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Wind Energy–A Greener and Cleaner Energy Perspective

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Abstract—*Energy Sources from the social point of view has been the cradle of the modern civilisation. To continue it in a peaceful, sustainable way, humans nowadays have been interested on alternative sources of resources which do not bear any harmful consequences to the nature and its beings. Of the alternative sources of energy that has been discovered, Wind Power plays a major role. It has been found out that out of the major renewable energy sources that are available on the earth, besides solar and hydro-power, Wind is another huge potential energy reservoir. Humans harnessed Wind Power from long time ago. In earlier times Wind Power has been used in Wind pumps for drawing up water, or in crushing wheat to make flour in Wind Mills. In modern times human found its application as a source for generating electricity. A little ago, thermal power was the only option for producing electricity. But it had adverse effects on Nature and also the raw material was a non-renewable source of energy. So, as an option for eco-friendly technology Wind Power for generating electricity has been widely acceptable. In modern days, the harnessing of Wind Power for electricity can be categorised in two ways, Onshore and Offshore. Offshore Wind Energy generation has more benefits than the Onshore process.*

A detailed theoretical investigation was carried out on Offshore Wind Power Harnessing so as to find out its various positive impacts for a sustainable development in our society. Besides being Eco-friendly, Offshore wind power generation is highly beneficial in the long run.

Keywords*: Renewable Source of Energy, Offshore Wind Power, Eco-friendly technology, Sustainable Development*

1. INTRODUCTION

Wind Power from ancient times have been harnessed by people for using it in various purposes. It has been seen from earlier times recorded in history that Chinese people used wind power for Water pumping application using simple wind mills, while Persians and Middle-East people used woven reed sails for grinding application. And it has been known by people in almost every corner of the world where water and wind both are simultaneously and continuously available, how people used to sail around. So, if history is tracked, these common applications continued from 5000 B.C. up to late 19th century. But slowly times changed, and so its beings. People found its application in a new way by generating electricity. Throughout the 20th century, small wind plants, suitable for farms and residencies and some larger utility-scale wind farms that could be connected to electricity grids were developed in the European countries. This continued for the time being and then it was shut down due to the cheaper oil that was available then. But after 1970, the scenario somewhat changed due to people's realization about non-renewable substances. So, their search for alternative sources began and again the importance of Wind Energy came into being.

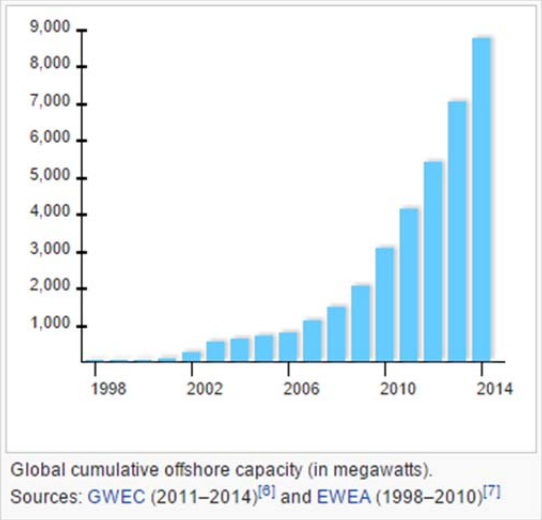
The wind farms at the beginning were set up on land following the traditional method. But later on due to the realization of the power of winds in the Offshore regions, an experimental setup was installed off the coast of Denmark in 1991. It was a huge success and immediately after that the commercialisation for Offshore Wind Power followed around the world, mostly in Europe at that time.

2. OFFSHORE WIND POWER

Offshore Wind Power refers to the construction of wind farms on the bodies of Water to generate electricity by harnessing the power of wind.Offshore Wind Power's contribution to electricity is much more than the Onshore ones. Unlike the typical usage of the term "Offshore" in marine industry, Offshore wind power includes inshore water areas such as lakes, and sheltered coastal areas using Traditional fixed-bottom Wind Turbine technologies as well as in deep water areas using Floating Wind Turbines. The idea of Offshore Wind power came into minds cause it was observed that the winds blowing over water bodies had more speed and were uniform than on lands. The potential energy gained is directly proportional to the cube of the wind speed. As a result a few miles per hour in the speed can result in significantly larger amount of electricity. For instance a turbine at a site with an average wind speed of 15 mph would produce almost 50% more electricity than at the same site with the same turbine and with average wind speeds of 13mph.

3. GLOBAL SCENARIO

Currently Europe is the World leader in Offshore Wind power. After its first wind farm installation in Denmark in 1991was a huge success, it started to expand its possibilities around the area in this field. In 2013, Offshore wind power contributed



Global cumulative offshore capacity (in megawatts).
Sources: GWEC (2011–2014)[6] and EWEA (1998–2010)[7]

to the 1567 MW of the total 11,159 MW that got produced by wind power. By January 2014, United Kingdom has by far the largest capacity of offshore wind farms with 3681 MW. Denmark is the second with 1271 MW installation and Belgium is third with 571 MW. Next comes Germany(520 MW) followed by Netherlands(247 MW) , Sweden (212 MW), Finland(26 MW), Ireland(25 MW), Spain (5 MW), Portugal(2 MW) and Norway(2 MW). Projections for 2020 calculate a wind farm of capacity 40 GW in European waters which would meet 4% demand of the European Union's electricity.

As for other countries, China has two Offshore Wind farms in operation of 131 and 101 MW capacity. By May 2015, the country had a capacity of 565 MW offshore wind power. Canada, United States and many countries have the same in an experimental stage.

4. TECHNICAL DETAILS

The engineering and design of offshore wind facilities depends on site-specific conditions mainly water depth, geology of the seabed and wave-loading.

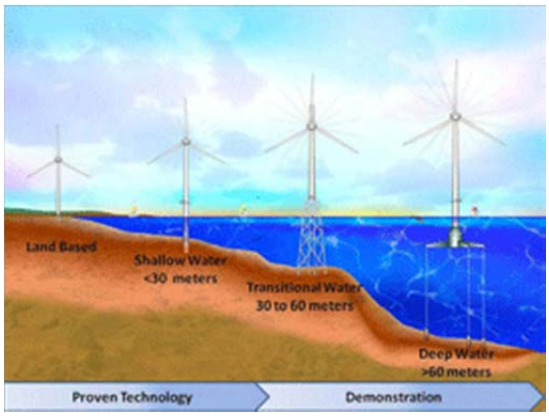
The Advantages of it and challenges which are faced are:

Advantages: Area, Wind Speed, Turbulence, Visual Impact

Challenges: Cost, Technology, Data, Security

Yet, on the long run, the advantages would pay more than the cost of the challenges faced and henceforth, Offshore Wind Power harnessing has been counted for the Sustainable Development of the society.

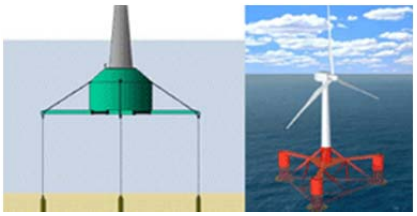
As far as the construction goes, first come the turbine construction. For better results, different methods have been developed for the construction of the wind farms depending on the depth and current of the waterbodies.



Different Designs of the Wind turbine depending upon the Depth of the Waterbody (CREDIT: NREL)

In shallow areas (depth till 30 mts), monopoles are the preferable foundation type. A steel pile is driven into seabed supporting the tower and nacelle. The nacelle is a shell that encloses the gearbox, generator and blade hub and the remaining electronic components.

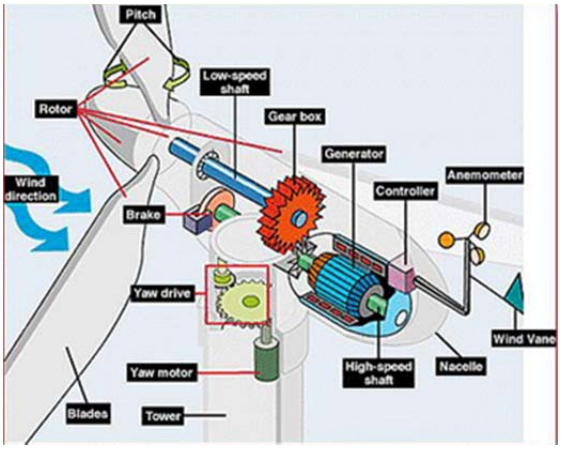
In transitional waters (30-60 mts), Gravity base structures can be used. Also the Tripod Piled Structure and the Tripod Suction Caisson structure are appropriate for this depth range. Conventional Steel Jacket structures as used in Oil and Gas industry seem perfectly favourable too in this case.



Floating Wind Turbines (CREDIT: NREL)

For deeper waters, a newer technology has been developed called the Floating Wind Turbines. In this type of structure, a floating device is attached to the turbine stand which is anchored.

Nacelle: The nacelle contains the gearbox, generator and blade hub and the remaining components. Generally a three blade rotor is connected through the drive train to the generator. Once the turbine is operational, the nacelle is faced into the wind by the wind sensors connected to the yaw drive system thereby maximising the amount of electricity produced.



5. PROS. & CONS.

- **Area:** Availability of greater area for setting up large projects is one of the primary advantages of moving towards offshore projects.
- **Wind Speed:** Wind Speeds are significantly higher at the offshore regions. A global study of wind patterns found that offshore wind speeds in average are 90% higher than onshore wind speeds.
- **Turbulence:** Less turbulence is found in winds at seas than on lands which results in lower mechanical fatigue load and thus longer life of the turbines.
- **Visual Impact:** Offshore Wind farms are located far from land and they have less visual impact which helps with public acceptance issues. As they come much less into human contact, people do not need to deal with the noise pollution and eye-sore that turbines cause for some. Farmers complain sometimes that the 'whirring' noise of the turbines do scare their livestock while others simply do not like the site of the turbines. Since away from land the sounds and images of turbines are nearly unnoticeable. Fishes and Fishermen are least disturbed with proper placement of turbines. Also it helps in accommodation if managed properly into marine areas.
- **Challenges:** Even though wind is available everywhere, harnessing that wind for electricity requires some thresholds for wind speeds. Lack of geographic and geological locations suitable for installing Wind turbines and transmitting power to where is needed is the main challenge faced on the way of setting up offshore wind farms.
- **Cost:** The capital cost of Offshore Wind farm projects is higher compared to onshore wind power projects. The cost is mainly based on the points like turbine installation vessels, Construction Support vessels, Sub-Structure manufacturing and trained man-power.
- **Technology:** Offshore Wind projects also require different transmission lines for feeding the output to the grid. Since salt water is conductor of electricity, heavy insulation is to be done to the submarine transmission cables to prevent any leakage. Windy areas also have rough waters and rocky coastlines might wear out transmission cables. Protection should be taken against these too.
- **Security:** Turbines are much less accessible when they are placed offshore. Thus reliability is more important than the onshore ones. Therefore the manufacturing should be strong. The other devices attached that recognizes hazards should be well functioning. In case a special team should be prepared either with travelling facilities (if near to shore) or with accommodation facilities at the site.

6. ECONOMIC BENEFITS:

The pre-installation of Offshore Wind power bears a cost that is to be taken by the authority which if compared is definitely more than the onshore process. But it has been found out and estimated that the net benefit that is to be gained by installation of the Offshore farms is far greater than the cost born. Moreover, it has also been projected that there would be new industries focussed on Offshore market thus creating various Job opportunities for people. Also this Offshore installation and maintenance program would simultaneously create job market for the people in various sectors. Thus Economy grows again.

The table below shows the Job projection in UK by 2020 by category:

COMPANY TYPE	LOW PROJECTION	HIGH PROJECTION
R&D, engineering And Design	3,000 8%	4,000 6%
Turbine and Component Manufacturing	7,000 18%	15,000 21%
Installation, Operation and Maintenance	8,000 20%	29,000 41%
Services	22,000 55%	22,000 31%
Total:	40,000	70,000

Source: Carbon Trust

Also mass-production of electricity from a non-renewable resource will automatically decrease its price. Furthermore the research and development teams who wish to see a successful green environment around the world where Offshore Wind power has major contribution, are in progress of finding newer technology that is more sustaining, more economic, more eco-friendly and more beneficial for the sustainable development of the society.

7. COMPANIES LEADING GLOBALLY IN OFFSHORE WIND MARKET

It has been reported that currently the Offshore Wind power market is in the midst of a boom, and high rate of Interest for vendors in the market is positively influencing the market growth at a CAGR of 17.5% from 2014 to 2019.

The top ten global companies who are investing in offshore wind power farming as an answer to a complete renewable technology worldwide are:

- Siemens
- Vestas
- GE Energy
- Senvion
- Sinovel
- Alstom
- Areva
- Clipper Windpower
- Doosan Heavy industries and Construction
- Gamesa Technology

It's been reported that these companies have been actively participating in the manufacturing of Offshore Wind farm materials as well as investing in its Research and Development Sector for newer technologies and also setting up farms around the world, thus contributing to a green future.

8. CASE STUDY: INDIA

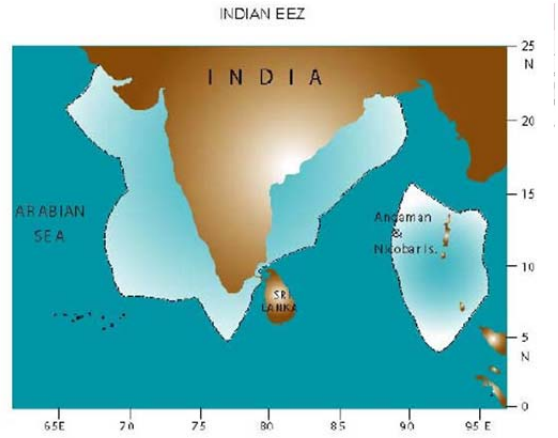


Fig. 1. Study region, the dashed line represents the Exclusive Economic Zone (EEZ); (Courtesy: www.niobioinformatics.in)

India has a very long coastline of 7500 kms including the island territories and also has an EEZ (Exclusive Economic Zone) of 2.172 million sq. km. it is surrounded by Bay of Bengal in the East, Arabian Sea in the West and Indian Ocean in the South. India has high Wind potential on the shore and offshores.

Essentially primary parameters such as bathymetry, wind velocity, proximity to the coast, ports, marine protected areas, harbours, marine sanctuaries which are used in assessing the feasibility of offshore wind farm using the GIS environment. Weekly Climatology of Quick SCAT wind speed data with resolution 0.25 x 0.25 degree was used for the period 1999-2009 for the exploration of the seasonal wind potential.

Bathymetry: The Water depth of the sea or ocean, is an essential parameter because decides the primary cost of the installation cause after a certain depth installation might not be feasible cause it will complicate structures that will unnecessarily increase the cost. The feasible depth for installation is 15-75m. The different range of Indian waters within which different designs are feasible are:

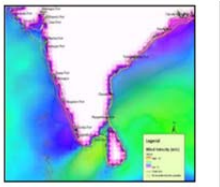
a) 0m to-24.9
b) -25m to -49.9m
c) -50m to -74.9m

Bathymetry Surrounding the Indian subcontinent (Data Source: GEBCO)

Wind Speed: Wind speed is a very important parameter that decides the feasibility of a particular site. Certain thresholds are to be followed for optimum power generation. The minimum wind speed of 5 - 5.5 m/s has been considered threshold for wind energy development. Therefore, for offshore installation it should be checked that the minimum wind speed is more than the minimum onshore desired.

Proximity to the coast, ports, harbours: All the traffic near the coast has to be kept in check so as to avoid collision of vessels with the farm or HV station thus preventing loss of potential energy. Areas near to ports or 50 kms distance from

the coast are considered for study, so that the traffic by the ship and long cable laying could be avoided.



Wind Velocity (m/s) (Averaged over 52 weeks)

Ports with 50 Km coastline buffer

Marine protected Areas: The sites which are protected by law cannot be considered as feasible site for wind farm installation. Wind farm installation considers some kind of works that disturbs the eco-system. So, as a result the Marine Protected Areas which heavily occupied by different flora and fauna maintaining a balance in their eco system should not be disturbed.

Conclusion: India has major scopes of putting Offshore Wind power into use if there is a little improvement in technology. It is due to India's offshore wind speed which is a little less than the pacific one. So, an improvement in the turbines includes some technical advances like working in low wind speeds. Also wind varies here according to different seasons in India which will produce different results as par. So, technologies should be appropriate to cope up with that.

9. TO CONCLUDE:

Offshore Wind Energy is a powerful potential energy reservoir that is almost unexplored in most parts of the world. There are advancements in technology ground and there is a dire need on scientific methods. The feasible regions that are found out should be studied in more details for best outputs. It is suggested to form a dedicated policy and framework which will promote Off Shore Wind power so that the presence and the potential can be tapped to the fullest.

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