Renewable energy sources acceptability for decentralized energy system in Nigeria: Issues, challenges and prospects

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Abstract. The increasing awareness of environmental concerns, coupled with the need to enhance energy security and alleviate the impacts of climate change, has fast-tracked an intensive exploration of renewable energy technologies. The development has indeed recorded remarkable growth in most developed countries like China, USA, Brazil, and China. However, this is not the same as most developing countries in Africa. This work carried out a comprehensive review of the available Renewable Energy Sources (RES) in Nigeria, assessed its level of utilization, identified the challenges, and suggested effective ways of ensuring the adoption of a decentralized energy system through the use of RES. A critical analysis of public opinions on the acceptability of RES as a decentralized energy system in the country was carried out. The work sampled the opinions of people in the adoption of RES for a decentralized energy system using southwest, Nigeria as a case study. The population involves power stakeholders, rural dwellers, RES experts, and policymakers across the six states of southwest, Nigeria. A well-structured questionnaire was designed to capture nuanced responses on a range of key parameters, including awareness levels, acceptance, and perceived benefits and challenges associated with decentralized renewable energy systems. The research findings (through the use of questionnaires) showed a very low level of awareness and acceptability of RES and provided valuable insights into the potential barriers and possible facilitating conditions for the adoption of renewable energy technologies.

Keywords: Decentralized systems, Energy policy, Renewable energy, Sustainability, Public opinion.

1 Introduction

Renewable energy means the kind of energy derived from sources that are naturally replenished, making them sustainable and environmentally friendly. It has lesser or no harmful environmental impacts in contrast to fossil fuels is finite and has a high contribution to the degradation of the environment. Unlike fossil fuels, which release greenhouse gases (such as carbon dioxide) when burned, renewable energy sources produce electricity with significantly lower or zero emissions. This is crucial for reducing the rate of greenhouse gas emissions, which contribute to climate change. An increase in people’s thirst for Renewable Energy Sources (RES) adoption will decrease cases of environmental degradation. In other words, growth in RES’ adoption is beneficial and well attached to improved environmental quality [1, 2].

Integration of renewable energy sources into the global energy landscape represents a pivotal and trans-formative shift in the way societies generate, distribute, and consume power. The increasing awareness of environmental concerns, coupled with the imperative to enhance energy security and alleviate the negative impacts of climate change, has fast-tracked an intensive exploration of renewable energy technologies. This new phase is enhanced by gradual public awareness of the negative impacts of conventional fossil fuel-based energy sources on the environment [3].

The country, Nigeria faces considerable challenges in providing electricity access to its citizens, especially in the rural areas. The country largely depends on oil exports, making its economy vulnerable to fluctuations in global oil prices [4]. By incorporating decentralized renewable energy solutions, Nigeria can enhance its energy security, reduce dependence on fossil fuel imports, and bolster its resilience to energy supply disruptions [4, 6].

Adoption of renewable energy technologies as decentralized energy systems can help bridge this energy access gap, uplifting living standards, supporting small businesses, and fostering rural development [4, 5]. Renewable energy sources adoption as a decentralized energy system in the
country represents an opportunity to address a multitude of pressing challenges, ranging from energy access and environmental sustainability to economic diversification and health improvement.

There is a need to enhance sustainable energy strategy for rapid and significant improvement in the energy sector. A sustainable energy strategy considers all aspects of energy use within a country to ensure a holistic and sustainable long-term plan that considers the social and economic life of its citizenry. This ensures that the present energy needs are met without causing harm to the environment in the future.

Considering the current global climate change demands, a comprehensive energy policy should include RES acceptability/application, improved energy efficiency, and well-informed targets for greenhouse emission reduction. This should also include the introduction of incentives and regulations to attract and encourage investment in clean energy technologies [5, 7]. A comprehensive natural energy policy is essential as it provides a structured framework upon which the government and relevant stakeholders build and implement sustainable energy strategies.

This work carried out a comprehensive review of the available Renewable Energy Sources (RES) in Nigeria, assessed its level of utilization, identified the challenges, and suggested effective ways of ensuring the adoption of a decentralized energy system through the use of RES. A critical analysis of public opinions on the acceptability of RES as a decentralized energy system in the country was carried out. The work sampled the opinions of people in the adoption of RES for a decentralized energy system using southwest, Nigeria as a case study.

1.1 Potential and status of renewable energy sources in Nigeria

The country is abundantly blessed with diverse RES spread across all over the country as shown in Figure 1. Most of these RES remain largely untapped and underutilized. Recent reports from the literature showed that Nigeria is yet to harness its off-grid RES potentials up to full capacity. Even though there are few RES projects in the country (like 7.1 MW and 2.8 MW Solar hybrids at Bayero University, Kano State, and Ebonyin, Eboyin State respectively. The available RES can be said to be under-exploited. Table 1 shows the available RES resources and their locations across Nigeria while Table 2 shows the installed capacity of RES in Nigeria. Nigeria has numerous major obstacles and problems in the implementation of renewable energy. Nigeria is a country rich in renewable energy resources, such as solar, wind, and hydroelectric power. However, the adoption and expansion of renewable energy technologies are hampered by a number of social, technological, economic, and regulatory issues. Some of the obstacles are; inadequate infrastructure, expensive initial outlays, funding availability, grid integration, inconsistent policies, dearth of incentives, unpredictable resource availability, and public perception.

Public acceptance of renewable energy may be constrained by misunderstandings regarding its cost and dependability as well as a lack of knowledge about its advantages. It is also believed by some that certain machinery, such as those for manufacturing and production, industrial sewing, pure water generation, and water pumping, cannot be powered by solar energy. Solar energy, on the other hand, can power anything that uses electricity [8].

![Figure 1. Map of Nigeria showing available Renewable Energy Sources and their locations across the country [8].](image-url)
The physical and emotional well-being of people is enhanced by clean energy and energy efficiency. Nearly all of the dangerous pollutants produced by clean energy technologies, also referred to as greenhouse gases and including carbon dioxide, are linked to a variety of health issues. Environmental safety and health are also impacted by clean energy. Some of the major RES available in the country are as discussed in the subsequent sub-sections.

### 1.1.1 Hydro resources

The country is abundantly blessed with abundant hydropower resources. Electricity production from hydropower resources in Nigeria accounted for over 30% of the total installed power. The three large hydropower stations at Kainji, Jebba, and Shiroro have 760 MW, 578 MW, and 600 MW installed capacities respectively. The large hydropower generation capacities are as in Table 3.

Small hydropower (SHP (SHP) potentials have been identified all over the country. SHP power can be harnessed to improve power production for rural, on-grid, and off-grid customers. The estimated SHP capacity is about 3500 MW. Proper maintenance of the hydro installations and implementation of more hydro projects all over the country will enhance rapid growth in electricity generation.

### 1.1.2 Solar energy

There is abundant Solar energy potential remaining untapped in Nigeria. Nigeria’s solar radiation is about 3.5 kWh/m²/day in the Southeast region and 7.0 kWh/m²/day in the north. Electricity that can be produced from concentrated solar power and Solar PV is estimated to be about 42700 MW [14]. Solar energy exploitation is gradually becoming popular among Nigerians especially the rich who can afford the high capital cost. Solar energy is infinite and not as capital intensive compared to conventional fossil fuel energy resources [15].

### 1.1.3 Wind energy

Nigeria’s wind speed ranges from 1.4 m/s to 3.0 m/s in the Southern areas and 4–5.12 m/s in the extreme north. The wind speed is generally weaker in the Southern part of the country than in the northern part except in coastal regions and offshore destinations. There are not many wind turbine installations in Nigeria. The only active wind electricity system in the country is the Soyya Gidan Gada village, Sokoto state.
1.1.4 Biomass energy

The available Biomass resources in the country include wood, grasses and shrubs, charcoals, agricultural crops, residues and wastes (industrial, forestry, agricultural, municipal), and aquatic biomass. Biomass that is being used for energy production is about 34% of the total biomass in the country. Biomass such as fuel wood, coal, dead leaves, and bamboo trunks is mostly used for cooking and heating purposes in some rural areas of the country.

1.2 Research questions

The research questions are:

(i) What is the level of adoption of RES technologies among rural dwellers?
(ii) Is the present policy formulation on RES effective enough for the needed transformative agenda on climate change?
(iii) What are the major challenges and prospects of RES in your area?
(iv) What are the effective ways of achieving the needed growth for sustainable energy growth in Nigeria?

2 Material and methods

This work carried out a comprehensive review of the available Renewable Energy Sources (RES) in Nigeria, assessed its level of utilization, identified the challenges, and suggested effective ways of ensuring the adoption of a decentralized energy system through the use of RES. This study used a descriptive research survey type and the targeted population is the Southwest, Nigeria. This region consists of six states – Ondo, Ekiti, Ogun, Lagos, Oyo, and Osun.

A well-structured questionnaire was designed to capture nuanced responses on a range of key parameters, including awareness levels, acceptance, and perceived benefits and challenges associated with decentralized renewable energy systems. A critical analysis of public opinions on the acceptability of RES as a decentralized energy system in the country was carried out. The population involves power stakeholders, rural dwellers, RES experts, and policymakers across the six states of southwest, Nigeria. The total number of respondents is 10448.

Table 3. Installed generation capacities (MW) and the average availability of Nigeria’s large hydropower stations.

<table>
<thead>
<tr>
<th>Power station</th>
<th>Availability factor (MW)</th>
<th>Installed capacity (MW)</th>
<th>Average availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kainji</td>
<td>0.50</td>
<td>760.00</td>
<td>382.90</td>
</tr>
<tr>
<td>Jebba</td>
<td>0.75</td>
<td>578.40</td>
<td>435.82</td>
</tr>
<tr>
<td>Shiroro</td>
<td>0.72</td>
<td>600.00</td>
<td>434.59</td>
</tr>
<tr>
<td>Total</td>
<td>0.65</td>
<td>1938.40</td>
<td>1253.77</td>
</tr>
</tbody>
</table>

Sources: [12, 13].

3 Results and discussions

Distributions of the questionnaire, analysis of data, interpretation of data, and discussion of results were fully considered in this section.

Demographics

(a) Gender

This study sought to know the gender of the respondents. Male with 6417 respondents has a percentage of 61.41 while the female with 4031 frequencies of respondents has a percentage of 38.58 as shown in Figure 2.

(b) Geographical Spread of Respondents by State in South West, Nigeria

Figure 3 shows that 1215 of the respondents were raised from Ondo State, 1619 of the respondents claimed to emanate from Oyo State, 2715 of the respondents came from Lagos State, 1379 of the respondents reported that they came from Osun State, 1210 of the respondents are indigene of Ekiti State while 2310 of the respondents stem from Ogun State (Figure 4).

(c) Age Range of Respondents

(d) Knowledge Range Assessment of the Respondents

Figure 5 shows that 1358 representing 13.0% of the respondents chose very low, 2298 representing 21.99% chose Low, 1180 representing 17.99% chose Average, 3761 representing 36.00% chose High, and 1151 representing 11.02% chose Very High.
Research Question 1:
What is the level of adoption of RES technologies in your area?

(i) Do you use any RES in your household or business?

It is shown in Table 4 that 3134 respondents have used one type of RES in either households or in business centers while 7314 respondents have not used any type of RES at all. This showed that the level of RES adoption in this part of the country is very low.

(ii) Which of the RES is the most popular in your area?

The number of respondents using Solar PV is 9507, SHP is 57, and Biomass is 841. Respondents using other forms of RES apart from the listed three are 43. This showed that Solar PV is the most accepted RES. This is a popular and widely adopted form of energy globally. This may be attributed to the decreasing cost of Solar panels globally (Tables 5–8).

(iii) What motivates you to your choice of RES?

A total number of 4475 respondents chose the types of RES adopted because of its dependability while 3999 respondents made their choices because of its cost saving. 1234 made their choice because of environmental concerns and 740 respondents chose the types of RES because of the ease of maintenance. This shows that most of the respondents made their choices based on dependability because of the frequent power failure being experienced by the utility distribution companies; so most people prefer to go for RES. The issue of cost-saving is also a significant factor in choosing the types of RES.

(iv) Are you aware of the negative environmental effects of fossil fuels?

The total number of respondents who are quite aware of the negative environmental effects of fossil fuels is 6684 while 3764 respondents are not aware of the negative environmental effects.

(v) Do you enjoy any community-based or government-sponsored RES initiatives?

The number of respondents who enjoyed community/government-sponsored RES initiatives is 941 while 9507 respondents have never enjoyed such benefits.

Research Question 2:
Is the present policy formulation on RES effective enough for the needed transformation on climate change?

(i) Are the present RES policies effective enough in achieving the global sustainable goals on climate change?

Table 9 showed that 5746 respondents believed that the present policies on RES are effective enough in achieving the global sustainable goals on climate change while 4702 respondents did not believe that the present policies on RES are effective enough to achieve the global RES is not effective enough to achieve the global RES target.

(ii) Are you optimistic or pessimistic about the future growth of RES considering the existing policies?
Table 10 shows that 5313 respondents are optimistic about the future growth of RES, 4732 respondents are pessimistic and 403 preferred not to say.

(iii) Is the (local, state, and Federal) government doing enough in promoting RES for decentralized energy system?

Table 11 showed that 5746 respondents agreed that governments at all levels are doing enough in promoting RES adoption for decentralized energy systems while 4702 believed that the government is not doing enough in promoting RES for decentralized energy system.

Research Question 3:

What are the challenges and prospects of RES adoption in your area?

(i) What are the major challenges of RES adoption in your area?

It is shown in Table 12 that 4074 respondents chose high initial cost, 2014 respondents chose lack of awareness, 764 chose fluctuation, and 1044, 1212 chose a lack of standard quality control measures while 1340 chose a lack of indigenous technical experts.

The high initial cost is a common challenge with RES utilization. These may include solar panel costs, turbines, and other equipment. Even, through RES can yield long-term cost savings, initial costs still remain a major barrier/impediment for local dwellers or low-income earners.

Lack of information or awareness may hinder RES adoption, since users may not be familiar with the prospects, benefits, and available latest technologies on how to make informed decisions on RES utilization and adoption.

Many people in the country are ignorant of the numerous benefits of RES technologies. Without adequate knowledge and a high level of awareness of the cost-savings and environmental benefits inherent in these technologies, people may be ignorant to invest or be attracted to them.

Prices of renewable energy technologies or its services have a notable negative influence on the use of renewable energy in Nigeria. This means that when renewable energy technologies are expensive for consumers, they are less likely to adopt and use them. High prices can act as a barrier to entry and can discourage individuals and businesses from investing in clean energy solutions.

(ii) What are the prospects of adopting RES in your area?

Table 13 shows that 3238 chose Job creation, 2594 chose Energy dependability, 1064 chose Improved energy Access, 2194 chose Economic Growth, And 1358 chose Increased Greenhouse Gas Emissions.

Research Question 4:

What are the effective ways of achieving the needed growth for sustainable energy growth in Nigeria?

Table 14 showed that 2119 respondents favored the introduction of incentives/subsidies, 3970 respondents believed in creating more awareness about the prospects and benefits of RES, and 858 respondents recommended...
the establishment of well-equipped research and development centers. 1254 respondents believe that improved funding of RES projects, 1035 suggested formulation of robust and appropriate RES energy policies and 1212 respondents agreed on the training of indigenous technical personnel.

### 4 Analysis and discussions of the research questions

**Research Question One**

The level of acceptance of RES technologies among the populace can be said to be at a very low level. Most people are yet to be fully aware of the benefits of RES technology adoption. The most popular RES choice is Solar PV is readily available in homes and business centers, especially among rural dwellers. Solar PV technologies are very common for usage as lighting points, phone battery charging, etc. The use of Solar PV is so popular due to its dependability, cost savings, environmental consideration, and ease of maintenance.

**Research Question Two**

Considering responses on whether the existing policy formulation of RES is effective in achieving the goals and objectives of the global trans-formative agenda on climate change. The majority of the respondents agreed that the existing policies are effective enough to achieve the goals. About 45.1% of the respondents, however, disagreed that the existing policy is effective enough to achieve the objectives.

**Research Question Three**

Some of the identified major challenges are the high initial cost, lack of awareness, fluctuations, defective policies, lack of standard quality control measures, and lack of indigenous technical experts. The majority of the respondents believe that high initial cost is the most common challenge militating against rapid adoption of RES. Lack of awareness stands to be another significant obstacle against RES technology adoption. Major benefits/prospects of its adoption are job creation, energy dependability, improved energy access, rapid economic growth, and reduced environmental pollution.

**Research Question Four**

Some of the strategies for overcoming RES adoption are the introduction of subsidies/incentives, creation of more awareness, the establishment of Research and Development centers, better funding of RES projects, training of indigenous RES technical personnel.

### 5 Conclusion

This paper highlighted how RES can be widely accepted by all citizens as a way of bridging the wide energy gap between supply and demand. Despite the abundant RES with significance spread across the country, RES exploitation is still very low. Significant improvement can be made in the sector by creating favorable policies on the environment that will attract investors and introduction of new technologies. This research work was carried out in order to investigate the level of awareness and adoption of RES in a decentralized energy system. The study (through the use of questionnaires) showed a very low level of awareness and acceptability of RES. The study suggested that more
awareness campaigns should be done to educate people about the benefits/prospects of RES and the negative effects of fossil fuels on the environment. There is also the need for the government to introduce incentives in order to attract investors and enhance the capabilities of more people in RES adoption.

Table 14. Strategies for overcoming the current challenges of RES adoption?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Number respondents</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction of subsidies/incentives</td>
<td>2119</td>
<td>20.28</td>
</tr>
<tr>
<td>Creating more awareness about the prospects, energy efficiency, and benefits of RES</td>
<td>3970</td>
<td>38.0</td>
</tr>
<tr>
<td>Establishment of well-equipped research and development centres</td>
<td>858</td>
<td>8.21</td>
</tr>
<tr>
<td>Improved funding of RES projects</td>
<td>1254</td>
<td>12.82</td>
</tr>
<tr>
<td>Formulation of robust and appropriate RES energy policies</td>
<td>1035</td>
<td>9.91</td>
</tr>
<tr>
<td>Training of indigenous RES technical personnel</td>
<td>1212</td>
<td>11.6</td>
</tr>
</tbody>
</table>

References

3 Jacobson M.Z. (2017) 100% clean and renewable wind, water, and sunlight. All-sector energy roadmaps for 139 countries of the world, Joule 1, 1, 108–121.66.