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Storage Wind Power In Upper Reservoir Method And Environmental Obstacles In North Africa

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***Abstract**:*
This paper aims to explore a renewable energy storage solution suitable for a specific region in the African continent. The discussion begins with an Applied examples of artificial lakes for constructing upper reservoirs Additionally, we will delve into the Topography in north Africa and Economically viable winds in North Africa. The paper will also provide insights into the feasibility study of wind-assisted pumped storage for hydroelectric power generation in North Africa.
Finally, it will address the environmental impacts of the project, focusing on the location of wind turbine field construction and their effects on bird migration routes, as well as the potential adverse effects on the health of residents living in proximity due to noise pollution. Furthermore, the paper will examine the impact on groundwater in the event of seawater leakage from the upper reservoir and its consequences on marine currents and marine organisms during water withdrawal and storage.

***Keywords**: wind turbines, North Africa, Storage power, environmental obstacles.*

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I. Introduction

The turbulent increase in the consumption of electrical energy generated from renewable sources has made major companies invest in producing the largest amount of renewable sources of energy, of which wind is considered the largest part in this approach to industry. Although the most important source of renewable energy, which is wind, is facing the obstacle of storing it and increasing reliability in Relying on this type of renewable energy, artificial lake projects must be established as a source of energy storage to overcome the obstacle of fluctuation in the intensity of wind gusts and consumption [1].

North Africa is well-known for its abundant renewable energy resources, particularly solar and wind power. While solar energy has been extensively harnessed in the form of vast solar farms, the potential for wind power remains largely untapped. This presents a significant opportunity for the development of wind power in North Africa, especially in countries like Libya, Morocco, Tunisia, Algeria, and Egypt [2].

It will examine existing wind power projects and highlight the potential for energy storage solutions to enhance the reliability and efficiency of wind energy production. Moreover, it will discuss the - environmental benefits of such integration, emphasizing the role of wind power storage in driving sustainable development in North Africa.

This paper aims to highlight the transformative potential of wind energy storage in North Africa, as well as the obstacles facing this type of project, such as environmental obstacles represented by soil pollution, noise [8], changing bird migration paths, and the impact on the properties of seawater drawn from sea currents and organisms, and to inspire further research and investment in this field [5].

II. Material And Methods

Artificial lakes

Applied examples of artificial lakes

Figure. 1 shows artificial lakes

Figure. 2 shows Coastal artificial lakes

Figure. 3 shows Artifical lake on river side

Topography in north Africa

As the position of the artificial lake increases above sea level, or the difference between the levels of the two lakes, this leads to an increase in the storage capacity for potential energy. Therefore, the importance of this depends on the topography of the earth. The following figure shows the topographic distribution in the North African region.

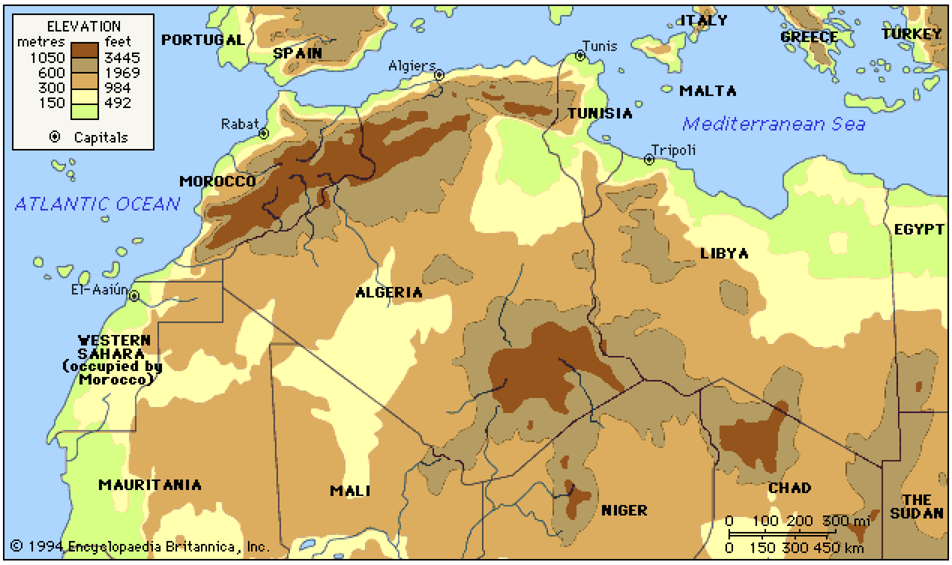

Figure. 4 shows Topography in north Africa

Economically viable winds in North Africa

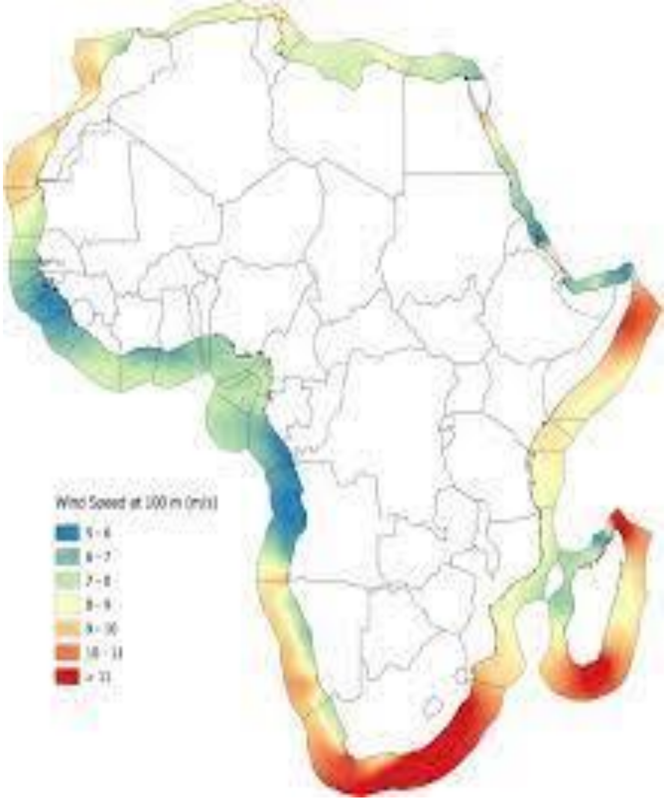

Figure. 5 shows Economically viable winds in Africa

Environmental effects

Marine currents in North Africa

Pumping, withdrawing, and storing seawater in an overhead tank in the form of potential energy to store the electrical energy generated from a wind energy project has no effects on marine life and sea currents for two reasons. The first is that the water withdrawn is close to the shore and not from the depths, where there is a great diversity of living organisms. The other reason is that there is no There is no thermal or chemical treatment so that there is no loss of the properties of the drawn water.

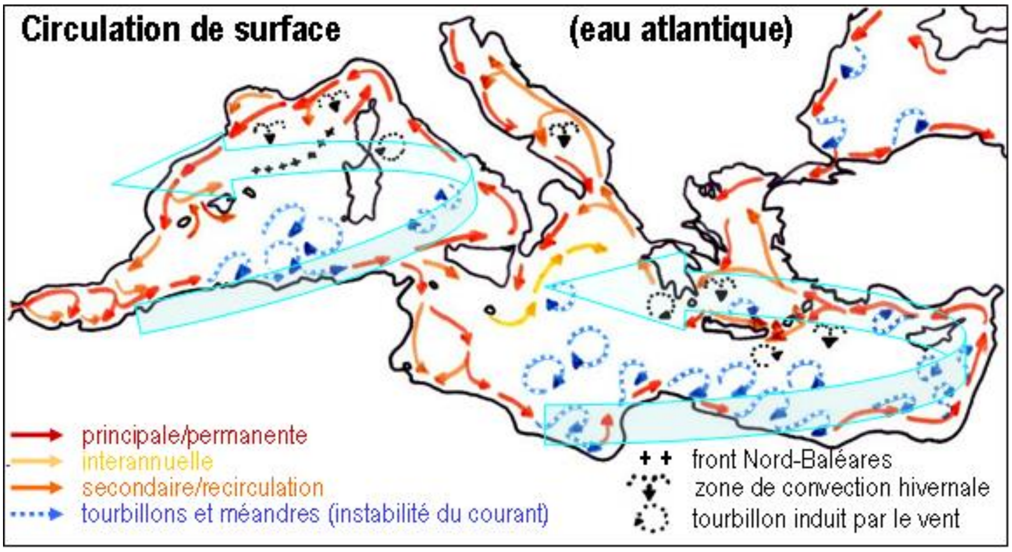

Figure. 6 shows Marine currents in the Mediterranean-Sea

Bird migration lines in north Africa

Wind turbine farms are established where the paths of wind currents are abundant, but this intersects with the migratory routes of birds that exploit those currents to provide energy during the wind. This led to a decrease in the number of birds that take these paths as a result of direct collision with turbines or avoiding those sites and changing paths, which led to another secondary result, which is a decrease in the number of birds of prey that depend on preying on native birds. Therefore, these negative effects are reduced by either establishing wind farms as far away from these paths as possible, or stopping them during the migration of these birds, or using a modern type of turbine that does not affect the migration of birds.

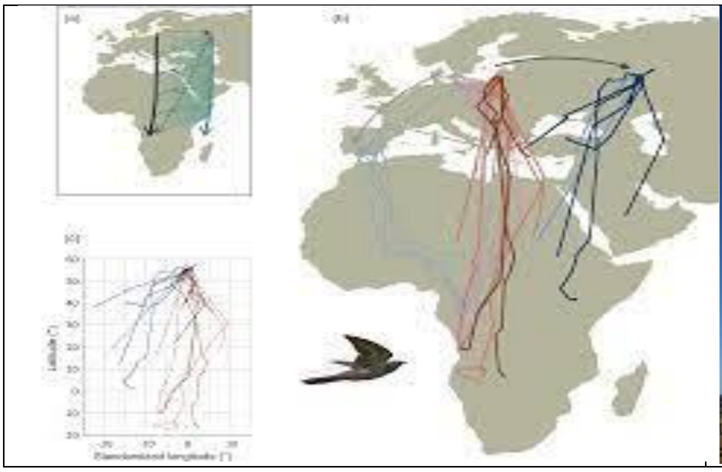
Figure. 7 shows Bird migration lines in Africa


Figure. 8 shows vertical wind turbine

Groundwater in north Africa

The idea of a project to store electrical energy generated from wind turbines by pumping seawater and collecting it in an upper tank in the form of potential energy. This may lead to impacts on the quality of groundwater as a result of water leaks in the upper reservoir, which affects the percentage of groundwater salinity, but because most of the groundwater In North Africa, there are strong sabkha waters, so seepage from seawater with an acidic pH is not considered a major threat in those areas, such as pollution.

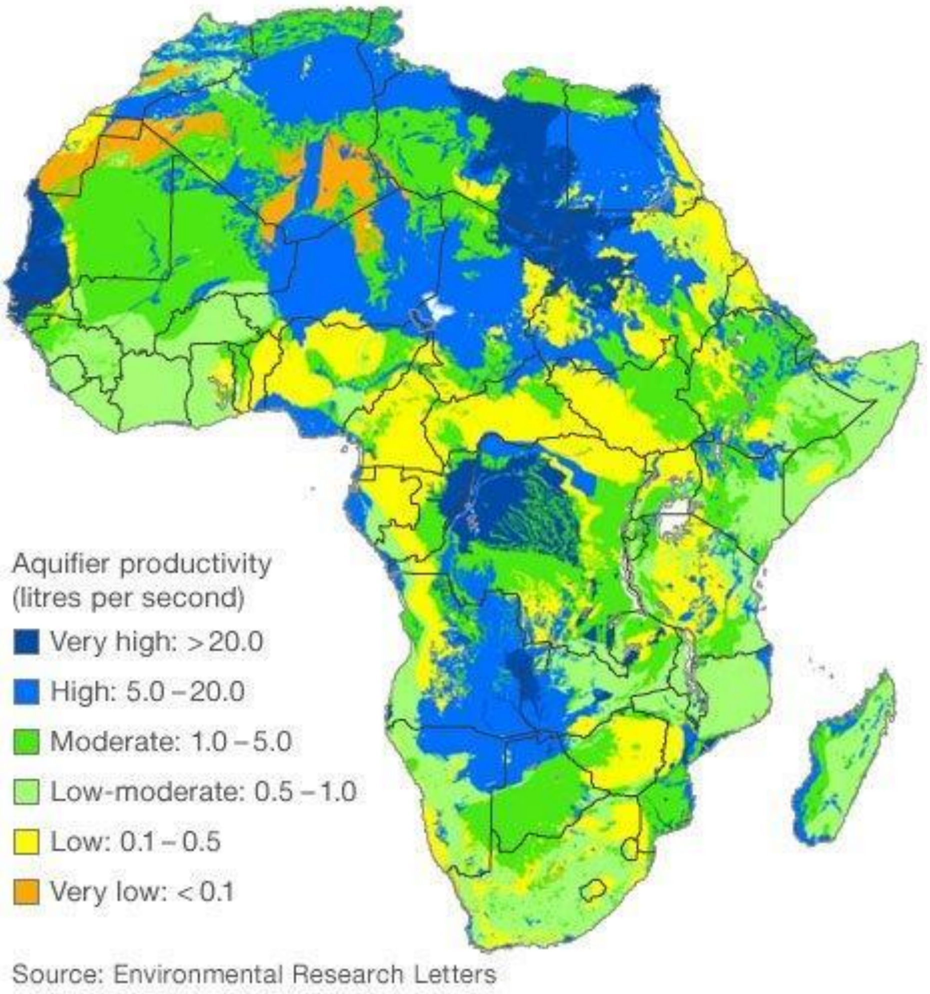

Figure. 9 shows Groundwater in Africa

Noise generated by wind turbines

There are no studies proving a link between what is known as wind syndrome and renewable energy generation projects from wind turbines, as they have been adopted as a reliable source of electrical energy generation. However, some countries have been obligated to maintain a safe distance between wind turbine fields and residential areas, such as an industrial zone if proven so. Any future studies related to health damage resulting from noise

III. Result

The following curves show the results of the research which are measured in four countries from group of six in north Africa during eight years, electricity final consumption electricity generation, total electricity installed capacity in wind and electricity installed capacity in hydropower these curves are designed excelprogram the following tables represent the database in which the grades are stored and designed by the same software . Measure were taken on 8 years from 2013 to 2020

. • The following tables contain the set of reading database for electricity final consumption Electricity generation, Total measured by (GWh) unit. Also, Electricity installed capacity in Wind Electricity installed capacity in Hydropower measured by (MW) unit.

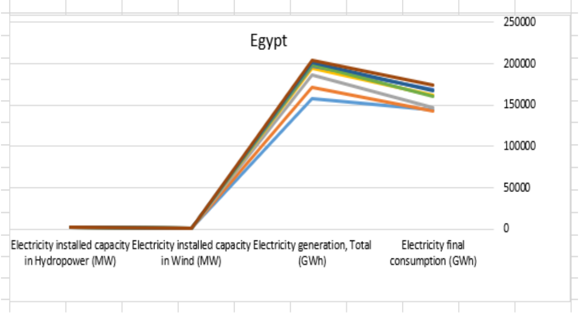

Figure 12 shows share of renewable energy compared to conventional energy in Egypt

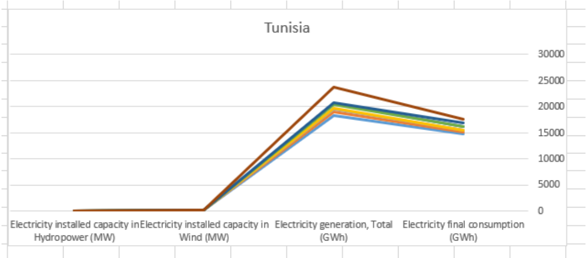

Figure 13 shows share of renewable energy compared to conventional energy in Tunisia

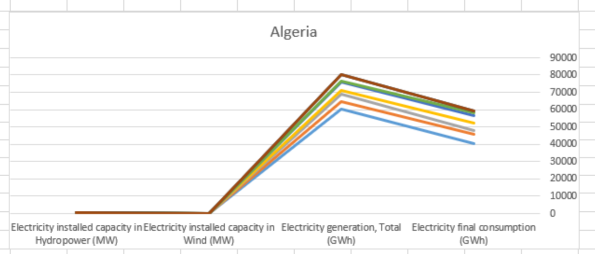

Figure 14 shows share of renewable energy compared to conventional energy in Algeria

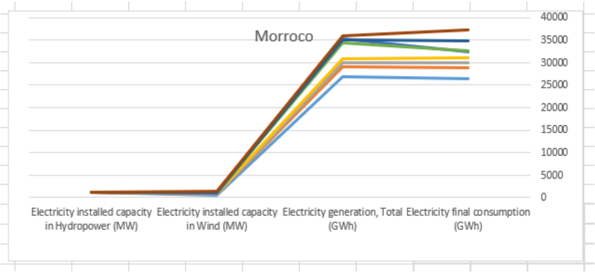

Figure 15 shows share of renewable energy compared to conventional energy in Morroco

	Egypt								
		2020	2019	2018	2017	2016	2015	2014	2013
	Electricity final consumption (GWh)	173946	167156	160778.1	168472.1	162275	146452.1	143120	143323
	Electricity generation, Total (GWh)	203949	201414.9	198970.9	196617.6	194357.8	186207	171719	157029.4
	Electricity installed capacity in Wind (MW)	1375	1375	1125	750	750	750	550	550
	Electricity installed capacity in Hydropower (MW)	2832	2832	2832	2800	2800	2800	2800	2800

Table 2 shows share of renewable energy compared to conventional energy in Egypt

Morroco								
	2020	2019	2018	2017	2016	2015	2014	2013
Electricity final consumption (GWh)	37212.8	34785.3	32586.8	32452.7	31066	30055	28806	26494
Electricity generation, Total (GWh)	35841.5	35130.8	34453.2	35246.6	30842	29916	29145	26871.3
Electricity installed capacity in Wind (MW)	1405	1225	1225	1023	897	797	797	495
Electricity installed capacity in Hydropower (MW)	1305.5	1305.5	1305.5	1305.5	1305.5	1305.5	1305.5	1305.5

Table 3 shows share of renewable energy compared to conventional energy in Morroco

Algeria								
	2020	2019	2018	2017	2016	2015	2014	2013
Electricity final consumption (GWh)	60044.3	59053.7	58152.6	56376.1	52288	47957	45751	40188
Electricity generation, Total (GWh)	84104.5	80234.7	76663.1	76017.4	70997	68798	64527	60121
Electricity installed capacity in Wind (MW)	10	10	10	10.2	10.2	10.2	10.2	0
Electricity installed capacity in Hydropower (MW)	228	228	228	228	227.6	227.6	227.6	227.6

Table 4 shows The share of renewable energy compared to conventional energy in Elgeria

Tunisia								
	2020	2019	2018	2017	2016	2015	2014	2013
Electricity final consumption (GWh)	17672.6	16927.2	16226.7	16113	15569.3	15571.7	15190	14728
Electricity generation, Total (GWh)	23812.7	20694	20379	20610.7	19626.2	19474.9	19015.2	18369.1
Electricity installed capacity in Wind (MW)	244	244	244	244	244	244	233	200
Electricity installed capacity in Hydropower (MW)	62	62	62	62	62	62	62	62

Table 5 shows The share of renewable energy compared to conventional energy in Tunisia

IV. Discussion

Measures have been regested among north Africa countries with exception of two countries, Libya and Mauritania during approval of almost decade. This is due to the energy wind in Libya is still under construction while Mauritania's economic wind speed data has not been collected yet.

Electricity installed capacity in Wind, notice in Morroco following by Egypt ,Tunissa and Algeria at the bottom. Alhough, Egypt is the largest energy consumer country at the regen, it does not follow Morroco in renewable energy projects due to subsidize consuming energy that based on fossil fuel.

In terms of Electricity installed capacity in Hydropower, the majority of the energy consumed in Egypt depends on fossil fuels, the remaining portion generated from renewable energy is mostly from the Aswan High Dam station, which generates more renewable energy than the rest of the North African countries.

Power of Water Turbines

The power output of water turbine varies with the head, the flow rate of the turbine, the density of water, and the overall efficiency of turbine. The power output of a water turbine is:

P = p * g * H * V* n o (1)

Where;

p: the density of water.

g : the free fall acceleration.

H : the head.

V: the flow rate of the turbine.

Wind-farm

The number of wind turbines, of nominal power P each, is determined as:

$$Z_{min} < Z < Z_{max}$$

Where; the minimum number of wind turbines $Z_{min}$is given as follows:

$Z_{min} = E/(Cf * P * Ta * 8760)$ (2)

Where,

E: is the total annual energy consumption of the local grid taking into account an appropriate safety factor related to the projected increase of the energy demand in the near future.

C_f: is the capacity factor and depends on the local wind potential and wind turbines,

T_a: is the mean value of wind farm's technical availability.

The minimum number of the wind turbines z min takes into account the fact that part of the energy produced by the wind farm will not be fed to the consumers directly but will be stored as hydrodynamic energy in the hydroelectric system. Also, the maximum number of wind turbines $Zmax$ is determined considering the worst-case scenario, when the total energy consumption will be produced by the stored energy. In this case, Z_{max} is given as follows:

$Z_{max} = E/(Cf * P * Ta * n * \ 8760)$ (3)

Where n is the total conversion coefficient of the stored energy to consumers. Generally, from experimental studies, it was found that the combined operation of wind/hydro plant incurs losses of the order of 30-50%.

Therefore, the number wind of turbines takes values between:

$Z_{min} = E/(C_f * P * \ T_a * 8760 < Z < E/(C_f * P * \ T_{a*}n * \ 8760) = Z_{max}$ (4)

Water reservoirs

The selection of the dimensions of the water reservoir depends on the required system's autonomy, energy needs and the ground configuration as well. The number of the autonomy day's d is given as follows:

$d = ng * nt * H * e * v/(\frac{E}{365})$ (5)

Where;

ng : The conversion coefficient of the energy generator (%)

nt: The conversion coefficients of the turbine (%), H the effective head (m), v the volume water-reservoir area (m3), e is the specific weight of water (9.81 kN/m3).

Hydropower plant

The nominal power of a hydropower plant is determined by the requirement to cover the peak power demand of the local grid with an optimal future increase. Practically, in order to select the power of reversible water turbine the peak load plus an appropriate 30% increase accounting for the future peak demand is taken into account.

The output power of each water turbine is given as:

$PH = p * g * H * V * nH * nel$ (6)

Where :

p : the density of water (Kgr/m3)

g: the free fall acceleration (m/sec2)

H: the head (m)

V: the flow rate of the turbine (m3/sec),

nH: The water turbine's efficiency (%),

nel: The electric-generator's efficiency (%).

The output power of each water turbine constituting the hydropower station is a function of turbine net head H and the corresponding rate of flow V:

$H < (h_1 - h_2) - dHf = (h_1 - h_1) - KHV_2$ (7)

Where,

dHf: is the total hydraulic loss when the water circuit is used for energy's production.

Using the data by the manufactures of the water turbines, it is obvious the relation
Between"V" the flow rate of the turbine with the H Head and the power of the turbine

$H = H(V, a)$ (8)

$nH = nH(V, a)$ (9)

$PH = PH(V, a)$ (10)

Water pump station

The pump station, in conjunction with the reversible water -turbines operating as water pumps, is chosen to transfer water from the lower to the higher reservoir. It also absorbs the wind energy surplus of the combined power plant. For increased reliability reason, it be selected a constant-speed water pump, its input power depends on the net hydraulic head H and the corresponding flow rate "V".

$P_\rho = \rho * g * H * \frac{H}{*n_\rho} * n_{el}$ (11)

Where,
ρ : The density of water (Kgr/m3).
g: The free fall acceleration (m/sec2).
H: The head (m).
V: Theflow rate of the pump (m 3/sec).
n_{ρ} : The water pump’s efficiency (%).
n_{el}: Efficiency of water pump's electric motor (%).

VI. Conclusion

Following the assessment that shows the power of blowing wind in the tables, the appropriate places to construct wind turbines fields are located in the northern west of Atlas mountains . Also, the project can be built in the northern east of Tunisia, but some obstacles may face this project in Egypt and Libya cause topography and subsides the consuming the energy in those countries.

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