YRKESHÖGSKOLAN NOVIA

AN OVERVIEW OF WIND POWER IN AFRICA

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Thesis for Bachelor - degree

The Degree Program of Energy and Environmental Engineering

Vaasa 2016

BACHELOR'S THESIS

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Title: **An Overview of Wind power in Africa**

Date: 12.09.2016 Number of pages: 45 Appendices: 5

Abstract

As society becomes increasingly more educated and environmentally-aware, demand for clean energy continues to rise. Africa hosts a significant proportion of the world population but as a whole, it is also severely under-energized. The subsequent high demand for energy and her growing middle class has created pockets of renewable energy markets around the continent. Private rooftop off-grid solar power is plentiful and much is already said about Africa's plentiful sunshine, however, the discussion about wind and the development of wind power in Africa have been very limited.

This thesis study examines the nature of the current wind power market in Africa, precisely by looking at select markets around the southern (South Africa), northern (Egypt) and Western (Ghana) socio-economic regions of Africa. It sheds light on important completed, ongoing and planned wind power projects. It also reveals the principal market actors, but more importantly, attempts to discuss the main legislations and government programs driving or affecting the growth of wind power in the studied markets. Where possible, it identifies the nature of the tariff regime in place for independent power producers (IPPs) and investors; and discusses some of the main challenges inhibiting market growth. Finally, this study report summarizes and compares the characteristics of the studied markets against each other and from these, draw relevant conclusions about the state of wind power in Africa today.

Language: English

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1 Introduction

Africa as a continent is near synonymous with abundant sunshine. This has inadvertently influenced the direction of most local and foreign investments cum interest in continent within the area of renewable energy. Currently, a lot of talk and plans for renewable energy projects on the continent are focused on the development and installation of photovoltaic cells and solar parks. Thus, failing to take advantage of the high wind potentials available in some parts of the continent especially along the continental shelves and coastlines.

According to the International Energy Association's (IEA) *African Energy outlook* report (2014), more than 600million Africans are without adequate and reliable electricity and power supply. Therefore, for Africa to achieve full energy sufficiency and at very minimal impact to the environment, it is important that the continent tap the available clean energy resources such as wind power, and also diversify already existing energy sources. In addition, it is also essential that a "light is shone" and interests vamped up, around the opportunities present within the African energy industry especially within currently underdeveloped and underutilized areas such as wind power; and in that way, attract more research and private investment to these areas. This is part of what this study will attempt too achieve.

To get an idea of the current situation and potential for wind power development in Africa, selected African countries with potentials for wind power production indicators have been studied and compared. This report discusses their unique socio-economic and regulatory properties and "shines a light" on the wind energy industry and related activities of the discussed African countries. It tackles the subject-topic from a wind developer perspective; trying to understand and identify the opportunities, current direction and future prospects available in the different wind power markets, while simultaneously underscoring the important regulations and potential risks / difficulties present in said market.

1.1 Brief history of wind power

Wind has historically been understood by man as a viable source of energy. As far aback as 5000BC, boats sailing the Nile River were powered by the wind. By 200BC, Wind mills were already being used to pump water and for other farm chores around the middle east and Asia.

By the 14th century, the Dutch were already using windmills to drain rivers and marshes in Europe. All through the 20th century, small wind generators suitable for residences and farms and also larger utility scale windfarms that could be connected to the main grid were developed. During World War 2, a 1.25MW wind turbine, the largest at that time was built in the US, to supply electricity to the grid. Wind power for electricity generation persisted in Denmark until the 1950s when it lost to cheap oil. [1]

The oil shortages of the 1970s and increased public awareness about the environmental impacts of energy production and use, rekindled interest in the development of alternative energy sources such as wind power, especially in Europe. [1] [2]

Fast forward to the present day, the wind power has developed tremendously. Present day Wind power generators are sleek and come in a variety of designs, a far cry from their now obsolete less efficient ancestors. They can operate in a wide range of capacities, from small turbines to charge batteries at isolated residences to offshore windfarms with capacities of several megawatts.

1.2 Mechanism of a wind turbine

Wind as we know it is really a form of solar energy, and is “created” by a combination of factors such as the uneven heating of the earth’s atmosphere by the sun, the irregular shape of the earth’s lithosphere and the rotation of the earth.

Wind turbines, unlike fans, are devices which are able to convert the kinetic/mechanical energy present in flowing wind into electrical energy. [3]

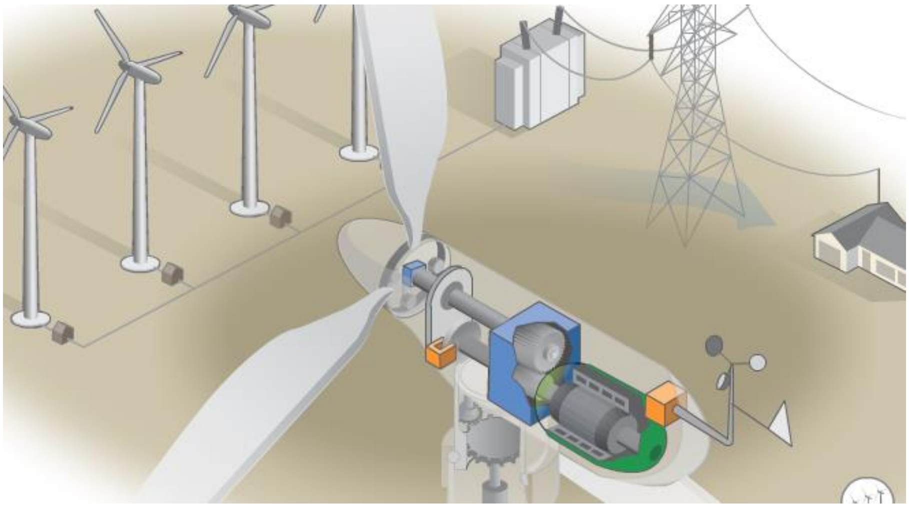


Figure 1: ***Cross-section of a wind turbine*** **[3]**

The wind turns two or three propeller-like blades around a rotor. The rotor in turn spins a shaft connected via gears to a generator to produce electricity.

2 Thesis Objectives and Methodology

In simple terms, the main objective of this thesis work is to analyse the African wind power market, precisely via the markets in South Africa, Ghana and Egypt; on behalf of the sponsor company Etha Wind Oy. It is expected that the completed thesis work should provide a better knowledge and a clear picture of the current trends in these markets and Africa by extension. The thesis project should identify not only the opportunities but also the potential challenges to be expected by any party interested in entering said markets. However, it is crucial to mention that for this project, the projects (markets) of interest have been limited by the sponsor to medium sized wind power projects or larger (20MW capacity or more).

The objectives of the work will be completed by studying, researching and documenting existing and planned wind power projects, important industry players and also the regulatory/ legislative frameworks applicable to the chosen wind market. The study would be primarily carried out over the internet. For instance, through E-reports, credible news sites, government, industry and project websites, press releases etc.

2.1 Thesis Sponsor: Etha Wind Oy

The company "Etha Wind Oy" which has commissioned this thesis work is a Finnish wind energy consultancy based in Vaasa. Established over a decade ago to provide both technical and business support to the wind energy industry.

Figure 2: ***Etha Wind Oy***

It has so far, more than 5000MW of wind energy project involvement and experience under her belt. For a clearer picture and better understanding of the business nature of Etha Wind Oy, below is break down of some crucial services provided by the company.

- Wind farm design & Layout optimization: this include preliminary wind resources assessments, standardized noise calculations to predict the environmental noise at different distances from a potential wind turbine. They also provide impact visualizations and wind power –related Maps. For example, Zone of Visual Influence (ZVI) maps which help developers and authorities plan for better landscape aesthetic by showing from where in the surrounding area, a planned wind turbine(s) will be visible.

- Permitting and Procurement management: Etha Wind Oy is also involved in EIAs and environmental permit acquisitions for the power sector; and has extensive experience especially in Finland for this. The company also provide procurement services to clients and have negotiated contracts with major wind technology suppliers such as vestas, Nordex, Gamesa and Siemens.

- Supervision and software programs: Etha Wind Oy is also in the business of providing operational supervision on behalf of clients/owners of completed wind power installations using software. They also provide Computational Fluid Dynamics (CFD) Calculations and programs to interested parties.

Other services provided by Etha Wind Oy include Owners' engineer, transaction support, etc.

3 Wind Energy in Africa

While previously wind power was primarily only associated with advanced countries, things are slowly changing. Between 2001 and 2011, the global wind energy production has risen and the cumulative installed global capacity has increased from 24 GW to 237 GW (The Wind Power, 2013). According to the Global Wind Energy Council (GWEC) developing countries and emerging economies - some of whom were barely on the global wind map only a few years ago - have now surged to the forefront in terms of new installed wind capacity (Global Wind Energy Council, 2011). A study in 2007 about wind energy within all the World Bank regions showed 8 African countries among the top 27 developing countries with high wind energy potential.

Table 1: ***Numbers of developing countries per world bank region with the high potential for different forms of renewable energy.***

Region	Total Renewable Energy	Solar	Wind	Hydro	Geothermal
Africa	18	24	8	11	9
East Asia/Pacific	4	5	3	6	4
Europe/Central Asia	3	0	6	5	14
Latin America/ Caribbean	7	5	8	9	3
Middle East	1	0	1	0	0
South Asia	0	0	1	1	0
All World Bank Regions*	33	34	27	32	30

Source [38]

**All world bank regions is equivalent to 188 countries.*

However, in spite of these positive trends and indicators, the African contribution to the global installed capacity total is still about 1% or less. The GWEC –global wind report 2015 put the cumulative Installed capacity of the African and Middle East regions at 3,489MW at the end of 2015. Nonetheless, strong growth figures are expected in a couple of African countries – especially along the coastlines, Kenya, Egypt, Ethiopia, South Africa, Morocco - in the coming years.

3.1 Wind distribution

Africa's wind resources are mainly concentrated along the coastal regions and continental shelves. These areas typically have high onshore and offshore wind potentials. A study in 2004 by the African Development Bank to create a wind atlas of Africa used the Wind Energy Simulation Toolkit, 8WEST, to produce a quantitative map of wind speeds across the continents at an altitude of 50m and a resolution of 50km. The results from the study demonstrated that Africa's best wind are found in a handful of countries aligned along the western, northern, eastern and southern coasts of the continent. The exceptions are landlocked countries like chad and Ethiopia where the topographical features of the land were responsible for the high wind speeds observed in some high altitude areas.

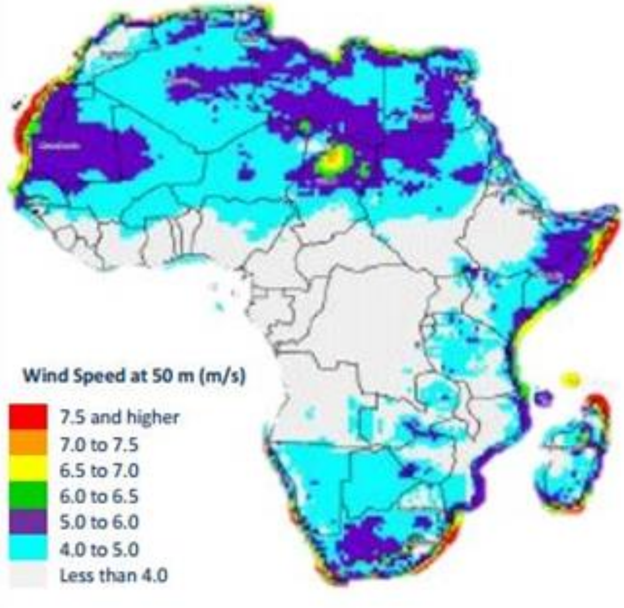


Figure 3: ***Wind speeds in Africa at altitudes of 50m.*** Source [37] **Figure 4: Map of Africa for guide** source [Web]

Another complementary study by Buy et al (2007), found that 8 african countries namely Egypt, Mauritania, somalia, sudan, libya, Chad, madagascar and kenya have high onshore wind potential. While five (5) other countries like Tanzania, Mozambique, South Africa, Angola and namibia have potentially high off-shore wind resources. Both studies agree that on avearge, the wind speed in most of mainland (landlocked) africa is too low to be viable for electricity generation.

4 Country Profiles

As already mentioned in the previous chapter, not all countries in Africa are suitable for wind power. Going forward, it is imperative to add that not all of the African countries with high wind potentials are presently, actively involved in wind power production and utilization. Some of the countries mentioned in chapter 3 though having high wind speeds, have very little or no wind energy related activities going on in them. In the subsequent chapters, we will discuss one country each from the North (Egypt), South (South Africa) and west of Africa (Ghana). All has an established and or a growing wind industry, and their local economies, social and business environments are to a large extent representative of their broader regional environment.

4.1 South Africa

The republic of South Africa is the southernmost country in Africa. It is bounded in the south by about 2,798km of coastlines stretching along the south Atlantic and Indian oceans. Stretching between latitudes 22˚S and 35˚S and longitudes 17˚E and 33˚E, South Africa's land area covers 1219602km^2, making it the 25th largest country in the world by land area. And with a population of about 55million, it is ranked as the 25th most populous nation in the world. South Africa is a relatively dry country with an average annual rainfall of around 4.64cm compared to the global average of 8.60cm. Owing to greater elevation, Temperatures in South Africa tend to be lower than in other countries like Australia, at similar latitudes. Gale-force wind is frequently observed around her southern coasts. [4]

4.1.1 Energy Infrastructure

South Africa generates as much as 90% of her electricity from coal power plants. Electricity generation is dominated by *Eskom* a wholly state owned utility company. Eskom also owns and operates the national grid, and supplies an estimated 95% of South Africa's electricity- making it one of the largest utilities in the world. The remaining 5% are split between IPPs and municipal producers. While Eskom does not have exclusive generation rights, it holds a virtual monopoly over bulk electricity. It operates 23 power stations with a total nominal capacity of 42 090MW and controls over 28000km of transmission lines through which it delivers power to the end-consumers via their municipalities. [5] [6]

According to energy market survey, between 2014 and 2015 the average price of electricity in south Africa increased by 8.2% to 8.46cents (US) per KWh- the second biggest country jump for the studied period, after Belgium's 9.9% increase. However, it is crucial to note that the final price paid for electricity in south Africa is dependent on a combination of several factors such as the total amount of consumption (customers are separated into consumption blocks), the distance/location of consumers, the transmission voltage, type of customer- pre-paid or post-paid etc. In essence, the market is broken into "packages" - *Nightsave, Megaflex etc.*, very similar to "data plans" offered by mobile networks. The tariff one pays are determined by what electricity package they subscribe to.

Below is a table with an array of average basic electricity prices around the world in 2015.

Table 2: ***Average electricity tariffs around the world in 2015***

	Country	*Electricity price (USc/kwh)*	*Change from 2014 (%)*
1	Italy	15.70	-6.8
2	Germany	15.22	-1.2
3	United Kingdom	14.16	+1.3
4	Belgium	11.17	+9.9
5	USA	9.43	-5.7
6	France	8.97	+4.2
7	**South Africa**	**8.46**	**+8.2**
8	Poland	8.33	-1.6
9	Canada	7.23	+2.3
10	**Finland**	**6.42**	**-6.7**
11	Sweden	5.34	-13.2

Source: NUS Consulting Group (2015)

In March 2016, the South African regulatory body NESRA, approved a Further 9.45% increase in the average price of electricity from Eskom. The new price became effective from 1st April for Eskom's direct customers (bulk buyers like municipalities and industries). Tariffs for domestic customers that are supplied by municipal distributors will increase from 1 July and it is expected to increase by equivalent percentage.

The South African electricity network also has provisions for independent power producers (IPPs). South African IPPs account for about 3% of production. They employ both renewable and non-renewable sources to produce electricity and thereafter sell the electricity directly to Eskom. According to Eskom, the average cost of electricity procured from IPPs was ZA87c/Kwh (2014/2015) – equivalent to ~5.6UScents/Kwh (May 2016 conversion rates).

4.1.2 Wind power in South Africa

Touching off at 1,053MW of installed capacity at the end of 2015, the South African wind power market has experienced exponential growth in recent years. This is undeniably the result of the Renewable Energy Independent power producer procurement program (REIPPP) launched by the government in 2011.

The REIPPP Is a tender/bidding process consisting of Rounds or windows in which the IPPs offering the cheapest tariffs and most competitive Economic Development points are awarded a 20-year Power Purchase Agreement (PPA) with Eskom. The Power Purchase agreements are fully underwritten by the South African National Treasury. With such a program in place, within the short period of 2014 to 2015, South Africa has cemented its position as the leading wind power market in Africa; becoming the first African country to pass the 1 GW mark of installed wind capacity. And according to the GWEC-Global wind report 2015, there are 3000MW more in different stages of development around the country.

Some of the more notable windfarm projects in South Africa are discussed below.

4.1.2.1 West coast 1 Windfarm

The West coast 1 windfarm is a 94MW windfarm located near Cape Town. It is operated by an IPP, Aurora Wind power – which is a consortium of International IPP, ENGIE (Formerly GDF SUEZ of France) and south African investors, Investec Bank Ltd and Kagiso Tiso Holdings (KTH). The farm consists of 47 turbines of 2MW each and was secured in the second bidding rounds of the REIPPP. The west coast 1 windfarm became fully operational in June 2015

4.1.2.2 Sere Wind Farm

The Sere Windfarm is located in the western cape of South Africa, within the Matzikama and West Coast Municipalities. Covering 3700hectares of land and with a capacity of 100MW, it is one of southern Africa's biggest windfarms. It comprises of 46 Siemens 2.3VS-108 turbines of 2,3MW each. Fully commissioned in March 2015, it is Eskom's (owned) largest and first commercial scale windfarm.

The turbines at Sere have an average hub height of 115m, a cut-in speed of 3-4m/s, rated power at 11-12m/s and cut out speed of 25m/s. The Rotor has diameter of 108m, speed range of 6-16rpm and tilt angle of 6 degrees.

It is expected to produce 233000MWh of energy annually and reduce South African Carbon Emissions by 4.7million tonnes in its 20years life span.

4.1.2.3 Cookhouse Windfarm

With A capacity of 138.6MW, the cookhouse windfarm is one of the largest windfarms in Africa. It is located near the town of cookhouse in the Eastern Cape Province and consist of 66 turbines (Hub Height 80m). Cookhouse windfarm has been delivering electricity to the Eskom grid since 2014 and is expected to deliver as much as 370,000MWh annually over 20years. The local community own 25% of it through the cookhouse community trust.

4.1.3 Stakeholders in South African Wind power

There are different players which are in one way or the other involved in the wind power industry in South Africa. The influence some these players wield over the renewable energy industry are very direct and more obvious whereas the influence of some other players are less direct but emanate from having influence over the actions of a third entity. Below is a presentation of some of the players.

4.1.3.1 Governmental and public actors

4.1.3.1.1 Department of Energy (DOE)

The DOE is the ministry solely responsible for the South African energy sector. Previously it was known as the department of Mines and Energy (DME) but was renamed in 2009. The DOE is in charge of planning, development, implementation and monitoring the South African government's energy related policies and programs, including renewable energy programs.

The DOE is responsible for formulating policies that guide and regulate the electricity market. It is also responsible for drafting green and white papers for the South African energy industry as well as drafting *integrated resource plans* (IRPs) for electricity generation and capacity building and the general energy plan for the country.

All energy Policies and plans from the DOE are subject to final approval by a cabinet comprise of the president, VP and all country Ministers. [7]

4.1.3.1.2 National Energy Regulator of South Africa (NERSA)

NERSA is the regulatory body which according to the South African national energy regulator act (2004) is responsible for “all piped and grid-linked energy sources”. One of Its primary tasks is the issuance of licenses and permits for the generation, transmission (monopolised by Eskom) and distribution of electricity. It is also responsible for the determination and approval of electricity tariffs all over the country.

NERSA is also the main body in charge of securing and implementing the standard Power Purchase Agreement (PPA) for renewable energy. For instance, between 2009 and 2011, NERSA ran the renewable energy feed-in tariffs (REFITs) program with Eskom as the “Single Buyer Office” (SBO). Therefore, since then, any IPP interested in connecting his Windfarm to the national grid needs a generation license from NERSA and a PPA signed by the SBO, Eskom.

In 2011, the NERSA scrapped the REFIT program and replaced it with the Renewable energy independent power producer procurement program (REIPPPP).

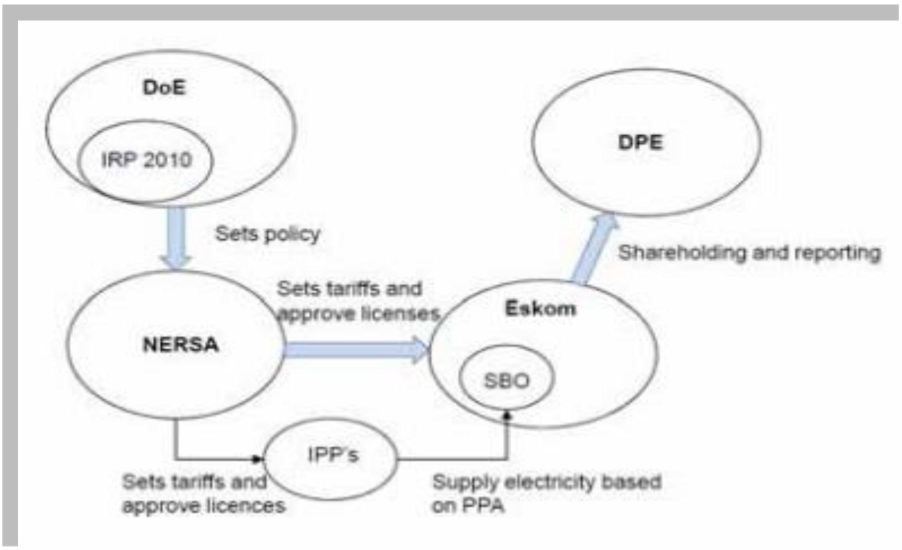


Figure 5: ***Relationships between the different stakeholders*** source **[7]**

4.1.3.1.3 Department of Environmental Affairs (DEA)

The DEA is in charge of the protection and conservation of the natural environment, climate and sustainable use of the nation’s natural resources. On the basis of this, it is the main government body responsible for managing South Africa’s climate change policies.

Though the mandate for clean renewable energy lies with the department of energy, the DEA exerts significant influence through for example spatial planning/development regulations such as Environmental Impact Assessments regulations and also through being responsible for setting the overall climate targets

4.1.3.1.4 Department of Public Enterprises (DPE)

The DPE is in charge of all state owned public companies, including the utility company Eskom. The DPE controls and oversees the appointment of the board of directors of Eskom. This does sometime create some conflict between the DPE and DoE as they don't always necessarily have the same objectives as per the control of Eskom.

4.1.3.1.5 Renewable Energy Finance and Subsidy Office (REFSO)

Launched by the Department of Mines and Energy (DME) now DOE, REFSO is a government agency primarily tasked with providing grants and subsidies for renewable energy technologies. Its official mandate is the management of subsidies; and offering of advice to both local and international developers and other stakeholders on renewable energy finance and subsidies – including information on size of awards, eligibility, procedural requirements and opportunities for accessing finance from other sources. Since its establishment, REFSO has subsidized six projects, of which include wind energy.
Some of the different financing options available to developers include: Grants for feasibility studies, long and short term finance, export credit and soft loans, equity or loans, and purchase of carbon emission reduction credit.

4.1.3.1.6 Central Energy Fund (CEF)

Founded by the then Department of Mineral and Energy, the CEF is active in providing funding for promising conventional and renewable solutions to the country's energy supply needs. The Energy Development Corporation (EDC), a department of the CEF, since 2004 has been active in supporting investments in renewable energy. The EDC focuses on Wind, solar, hydro, biomass and low-smoke fuels.

The CEF supports energy development in South Africa by playing both commercial and social developmental roles. In other words, they can get involved in projects for profits or as means to development the energy infrastructure of a given area. [7] [8]

4.1.3.1.7 Eskom

This is in continuation cum addition of what has already been stated in chapter 4.1.1. Eskom because of the position it occupies as a monopoly within the south African electricity sector, is one of most crucial players. it is a vertically integrated utility and owns 100% of the electricity transmission grid plus a significant chunk of the distribution grid. As the "Single Buyer Office" (SBO), Eskom plays an important part in securing and implementing PPAs with Independent power producers (IPPs).

Eskom's *Peak generation division* located in the Western Cape is responsible for all electricity generation from all sources other than coal and nuclear [7]. Because the mandate of this division covers renewable energy, every wind farm developer will have to work with it at one point or the other.

4.1.3.2 Private Actors and interest groups

4.1.3.2.1 Independent power producers (IPPs)

More recently Independent power producers (IPPs) cum Private power generation companies have begun to see more action, especially those involved in renewable energy production. By the end of 2014, nearly 2000MW of wind capacity has been awarded through the Renewable Energy Independent power producer procurement program (REIPPP) to 22 IPPs; of which more than 25% of the awarded capacity are now operational and connected to grid.

Bigger roles are predicted in the future as a result of the planned expansion of REIPPP and the National developmental plan (NDP) which supports a further unbundling of the electricity sector to enable as much as 30% of the electricity supply to be provided by IPPs. [7] [9]

4.1.3.2.2 Distributors

The ownership of south African electricity distribution network is partly decentralized. The ownership is split between Eskom (40%) and the 187 municipalities (60%). Obviously, South African municipalities play important role in the transportation of generated power to the final consumers.

4.1.3.2.3 Project Sponsors, Financiers and Equity holders

The RE industry in South Africa has attracted a variety of both local and international project sponsors, equity shareholders and financiers. For all the 64 Projects (including wind power) successfully awarded through the REIPPPP, there are more than 100 different shareholder entities represented, 46 of which participated in more than one project and 25 in three or more projects. The most prominent equity players/ sponsors so far have been insurance companies (old mutual); banks (Standard Bank of South Africa) and the Industrial Development Corporation, specialist funds such as the Africa Infrastructure Investment Fund, and project sponsors such as Mainstream, Italian utility; Enel Green Power etc.

Approximately two-third of the 64 projects have debt funding, majority (64%) of which have been obtained from either of South Africa’s five largest commercial banks (Standard, Nedbank, ABSA, RMB, and Investec) and the remaining from obtained direct foreign investments (DFIs, 31%) and life/pension funds (5%). [10]

4.1.3.2.4 Wind Associations

There are two main wind associations active in South Africa: The African Wind Energy Association (AfriWEA) and the South African Wind Energy Association (SAWEA). They represent the interests of their members which include companies/developers, investors and manufacturers of wind power and wind power products.

4.1.4 Supportive Legislative frameworks, Policies and Programs

The legal framework of South Africa’s energy sector is enshrined in the energy act of 2008. The Act ensures sufficient and affordable energy supply to south Africans, to foster both economic and social development. The Act also make provisions for increased introduction of renewable energy sources to the national energy mix. It stipulates that measures should be taken (Incentisation, for instance) and policies designed in order to promote the production, consumption, research and development, and investments in the renewable energy sector. [7]

The growth and development of the wind industry in south Africa is in most part due to a series of supportive legislative frameworks and policy-programs enacted by the national government or its departments. Some of the more prominent frameworks and programs are include:

4.1.4.1 Energy Act (2008)

The Energy Act of 2008 resulted in the creation of different legislative and economic instruments for increasing the growth rate of renewable energy in South Africa. One of such instruments is the RESFO (see Chapter 4.1.3.1.5). The REFSO stipulates how and the conditions for independent and private Renewable energy developers and producers to be subsidized.

4.1.4.2 Renewable energy Feed-In Tariff, REFIT (2009)

In March 2009, NERSA launched the REFIT guidelines as an instrument to regulate the electricity tariffs in the country. The Feed-in tariff required the national utility, Eskom as the single buyer office, to purchase renewable energy from licensed producers at pre-determined prices. The pre-determined prices were supposed to act as incentive to private producers and investors by signalling market certainty and the reduction of financial risks.

The technologies covered by the REFIT program was rolled out in two phases. Wind power was included in the phase one.

The tariffs set out in the REFIT program were quite generous compared to what was available internationally at the time, with Wind power at 0.13euro/KWh and Solar power with storage at 0.21euro/KWh. [11]

However, the REFIT program wasn't very successfully implemented as no Power Purchase Agreements (PPAs) were signed. This was blamed on concerns and the absence of clarity on the cost recovery mechanisms. Although REFIT did state that cost will be recovered from the final consumers through "pass-through" mechanisms, there were still concerns about the potential impact of the "attractiveness of the tariffs to developers" on the overall electricity price should the tariff spur high interest and therefore, high level of participation from developers. The resulting higher electricity prices could have a negative impact on the industrial economy and the country's poor. [7] [11]

In 2011, the REFIT was replaced by the better designed Renewable energy independent power producer procurement program (REIPPPP). REFIT did however, accomplish one of its key objectives, which was to create an enabling environment for the growth of RE in

South Africa. It did clear the way and prepared the energy sector for a more active participation by private producers of renewable energy.

4.1.4.3 Integrated Resource Plan (IRP 2010)

The IRP2010 is the current long term electricity and capacity plan for South Africa. It estimates how much capacity is needed in the future (as far as 2030) and sets energy targets to meet said capacity, including how the mix of energy sources will be. Thus, the targets set by IRPs tend to have significant and long term impact on south African Energy Industry. For example, The First Integrated Resource Plan (IRP1, 2009) set a target of 700MW of wind power by 2013 while the IRP2010 sets a target of 8.4GW from 2014-2027.

4.1.4.4 Renewable Energy Independent Power Producer Procurement Program (REIPPPP)

In August 2011, the DOE announced a competitive bidding process for renewable energy, known as the renewable energy independent power producer procurement program (REIPPPP); which has been credited for the current rapid growth being experienced in South Africa's RE industry.

To run REIPPPP, the DOE and National Treasury (NT) established the independent power producer procurement program office (IPP office) whose primary mandate is to secure electricity from Private producers and also provide advisory, evaluation and contract management services for energy projects.

At its launch, the REIPPPP was designed to use bid windows to procure 6925 MW of RE by 2020 from onshore wind (3500 MW), CSP (600 MW), solar PV (2700 MW) and others (125 MW).

Table 3: ***The bid prices (SA ZAR/Kwh) obtained for the different technologies in REIPPPP bid windows concluded by march 2015.***

Technology type	Bid Window 1	Bid Window 2	Bid Window 3	Bid Window 3.5	Average price per technology
Onshore wind	1,28	1,01	0,74	-	1,01
Solar PV	3,10	1,85	0,99	-	1,98
Solar CSP	3,02	2,82	1,64	1,53	2,25
Landfill gas	-	-	0,94	-	0,94
Biomass	-	-	1,40	-	1,40
Small hydro	-	1.16	-	-	1,16
Weighted average RE bid price	2,15	1,42	1,14	1,53	

Source [9]

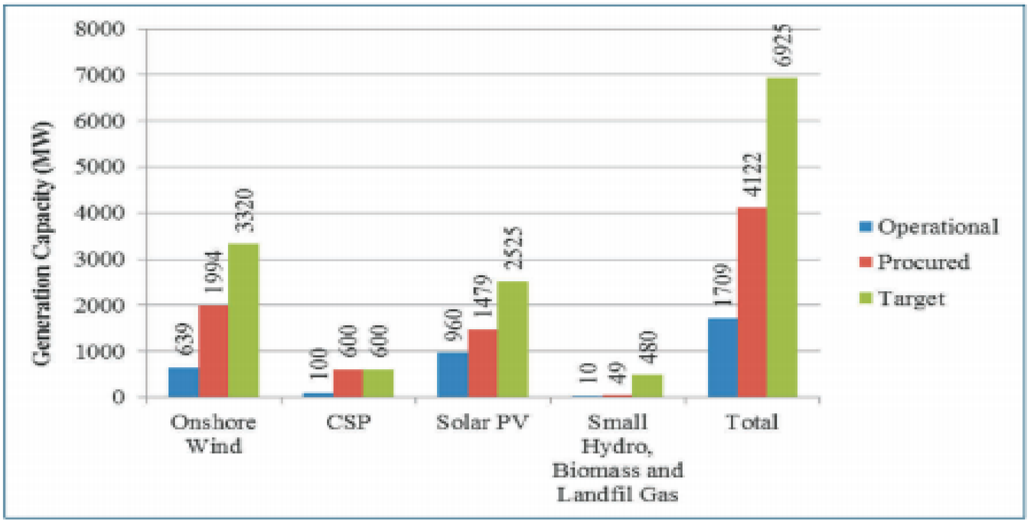


Figure 6: ***Operational vs procured vs Target capacities under the REIPPPP by march 2015.*** Source **[9]**

Under the REIPPPP, IPP bidders are reguired to meet six minimum conditions, namely; Environmental impact assessments, land ownership, commercial and legal, economic development, financial and technical. Compliant bidders are then selected on a 70/30 split, where bid prices (tariff charged) account for 70% of the total score and economic development for the remaining 30%. [9]

4.1.5 Challenges

The challenges facing the development of wind energy in south Africa can be loosely classified mainly as political, socio-economic, legislative and infrastructural.

For a very long time now, the South African power industry has been addicted to the supposedly cheaper coal (+ nuclear) power. This, coupled with the country's strong involvement in the mineral and fossil sectors has created a strong and financially well-oiled pro - coal and nuclear lobby fighting to the keep the aforementioned power sources as the number one power choice in south Africa. In addition to this, the south African government has for many years subsidized coal powered electricity to tunes of over USD8 billion according to a G20 report. This in turn, has created an uneven playing financial field in the sense that, the high capital cost of wind installations become an economic barrier to development of the sector. [34]

Other limitations to the development of wind energy in South Africa include the current undersupply of skilled local expertise to maintain and service windfarms, lack of education about wind energy –this discourage the wider adoption of wind power as a lot of south African still do not understand nor appreciate the benefit of wind power. Also poverty and inadequate grid access means that some areas of south Africa cannot access nor afford alternative sources of energy. For example, Stats SA (2013) showed that as much as 12.6% of South Africans mainly in rural provinces still use wood fuel as the primary source of energy. For this section of the society, Renewable energy including wind energy might be regarded as a “no-go” area as it is either inaccessible or too expensive. [34] [35]

4.2 Egypt

The Arab republic of Egypt lies in the north-eastern end of the African continent. With an estimated land area of 1001450 square kilometers, it is the 30th largest country in the world. However, due to the prevailing arid climate, the population centers are concentrated mostly along the narrow Nile valley and delta. It is estimated that more than 95% of Egyptians live on less than 6% of her sovereign land area.

4.2.1 Wind energy potential

Egypt exhibits positive indicators for wind power development. For one, it has very good wind regimes especially along the coastal regions. For example, Locations around the Gulf of Suez have consistently produced wind readings with average speeds of 10m/s or higher at heights from as low as 25m. In addition, the abundance of large desert and thinly populated areas makes Egyptian land territory well suited for the construction of wind farms.

The previous (pre-Arab spring) national energy plan was to increase the amount of renewable energy in the country’s energy mix by 20% by 2020. The target was to be met largely by developing more of wind power (12%, 7.2GW), as solar and hydro power were considered relatively more expensive and non-optimal energy options [12] [13], however, the target was disrupted by years of turmoil and political instability and had to be scaled back. Now the current plan is to increase the amount of renewable energy by 4.3GW by 2022. Of the new target, 2GW will be made up of wind power, another 2GW from solar power and 0.3GW from Hydropower.

4.2.2 Trends and State of the wind industry

At the end of 2015, Egypt had only 810MW of wind power [14] . Not much going by what is available in leading wind energy countries. However, judging by news coming out of Egypt and the gradual return to political stability, one would expect a significant increase in wind activity in the near future. For along with the plan to add 2000MW of wind power by 2022, Egypt is also in pursuit of an ambitious plan to become, within less than a decade, a major manufacturing hub for wind power equipment for the African, middle eastern and European markets. [15]

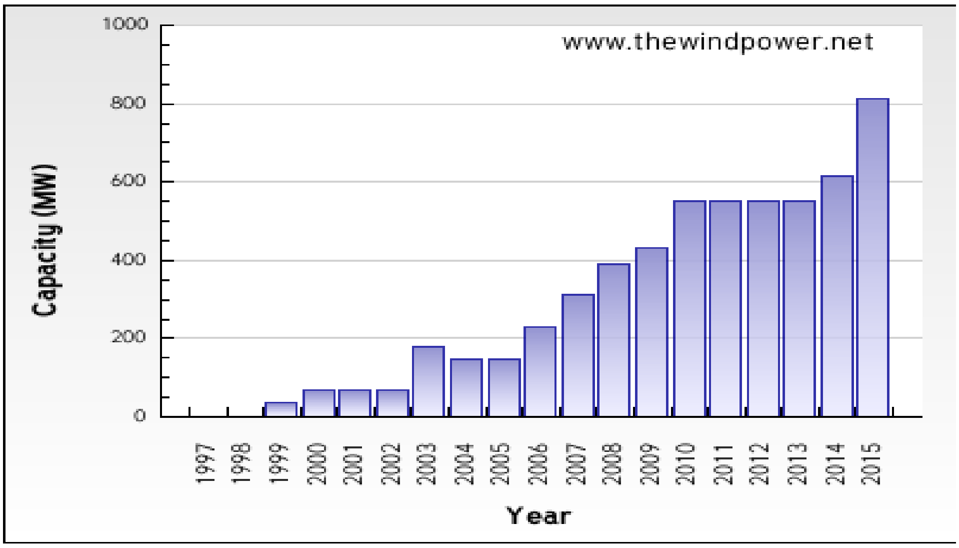


Figure 7: ***Windpower capacity in Egypt across the years.*** Source **[14]**

In addition, the Egyptian wind sector has been relatively successful in attracting interest and investment from foreign governments (The EU, Danish, German & Japanese governments have all sponsored projects) and multinational companies (Gamesa, Siemens, GE etc.). As at the end of 2015, Siemens alone had signed deals worth about 8Billion euros for the supply of wind power technology for 12 wind farms (~600 turbines) and the construction of a rotor blade factory. [15] [16]

Furthermore, to spur wind and other renewable energy development, the Egyptian government plan to invest US$10Billion into the RE sector over the next decade and has also put forward developer-friendly schemes such as the BOO (Build, Own and Operate) and FiT (Feed-in Tariffs) as means for securing long term profits. The FiT scheme for example, offers developers a generous and consistent rate of US$9.57cents/KWh over the first five years of the wind installation. [16]

Some of the more notable **operational** wind power projects in Egypt today include:

4.2.2.1 Zafarana Wind farm

The Zafarana Windfarm is the first large scale windfarm built in Egypt and one of the world's largest onshore windfarms. It is located 120km south of the Suez Canal and consist of a series of linked windfarms. The first phase of the windfarm was constructed in 2000 with 50 turbines with nominal output of 30MW but the project has since been expanded and extended eight (8) times.

Table 4: ***Phases and added Capacities of the Zafarana Windfarm, Egypt***

Project Phase	**Total Capacity**	**Number of Turbines**	**Turbine Supplier**
Zafarana 1	30MW	50	Nordex
Zafarana 2	33MW	55	Nordex
Zafarana 3	30.4MW	46	Vestas
Zafarana 4	46.9MW	71	Vestas
Zafarana 5	85MW	100	Gamesa
Zafarana 6	79.9MW	94	Gamesa
Zafarana 7	119.9MW	141	Gamesa
Zafarana 8	119.9MW	141	Gamesa

Source [14]

4.2.2.2 Gulf of El-Zayt

The El-Zayt windfarm consist of 100 Gamesa turbines with total nominal output of 200MW. It is located 120km north of the popular tourist resort of Hurghada. The project was commissioned in 2015 and funded by the European Union and German government. Gamesa is reported to have recently won a contract to add some additional capacity to the facility.

Other notable projects **in the pipeline** and or currently on the discussion table include:

4.2.2.3 Vestas-led consortium 2.2GW windfarm

In May 2016, Danish Vestas wind Systems led a consortium of parties including HSBC, EFK Denmark, Euler Hermes, Danida etc., which submitted a proposal to the Egyptian ministry of electricity and renewable energy for the construction of a 2.2GW windfarm. The project, valued at US$2.2Billion, if successfully implemented, would be located within 1600 square kilometers of the west Nile region and would include the construction of a wind turbine blade maintenance facility. [16]

The predicted project initiation date is late 2016; Estimated project completion date is yet to be announced, project feasibility study is still ongoing as at the time of this report.

4.2.2.4 Lekela Power 250MW windfarm

Located on the Gulf of Suez, The Lekela windfarm on completion would have a total nominal capacity of 250MW and would be Lekela power’s second windfarm and largest energy project (Solar inclusive) in Egypt. The project valued at US$357million was initiated in November 2015 and is estimated to be completed by late 2017. the project is managed under the Egyptian Government’s Build-Own-Operate (BOO) Framework. [16]

Lekela power is a Pan-African Independent power producer focused mostly on renewable energy. As at the time of this report, the company has a project portfolio of more than 1200MW spread over South Africa, Egypt, Ghana and Senegal. [16] [17]

4.2.2.5 GDF Suez 250MW windfarm

In May 2016, A consortium comprising Toyota and Egyptian companies GDF Suez and Orascom signed an agreement with the Egyptian government to construct a 250MW windfarm in the Gulf of Suez. By the terms of the agreement, construction was slated to start in June 2016. The US$350million project is secured through a 25-year period Power Purchase Agreement (PPA). [16] [18]

4.2.2.6 Other windfarm projects

Renewable energy developers - Access power Dubai and Alcazar Energy, have both received approval (2016 & 2015 respectively) for the construction of a 50MW facility each. Access power was contracted by US$200million to provide 115MW renewable energy, of which 50MW of wind power, estimated to be finished by early 2019, will be added to the Zafarana windfarm and 65MW of solar power will be built in the Aswan area of Egypt. The other 50MW facility to be developed by Alcazar energy in the Suez Gulf area, is a product of one of the ten Memorandum of Understanding (MoUs) between Alcazar Energy and the Egyptian Government. The ultimate aim of these MoUs is to see the construction of 500MW of Wind power around the Gulf of Suez area. [16] [19]

Italian company Italgen S.P.A is also reported to be in talks to construct a 320MW wind facility. The US$200Million project will be split into 2 phases. The first Phase of which will see the construction of a 120MW wind power facility in the Gulf of El Zeit. [20]

4.2.3 Stakeholders

The different players in the Egyptian wind industry include both Governmental institutions, Egyptian and foreign companies and a handful of wind associations.

4.2.3.1 Governmental Actors

The Egyptian ministry of electricity and energy (MEE) is the top most player in the Egyptian energy sector and exercises control over all other players. it is responsible for supervising everything related to electricity and energy projects. It suggests electricity prices and publishes data and statistics relating to the electricity situation in Egypt. The figure below depicts the structure of the Egyptian energy sector and shows the relationship between the MEE and the other stakeholders.

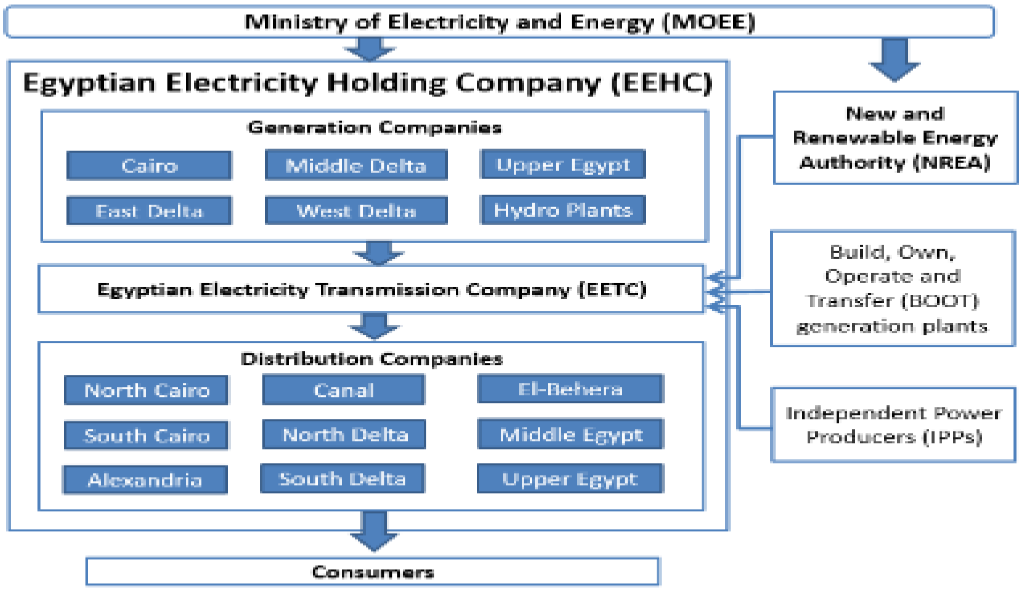


Figure 8: ***Structure of egyptian energy sector and stakeholder interactions.*** source **[36]**

In 1986, The MEE established the New and Renewable Energy Authority (NREA). The NREA is one of the most important players in Egypt's wind market today. it was established to act as the national focal for expanding effort by the Egyptian government to develop and introduce renewable energy technologies in Egypt on a commercial scale. [21]. It is responsible for the development, ownership and operation of the governmental wind projects. [22]. Due to its mandate, all things relating to renewable energy in Egypt falls under the umbrella of the NREA. The NREA is therefore a common signatory to most, if not all the RE agreement signed in Egypt till date.

The Egyptian Environmental Affairs Agency (EEAA) serves as the executive arm of the Ministry of Environment. Its primary functions include the formulation of environmental policies, the development and monitoring of projects and the implementation of pilot projects. The EEAA is also the national authority in charge of fostering understandings around environmental subject between Egypt and third parties.

The Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptERA**)** was established in 1997 and primarily tasked with balancing the interests of electricity producers, electricity providers and end users. Its mandate is to ensure a reliable long term supply of electricity for Egypt and at the same time promote environmental protection and operational reliability in the energy sector. It is also responsible for licensing the construction and operation of electricity generation, transmission and distribution facilities as well as for electricity trading. [22]

The government-owned and operated utility; Egyptian Electricity Holding Company (EEHC), supervises, coordinates and monitors the activities of affiliated companies as it pertains to the production, transmission and distribution of electricity. The Egyptian Electricity Transmission Company (EETC), a subsidiary of the EEHC, is responsible for the countrywide transmission of electricity to regional and local distributors. [22]

Foreign governments such as the Danish, Spanish, German, EU and Japanese are also involved in windfarm project funding in Egypt.

4.2.3.2 Commercial Actors

The commercial players within Egypt's wind industry include several big-name turbine manufacturers such as Nordex, Gamesa, Vestas, Siemens etc., and also independent power producers of different sizes.
Currently, the Spanish company, Gamesa is the market leader for wind turbines. Gamesa which entered the Egyptian market in 2004, is reportedly responsible for as much as 80% of the turbine installations in Egypt. Its first two wind installations were in Zafarana. [23]

Both Siemens and Vestas are gearing up to challenge Gamesa's market position in the foreseeable future. Siemens for one, already signed agreements that would see it install nearly 600 turbines and build a turbine blade factory in the next years.

The Egyptian company El Sewedy, through its subsidiary SWEG, is involved in the manufacturing of wind power components. In 2009, SWEG was set to establish three factories within the next five years to manufacture wind towers, turbines and rotor blades. However, that plan was disrupted by the subsequent political instability brought by the Arab spring. As at the beginning of 2016, SWEG reportedly produces seven wind towers every month and plans to double that number in the coming months, with the intention to export the surplus output to the rest of Africa, Europe and the middle east. [15] [24]

Other commercial players in the market include RE developers and IPPs such as Lekela Power (A partnership between mainstream RP and Actis), Alcazar Energy, Access Power Dubai etc. (See chapters 4.2.2).

4.2.3.3 Wind Associations

The Egyptian Wind Energy Association (EGWEA) is the Egyptian chapter of the Wind Energy Association (WEA) that is present all over the globe. The EGWEA is the main organization, representing the wind energy sector in Egypt. It facilitates the interaction and co-operation between all parties and players involved in the wind energy industry. Its objective is to promote and support the development of wind energy in Egypt by providing interested parties with the means and opportunity to exchange technical information, expertise and experience in the wind energy sector. The association also conducts studies, provides information on tenders and conferences, and also organizes workshops for interested parties. [22]

The Egyptian organization for wind power projects presents itself as an organization whose mission it is to encourage the Egyptian public and private sectors to construct windfarms to reach the 3GW mark by 2020. In addition, to take advantage of the promising wind locations that supposedly abound in Egypt. According to its website, the organization is partnered with the New and Renewable Energy Agency (NREA).

4.2.4 Supportive frameworks and policies

The key legal framework relevant to renewable energy development in Egypt is mostly contained in law 102-1986, which establishes amongst others the functions and mandate of the New and Renewable Energy Authority of Egypt (NREA). It also stipulates the frameworks for the tendering of competitive bids. [25]

Prior to the political unrest that swept through the country, the primary policy driving growth in the wind power sector was the national renewable energy strategy adopted by the Egyptian government in February 2008. The strategy sets out the ambitious target to supply 20% of Egypt's energy demand from renewable sources by 2020. Of which 12% of this demand, equivalent to 7.2GW was to be met by wind power. However, the 20/20 target has since been modified downwards into: adding 2GW wind power (4.3GW of RE) by 2022. As The plan is to the finance the new capacity through both public (NREA + world bank, AfDB, EU etc.) and private investments, Different support policies and schemes have been put in place. The private sector projects are supported by policies split into three phases;

Phase 1 involves issuance of tenders and competitive bidding from the private sector to supply electricity from renewable energy sources at competitive prices.

Phase 2 involves the implementation of a supposedly generous feed-in tariff (FiT) scheme as depicted in the table below. A renewable energy support fund to be financed through the subsidy then available to fossil fuels and the state budget, was to be established to support the FiT scheme.

Table 5: ***Feed-in tariff for wind power in Egypt in 2014***

Full Operating Hours (FOH)	Feed-in Tariff for the 1st tariff segment (5-year period) ($.Cent/kWh)	Feed-in Tariff for the 2nd tariff segment (15-year period) ($.Cent/kWh)
2500	11.48	11.48
2600		10.56
2700		9.71
2800		8.93
2900		8.19
3000		7.51
3100	9.57	8.93
3200		8.33
3300		7.76
3400		7.23
3500		6.73
3600		6.26
3700		5.81
3800		5.39
3900		4.98
4000		4.60

Note: 1US$ = E£7.15 source: [26]

The FiT values above was approved in september 2014 and contain fixed feed in tariffs for wind power for over 20 years. The FiT is typically paid in Egyptian pound and calculated according to the following equation;

Wind Feed-in Tariff (E£) = [30% of Feed-in Tariff ($. cent) X 7.15 (E£)] + [70% of Feed-in Tariff ($. cent) X exchange rate on the bill issuance day, as stated in the contract]. [25]

The current FiT scheme will be adjusted as soon as the target of 2GW of new wind capacity is reached. Complementing the FiT Scheme is a legislation which obliges electricity transmission and distribution companies such as EEHC to give priority to electricity from renewable sources and the government to pay for any grid extension (producer pays for connection) required to connect a RE source. [22] [26]

Phase 3 of the support policy is structured to encourage developers, especially energy intensive industries, to build, own and operate windfarms to generate electricity for their own use and or to sell electricity to other consumers through the national grid. [22]. Italgen plans to use this scheme to supply as much as 40% of the electricity needs of its cement manufacturing arm, Italcementi.

Other support structures put in place to foster wind power development include full guarantee from the Egyptian central bank for all financial obligations of the Egyptian Electricity Transmission Company (EETC) to wind farm developers, reduction of custom duties for all wind farm equipment and spare parts from 5% to 2%, carbon credits and fast tracking of land allocation and licensing etc. [27]

4.2.5 Challenges

Obviously, one of the key challenges facing the Egyptian wind industry is the intermittent political instability and unrests that sweeps across the country. On different occasions in the recent past, projects have had to be paused or cancelled completely and foreign workers airlifted abroad out of safety concerns.

Another key challenge is the high incidence of foreign donors in Egyptian wind power sector. In other words, a significant percentage of the financial bloodline of the wind sector originates from abroad. The industry is therefore potentially at the mercy of big foreign donors like Germany. Next is the low availability of skilled Egyptian manpower for the wind industry, which translates to higher cost as new workers will have to be trained for each windfarm project to be effectively operated and or maintained.

4.3 Ghana

The republic of Ghana is located in the west African sub region. It lies just a few degrees above the equator and is bordered by the Atlantic Ocean in the south. Its landmass spans 238,535 square kilometers and coastline stretches as long as 560km. the estimated population size Is over 27million people. [28]

4.3.1 Wind energy potential

The wind resource potential of Ghana is at best considered average to marginal. It is known that countries further from the equator tend to have greater wind resource than those closer to it. This is the case with Ghana which lies just 4 degrees north of the equator. the best wind speed at 50M height, averages between 4-6.5m/s and tends towards the coastline areas. Further inland, wind speeds are about 3.3m/s or lower except in some hilltop areas and ridges (South eastern Ghana). However, some studies did also report good-excellent wind conditions at the elevated ridges near the Ghanaian border with the republic of Togo. [29]

According to a report by the Ghanaian Energy Commission and the US-based National Renewable Energy Laboratory (NREL), Ghana has an estimated total wind power potential

Table 6: ***Gross wind energy potential of Ghana***

Wind Resource Utility Scale	Wind Class	Wind Power at 50 m	Wind Speed at 50 m	Total Area	Percent Windy Land	Total Technical Capacity
		W/m²	m/s	km²	%	MW
Moderate	3	300 - 400	6.4 - 7.0	715	0.3	3,575
Good	4	400 - 500	7.0 - 7.5	268	0.1	1,340
Very Good	5	500 - 600	7.5 - 8.0	82	<0.1	410
Excellent	6	600 - 800	8.0 - 8.8	63	<0.1	315
Total				**1,128**	**0.5**	**5,640**

Source: [30]

of about 2GW (wind class 4-6, good to excellent) that could be tapped and connected to the national grid. Note that this figure, becomes 5.6GW when wind class 3 (moderate) is counted.

4.3.2 Trends and state of the wind industry

As at 2015, Ghana had an average electrification rate of 54% whereas Ghana's so called "vision 2020" sets a target of 100% electrification by 2020. According to the Ghanaian Strategic National Energy Plan (SNEP), this translate to a generation capacity increase to over 3.5GW by 2020. Of this, at least 10% of the energy mix would be met by renewable energy (excluding large scale hydropower) [30]. Furthermore, a 2015 report by the German economic ministry, citing the Ghanaian ministry of power sets the target of installed wind capacity at 150 – 300MW by 2020. [31]

Currently there are no operational utility scale wind energy installations in Ghana; only small off-grid turbines set up for demonstration purposes. this would however, change when the 225MW Ayitepa windfarm is completed sometime in 2017 (estimated).

The **Ayitepa project** is a hybrid power project (225MW wind and 50MW solar) being developed by Swiss, NEK Umwelttechnik and Lekela Power. The entire project is reportedly worth US$525million and would be located 40km from the Ghanaian capital, Accra, on the east coast of Ghana. According to the Feed-in tariffs scheme, established by 2011 renewable energy act, the FiT for utility scale wind power are as follows;

- Without grid stability system: Ghp 55.763/kWh (US$c14)
- With grid stability system: Ghp 51.4334/kWh (US$c13)

Note that the above are calculated 2015 rates. The FiT rates are guaranteed for 10 years and are eligible for review every two years. [30] [31]

By all indication, the Ghanaian wind energy sector is still very young and small. Very few projects are ongoing or have reached financial closure. Most news coming out of Ghana at the moment are mostly indicative of future plans and intentions, without clear cut details. For instance, the same German report mentioned earlier, revealed that the Ghanaian Energy Commission, regional utility company; Volta River Authority (VRA) and UP Wind (Swiss Company) were making wind resource assessment and feasibility studies. Measurements were mostly limited to the eastern coast of Ghana where Wind speeds are higher than 4m/s. [31]

Another source, reported VRA as having intentions to build a wind power plant as a joint venture project in the near future. The utility was also reported to have entered into agreements with two wind equipment manufacturers and project developers - Vestas Mediterranean and Elsewedy (see Egypt) - to develop two wind parks, capable of producing 150-200 MW, and has also signed contracts for additional wind speed measurement at six sites; Anloga, Lekpoguno, Akplabanya, Mankoadze, Amoma South and Gambaga (eastern Ghana. Probably same as measured in the German report) to determine which are best for wind power development. [30] [32]

China Wind Power reportedly have plans for windfarm projects up to a 100MW. Feasibility studies were to be undertaken on four inland and four coastal sites. NEK Ghana is similarly planning a 50MW farm in Prampram [32]

4.3.3 Stakeholders

The Ghanaian energy system is principally managed and controlled by the national government through various ministries and institutions. The next paragraphs review these key government actors and also some important Non-governmental and private players able to influence the Ghanaian wind energy sector.

4.3.3.1 Governmental Actors

At the top are the national ministries. The ministries of Energy & Petroleum (MoEP) and power (MoP) are responsible for formulating, implementing, monitoring and evaluating energy and power sector policies respectively. [30]. Combined they are responsible for driving Ghana's renewable energy policies. In 2010, the ministry of Energy established a directorate to focus exclusively on developing and promoting renewable energy generation in Ghana. [33]
They also oversee the activities of state-owned National Gas and National Petroleum Companies and also the public electric utilities—VRA, BPA, GRIDCo and ECG

The Volta River Authority (VRA) and Bui Power Authority (BPA) are state-owned utilities that generate the bulk of the country's electricity supply. The Ghana Grid company limited (GRIDCo) manages and operates the national transmission system and supplies electricity to industrial and mining units as well as to the two electricity distribution companies: ECG and NEDCo. The electricity company of Ghana (ECG) is responsible for distributing electricity to southern part of Ghana. It is the bigger of the two electricity distribution companies and is responsible for 90% of the electricity distributed in Ghana. On the other hand, the Northern electricity distribution company of Ghana (NEDCo), a subsidiary of VRA, is responsible for the remaining 10% and distributes electricity in the northern part of Ghana. [30] [33]

Other public bodies whose actions can influence the renewable energy trajectory in Ghana are: The Public Utilities Regulatory Commission (PURC), The Energy Commission (EC), The environmental protection Agency and the Ghana Standard board.

The PURC regulates and oversees the provision of utility services by the public sector to consumers. It is responsible for deciding and setting tariff plans for consumers and generators - Feed-in Tariffs for delivery of electricity to the grid. PURC is also responsible for promoting fair competition among electricity providers. The EC was established to regulate and oversee the optimum utilization of the energy resources in Ghana. It advises the government on energy policy and strategy and is responsible for promoting a greater participation of the private sector in the energy business. The EC is the final statutory body required to issue licenses for RE business in Ghana. The EPA and the Ghana Standard Board are respectively Responsible for issuing environmental permits and certifications for technical equipment imported for use in Ghana. [30] [32] [33]

4.3.3.2 Commercial Actors

Compared to, for instance South Africa, there are not that many established private developers and IPPs involved in the wind energy market in Ghana at the moment. As at September 2015, Swiss wind farm developer, NEK Umwelttechnik was the only investor that had acquired a siting permit [31]. The permit was for the Ayitepa windfarm already discussed earlier. The company operates in Ghana as NEK Ghana; a venture between it and the Atlantic International Holding company of Ghana. Other than NEK, other commercial entities involved in the wind sector include Lekela power which is a partnership between Mainstream renewable power and Actis (a US$6.5Billion private equity firm that invest in emerging countries); Swiss Upwind International AG – a Swiss holding company which plans and develops RE projects, mainly windfarms in Eastern Europe and Africa, and of course, the other businesses mentioned in chapter 4.3.2.

4.3.3.3 Non-Governmental Actors

There are a handful of active NGOs, Foundations and think-tanks active in the Ghanaian wind and renewable sectors. The *Energy Foundation* for example, is devoted to promoting energy efficiency and renewable energy as a way to meet and manage Ghana’s growing energy needs in a sustainable manner. The *Kumasi Institute of Technology and Environment* (KITE) and the *Center for Energy, Environment and Sustainable Development* (CEESD) are involved in Energy policy & clean energy, studies, analysis and development; and technologies that offer engineering solutions to climate change, energy poverty, pollution and environmental degradation respectively. “*New Energy*” is another Ghanaian NGO that is involved in developing and implementing Clean energy initiatives. [30] [33]

4.3.4 Supportive frameworks and policies

In the last two decades, the government of Ghana has made broad and wide reforms in the Ghanaian energy sector in order to improve the generation and consumption of power. Some of these reform policies specifically target the renewable energy sector, and were made to attract interest and encourage the development of RE in Ghana.

The *Energy of Sector Strategy and Development Plan* put forward in 2010, for instance, had three main objectives for the RE sector in Ghana. First, was to see the increase of the amount of RE in the national energy mix to 10% by 2020. The Second, was to see to the creation of a legislation specifically for designed to encourage RE/clean energy development in Ghana. The Third, relates to waste-to-energy development. In 2011, the second objective did come to fruition, the Renewable energy act was adopted by the Ghanaian parliament. [30]

The *Renewable energy act (Act 832, 2011)* is arguably the single most important force driving the Ghana Wind/RE sector today. Put Simply, the Act aims to support the sustainable management, utilization and supply of renewable energy in Ghana. The achieve these aims, the act has “created” different policy instruments and measures such as the Feed-in tariffs (FiT) schemes, Renewable energy Purchase Obligation (RPO), Licensing procedures for private participation in the RE sector, wood fuel regulations etc.

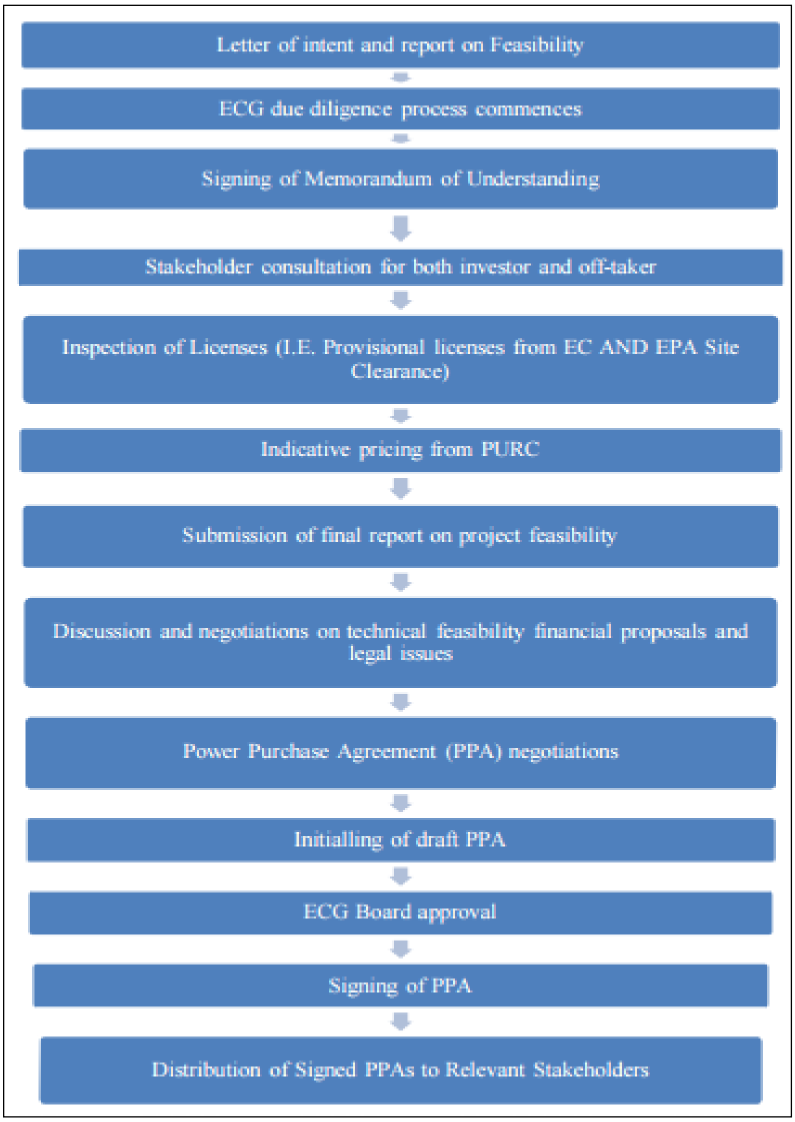


Figure 9: ***process for RE development in Ghana as stipulated by the Renewable Act of 2011***

Source: [31]

The Act also provide rules on how independent RE producers can connect their plants to the national grid and is also responsible for the creation of the Renewable Energy Fund (RE Fund). The goal of the RE Fund is to mobilise finance for the promotion and development of renewable energy resources. The capital from the fund can be used in all thing from initial RE studies to technical development to programs which encourage the local adoption of RE energy technologies. [30] [33]

Other frameworks in place to stimulate and encourage growth in the Ghanaian wind sector include total or near total exemption from import duties & taxes for the importation of wind turbines and other wind equipment, and the ongoing standardization of grid infrastructure to accommodate RE systems etc.

4.3.5 Challenges

As the republic of Ghana look forward to develop an attract private investment to her wind and renewable energy sector in the near future, some of the barriers and challenges inherent in the sector will have to be considered and factored in, and or possibly duly addressed by the affected stakeholders. These challenges and barriers include:

The effect of Ghana's geographical location on her wind resource. Countries located closer to the equator as a rule of thumb, tend to have relatively low wind energy potential compared to countries further away. Ghana's average max wind speeds of 4m/s to 6m/s have been considered by some investors as not being sufficient for a viable investment / bankable power purchase agreement [31]. The proximity to the equator, with the accompanying abundance of sunshine, also creates a more pro-solar power mentality among citizens.

To enter the Ghanaian electricity market, a RE producer needs a cocktail of licenses. In Ghana, this means a wind IPP or investor has to deal with the myriad of regulatory agencies from the Energy Commission and Public Utilities Regulatory Commission (PURC), to the Environmental Protection Agency, Ministries of Power and Finance, and down to the Ghana Investment Promotion Agency and landlords. This procedure can be, not only very protracted and confusing but also possibly results in higher administrative cost and loss of motivation on the part of private investors/developers. [30]

The degree to which payments are guaranteed after a PPA has been signed remains uncertain, as the Ghanaian electricity distribution Companies ECG and NEDCo are reportedly saddled with debt and are unable to meet their payment obligations to current suppliers. they therefore may not have the financial credibility to partake in a viable renewable energy investment alongside an IPP until their financial standing is improved.

The current Ghanaian grid code lacks to a large extent, generation forecasting and priority dispatch for renewable energy. The current code requires grid-connected generators to present their output forecast latest a day before. This, and the lack of provision for priority dispatch pose a barrier to the grid-connection of utility scale wind farms, as wind power are forecasted more accurately on an hourly or still sub-hourly basis and wind power is better if used (Sent into the grid) as soon as it is generated. However, the national grid code is reportedly being revised to resolve these two inadequacies. [30]

A decrease in the value of local currency (Ghana cedi, GHS) could have implications for the Wind investor, as nearly all equipment is imported and investments are typically denominated in foreign currency; whereas revenues are expected in Ghanaian cedi. Apart from the two year-interval review of the FiT mentioned in previous chapters, I am not aware of any currency risk mitigation instruments available to (foreign) IPPs and developers in Ghana at the moment.

Finally, Banks in developing countries such as Ghana tend to prioritize more on financing short-term projects over long term; and consider renewable energy projects as long term projects. Windfarm investors, especially rookies, may therefore encounter difficulties in getting banks to finance their projects. [31]

5 Conclusion

As this thesis study was undertaken to give an overview of the wind power situation in Africa, the focus market of this study was not limited to only the three countries documented in this report. Information about the wind power situation in other countries was surfed and read. Thus, the conclusions below hold fairly accurate on the continent level where applicable, and not just for the three countries documented in this report. That said,

at the end of this study, I have come to the following conclusions;

Wind as a resource is not evenly distributed around the African continent. The best wind potentials at 50m heights are often located offshore and or near the coastlines. Consequently, nearly all the buoyant wind power markets in Africa are found in coastal countries. On the other hand, most of mainland Africa possess average, little or no wind resources except in a handful of locations with high elevations. Consequently, the wind markets in mainland Africa is virtually non-existent.

The African wind power industry is very fragmented, in the sense that, I didn’t find a lot of evidence of cooperation, standardization and uniformity of procedures relating to RE development between countries. Typically, it is each country making their own rules and setting their own RE objectives. Consequently, the market environment and policies varies very much from one market to the next. For instance, in south Africa, community part-ownership (which can be as much as 25%) of a windfarm is sometimes obligatory in order to secure licenses/permits for windfarm development. I didn’t find anything similar in the other markets.

Despite reporting on only three countries: Ghana, south Africa and Egypt, I am of the opinion that this study did still accomplish its objective of presenting a general overview of the wind power situation in Africa, as these countries are reflections of the region's general nature and situation as regard wind development. Southern, then followed by northern Africa are the wind market hotspots whereas west Africa is relatively quiet at the moment. Eastern Africa like Kenya is warming up. For the purpose of comparison, below is a summary table for the natures and peculiarities of the wind industries of these three countries

Table 7: ***Summary and comparison table for wind market in south Africa, Egypt and Ghana***

	South Africa	**Egypt**	**Ghana**
Installed Capacity	1053MW	810MW (2015)	None (2015)
Top public player	Department of energy	ministry of electricity and energy (MEE)	Ministry of Power, Ministry of Energy & Petroleum (MoEP)
Principal supervisory and Regulatory Bodies	National Energy Regulator of South Africa (NERSA)	New and Renewable Energy Authority (NREA) and Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptERA)	Public Utilities Regulatory Commission (PURC)
Main RE policy/ framework	Renewable Energy Independent power producer procurement program (REIPPP, 2011)	national renewable energy strategy (2008)	Renewable Energy Act (2011)
Main electricity Utility	Eskom	Egyptian Electricity Holding Company (EEHC)	Volta River Authority (VRA). Bui Power Authority (BPA)
Single buyer Office	Eskom	EEHC/EETC?	ECG & NEDCo
Average wind Feed-in tariff	US$9cents/KWh – US$4.4cents/KWh, gauranteed for 20 years. Tariifs depend on which bid window between 1 – 4 the project was secured.	US$9.57cents/KWh for first 5 years. However, tariffs are dependent on the full operating hours (FOH) of the windfarm.	US$13cents/KWh guaranteed for 10 years and up for review every 2 years. Tariffs depend on the presence or absence of grid stability systems.
Average consumer electricity tariffs	US$8.46cents/KWh Prices however, depend on factors like electricity quantity, plans, distance etc	US$3cents/KWh. One of the lowest in the world. This is due to high level of subsidization. But subsidies might be removed soon.	US$17cents/KWh. Tariffs are dependent on quantity. Ghana increased tariffs by as much as 80% in the last 2 years.
Sources of fund	Public, Banks, foreign	Egyptian and Foreign	Mostly Government and

	investors and equity funds	governments (DK, DE, JP)	private companies.
RE subsidies and Grants	Renewable Energy Finance and Subsidy Office (REFSO)	Renewable energy support fund – provides subsidies previously available to fossil fuels (About 7% of GDP, ~ 13.8 billion EUR)	Renewable Energy Fund – available for all project stages including feasibility studies.
Milestones and flagship projects	First African country to cross the 1GW mark. 3GW in the pipeline, of which more than 2GW was awarded to IPPs.	Zafarana windfarm is one of the largest onshore windfarms in the world. Its been expanded 8 times! Plans also to become a manufacturing hub for windpower within a decade.	The Ayitepa project is a hybrid power project (225MW wind and 50MW solar) billed to come online in 2017.
Biggest Challenge to wind power	Widespread use and long subsidization of coal power. The subsequent, presence and influence of a strong Coal lobby.	Political instability and civil unrests. High subsidization of fossil power.	Not very bankable wind resource. Pro-photovoltaic mentality.

Compared to leading wind power markets, the African wind power market is quite small and limited. At the moment, less than 3GW of capacity is operational on the entire continent. This limited growth was the result of a combination of challenges, mainly economic, social, infrastructural and political.

In terms of political support, the wind market in south Africa appears to enjoy the most political support at the moment. That combined with relatively good infrastructure might account for south Africa's current position as the leading wind market in Africa. Egypt which has even better wind resource potential has seen its wind development inhibited by long periods of political instability. East Africans; Kenya and Ethiopia are two countries where there appears to be growing political support for wind power especially after the successful implementation of the lake Turkana windfarm project. However, generally, in equatorial Africa, such as Ghana and Nigeria, it does appear that wind power does not enjoy the same social support and awareness as do solar photovoltaic or solar panels are they are known by the locals.

Judging from the oversubscription and ultimate success of REIPPP in South Africa, everything points to the fact that what Africa needs in in order to develop its wind power potential and attract private investment is to provide investors with stability and financial certainty through clear and consistent policy frameworks, plus transparent and streamlined project guidelines and procurement procedures. The complex permitting and licensing procedures in Ghana for example might be inhibiting wind power growth in Ghana.

Finally, just like most other studies, this study has its limitations too. First, it is merely "overview" in nature and may not provide as much detail as might be needed. Secondly, in terms of methodology, only internet sources were used, therefore even though I tried to use up-to-date information as much as possible. It is possible things could have changed and the reality on ground, a little different than what is reported here; exchange rates, tariffs for instance. Thirdly, although East Africa looked interesting as per wind power development, no east African country was presented in this report. Nonetheless, all of these limitations provide opportunities for further studies to complement mine and potentially present a fuller and more balanced picture of the wind power situation in Africa.

References

[1] D. M. Dodge, “Illustrated history of wind power development,” TelosNet Web Development, [Online]. Available: http://telosnet.com/wind/20th.html. [Accessed 10 May 2016].

[2] U.S Energy Information Adminsitration, “Wind Explained, History of Wind power,” U.S department of Energy, 7 january 2016. [Online]. Available: http://www.eia.gov/energyexplained/index.cfm?page=wind_history. [Accessed 12 may 2016].

[3] Office of energy efficiency and renewable energy, “How do turbines work?,” U.S department of energy, [Online]. Available: http://energy.gov/eere/wind/how-do-wind-turbines-work. [Accessed 13 May 2016].

[4] South African Government, “Home>> About SA,” [Online]. Available: http://www.gov.za/node/65. [Accessed 15 May 2016].

[5] department of Energy, “Basic Electricity: Overview,” Republic of South Africa, [Online]. Available: http://www.energy.gov.za/files/electricity_frame.html. [Accessed 15 May 2016].

[6] Eskom, “Company information overview,” Eskom Holdings SOC Ltd, 2016. [Online]. Available: http://www.eskom.co.za/OurCompany/CompanyInformation/Pages/Company_Information.aspx. [Accessed 17 May 2016].

[7] K. Wiesegart, A. DuBois,, D. Sommer, W. Weisheng and W. Yang, “Options for the Establishment of a South African Wind Energy Center (SAWEC) with Lessons learnt from China and Germany,” Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Pretoria, 2011.

[8] Central Energy Fund, “The CEF Group,” BWD, [Online]. Available: http://www.cefgroup.co.za/the-cef-group/. [Accessed 20 May 2016].

[9] D. Fourie, L. K. Niekerk and N. Marillize, “An overview of the renewable energy independent power producers procurement program (REIPPPP),” *Energize RE: Renewable Energy Supplement ,* vol. 15, pp. 9-12, 2015.

[10] A. Eberhard, J. Kolker and J. Leigland, “South Africa’s Renewable Energy IPP Procurement Program: Success Factors and Lessons,” Public-Private Infrastructure Advisory Facility (PPIAF); World Bank Publications, The World Bank Group, Washington, 2014.

[11] Energypedia, “South African Renewable Energy Feed-in Tariff,” Energypedia, 9 Decemeber 2015. [Online]. Available: https://energypedia.info/wiki/South_African_Renewable_Energy_Feed-in_Tariff. [Accessed 25 May 2016].

[12] The Work Bank, “Egypt - New and Renewable Energy Authority (NREA) Wind Farms Financing,” 26 March 2014. [Online]. Available: https://energypedia.info/images/2/2a/Egypt_-_NREA_wind_farms_financing_.pdf. [Accessed 26 May 2016].

[13] H. Razavi, “Clean Energy Development in Egypt,” The African Development Bank Group, Tunis-Belvedere, 2012.

[14] T. W. W. p. m. Intelligence, “Online access > Countries > Egypt > General Data,” The Windpower, June 2016. [Online]. Available: http://www.thewindpower.net/country_en_22_egypt.php. [Accessed 6 June 2016].

[15] L. Graves, “Egypt revives wind turbine plans,” *The National ,* 24 January 2016.

[16] IQPC, “State of the Market: Wind power projects in Egypt,” Alternative Energy Mag, 14 6 2016. [Online]. Available: http://www.altenergymag.com/article/2016/06/state-of-the-market-wind-power-projects-in-egypt/23853. [Accessed 16 June 2016].

[17] L. Power, “Lekela,” Lekela Power, [Online]. Available: http://lekela.com/. [Accessed 30 June 2016].

[18] M. Farg, “Electricity Ministry signs with EDF Suez, TOyota, Orascom to establish Gulf of Suez wind power plant,” *The Daily News Egypt,* 29 May 2016.

[19] Wind power Intelligence, “EGYPT: NREA signs ten MoUs for 500MW in Gulf of Suez region,” *Wind power Intelligence,* 31 August 2015.

[20] Italgen, “Italgen and the Italian Business Delegation visiting Egypt for investment opportunities,” Italgen Media Center, 10 March 2015. [Online]. Available: http://www.italgen.it/ENG/Media+Center/News+and+press+release/20150310.htm. [Accessed 1 July 2016].

[21] New & Renewable Energy Authority (NREA), “ New & Renewable Energy Authority (NREA): Homepage,” New & Renewable Energy Authority (NREA), [Online]. Available: http://www.nrea.gov.eg/english1.html. [Accessed 4 July 2016].

[22] Energypedia, “Egypt Energy Situation,” Energypedia, 9 December 2015. [Online]. Available: https://energypedia.info/wiki/Egypt_Energy_Situation#Governmental_Bodies_and_Agencies. [Accessed 5 july 2016].

[23] T. Isenburg, “Egypt: Wind potential vs. political instability,” *The Sun & Wind Energy,* 12 October 2015.

[24] Elsewedy, “Home / Our Sectors / Wind Energy,” Elsewedy Electric, [Online]. Available:

http://www.elsewedyelectric.com/FE/Common/SectorDetails.aspx?ID=25. [Accessed 9 July 2016].

[25] EgyptERA, “Current Legal and Institutional framework,” EgyptERA, 1 July 2011. [Online]. Available: http://egyptera.org/en/leg_inst_fw.aspx. [Accessed 10 July 2016].

[26] EgyptERA, “Renewable Energy – Feed-in Tariff Projects’ Regulations,” EgyptERA, 2014.

[27] M. S. Elsobki, *Wind Energy In Energy,* Cairo: Faculty Of Engineering, Cairo University, Egypt.

[28] Wikipedia, “Ghana / Geography,” Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Ghana#Geography. [Accessed 20 July 2016].

[29] SWERA, “Solar and Wind Energy Resource Assessment (SWERA),” [Online]. Available: http://www.energycom.gov.gh/downloads/Technical%20Reports/SWERA%20-%20National%20Report.pdf. [Accessed 26 June 2016].

[30] G. Singh, S. A. Nouhou and M. Y. Sokona, “GHANA: Renewable Readiness and Assessment,” International Renewable Agency (IRENA), 2015.

[31] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, “Wind Energy in Ghana: Potential, Opportunities and Challenges,” Federal Ministry for Economic Affairs and Energy (BMWi), Berlin, 2015.

[32] G. Ofei, “Sector Report on Business Opportunities Fror Renewable Energy in Ghana,” Netherlands Enterprise Agency (RVO.nl), Hague, 2014.

[33] Energypedia, “Ghana Energy Situation,” Energypedia, 11 December 2015. [Online]. Available: https://energypedia.info/wiki/Ghana_Energy_Situation#_ftn1. [Accessed 4 August 2016].

[34] A. Gets and R. Mhlanga, "Powering the Renewable Energy Roll out in South Africa," Green Peace, Johannesburg, 2013.

[35] D. D. Jongh, D. Ghoorah and A. Makina, "South African renewable energy investment barriers: An investor perspective," Journal of Energy in Southern Africa, vol. 25, no. 2, 2014.

[36] A. Aly, "Optimized Integration of Renewable Energy Technologies into Egypt s Power Plant Portfolio," Technische Universit�at Berlin (TUB), Berlin, 2014.

[37] A. D. Mukasa, E. Mutambatsere, Y. Arvanitis and T. Triki, "Development of wind energy in Africa," African Develoment Bank, Tunis Belvédère, 2013.

[38] D. Mentis, "Wind Energy Assessment in Africa. A GIS-based approach," KTH School of Industrial Engineering and Management, Stockholm, 2013.

Appendix A: Wind turbine manufacturers operating in Africa

Manufacturer	Domiciliation	Country Coverage	Installed Capacity	Pipeline Capacity
Gamesa†	Spain	Egypt, Morocco, Tunisia	630.8	590.0
Vestas	Denmark	Egypt, Kenya, Morocco, South Africa, Cape Verde, Algeria	136.3	55.0
Alstom Ecotècnia	Spain	Morocco	100.0	-
Nordex	Germany	Egypt	63.0	-
Fuhrländer	Germany	South Africa	5.5	-
Enercon	Germany	Morocco	3.5	-
Wincon	Denmark	Egypt	2.6	-
Vergnet	France	Eritrea, Mauritius, Ethiopia, Mauritania	1.0	125.0
Ventis	Denmark	Egypt	1.0	-
Jeumont	France	South Africa	0.8	-
Wind World	Denmark	Namibia	0.2	-
Vensys	Denmark	Algeria	-	14.0
Siemens	Germany	Morocco	-	50.6
Alstom	France	Morocco	-	200.0
El Sewedy Electric	Egypt	-	-	-

†Includes MADE and Eólica turbines

Appendix B: RE promotion policies in Africa

Country	Feed-in tariff (FiT)	Capital subsidies, grants, rebates	Investment or other tax credits	Sales tax, energy tax, excise tax or VAT reduction	Public investment, loans or financing	Public competitive bidding
Algeria	x		x	x		
Egypt				x		x
Ethiopia				x		
Ghana		x		x	x	
Kenya	x		x			
Mauritius		x				
Morocco			x	x		
Rwanda	x				x	
South Africa	x	x		x	x	x
Tunisia		x		x	x	
Uganda	x	x		x	x	
Zambia				x		

Appendix C: Summary of wind results from different locations in Egypt and Heights

Table 1. Summary of wind observations at the meteorological stations: Data-collecting period, height above ground level of anemometer, data recovery rate (R), Weibull A- and k-parameters, mean wind speed (U), mean power density (E), and direction (D_U) and magnitude ($|U|$) of the mean wind vector.

Region/Station	Period	Height [m]	R [%]	A [ms^{-1}]	k	U [ms^{-1}]	E [Wm^{-2}]	D_U [deg]	$\|U\|$ [ms^{-1}]
Northwest Coast									
Sidi Barrani (62301)	10 y	10.0	n/a	7.0	2.16	6.2	254	324	2.8
El-Mathany	1 y	24.5	99.5	6.4	2.33	5.7	190	284	2.0
Ras El-Hekma	1 y	24.5	99.8	7.2	2.23	6.4	275	309	3.1
El-Galala	1 y	24.5	97.2	6.7	2.41	5.9	206	324	2.6
Alexandria (62318)	10 y	10.0	n/a	5.2	2.42	4.6	99	329	2.9
Northeast Coast									
Port Said	1 y	24.5	66.2	5.3	2.32	4.7	105	301	1.6
El Arish (62337)	10 y	8.5	n/a	3.0	1.44	2.8	37	303	1.0
Gulf of Aqaba									
Nuweiba	1 y	24.5	80.9	6.2	2.58	5.6	161	027	4.0
Nabq	1 y	24.5	97.6	7.7	2.04	6.8	367	009	5.9
Gulf of Suez									
Katamaya	1 y	24.5	79.5	6.0	2.66	5.4	143	357	2.8
El-Suez (62450)	10 y	10.0	n/a	6.2	3.17	5.5	140	350	3.9
Ras Sedr	5 y	24.5	84.1	8.5	3.06	7.6	368	341	6.0
Abu Darag NW	3 y	47.5	82.3	9.6	3.34	8.6	519	352	6.9
Abu Darag	14 y	24.5	82.5	10.1	3.50	9.1	598	355	7.6
Zafarana M7	7 y	47.5	79.1	11.1	3.57	10.0	788	356	8.4
Zafarana	14 y	24.5	85.2	10.2	3.19	9.1	626	358	7.0
Saint Paul	5 y	24.5	82.7	9.4	3.25	8.5	498	332	7.0
Ras Ghareb	5 y	24.5	85.5	11.0	3.40	9.9	775	322	8.7
Gulf of El-Zayt NW	5 y	24.5	82.0	11.8	3.70	10.7	950	313	9.4
Gulf of El-Zayt	7 y	24.5	83.8	11.5	3.29	10.3	900	322	9.0

Appendix D : Summary of wind results from different locations, at 60m hub height in Ghana

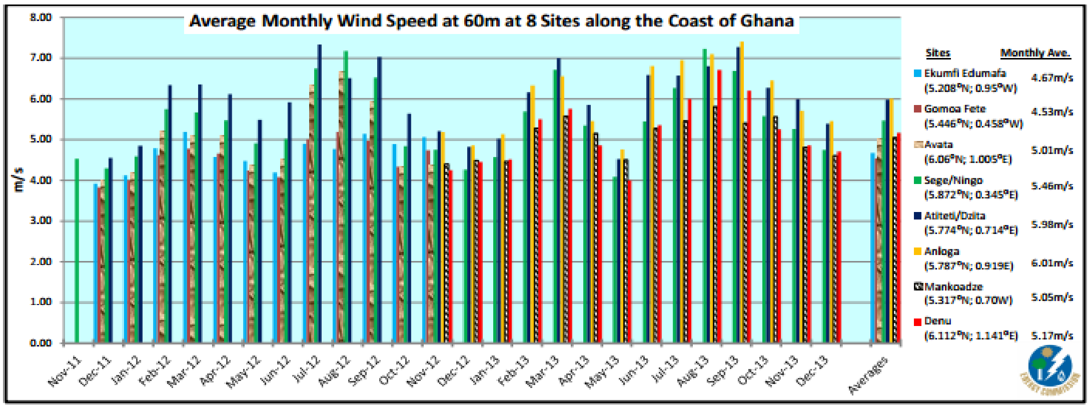
SUMMARY RESULTS OF WIND ENERGY RESOURCE ASSESSMENT AT 8 LOCATIONS ALONG THE COAST OF GHANA CONDUCTED BY THE ENERGY COMMISSION UNDER GEDAP/MoEP

The Energy Commission under the Ghana Energy Development and Access Project (GEDAP)/Ministry of Energy and Petroleum conducted a wind energy resource assessment at eight (8) locations along the coast of Ghana to measure wind data at reference height of 60m above ground level.

The eight (8) locations are detailed in the Table below:

#	Site Name	Location	Coordinates	Period	Monthly Average Wind Speed @ 60m (m/s)
1	Ekumfi Edumafa	Mfantsiman Municipality, Central Region	(5.208°N; 0.950°W)	2011-2012	4.67
2	Gomoa Fete	Gomoa East District, Central Region	(5.446°N; 0.458°W)	2011-2012	4.53
3	Avata	Ketu South Municipality, Volta Region	(6.060°N; 1.005°E)	2011-2012	5.01
4	Sege/Ningo	Dangme West District, Greater Accra Region	(5.872°N; 0.345°E)	2011-2013	5.46
5	Atiteti/Dzita	Keta Municipality, Volta Region	(5.774°N; 0.714°E)	2011-2013	5.98
6	Anloga	Keta Municipality, Volta Region	(5.787°N; 0.919E)	2012-2013	6.01
7	Mankoadze	Winneba Municipality, Central Region	(5.317°N; 0.700W)	2012-2013	5.05
8	Denu	Ketu South Municipality, Volta Region	(6.112°N; 1.141°E)	2012-2013	5.17

The monthly wind speed data for the various eight (8) sites are shown in the graph below.



For any enquiry contact Mr. Frederick Ken. Appiah at the Energy Commission on appiahfk@energycom.gov.gh.

NB: The raw wind data for all the sites are being sold at GHC 2,700.00 per site.

April 2014

Appendix E: Feed-in tariffs for wind power across Africa

Country	Rate and year	Comment	Reference
South Africa	2009: 1.25 ZAR/kWh (0.14 USD/kWh) 2011: 0.938 ZAR/kWh ($0.14 USD/kWh) 2011: ceiling price (REBID reforms) (115c/Kwh)	South Africa's wind energy tariff started off greater than that offered in Germany (€0.092/kWh) and more than that proposed in Ontario, Canada ($0.135 CAD/kWh). In 2011 it was proposed that the FiT should be reduced to 0.938 ZAR/kWh, and at the same time, revised the procurement process from direct procurement to a two-stage bidding process known as ReBid. These changes caused discontent in the industry, but the 2011 bidding process has been rated as successful.	Renewable Energy World: www.renewableenergyworld.com/rea/news/article/2009/04/south-africa-introduces-aggressive-feed-in-tariffs Edkins, M. T. (2012), Local, National and Regional Policy, barriers and incentives – Renewing Wind Policy Risk in South Africa, World Wind Energy Conference 2012, Bonn Germany.
Kenya	2008: 0.09 USD/kWh		Ministry of Energy report
Algeria	2004 to date: 300% of the of the average electricity price	Tariff payment under the Algerian feed-in tariff scheme is expressed as a percentage of the average electricity price which is set annually by the power market operator, so there is not a specific contract term. Even though the tariff level can vary every year (due to the connection to the electricity price), tariff payment is guaranteed for the full lifetime of a project.	World future council: www.futurepolicy.org/2689.html
Tanzania	2009: 86.50 TZS/kWh (0.054 USD/kWh – wet season) 115.33 TZS/kWh (0.072 USD/kWh – dry season) For off-grid small power projects 334.83 TZS/kWh (0.21 USD/kWh)	The standardized tariff is above the market rate to cover cost of generation plus a reasonable profit. Tariffs are calculated differently for dry season and wet season. The amount of tariff for off-grid SPP is higher and is calculated on the basis of avoided cost of replacing diesel generators.	Tanzania electricity supply company limited: www.geothermie.de/fileadmin/useruploads/aktuelles/Geothermiekongress/vortraege/EA_Kabaka.pdf
Morocco	No FiT.	Auto-producers may sell extra energy from wind farms to the national utility, ONE for a price of 70 % of ONE-tariffs.	