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Community/shared solar power option: a pathway to sustainable rural electrification in Nigeria

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Abstract. Nigerian governments at all levels have been making concerted effort to extend electricity supply to the rural areas. Among the several efforts by various governments are formulation of rural electrification policies, creation of agencies for the administration of rural electrification projects, installation of diesel power generators, and development of public-private partnership strategies in solving rural power supply problems. While significant progress has been made, several rural communities are yet to have access to electricity supply. Rugged terrain and limited financial resources are among the constraints to extension off-grid to the rural areas. However, electricity supply, being one of the drivers of economic development and social well-being, is a problem that has to be tackled head-on. The current climate change concern and many other environmental issues of our time necessitate finding a sustainable solution to the problem. Consequently the goal of this study was to examine the potentials of community solar power option as a sustainable rural electrification approach in Nigeria. Other goals included identifying potential hick-ups and solutions to lifecycle management of community solar. Moreover, the study was to determine the suitable configuration for efficient and sustainable community solar power management in Nigeria. The study methodology involved intensive literature survey, historical data collection and case studies on rural electrification in Nigeria as well as examples of community solar projects in Nigeria. Preliminary results revealed that community solar power would be a sustainable approach to rural electrification in Nigeria if a number of conditions are satisfied. Some of the conditions to be satisfied include devolving the management of a community solar system to a participative committee of stakeholders representatives, and incorporating community capacity building in the plan. Other conditions are government, corporate and municipalities' collaboration in funding such projects from scratch till after one or two years of operation, and incorporation of monitoring and intervention strategies for continuous power supply and further improvement.

Key words: community solar, lifecycle management, renewable energy, rural electrification, shared solar, sustainable energy.

INTRODUCTION

Rural electrification in Nigeria

Nigeria is a developing country of about 200 million population. According to the world bank's 2018 estimate, 49.66% of the population live in rural areas (indexmundi,

2021). Like many other developing countries, Nigeria is faced with acute shortage of electric energy supply. While the problem is prevalent in most parts of the country, rural communities experience more outages and epileptic power supply. Several sparsely populated rural towns, especially those that are located in rugged remote terrain are not connected to the public power supply system. According to Umana (2018), only 36% of the rural population are connected to the national grid. This erratic power supply situation has caused serious setbacks to socioeconomic development in the rural communities (Akpan et al., 2013; Umana, 2018). Individuals and businesses have attempted solving the problem by turning to fuelwood and petroleum powered electric generators for their energy needs. Utilization of these energy sources have been causing enormous noise pollution and greenhouse gas releases with the attendant environmental and human health problems.

Governmental and Non-governmental efforts on Rural Electrification in Nigeria

Governmental and non-governmental organisations (NGOs) have been grappling with the efforts aimed at solving Nigeria's rural electricity supply problems for several years. These efforts by governments include formulation of rural electrification policies, creation of agencies for the administration of rural electrification initiatives/projects, and development of public-private partnership strategies in solving rural power supply problems. There are also a number of Inter-agency and inter-sectoral collaborations that brought governmental agencies, development partners and the private sector together to foster off-grid energy supply systems' development, promote synergy and prevent duplication of functions. Examples of some recent collaborations include the U.S. Agency for International Development (USAID)'s Nigeria Power Sector Support Program (NPSP), All On, and Nigeria's Rural Electrification Agency on an initiative called Energizing Economies Initiative (EEI). The initiative, according to USAID (2019), is aimed at 'rapid deployment of off-grid electricity solutions to provide access to over 80,000 retail shops, empower 340,000 micro, small and medium sized enterprises, and create over 2,500 jobs while serving over 18 million Nigerians'. All On is a Shell-funded impact investment company that brings together investors and access-to-energy providers to roll out solutions that are scalable and commercially sustainable (All On, 2020). Similarly, it was reported that in 2020, Nigeria's Rural electrification Agency (REA) implemented several projects across the six Nigerian geo-political zones. Among the implemented rural electrification projects are: 218 grid extension projects, 10 solar mini-grid projects, three injection substations projects, and 197 solar street lights (The Nation (2021)). Some of the projects have been completed, while others are at different levels of completion. In 2020, the World Bank and the African Development Bank (AfDB) supported Nigerian government energy development drive with a $350 million grant and $200 million respectively. The goal of the project was to increase electricity access to 105,000 households, 20,000 Nigerian Micro, Small, and Medium Enterprises (MSMES), and 8 federal universities across Nigeria. Others include the deployment of 12 Mini-grids and over 19,000 Solar Home Systems through Nigerian rural electrification fund.

While these are significant/commendable efforts in the right direction by various governments and NGOs, there are several rural communities that are yet to have access to electricity supply. Although difficult/rugged terrain and small population dispersed over large areas that make electric transmission investment uneconomic are genuine

reasons for poor electric energy supply to the rural areas, it is essential to find cheap and sustainable energy solutions that enable all and sundry to have access to stable and affordable electric energy supply. This is because electric energy is needed for smooth and effective operation of many of our socioeconomic activities such as our healthcare facilities, economic activities, and recreational facilities. Umana (2018) buttressed this point by stating that 'Sufficient energy supply is indispensable for sustainable economic development of Nigeria and any nation'. The current climate change concern and many other environmental issues of our time necessitate finding sustainable and affordable solutions to the problem. All sustainable energy options should be considered to address the dire need. Seeing that community/shared solar has not been reported in any literature as one of the options being considered for rural electrification in Nigeria, it is the goal of this study to bridge the research gap. The contribution of this research is in the evaluation of the characteristics of community solar, effectiveness of its use, and its potential utilization as a sustainable rural energy source for Nigeria.

MATERIALS AND METHODS

The study methodology involved an intensive literature survey and case studies on rural electrification in Nigeria. More than 50 Scholarly journals, government and non-governmental websites, and news media were searched for statistical data, history and trends. Approaches to rural electrification in Nigeria and their outcomes were also examined. There was also a literature survey on community solar, shared solar and their use for rural electrification in various countries. The criteria adopted in determining which article to include or exclude are fitness into the searched terms, and publication within the period of 1990–2021. The searched terms are 'rural electrification in Nigeria', 'rural electrification agency', 'community solar', and 'shared solar'. In addition, there was an assessment of potential use of community solar in Nigeria and their potentials for successful implementation. Three common community solar adoption models were examined. Collaborative lifecycle management based stakeholders operated community solar system is proposed as a sustainable community solar model for Nigeria. The proposal was based on personal experiences growing up in a rural community of Kwara State, Nigeria; previous research experience, and data gathered from the literature reviewed.

This paper was arranged as follows: The next session details the results and discussion on the findings regarding the trends in rural electrification in Nigeria. This is followed by the proposed sustainable community solar energy model for rural communities in Nigeria. Potential challenges to community solar implementation in Nigeria as well as possible solutions were then discussed before making conclusions and recommendations on the way forward to achieving sustainable energy supply for rural communities in Nigeria.

RESULTS AND DISCUSSION

Features and Characteristics of Community Solar

Community solar, according to the Solar Energy Industries Association (SEIA (2021)), refers to 'local solar facilities shared by multiple community subscribers who receive credit on their electricity bills for their share of the power produced'. Putting it in a simpler way, Energysage (2020) described a community solar project as 'a solar

power plant whose electricity is shared by more than one property'. Community solar is known as community shared solar or simply shared solar. The main objective of community solar is to enable members enjoy the opportunity of sharing in the benefits of electricity generated from solar, even when due to one reason or another they could not install solar panels on their own property. One advantage of community solar is that the electricity generated is cheaper than the one from the utility company. Community solar energy supply systems are increasingly being utilized all over the world. For example, there have been reported cases of community solar use in Australia (Hansen et al., 2020); Hungary (Deutsch & Berényi, 2020); South Korea (Yang et al., 2021), USA (Michaud, 2020), UK and other European Countries (Peters et al., 2018). Adoption of community solar as an alternative energy source has been growing over the years, especially in rural America. According to SEIA, 2,579 megawatts of community solar have been installed in the U.S. through 2020. To illustrate the feasibility of community shared solar in meeting energy needs, SEIA projected that in the next five years the U.S. community solar market will add up to 3.4 GW. That energy is enough to power about 650,000 homes. According to Klein et al. (2021), 'Community solar farms (CSF) have the potential to expand solar access and improve financial viability compared to traditional residential and commercial solar options.' There has been some discussions regarding the merits and demerits of community solar. The main issues against community solar involve finding appropriate sized sunshine receptive land areas for the solar farm to be installed (Daware, 2021). This is not expected to be an issue for Nigerian rural communities where there are low-cost expanse of underutilized lands that could be used for the project (Global Solar Atlas, 2021). Another issue is the cost.

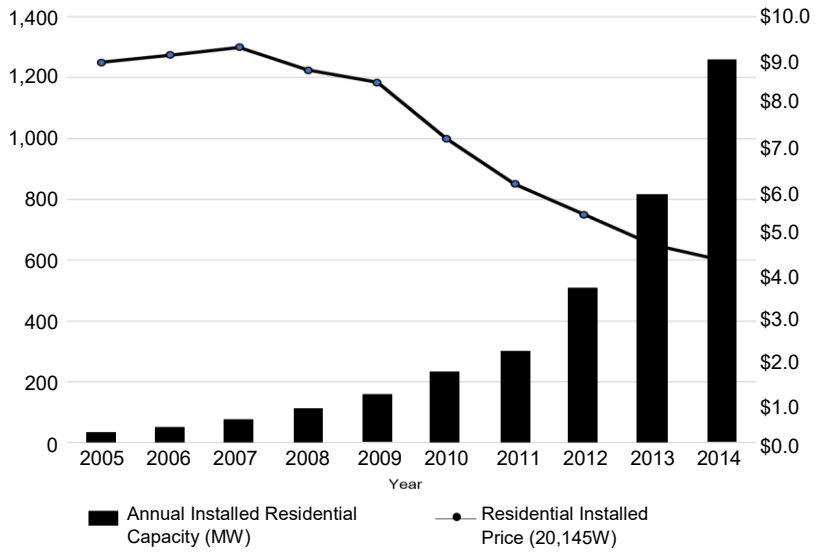

Figure 1. US annual residential installed capacity and price changes from 2005 and 2014. [Source: Augustine & McGavisk, 2016].

The cost of solar systems have been decreasing since 2007. Fig. 1 shows the US annual residential solar installed capacity and price changes from 2005 and 2014. One could see that the price has dropped by more than 50% over the period. That is the

general trend all over the world. Another crucial consideration is in selecting a suitable management approach for the effective operation and maintenance of the community solar system. This would not be a big challenge with appropriate organization and supportive governmental policies (Augustine & McGavisk, 2016; Dunmade, 2016; Theophilus, 2017; Hansen et al., 2020; CCSA, 2021).

Potentials of community and shared solar power as a sustainable rural electrification approach in Nigeria

Nigeria, is endowed with abundant renewable energy resources in the form of solar radiation, biomass, wind and water resources that could be harnessed for small hydro energy supply. For example, Nigeria enjoys an estimated 8 hours/day of intense sunshine all year round. Fig. 2 shows the Nigerian solar irradiation and PV power potential map. In addition, Iwayemi (2008) put the estimate of Nigeria's hydro resources, solar power potential and wind energy potential at 14,750 MW, 7.0 KW m^{-2} per day, and 150,000 TJ yr^{-1} and 144 million tonnes per year respectively. Simonyan & Fasina (2013) also estimated the Nigerian biomass resources from residues and wastes at 47.97 Million tonnes of oil equivalent (MTOE), that is about 2008 PJ energy. These renewable energy resources can be harnessed to solve the perennial epileptic energy supply problems. Transitioning to the use of renewable energy sources from fossil energy is important not only because that is a global trend now but also because of its numerous benefits and applications (Pikk & Annuk, 2014; Papez & Papezova, 2016; Vinnal et al., 2020). As earlier highlighted, governments and other agencies have been making efforts at harnessing them to solve rural electricity supply problems. However, there has not been any reported utilisation of community and shared solar as one of the options being used for rural electrification in Nigeria.

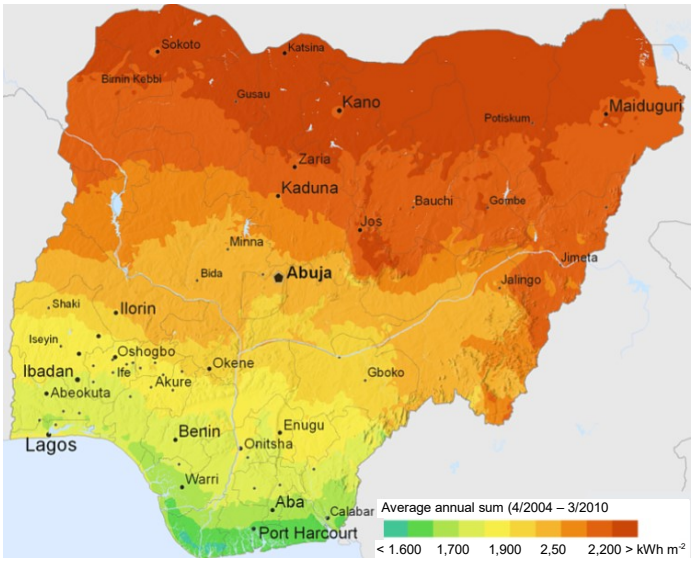

Figure 2. Nigerian solar irradiation and PV power potential map.
Source: https://globalsolaratlas.info/global-pv-potential-study

A valid concern regarding introduction of a new technology, a new program or initiative is whether the desired goal(s) will be achieved. There may also be the question regarding the sustainability of such endeavours.Reports (Sunmetrix, 2013; Energysage, 2020; YSG Solar, 2020; Elevateenergy, 2021; Etelson, 2021; Gagne & Aznar, 2021; Global Solar Atlas, 2021) have shown the usability of community solars for electric power supply all over the world wherever there is unobstructed sunshine over some hours of the day. There is also reported evidence of community solar's installations in remote locations and rugged terrains. Utilization of community solar is environmentally sustainable as it is a renewable energy source with lower ecological footprint. Community solar is also economically sustainable as it is scalable to the capability of the subscribers. In addition, it is a feasible and far cheaper option than the connection of remote and sparsely populated small villages to the national grid (Radl et al., 2020). Similarly, it is socio-culturally inclusive as community solar provides opportunity for all citizens of various socioeconomic status to participate in the transition from the use of environmentally harmful energy sources to a renewable one. It is also affordable as individuals can choose the extent they wish to be invested in the project and they can increase their involvement over time.

Approaches to community/shared solar development and management organisation

Community solar as an electricity supply option would really impact all aspects of life of rural communities in Nigeria in a positive manner. There are several possible benefits of its incorporation into the Nigerian rural electrification equation. Among the many benefits of community solar is that, in view of its smaller capital outlay requirement, it is a viable alternative to the epileptic and expensive Mega-Scale electric energy distribution system (Radl et al., 2020). It is also not only renewable but also scalable to the needs of the community being served. With its location in the tropical region, almost all areas of Nigeria receives abundant sunlight all year round. This provides a great potential for sufficient power generation to meet the needs of the population. Furthermore, community solar is amenable to local involvement in the planning, development and management operations of the system. This is an added advantage for its sociocultural sustainability.

Development and management of community solar systems are often structured on the bases of financial and organizational expediency. There are three common community solar business models, namely: utility-owned community solar, developer-owned community solar, and special purpose entity-owned community solar. Utility-owned community solar was reported to be the most common of the three. According to Elevateenergy (2021), utility-owned community solar model is a situation where the solar array is owned by the local utility. The utility then sells or leases the solar panels to subscribers or sells a certain amount of solar electricity at a fixed price for a specified time period. Participation in the community solar project involves purchasing a share of the project while receiving credits on the electricity bills. In the developer owned community solar model, a solar developer is responsible for the entirety of everything about the solar system right from the design to the operation and maintenance of the system. However, the developer enlists the services of a subscriber management organisation who helps him/her in getting subscribers and managing them. The third approach is the special purpose entity model where the community solar is owned by a

business entity. The business entity could be a for-profit or non-profit organisation. The advantage of this third model is that the benefits of the community solar project are retained in the community (Etelson, 2021; Gagne & Aznar, 2021). Fig. 3 is an illustration of the three common types of community solar.

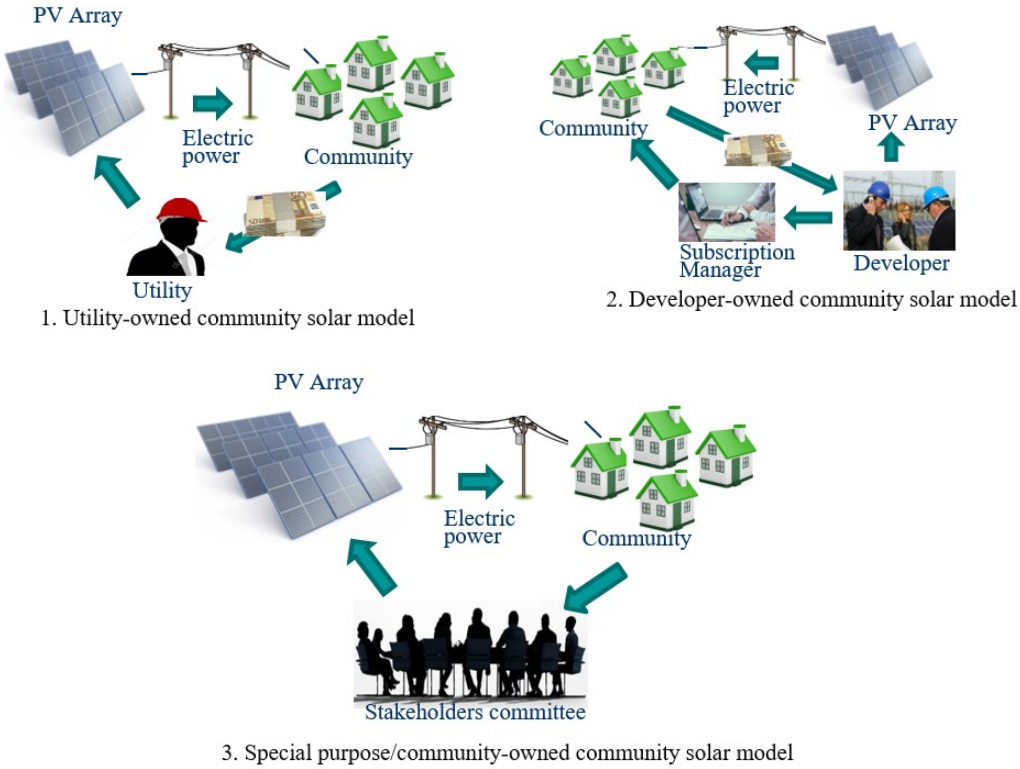

Figure 3. The three common types of community solar.

The development and management of a sustainable community scale solar energy supply system require supportive regulatory policies. According to Wiseman & Bronin (2013), supportive policies for a sustainable community scale solar energy supply system would need to include 'land use planning, acquisition, and installation of renewable equipment. It would also need to cover maintenance and operation of the equipment, and the sale of energy (Furthermore, Wiseman & Bronin (2013) stated that communities must be able to form business enterprises that govern the purchase, installation, operation, and maintenance of generation infrastructure and that manage the sale of energy produced.'

Suitable configuration for efficient and sustainable community solar power management in Nigeria

Our study, based on literature reviewed and personal experience of Nigeria, revealed that community solar power would be a sustainable approach to rural electrification in Nigeria if it is appropriately configured for efficiency. A sustainable approach to community solar deployment in Nigeria would require devolving the

lifecycle management of the community solar system to a participative/collaborative committee that involves all stakeholder groups' representatives right from the planning stage throughout the entire lifecycle of the system (Chan et al., 2017; Hansen et al., 2020; Hess & Lee, 2020; Michaud, 2020). Fig. 4 is a schematic diagram of the proposed community solar system while Fig. 5 is an illustration of the process that could be used to achieve a suitable configuration for an efficient and sustainable community solar power management system. It emphasizes participation of all the stakeholders throughout the life of the project. It also recommended assessment of needs, evaluation of local community situation, development of supportive policy, sustainable design and manufacturing of the power supply system, and evaluation of the system for suitability determining factors (Palm, 2016; Michaud, 2020). The adoptable plan also included community capacity building for effective transfer of the technology to the locality. Such capacity building would need to cover areas of operation, repairs, component fabrication and management of the system. These would essentially require the development of programs for the training of various levels of manpower that would be needed to locally design, manufacture, operate, maintain, upgrade and manage the system in environmentally-, socially- and economically sustainable manner.

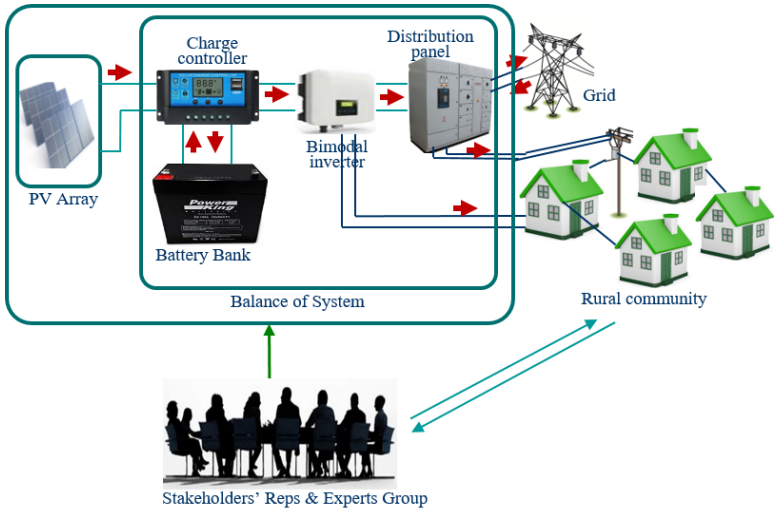

Figure 4. A schematic diagram of the proposed the community solar system.

Other conditions for effective and sustainable community solar projects are government, corporate and municipalities collaboration in funding some demonstrative community solar power supply projects, and incorporation of monitoring and intervention strategies for continuous power supply and further improvement (Wiseman & Bronin, 2013; Awad & Gül, 2018; Salihu et al., 2020). Approaching the introduction of community solar as a rural electrification option will enhance availability of electric power for rural development and improve the standard of living for rural communities in Nigeria. It will drastically reduce losses of fruits, vegetables and many other agricultural products from the villages that get spoiled due to lack of modern processing and storage facilities that require electric power. Introduction of community solar as an electricity supply option for rural Nigeria would not only positively impact their

agriculture, the commerce sector will also benefit by making it possible for them to use electricity powered machines to process their agriculture products to various value-added commodities. This would lead to improved earnings and thereby reduce poverty and improve their standard of living. In addition, community solar would enable students to comfortably read into the night and to have access to new learning tools thereby improve their education. Improvement in their education will give them access to new opportunities in the future and facilitate breaking the cycle of poverty. Furthermore, the introduction of community solar would facilitate cleaner air in the homes as electric light will eliminate the use of kerosene lamps that contribute to air pollution and negatively impact human health. Similarly, rural healthcare facilities would be able to use electric powered medical devices and enable them to attend to night emergency services more comfortably. They would also be able to store certain medicines that require electricity dependent special care (Independent Evaluation Group, 2008; Torero, 2015; Syed et al., 2020; Alliance for Rural Electrification, 2021).

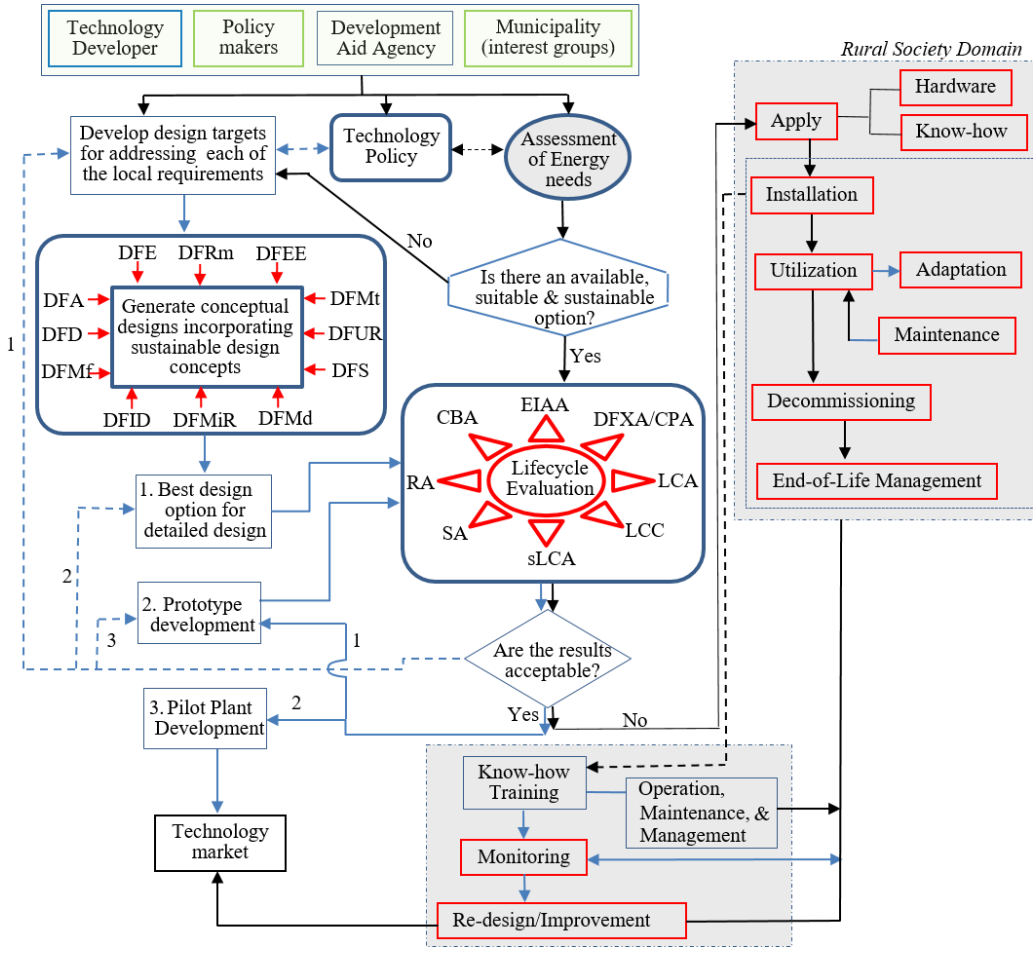

Figure 5. A framework for the evolution of suitable configuration for efficient and sustainable community solar power development and management in Nigeria.

Comparison of community solar adoption in some countries and the economic impacts

Community solar is most widely adopted in USA as an alternative means for rural electrification, especially in sparsely populated regions and areas with rugged terrain (Augustine & McGavisk, 2016). According to Guidehouse (2021), the total installed capacity of community solar programs in 2018 was '734 MW, with approximately 387 MW installed in 2017'. Adoption of community solar is widespread across 36 states in USA. However, community solar utilization in Europe is limited, despite its over 20 years of electricity liberalization. Although there is an existing European regulatory framework for its adoption, actual community solar projects are only recently launched in some European localities like London. Deutsch & Berényi (2020) also did a case study on the economic potentials of community solar models in Hungary. They reported that community financed model is the best of the three community solar models that are commonly used in the country. Furthermore, although provinces like Alberta, Ontario and Saskatchewan have been making significant progress in developing the solar market, adoption of community solar in Canada is not widespread (Oyasolar, 2020). Majority of the successful adoption of community solar is recorded in the USA.

There are several economic and environmental benefits attributed to the development and adoption of community solar across various jurisdictions. These include reduction in the electricity bill of the subscribers and creation of new employment opportunities (Alliance for Rural Electrification, 2021). For example, Oyasolar (2020) reported that since 2006, community solar programs has led to 52% growth in solar market and creation of over 260,000 jobs across the US. This makes it a major contributor to the economy. Oyasolar (2020) also reported that adoption of community solar have helped in reducing ecological footprint of communities and is facilitating the achievement of the climate goals.

Potential hick-ups in the successful deployment of community solar in Nigeria and suggested solutions

The first anticipated challenge involves selling the ideas to investors and appropriately educating the public regarding the suitability of the system for their community. Another challenge is in addressing the political and economic barriers in the region. Yet another possible hick-up in the sustainable deployment and operation of community solar electric power supply systems to rural communities in Nigeria is in ensuring effective transfer of the technology to the local technicians that would have to repair and maintain the system (Augustine & McGavisk, 2016; Peters et al., 2018).

Governments and intergovernmental agencies, like they are doing in other infrastructure projects, can help in preventing the aforementioned- and other problems by sponsoring public education programs and bankrolling the first set of demonstrative projects all across the country. Government can also encourage citizens and corporate organisations to participate in the project by developing supportive regulations and providing incentives. The incentives could include subsidies and tax rebates. Government can also provide scholarships for the training of manpower needed for local proliferation, adaptation, and maintenance of the technology.

CONCLUSIONS

This paper presented results of an assessment regarding the potentialities of adopting community solar as a sustainable electric power supply option for rural communities in Nigeria. Implementation of the proposed framework will facilitate the development and operation of an r efficient and sustainable community solar power supply. The deployment of community solar power supply systems to rural communities in is expected to result in significant improvement in rural economy, education, healthcare, supply of goods and services and improved standard of living for the rural population in. Adoption of the proposed framework is also expected to result in the smooth running of community solar power systems in Nigeria. Other developing nations in the same situation would be able to adopt the same approach to tackling the problem of rural electrification in their region. Consequently, taken such steps would lead to reduction in poverty, progression towards zero hunger, improvement in health and wellbeing, and facilitate the achievement of several sustainable development goals in rural communities.

REFERENCES

Akpan, U., Essien, M. & Isihak, S. 2013. The impact of rural electrification on rural micro-enterprises in Niger Delta, Nigeria. *Energy for sustainable development* **17**(5), 504–509.

Alliance for Rural Electrification. 2021. Benefits of Clean Rural Electrification. Accessed online on 5th June 2021 at https://www.ruralelec.org/benefits-clean-rural-electrification#:~:text=Rural%20electrification%20with%20the%20use,productive%20use)%20for%20rural%20populations

All On (2020). All On and Auxano Solar Nigeria sign $1.5m Investment deal for Solar Panel Assembly Plant Expansion. An All On Press Release on Sep 21, 2020 and accessed online on 26th Jan 2021 at https://www.all-on.com/media/media-releases/all-on-and-auxano-solar-nigeria-sign-dollar-1-point-5m-investment-deal-for-solar-panel-assembly-plant-expansion.html

Augustine, P. & McGavisk, E. 2016. The next big thing in renewable energy: Shared solar. *The Electricity journal* **29**(4), 36–42.

Awad, H. & Gül, M. 2018. Optimisation of community shared solar application in energy efficient communities. *Sustainable cities and society* **43**, 221–237.

Chan, G., Evans, I., Grimley, M., Ihde, B. & Mazumder, P. 2017. Design choices and equity implications of community shared solar. *The Electricity journal* **30**(9), 37–41.

CCSA (Coalition for Community Solar Access). 2021. Community Solar Explained. Accessed online 27th Jan 2021 at http://www.communitysolaraccess.org/about-us/community-solar-explained/

Daware, K. 2021. What is Community Solar? Everything You Need To Know. Accessed online 27th Jan 2021 at https://www.electricaleasy.com/2019/04/community-solar.html

Deutsch, N. & Berényi, L. 2020. Economic potentials of community-shared solar plants from the utility-side of the meter – A Hungarian case. *The Electricity journal* **33**(8), 106826.

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.

Elevateenergy (2021). Three common community solar business models. Accessed online on 5th February 2021 at https://www.elevateenergy.org/programs/solar-energy/community-solar/business-models/

Energysage (2020). Community solar: what is it? Accessed online on 2nd February 2021 at https://www.energysage.com/solar/community-solar/community-solar-power-explained/

Etelson, E. 2021. Promoting Community Solar: How to Bring Clean Energy to Your Neighborhood. Accessed online 26th Jan 2021 at https://www.letsgosolar.com/consumer-education/community-solar/

Gagne, D. & Aznar, A. 2021. Low-Income Community Solar: Utility Return Considerations for Electric Cooperatives. Accessed online 26th Jan 2021 at https://www.nrel.gov/docs/fy18osti/70536.pdf

Global Solar Atlas. 2021. Global Photovoltaic Power Potential by Country. Accessed online 26 Jan 2021 at https://globalsolaratlas.info/global-pv-potential-study

Guidehouse Insights (2021). Community Solar PV Comes to the UK. Accessed online at https://guidehouseinsights.com/news-and-views/community-solar-pv-comes-to-the-uk

Hansen, P., Morrison, G.M., Zaman, A. & Liu, X. 2020. Smart technology needs smarter management: Disentangling the dynamics of digitalism in the governance of shared solar energy in Australia. *Energy research & social science* **60**, 101322.

Hess, D.J. & Lee, D. 2020. Energy decentralization in California and New York: Conflicts in the politics of shared solar and community choice. *Renewable & sustainable energy reviews* **121**, 109716.

Independent Evaluation Group. 2008. The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/6519 License: CC BY 3.0 IGO.

Indexmundi (2021). Nigeria - Rural population. Accessed online on 4th February 2021 at https://www.indexmundi.com/facts/nigeria/rural-population

Iwayemi, A. 2008. Investment in Electricity Generation and Transmission in Nigeria: Issues and Options. Accessed on 12th February 2014 at https://www.iaee.org/documents/newsletterarticles/Iwayemi.pdf

Klein, S.J.W., Hargreaves, A. & Coffey, S. 2021. A financial benefit-cost analysis of different community solar approaches in the Northeastern US. *Solar Energy* **213**, 225–245.

Michaud, G. 2020. Perspectives on community solar policy adoption across the United States. *Renewable energy focus* **33**, 1–15.

Oyasolar, 2020. The Green Revolution We're Missing: Solar In The U.S. And Canada. Accessed online on 6th June 2021 at https://oyasolar.com/blog/the-green-revolution-solar-in-canada/

Palm, A. 2016. Local factors driving the diffusion of solar photovoltaics in Sweden: A case study of five municipalities in an early market. *Energy Research & Social Science* **14**, 1–12.

Papez, V. & Papezova, S. 2016. Optimization of a solar power station with LiFePO4 accumulators. *Agronomy Research* **14**(S1), 1200–1211.

Peters, M., Fudge, S., High-Pippert, A., Carragherd, V. & Hoffmane, S.M. 2018. Community solar initiatives in the United States of America: Comparisons with – and lessons for – the UK and other European countries. *Energy Policy* **121**, 355–364.

Pikk, P. & Annuk, A. 2014. Case study of increasing photovoltaic energy solar fraction in a conventional office building in northern latitudes. *Agronomy Research* **12**(2), 563–574.

Radl, J., Fleischhacker, A., Revheim, F.H., Lettner, G. & Auer, H. 2020. Comparison of Profitability of PV Electricity Sharing in Renewable Energy Communities in Selected European Countries. *Energies* **13**, 5007. https://doi.org/10.3390/en13195007

Salihu, T.Y., Akorede, M.F., Abdulkarim, A & Abdullateef, A.I. 2020. Off-grid photovoltaic microgrid development for rural electrification in Nigeria. *The Electricity journal* **33**(5), 106765.

SEIA. 2021. Community Solar. An online write up accessed on 26th Jan 2021 at https://www.seia.org/initiatives/community-solar

Simonyan, K. & Fasina, O. 2013. Biomass resources and bioenergy potentials in Nigeria. *African Journal of Agricultural Research* **8**(40), 4975–4989.

Sunmetrix (2013). Where is the best location on Earth for solar energy? https://sunmetrix.com/where-is-the-best-location-on-earth-for-solar-energy/

Syed, M.M., Hansen, P. & Morrison, G.M. 2020. Performance of a shared solar and battery storage system in an Australian apartment building. *Energy and buildings* **225**, 110321.

The Nation. 2021: Rural electrification to gain momentum. An online publication accessed on 26 Jan 2021 at https://thenationonlineng.net/2021-rural-electrification-to-gain-momentum/

Theophilus, A.I. 2017. Sorting out Renewable Energy Powered Rural Electrification in Nigeria. *The holistic approach to environment* **7**(2), 75.

Torero, M. 2015. The Impact of Rural Electrification: Challenges and Ways Forward. *Revue d'économie du développement* **23**, 49–75.

Umana, K. 2018. Impact of Rural Electrification on Socio economic Development in Nigeria. Accessed online on 22nd Jan 2021 at https://researchcyber.com/socio-economic-development-rural-electrification-nigeria/

USAID (2019). Power Africa helps Nigeria tap the private sector to boost off-grid electricity for small businesses. A July 24, 2019 USAID online report accessed on 26 Jan 2021 at https://www.usaid.gov/nigeria/news/power-africa-helps-nigeria-tap-private-sector-boost-grid-electricity-small

Vinnal, T., Puusepp, H., Shabbir, N., Kutt, L. & Iqbal, M.N. 2020. Case study of non-linear PV inverter devices attached to the LV distribution network. *Agronomy Research* **18**(4), 2639–2652. https://doi.org/10.15159/AR.20.233

Wiseman, H.J & Bronin, S.C. 2013. Community-Scale Renewable Energy. A FSU College of Law, Public Law Research Paper No. 642. Accessed online on 5th February 2021 at https://poseidon01.ssrn.com/delivery.php?ID=436070084067080011124094023066124098100075028006087054119098108100087071077081093022097027039000046111005102108126123092104075042057047080049031097111072073065066005016083005010086120027065127126000076095113080066073102000091119093087115084095074082&EXT=pdf&INDEX=TRUE

Yang, S., Chen, W. & Kim, H. 2021. Building Energy Commons: Three Mini-PV Installation Cases in Apartment Complexes in Seoul. *Energies* **14**(1), 249. https://doi.org/10.3390/en14010249

YSG Solar (2020). Is My Land Suitable For A Solar Farm? Accessed online on 5 June 2021 at https://www.ysgsolar.com/blog/my-land-suitable-solar-farm-ysg-solar