

Exploring the Efficacy and Feasibility of Wind Energy as A Panacea for Eskom's Sustainable Generation with Energy Security and Energy Poverty

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Abstract

There is ample proof that South Africa's ongoing reliance on fossil fuels as its primary source of energy consumption. It has contributed to the release of greenhouse gases that have exacerbated ecosystem disruption causing global warming and climate change. The study investigated and evaluated the effectiveness and feasibility of wind energy as a magic bullet to improve energy security, sustainable energy production, and alleviate energy poverty in South Africa. This is in order to improve sustainable energy generation, energy security, and the elimination of these problems. A thorough literature review of papers published between 2015 and 2022 was done in this study. SWOT analysis method (strengths, weaknesses, opportunities, and threats) is also used in the study. According to the analysis, Eskom's deployment of wind energy at a large scale can enhance South Africa's energy security and sustainably provide power while also lowering the country's present level of energy poverty. The systematic literature review indicates that South Africa, particularly in the Eastern and Western Cape regions, offers significant potential for and capacity for renewable wind energy. In order to incorporate renewable sources into its energy mix and achieve energy sustainability, Eskom should use macro-level strategies that discourage carbon-based energy.

Keywords: Efficacy; Feasibility; Renewable Energy, Non-Renewable Energy, Fossil Fuel, Environment, Green Energy, Wind Energy, Fossil Fuels, Eskom, Energy Poverty, Sustainable Energy, and Energy Security.

INTRODUCTION

Most of the world now relies on fossil fuels and other non-renewable energy sources as their primary energy sources, however they are quickly depleting (Mas'ud, Wirba, Ardila-Rey, Albaracin, Muhammad-Sukki, Duque, Bani&Munir, 2017). Non-renewable resource pollution is a problem that harms both the environment and human health. These issues have led to the necessity for renewable energy in numerous countries all over the world. Power companies like Eskom should move from fossil fuels to other energy sources to combat climate change (Arent, Arndt, Miller, Tarp & Zinaman, 2017; Isoaho, Goritz & Schulz, 2017). The modern energy

transition is typically greatly influenced by changes in legislation, technology, and economic growth (Cherp, Vinichenko, Jewell, Brutschin & Sovacool, 2018).

Nonetheless, it appears that among the most crucial factors impacting the processes of the energy transition are supporting policies and effective institutions (Jacobsson & Lauber, 2006). Several nations have pledged to do more to achieve a clean energy transition in order to fulfill the ambitions of the Sustainable Development Goals (SDG) agenda regarding SDG 7 (energy and energy access) and SDG 13 (climate change), as well as the commitments made during the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in Paris in 2015. However, the analysis of the effectiveness and viability of switching to renewable wind energy in developing countries, particularly in Africa and South Africa, has received less attention (Cherp, Vinichenko, Jewell, Suzuki & Antal, 2017; Cherp et al., 2018). In the context of Africa, the shift to renewable energy should be viewed as clean energy modernization and expansion rather than a transition in and of itself (Aliyu, Modu, Tan, 2018; Akinyoade, Uche & Dangote, 2017; IEA. Energy access outlook, 2017).

Background and Context of the Study

Due to its difficulty in producing enough electricity to fulfill demand, South Africa is currently experiencing an energy crisis. The result of this has been a number of loadshedding cycles. While Eskom works to get the nation's energy production back to sustainable levels, a reliable grid ought to be a top priority for all stakeholders on a national level.

Regarding this situation, South Africa has recognized wind energy as a solution to simplify the switch from non-renewable energy sources to renewable energy sources like wind energy in order to lessen the challenges and drawbacks associated with using fossil fuels as energy sources (Mukonza & Nhamo, 2018). A few of the organizations in South Africa that support renewable energy are the Department of Energy (DoE), Energy Development Corporation, South Africa National Energy Development Institute, South Africa Wind Energy Association, South African Renewable Energy Council, South African Renewable Initiative, and Sustainable Energy Society Southern Africa. In collaboration with the Department of Trade and Industry (DTI), which hosted the WINDABA conference for African wind energy companies in 2014.

The fastest-growing renewable energy source in the world is wind energy, which has also become one of the most economically advantageous sources of raw materials per unit of power produced (Aliyu, Modu & Tan, 2018). Due to the abundance of renewable energy resources in some locations, empirical studies have shown that more than 62% of South Africa's electricity needs may be satisfied by wind resources (Zhang, Gari, & Hmurcik, 2014).

This shows that there would be enough wind farms to create around 6700GW, which would be sufficient to meet the world's electricity needs, if they were erected everywhere in the country, excluding exclusion zones (Yahiaoui, Benmansour, & Tadjine, 2016). Furthermore, according to the CSIR, over 80% of South Africa's land mass has sufficient wind resources for the optimal and technologically advantageous operation of wind farms with a very high annual load factor of around 30%. (Bracco, Delfino, Pampararo, Robba, & Rossi, 2015; Izadbakhsh, Gandomkar, Rezvani, & Ahmadi, 2015).

The production of wind energy is a cheap and widely available resource. As a result, more and more nations are realizing that the potential for future power production from wind energy is enormous (Singh et al., 2022; Qin, Yan, Zhu, Xu & Kammen, 2021; Maldonado-Correa, Solano & Rojas-Moncayo, 2021).

Given how wind energy contributes to achieving the SDGs connected to energy, it has been expected that wind resources will actively contribute to supplying the world's energy requirements, particularly in developing and impoverished nations.

The option of supplying electric energy from renewable energy resources has essentially become more popular due to the combined impact of South Africa's solar and wind energy resources (Bracco, Delfino, Pampararo, Robba, & Rossi, 2015). Despite South Africa's potential for wind energy, wind power is still not fully incorporated into the country's energy mix (Adefarati, & Bansal, 2017).

Present Energy Mix in the South African Grid

Coal is used to generate around 89.9% of the power used in South Africa (Bekun, Emir & Sarkodie, 2019). Nonetheless, steps have been taken in South Africa to cut CO₂ emissions and encourage the expansion of renewable energy sources. These changes as well as the difficulties that existed will be examined in this assessment.

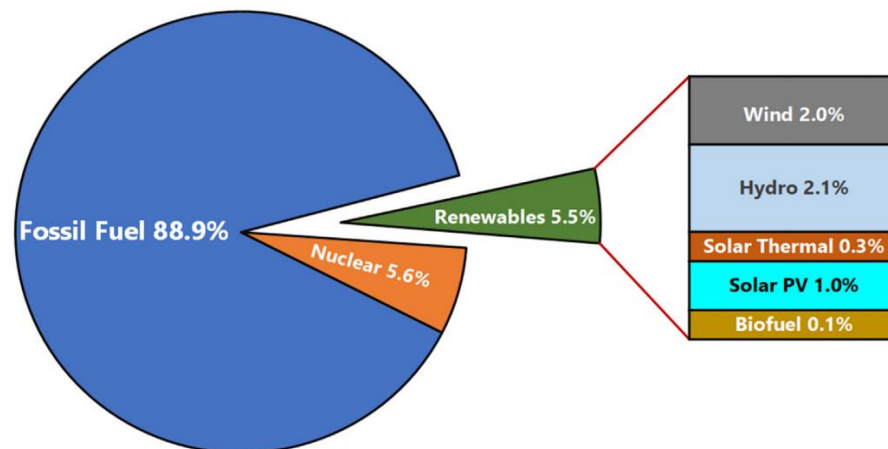


Figure 1: The Energy Mix in South Africa (Source: Data & Statistics, IEA, <https://www.iea.org/data-and-statistics> (accessed November 30, 2022)).

In South Africa, there are many renewable energy options, which makes it possible to find a practical solution to the load shedding issue that has plagued the nation's supply.

South Africa's renewable energy resources have the largest reserve capacity on the continent and, if completely utilized in a clean and sustainable manner, are expected to be able to meet the country's energy needs.

Adefarati and Obikoya claim that South Africa has the ability to utilise wind resources to generate electricity to meet the demands of the nation (2019). Pretoria is the least windy

location among the ten cities or towns chosen for this research effort, while Cape Town, a coastal city, is the most windy location among the locations evaluated in this study for the installation of the WT. Pretoria has a capacity factor of 8.19% and a wind penetration of 28.4%. The capacity factor has a favorable effect on the amount of energy generated by the wind system. Figure 2 below displays South Africa's wind potential.

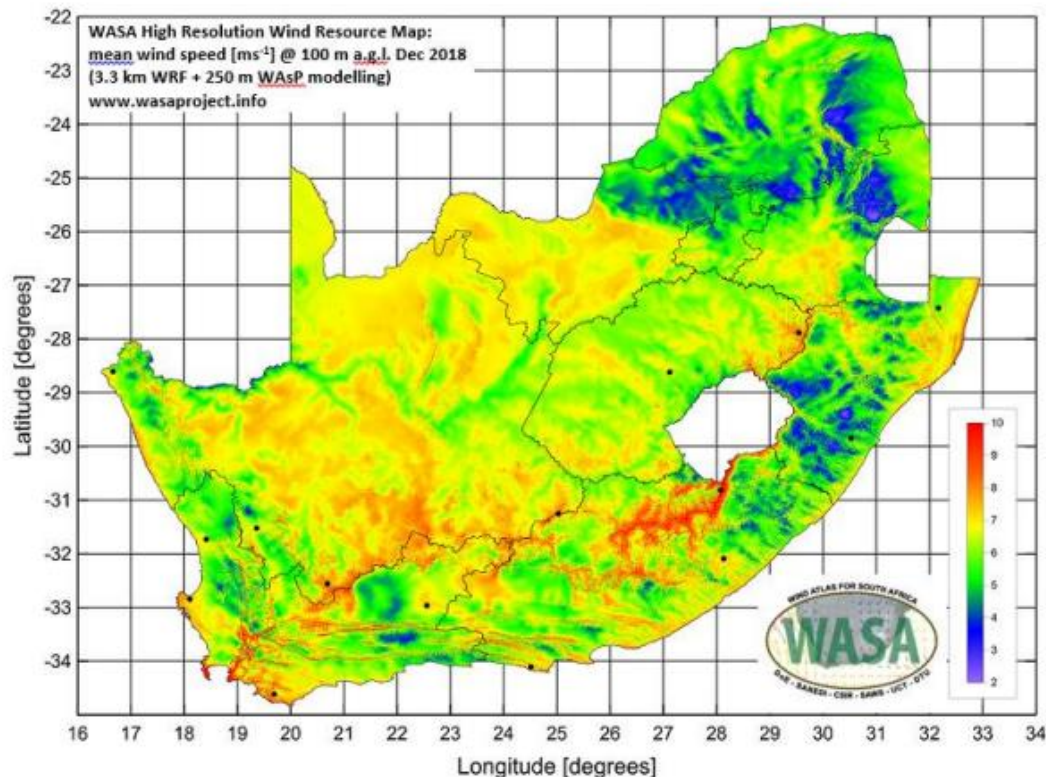


Figure 2: Wind potential of South Africa (WASA, 2020)

Its coastline reaches for more than 2,500 kilometers (1,553 mi) along two oceans (the South Atlantic and the Indian).

Cape Fold Highlands are found in a variety of shapes in the coastal zone beneath the southern and southern-western portions of the Great Escarpment. There are plenty of resources for wind energy in the Great Escarpment's extensive coastal strip and inner escarpments, which separate it from the ocean and have the greatest potential for wind energy. Despite the fact that the country has a lot of wind energy, it can only be used where there are reliable, strong winds. The Western Cape, Northern Cape, Eastern Cape, and KwaZulu-Natal are the provinces with the greatest potential for wind energy (Business Insider SA, 2021; IRENA, 2015; CCE News Team, 2021).

As a result, the Department of Energy (DoE) of South Africa estimates that the average annual wind speed at 10 meters will be 6 m/s in 2016, which is compatible with the country's expected total annual wind generating capacity of 60 TWh. Based on land availability, 410,000 km² of

land are subject to winds stronger than 6.5 m/s. Just 1,174 km² are anticipated to be suitable for wind turbines. As a result, South Africa has the possibility of having pleasant winds, particularly on and around the beaches of the Western and Eastern Cape. The wind farms in Cape Town's Klipheuwel and Darling are currently operational and have been since 2007. Southern Africa. 2004's Info Reporter.

Purpose & Aim of the Study

This study's main objective was to provide a critical assessment of the viability and usefulness of renewable wind energy sources for Eskom in South Africa. The researchers looked into and evaluated variables that may affect Eskom's scaling up of renewable wind energy in South Africa. The study focused on analyzing how the growth of wind energy influenced South Africa's reliable electricity supply, energy poverty, and environmentally friendly energy production. Above importantly, the report fairly assessed the challenges South Africa faces in creating sustainable wind energy infrastructure. Eskom may use the findings to increase the viability and feasibility of wind energy in South Africa by implementing the study's suggestions. This study was carried out at a time when South Africa's energy utility business faces challenges in meeting the country's energy needs and is forced to implement tight loadshedding and reduction plans in order to avoid total energy depletion.

Aim of the study was to explore potential of wind energy resource to generate electricity in South Africa to promote sustainable development in order to meet SGD goal 2030.

REVIEW OF RELATED EMPIRICAL STUDIES

According to empirical studies (Boie et al., 2016, Bos et al., 2018, Gebreslassie, 2020, Ortega-Izquierdo and del R'o, 2020, and Zhang et al., 2016), wind energy has the ability to support economic growth and development. There are numerous opportunities for wind energy's global expansion. Cross-cutting topics that can be studied in literature include rising energy demand, energy security, energy sector changes, and environmental quality. Technical limitations (Berrezzek et al. 2019), financial and cost concerns (Bos et al. 2018; Ouedraogo, 2019; Pueyo; 2018; Rehmatulla et al. 2017), and infrastructural issues (Bos et al. 2018; Dio'genes et al. 2020; Chaurasiya) are the key barriers to the growth of wind energy. Contrary to the widespread view that wind energy is the answer to the threat to energy security and poverty, Dorile (2021) argues that wind energy offers a magnificent alternative to the usage of fossil fuels for the manufacture of electrical energy. Yet it's crucial to keep in mind that wind energy is not a magic bullet, and that system planners and grid operators may run into a number of challenges as a result.

Barriers Bedeviling Wind Energy Development for Eskom

Alemzero, Acheampong, and Huaping investigated the current situation and obstacles to the uptake of wind energy in Africa (2021). The researchers emphasized that many African nations are not increasing their production of wind energy. Alemzero et al. (2021) recognized economic, technological, market, and socio-political constraints as the four main categories of hurdles.

Economic and Financial Barriers

Since the negative externalities of wind energy are still not being properly accounted for, it competes unfairly in Africa with other power sources like fossil fuels. The high tax burden in

many African nations prevents the swift deployment of wind energy. Costs for operations, wind energy equipment, and supplementary services provided to the sector rise as taxes rise. However, the bulk of African nations continue to support fossil fuel power facilities with subsidies.

Wind energy is expensive in some countries due to subsidies for fossil fuels, making it difficult for it to compete favorably with these established sources and limiting its appeal for private sector investments that are required to build economies of scale and further cut prices.

Institutional and Regulatory Barriers

Most African nations have laws and regulations in place to encourage the use of wind energy. But little is actually being done to ensure that these frameworks become the actual investments required to enable the expansion of wind energy; they only exist on paper. This issue is closely tied to the lack of industrial groups and professional organizations in the majority of nations that would help to promote and expand the use of wind energy. With the South African Wind Energy Association, this is not the case (SAWEA). Through public lectures and forums, they have been able to promote, uphold, and inform the general public about the advantages of using wind energy in South Africa and other parts of Africa. The depth and breadth of South Africa's improved wind energy potential are evidence of some of their work.

Technical Barriers

Due to aging power infrastructure, integrating unreliable renewable energy sources like wind energy is more difficult. Lack of updated building codes, standards, and certifications further exacerbates issues. In order to accommodate the generation of wind energy and other renewable energy sources, national grids must be altered somewhat. As there aren't enough people with the necessary commercial and technical skills to install wind across the continent, it is also difficult to manage the sector. Additionally, we learn that the continent lacks easy access to equipment for operation and maintenance (O&M) tasks because the business is still in its early phases. Due to the higher cost of importation, the cost of purchasing such equipment will fall if economies of scale are created.

Wind energy fluctuates; thus, it must be controlled to maintain system balance and prevent blackouts. Unfortunately, when the system is oversupplied, there is no way to store the extra energy, or when demand exceeds supply, South Africa's grid architecture is unable to accommodate wind energy.

Because wind energy is stochastic, system balancing necessitates an understanding of system planning to guarantee the dependability and stability of the grid. For governments looking to incorporate wind power into their grid, this could be difficult. The cost of land or the procedures for locating a spot to build a wind farm have an impact on the ability to generate power from the wind.

Market Barriers

In Africa, traditional fuel sources continue to receive tax exemptions and financial incentives, which is detrimental to renewable energy. This does not promote the use of renewable energy sources. In Africa, it seems that the proverb "the devil you know is better than the angel you do

not know" holds true. This is due to the fact that Africans are less familiar with renewable energy sources than they are with fossil fuels. Although though the continent may profit from renewable energy on many different levels, both commercially and socially, just 2% of the world's installations come from Africa. For the teeming youth of the continent, wind energy and other renewables can help create decent jobs. Given these cost reductions, a suitable market structure will guarantee the sector's swift adoption throughout Africa.

Social Barriers

Many worry that the growth of wind farms could lead to social and environmental issues. Disagreements arose as a result of the development of wind farms in Ontario, Canada, the location of this occurrence. A large portion of the continent's population also believes that wind energy is expensive, does not require government assistance, and that the average person knows very little about it. This is how most people in society view RE technology generally, not only with regard to wind energy.

MATERIALS AND METHODS

Systematic Literature Review

Systematic evaluations can be useful for academics and researchers in both academia and practice (Leucht, Kissling & Davis, 2009). Systematic reviews, which include but are not limited to meta-analyses, can be used to analyze a lot of information for decision-makers in the disciplines of research, policy, and energy production. Systematic reviews are typically more helpful than the findings of a single study for determining what is known and what is unknown about a subject (Cook, Mulrow & Haynes, 1997). The process is extensive enough to ensure that study results are comparable across groups and places and can be generalized (Mulrow, 1994). The results of numerous quantitative research are statistically combined in a process known as meta-analysis. Notwithstanding the fact that many systematic reviews present their findings without statistically integrating data in this way, Grant and Booth (2009:98) argue that a robust systematic review is essential to a meta-analysis of the literature. The researchers conducted a systematic literature review in accordance with the recommendations made by Kitchenham and Chambers (2007) and Petticrew and Roberts (2008). Between 2014 and 2022, both automated and manual job searches adhered to a strict methodology.

SWOT Analysis

SWOT analysis is a stochastic tool to analyze effectivity and viability of a system (Islam & Sangaran, 2022). SWOT analysis is also a structured, thorough analytical tool used in commercial environments for strategic planning (Srdjevic, Bajcetic & Srdjevic, 2012). Both internal and external criteria are used to evaluate the work. Eskom's internal characteristics are analyzed to identify and understand its strengths and limitations, which affect how much wind energy it will scale up.

In a similar way, external factors are connected to the macroenvironment aspects that are present and they can help or hurt Eskom's adoption of wind energy production. Strengths encompass all available resources and can facilitate Eskom's implementation of large-scale wind production. The inadequacies are drawbacks that might limit Eskom's use of wind energy generation.

The study's data came from working documents and pertinent literature on the growth of renewable energy in South Africa. The SWOT analysis approach was chosen by the researcher since it has a number of benefits. The key benefit of the SWOT analysis approach is that it makes it possible for the researcher to get important data about the viability and effectiveness of wind energy as a solution to Eskom's South African energy issue.

SWOT analysis is a reliable and useful technique that can be used to highlight Eskom's current shortcomings with regard to scaling up wind energy. The study makes the claim that the viability and effectiveness of wind energy as a solution to South Africa's energy poverty and insecurity depends on Eskom's willingness to increase wind energy production through a massive program of purchasing and constructing wind farms throughout the nation's nine provinces.

RESULTS AND DISCUSSION

According to the literature review, South Africa is gradually transitioning to a low-carbon, climate change-resistant, and environmentally sustainable economy. Investments totaling R209.7 billion have already been committed in South African wind energy projects, according to the South African Wind Energy Association (SAWEA). The analysis revealed that wind power now accounts for a larger part of South Africa's planned expenditures on renewable energy. By 2030, 17742 MW, or 22.7% of South Africa's required electricity, will likely come from wind energy. (2002) (Rad, Bekker, and Arashi). The use of wind energy will lead to an increase in employment. The 22 wind Independent Power Producers (IPPs) that have so far successfully begun doing business have created 2 723 jobs for South Africans.

The thorough study of the literature revealed that South Africa has great potential for and capacity for renewable wind energy, particularly in the Eastern and Western Cape regions (Rad et al., 2022). South Africa's climatology is favorable for producing significant amounts of wind energy, especially along the shores of the Eastern and Western Capes.

There are 33 wind farms in South Africa, 22 of which are operational and 11 are still being built (Gomez & Lundquist, 2019). It is important to note that South Africa has an abundance of alternative power sources based on a variety of energy indicators collected throughout the years.

Without a doubt, renewable wind energy is already planned for inclusion in South Africa's energy mix. Although IPPs produce a larger portion of the wind energy, they sell Eskom the energy that the wind produces. This still presents the biggest issue, as the study points out. Further advantages of Eskom's large-scale wind energy production include the creation of jobs through viable RE sectors, an increase in energy production, and improved energy efficiency (Nogaya, Nwulu & Gbadamosi, 2022).

In this regard, empirical research has demonstrated that Eskom should implement the usage of renewable wind energy into the energy system as a matter of national priority in order to satisfy electricity demand and reduce the current load shedding threat plaguing the nation.

CONCLUSIONS

The study gave particular attention to the possibilities and applications of wind energy in South Africa today. The demonstration of a powerful wind flow for the creation of energy and other services came next. There are opportunities to include South Africa's wind generation into the overall energy policy because it is the continent's largest wind market. There is a significant risk to South Africa as a result of the country having only one electricity provider.

Eskom's failure suggests that there would be no other option for the nation's long-term energy sustainability. There is a significant risk to South Africa as a result of the country having only one electricity provider. Eskom's collapse suggests that there would be no other option for the nation's energy sustainability.

Declaration of Conflicting Interests

There were no conflicting interests when the study was conducted since the researcher conducted the study from an independent perspective.

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