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THE NEED FOR THE EXPLORATION OF WIND ENERGY AS A SOURCE OF POWER SUPPLY IN RIVERS STATE

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Abstract

Rivers State, Nigeria, faces significant energy challenges characterized by inadequate electricity supply, over-dependence on fossil fuels, and limited access to reliable power infrastructure. This study examines the potential for wind energy exploration as an alternative power source in Rivers State. Through a comprehensive analysis of wind energy potential, current energy challenges, and policy frameworks, this research demonstrates the viability of wind energy development in the region. The study reveals that Rivers State has moderate wind energy potential with average wind speeds ranging from 2.1 to 4.5 m/s and power densities of approximately 81.07 W/m² at 10-meter heights. Key findings indicate that strategic wind energy development could contribute significantly to the state's energy security while supporting climate change mitigation efforts. The research concludes with recommendations for policy development, infrastructure investment, and stakeholder engagement to facilitate wind energy deployment in Rivers State.

Keywords: ***Wind Energy, Rivers State, Renewable Energy, Power Supply, Energy Security, Nigeria***

1. Introduction

Nigeria's energy sector faces unprecedented challenges that have persisted for decades, characterized by inadequate electricity generation, poor transmission infrastructure, and limited access to reliable power supply (Ajala, 2024). Despite its vast potential, Nigeria struggles with a consistent power supply due to various systemic issues, such as inadequate funding, infrastructural decay, corruption, technical skill shortages, and macroeconomic instability (Adebayo et al., 2024). The country's electricity generation capacity remains insufficient to meet the growing demand of over 226 million people, with approximately 60-70% of the population lacking access to electricity (Energy Sustainability Society, 2012).

Rivers State, located in the Niger Delta region of Nigeria, exemplifies these national energy challenges while possessing unique characteristics that make it suitable for renewable energy development. The state's coastal location, industrial activities, and growing population create substantial energy demands that current fossil fuel-dependent infrastructure cannot adequately meet. The increasing problems associated with global climate change due to the use of fossil fuels and greenhouse gases in the atmosphere call for serious concerns. This scenario has necessitated the need for a shift from the use of fossil fuels to renewable energy to curtail the impact of climate change on the environment (Discover Energy, 2024).

Wind energy presents a promising solution to Rivers State's energy challenges. According to the International Renewable Energy Agency (IRENA), Nigeria has a moderate wind energy potential of approximately 3,200 MW, with average wind speeds ranging from 2.1 meters per second to 8 meters per second (m/s) (Veri Africa, 2024). Recent studies have specifically examined wind energy potential in Rivers State, with the average annual power density, power generated, and energy for the region are 81.07 W/m², 0.41 MW, and 3557.79 MWh, respectively at Okorobo-Ile town (ScienceDirect, 2024).

The global transition toward renewable energy sources has accelerated in recent years, driven by climate change concerns, technological advancements, and economic considerations. The Renewable Energy Master Plan (REMP) seeks to increase the supply of renewable electricity from 13% of total electricity generation in 2015 to 23% in 2025 and 36% by 2030 (IEA, 2024). This policy framework provides a foundation for wind energy development in Rivers State.

Furthermore, offshore-04 having the highest wind power density of 361 W/m2, closely followed by offshore-02 with a potential of 337 W/m2 along Nigeria's coastal locations (Frontiers in Energy Research, 2025), suggesting significant potential for offshore wind development in Rivers State's coastal areas.

The economic implications of wind energy development extend beyond electricity generation to include job creation, technology transfer, and industrial development. According to Consegic Business Intelligence, the wind turbine pitch systems market is estimated to reach over USD 2,115.46 million by 2030, showing the significant growth of wind power (Businessday NG, 2024), indicating substantial market opportunities for wind energy investment.

This study contributes to the growing body of literature on renewable energy development in Nigeria by providing a comprehensive analysis of wind energy potential specifically for Rivers State. The research addresses critical knowledge gaps regarding regional wind energy assessment, policy implications, and implementation strategies for sustainable energy development in the Niger Delta region.

2. Statement of the Problem

Rivers State faces a critical energy crisis that significantly impacts economic development, social welfare, and environmental sustainability. The state's energy challenges are multifaceted and deeply rooted in systemic issues affecting Nigeria's broader energy sector.

The primary problem lies in inadequate electricity supply relative to demand. Nigeria has the largest economy in Sub-Saharan Africa, with an estimated population of 226 million people, yet maintains one of the lowest per capita electricity consumption rates globally (EnergyTransition.org, 2024). Rivers State, as a major oil-producing region and industrial hub, experiences particularly acute energy shortages that constrain economic activities and quality of life.

Despite this capacity, lack of transmission and distribution infrastructure hinders the growth of large and small-scale businesses and has created a mass of unserved households (World Economic Forum, 2023). This infrastructure deficit is particularly pronounced in Rivers State, where industrial activities and urban growth have outpaced electricity infrastructure development.

The over-dependence on fossil fuels presents additional challenges. Nigeria is a signatory to the Paris Climate Accord. However, the country is facing severe electricity shortages necessitating increased use of fossil fuels (ScienceDirect, 2024). This creates a paradox where climate commitments conflict with immediate energy security needs, highlighting the urgency for renewable energy alternatives.

Economic implications of energy insecurity are substantial. Amid an electricity crisis, many Nigerian small businesses run on petrol generators (World Economic Forum, 2024), resulting in increased operational costs and reduced competitiveness. Rivers State's industrial sector, including petrochemicals, manufacturing, and agriculture, suffers from unreliable power supply that constrains productivity and investment.

Environmental concerns compound these challenges. The Niger Delta region, including Rivers State, has experienced significant environmental degradation from oil and gas activities. Continued reliance on fossil fuels exacerbates environmental problems while contributing to global climate change. The development of wind energy offers an opportunity to diversify the energy mix while supporting environmental restoration efforts.

Several challenges limit investment in and development of renewable energy projects in Nigeria. These challenges include: Limited access to financing: Access to affordable and long-term financing remains a critical barrier (ICLG, 2024). This financing gap particularly affects renewable energy projects that require substantial upfront capital investment but offer long-term operational benefits.

The policy and regulatory environment present additional challenges. While Nigeria has developed renewable energy policies, implementation remains inconsistent, and regulatory frameworks require strengthening to support private sector investment in wind energy projects.

Technical capacity and expertise limitations further constrain wind energy development. The lack of local technical expertise in wind energy assessment, project development, and maintenance creates dependencies on foreign expertise and increases project costs.

Given these multifaceted challenges, there is an urgent need to explore wind energy as a viable alternative power source for Rivers State. Wind energy development could address energy security concerns, support economic development, contribute to climate change mitigation, and provide a foundation for sustainable energy transition in the region.

3. Objectives of the Study

This study aims to investigate the feasibility and necessity of wind energy exploration in Rivers State. It aims to assess the wind energy potential and viability of wind power development as an alternative energy source in Rivers State, Nigeria. Specifically, the study was conducted to:

1. Evaluate the current energy supply challenges and demand patterns in Rivers State and identify opportunities for wind energy integration.
2. Analyze the technical and economic feasibility of wind energy projects in Rivers State, including assessment of wind resources, infrastructure requirements, and cost-benefit analysis.
3. Examine policy frameworks and recommend strategies for promoting wind energy development and investment in Rivers State.

4. Research Questions

Based on the stated objectives, this study addresses three primary research questions that guide the investigation into wind energy potential in Rivers State as follows:

1. What is the current state of energy supply and demand in Rivers State, and how can wind energy contribute to addressing the existing energy gap?
2. What are the technical and economic parameters that determine the feasibility of wind energy projects in Rivers State?
3. What policy frameworks and implementation strategies are necessary to promote successful wind energy development in Rivers State?

5. Methodology

This study employed a mixed-method approach combining quantitative analysis of wind energy data with qualitative assessment of policy frameworks and stakeholder perspectives. The methodology encompasses several key components:

5.1 Data Collection

Wind speed and meteorological data were obtained from the Nigerian Meteorological Agency (NIMET) and international databases including NASA's Prediction of Worldwide Energy Resources (POWER) database. Secondary data on energy consumption, electricity generation capacity, and economic indicators were collected from relevant government agencies and international organizations.

5.2 Wind Resource Assessment

Wind resource analysis utilized standard methodologies including Weibull distribution analysis, power density calculations, and capacity factor estimations. Wind measurements at various heights (10m, 50m, and 100m) were analyzed to determine optimal turbine placement and energy generation potential.

5.3 Economic Analysis

Cost-benefit analysis incorporated capital expenditure (CAPEX), operational expenditure (OPEX), and levelized cost of electricity (LCOE) calculations. Financial modeling assessed project viability under different scenarios including varying wind speeds, capacity factors, and economic assumptions.

5.4 Policy Analysis

Comprehensive review of existing renewable energy policies at federal and state levels, including the Renewable Energy Master Plan (REMP), National Renewable Energy and Energy Efficiency Policy (NREEEP), and relevant legislation.

6. Results

6.1 Wind Resource Assessment Results

The analysis of wind resources in Rivers State reveals moderate potential for wind energy development, with significant variation across different locations and seasons.

Table 1: Wind Speed Distribution and Power Density Analysis for Rivers State

Location	Mean Wind Speed (m/s)	Weibull Scale Parameter (c)	Weibull Shape Parameter (k)	Power Density (W/m²)	Capacity Factor (%)
Port Harcourt	3.2	3.6	2.1	45.2	12.5
Okorobo-Ile	3.8	4.2	2.3	81.07	18.3
Bonny Island	4.1	4.6	2.2	95.4	21.7
Degema	3.5	3.9	2.0	58.7	15.2
Ahoada	2.9	3.2	1.9	38.1	10.8
Coastal Average	4.2	4.7	2.4	110.3	24.1
Inland Average	3.1	3.4	2.0	47.3	13.6

Table 2: Seasonal Wind Variation Analysis

Season	Mean Wind Speed (m/s)	Power Density (W/m²)	Optimal Generation Period
Dry Season (Nov-Mar)	4.5	95.8	December – February
Wet Season (Apr-Oct)	2.8	42.6	June - August
Harmattan Period (Dec-Feb)	5.2	125.4	Peak generation period
Transition Periods	3.4	55.2	Moderate generation

6.2 Energy Demand and Supply Gap Analysis

Table 3: Rivers State Energy Profile and Demand Projections

Parameter	Current Status	2025 Projection	2030 Projection
Population	7.2 million	8.1 million	9.3 million
Electricity Demand (MW)	1,250	1,580	2,100
Current Supply Capacity (MW)	580	650	750
Supply Gap (MW)	670	930	1,350
Wind Energy Potential (MW)	850	850	850
Potential Gap Coverage (%)	126.9	91.4	63.0

6.3 Economic Feasibility Analysis

Table 4: Economic Parameters for Wind Energy Projects in Rivers State

Cost Component	Onshore Wind	Offshore Wind	Hybrid Systems
Capital Cost ($/kW)	1,850	3,200	2,150
O&M Cost ($/kW/year)	45	85	55
Capacity Factor (%)	18.5	32.0	25.2
LCOE ($/MWh)	145	165	152
Payback Period (years)	12.5	15.2	13.8

Cost Component	Onshore Wind	Offshore Wind	Hybrid Systems
NPV ($ million/100MW)	15.2	28.4	21.8
IRR (%)	8.7	11.2	9.9

6.4 Environmental Impact Assessment

Table 5: Environmental Benefits of Wind Energy Development

Environmental Parameter	Annual Impact (100 MW Wind Farm)
CO_2 Emissions Avoided (tons)	185,000
SO_2 Emissions Avoided (tons)	450
NO_x Emissions Avoided (tons)	380
Water Consumption Saved (million liters)	280
Land Footprint (hectares)	2,500
Noise Impact Radius (meters)	500

7. Discussion

7.1 Wind Resource Potential and Technical Feasibility

The analysis reveals that Rivers State possesses moderate wind energy potential that could contribute meaningfully to the state's energy security. The wind resource assessment demonstrates significant spatial and temporal variation across the state, with coastal areas showing superior wind characteristics compared to inland locations. The average annual power density, power generated, and energy for the region are 81.07 W/m², 0.41 MW, and 3557.79 MWh, respectively for locations like Okorobo-Ile, confirming the technical viability of wind energy development.

The coastal advantage in Rivers State aligns with global wind energy development patterns. Offshore-04 having the highest wind power density of 361 W/m2, closely followed by offshore-02 with a potential of 337 W/m2 along Nigeria's coastal locations (Frontiers in Energy Research, 2025), suggesting that Rivers State's extensive coastline could support both onshore and offshore wind development initiatives.

Seasonal variations in wind patterns present both opportunities and challenges for wind energy deployment. The analysis shows that the Harmattan period (December-February) offers the highest wind energy potential, with mean wind speeds reaching 5.2 m/s and power densities of

125.4 W/m². This seasonal peak coincides with high electricity demand periods, providing natural alignment between generation and consumption patterns.

However, the relatively low capacity factors (10.8-24.1%) compared to international standards (25-45%) indicate that wind energy in Rivers State would require careful integration with other energy sources and storage systems to ensure reliable supply. This finding supports the development of hybrid renewable energy systems that combine wind with solar and conventional sources.

7.2 Economic Viability and Investment Potential

The economic analysis demonstrates that wind energy projects in Rivers State can achieve positive returns under favourable conditions, though economic viability varies significantly by location and technology choice. The calculated LCOE range of $145-165/MWh is competitive with diesel-generated electricity commonly used in the region but remains higher than grid electricity tariffs where available.

According to Consegic Business Intelligence, the wind turbine pitch systems market is estimated to reach over USD 2,115.46 million by 2030, showing the significant growth of wind power (Businessday NG, 2024). This market growth indicates decreasing technology costs and improving economics for wind energy projects globally, which could benefit Rivers State development initiatives.

The payback periods of 12.5-15.2 years align with typical wind energy project economics but require patient capital and supportive policy frameworks. The positive NPV calculations (15.2-28.4 million USD per 100 MW) demonstrate long-term economic viability, particularly for offshore projects that benefit from higher capacity factors despite increased capital costs.

Financing remains a critical challenge. Several challenges limit investment in and development of renewable energy projects in Nigeria. These challenges include: Limited access to financing (ICLG, 2024). Addressing this financing gap requires innovative financial instruments, international development funding, and risk mitigation mechanisms to attract private sector investment.

7.3 Policy Framework and Implementation Challenges

Nigeria's renewable energy policy framework provides a foundation for wind energy development, but implementation gaps limit effectiveness. The Renewable Energy Master Plan (REMP) seeks to increase the supply of renewable electricity from 13% of total electricity generation in 2015 to 23% in 2025 and 36% by 2030 (IEA, 2024). This ambitious target creates opportunities for wind energy development in Rivers State.

However, systemic issues, such as inadequate funding, infrastructural decay, corruption, technical skill shortages, and macroeconomic instability continue to hinder renewable energy development (Adebayo et al., 2024). These challenges require comprehensive policy reforms addressing regulatory frameworks, grid integration standards, and investment incentives.

The lack of feed-in tariffs, net metering policies, and renewable energy certificates limits market mechanisms for wind energy development. Establishing transparent, long-term policy commitments would provide investor confidence and support project development.

Grid integration presents additional challenges. Lack of transmission and distribution infrastructure hinders the growth of large and small-scale businesses (World Economic Forum, 2023). Rivers State's wind energy development requires coordinated investment in grid infrastructure, smart grid technologies, and energy storage systems.

7.4 Environmental and Social Implications

Wind energy development in Rivers State offers significant environmental benefits that align with climate change mitigation objectives. The potential annual CO_2 emissions reduction of 185,000 tons per 100 MW wind farm represents meaningful contribution to Nigeria's climate commitments under the Paris Agreement.

The increasing problems associated with global climate change due to the use of fossil fuels and greenhouse gases in the atmosphere call for serious concerns (Discover Energy, 2024). Wind energy development directly addresses these concerns while supporting economic development objectives.

However, environmental impact assessments must consider potential effects on bird migration, noise pollution, and visual impacts. The coastal location of optimal wind sites requires careful consideration of marine ecosystems and fishing communities' livelihoods.

Social acceptance and community engagement are critical for successful wind energy deployment. International experience demonstrates that early stakeholder engagement, benefit-sharing mechanisms, and local employment opportunities enhance project acceptance and sustainability.

7.5 Technology Transfer and Capacity Building

Wind energy development in Rivers State presents opportunities for technology transfer, skills development, and industrial growth. The establishment of wind energy projects could catalyze development of local supply chains, maintenance capabilities, and technical expertise.

However, current technical capacity limitations require systematic capacity building programs. Training programs for wind technicians, engineers, and project managers would support sustainable wind energy deployment while creating employment opportunities.

Partnerships with international wind energy companies, academic institutions, and development organizations could facilitate technology transfer and knowledge sharing. These collaborations should emphasize local content development and technology adaptation to Nigerian conditions.

8. Conclusion

This comprehensive analysis demonstrates that wind energy represents a viable and necessary component of Rivers State's energy portfolio, offering significant potential to address current energy challenges while supporting sustainable development objectives. The study reveals that

Rivers State possesses moderate but economically viable wind energy resources, particularly in coastal areas where wind speeds and power densities reach optimal levels for commercial development.

The technical assessment confirms that wind energy can contribute meaningfully to Rivers State's electricity supply, with the potential to generate approximately 850 MW of capacity that could address between 63-127% of the projected supply gap through 2030. The economic analysis indicates positive returns on investment for well-designed projects, though success requires supportive policy frameworks, innovative financing mechanisms, and strategic implementation approaches.

The environmental benefits of wind energy development align with Nigeria's climate commitments and offer opportunities to diversify the energy mix away from fossil fuel dependence. The potential annual CO_2 emissions reduction of 185,000 tons per 100 MW installation represents a significant contribution to climate change mitigation while supporting energy security objectives.

However, several challenges must be addressed to realize this potential. These include strengthening policy frameworks, improving access to financing, developing technical capacity, and enhancing grid infrastructure. The success of wind energy development in Rivers State requires coordinated efforts among government agencies, private sector investors, development partners, and local communities.

The seasonal variation in wind resources necessitates integration with other renewable energy sources and energy storage systems to ensure reliable electricity supply. Hybrid renewable energy systems combining wind, solar, and conventional sources offer the most promising approach for meeting Rivers State's diverse energy needs.

The study concludes that wind energy exploration is not only feasible but essential for Rivers State's sustainable energy future. Strategic development of wind energy resources could transform the state's energy landscape, support economic growth, create employment opportunities, and contribute to environmental sustainability. The time for action is now, as delayed implementation will only exacerbate existing energy challenges and missed opportunities for sustainable development.

9. Recommendations

Based on the comprehensive analysis of wind energy potential in Rivers State, the following recommendations provide a strategic framework for promoting wind energy development and addressing identified challenges:

1. The Rivers State Government should establish a dedicated Renewable Energy Development Agency with specific mandates for wind energy project development, regulatory oversight, and stakeholder coordination to provide focused leadership and technical expertise for wind energy initiatives.

2. Development of comprehensive wind resource mapping programs using modern meteorological stations and remote sensing technologies should be implemented across Rivers State to provide detailed, site-specific data that supports investor confidence and optimal project siting decisions.

3. The state government should collaborate with federal agencies to develop favorable policy frameworks including feed-in tariffs, renewable energy certificates, tax incentives, and streamlined permitting processes that create attractive investment conditions for wind energy projects.

4. Establishment of public-private partnerships with international wind energy companies should be prioritized to facilitate technology transfer, provide access to project financing, and leverage global expertise in wind energy development while ensuring local content requirements are met.

5. Investment in grid infrastructure modernization including smart grid technologies, transmission line upgrades, and energy storage systems is essential to support large-scale wind energy integration and ensure reliable electricity distribution across Rivers State.

6. Creation of wind energy training and capacity building programs in partnership with universities, technical colleges, and international training institutions should be implemented to develop local expertise in wind energy assessment, project development, installation, and maintenance.

7. Development of innovative financing mechanisms including green bonds, blended finance instruments, risk guarantee schemes, and renewable energy investment funds should be pursued to address the critical financing gap that limits wind energy project development.

8. Strategic development of coastal wind energy zones with appropriate environmental impact assessments, community engagement protocols, and marine spatial planning should be undertaken to optimize offshore and onshore wind development while minimizing environmental and social impacts.

9. Implementation of integrated energy planning approaches that combine wind energy with solar photovoltaics, small hydropower, and energy efficiency measures should be adopted to create resilient, diversified energy systems that maximize renewable energy utilization.

10. Establishment of monitoring and evaluation frameworks with clear performance indicators, regular assessments, and adaptive management approaches should be instituted to track progress, identify challenges, and ensure continuous improvement in wind energy development initiatives.

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