

RENEWABLE ENERGY

PROBLEMS FACING RENEWABLE ENERGY IN KENYA: A CASE STUDY OF NGONG HILLS, NAIROBI, KENYA

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ABSTRACT

Wind is the natural movement of air above the earth surface. Wind possesses high amount of potential energy that can be harnessed to provide a reliable source of renewable energy. In Kenya, Ngong hills has been found a suitable location for the Ngong hills wind power project managed by Kenya electricity generating company (KenGen) currently having a nameplate capacity of 25.5 megawatts and generates approximately 12 gigawatt-hours of electricity annually. It is therefore relevant to conduct research on the problems facing wind power generation in Ngong hills wind power project. GNSS surveying was done for accurate location mapping and levelling and triangulation was done for elevation and slope analysis to determine the suitability of the wind turbines in the area. satellite imagery using sentinel 2 was done for remote sensing to detect land degradation, vegetation encroachment, erosion and infrastructure changes. A GIS based spatial analysis was done through buffer analysis around wind turbines to assess proximity to sensitive zones. The use of WAsP to model wind flow and energy yield was of great relevance. Overlay geological and hydrological data was used in identifying natural threats like landslides and floods. the analysis below will be of great roadmap for smarter conflict sensitive wind power development and it will enable data driven recommendations for site selection, infrastructure investment and policy reforms concerning the wind power project.

INTRODUCTION

In Kenya's vision 2030, Kenya aims at becoming a newly industrializing middle income country. With energy as a key enabling factor, Kenya aims at improving the production of energy more so clean renewable energy for use throughout the country. Within the strategic goals and commitments that Kenya aims to achieve include universal electricity access to all citizens, the electricity should be reliable and affordable to all citizens. As at 2022 most of Kenya's electricity generation came from renewable energy sources with geothermal providing forty seven percent, hydroelectric power generating twenty one percent, wind generating sixteen percent and solar providing four percent which all of them add up to ninety percent, (NATIONAL ENERGY POLICY 2025-2034). Kenya is also focusing on green industrialization and climate resilience with which renewable energy is the first step to reduced emissions.

Ngong Hills is located at latitude $1^{\circ}23'59.99''S$ and longitude $36^{\circ}37'59.99''E$ along the great rift valley, south west of Nairobi, Kenya (Latitude.to). the Ngong Hills wind project had a capacity of 0.35 megawatts in 1993 from two donated turbines that are now retired. in 2009 it was expanded to produce 5.1 megawatt of electricity by installing six vestas V-52-850kW turbines. in the year 2015 it was expanded to produce 25.5 megawatt of electricity becoming fully operational and connected to Kenya's national grid ([KenGen](#))

Despite its promise, the Ngong hills project faces technical, financial, policy and social challenges which threaten the productivity and sustainability of wind energy in Kenya. this term paper explores the challenges facing wind energy through a focused case study of Ngong Hills wind power project reviling critical insight into the technical, economical, policy and social barriers that should be addressed to unlock the full potential of the Ngong wind power project.

METHODOLOGY

STUDY AREA

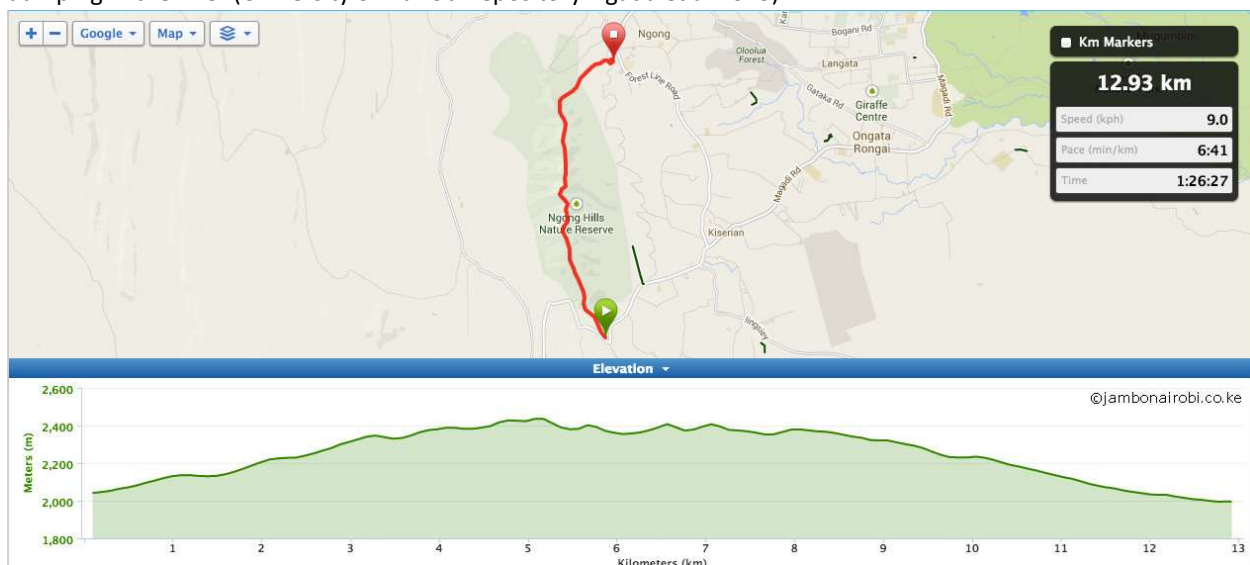
Ngong Hills wind project is located 35kilometers southwest of Nairobi CBD, firmly a d geographically in Kajiado county just outside Nairobi southwestern boundary (Ngong hill wind power station-wikipedia.org), (Ngong hill wind power station25.5MW-kengen-www.kengen.co.ke)the area is located at latitude 1.38071 and longitude 36.635542.

Wind speed in the area ranges from 7.861 and 9.254metres per seconds. Weibull scale parameter rangesbetween2.17 to 2.13 suggesting moderately wind patterns and wind direction which is predominantly between 90 degrees to 135 degrees showing that wind moves mostly Eat to southeastern (ENERGY RATIO ANALYSIS OF THE 5.5-MEGAWATT NGONG HILLL WIND PROJECT, www.wjert.org)

The area where the wind power station is located is mostly covered by woodland grassland with patches of montane dry forest and bushland shrubs (Kenya forest service-Ngong hill forest reserve)

The most dominant soil in the wind power station area is Andosol which is a type of volcanic soil that is well drained (RCMRD-Kenya soils map)

The most reliable source of water in the Ngong hill wind project is underground acquirers and boreholes. The Ngong River is unreliable because it is heavily pollutedly raw discharge, industrial effluents and solid waste dumping in the river (University of Nairobi repository Ngatia et al.2023)



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Challenges facing Ngong hills wind project

Technical challenges

1wake effect

When turbines are placed too close together as in case in gun heels or aero spacing is roughly 150 to to 60 meters for the Vestas V52 turbines. This person causes wind to slow down and become more violent this interruption is called weak effect a simulation -based study conducted revealed that wealth interactions between turbines significantly reduce energy output for downward unit due to small space for the turbines and and turbine spacing. These aspirants led to their adaptation of hybrid layout to reduce weak effect by up to 18.2% the adapted hybrid layouts require complex design and higher capital investment [American General of energy research, 2025, volume 13 no.272 to 79]

2 Monitoring and evaluation gaps

2023 thesis found that weak monitoring and evaluation structures have limited technical expertise in monitoring practices usually impact the performance of the project negatively. This has led to increased poor performance tracking, delayed maintenance and underutilization of wind energy. Due to lack of proper monitoring the turbines went fault unnoticed, vegetation management was neglected and only 28% of the available wind energy was converted to usable energy. [assessment of monitoring and evaluation practices on project performance in Kenya energy sector, deyser University]

3Infrastructure limitation

I'm going to kill with the project is located on a rugged landscape which poses logistical challenges for turbine maintenance and component transport the Mar the Maram roads Create another problem in the transportation of labor to the wind power station especially during rainy season9global terrain monitor, Ngong hill wind power project)

4Cost efficiency trade offs

Layouts with the larger turbines such as the V90 at three megawatts of a higher energy potential but suffer from increased work effect and higher capital this results to a higher levelized cost of energy LCOE of energy at 58 US dollars compared to 37 US dollar megawatt for optimized hybrid layout (Global terrain monitor Ngong hills wind power project)

Economic challenges facing the Ngong hill wind power project

1Expansiom funding and investment gap

In 2024 a proposal was made by Ken Jen on expanding the capacity of going hill wind power project by an additional loaf 10 megawatt. This requires significant investment and the environmental impact assessment which require higher capital in addition to that the expansion may arouse land use conflicts because the area is popular hiking and tourism destination in which when interfered with may create tension between energy development and tourism (mojatu) The expansion may also arise the need to upgrade the Kenyan's grid in order to optimally utilize the additional energy generated land acquisition and development cost may raise economic challenges because land procurement involves financial compensation legal fees and potential delays that inflate the project cost(American journal of energy research)

Policy challenges for assuming the Ngong Hill wind power project

1 tariff and uncertainty and regulatory delays

For quite a while the Kenyans feed in tariff system has been instrumental in promoting renewable energy. The recent shift towards auction-based model has created uncertainty in investors. They have made investors to be assistant in funding with projects like the Gong Hill Wind Power Project expansion because they cannot predict how much revenue they earn due to the shift from fixed feed in tariff to competitive auction which has delayed power purchase agreement and raised financial risks and made returns less reliable leading to stalled investments and higher borrowing costs .(Stakeholders perspective on the field in tariffs and renewable energy auctions in Kenya, Stockholm in environment institute)

2 delayed implementation and policy gaps

The shift from fixed feed in tariffs to renewable energy auction has cost delays because the auction system is not fully implemented the system has not clear bidding processes pricing values or indicated timeline rendering it unreliable. This policy makes it difficult for investors to plan causing a delay in the project approval and financing especially wind farms in Kenya like Ngong Hill Windpower Project

Environmental and land use regulations

The expansion of the ongoing wind power project requires environmental impact assessment which is governed by national policies. Thus, therefore navigating these regulations especially not worried sensitive area like the Gong Hills can be time consuming and costly the national environmental management authority requires the Ken Jen to conduct environmental impact assessment in order to expand the farm in which results to delays in upcoming projects like the expansion of the incoming going healing project in general. [National Environmental Management Authority, (NEMA)]

The lack of coordinated renewable energy strategy has implemented much especially in the 2030, an ambitious renewable energy calls by the implementation is divided across different agencies within the government. This division across different agencies within the government is a sign of lack of

coordination which can lead to overlapping mandates law approvals and inefficient resource allocations to the wind power projects.

Conclusion

The wind power energy Production is a vital sector in an energy production in Kenya on corn hills being one of the wind power production projects are facing enormous challenges that would the government and the community in general are supposed to be responsible in the improving and even the development of the wind park project. If this sector is left unimproved it will deteriorate and and at last it may fail to reach its potential in providing energy throughout the country

Possible solutions to solving challenges facing wind power projects in Kenya

1.Mitigation of the wake effect

Modern simulation models like the Jensen wake model should be encouraged to optimize turbine spacing layout. Modern technology has also facilitated the development of algorithms such as the genetic algorithms that design layouts that minimize wake losses while maximizing energy output.in this way the turbine may achieve its optimum potential

2.Proper choice and configuration of turbines

Mixed turbines configuration usually reduces the wake losses and improves cost efficiency. This balances performance and thus achieving lower levelized cost of energy

Increase maintenance to reduce downtime

There should be constant maintenance and use of real-time monitoring equipment to reduce the chances of unexpected failure in the wind power station

3. use of viable government policy

Policies such as the Feed-in-tariffs policy impacted greatly on the development of wind projects such as the Ngong hills wind power project due to the pre set tariffs making it financially attractive to investors

Proper management of vegetation in the region

The technical team in cooperation with the authority and the community in general should work to ensure that the Liberian reserve is protected from reach to avoid land-based conflicts. This would also help in ensuring that tall buildings and trees that block wind are not constructed at an area where they would block wind from reaching the turbines and the wind power station in general