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A Brief Survey Report on Wind Mills and its Buoyancy

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Abstract:
In the present day energy scenario, non -conventional energy resources are gaining a significant role in meeting the ever increasing energy demand of the entire human population all around the world. Among all the sustainable energy sources, wind energy extraction is the fast developing and hence the major contributor. Especially, offshore wind energy is currently getting more traction and attraction compared to onshore plants, as sea winds are of high velocity and abundance. This article investigates in short, the history, energy extraction, types, the challenges faced during construction and installation of buoyant wind energy conversion systems.

Keywords: *buoyancy, floating, onshore, offshore, platform, sustainable.*

I. Introduction

Over the years, all the developed and developing countries are equally depending on conventional sources of energy (fossil fuels like coal and oil, nuclear fuel) for supplementing their energy demand (electricity, transport, industries and agriculture). Further, the energy consumption rate always shows a sharp increase with the per capita income, industrialization and the population of a country. India stands fourth behind US, China and Russia in energy consumption.But these traditional energy sources are scarce in supply and non – green. Hence every country is in the constant look out for suitable alternative energy options in the form of solar, wind, tidal, biomass, ocean etc…Such renewable energy sources are inexhaustible, sustainable, clean, green and available in plenty. India's energy installation capacity share ratio is 79.8:20.2 % between conventional and non-conventional (Fig. 1). According to the recent Indian statistics, wind power accounts about 49.3 %, followed by solar (31.4 %), and bio mass (12.6 %) (Fig. 2)

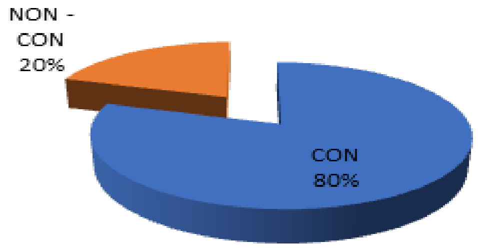

Fig. 1 Energy Installation Capacity – Share Ration

Wind energy conversion systems are the promising alternate for the conventional methods of energy production. The two broad methods of harnessing the wind is land based onshore and sea based offshore windmills. This paper discusses about the significant differences between onshore

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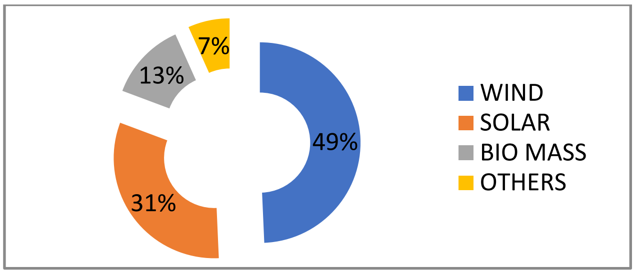
and offshore windmills, various types of offshore windmills, existing plants and relative analysis that has been carried over for the past years.

The structure of this manuscript is as follows: Section II reviews the general history and growth of the windmills. Section III shows the types and comparison of onshore and offshore windmills. Section IV explains the challenges faced in the installation of offshore plants and the consequent measures undertaken to overcome them.

I. WIND AND WINDMILLS – HISTORY AND GROWTH

A. *Wind and Wind Mills*

Solar energy being the primary source of all its derivatives indirectly produces wind. Due to the uneven heating of the ocean and the land surface, a pressure gradient is set up leading to the movement of air i.e., WIND [4]. The energy inherent in wind can be partially converted to its electrical equivalent with the arrangement called as windmills. The working principle of the wind mills involves the passing of wind through the airfoil section of the blades. A torque generated by the lift produced is then transformed to electricity in the generator. Therefore the windmills thus involve two major conversion stages: wind kinetic energy to mechanical energy by the turbine blades and the mechanical energy to electrical energy conversion by the generator.



Wind Energy Conversion Systems(Fig. 3a) has several

A wind energy conversion system (Fig. 3a) has the following components: Wind turbine rotor, a hub housing the gear box , generator , measurement and control mechanisms, tail vane and a supporting tower structure to balance the top turbine mass. Wind turbine rotors may be vertical axis or horizontal axis on the basis of its axis of rotation. The direction of the wind that first hits the turbine's face decides whether it's an upwind or downwind system. The more popular horizontal axis wind power plants are in use since medieval days for grinding, water pumping applications. The number of turbine blades may be between 2 to 5. Large scale turbines use nylon fiber for fabrication of their blade structure. Vertical axis wind turbines are in rare existence and classified into Darrieus and Savonius types [5]. A Darrieus machine (Fig. 3b) has a vertical shaft with 2 blades vertically revolving around it thus shaped up like an eggbeater [5]. Two cup/ scoop shaped structures revolves around the vertical shaft giving an S Shape in Savoniusrotor (Fig. 3c) [5]. Darrieus Machines enjoys more credible features than Savonius types as they are fast rotating with higher torque and efficiency [5].

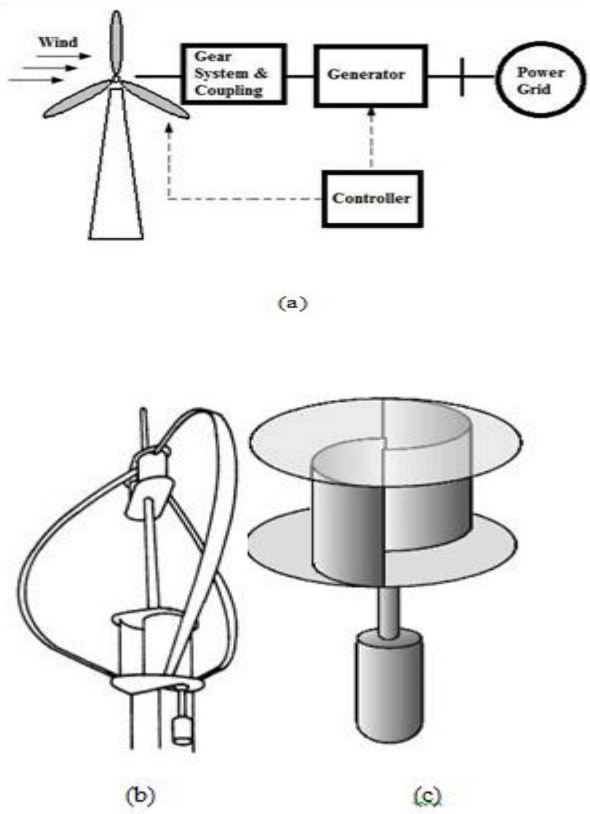


Fig. 3. (a) WECS (b) Darrieus Rotor (c)Savonius Rotor

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The wind energy conversion systems works with the following equations:

$$Kinetic\ Energy\ of\ Wind = \frac{1}{2}\ m\ v^2$$ □ □ □

$$Mass,\ m = \rho\ A\ v$$

$$Wind\ Power = \frac{1}{2}\ \rho\ A\ v^3$$

$$Swept\ Area,\ A\ \ \pi\ r^2$$

$$Maximum\ Wind\ Power = \frac{16}{27}\ \rho\ A\ v^3$$

$$Maximum\ Wind\ Power C_{pmax}\ \ \rho\ A\ v^3$$

$$Betz\ Co-efficient,\ C_{pmax}\ = 0.593$$

B. *History and Growth*

[6]In India, the state of Tamil Nadu tops in the installation capacity with the city, Muppandal being the single largest wind farm with 1500 MW capacity. [6] Maharashtra ranks second with its installed capacity of 4442.05 MW. Gujarat, Rajasthan and Karnataka take the third, fourth and the fifth places respectively [6].[6]Other wind farms are found scattered in isolated places like Dewas ,Nagda Hills (Bhopal -MP), Penukonda, Nallakonda (AP), Kanjikode, Ramakkalmedu (Kerala) etc…[6].Also, given India's coastline of 7600 KM, the country has an enormous potential of offshore wind energy. National Institute of Wind Energy, Chennai, and Tamil Nadu has identified some potential locations for the construction of off shore plants along a 1000 KM coast line. Globally UK is high in the status of offshore wind markets followed by Germany, Denmark, China and Netherlands.

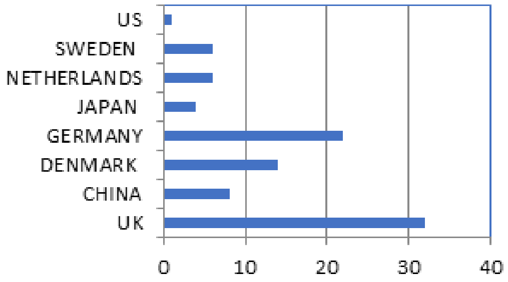

Fig. 4 Buoyant Windmills in Full Scale Operation

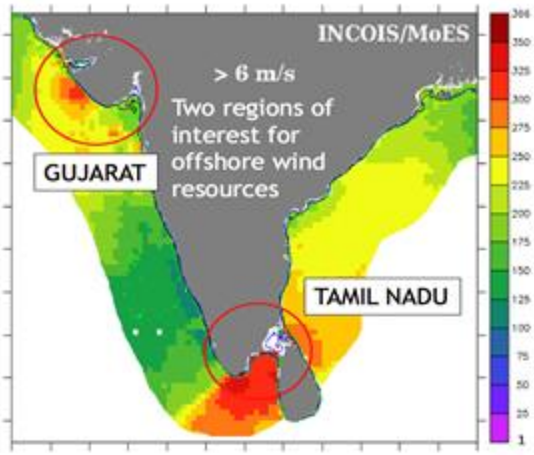

Fig. 5 Potential Offshore Locations in India

UK has 32 offshore wind plants in full scale operation. Some of the other countries that have utilized the ocean based buoyant wind mills are China, Denmark, Netherlands, Japan, Germany, and Sweden. United States is not far behind (Fig. 4). Indian Ministry of New and Renewable Energy (MNRE) has set up a target 30 GW capacity power generation by offshore plants by the year 2030. Gujarat and Tamil Nadu (Fig. 5) are identified as the potential sites. As a preliminary, LIDAR has been installed in Gujarat for testing the offshore wind quality and the results are fruitful.

II. Onshore and Offshore Wind Turbines

Major percent of the world's wind turbines are installed on land (Onshore). The pros and cons of onshore wind power plants in comparison with respect to offshore plants are detailed below:

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A. *Pros*

- Minimal costs for installation, operation and maintenance.
- Less complex infrastructure and construction
- Specialized and advanced technology not required.
- Simplicity in transmission of wind power

B. *Cons*

- Inconsistent variation of winds speed and its direction over land resulting in drop of efficiency
- Right of Way (ROW) and other land licensing problems
- Noise and visual Impact causing public dislike.

But offshore locations on sea offer more attractive factors compared to onshore locations. Hence buoyant wind plants are springing up on several places across the world. Offshore technology is not a new aspect and is in existence for several decades in the form of oil wells/oilrigs. Offshore constructions enjoy the same advantages as that of their onshore counterparts and much more. Winds above ocean surfaces are generally much higher, more consistent and predictable leading to highly efficient plants. Floating wind plants on sea when optimized to capture the rising wind speeds of the noon will be able to deliver maximum energy output especially during peak demand periods when utility grids need the emergency boost.

The different types of offshore windmills depending on the depth and the base design are shown (Fig. 6). On the depth factor, plants may be shallow, transitional and deep water. On the platform type, buoyant wind mills may be deep water spar buoy, deep water pontoon type, shallow water monopod caisson up to 30m water depth, shallow water gravity base up to 30 m water depth, shallow water monopile up to 30m water depth, transitional water depth tripod/ jacket Quadra pod 30 to 60m water depth, mooring stabilized TLP/ semi-submersible with vertical anchors 60 to 300m water depth etc..

Onshore and Offshore Plants

	Comparison Table	
	Onshore	***Offshore***
Size	Large	Very Large
Structure	Simple	Complex
Construction	Easy Installation	Tedious Installation
Technology	Less Sophisticated	Advanced
Noise	Serious Problem	Not a Serious Problem
Cost	Least Comparatively	Very Expensive
Risk	Minimal	Maximum
Safety	Normal Procedure	Complex Measures
Visual Impact	Greater on Land	Minimal on Sea
Land Rights	Difficult to Obtain	-
Environment	Gust, Ice…..	Dynamic Sea Motions..
Transmission	Simple	Difficult
Wind Velocity	Inconsistent	Consistent
Energy Yield	High	Very High

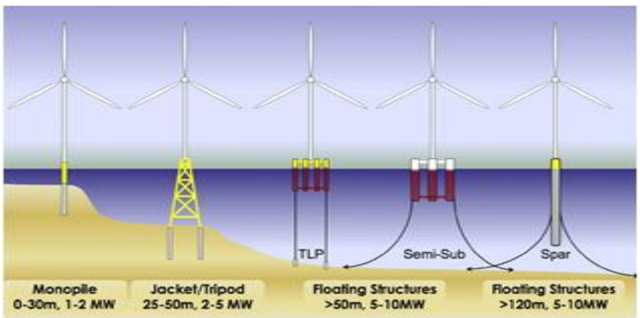

Fig. 6. Types of Floating Wind Mills

III. CHALLENGES AND SOLUTIONS- SURVEY IN BRIEF

[2] describes the technology behind floating platforms classified on the basis of number of turbines (single and multiple) ,mooring (vertical and catenary) and anchorage(gravity based and

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embedded drag). The author of [18] has developed a downsized spar buoy model of low cost for further testing and experimentation. In [3], the author presents a HydroDyn simulation tool for modeling dynamic response analysis of different models and integrated load analysis of the same.The article also gives the cost comparison between NREL TLP and Dutch trifloater.[7]The study surveys the construction roadmaps of deep water wind turbines. The knowledge and activities of innovation involved in the design, testing and experimentation for translating the pilot plant to the full scale commercial plant are discussed.[8] presents problems in selecting the site conditions , installation limits technology wise and relative solutions developed based on the characteristic parameters of the plant.[9], [4]studies methods of collection of variation in wind patterns on a global level, climatic weather at regional level, parameter variations around the wind turbine and plant.

[10] explains the necessary expenses that are to be spent in extra for careful construction, safety, maintenance and risk management. The installation should be capable of standing stable against higher wind velocities and severe sea storms with least wear and stress. Bigger turbines, new and advanced transmission technologies, floats required to support the offshore facility to make it stay upright from the ocean floor all add up to the cost incurred. [11] uses a simulator for collection of realistic data instead of labor based collection thus ensuring the safety of the personnel working in offshore facilities. [12] proposes the MPRF(Medium Pulse Repetition Frequency) method of radar range measurements to suppress unwanted clutter of signals and noise from wind farms. [20] gives a data fusion methodology for collection of dense statistics needed for wind potential estimation. It also describes SAR (Synthetic Aperture Radar) approach for achieving wind maps with higher accuracy.

A vacuum assorted resin infusion (VARI) technique can be used for the blade fabrication making it more prone to high humid conditions of sea[15]. The same article also presents a dynamic mechanical analysis (DMA) as a degradation test for aged blade specimens[15].[14] shows that (1/4)th of the theoretical Betz limit (of 0.593) i.e., (4/27 = 0.15) of useful wind power can be extracted from wind during the reel out phase of a Loyd's lift power airborne wind device (AWE). [13] proves that thrust and power characteristics has a strong dependence on tip speed ration (TSR). [19] proposes a free vortex method for doing behavior analysis of the plant under sea dynamics. [17] studies the functions of superconducting magnetic energy storage systems for reducing transient over voltages and high frequency power fluctuations of the HVAC cable lines. A 60 KM underwater cable line is modeled to study the transient problems caused by the capacitive effect. [16]reviews the problems in evaluating the transmission losses of HVAC system and how it affects the cost and economy of the plant.

IV. CONCLUSION

This paper describes the importance of clean renewable energy and off-shore wind power's contribution towards the cause. Firstly, a brief overview of wind and wind energy conversion systems, scope of onshore and offshore capacity in and out of India is presented. Secondly, significant differences between onshore and offshore plants, categories of offshore plants are discussed. The constructional and operational challenges, the probable and possible solutions, and the different analysis techniques are detailed in the last section.

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