality factor in terms of abundance of available resources and in the system management is crucial for a number of reasons. One of the problems of electric energy supply problems in Nigeria is lack of adequate regular supply of gas needed to power the generating systems. Capital cost installation and the cost of monitoring pipeline network for transferring gas from a far distance source to the power generating plant that is far away are huge and may be unaffordable. The long distance between the gas source and the plant using the gas makes the pipeline susceptible to vandalism and sabotage which is one of the current problems. Locating an electric energy generating plant where the resources needed for operating such plant is abundantly available will eliminate those costs and improve the power availability. Moreover, depending on acquiring resources needed for operating a plant from another jurisdiction increases power availability risk because political changes or relationship can lead to disruption of supply and many other restrictions that may arise in the future. Furthermore, locally managing the system in a collaborative manner does not only create a sense of ownership and responsibility, it also foster easier physical monitoring of the facility and timely intervention whenever any situation that may negatively impact smooth operation of the system may be about to arise. In addition, involvement of the local people is beneficial because of their knowledge of the terrain and history of the location, inhabitants and culture which may affect the system at one point or the other.

5.2. The Proposed Framework

The process starts with the development of the project charter and the appointment of a project champion who will facilitate the whole process. This is then followed up with identification of stakeholders, consulting them and requesting them to appoint a representative. A search conference is then organized for visioning exercise. This could be a one or two day meeting or series of meeting where every participant has the opportunity of providing insight to their perceptions on the proposed projects. It is at this meeting that ground rules for discussion and decision making are established. Another expected outcome of the conference is a pathway to follow for the design, development and management of the proposed energy supply facility. An advisory committee and working groups may also be formed at this meeting or a procedure for their formation may be developed at the meeting. The search conference will be followed by a design charrette consisting of planners, engineers, architects, community leaders, public officials and citizens working together to envision and evaluate various alternatives in terms of established criteria

for long term economic, social and ecological sustainability of the project. The group is expected to come up with a decision on the hybrid (i.e. mix) of technologies and sources of energy that would be developed as energy supply system for the municipality or the region. The design charrette is usually a two or three day workshop. An implementation committee with various working groups as sub-committees then takes over the results establish a management structure, performance standards, and timeline for implementation of various phases of the project.

There are several merits in this proposed approach. These include that fact that it is modular, flexibly deployable, and promotes renewable energy technologies. It can also reduce poverty by providing highly rewarding employment opportunities for the local population. In addition, this approach would foster community harmony, minimise financial risk and lead to a smaller ecological footprint than the current centralised large scale energy supply system approach.

5.3. Effectiveness of the Proposed Solution in Addressing the Nigerian Energy Crisis

There were reported cases of effective utilization of hybrid energy systems all over the world. Many of them are deployed in developing countries like Nigeria and significant number of them is being utilized in rural and remote locations [18]. There are reported development and utilization of hybrid solar-wind systems in India and Indonesia.

Moreover, several scholars have advocated bottom-up evolution of technology adoption and development. The prescriptions were based on the fact that adopting such approach in solving any important problem promote sense of belong, ownership and foster unity. It will also spur the community members to protect the infrastructure from vandalism and ensure effective monitoring of the system.

6. Conclusion

A framework for the development and management of sustainable energy infrastructure that is suitable for Western Nigeria was presented. Adoption of the simple lifecycle approach to the development of an appropriate energy supply system is expected to bring a permanent end to the long standing energy crisis in the region. The next step in this research is the implementation of framework with case studies at municipal levels.

References

- [1] Ejiofor, C. (2015). Nigeria Continues To Improve Electricity. Accessed online at <http://www.naij.com/367789-nigeria-continues-to-improve-electricity.html>
- [2] Emovon, I.; Adeyeri, M. K. and Kareem, B. (2011). "Power generation in Nigeria; Problems and solution," presented at the 2011 Int. Conf. Nigerian Association for Energy Economics, Abuja, Nigeria.

- [3] Iwayemi, A. (2008). Investment in Electricity Generation and Transmission in Nigeria - Issues and Options. International Association for Energy Economics. Accessed online at <https://www.iaee.org/documents/newsletterarticles/Iwayemi.pdf>
- [4] KPMG (2014) Overview of the Nigerian Power Sector: Industry Value Chain. Korean Trade Delegation Advisory July 2014.
- [5] Olugbenga, T. K; Jumah, A. A. and Phillips D. A (2013). The current and future challenges of electricity market in Nigeria in the face of deregulation process. African Journal of Engineering Research, Vol. 1(2), pp. 33-39, March 2013 Review.
- [6] NESI (2016). The history of the Nigerian electric power sector. Accessed online on 23 Nov 2016 at <http://nesi.com.ng/bookSection/Excerpts%20of%20Chapters.pdf>
- [7] Odior and Oyawale (2012). A review of some of the operations of power holding company of Nigeria. Int J Syst Assur Eng Manag (Apr-June 2012) 3(2):160–168 DOI 10.1007/s13198-012-0104-y.
- [8] Ogunsola, O. I. (1990). History of Energy Sources and Their-Utilization in Nigeria. Journal of Energy Sources 12(2): pp. 181-198.
- [9] Simonyan, K. and Fasina, O. (2013). Biomass resources and bioenergy potentials in Nigeria. African Journal of Agricultural Research, 8(40), pp. 4975-4989, 17 October, 2013 DOI: 10.5897/AJAR2013.6726.
- [10] USAID (2015). Power Africa: Investment Brief for the Electricity Sector in Nigeria. Accessed on 25 March 2017 at https://www.usaid.gov/sites/default/files/documents/1860/Nigeria%20_IG_2015_05_03.pdf
- [11] Dunmade, I. S. (2016). Hybridizing renewable energy systems in Nigeria: A contextual framework for their sustainability assessment. European journal of engineering and technology, 4(5):33-40.
- [12] Renewables First (2016). What is the difference between micro, mini and small hydro? Accessed at <http://www.renewablesfirst.co.uk/hydropower/hydropower-learning-centre/what-is-the-difference-between-micro-mini-and-small-hydro/>
- [13] Botkin, D. B. and Keller. E. A. (2014). Environmental Science: Earth as a Living Planet, 9th Edition. John Wiley & Sons Inc. Chapter 16. Alternative Energy and the Environment.
- [14] Dunmade, I. S. (2002) Indicators of sustainability: assessing the suitability of a foreign technology for a developing economy. Technology in Society 24 (4), 461-471.
- [15] Dunmade, I. S. (2010). Collaborative lifecycle design: A viable approach to sustainable rural technology development. International Journal of Technology Management & Sustainable Development, 9(2), 149-158.
- [16] Akinyele, D. and Levron, Y. The Environmental Impact of Distributed Energy Resources (DERs) in Modern Electric Power Systems, IEEE Smart grid, Newsletter, March 2017.
- [17] U. Sureshkumar, PS. Manoharan and APS. Ramalakshmi, Economic cost analysis of hybrid renewable energy system using HOMER, IEEE-International Conference On Advances In Engineering, Science And Management, 2012.
- [18] Pillai, G. M. (2014). Enabling Environment and Technology Innovation Ecosystem for Affordable Sustainable Energy Options. Accessed online on 25 March 2017 at <http://www.unescap.org/sites/default/files/Indonesia%20National%20Sustainable%20Energy%20Strategy%20Report.PDF>