THE STATUS OF
WIND IN AFRICA
OCTOBER 2023

GWEC
AFRICA WINDPOWER

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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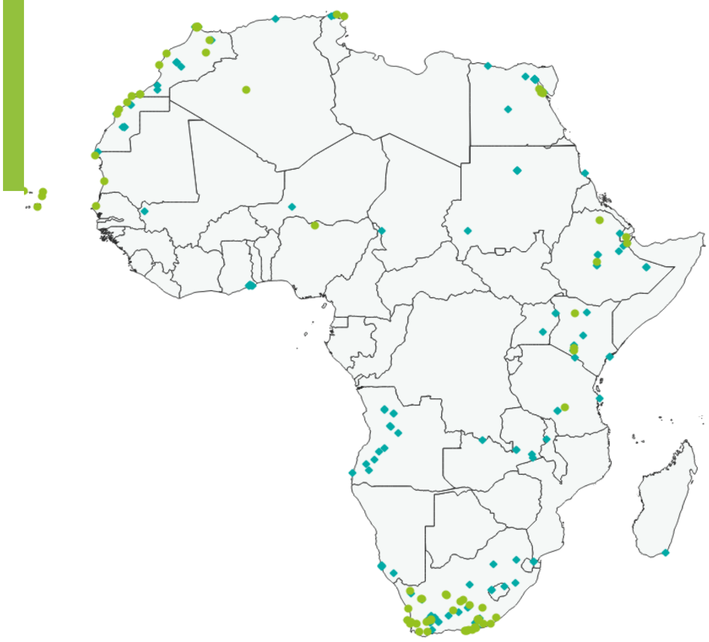
EXECUTIVE SUMMARY

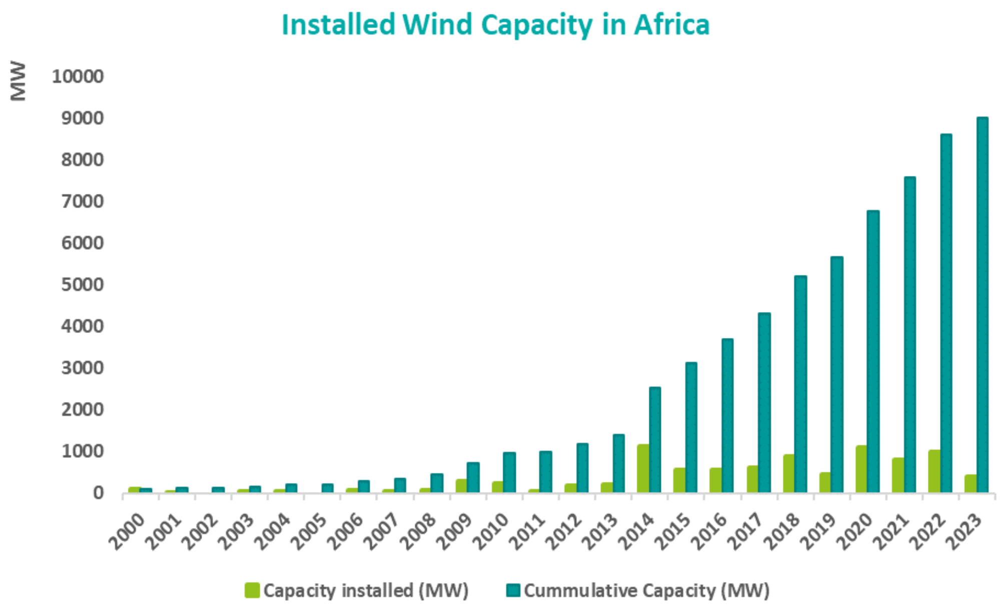
The Global Wind Energy Council (GWEC) has produced "The Status of Wind in Africa" report to take stock of wind energy's footprint, the role wind currently plays and its bright future prospects across the Continent. The **report maps out the Africa's current installed wind power plants of capacity greater than 1MW**, provides readers a better understanding of the current state of project activity in Africa's wind space and points to the future by highlighting the pipeline of announced projects and various drivers of new wind capacity installations.

Africa's Installed Wind Power Capacity

At the end of 2020 IRENA[1] estimated that 6.5GW of wind was installed in Africa with the main markets being South Africa, Morocco and Egypt, and secondary markets being Kenya, Ethiopia, and Tunisia. The i**dentified installed capacity in this study is 9 GW** considering plants that are installed and under construction and scheduled to be commissioned in 2023. Apart from additional installations in the mentioned markets, new builds have occurred in Senegal, Reunion, Nigeria, Tanzania and Djibouti.



There has been a steady increase in the installed capacity of wind in Africa since the year 2000. This growth has seen annual installations of 800MW and above during 2018, 2020, 2021 and 2022. The **year with the highest installation being 2014 where 1132 MW was installed.**



Source: GWEC market intelligence 2023

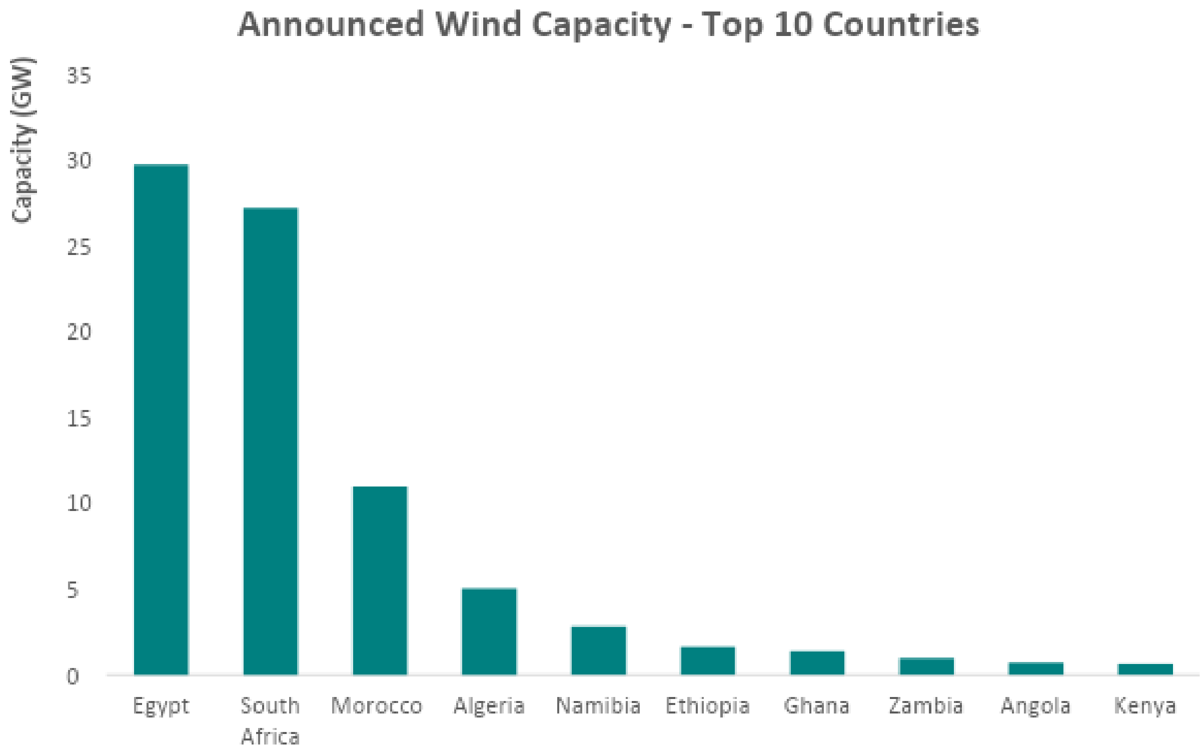
[1] IRENA and AfDB (2022), Renewable Energy Market Analysis: Africa and Its Regions, International Renewable Energy Agency and African Development Bank, Abu Dhabi, and Abidjan.

Considering the five sub-regions of Africa, **North Africa leads in terms of total installed capacity** due to the influence and early onset of renewable energy programs in Egypt and Morocco which saw initial utility-scale wind project commissioning in 1988 and 2000, respectively. Southern Africa, dominated by wind farms in South Africa largely installed through the REIPPP scheme, has the second highest installed wind capacity. Eastern Africa comes in third with several operational wind farms in Ethiopia and Kenya.

Source: GWEC market intelligence 2023

Overall, **140 projects planned across Africa representing 86GW of planned new wind capacity were identified and mapped.** These included projects in several countries new to wind such as Angola, Chad, Mali, Ghana, Sudan, Niger, Madagascar, Uganda, Zambia, and Malawi. For example, 700MW of planned wind capacity was identified in Angola across 13 projects, illustrating the untapped technical potential found even in Central Africa. More capacity additions are planned for the established wind markets in Southern, Eastern and Northern Africa.

Egypt looks set to dominate the wind sector in Africa over the coming decade considering its significant technical potential, existing installed capacity, established local manufacturing industry (e.g. steel towers, electrical switchgear, and cabling) and numerous recently announced projects. The Government of Egypt notably announced at COP27 in Sharm El Sheikh the signing of agreements for one of the world's largest wind farms, a USD 10 billion, 10GW wind farm in the Gulf of Suez region. A land agreement for this project was signed by Hassan Allam Utilities, Infinity Power and Masdar in early June 2023. The Egyptian Government also previously agreed with Saudi Arabia's ACWA Power, along with Hassan Allam, to execute a 1.1GW wind farm at Gabal el Zait on the Gulf of Suez scheduled to be commissioned by 2026. Scatec ASA is planning two 1.5GW wind farms and a consortium of Orascom Construction, Toyota Tshusho and Eurus Energy is planning 3GW wind farm. Some notable projects have been announced in the continent mainly in the countries with highest technical potential for onshore wind power.



Source: GWEC market intelligence 2023

Case Studies

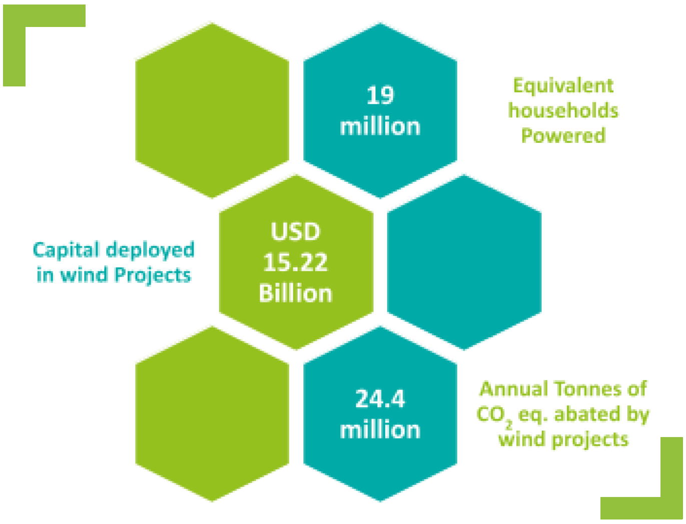
A total of 83 installed wind farms were identified in the study from four sub-regions of Africa. This section of the report examines six unique wind projects for being the first of their kind in their country, uniqueness in the value to their grid, significant capacity size and/or for involvement of local financing and community participation.

The six projects highlighted in this report are:

- The Hopefield Wind Farm in Western Cape Province, South Africa. COD 2014.
- The Mwenga Wind Farm in Iringa Region, Tanzania. COD 2020.
- Le Parc Eolien Taiba N'diaye, Région de Thiès, Senegal. COD 2020.
- The West Bakr Wind Farm, Red Sea Governorate , Egypt COD 2021.
- Le Parc Eolien Nassim Koudia Al Baida, Région de Tanger-Tétouan-Al Hoceïma, Morocco. COD 2000.
- The Lake Turkana Wind Farm, Marsabit County, Kenya. COD 2018.

Benefits of wind development

The development of the wind energy sector in Africa presents opportunities to impart socioeconomic benefits to households, communities, and countries. These benefits include employment opportunities, leading up to and during the roughly 25-year lifetime of a utility-scale wind asset, clean power for households and industrial consumers, direct (foreign and local) investments , including in supply chain facilities. The diagram below summarises the achievements so far with the approximately 9GW of identified projects.



The **deployment of wind energy in Africa has created 12,400[3] direct jobs during and after construction across 3000 MW of projects identified in this study.** These have been in Kenya, Tanzania, South Africa, Senegal, Egypt, and Morocco. To provide some context, the 310MW Lake Turkana project in Kenya, Africa's largest wind farm to date, employed 2,500 during construction and employs 329 for operations. Employing 600 during construction and 32 during operation; the Taiba N'diaye wind farm in Senegal employing 600 during construction and 24 during operation; and the Mwenga wind farm in Tanzania employing 50 during construction and 6 during operation. The total direct job creation from wind energy in Africa is several times higher given these projects are just a fraction of the total identified wind capacity of 9,000 MW, as of 2023. In addition to local job creation, wind energy also generates a number of additional benefits for countries in Africa.

Today's drivers

Additional Capacity and Energy

Wind has contributed to the growth of installed capacity and available energy to African grids that have capacity and energy constraints. **The Lake Turkana wind farm contributes 17% of Kenya's installed capacity while the Taiba N'diaye wind farm increased Senegal's installed capacity by 15%.** Wind farms provide needed capacity and energy to increase the level of electricity supply in the countries looking to expand supply and access to electricity, , with the added benefit of supplying renewable power.

Diversification of Supply

The generation mix in most African countries is dominated by hydropower plants, which can leave countries vulnerable to periods of drought and to aging hydropower infrastructure. Some large economies that are reliant on thermal plants (coal and natural gas) for the bulk of their generation are opting to increase renewable energy capacity to mitigate the economic risks of depending on imports of fossil fuels, particularly given the recent price volatility of international gas markets. Greater diversification of supply and lower dependency on imported fossil fuels increases the security and resilience of a country's energy mix.

Egypt, whose grid has historically been reliant on natural gas, is currently installing large scale wind and solar and **targets to reach an installed capacity of 42% renewable energy in its power mix by 2030** according to its nationally determined contributions (NDCs) under the COP process. South Africa, with a generation mix that is heavily reliant on coal, has also been pursuing renewable energy now having concluded its 6th round of renewable energy auctions. **As of 2022[5] the country's installed capacity of 54GW comprised 3.4GW wind**, 2.3GW solar PV, 0.5GW concentrated solar power, 0.6GW hydro, 39.8GW coal and 3.4GW diesel.

Grid stabilisation

Wind has been deployed together with other technologies to stabilise grids by complementing other generation sources. Wind and solar show complementarity, with the daytime dips in wind being complimented by peaks in solar, and loss of solar in the night often matched with strong wind supply. As such, wind has been particularly effective in firming up solar supply. Hybridisation has also been undertaken by combination with hydro as in the 2.4MW Mwenga wind Farm in Tanzania. The wind farm is installed in an isolated grid running primarily on a mini-hydro plant of 4 MW. The farm supports supply during periods of low hydrology, as is the case on a large scale with wind and hydropower complementarity in Latin American countries like Brazil, Uruguay and Costa Rica.

Captive Supply to Industry

Increasingly, industries are choosing to install their own wind farms to supply their power needs directly. This is motivated by cost, and a need to reduce the carbon footprint of their upply chain.

[3] This data is specific to the projects whose employment numbers were identified in this baseline study. The total number for Africa is higher considering the total installed wind capacity is 8,985MW.

This trend has been the case in Morocco's cement and fertiliser industries (e.g., OCP, LafargeHolcim, Italcementi, Cimat, Asment de Temara, etc.), Rio Tinto minerals in Madagascar, and in South Africa, where Seriti Green is developing a 500MW wind farm to power coal mining, with many other examples in other markets. This trend of wind farms being installed at a captive site of a commercial or industrial entity will continue as companies look to secure clean energy supply, reduce costs and ecarbonise their footprints. Beyond these socioeconomic and system benefits, there are also strong drivers for the continued expansion of wind energy across the continent:

Tomorrow's Drivers

Repowering of Wind Farms

As the installed wind farms in Africa approach the end of their commercial and technical lives, and wind turbine technology continues to improve, there will be a need to repower sites with strong wind technical resource. **From the commissioning dates of the identified projects there will be a peak of repowering activity in Africa between 2034 and 2038, as many power plants reach the end of contractual life.** The majority of the turbines installed in Africa before 2019 were sub-2MW turbines. Today single onshore turbines of 6 MW are available.

Repowering offers an efficient pathway for countries to maximise productivity and socioeconomic benefits from sites already designated for wind power production. Replacing older models with newer turbines that have larger power ratings, greater resilience to environmental elements and material upgrades can unlock a higher energy yield, increase resilience to environmental elements, lower downtime periods and operational expenditures, and improve cost reduction for offtakers, consumers and asset owners and operators. This may also be achieved on a fast-track basis, given the sites have already been permitted for wind farm use.

This is already the case for the **Kouda Al Baida wind farm in Morocco which is to undergo repowering from a 54MW wind farm to a 120MW** wind farm and later to a 200MW wind farm. The **La Perrière wind farm in Reunion was also repowered from a 37-turbine wind farm of 10MW to a 9-turbine wind farm** of 18MW in 2022 by TotalEnergies.

Green Hydrogen

Green hydrogen has been identified as having the potential to decarbonise hard-to-abate sectors of the economy that rely on hydrogen. These include ammonia production, methanol production and Direct Reduction of Iron (DRI) in the steel industry.

Green hydrogen could substitute fossil fuel-based feedstocks in energy end-use sectors where electrification of industrial process is not possible or uneconomical. These include processes which require intense heat, or transport segments such as long-distance shipping and aviation, where energy needs to be stored, transported and deployed efficiently. There is a huge demand by companies to secure supplies of green hydrogen by signing strategic partnerships. The International Energy Agency (IEA) **estimated that by 2030, globally, 9-14 Mt of hydrogen would be produced via electrolysis with a corresponding electrolyser capacity of 134 to 240 GW.**

To achieve a truly green hydrogen sector which is in line with decarbonisation and energy security goals, a ramp up of renewable energy installed capacity will be required. Wind is well placed to take a leading role owing to the relative abundance of underutilised high-quality sites such as in Egypt and Kenya, that offer higher capacity factors compared to solar. Wind provides a good opportunity to achieve firmer capacity as will be required for green hydrogen production.

E-mobility

The e-mobility market in Africa is diverse, with wide-ranging levels of advancement related to the overall development of a specific economy. For mass transportation, electric trains and buses are being adopted in Africa to wean countries from fossil fuel imports and reduce emissions from the transportation system. Electric buses are also being adopted across the continent, especially in countries reliant on import of fossil fuels. At another level are the two-wheeler and three wheelers that are predominant in much of Africa and serve as main forms of transportation in rural areas of Africa. The electrification of these is already underway in Ethiopia, Togo, Kenya, Rwanda, Uganda, Burundi, Madagascar, Sierra Leone, and Tanzania.

This new demand from e-mobility and the need to ensure low-carbon transportation is enhanced will send a demand signal for more wind power to be developed in the continent. Wind resource matches well with the nighttime charging of e-vehicles due to the higher resource availability at night often at times of low demand on the grid. This alignment puts wind at a better position among renewables to supply

[4] Comité Maghrébin de l'Electricité

charging power for the transport sector. The development of regional power trading markets, with appropriate structures and rules, across these power pools will increase the attractiveness of domestic supply of wind and other renewable energy, as offtakers will increasingly seek zero-carbon forms of energy.

Countries with a surplus of renewable generation at times where the wind and sun are strong, or even having employed short-duration or long-duration energy storage technology to capture renewable electricity, can generate economic gains by selling excess power across borders. This would also reduce the risk of curtailment of renewable power and improve the overall business case for investment in renewables in the country.

Regional Power Markets

The **integration of markets at a regional level will allow for development of wind plants in high potential countries for trade with high demand countries** allowing better integrated use of resources available in the region. The **African market has five active power pools** COMELEC[6], WAPP, CAPP, EAPP, and SAPP with some more active than others. There are also overlaps with some countries being members of more than one pool.

[6] Comité Maghrébin de l'Electricité

Chapter 1

INTRODUCTION

The Global Wind Energy Council (GWEC) in its efforts to promote the adoption of more wind energy in the African continent, undertook to develop this report on "The Status of Wind in Africa". The report maps out the continent's current installed wind power plants of capacity greater than 1MW. Wind power plants have been installed in new markets in the continent such as Senegal and Djibouti away from the traditional leading country markets of Egypt, Morocco, and South Africa. These traditional large wind markets have also seen an uptake of higher capacity wind farms and larger installed turbines.

The report documents the potential technical capacity for wind as reported by theInternational Renewable Energy Agency (IRENA) and the World Bank Group's International Finance Corporation (IFC). The regional distribution of wind energy's technical potential is analysed to reveal the regional trends in potential. Projects that have been announced are then identified and mapped.

A total of 223 wind projects that have been installed or are planned were catalogued bringing the total considered capacity to 67GW of projects. The installed and operational projects identified represent 9GW in total capacity.

The benefits and drivers of installation of wind are also looked at and analysed in order to better inform the reader of the likely trends to expect in the coming years with respect to growth in wind energy installations in Africa.

The report aims to give an understanding of the current state of project activity in Africa's utility-scale wind energy market and point to what the future looks like given the announced pipeline of projects and various drivers of new wind capacity. The continent is set to see continued growth in both population and economic activity. Wind energy is in a strong position to help power the future growth of the African continent.

Chapter 2

WIND FARMS IN AFRICA

The wind industry in Africa started off in Egypt in the late 1980s and early 1990s with an initial series of small utility-scale wind farms generally financed by soft loans from European donor countries. There were also a number of single turbine demonstration plants meant to be "proof of concept" for larger wind farms that started in the late 1990s and early 2000s. These were implemented in Cape Verde, South Africa, Kenya (KenGen's Ngong Hills), and Morocco amongst others. Larger utility-scale plants then started to come online beginning around 2000-2001. Notable examples include the Nassim Koudia Al Baida wind farm in Morocco in 2000, Ngong Hills in Kenya in 2001, Eskom's 3.2 MW Klipheuwel wind farm pilot plant in 2003, and the Boa Vista wind farm in Cape Verde in 2011. *Figure 1* shows the location of the identified installed wind farms in this report[7].

Figure 1: Mapping[8] of the identified wind farms in Africa

At the end of 2020 IRENA[9] estimated that 6.5GW of wind was installed in Africa with the main markets being South Africa, Morocco and Egypt, and secondary markets being Kenya, Ethiopia, and Tunisia. The **identified capacity in this study is 9 GW** considering plants that are installed and under construction and scheduled to be commissioned in 2023. Apart from the aforementioned countries, new capacity is being built in Senegal, Réunion, Nigeria, Tanzania and Djibouti. This growth reflects that wind power has now expanded across all major sub-regions of Africa, except for Central Africa.

Figure 2: Parc Eolien Taiba N'diaye

A noteworthy addition has been the Taiba N'diaye wind Farm (PETN) in Senegal. The 158.7 MW wind farm developed by Lekela Power and owned by Infinity Power is the biggest wind farm in Western Africa. It accounts for 15% of the installed capacity in Senegal and provides power for over 2 million Senegalese. It was commissioned in 2020.

There has been a steady increase in the installed capacity of wind in Africa since 2000. This growth has seen annual installations reach 800MW and above during 2018, 2020, 2021 and 2022, although the peak year of installations remains 2014 when 1132 MW was installed as in *Figure 3*.

[7] The identified projects were of 1MW and above that were under construction or installed in 2023 as identified by GWEC.

[8] Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by GWEC.

[9] IRENA and AfDB (2022), Renewable Energy Market Analysis: Africa and Its Regions, International Renewable Energy Agency and African Development Bank, Abu Dhabi, and Abidjan.

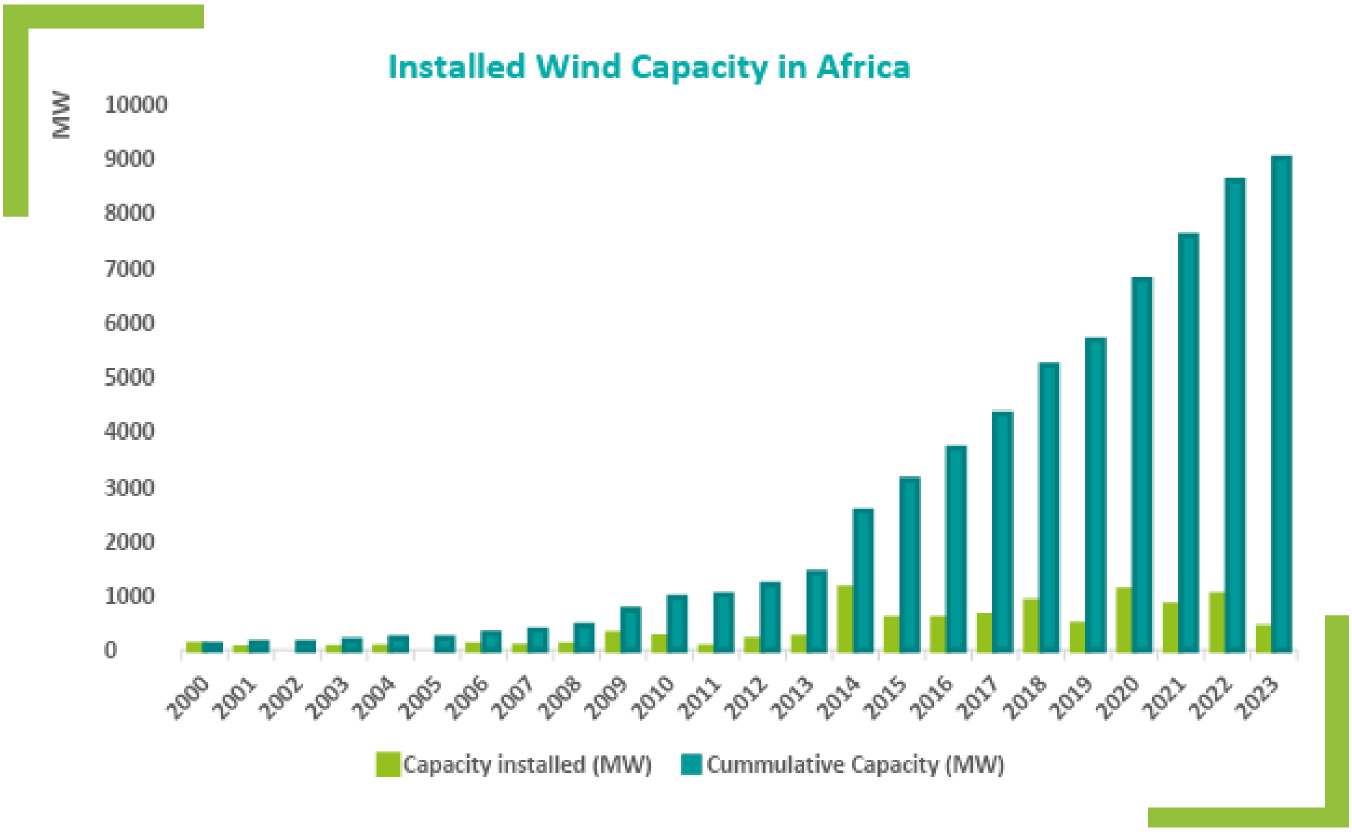


Figure 3: Annual installed wind capacity in Africa. Source: GWEC market intelligence 2023

This was buoyed by the achievement of commercial operation on six South African wind farms (Karusa, Kangnas, Nxuba, Oyster Bay, Perdekraal and Excelsior wind farms), the Taiba N'diaye wind farm in Senegal and the Midelt windfarm in Morocco. 2020 also saw the commissioning of the Mwenga wind farm in Tanzania, the country's first wind farm and an example of hybridisation with wind to strengthen power supply.

The leading country by installed capacity is South Africa followed by Morocco and Egypt. The South African Renewable Energy Independent Power Producer Procurement Program (REIPPPP) contributed to the uptick in installed capacity. Morocco and Egypt have also focused on big-volume procurement programs of renewable energy capacity mainly with the goal of reducing their reliance on fossil-fuel generation. As depicted in *Figure 4*, Ethiopia and Kenya complete the top 5 countries in terms of installed capacity.

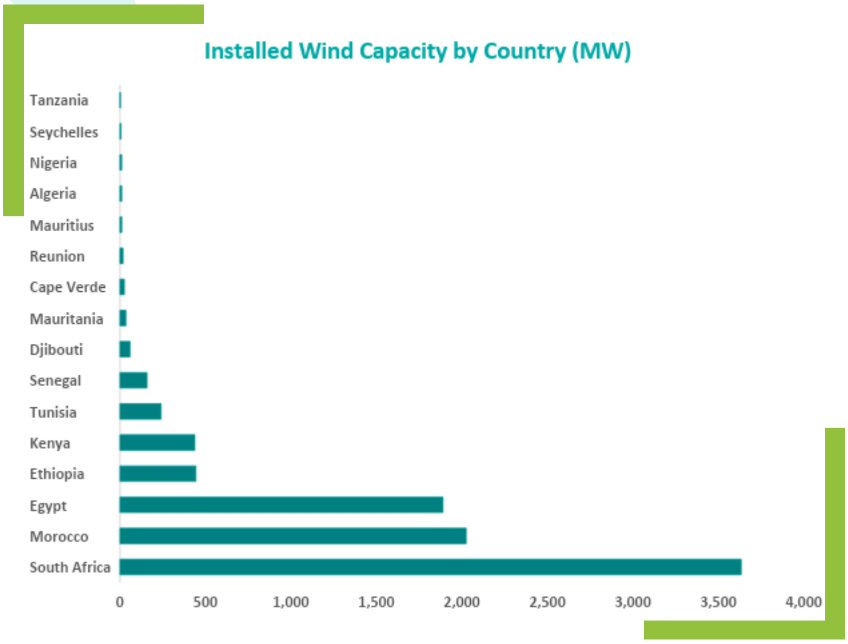


Figure 4: Installed wind capacity by country as of 2023. Source: GWEC market intelligence 2023

Considering the five sub-regions of Africa, **North Africa leads in terms of total installed capacity** due to the influence and early onset of renewable energy programs in Egypt and Morocco which saw initial utility-scale wind project commissioning in 1988 and 2000 respectively. Southern Africa, dominated by wind farms in South Africa largely installed through the REIPPP scheme, has the second highest installed wind capacity. Eastern Africa comes in third with several operational wind farms in Ethiopia and Kenya. The spread of wind projects in the African continent has improved with new projects in Western and Eastern Africa balancing the traditional markets of Northern and Southern Africa. Central Africa remains without largescale wind farms, a fact that could relate to its relatively lower spread of high wind potential areas as will be seen in chapter 4. *Figure 5* and *Figure 6* give a summary of the identified installed capacity of wind by region.

Northern Africa : 4165 MW

Top 5 Projects by size

- 580MW Jabal al-Zeit Wind complex, Egypt
- 544MW Zafarana Wind Complex, Egypt
- 301MW Parc Eolien Boujdour, Morocco
- 301MW Parc Eolien de Tarfaya, Morocco
- 262.5MW Ras Gharib Wind Farm, Egypt

Southern Africa : 3663 MW

Top 5 Projects by size

- 148MW Nxuba Wind Farm, South Africa
- 147.6MW Oyster Bay Wind Farm, South Africa
- 147MW Karusa Wind Farm, South Africa
- 147MW Soetwater Wind Farm, South Africa
- 147MW Roggeveld Wind Farm, South Africa

Eastern Africa : 950 MW

Top 5 Projects by size

- 310MW Lake Turkana Wind Power, Kenya
- 204MW Adama I & II Wind Farm, Ethiopia
- 120MW Ashegoda Wind Farm, Ethiopia
- 120MW Aysha Wind Farm, Ethiopia
- 102MW Kipeto Wind Farm, Kenya

Western Africa : 296 MW

Top 5 Projects by size

- 158MW Taiba N'diaye wind farm, Senegal
- 30MW El Mina Wind Farm, Mauritania
- 10MW Katsina wind farm, Nigeria
- 9.35MW Santiago wind farm, Cape Verde
- 7.65MW Sal wind farm, Cape Verde

Figure 5: Detailed Installed wind capacity by region Source: GWEC market intelligence 2023

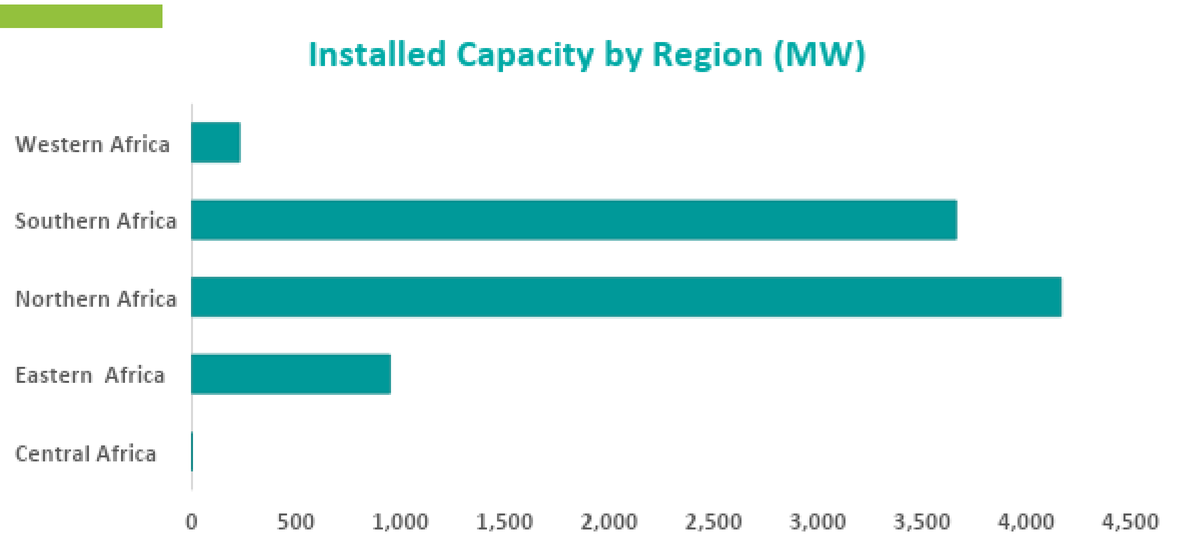


Figure 6: Regional comparison of Installed wind capacity in Africa. Source: GWEC market intelligence 2023

The leading OEM in terms of installed capacity in Africa is Siemens Gamesa comprising 48% of the wind turbine installations by MW capacity. This is likely boosted by the company's earlier manufacturing presence in the region. The list of the top 5 OEMs by installed capacity in Africa is completed by Vestas, Nordex Acciona, General Electric and Sany as depicted in *Figure 7.*

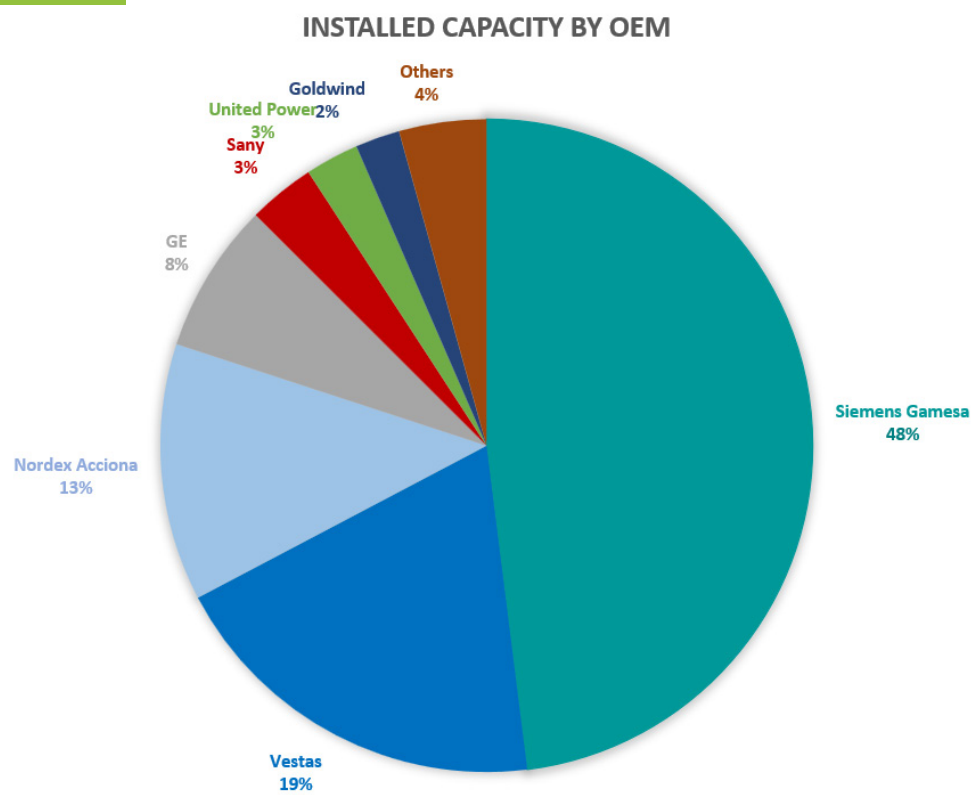


Figure 7: Installed wind capacity by Wind turbine OEM. Source: GWEC market intelligence 2023

The next chapter switches focus from what is installed to what the potential is for wind in Africa.

Chapter 3

POTENTIAL OF WIND POWER IN AFRICA

The International Renewable Energy Agency (IRENA) estimated a technical potential of 461GW for wind in Africa (Considering a 1% land-utilisation factor)[11]. Algeria, Ethiopia, Namibia and Mauritania were reported as possessing the greatest potential. *Figure 8* extracted from the global wind atlas shows that the greatest onshore wind potential is spread across the Sahel, North Africa, Eastern Africa, and Southern Africa. Islands of the East and West of the African continent also display significant potential. The greatest offshore potential in Africa is concentrated in the Western African coast and the Southern African Coast followed by the Red Sea and Mediterranean Coast as well as the East African Coast.

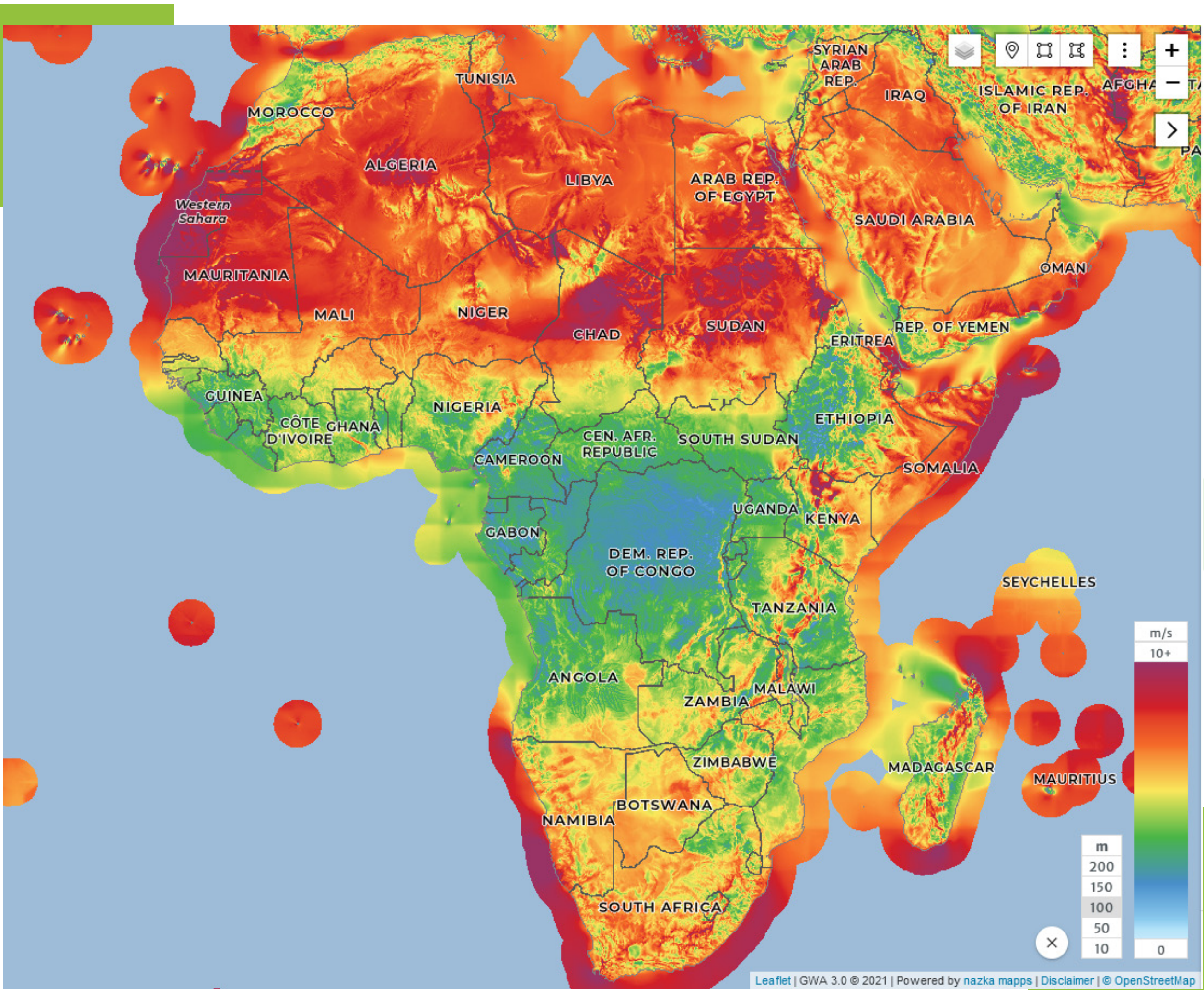


Figure 8:Map[12] of wind potential in Africa from the Global Wind Atlas showing wind speeds at 100m. Source: Global Wind Atlas

[11] IRENA and AfDB (2022), Renewable Energy Market Analysis: Africa and Its Regions, International Renewable Energy Agency and African Development Bank, Abu Dhabi and Abidjan.

[12] Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalwindatlas.info – Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by GWEC.

The IFC in 2020 put the potential for wind in Africa in energy terms at 180,000 terawatt hours (TWh) per year, enough to supply Africa's total demand 250 times over. The IFC estimated a total technical potential capacity of 33642 GW spread across the 5 African subs-regions[13].

This can be further broken down to show the main countries within the subregions as indicated in *Figure 10*. Central Africa was identified by the IFC as the subregion with the third largest technical potential though it does not have a wind farm installed. The potential in Central Africa being dominated by the potential in Chad.

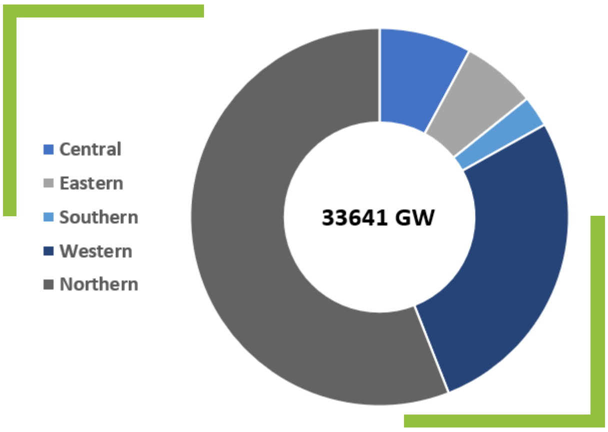
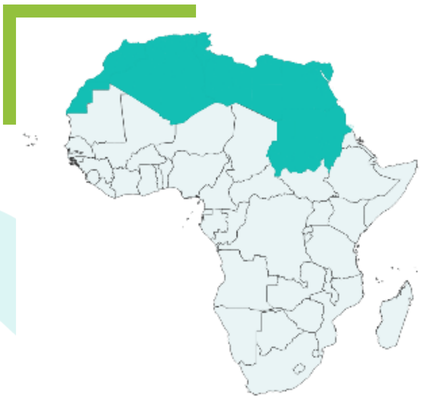


Figure 9: Technical Potential for Wind in Africa by region. Source: IFC

Regional Technical Potential Summary:

Greatest potential for wind is in Northern Africa followed by Western Africa, Central Africa, Eastern Africa, and Southern Africa respectively.



Northern Africa

Total: 18,822 GW

Main countries

Algeria : 6,191 GW

Libya : 5,079 GW

Sudan : 4,628 GW

Egypt : 2,319 GW

Western Africa

Total: 9,144 GW

Main countries

Mauritania: 3,955 GW

Mali : 2,758 GW

Niger : 2,348 GW

Central Africa

Total: 2,651 GW

Main countries

Chad : 2,647 GW

Cameroon : 4GW

Eastern Africa

Total: 2,133 GW

Main countries

Somalia : 1,238 GW

Ethiopia : 375 GW

Kenya : 243 GW

Southern Africa

Total: 891 GW

Main countries

South Africa : 404 GW

Madagascar : 210 GW

Namibia : 124 GW

Figure 10: Potential of various African regions[14 aw15]

[13] IFC worked in collaboration with Everoze, Vortex and GWEC to conduct the analysis. Everoze drew on high-resolution mesoscale data from the Global Wind Atlas and applied basic constraints for technical restrictions (i.e., slopes, elevation, minimum wind speed, land use cover) and basic environmental restrictions (i.e., population density, protected areas).

[14] Disclaimer: The maps provided are for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by GWEC.

[15] Data from IFC report

Algeria, Libya, Sudan, Mauritania and Chad showed the greatest technical potential despite them not having the greater share of installed capacity. Egypt, Morocco and South Africa continue to match their strong potential with significant installations.

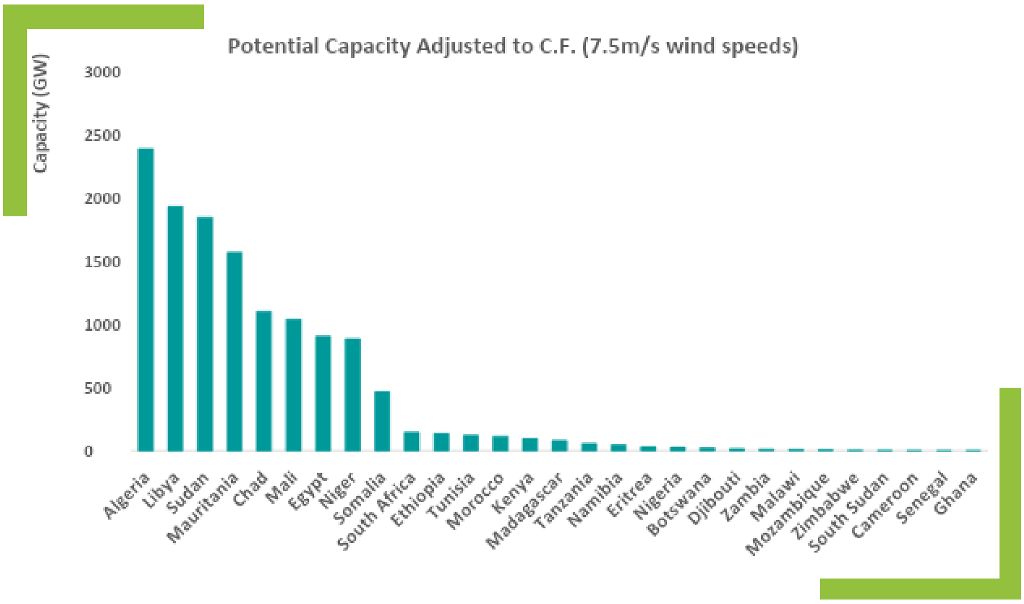


Figure 11: Potential technical capacity by country adjusted to capacity factor (Firm Capacity). Source: IFC

Figure 11 considers the value to the country grid, by mapping the technical capacity including estimated capacity factors to arrive at an estimated potential firm capacity. The technical potential as identified by previous studies would require to be refined by considering other aspects such as available transmission line capacity, demand levels in the country and grid stability considerations. GWEC[16] sees the need to build sufficient transmission capacity as essential in being able to develop the identified technical capacity.

Announced Wind Projects

A total of 86GW[17] of planned and announced wind projects across the continent was identified. The announcements have been mainly in the countries of high potential. *Figure 12* displays the top 10 countries by announced wind project capacity.

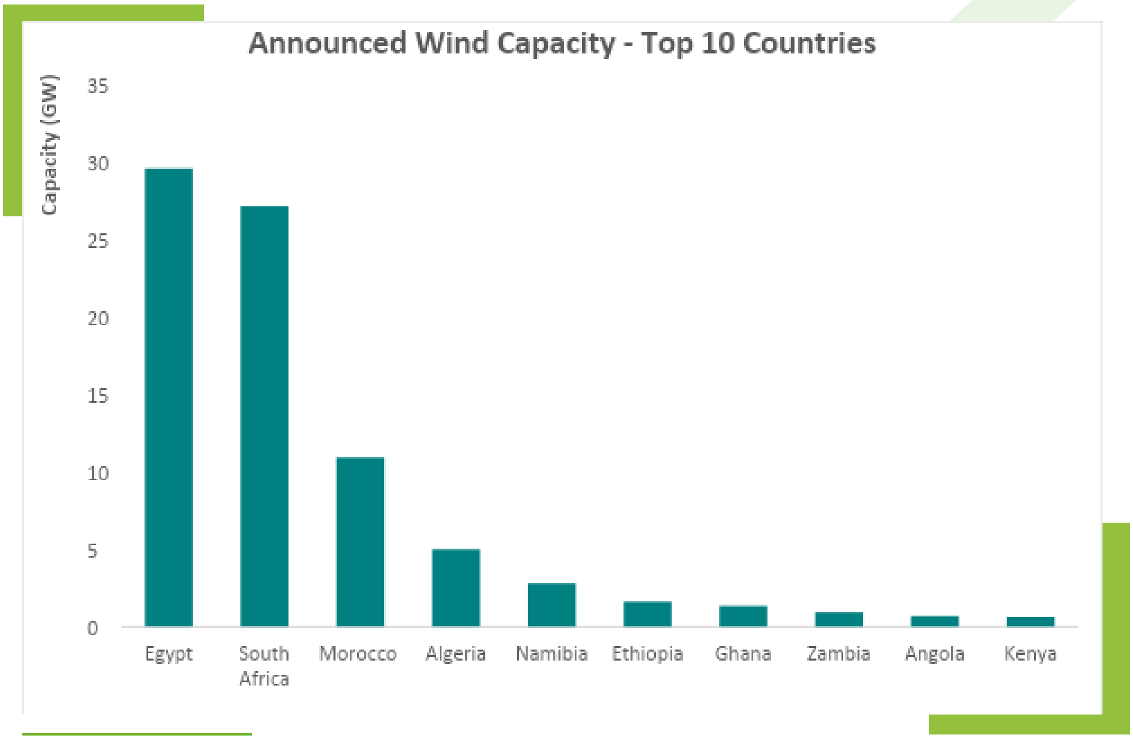


Figure 12: Top 10 Countries by announced wind capacity (at various stages before construction)

[16] GWEC Wind Energy Handbook
[17] Includes consolidated data from ESKOM survey of wind farms in South Africa

A summary of the top 10 identified announced projects by proposed installed capacity is as in Table 1.

	Wind Farm Name	Capacity (MW)	Country
1.	Masdar Sohag Wind Farm	10 000	Egypt
2.	Upper Plateaus Wind Farm	5 010	Algeria
3.	Total Eren-Guelmim-Oued Noun Wind Farm	5 000	Morocco
4.	Fortescue Green Hydrogen Wind Farm	4 600	Egypt
5.	Globeleq Green Hydrogen Wind Farm	4 500	Egypt
6.	Morocco-UK Wind Farm	3 500	Morocco
7.	Scatec Wind Farm	3 000	Egypt
8.	ReNew Green Hydrogen Wind Farm	2 820	Egypt
9.	SCDI Green Hydrogen Wind Farm	2 500	Namibia
10.	Masdar Green Hydrogen wind farm	2 000	Egypt

Table 1: Top 10 announced wind projects by size. Source: GWEC market intelligence 2023

Egypt looks set to dominate the wind sector in Africa over the coming decade considering its significant technical potential, existing installed capacity, established local manufacturing industry (e.g. steel towers, electrical switchgear, and cabling) and numerous recently announced projects. The Government of Egypt notably announced at COP27 in Sharm El Sheikh the signing of agreements for one of the world's largest wind farms, a USD 10 billion, 10GW wind farm in the Gulf of Suez region. A land agreement for this project was signed by Hassan Allam Utilities, Infinity Power and Masdar in early June 2023. The Egyptian Government also previously agreed with Saudi Arabia's ACWA Power, along with Hassan Allam, to execute a 1.1GW wind farm at Gabal el Zait on the Gulf of Suez scheduled to be commissioned by 2026. Scatec ASA is planning two 1.5GW wind farms and a consortium of Orascom Construction, Toyota Tshusho and Eurus Energy is planning a 3GW wind farm.

These projects align with the Country's ambition to have 42% of its energy from renewables by 2030. There is also a developing green hydrogen related wind generation capacity in Egypt by various parties. The areas East and West of Minya have been earmarked as a green hydrogen development zone. These projects have announced a total of 14.203 GW of new wind capacity dedicated to the green hydrogen industry. Namibia Has also seen the announcement of a 2.5GW wind farm dedicated to green hydrogen as discussed further in chapter 7.2.1

Overall, 140 projects planned across Africa representing 58GW of planned new wind capacity were identified and mapped as in *Figure 13*. These included projects in countries new to wind such as Angola, Chad, Mali, Ghana, Sudan, Niger, Madagascar, Uganda, Zambia, and Malawi. Angola is an interesting example where 700MW of planned capacity was identified across 13 projects, though the country is not seen to have low technical potential in Central Africa. More capacity is planned for the established wind markets in South, East and North Africa.

Chapter 5 focuses on some sample case studies for installed wind farms in Africa.

Figure 13: Map showing the spread of the identified planned projects[19]

[19] Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by GWEC.

Chapter 4

WIND PROJECT CASE STUDIES

A total of 83 installed wind farms were identified in the study from four regions of Africa. This section sampled six unique projects for being the first of their kind, uniqueness in the value to their grid, the biggest of their kind and/or for involvement of local financing and community participation.

The six projects that the study focused on are:

- The Hopefield Wind Farm in Western Cape Province, South Africa
- The Mwenga Wind Farm in Iringa Region, Tanzania
- Le Parc Eolien Taiba N'diaye, Région de Thiès, Senegal
- The West Bakr Wind Farm, Red Sea Governorate , Egypt
- Le Parc Eolien Nassim Koudia Al Baida, Région de Tanger-Tétouan-Al Hoceïma, Morocco
- The Lake Turkana Wind Farm, Marsabit County, Kenya

Figure 14: Location of the six sampled wind farms[20]

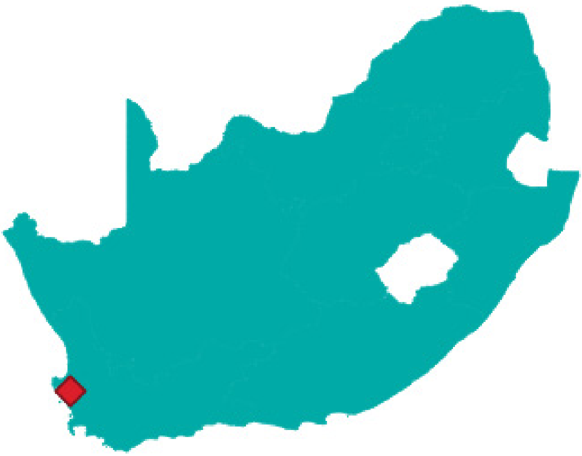
[20] Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by GWEC.

HOPE FIELD WIND FARM

Key Details

Capacity (MW):	66.6
Owner (s):	Umoya Energy (RF) Pty Ltd (Old Mutual, AIIM), Tomlo Commodities Pty Ltd and the Local Community Company
Developer (s):	Umoya Energy
Debt Provider:	Rand Merchant Bank
Project Cost (MUSD):	186.77
Annual Production (GWh):	176.6
Turbines:	37 Vestas V100 – 1.8 turbines of 1.8MW
Year of COD:	2014

Photo: Courtesy of Umoya Energy



Location: Western Cape Province, South Africa
(-33.093, 18.3987)

Enduring strength of local financing

First Wind Farm to reach COD under the REIPPPP. The project was funded by Old mutual, a local pension scheme and debt provided by the Rand Merchant Bank, a local bank. the developer of the project is also a South African company.

The project is now in its 9th year since COD and gives a good example of local participation in ownership of wind farms in Africa. The local community also has a direct stake in the project further cementing local participation. The involvement of local communities in ownership of wind farms is widespread in South Africa and Hopefield is among the first to adopt this model.

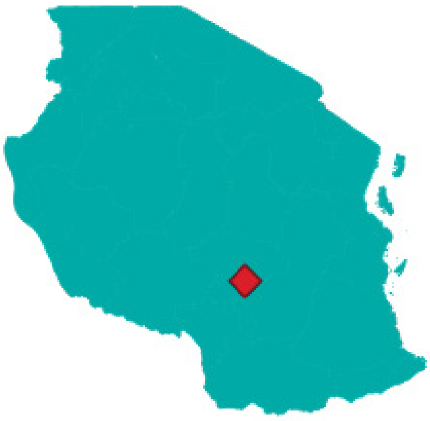
Other Statistics

Households Powered:	49,000
Employment (Construction):	100
Employment (Operation):	20
Abated Tonnes CO2/annum:	3,321

MWENGA WIND FARM

Key Details

Capacity (MW):	2.4
Owner (s):	Mwenga Hydro Limited
Developer (s):	Rift Valley Energy Group
Debt Provider:	Trade and Development Bank (TDB) and Renewable Energy Perfomance Platform (REPP)
Project Cost (MUSD):	4.1
Annual Production (GWh):	7
Turbines:	3 Enercon E53 turbines of 0.8MW
Year of COD:	2020



Location: Iringa Region, Tanzania (-8.21213, 35.663167)

Other Statistics

Households Powered:	5,500
Employment (Construction):	50
Employment (Operation):	7
Abated Tonnes CO2/annum:	3,321

Photo: Courtesy of Rift Valley Energy Group

Supporting the grid via hybridisation

The Mwenga Wind Farm is the first wind projectinstalled in the United Republic of Tanzania.The wind farm was constructed to ensure adequatesurplus generation capacity is always available to supply the rapidly growing Mwenga Hydro rural distribution network demand across the full calander year.

This rural network has been traditionalluy supplied by a 4MW hydro plant (since 2012), but in 2018 the continued growth of the rural network's energy appetite was projected to soon exceed the available

dry season generation capacity of the hydro (especially during the evening peaks). As the wind in this area blows hardest both in the dry season, and in the evening hours, the wind farm provided a logical and natural hybrid generation solution.

The wind farm layout has been designed to accomodate a maximum of 4MW of installed capacity (5 turbines), it was elected to initially install the first 3 turbines (2.4MW of generation capacity), as this better

matched the projected network requirements over the mid term. The remaining turbines will be installed once the rural network demand has increased sufficiently to justify the installation.

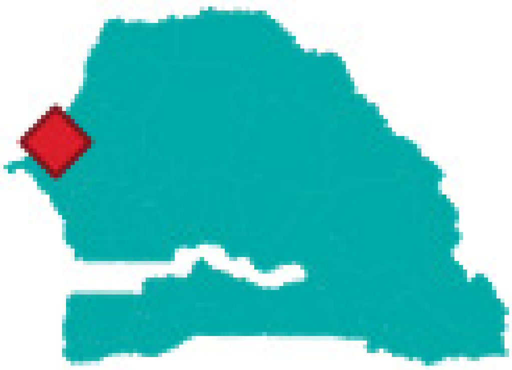
An 'easier to build' solar solution was initially considered, but quickly discarded as inappropriate to deal with the evening demand of the rural network.

PARC EOLIEN TAIBA N'DIAYE

Key Details

Capacity (MW):	158.7
Owner (s):	Lekela Power (Infinity Power)
Developer (s):	Lekela Power
Debt Provider:	United States International Development Finance Corporation (DFC)
Project Cost (MUSD):	330.9
Annual Production (GWh):	450 46 Vestas
Turbines:	V126 turbines of 3.45MW
Year of COD:	2020

Photo: Courtesy of PETN



Location: Région de Thiès, Senegal (15.065404, -16.89725)

Other Statistics

Employment (Construction):	600
Employment (Operation):	24
Abated Tonnes CO2/annum:	300,000

Breaking the regional glass ceiling

PETN is the largest wind farm in West Africa. It has increased the generation capcity of Senegal by 15%. PETN is a landmark project that provides much needed clean and economically priced energy into the rapidly expanding local grid system operated by Senelec (public electricity company). The project is Senegal's first utility-scale wind energy project and aligns with the Government of Senegal's strategy of increasing clean electricity production and diversifying Senegal's energy mix.

The project is also helping reduce the cost of electricity generation in Senegal.The project benefits from strong government and local community support and has implemented an extensive social investment programme. Up to US$20 million will be invested in the Taiba Ndiaye community throughout the lifetime of the windfarm.

The Taiba Ndiaye community also continues to benefit in terms of improved skills and knowledge, leading to better future employment prospects for community members. Several community projects have already been completed, in three areas: education and skills development, economic empowerment of women, and energy, environment and climate change.

WEST BAKR WIND FARM

Key Details

Capacity (MW): 250
Owner (s): Lekela Power (Infinity Power)
Developer (s): Mainstream Renewable Power andLekela Power
Debt Provider: EBRD, IFC and OPIC (now DFC)
Project Cost (MUSD): 186.77
Annual Production (GWh): 1000
Turbines: 96 Siemens Gamesa SG 2.6-114 turbines of 2.6MW
Year of COD: 2021

Photo: Courtesy of West Bakr wind farm

Location: Red Sea Governorate, Egypt
(28.554026, 32.822362)

Investing Big in Transition

The West Bakr wind farm increases Egypt's wind energy capacity by 18% and will be a key pillar of Egypt's renewable energy ambitions. The plant benefits from the world class wind resources of the Gulf of Suez and is the next phase in Egypt's renewable transition, leveraging private finance and expertise to build new, highly competitive, clean generating capacity.

The project builds on the success of Egypt's 1.5GW Benban solar complex, now nearing completion, which is also privately financed and for which EBRD is the largest financier. Reforming the energy sector is at the centre of Egypt's economic transition. The country has enormous potential in renewable energy, particularly wind and solar.

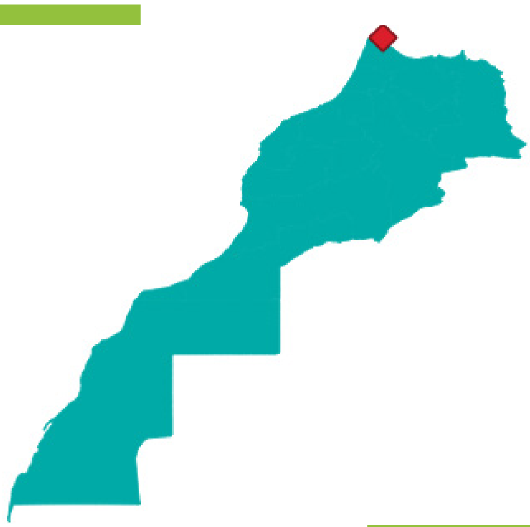
Other Statistics

Households Powered: 350,000
Employment (Construction):
Employment (Operation):
Abated Tonnes CO_2/annum: 550,000

PARC EOLIEN NASSIM KOUDIA AL BAIDA

Key Details

Capacity (MW):	54.6 repowered to 100
Owner (s):	EDF, PARIBAS and GERMA
Developer (s):	Compagnie Eolienne du Détroit (CED): ENGIE Green and MASEN
Debt Provider:	European Investment Bank (EIB)
Project Cost (MUSD):	52
Annual Production (GWh):	226
Turbines:	91 Vestas V42-600 and Enercon E-40 turbines of 0.6 M
Year of COD:	2000



Location[18]: Région de Tanger-Tétouan-Al Hoceïma, Morocco (35.806693, -5.462677)

Other Statistics

Households Powered:	420,000
Employment (Construction):	
Employment (Operation):	
Abated Tonnes CO2/annum:	235,000

Photo: Courtesy of Nassim Koudia Al Baida

Reinventing a Pioneer into a Colossus

The Nassim Koudia Al Baida project is amongst the earliest largescale wind projects in Africa. The original plant is set to be repowered and expanded. A repowering and extension program to 100 MW is currently underway by Masen and EDF Renewables This repowering will double the production capacity to 100 MW and later to a 200MW wind farm.

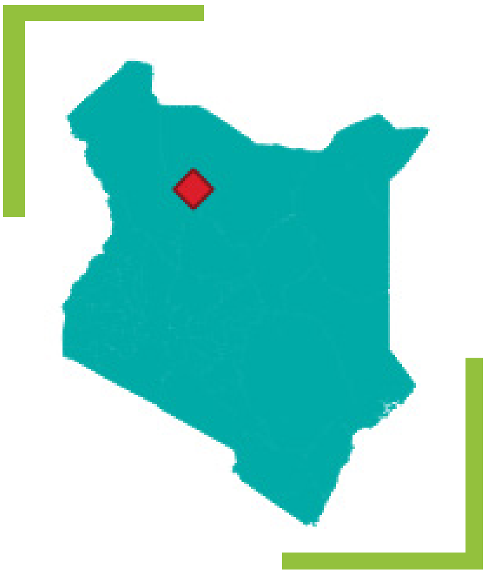
The project is financed by loans from national and international banks, namely: AttijariWafa bank, Banque Centrale Populaire, Bank of Africa, European Bank for Reconstruction and Development (EBRD) and Société Générale France. When it comes into operation, in the 2nd quarter of 2024, the annual electricity production of Nassim Koudia Al Baida will meet the consumption needs of around 420,000 households and will avoid the emission of the equivalent of 308,000 tonnes of CO2. per year.

[16]Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by GWEC.

LAKE TURKANA WIND FARM

Key Details

Capacity (MW):	310.25
Owner (s):	Lake Turkana Wind Power Limited
Developer (s):	Lake Turkana Wind Power Limited
Debt Provider:	African Development Bank, Standard Bank, Nedbank, European Investment Bank, PROPARCO, Netherlands Development Finance Company (FMO), East African Development Bank, Deutsche Entwicklungsgesellschaft and Eksport Kredit Fonden52
Project Cost (MUSD):	678
Annual Production (GWh):	1550
Turbines:	365 Vestas V52-850 turbines of 0.85MW
Year of COD:	2018



Location: Marsabit County, Kenya (2.6447, 36.7378)

Photo: Courtesy of LTWP

The giant that keeps giving

The Lake Turkana Wind project is the biggest single wind farm in Africa and accounts for 17% of Kenya's installed capacity. Since inception, LTWP has been dedicated to ensuring that the local communities benefit from the Project. As part of this commitment, LTWP established Winds of Change (WoC), through which LTWP undertake sustainable community development projects throughout the Project's Area of Influence (Laisamis Constituency). WoC is registered in Kenya as an NGO and has been operational since June 2015. The primary focus of WoC is to enhance access to education, health and water, as well as support miscellaneous community development activities.

Other Statistics

Households Powered:	1,500,00
Employment (Construction):	2,500
Employment (Operation):	329
Abated Tonnes CO2/annum:	736,615

[16]Disclaimer: This map is provided for illustration purposes only. Boundaries shown on this map do not imply any endorsement or acceptance by GWEC.

Chapter 5

BENEFITS OF WIND DEVELOPMENT

6.1. Socioeconomic Benefits

The development of the wind energy sector in Africa presents opportunities to impart socioeconomic benefits to households, communities, and countries. These benefits include employment opportunities leading up to and during the roughly 25-year lifetime of a utility-scale wind asset, clean power for households and industrial consumers, direct (foreign and local) investments , including in supply chain facilities. Figure 15 summarises the achievements so far with the approximately 9GW of identified projects.

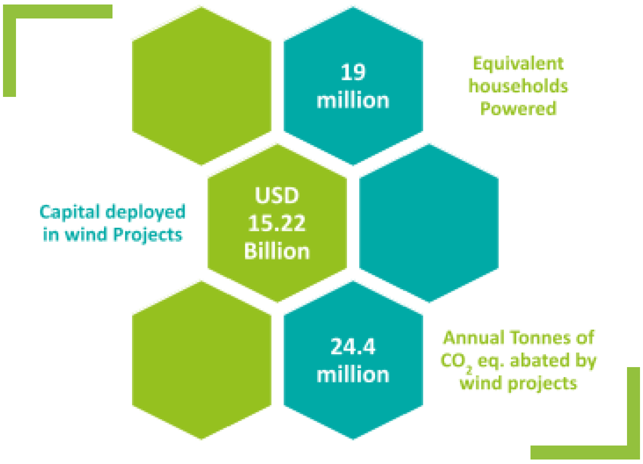


Figure 15: Summary of achievements of the wind sector in Africa

The d**eployment of wind energy in Africa has created 12,400 direct jobs during and after construction across 3,000 MW of projects identified in this study**. Some of the projects sampled are the Lake Turkana Wind Power Project in Kenya employing 2500 during construction and 329 during operation; the Parc Eolien Aftsati 1 in Morocco employing 600 during construction and 32 during operation; the Taiba N'diaye wind farm in Senegal employing 600 during construction and 24 during operation; and the Mwenga wind farm in Tanzania employing 50 during construction and 6 during operation. The total direct job creation from wind energy in Africa is several times higher given these projects are just a fraction of the total identified wind capacity of 9,000 MW, as of 2023. In addition to local job creation, wind energy also generates a number of additional benefits for countries in Africa.

6.2. Case for Local Manufacturing

Local manufacturing has been a desired outcome for many African countries looking to capture more value for their economies from the wind energy market. To assess the viability of local manufacturing an understanding of the current manufacturing ecosystem is important. Currently manufacturing hubs that service Africa exist in Europe and Asia with the additional option of the Americas. These hubs have various logistical and intrinsic (level of supporting industry development) advantages.

It is typical that the east and south of Africa is supplied from the Asia Pacific region while North and West Africa are supplied from continental Europe. The level of industrial development (particularly steel industry) of the country where the powerplant is located determines the viability of local sourcing of some components. Globally, the main turbine suppliers are Vestas, Siemens Gamesa, Goldwind, General Electric and Envision supplying more than 5GW in a year. Wind farms are mainly separated into five components being the tower, the nacelle, the blades, civil works, and balance of plant.

The nacelle is composed of various subcomponents that require an already existing strong (on standards and quality of supply) local supply chain that typically also supports various other electronics, electrical and allied industries. The balance of plant would require a similar environment to the nacelle. These two components are deemed harder to consider localisation in the current state of the African market.

The blade is less specialised but requires volumes and logistics to make a business case for manufacturing. The towers are made of steel and would need a well-developed steel industry that is already producing steel using similar processes. Civil works could benefit from locally supply where the appropriate quality of inputs such as steel reinforcement bars and cement are available in-country.

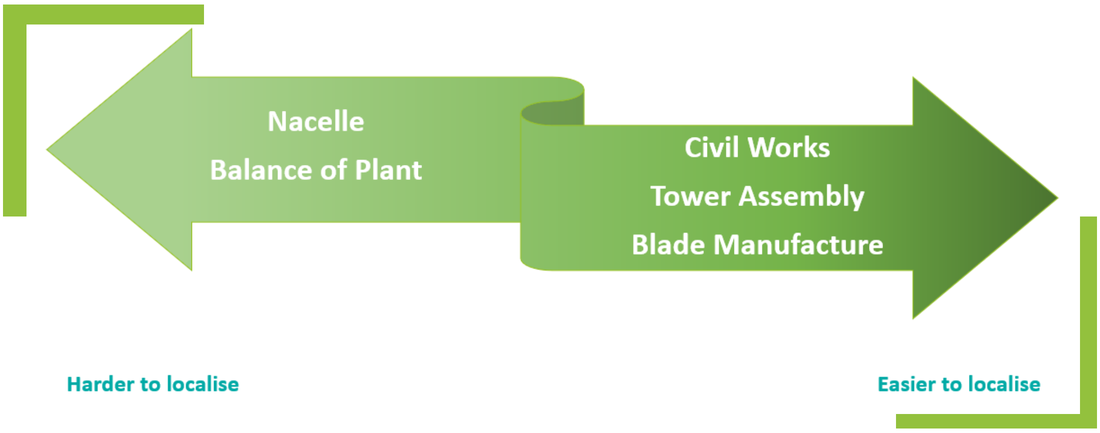


Figure 16: Ease of localising manufacture of wind energy converter components. Source: GWEC market intelligence 2023

For blade manufacturing to work a desired volume is necessary to support the economic operation of the manufacturing concern. GWEC estimates this at an annual market of **800 MW for at least 5 years** to justify a local manufacture facility. For this to be achieved, assuming a 50% stake for the local blade manufacturer, the total annual market would be at least 1600MW of wind projects annually. These numbers would imply 5 years continuous manufacturing for the plant and an **order commitment of 4000 MW** for the same product or its variants over the same period.

This market can be a consolidated pool where inland logistics allow movement of components from manufacturing facility to site. Any requirements for sea freight between African countries would expose the manufacturer to costs that may better be served from Asia, Europe or the Americas.`

Additionally, the ex-works cost of producing components will likely be less competitive to costs experienced out of the continent and particularly from Asia. This emphasises the need to have in place efficient land-based logistic connections between the manufacturing facility and the site. These include good rail and road interconnections, and presence of experienced freight and logistics companies active in the continent.

The rail and road network linking Southern, Eastern, lower Central Africa and Eastern part of Northern Africa suggest that such a cluster could form a possible market. This road and rail link could stretch through Egypt - Sudan - Ethiopia, Eritrea & Djibouti -Kenya, South Sudan, Uganda, Burundi, Rwanda & E. DRC – Tanzania – Malawi, Zambia, DRC & Angola-Zimbabwe & N. Mozambique - Botswana & Namibia - to South Africa (including Lesotho, Eswatini and S. Mozambique).

Figure 17: Map of Africa highlighting a possible common market for wind commodities.

The technical potential for wind in the key markets sampled in this region (with 7.5 m/s wind speeds) as estimated by the IFC in 2020 was 8733 GW. This number climbs to 9972 GW when Somalia is included. The consolidation of these markets into a pool would rely on there being minimal barriers of movement of manufactured products and skilled labour across national boundaries. This has been the goal of active regional unions such as the Common Market for East and Southern Africa (COMESA) and more recently the Africa Continental Free Trade Area (AfCFTA).

Should the free trade area be activated, and any missing road links completed, this region would present an interesting opportunity for blade and tower manufacturing.

In this region, South Africa and Egypt serve as examples for markets where the supporting industries are sophisticated enough to support tower and blade manufacturing. In South Africa, the establishment of the REIPPPP program with a predictable pipeline for wind farms contributed to thesetting up of a blade manufacturing facility. The first round of the auction program saw 632MW awarded.

The I-WEC facility set up with a target of producing 200 units per year that would be supplied to the South African market as well as the wider African market. Similarly, turbine tower manufacturing facilities were set up in South Africa by a south African engineering firm DCD and Gestamp wind from Spain.

These localisation efforts were influenced by the local content requirements for the REIPPP program that provided the incentive for projects to source components locally. The establishment of local manufacturing was aimed at boosting the supply of jobs.

Local content levels grew from 27% in the first round to 45% in the fourth round of auctions. Delay in the subsequent rounds meant that the factories had unreliable markets and had to be shut down.

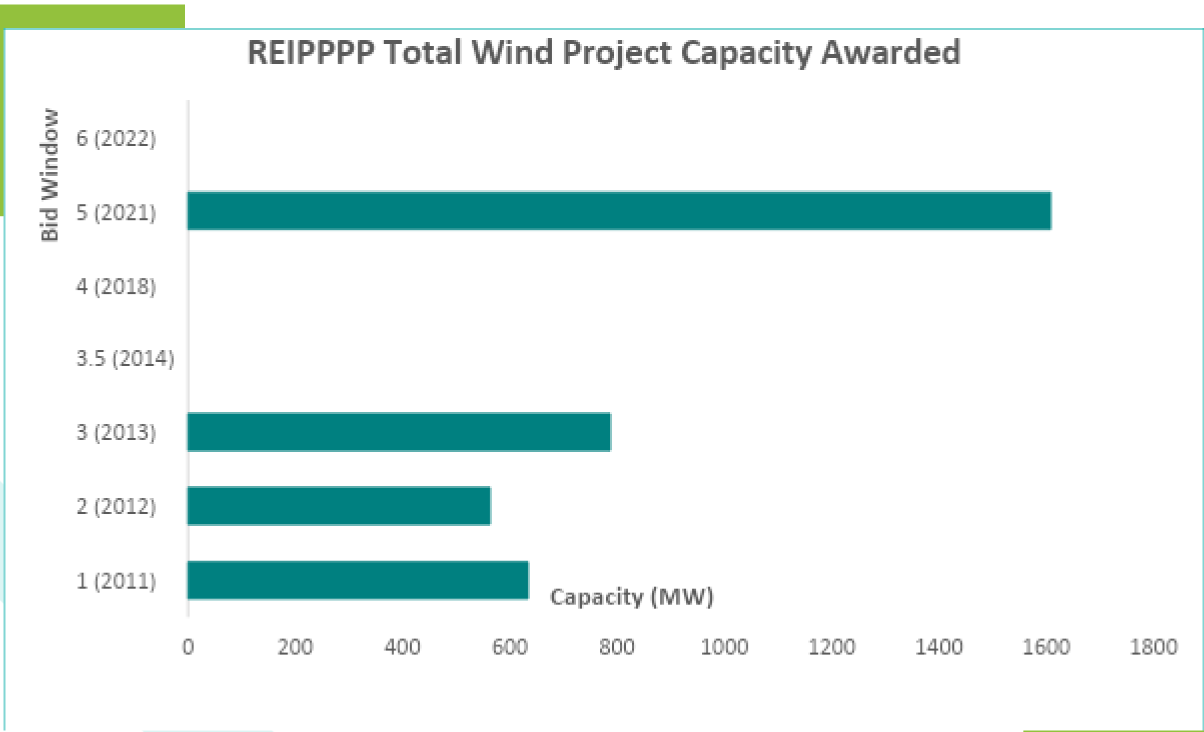


Figure 18: Wind Capacities awarded in the REIPPPP rounds. Source: GWEC market intelligence 2023

In Egypt Elsewedy towers[24] established in 2008 can produce 200 towers per year and is diversified to support other related industries such as supply of storage tanks, silos, bins, hoppers, and pipes. The Elsewedy group also manufactures electric cables that could be applied in the balance of plant. The facility in El Ain El Sokhna capitalises on both local and foreign markets supplying the European and American markets. Additionally, wind turbine blade manufacture facilities were established in Ain Sukhna by Siemens Gamesa with an annual capacity of 340MW of turbine blades targeted initially at the Egyptian market and then for export. This factory was reported to have the potential of providing 1000 jobs and was backed by Egypt's ambitious diversification into renewable energy that saw projects such as West Bakr, Jabal al-Zeit, Ras Gharib, Gulf of Suez and Zafarana projects all of which have Siemens Gamesa turbines.

Siemens Gamesa also built a blade manufacturing facility in Morocco to supply Europe ,Africa and the middle east in Tangier. The proximity of Morocco to continental Europe, the middle east market and the country's own wind pipeline supported the establishment of this facility. This has seen Siemens Gamesa turbines installed in multiple projects including Larfarge wind farm, Midelt, Aftissati and Oualidia.This factory was however discontinued due to commercial reasons in 2022.

[24] Elsewedy Towers Profile https://www.elsewedyelectric.com/media/2446/wind-tower-brochure.pdf

Chapter 6

OVERVIEW OF WIND ENERGY DRIVERS

7.1. Today's Drivers

According to IRENA the development of the wind sector in Africa has been tied to policy interest and the geography of the wind resources. African countries are choosing to implement wind farms to achieve their climate goals and power supply needs.

7.1.1. Wind for Additional Capacity and Energy

Wind has contributed to the growth of installed capacity and available energy to African grids that have capacity and energy constraints. **The Lake Turkana wind farm contributes 17% of Kenya's installed capacity while the Taiba N'diaye wind farm increased Senegal's installed capacity by 15%.** Wind farms provide needed capacity and energy to increase the level of electricity supply in the countries looking to expand supply and access to electricity , with the added benefit of supplying renewable power.

Wind for Grid Stabilization

Wind has been deployed together with other technologies to stabilise grids by complementing other supply technologies.

Wind to firm up solar

Wind and solar show complementarity with the daytime dips in wind being complimented by peaks in solar and loss of solar in the night matched with strong wind supply in the night. This has seen hybrid projects developed to improve the profile of supply from powerplants based on either wind or solar. Wind will continue to be applied in the stabilisation of solar installations. Wind has higher capacity factors and supplies at night when solar is unavailable. The CrossBoundary Energy hybridised (wind-solar-battery) Ehoala project in Madagascar is a striking example. *Figure 19* shows the Ehoala project. The project supplies power to Rio Tinto's the QIT Minerals Madagascar near Fort Dauphin as located in *Figure 23*.

Figure 19: CrossBoundary Energy's QMM hybridised project. Source: GWEC market intelligence 2023

The project consists of 8MWp solar PV and 16MW wind turbines with an 8MW battery storage system; the solar and battery portions of the grid are operational, with the wind component under construction. The project will displace generation from HFO that was supplied by the state-utility JIRAMA. QMM will export 30% of the generation to the local grid further supporting supply to the 67000 people in Fort Dauphin. The project will reduce the overall carbon intensity of QMM's grid by 60% and save 40,000 tonnes of CO2 equivalent emissions per annum. The project will create approximately 80 local jobs during construction and 5 during operation.

Wind Hybridisation with Hydro

Hybridisation has also been undertaken by combination with hydro as in the 2.4MW Mwenga wind Farm in Tanzania depicted in *Figure 20*. The wind farm is installed in an isolated grid running primarily on a mini-hydro plant of 4 MW. The farm supports supply during periods of low hydrology, as is the case on a large scale with wind and hydropower complementarity in Latin American countries like Brazil, Uruguay and Costa Rica.

Figure 20: The Mwenga wind farm, supporting Mwenga Hydro. Source: Rift Valley Energy. Source: GWEC market intelligence 2023

7.1.3. Wind for diversification of supply

The generation mix in most African countries is dominated by hydropower plants, which can leave countries vulnerable to periods of drought and to aging hydropower infrastructure. Some large economies that are reliant on thermal plants (coal and natural gas) for the bulk of their generation are opting to increase renewable energy capacity to mitigate the economic risks of depending on imports of fossil fuels, particularly given the recent price volatility of international gas markets. Greater diversification of supply and lower dependency on imported fossil fuels increases the security and resilience of a country's energy mix. Egypt whose grid has historically been reliant on natural gas as depicted in *Figure 21* is currently installing largescale wind and solar and **targets to reach an installed capacity of 42% renewable energy by 2030** according to its nationally determined contributions (NDCs).

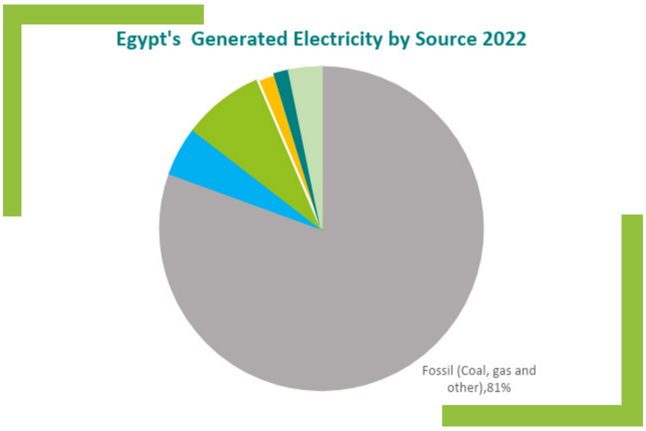


Figure 21: Egypt's generated electricity (TWH) by source. Source: Ember Climate

South Africa with a generation mix that is heavily reliant on coal as in *Figure 22* has also been pursuing renewable energy, now having concluded its 6th round of renewable energy auctions. **As of 2022 the country's installed capacity of 54GW comprised 3.4GW** wind, 2.3GW solar PV, 0.5GW concentrated solar power, 0.6GW hydro, 39.8GW coal and 3.4GW diesel

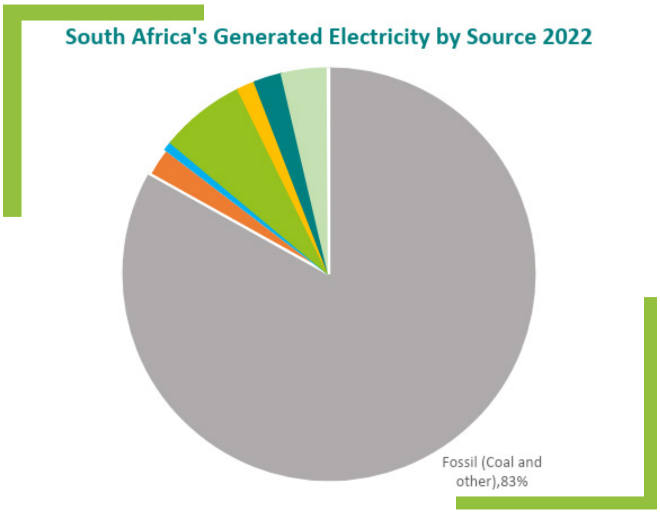
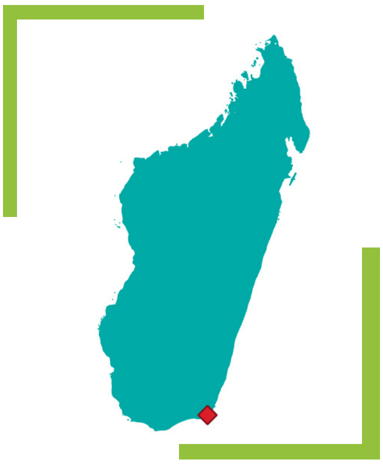


Figure 22: South Africa's generated electricity (TWH) by source. Source: Ember Climate

7.1.4. Captive supply to Industry

Industries are choosing to install their own wind farms to supply their power needs directly. This motivated by cost, and a need to reduce the carbon footprint of their products. This trend has been the case in Morocco with Lafarge, with Rio Tinto minerals in Madagascar and in South Africa where Seriti Green is developing a 500MW wind farm to power coal mining, with many other examples in other markets. The South African case will be buoyed by the removal of capacity cap on captive power supply that happened in mid-2022.

Ehoala Wind Farm, Madagascar



Project Size: 12MW
Location: Ehoala Port
Owner: Rio Tinto Minerals
Developer: CrossBoundary Energy
Expected COD: 2023
Type: Onshore Wind

Figure 23: Ehoala Wind farm (project also includes solar and battery storage)

[21]Statistics of utility-scale power generation South Africa, CSIR

This trend of wind farms being installed at a captive site of a commercial or industrial entity will continue as companies look to secure clean energy supply, reduce costs and decarbonise their footprints. Further, the continued expansion of wheeling arrangements will allow for more offsite generation. Wheeling is already in place in the southern African power pool, and regulations are under development in other pools and individual markets such as Kenya.

7.2. Tomorrow's Drivers

7.2.1. Repowering of wind farms

As the installed wind farms in Africa approach the end of their commercial and technical lives, and wind turbine technology continues to improve, there will be a need to repower sites with strong wind technical resource. **From the commissioning dates of the identified projects there will be a peak of repowering activity in Africa between 2034 and 2038, as many power plants reach the end of contractual life.** The majority of the turbines installed in Africa before 2019 were sub-2MW turbines. Today single onshore turbines of 6 MW are available. Repowering offers an efficient pathway for countries to maximise productivity and socioeconomic benefits from sites already designated for wind power production. Replacing older models with newer turbines that have larger power ratings, greater resilience to environmental elements and material upgrades can unlock a higher energy yield, increase resilience to environmental elements, lower downtime periods and operational expenditures, and improve cost reduction for offtakers, consumers and asset owners and operators. This may also be achieved on a fast-track basis, given the sites have already been permitted for wind farm use.

Figure 24: Kouda al Baida and La Perriere wind farms. Source: MASEN[27] and Total Energies[28]

This is already the case for the **Kouda Al Baida wind farm in Morocco which is to undergo repowering from a 54MW wind farm to a 120MW wind farm and later to a 200MW** wind farm. T**he La Perrière wind farm in Reunion was also repowered from a 37-turbine wind farm of 10MW to a 9-turbine wind farm** of 18MW in 2022 by TotalEnergies.

Green Hydrogen

Green hydrogen has been identified as having the potential to decarbonise hard-to-abate sectors of the economy that rely on hydrogen. These include ammonia production, methanol production and Direct Reduction of Iron (DRI) in the steel industry. The IEA[29] identified these as the main uses of hydrogen comprising 34 million tonnes (Mt), 15Mt and 5Mt respectively of the total 94Mt global demand for hydrogen. Hydrogen can also be used to produce chemicals, for fuel cells in electricity storage and for long-haul transportation. *Figure 25* describes the steel direct reduction iron process and the ammonia value chain. The hydrogen used has traditionally been supplied from fossil fuel sources.

[27] https://www.masen.ma/en/photo-library/wind-power-projects
[28] https://totalenergies.com/system/files/documents/2023-03/Sustainability_Climate_2023_Progress_Report_EN.pdf
[29] Global Hydrogen Review 2022

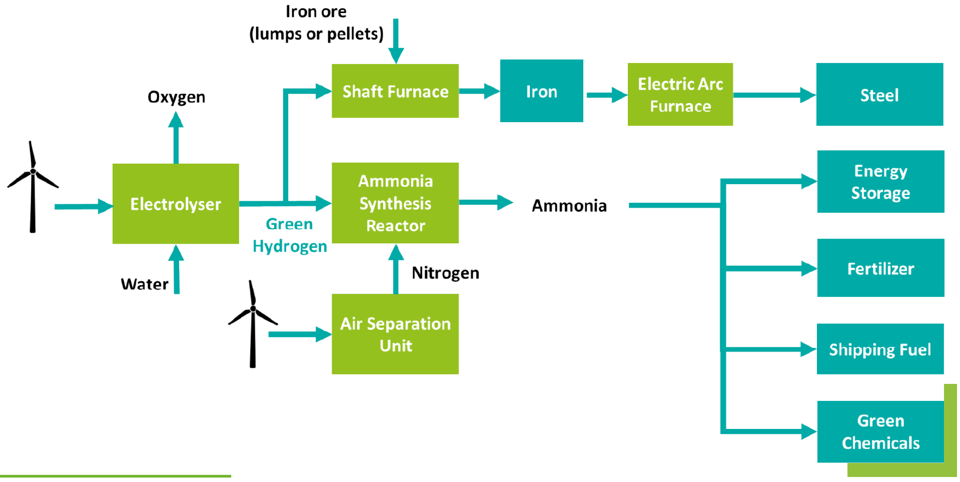


Figure 25: Green hydrogen steel and ammonia production process diagram

Green hydrogen could substitute fossil fuel-based feedstocks in energy end-use sectors where electrification of industrial process is not possible or uneconomical. These include processes which require intense heat, or transport segments such as long-distance shipping and aviation, where energy needs to be stored, transported and deployed efficiently. There is a huge demand by companies to secure supplies of green hydrogen by signing strategic partnerships.

Globally the IEA estimated 3.5GW of potential power generation capacity dedicated to green hydrogen supplying an overall hydrogen demand of 115 Mt. The International Energy Agency (IEA) estimated **that by 2030, globally, 9-14 Mt of hydrogen would be produced via electrolysis with a corresponding electrolyser capacity of 134 to 240 GW.** To achieve a truly green hydrogen sector which is in line with decarbonisation and energy security goals, a ramp up of renewable energy installed capacity will be required. Wind is well placed to take a leading role owing to the relative abundance of underutilised high-quality sites such as in Egypt and Kenya, that offer higher capacity factors compared to solar. Wind provides a good opportunity to achieve firmer capacity as will be required for green hydrogen production. There is interest in development of green hydrogen from wind resources in Africa.

There have been announcements of big wind farms in Africa that would be developed with the intention to focus on the production of green hydrogen. Egypt and Namibia have been at the forefront of these developments with announcements as in Figure 26Figure 26. South Africa has also had announcements of renewable energy projects related to green hydrogen production such as the 117MW SSC group wind farm planned for Jeffreys bay.

Announced Wind project(s)

- 4.6GW Fortescue Green Hydrogen wind farm
- 2.82GW ReNew Power Green Hydrogen Wind Farm
- 4.5GW Globeleq Green Hydrogen Wind Farm
- 2GW Masdar Green Hydrogen Wind Farm

Announced Wind project(s)

- 2.5GWSCDI Green Hydrogen Wind Farm

Owned by Hyphen Hydrogen energy. Plans to produce 350 tonnes/annum of green hydrogen and 2 million tonnes of ammonia per year[30].

Figure 26: Announced wind farms tied to green hydrogen production in Egypt and Namibia.

[30] Southern Corridor Development Initiative (SCDI) Namibian Green Hydrogen Project. Can be accessed at https://hyphenafrica.com/projects/

African countries are endowed with good renewable energy resources, arable land, and iron ore. These could be exploited to solve food security, develop manufacturing as well as explore export markets for ammonia and other processed products. The production of steel using green hydrogen based DRI is however novel with one demonstration plant successfully producing fossil-free steel[31]. This success has led to great interest amongst steel manufacturers to implement commercial scale plants and secure renewable energy sources.

7.2.3. E-mobility

The e-mobility market in Africa is diverse, with wide-ranging levels of advancement related to the overall development of a specific economy. For mass transportation, electric trains and buses are being adopted in Africa to wean countries from fossil fuel imports and reduce emissions from the transportation system. Electric buses are also being adopted across the continent, especially in countries reliant on import of fossil fuels. At another level are the two-wheeler and three wheelers that are predominant in much of Africa and serve as main forms of transportation in rural areas of Africa. The electrification of these is already underway in Ethiopia, Togo, Kenya, Rwanda, Uganda, Burundi, Madagascar, Sierra Leone, and Tanzania.

Figure 27: A K6 electric bus in Nairobi. Source: BasiGo (www.basi-go.com)

This **new demand from e-mobility and the need to ensure low-carbon transportation is enhanced will send a demand signal for more wind power** to be developed in the continent. Wind resource matches well with the nighttime charging of e-vehicles due to the higher resource availability at night often at times of low demand on the grid. This alignment puts wind at a better position among renewables to supply charging power for the transport sector.

Figure 28: The Zembo electric motorbike. Source: Zembo website - www.zem.bo

[31] Swedish Hybrit project, a joint venture of Vatenfall (power producer), LKAB (mining group) and SSAB (Steel manufacturer). https://www.hybritdevelopment.se/en/we-have-done-it/

Regional Power Markets

The **integration of markets at a regional level will allow for development of wind plants in high potential countries for trade with high demand countries** allowing better integrated use of resources available in the region. The development of regional power trading markets, with appropriate structures and rules, across these power pools will increase the attractiveness of domestic supply of wind and other renewable energy, as offtakers will increasingly seek zero-carbon forms of energy. Countries with a surplus of renewable generation at times where the wind and sun are strong, or even having employed short-duration or long-duration energy storage technology to capture renewable electricity, can generate economic gains by selling excess power across borders. This would also reduce the risk of curtailment of renewable power and improve the overall business case for investment in renewables in the country.

The growth of electricity demand in tandem with population and economic growth in Africa will open possibilities of trade in Africa. The African Union launched the Africa Single Electricity Market (AfSEM) in 2021 looking to interconnect the 55 African countries and allow for trade in electricity. There is a need to build regional interconnectors within and across the power pools of Africa to enable trade. A further step is the development of market frameworks across the region allowing for trading of long-term and short-term capacities both bilaterally and in wholesale markets.

The African market has five active power pools COMELEC[32], WAPP, CAPP, EAPP, and SAPP as depicted in Figure [29] with some more active than others. There are also overlaps with some countries being members of more than one pool.

African Power Pools28[33]

- The SAPP is the most advanced of the power pools with an active electricity market bilateral and short-term trading enabled.
- COMELEC follows with multiple interconnections but not yet trading.
- WAPP has planned interconnection projects.
- EAPP has 5 active interconnections currently trading bilaterally.
- CAPP is lacking in large infrastructure and demand.

The South African Power Pool (SAPP)

The North African Power Pool (COMELEC)

[32] Comité Maghrébin de l'Electricité
[33] Journeying towards and African Electricity Market. Https://www.afronomicslaw.org/category/analysis/journeying-towards-african-electricity-market-international-economic-law

The West African Power Pool (WAPP)

The Eastern African Power Pool (EAPP)

The Central African Power Pool (CAPP)

Figure 29: The Power Pools of Africa. Source: GWEC market intelligence 2023

For the East African power pool electricity from wind can be produced from countries such as Sudan with high potential in wind and interconnected to Egypt and sold through the pool to Egypt or vice versa given the high potential for Wind in both countries. The integration of markets at a regional level will allow for development of wind plants in high potential countries for trade with high demand countries allowing better use of resources available in the region.

Chapter 7

CONCLUSIONS

This report built a database of the wind projects that are announced, in operation, or under construction in Africa. A total of 223 projects were identified representing an installed capacity of 67 GW. These projects are spread across the continent with concentration in Morocco, South Africa, Egypt, Ethiopia and Kenya.

The total technical potential for wind as identified by the IFC is 34700 GW. Each of the five regions of Africa has significant potential with North Africa having the highest potential at 18GW. This potential shows that with the right regulatory environment and grid conditions, wind can play a significant role in electricity supply in the continent.

The identified installed and projects under construction account for an estimated USD 15 billion in investments and 24.4 million tonnes of CO2 abated annually.

Localisation has also begun to take root in the wind industry with local funds (pension schemes and banks) being invested in projects. This trend is apparent in South Africa and increasingly in Morocco. Community owned projects and projects partially owned by local development companies are also noted. Though there is a push for more localisation of manufacturing there will be a need to develop an 800MW a year market for at least 5 years to justify local manufacture of blades. The nacelle and balance of plant are more complex and may still require manufacturing in more diversified economies.

Overall, wind is deployed to contribute to countries' reduction in carbon footprint, to reduce the cost of supply, to increase available energy capacity in grids, to diversify supply, and to captively supply industries. Green hydrogen, repowering, e-mobility and activation of regional power pools are seen as the future areas from which demand for new wind capacity will emerge. With so much untapped potential, wind will continue to play a big role in Africa's electricity supply for the foreseeable future.