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Overview of barriers to wind energy deployment in Africa

Abstract

Despite the high wind potential in Africa, wind based electricity contributes less than 1 percent to installed electricity generation capacity. The disparity between potential and extent of exploitation raises questions about barriers to development of wind energy on the continent. This study aims to identify and analyse the current barriers to the deployment of wind energy industry in Africa and suggest strategies to overcome them. Literature overview was conducted to determine the barriers to the deployment of wind energy industry in Africa from 2013 up-to-date. Data sources included peer reviewed journals, dissertations and technical reports while data bases included Google Scholar, Elsevier and institutional respiratory. The current paper identified economic, technical, social and political barriers to wind energy deployment in Africa. In light of these findings, the paper suggested the removal of fossil-fuel subsidies, pricing carbon emissions, setting sound long-term objectives supporting wind energy, providing investors in wind energy projects with well-designed incentives, easing licensing for clean energy projects and ensuring that wind energy policies support renewable energy sources. African countries should develop a regional approach whereby nations with greater potential establish large scale wind projects to address the needs of neighbouring countries.

1. Introduction

Energy insecurity adversely impacts key aspects of sustainable development activities such as healthcare, food security, employment creation job, industrialisation, clean water supply, education and public infrastructural development [1,2] Power outages and restricted access to electricity undermines poverty-reduction strategies in Africa. A transit from fossil fuels to renewable energy is key to addressing energy insecurity and climate change in Africa. Approximately 600 million Africans do not have access to reliable energy services [2, 3]. The electrical energy generation capacity for most African countries averages 28 Gigawatts [3]. South Africa generates approximately 58 Gigawatts of electricity, the highest generation capacity in Africa [3, 4].

Africa's renewable energy resources are the highest in the world and the continent has enough renewable energy potential to meet its future energy needs [2, 3]. It is estimated that 18 of the top 35 less economically developed countries ranked highest in renewable energy reserves, are in Africa [4]. Although Africa has potential supply of wind energy, the installed capacity of wind-based electricity in the continent does not surpass the 0.5% of global capacity [4].

Strikingly, wind-based electricity contributes less than 1 percent to installed electricity generation capacity on the continent [4, 5]. Table 1 highlights electricity generation capacity in top ten African countries.

Table 1: Electricity Generation from wind energy in Africa as of 2020 by country [5]

Country	Wind electricity generation in terrawatt hours
South Africa	5.9
Morocco	4.59
Egypt	4.35
Kenya	1.80
Ethiopia	0.53
Tunisia	0.5
Cape Verde	0.08
Mauritius	0.02
Algeria	0.01

Africa generates approximately 6.468MW of wind energy, the figure represents a small fraction of the continent's wind potential. The disparity between potential and extent of exploitation raises questions about barriers to the deployment of wind energy on the continent. Africa has the potential of focusing on wind energy to provide clean and reliable energy. This study aims to identify and analyse the current barriers to the deployment of wind energy industry in Africa and suggest measures to overcome the problems.

Several papers have been conducted to identify barriers to wind energy deployment worldwide, however, a few have been done in Africa. In this paper, fours barriers namely social, economic, political and technical have been considered guided by technical reports, scientific papers, and academic research. It is worth to note that not all the barriers are evident in all African countries and there could be some that have not been conceptualised.

2. Methodology

2.1 Protocol

Research design encompassed eligibility criteria and data items that involved data sources, study selection, risk of bias and data analysis. Systematic review was guided by PRISMA requirements [6].

2.2 Eligibility Criteria

Technical reports, peer-reviewed journal articles and dissertations were reviewed and selected after reading title and abstract and full articles about barriers to wind energy in Africa. Information sources was done using key words searches such as barriers to wind energy deployment in Africa using Google.

2.3 Data items

Literature review was retrieved from Institutional respiratory, Elsevier and Google scholar. Thirty-seven articles were selected after reading the title and abstract. Thirty-two papers were considered after full-text reading, as they answered the guiding question. Such a small number of papers justifies the need for this review article. To reduce bias, the researcher sought outside peers with methodological expertise to review the research plan and data. Data analysis entailed synthesising, analysing and presenting descriptive summaries. Research findings were classified according to economic, technical, political and social barriers.

Several studies have proposed a basic framework set to the analysis of barriers facing the wind energy industry in Africa [7 - 13]. Barriers are classified as economic, technical, political and social. Literature review of technical reports, scientific papers, and academic research provide profound insights about the barriers to wind energy deployment especially if similar economic, natural, political, social, political, regional or natural conditions exist in the studied areas to derive suggestions for future research [7 - 13]. This research aims to add validity to the analysis presented using recent peer-reviewed papers.

3. Results

This section presents data on economic, technical, political and social barriers to the development of wind energy in Africa (Table 2).

Table 2: Barriers to wind energy development in Africa [1 - 5, 7 -15]

Classification of barriers	Examples of barriers
Economic	• high initial costs of wind energy installation • lack of access to credit facilities • utility monopoly of generation • market distortion
Technical	• Limited infrastructure and technology • inadequate systems to contain wind energy

Classification of barriers	Examples of barriers
	• insufficient research about wind energy • Interconnection problems with the distribution grid
Political	• lack of appropriate, clear and strategic regulatory framework • disparency among policy targets and real implementation • lack of prioritization of wind energy transmission and distribution of energy • subsidies of fossil fuel
Social	• lack/limited public awareness to conventional energy resources • limited educational institutions and skilled human capital • limited support from social institutions, and entrepreneurs in the energy industry) • resistance of wind energy project by local communities

3.1 Economic Constraints

Establishing a wind energy project is capital intensive, however the costs related to the lifespan of wind energy projects are less costly as compared to other energy generating energy sources [11, 12]. In Africa, a commercial average-sized wind turbine costs between $2.6 million to $4 million per megawatt [13]. In Kenya, the Lake Turkana Wind Power farm of 365 turbines cost approximately USD 700 million to build. The project faced challenges in securing funds and had project implementation delays. The project involved an arrangement of sixteen partners [15].

The high upfront costs cost associated with energy projects dampen investor interest. Papers by [15, 17], identified the high capital cost as a barrier to the development and expansion of wind energy in Africa. Wind energy projects in Africa should be developed in close proximity, to reduce upfront costs (the need for purchasing new, ancillary infrastructure) [11, 12].

Since wind energy projects are associated with high wind installation costs, financial institutions are unlikely to offer credit facilities to renewable energy sources that have not been widely used and tested [14, 17]. Financial institutions may request a premium in lending rates for financing such projects, since more capital is being risked up front [14, 17]. Banks expect to see well established policies for nascent wind energy technologies in light of mounting market risks.

A distorted market creates an uneven playing field for wind energy industry, in addition to the government subsidies provided to other conventional power generation sources like coal fired power generation [18 - 20]. In Nigeria import duties on renewable energy technologies coupled with subsidies on fossil-fuels make conventional energy sources to have a competitive edge to no-convectional energy sources like wind energy [20]. In Nigeria, poor regulatory environment, inadequate infrastructure and price distortions embody present energy market conditions.

The total production cost of large wind energy projects is relatively higher than that of fossil fuels thus market prices for non-conventional energy sources like wind are relatively high. Since most consumers prefer cheaper options, wind energy technologies suffer from biased market competition from conventional energy sources whose development and production costs are in most African countries subsidised [20, 21].

3.2 Technical barriers

There are several technical barriers to the widespread deployment of wind energy. They include limited infrastructure, limited knowledge of operations and maintenance, insufficient research about wind energy and technical complications such as wind energy storage [4, 7, 8, 9, 11, 12, 13]. More economically developed nations possess skills and technical capacity to conduct wind energy research and development, however this is not the case in several African countries. Although Africa nations may be equipped with skilled labour force, lack of investment in research is a major obstacle to the deployment of large scale wind energy projects [13, 14, 17] The challenge is for African countries to develop programs that are meant to assess the applicability of renewable energy technology that meets local conditions. Through such applied research, African nations can adopt the applicable technologies in regards to costs and benefits [17 - 20].

Wind energy is not a good base load capacity. It results in irregular electricity output and is non-storable as compared to other renewables such as water, which can be stored and used in response to demand [18, 19, 20]. Most national grids in Africa are demand driven therefore require stable base load capacity.

African nations are faced with a problem of integrating large wind-based electricity flows into the grid system that require grid infrastructure overhaul. This relates to the power system dispatcher and grid resilience to peaks and troughs in electricity flows from the wind energy farms [18 - 20]. Moreso, conventional demand-driven grids make this integration complicated [18 - 20]. Grid integration requires reliable, cost, effective efficient back-up plants with cleaner new energy generators to regulate volatility in electricity flows. With the current state of electricity grids in several African countries, these elements present a major setback to the development of wind energy projects. For example, South Africa declined bids for more than 4GW of wind capacity because it failed to connect 23 projects offered in the grid [21].

Researches [18 - 20] have indicated that wind turbines operate far below their capacity because of the intermittent nature of wind. Generally, wind turbines produce electricity at maximum capacity in wind speeds ranging from 30 to 55mph [19]. However, the electricity production falls drastically at lower wind speeds. The average capacity factor for wind energy (34%) reduces its competiveness to capacity factors of other convectional and non-convectional energy sources, like hydropower (52%), coal (85%) and natural gas (87%) [19] Several studies have concluded that interconnection problems with the distribution grid as the main barrier to the deployment of wind energy in Africa [17 – 19].

3.3 **Policies and legal frameworks**

Several barriers, as a result of government failures (fossil-fuel subsidies, the lack of effective and supportive policies) hamper investment in wind energy. Several African nations are yet to remove tax on imports of equipment related to wind energy projects. The absence of fiscal financial incentives contributes to the problems associated with the deployment of wind energy projects [22 - 26].

The wind industry requires appropriate, clear and strategic regulatory framework to be able to expand [22, 28] However, few African nations for example South Africa and North African countries are slowly developing and implemented strategic plans to develop the wind energy industry. International agreements like the Paris Accord, saw 34 out of the 55 African countries formulating renewable energy targets. There is still a considerable disparency with the implementation process [4, 8, 12, 22, 28].

In several African nations, power utilities still adopt a monopoly system on electricity production and distribution. There is a growing consensus that private sector led economies are more efficient than those dominated by state ownership [4, 8, 12, 24]. In the absence of a legal framework, independent power producers may be discouraged to invest in wind energy technologies [4 - 30]. This makes it a challenge for wind energy project investors to plan and

finance projects. Studies have shown that economically developed countries with a heavy investment in wind energy, have appropriate legal frameworks related to the use of all forms of energy [10, 22].

African nations have ineffective legal frameworks that govern the renewable energy sector. Where legal frameworks do exist, they are biased towards the use of non-renewable energy technologies. The development of appropriate legal framework stimulates the participation of investors in the development of wind energy technologies, which leads to variation of the countries' energy supply mix [23]. This in turn spurs innovation, reduce in the use of fossil fuels, reduce environmental degradation and promote employment opportunities. This, is particularly vital for African countries, which often rely on a limited number of convectional energy sources.

International Renewable Agency (IRENA) pointed out that apt policies, legislation, governance and access to financial markets, sub-Saharan Africa could meet up to 67 per cent of its energy needs by 2030 [1, 3]. Several African countries have developed laws and policies on tax incentives on renewable energy. The Madagascar Tax Code of 2015 provides for the following tax incentives of renewable energy; a reduction in corporate income tax equivalent to 50% of the investment and exemption of VAT on equipment used in the production of renewable energy [23, 30].

The South Africa Income Tax Act provides several tax incentives that promote the renewable energy sector. These include exemption of certified emission reductions, allowances for energy efficiency savings and capital allowance for machinery used in the production of renewable energy and [30]. The Kenya Finance Act of 2021 First Schedule of the Value Added Tax Act exempt taxing of solar and wind energy equipment. The law encourage the adoption of non-convectional energy sources. New regulations and fiscal incentives promoting adoption of wind energy technologies can help the wind industry to flourish [30].

3.4 **Social aspects**

Several papers has cited consumer behaviour and educational level as significant barriers to the deployment of wind energy technologies in Africa [4, 19]. There is limited public awareness to conventional energy resources such as wind energy about its economics and benefits. Lack of awareness on the potential benefits of wind energy makes it a challenge for consumers to switch from conventional energy sources to wind energy.

Wind energy farms face resistance and opposition due to acquisition of land which could be used for other land uses like agriculture. In Kenya, the Rendile, Samburu and Turkana communities felt excluded from the Lake Turkana Wind Power. The distressed communities sued the government for unlawful apportionment of 150 000 acres of community land for Lake Turkana Wind Power

project. The land has assisted the local people to uphold their pastoralist way of life for centuries providing alternate grazing land and water for livestock, and sparing them from devastating effects of drought [15]. Lack of stakeholder consultation, limited information regarding environmental and financial gains, and limited/ lack of awareness of wind energy technologies hinder the development of wind energy projects [4, 15, 19]. Similarly, limited educational institutions, limited human capital, limited support from social institutions and entrepreneurs in the energy hinder development of wind energy industry in several African countries. Social institutions are a missing link in the development of the wind energy industry in Africa [4, 31, 32].

4. Conclusion

In summation, there are a myriad of hurdles that impede the deployment of wind energy industry in Africa. The economic barriers included high initial costs of wind energy installation, lack of access to affordable capital, banks unwilling to offer credit facilities and distorted market. Technical barriers identified included limited infrastructure, limited knowledge of operations and maintenance, insufficient research about wind energy and technical complications such as wind energy storage. Political barriers entailed poor or limited wind energy regulatory framework for independent power producers, power purchase agreements transmission, distribution of energy and subsidy of fossil fuels, absence of fiscal financial incentives and monopoly system on electricity production and distribution. Social barriers included limited public awareness to conventional energy resources such as wind energy about its economics and benefits, limited educational institutions and skilled human capital, limited support from social institutions and resistance from local communities. Despite a relatively low volume of new installations compared to the wind energy leaders in the world, the share of wind energy in some African countries like Egypt, South Africa and Morocco is steadily growing.

5. Recommendations

- African government should develop holistic strategies for financing wind energy projects through a regulatory framework for sound incentives and policies. These may involve capital market development and issuing green bonds for impact financing in wind energy projects.
- African governments should promote clean energy investments, by shifting investment incentives away from fossil fuel energy towards wind energy. This will require taking a range relevant measures including: removing fossil-fuel subsidies; pricing carbon emissions; setting sound long-term objectives supporting wind energy; providing investors in wind energy projects with well-designed incentives, easing licensing for clean energy projects; and ensuring that wind energy policies support renewable energy sources.

- African nations should call for the participation of the private sector in power generation, transmission and distribution, ensure a fair treatment across the electricity sector and provide the electricity authority adequate and appropriate renewable energy resources
- Access to the electricity supply grid is one major barrier encountered by renewable energy producers. Providing regulated third party access to the electricity supply grid assist to and promote the use of different approaches depending on the local problems. In Germany, there is regulated third party access, as such, renewable energy producers benefit from a preferential connection.
- Africa nations should engage and develop a regional approach whereby nations with greater potential establish large scale wind projects to address help address the needs of neighbouring countries.
- Since most grid systems in African countries lack the capacity to contain diverse renewable energy sources for grid integration, effort should be put on smart grids with battery storage capacity for better integration of renewable energy sources. Large scale battery can be beneficial in the storage of wind energy of the day because of intermittency of wind power with variable wind speed during the day.

Declaration of competing interest

The author declares that he has no known conflicting interests to influence the work reported in this paper.

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