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TRADEOFFS RENEWABLE ENERGY IN EGYPT (TREE)-SUSTAINABLE ENERGY FUTURE IN GULF OF SUEZ

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ABSTRACT

The Limited availability of conventional energy along with growing environmental issues have become increasingly prominent. With the world's growing demand for energy and the limited reserves of conventional non-renewable resources, mankind is facing a serious energy crisis. Coupled with the use of fossil fuels, this has brought serious environmental pollution problems. Thus, the current trend of international attention to environmental protection and renewable energy. In other words, the transition to energy development is imminent and the need is growing to constantly develop green renewable energy generation technologies.

Although wind, solar and tidal resources at one location will always be intermittently when they are considered in isolation, several methods exist to reduce intermittent of delivered power. These include combining geographically disperse intermittent sources of the same type, using storage, and combining different renewable with complementary intermittencies (Hoste, Dvorak and Jacobson, 2011. p2)

The focus of this paper is to discuss the prospects of combining a number of renewable energy sources within the Gulf of Suez region to overcome the problem of intermittency. Different mixes are proposed while taking into consideration the necessary tradeoffs.

KEYWORDS: *Tradeoffs Means of Exchanges Availability Sources of Renewable Energy, Renewable Energy Generated from Many Nature, Sources, Wind, Solar, Hydro and Geothermal are Available in Egypt Country in Different Locations*

INTRODUCTION

That is no doubt; sharing is the power even in kinetic generated energy; therefore the opportunity of tradeoffs energy sources to involve reaching the smart grid generation farm. In long-term point of view, the development of smart grid not only enhances the level of energy security but also guides and changes the user's energy consumption habits; improve the efficiency of energy utilization. Rely on a strong and the smart grid intelligent allocation of energy resources to become a key factor to enhance the sustainable development of Egypt energy.

Transition to a sustainable energy future, use tradeoffs renewable energy, in the pursuit of sustainable development, energy access, and energy security and low carbon economic growth. The potential of complementary the renewable energy in Egypt by utilizing the sources power from the sun, wind and hydro.

The paper demonstratebalancingtradeoffs of wind, tidal and solar power, when packaged with the flexibility of tradeoffs, serve to sufficiently smooth the delivered supply from a renewable portfolio to allow it to follow demand throughout the day.

The paper is looking for Trading Renewable Energy in Egypt and the officiant for complementary and integrating sustainable, renewable energy sources to involve in grid to generate continuous electricity.

Smart grid is a combination of two or more sustainable, renewable energy sources to avoid the isolation source disadvantages, smart grid gives opportunity to continuously generate electricity from two or more sustainable renewable energy sources.

TIDAL ENERGY

Tidal currents are typically much slower than the wind, though the much greater density of water compensates for this in terms of power, allowing tidal stream devices to generate similar levels of output to wind turbines. In contrast to wind power, there are no extreme flow speeds underwater that could potentially damage devices or force them to shut down; however, tidal stream devices must still be durable to withstand the greater loading forces generated by water.*(Roberts, 2016.P. 229)*

Tides are the function of the motion of the moon and sun relative to the earth. These gravitational forces in combination with the rotation of the earth on its axis cause periodic movements of the oceans and seas. As explained by Mofor 'the vertical rise and fall of water, known as the tides range is accompanied by an incoming (flood) or outgoing (ebb) horizontal flow of water in bays, harbors, estuaries and straits'. It is this flow that is known as tidal current or tidal stream. Tidal stream devices working in a similar fashion to wind turbines using water currents instead of wind to convert kinetic energy into electricity.*(Magagna and Uihlein, 2015*)

A number of European studies for 2020 for current tidal technologies are between EUR 0.17/kWh and EUR 0.23/kWh, although current demonstration projects suggest the liveliest cost of energy (LCOE) to be in the range of EUR 0.25-0.47/kWh. It is important to note that costs should not be considered as a single performance indicator for tidal energy. For example, the costs for both tidal range and tidal stream technologies can fall by up to 40% in cases where they are combined and integrated in the design and construction of existing or new infrastructure. With the planning and design of new infrastructure for coastal zones. *(IRENA, 2014. PP 4:5)*

Categories of Tidal Energy Technologies

Tidal energy technologies can be subdivided into three categories.

Tidal Range Technologies

Tidal range technologies harvest the potential energy created by the difference in head between ebb tide and flood tide. Such resources exist in locations where due to geological and ecological conditions, large water mass flow into compounds areas or bays and estuaries. Furthermore, tidal range energy is predictable, as the energy production is not influenced by weather conditions, but rather by the cyclical constellations, the gravity of the moon, sun and earth, providing a predictable bi-week, biannual and annual cycle.*(IRENA, 2014. P 6)*

One important new avenue is the use of tidal range applications to promote ecological improvement. In all these solutions (e.g., in the case of the Sihwa barrage or potentially in the case of the Grevelingen lake in the Netherlands), the installation of tidal range technology leads to several important societal benefits besides renewable energy. These include flood defense, improved environmental and ecological water quality, and fisheries and tourism functions. An important new application for tidal range energy under development is one which is focused on harvesting energy from low head tidal differences of less than 2 meters. *(IRENA, 2014. P 5)*

Tidal Current or Tidal Stream Technologies

Tidal current or tidal stream technologies have had more than 40 new devices introduced between the period 2006-2013. The major differences between the devices are the turbines, which can be based on a vertical or horizontal axis, and in some cases are enclosed (ducted). Full-scale deployment of single turbines has been achieved, and the next step is the demonstration of arrays of turbines Up to 2010, the industry was dominated by small entrepreneurial companies, but in the last three years large engineering firms and turbine manufacturers like ABB, Alstom, Andritz Hydro, DCNS, Hyundai Heavy Industries, Kawasaki Heavy Industries, Siemens, and Voith Hydro have entered the market. Furthermore, companies like General Electric (GE) have also shown an interest and are supplying the electrical power systems for some of the prototypes. Also, large utilities like Bored Gáis Energy, Électricité de France (EDF), GDF Suez, and Iberdrola are running demonstration projects.(*IRENA,2014. P 3)*

For tidal stream technologies, continued support for demonstration and grid connection of larger scale arrays will be critical. With these experiences, the materials, operation and maintenance costs can be improved. Furthermore, high installation costs of both tidal range and tidal current solutions need to be overcome through capital investments, aiding commercialization, feed-in investment mechanisms in innovation. The simultaneous research and development of new infrastructure of flood defenses, coastal restructuring, bridge and road construction, also offer opportunities to advance tidal energy technologies. *(IRENA, 2014. P 5)*

Hybrid Applications

Hybrid applications are forms of tidal range technologies that have great potential if their design and deployment can be combined with the planning and design of new infrastructure for coastal zones. Project proposals for hybrid applications exist in Canada (British Columbia), China, the Netherlands (Grevelingen), Norway (E39 road project) and the UK (Bristol Channel). Furthermore, there are plans for a hybrid form of tidal range and current power generation called ‘dynamic tidal power’. Again, no full-scale prototype has been tested or demonstrated yet.*(IRENA, 2014. P3:4)*

This flexibility for the three categories makes tidal energy suitable to be combined with other renewable energy, for example wind power. When there is little wind and the wind power plants are not producing enough, adjustable hydropower production can easily be phased into the supply system. *(Fossdal,2007. P 62)*

Tidal Turbines

Tidal turbines extract energy from a moving fluid; consequently, they are somewhat analogous to wind turbines. Like wind turbines, most tidal turbines feature blades with aero-foil cross sections and operate according to the principles of aerodynamic lift, since this is more efficient than utilizing aerodynamic drag. However, there are major differences between the two technologies. The most immediately obvious are physical differences between the fluids; the density of seawater is approximately1025 kg/m3, compared with around 1.25 kg/m3 for 1 atm. of air at room temperature.

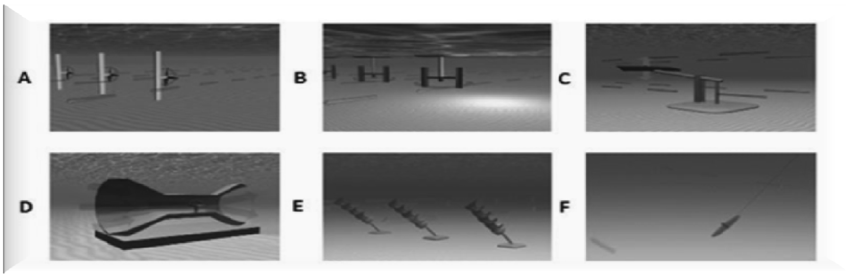

Figure 1: Tidal Stream Devices (*World Energy Resources, 2016.P17)*

A - Horizontal-Axis Turbine.

B - Vertical-Axis Turbine.

C - Oscillating Hydrofoil.

D - Ducted Turbine or Enclosed Tips.

E - Archimedes' Screw.

F - Tidal Kite

Axial Flow Turbine

Axial turbines currently appear to be the most popular tidal stream design true axial-flow turbines (with an axis of rotation parallel to the flow direction) *(Roberts, 2016. P.230)*

Cross Flow Turbines (CFTs)

Crossflow turbines (CFTs) rotate about an axis that is perpendicular to the flow direction. This axis can be positioned in either the vertical or horizontal plane relative to the flow, resulting in vertical-axis CFTs or horizontal axis CFTs (also known as transverse horizontal axis turbines. (Roberts, 2016. P.232)

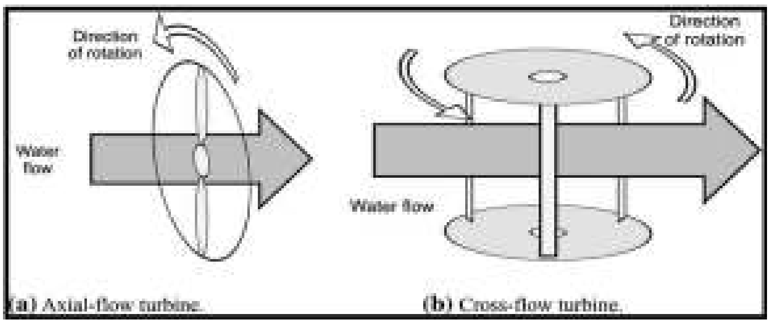

Figure 2: Axial flow and Cross Flow Turbines (*Roberts, 2016. P.232)*

WIND ENERGY

Due to the increase in wind energy penetration to the global energy mix, and the liberalized nature of many electricity markets today, there is also the growing need to accurately forecast expected wind power generation in the short term (i.e. Days ahead of schedule), in order to manage the variability of wind energy. Transmission system operators require forecasting to ensure electricity supply and demand remain balanced at all times, power traders use forecasting to trade wind generation on electricity futures markets, and site operators utilize forecasting for scheduling their operations and maintenance. According to the European Wind Energy Association, “to integrate wind energy successfully into an electricity system at penetration levels of more than 10%, accurate wind energy predictions are needed”. (*World Energy Resources,2016.P14)*

China has once more underpinned its role as the global wind power leader, adding 33 GW of new capacity. This represents a market share of 51.8%. The US market saw the good performance with 8.6 GW of added capacity, the strongest growth since 2012. Germany, in anticipation of changes in legislation, installed 4.9 GW. Brazil was the fourth largest market for new turbines with a market volume of 2.8 GW. India saw 2.3 GW of new installations by November 2015.

Global wind power generation amounted to 950 TWh in 2015, nearly 4% of total global power generation. Some countries have reached much higher percentages. Denmark produced 42% of its electricity from wind turbines in 2015 year, the highest figure yet recorded worldwide. In Germany wind power contributed a new record of 13% of the country’s power demand in the 2015.

The wind power market can be divided into large wind onshore (422 GW, around 210,000 machines), small wind onshore (less than 1 GW installed by the end of 2015, more than 800,000 machines), and offshore (around 12 GW installed by the end of 2015, around 4,000 machines). Large onshore and offshore wind turbines are typically arranged in a wind park. The largest wind parks exceed 1 GW in sizes, such asthe Gansu Wind Farm in China, Muppandal Wind Park in India or Alta Wind Energy Center in the USA. World wind power generation capacity has reached 435 GW by the end of 2015, around 7% of total global power generation capacity.. *(World Energy Resources, 2016. P 3)*

Cost of Wind Energy for Two Decades

From figure No. 3 the cost of the wind energy declined from 37 cents/kWh in 1980 to 4 cents/kWh in 2000, At the main time the wind energy stands out as one of the tradeoffs renewable energysources. Many countries promote the wind power and recently Egypt enjoys excellent wind along the Suez Gulf with an average wind speed of 10.5 m/sec, and Egypt is just one of 38 countries in the world with a published National Wind Atlas. The Government of Egypt is planning to provide 12 percent of generating electricity (6.8 GW) through generated wind energy by 2022. (Egypt Country Commercial Guide,2017)

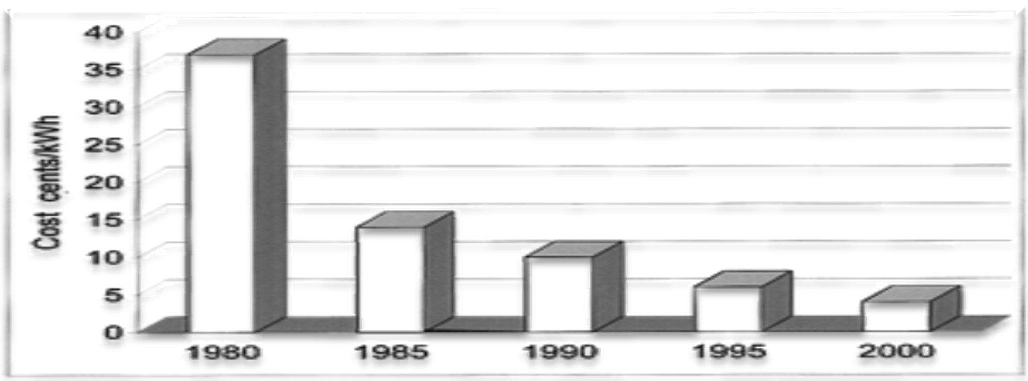

Figure 3: Declining Cost of Wind-Generated Electricity (***Patel, 1999. Fig.2, 2***)

SOLAR ENERGY

Solar energy resources are massive and widespread, and they can be harnessed anywhere that receives sunlight. The amount of solar radiation, also known as insolation, reaching the Earth's surface every hour is more than all the energy currently consumed by all human activities each year. A number of factors, including geographic location, time of day, and weather conditions, all affect the amount of energy that can be harnessed for electricity production or heating purposes *(Center of climate and energy solutions,2017)*

Egypt's Solar Atlas states that Egypt is considered a "sun belt" country with 2,000 to 3,000 kWh/m2/year of direct solar radiation. The sun shines 9 to 11 hours a day from North to South of Egypt, with few cloudy days. The first Solar Thermal Power Plant at Kuraymat was built in 2011. It has a total installed capacity of 140 MW, with the solar share of 20 MW based on parabolic-trough technology integrated with a combined cycle power plant using natural gas. The power plant is financed from the Global Environmental Facility (GEF) and the Japan Bank for International Development. A 10 MW power plant has been operating in Siwa since March 2015, and the remaining plants are expected to be implemented and operated consequentially in 2016. (*Egypt Country Commercial Guide,2017)*

INTEGRATING TRADEOFFS RENEWABLE ENERGY SOURCES

In the context of other forms of intermittent renewable electricity generation being added to the grid, such as wind, solar and hydro energy offers a complementary form of renewable energy that could 'flatten out' the load on the grid and thus improve the synchronicity of electricity supply and demand. For example, wave energy is sometimes out-of-synch with wind energy because whilst waves are generated by winds it takes some time for waves generated by winds offshore to reach the shoreline. Even so, it is perfectly possible for the variable peak of these different forms of ocean energy to coincide not just with one another but other forms of intermittent renewable energy (e.g. wind, solar).

Under these conditions the grid can come under immense pressure due to the increased electrical load and raise issues with regards to the integrity of the grid. Conversely, it is also possible that the lowest output from these forms of renewable energy generation could coincide presenting a real danger of blackouts. Both situations pose problems for energy security and which would require energy storage to resolve. *(World Energy Council, 2016. p4*)

INTERNATIONAL RENEWABLE ENERGY VISION

The work of the two agencies, IEA (International Energy Agency) and IRENA (International Renewable Energy Agency) is complementary to assess the total energy mix including renewable, not just renewable in isolation. They continue to work in the fields of renewable, assessing their competitiveness against other energy sources and their outlook in the Agency's world energy scenarios. The effectiveness analyses of renewable energy policies to identify best practices and securely integrate large shares of renewable into the energy mix, in particular in developing countries. The IEA has been very collaborative with IRENA from its inception. On January 2012, the two Agencies signed a Letter of Intent which identifies three initial areas of co-operation:

a) development and publication of a joint Global Renewable Energy Policies and Measures Database, which expands on the existing IEA database to cover up to 150 countries, including all IRENA member countries; b) co-operation in technology and innovation, including the involvement of IRENA in the IEA Technology Collaboration Programs (TCPs); and, c) sharing of renewable energy statistics data and methods between the two organizations.

(*IEA,2018*)

Energy derived from natural processes (e.g. Sunlight, tidal stream and wind) that are replenished at a faster rate than they are consumed. Variable renewals include wind, solar, wave and tidal energy are based on sources that fluctuate during the course of any given day or season. Variability is not new to power systems, which must constantly balance the supply and variable demand for electricity and face all kinds of contingencies. However, large shares of-variable renewable supply may increase pressure on power systems, which may need increased flexibility to respond to this balancing issue.*(IEA,2018)*

The demand for carbon free electricity is driving a growing movement of adding renewable energy to the grid. Renewable Portfolio Standards mandated renewable energy potential of hydro, wind and solar far exceeds these targets, suggesting that renewable energy ultimately could grow well beyond these initial goals.

The grid faces two new and fundamental technological challenges in accommodating renewable: location and variability. Renewable resources are concentrated at mid continent far from population centers, requiring additional long distance, high-capacity transmission to match supply with demand. The variability of renewable due to the characteristics of weather is high, up to 70% for daytime solar and 100% for wind, much larger than the few percent uncertainty in load that the grid now accommodates by dispatching conventional resources in response to demand.*(ABS, 2011..P2*)

Table 1: Total Renewable Energy Producted at Some of Developing Countries

Country	Year	Total Renewable (GWh)	Hydropower (GWh)	Wind power (GWh)	Biomass (GWh)	Solar Power (GWh)	Geothermal	% of Total Generation
Argentina	2015	42,072	41,464	608	-	608	-	31.1%
Austria	2012	50,881	43,352	2,463	4,728	337	1	78.39%
Brazil	2015	430,410	359,745	21,625	49,039	-	-	75.50%
Cambodia	2012	535	512	-	20	3	-	38.91%
Canada	2015	422,539	380,598	26,446	12,600	2,895	-	66%
China	2015	1,425,180	1,130,270	185,766	52,700	45,225	125	24.32%
Colombia	2012	47,661	47,106	55	500	-	-	82.44%
Egypt	2012	14,721	13,224	1,260	-	237	-	9.48%
Gabon	2012	908	899	-	9	-	-	43.01%
India	2015	213,020	138,052	42,790	24,892	5,636	-	19.11%
Vietnam	2012	52,994	52,850	87	57	-	-	44.85%

IEA International Energy Agency, 2017

From the table of total renewable energy production at some of developing countries we observe the percentage of total electricity generation in China, India, Colombia, Canada, Gabon, Cambodia, Austria, Argentina, Brazil and Egypt.

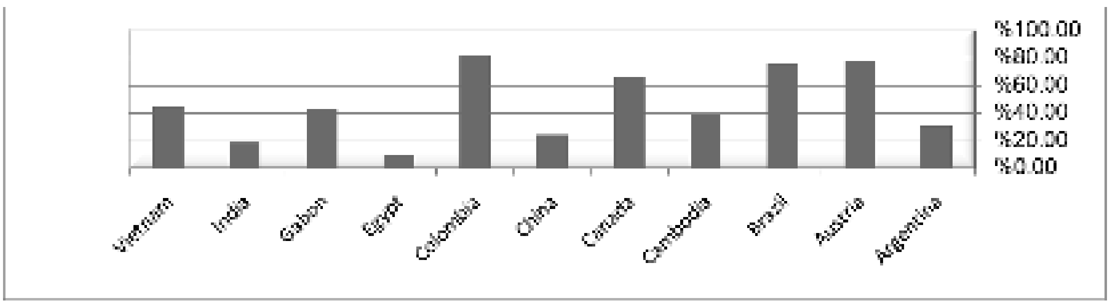

Figure 4: Percentage of Renewable Energy at Some Developing Countries (IEA, 2017)

At figure No 4 the bar chart clarify the percentage of total renewable energy generation of electricity from the total supply, the observation of Colombia, Austria, Brazil and Canada is running for needlessness by sharing renewable energy sources also China, Argentina and India integrating three and more of renewable energy sources. From barchart in figure No.5 for total renewable energy by the Giga wat hour (GWh). The china is integrating to reach 1,425,180 (GWh) at 2015. Egypt in 2012 with mainly hydro energy beside solar and wind energy product electricity 14,721(GWh).

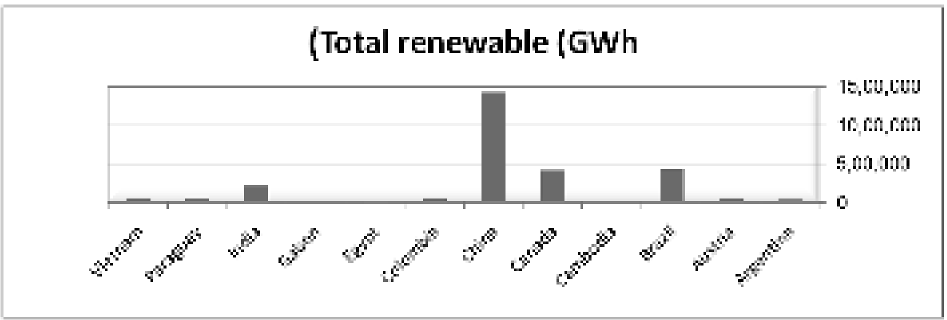

Figure 5: Total Renewable Energy (GWh) at Some Developing Countries. ***(IEA, 2017)***

INTEGRATING RENEWABLE ENERGY AT GULF OF SUEZ

The renewable energy sources are intermittent or variable at the gulf of Suez, tidal stream, solar and wind energy, the development of smart grid not only enhances the level of energy security but also; improves the efficiency of energy generation. Rely on a strong and smart grid intelligent allocation of energy resources to become a key factor to enhance the sustainable development of energy.Combining a number of renewable energy sources within the Gulf of Suez region to overcome the problem of intermittency of power supply. Different mixes are proposed while taking into consideration the necessary tradeoffs for continuous generation.

Solar Energy

A perfect area to generate energy for solar technology, sunny land over all the year. Figure No. 6also indicate temperature over the south of the Gulf of Suez, which is average 20 C, Egypt weather is perfect for renewable energy sun and wind, with addition locations eg. Mediterranean, red sea and also over Nile river, the hydro energy must conside one of alternative renewable energy in Egypt.

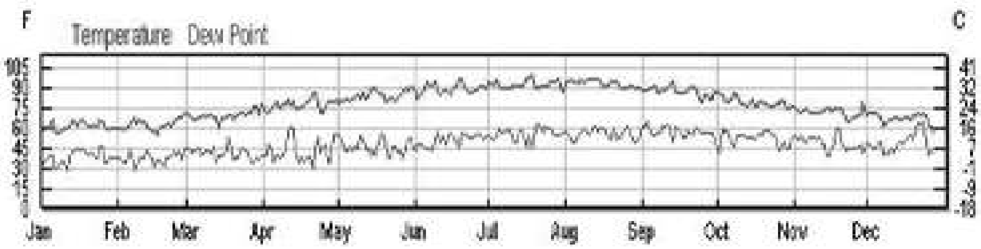

Figure 6: Temperature at Gulf of Suez in 2017. (Weather Ground, 2017)

Wind Power in Gulf of Suez

The Gulf of Suez is approximately 195 miles (314 km) in length. The width runs from 12 to 27 miles (19 to 43 km).Figure No. 6clarifies that the most observed wind speed which is almost over the13 knots, Theaverage wind speed suitable for generate energy, the Ziet wind farm turbines ideal speed is from 13 to 23 knots, kineticfrom wind converted to energy, topography of Suez gulf and weather above the area between ithaca and red sea mountain with Sinai topography, the both coast line by round 500 k/m also effects of wind over the gulf specially in south pound of gulf from straight of Gopal to Shaker island,

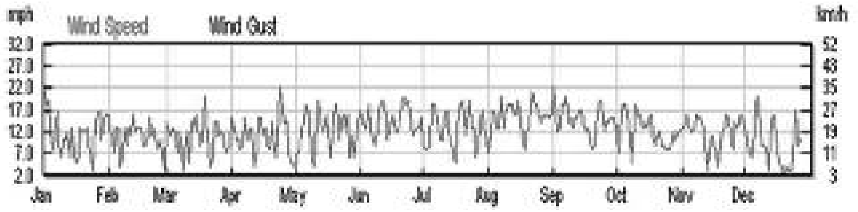

Figure 7: Wind Speed at Gulf of Suez in 2017. ***(Weather Ground, 2017)***

Figure No. 8 clarifies that wind direction at south gulf is almost continuous from north to North West, which is efficient to run wind farm.

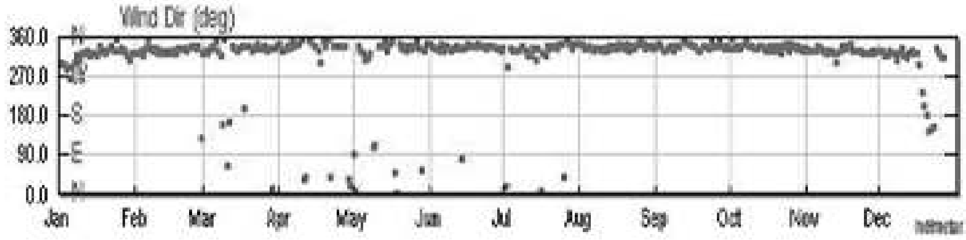

Figure 8: Wind Direction at Gulf of Suez in 2017. (Weather ground, 2017)

Opportunity for wind farm no doubt needs incessantly direction and speed of the wind is; therefore, wind one of the alternatives to the smart renewable energy grid.

Egyptian Wind Farm

Since 2001, a series of large-scale wind farms have been established, with total capacity of 550 MW, in cooperation with Germany (KFW), Denmark (DANIDA), Spain, and Japan (JICA). Implementation of the Spanish project in Jebel El Ziet took place in 2013 which clarifies the huge increase in Egypt imports for renewable that year, which were mainly wind generators imported from Spain.

In 2014 the implementation of a JICA wind project started with expectations to raise imports by USD 200 million. Another 540 MW project is under construction in the Gulf of Suez, a 580 MW project is in financing also at the Gulf of Suez and a feasibility study is under way for a 200 MW project at West Nile. Additionally, more projects are under preparation in cooperation with Germany, AFD, EIB and EU (200 MW), MASDAR (200 MW), Germany and AFD (200 MW), and Japan (200MW). Recently, the GOE allocated an area of about 7,845 square kilometers in the Gulf of Suez region and the Nile Banks for NREA to implement additional wind energy projects. (Egypt Country Commercial Guide, 2017)

Gulf of Zeit Wind Farm

The 4 stages of wind farms

KFW kreditanstalt fur wiederaufbau (reconstruction credit institute) 100 unit.Turbine model G80 2 MW turbine, Simanes Gamesa production.Total capacity of the wind farm KFW 100 * 2 = 200 MW.This wind farm 2017 have new extension 20 turbine same model, So the total capacity of KFW = 120 * 2 = 240 MW.JICA wind farm 110 towers with a same turbine model with capacity 220 MW.FIME wind farm 60 turbines with same model total capacity 120 MW.

Turbine characteristics are Nacelle weight with lifting tools around 90 ton Blades weight is 2.8 tons for one blade tower consists of 3 sections, assembly over each other, T1, T2, T3 total height around 69 m. Fourth stage: There are other turbine model will be in Egypt next year as a new project with a capacity around 2.7 MW Semanis Gamesa. The project name BO including 120 towers with the capacity of the farm 120 * 2.7 =324 MW.The average wind speed suitable for generation from 13 to 23 knots less or more than this range not compete generation.

Tidal Stream at Gulf of Suez

With a rising tide at Suez the tidal stream throughout the gulf is north going and on a falling tide at Suez the tidal stream is south going. In mid channel both streams tend to follow the alignment of the gulf with a maximum rate of 1.5 knots at springs and 0, 5 knots at neaps. In the vicinity of Ras Abu el Darag and near Sheratib Shoals, which have strong tide races over them even in calm weather.comparingrange of tide at spring and neap tides with the tidal stream rate of current; therefore, daily observation of height of tide collects from Admiralty tide table volume 3 2017 for the 12 months, researchers estimate the change of rate of current from 0.5to 1.5 knots related to range of tide which is move between 0.6 to 1.9 meters and by estimation of tidal stream rate of current depend on range of tide for whole year as the 1.5 knots occurred with maximum range 1.9 meters at spring and rate 0.5 knots occurred with 0,6 meter minimum range at neap. (*UKHO, 2017)*

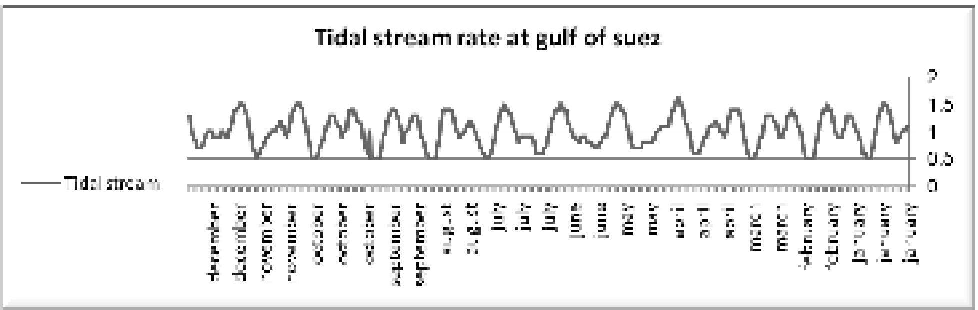

Figure 9: Rate of Tidal Stream at Gulf of Suez for the Year *(UKHO, 2017*)

Figures 8 &9 clarify the observed range of tide and rate of tidal stream at the Gulf of Suez from Admiralty Tide Tables as discussion of tidal stream at the Gulf of Suez from sailingdirection NP 64 (pilots)

Hydropower with storage reservoirs has a high level of reliability. It is simple to control production, and the ability to adjust to load changes. It is a trusted technology with a long working life, high efficiency, and low operation and maintenance costs. (*Fossdal, 2007. P 62)*

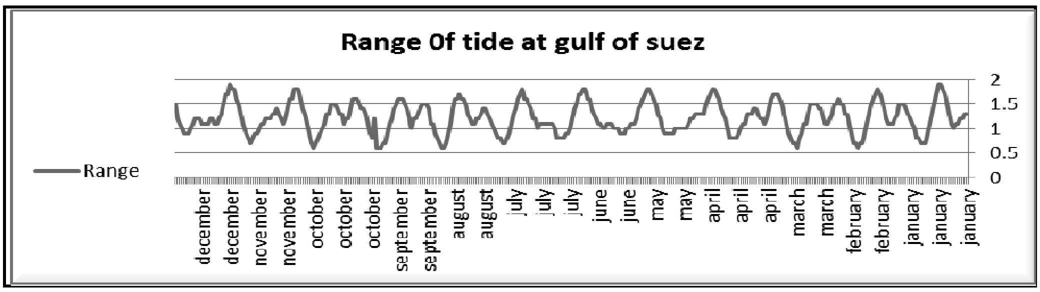

Figure 10: Range of Tide at Gulf of Suez for the Year. (*UKHO, 2017)*

It is difficult to store large amounts of electrical energy. It has to be produced at the same time as it is used. This physical fact is a challenge for the power supply system. As opposed to most other energy sources, hydro power production with regulation storage reservoirs is easy to adjust. It makes the hydro power suitable to combine with other energy sources. (*Fossdal, 2007. P 62)*

A CASE STUDY FOR CALIFORNIA IN 2020 MATCHING HOURLY AND PEAK DEMAND BY COMBINING DIFFERENT RENEWABLE ENERGY SOURCES

Many renewable resources are intermittent or variable by nature, producing power inconsistently and somewhat unpredictably while on the other end of the transmission line, consumers demand power variably but predictably throughout the day. The Independent System Operator (ISO) monitors this demand, turning on or off additional generation when necessary. As such, predictability of energy supply and demand is essential for grid management. For natural gas or hydroelectricity, supplies can be throttled relatively easily. But with a wind farm, power output cannot be ramped up on demand. In some cases, a single wind farm that is providing power steadily may see a drop in or complete loss of wind for a period. For this reason, grid operators generally pay less for energy provided from wind or solar power than from a conventional, predictable resource.

Figure 12 shows the estimated proportions of generation from each RPS (Renewables Portfolio Standard) -eligible renewable technology type in 2017. As shown here, wind and solar together account for more than 67 percent of all renewable electricity generated, with geothermal, biomass, and small hydroelectric generators accounting for the remainder. (*California Energy Commission, 2017)*

Although wind, solar, tidal, and wave resources will always be intermittently when they are considered in isolation and at one location, several methods exist to reduce intermittent of delivered power. These include combining geographically disperse intermittent resources of the same type, using storage, and combining different renewable with complementary intermittencies. This paper discusses the last method: integration of several independent resources, they demonstrate that the complementary intermittencies of wind and solar power in California, along with the flexibility of hydro, make it possible for a true portfolio of renewable to meet a significant portion of California's electricity demand. In particular, they estimate mixes of renewable capacities required to supply 80% and 100% of California's electricity and 2020 and show the feasibility of load- matching over the year with these resources. Additionally, they outline the tradeoffs between different renewable portfolios (i.e., wind-heavy or solar-heavy mixes). They conclude that combining at least four renewable, wind, solar, geothermal, and hydroelectric power in optimal proportions would allow California to meet up to 100% of its future hourly electric power demand assuming an expanded and improved transmission grid. *(Hoste, Dvorak and Jacobson, 2011) P2*

CASE STUDY NO. *2 COOPERATION AND STORAGE TRADEOFFS IN POWER GRIDSWITH RENEWABLE ENERGY RESOURCES*

Explored the benefits of energy storage and cooperation among interconnected MGs (Macro Grid) as a means to combat the uncertainty in harvesting renewable energy. Modeled the set-up as an optimization problem to minimize the cost of energy exchange among the grid for a given storage capacity at the MGs. First, provided an analytical expression for the time average cost of energy exchange in the presence of storage by analyzing the steady state of the system for some special cases of interest. Then developed an algorithm based on Lyapunov optimization to solve this problem, and provided performance analysis of this algorithm. Results show that in the presence of limited storage devices, the grid can benefit greatly by cooperating even among only a few distributed sources. Cooperating MGs leads to a greater diversity in energy production and hence greater possibility of sharing energy among the MGs.

The decrease in the normalized cost (as a function of the number of cooperating MGs) is greater for lower values of storage capacity. For higher values of storage capacity, the normalized cost does not reduce with increasing N. (Number of sources). This is due to the fact that with greater storage capacity, the MGs are able to store any excess harvested energy (during the time slots when the harvested energy is greater than the aggregate load) and use it during the time slots when the harvested energy is deficient, thereby, eliminating the need for energy cooperation. Further, most of the reduction in the time average cost is achieved by cooperation among only a few neighboring MGs. The incremental gain obtained by cooperation among a large number of MGs is not significant.

The combination of the storage and a number of cooperating MGs that yields a normalized time average cost NC = 10^7 units as the benchmark (The choice of 10^7units comes from the fact that pi;j [t] = units and 10^7corresponds to the 10 MW demand per time slot). They plot the optimal value of N and Emax required to make the normalized cost below 1 unit in Figure 13. The numerical results by choosing = 1: It can be seen that for a given number of cooperating MGs, there exists an optimal storage capacity requirement to eliminate the need for borrowing energy from the macro-grid. It is evident that as the number of cooperating MGs increases, the optimal storage capacity requirement reduces. However, in the presence of large storage, cooperation does not yield much benefit. Our solution can be useful for the power grid designer in terms of choosing the optimal combination of storage size and cooperation in order to meet a specific cost criterion.(Lakshminarayana,2014) p.9:10

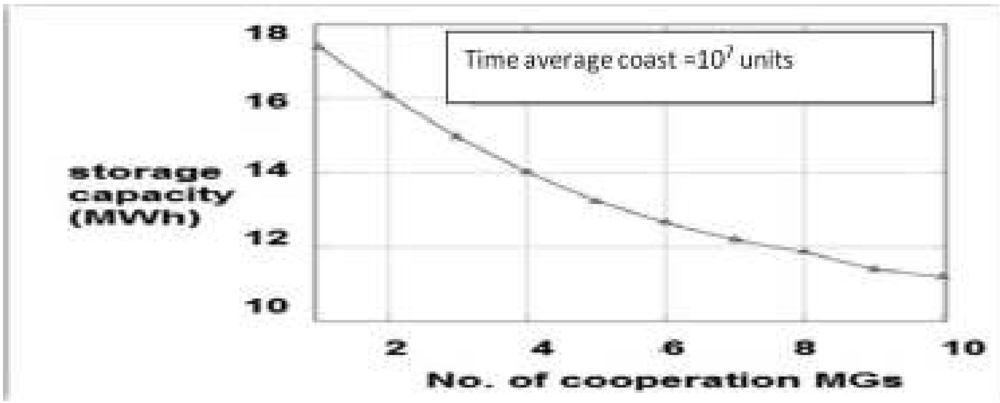

Figure 12: Storage Capacity Vs Number of Cooperating MGs to Achieve a Time Average Cost of 10^7 Units

CONCLUSIONS

Egypt location combined geographical disperse intermittence sources of the same type, using storage, and combining different renewables with complementary intermittencies; complementary exchanges of wind, tidal,solar and geothermal power, when packaged with the flexibility of tradeoffs renewable energy, serve to sufficiently smooth the delivered supply from a renewable portfolio to allow it to follow demand throughout the day. Climate change (also called global warming) is a change in the Earth's climate because of the pollution created by humans particularly the carbon dioxide (CO_2) produced when we burn fossil fuels like oil and gas. We can try to reduce climate change by using renewable energy instead of fossil fuels. (*Uswitch,2017)*

Achieves Tradeoffs Renewable Energy at Egypt (TREE): complementary at Gulf Of Suez mirror influence, improvement, future visualization, and management in renewable energy and sustainability of wind, solar and tidal resources will always be intermittent when they are considered in isolation, Most national energy policies worldwide aim at ensuring an energy portfolio that supports a cleaner environment and stronger economy and that strengthens national security by providing a stable, diverse, domestic energy supply. Clean energy is a global and the urgent imperative renewable energy generation, especially from wind, hydro, solar and geothermal energy sources.

Smart-grid concepts are critical technologies needed to address global warming and related issues. The key challenge is to reduce the cost of renewable energies to affordable levels; Control and related technologies will be essential for solving these complex problems to control smart grid using combined tradeoffs renewable energy resources.

RECOMMENDATION

- Egypt's future sustainable energy development needs to support the integration of smart grids. Mostly with the conditions for the development of large-scale hydro, wind and solar energy as a smart grid, the implementation of a wide range of the optimal energy sharing out of different resources which give the opportunity of integrating tradeoffs renewable energy.
- The concepts of Trading Renewable Energy in Egypt (TREE) by utilizing complementary of variable energy sources to fill temporary gaps between demand and generation for the single source; i.e.;use "smart" demand response management to shift flexible leads to a time when more renewable energy is available.
- Interconnect geographically dispersed, naturally variable energy sources (e.g., wind, solar and tidal), which smoothes out electricity supply and demand significantly at the Gulf of Suez.
- Smart farms along the Gulf of Suez, including the southern part of Suez canal will support the logistic merchant hub, through over the development of the Suez Canal axe and Sinai.
- Measure the ability of Nile river flow to complementary wind and solar energy along the Egyptian Nile pass over total length of Egypt.
- Shaker Island is a barren, rocky island 30 miles southwest of the Egyptian city of Sharm el-Sheikh on the Sinai Peninsula and 20 miles northeast of el Gouna. It is the largest of a group of islands in the mouth of the Gulf of Suez in the northern Red Sea and measures 16 kilometers (9.9 Miles) in length, and between 3–5 kilometers (1.9–3.1 Miles) wide. Shaker Island can be used as smart grid combined sources of wind, solar and tidal stream.
- Through the Gulf of Suez and Suez Canal there is availability of complementary tradeoffs renewable energy to combine with a smart grid.

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