Floating Power Station With Emergency Rescue Passenger Space For Life Saving As Part Of The Ship

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Abstract: This paper relates to the ship having tethered wind turbine system for power generation and emergency rescue passenger space for passengers to save their life during an emergency situation. It is a lighter system that rotates about a horizontal axis in response to sea breeze and wind produced during sailing is used to generating electrical energy. This electrical energy is transferred to the ship for immediate use. Helium (an inert non-reactive lighter than air) sustains the Air Rotor which ascends over stern deck to an altitude for best wind and its rotation with the sailing causes the Magnus effect. This provides additional lift, keeps the device stabilized, and keeps it positioned within a very controlled and restricted location. Commercial ships will use this electrical energy for their ship auxiliary power system additional to their fuel. Virtually all emission from the vessel including NO_x, SO_x and CO_2, are reduced by using power generated from this turbine. Whenever, the ship is at risk, this Helium filled gas turbine can raise the emergency rescue passenger space and save passengers.

INTRODUCTION

In general, a ship uses generators autonomously so as to smoothly utilize electricity and provide power during emergencies. Such a generator receives energy generated by mechanical motion of an engine to convert the energy into electrical energy through magnetic coupling between a stator and a rotor, thereby supplying the electricity energy to a load. However, a ship using an engine as a power source uses mixed oil of bunker –C oil and diesel oil as fuel. Maintenance and sailing costs are very high. Furthermore, oil fuel such as the mixed oil used in ships may generate noxious gases during combustion to cause air and sea pollutants. The more the number of ships, the more will be the air and sea pollution. Accordingly, this may have a serious bad influence on the ecological system as well as marine organisms.

However, energy sources such as wind power, sea water and solar are inexhaustible and boundless clean energy. Thus, what we require in a ship is an electricity generating apparatus in which electricity is generated using wind, seawater, solar light, which are natural power may be stored in a battery, and then used in various electric devices or directly used as power source to significantly reduce the usage of mixed oil. Accordingly, in the light of the above-described views, a number of inventions related to a ship with a typical windmill style, tower-mounted power generator are being proposed. However, the inventions are expansive and have limitation that the total amount of wind introduced into a wind turbine is limited. For these reasons, typical wind resource electrical generation systems for ship may be undesirable.

Accordingly, there is a need for systems and methods for tethered wind turbines for ship that address these and other problems found in existing technology.

ENVIRONMENTAL IMPACT OF COMMERCIALSHIPPING

A report called "Air pollution from ships" published by a number of environmental Organizations in Northern Europe described the challenge of ship emissions.

Emissions from ships engaged in international trade in the seas surrounding Europe –the Baltic Sea, the North Sea, the north-eastern part of the Atlantic, the Mediterranean and the Black Sea – were estimated at 2.3 million tonnes of sulphur dioxide (SO), 3.3 million tonnes of nitrogen oxides (NO_x) and 250,000 tonnes of fine particles (PM) a year in 2000.Under current legislation, it is expected that shipping emissions of CO_2 and NO_x will increase by 40-50 per cent up to 2020, as compared to 2000. In both cases, by 2020 the emissions from international shipping around Europe are expected to equal or even surpass the total from all land based sources in the 27 EU member states combined.At the core of the problem is the nature and quality of fuels used by the marine industry. This fuel, referred to as bunker fuel, is one of the least pure products of the refining process. An international convention that went

into force in May 2005 limited the sulphur content of these fuels worldwide (at sea and in port) at 4.5 per cent. The vast majority of ship emissions are released within 400 kilometers of land. Coastal region along busy trade routes such as the English Channel and the Straits of Malacca show the highest frequency of adverse health effects. Port areas are also particularly exposed to these emissions, as ships calling in port currently use diesel auxiliary engines for their power needs. Container ships can use as much as 6 MW during port operations, Ro-Ro/car carrier vessels from 1 to 3 MW, and cruise ships up to 10MW. Major emissions coming from ships' auxiliary engines include nitrogen oxides (NOx), sulphur oxides (Sox), volatile organic compounds (VOC) and diesel particulate matter (PM). While the content of these materials are controlled in ships' fuel, the actual emissions are currently uncontrolled for most ships.

The Port of Los Angeles and Long Beach commissioned a study of NOx emissions from ships calling at their ports from 1 June 2002 to 31 May 2003. This study analyzed the relative amounts of emissions created by ship's main propulsion engines and their auxiliary engines. This study demonstrated that as much as one-third of ships' NOx emissions were created while the ship was docked at the quay. These emissions amounted to an average of 13 tonnes of NOx per day, which is equivalent to approximately 13 million cars' emissions per day. The cruise industry has been the focal point of studies related to emissions in or near port areas, as they are large power consumers. A 2009 report for the European Commission on cruise tourism explored the environment factor in cruise tourism, and specifically emissions released in ports. This study reported that cruise ships in EU ports in 2009 released over 20,000 tonnes of NOx, 650 tonnes of So, 1 million tonnes of CO_2 and 2000 tonnes of PM. The study attached an economic cost to the EU's largest ports in terms of cruise ship emissions; in Barcelona, this equaled over EUR 35 million per year, in Naples EUR 23 million and Piraeus EUR 19 million. Another study is commissioned to compare the emissions created by ships' auxiliary engines with emissions created during the generation of power at tethered wind turbine is zero. Tethered wind turbine power supply reduced emissions of (NO_x), VOC and PM by at least 10 percent, compared to ships using their own auxiliary engines to create power. A life-cycle environmental analysis of ship based power would include emissions related to the extraction of crude oil, crude oil transportation, refining, transport of refined products and finally consumption on the ship. A life-cycle environmental analysis of tethered wind turbine is Eco-friendly. Noise contributes to health problems as stress, sleep disturbances, cardio-vascular disease, and hearing loss. Noise and vibration effects are felt primarily by passengers and workers in the port

area; they can also significantly impact the local environment in port areas. Noise and vibration are usually part of ports' environmental permits, and noise and vibration levels can effectively put a damper on port expansion in some cases. Comparing the relative merits of tethered wind turbine based power generation and ship based power generation. Tethered wind turbine based power generation is pollution free inexhaustible and boundless clean energy.

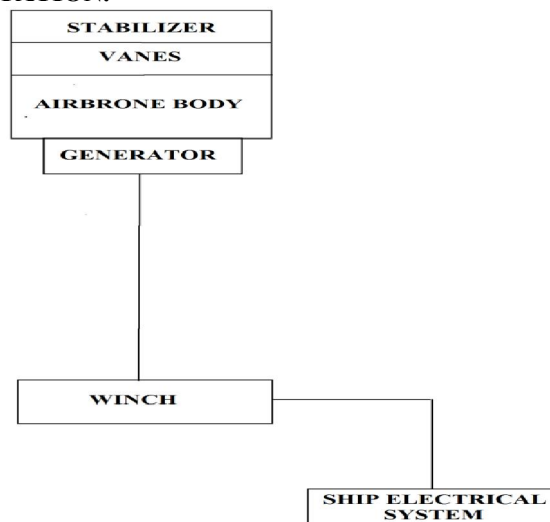**BLOCK DIAGRAM OF FLOATING POWER STATION.**

Figure 1: Block Diagram
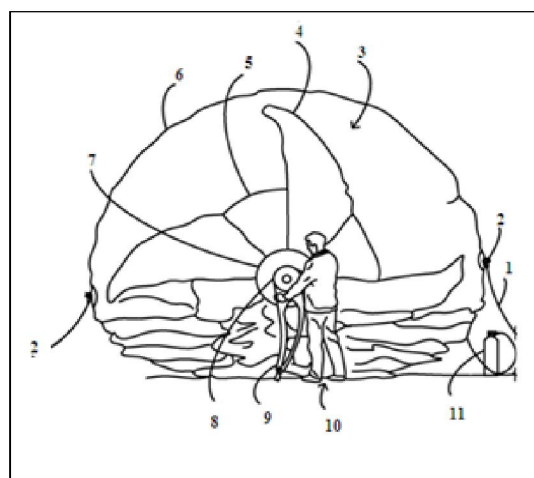
NOMENCULTARE OF TETHERED WIND TURBINE

Figure 2: Structure of tethered wind turbine
Stay. (2) Securing point. (3) Envelope. (4) Vanes. (5) Body. (6) Integral stabilizer. (7) End plate. (8) Generator. (9) Yoke. (10) Operator. (11) Compressor.

According to some embodiment, the tethered wind turbine may comprise a single collapsible or

inflatable unit including a body, an envelope, and one or more vanes. The envelope and body are pressure against two end plates. The tethered wind turbine may comprise of two generators, yokes and one or more securing point. In some embodiment, the yokes are coupled to tethers and external securing points are coupled to one or more stays. In some embodiment, the tethers also coupled to tether coupler. The envelope defines various portions of the wind turbine such as the body, the vanes, and integral stabilizer. The body and envelope may extend horizontally between two end plates. The wind turbines comprise end plate having inner side coupled to the body and outer side comprising projection [4].
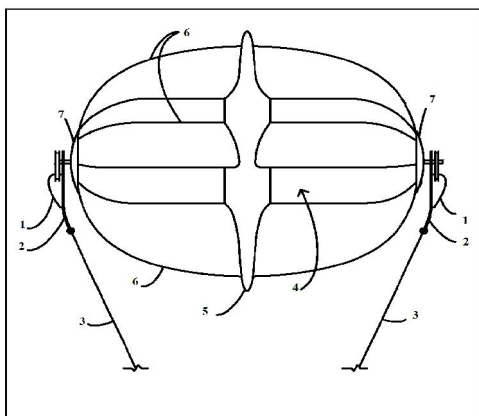

Figure 3: Front view of tethered wind turbine
(1) Generator. (2) Yokes. (3) Tethers. (4) Envelope. (5) Integral stabilizer. (6) Vanes. (7) End plate.

The wind turbine also comprise of an integral stabilizer to facilitate orientation of wind turbine perpendicular with respect to prevailing wind force. The stabilizers allow the wind turbine to be self positioning and automatically re-positioning as prevailing wind force change direction. In such a manner vanes may generally be positioned such that the prevailing wind force acts upon the frontal surface of the vanes to cause the body to rotate (clockwise or backward) about horizontal axis. The stabilizer is shown in phantom to increase visibility of components (generator, yokes) that may otherwise be obscured. The yokes comprise one or more flanges, projections, couplings and object associated with generator. The woven outer part is actually made from the same material used in bulletproof vests and is lined with a coating that protects it from UV rays and abrasion. The inner portion is coated with Mylar to prevent the gas from escaping [3].

This turbine envelope will be made of a durable material. Since the turbine is located at such high altitudes, it was also designed to be able to withstand strong wind. While conventional turbines will shut down at wind speeds in excess of 45 mph, this turbine can function at speeds greater than 63 mph. At the other end

of the spectrum, this turbine can also convert wind energy into electricity.
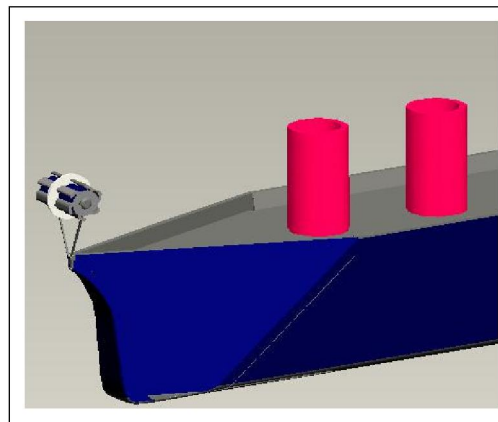
WIND POWER ON SHIP BOW

Figure.4: Tethered wind turbine on ship Bow

The Tethered wind turbine is a cylindrical device which is filled with pressurized atmospheric gas. At bow of the ship 'V' shaped support made of steel is retrofitted. The tethered wind turbine is placed at the top of the 'V' shaped support. When the ship moves in the water, wind energy is obtained by tethered wind turbine. Tethered device that rotates about a horizontal axis in response to the wind efficiently generates clean renewable electrical energy. This electrical energy is transferred to the ship's auxiliary power system through a cable.

WIND ENERGY GENERATION FOR SHIP BASED ON THE PROPOSED MODEL.

Tethered wind turbine is an innovative lighter-than-air device filled with Helium to achieve static, buoyant list. The cylindrical wind turbine rotates about its horizontal axis in response to the wind. A Magnus lift is generated proportional to the speed of the air flowing over the cylindrical device. This effect also enables the unit to stay at higher attitude, rather than constantly drifting downwards.
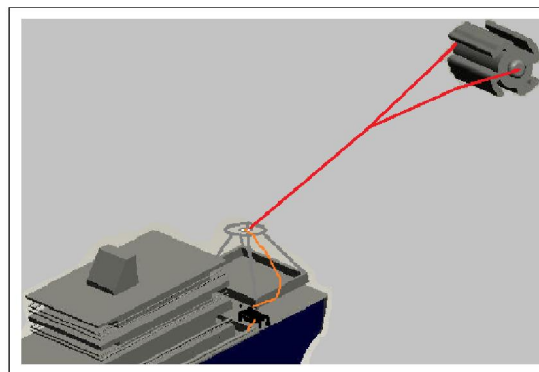

Figure.5: Wind power at 300m over stern deck

The wind turbine rotates backward as the ship sail forward. The resulting lift will be greater than the total buoyant lift which could be up to 5 tons of payload, depending on airborne body design. This turbine is deployed at 1000ft of maximum altitude, from the surface of deck. As the speed of the ship increases, the speed of the wind, the rotation of the cylindrical device and the lift increases. At the same time drag will be minimized because of reduced leaning of the tethered wind turbine and the increase of stability. Once the wind passes over the unit, electricity is generated by the rotation of the turbine unit, and it is then transferred by cables to the ship auxiliary power system. Tethered wind turbine is filled with He gas. Helium is the second most abundant element in the universe. It is also plentiful, inexpensive and environmentally safe. It is inert and non-flammable. The lifting gas creates a lift force that is more than the total weight of the unit. He gas provides at least twice the positive lift versus the overall weight of the unit. Additional lift is also created when the turbine spins in the wind. The aerodynamic effect that produces additional lift is the Magnus effect.

TETHERED WIND TURBINE ELECTRICAL SYSTEM IN SHIP

By holding existing technology we can develop a reliable infrastructure to transport this wind power.

Some basic elements for deployment of electrical system:
- ✓ Enabling the vessel power supply.
- ✓ A transformer for ship power supply.
- ✓ Switchgear equipment such as breaker and disconnector for ship power supply.
- ✓ An automated earthing switch for ship power supply.
- ✓ A frequency converter, if power frequency needs to be stepped down from 50 Hz to 60 Hz or, vice-versa, stepped up.
- ✓ Protection relays in order to assure safety for cable-handlers.
- ✓ Galvanic Separator.

In order to transfer electrical energy from tethered wind turbine to ship auxiliary power system, there must have a dedicated electrical room. This dedicated room consists of transformer, static frequency converter, switchgear equipments, circuit breaker and protection relay. The transformer serves two purposes. First, it provides galvanic separation (a Non-metallic direct connection between the wind turbine power supply grid and the ship internal electrical System), so that an earthing fault in the ship internal electrical system will not endanger the wind turbine grid or vice-versa.

Secondly, the transformer steps down the voltage supply from a voltage level optimized (20 kilovolts) to one of the two voltage levels standardized for floating power station connections: 11 or 6.6 kilovolts. Switch gear equipments with an automated earthing switch. In essence, this switch ensures that there is no power in the cables between the ship auxiliary power system and tether wind turbine grid while they are being handled and connected. The majority of ships operate with 60 Hz supply, whereas tether wind turbine power grids supply 50 Hz. As a result, most floating power station connections will require a frequency conversion. Static frequency converters provide an economic solution to connect any ship to any grid independent of the required frequency.

SHIP SIDE TECHNOLOGY

Ships must be either built or retrofitted with equipment that enables the connection to wind turbine, synchronizes the power change over from wind turbine to ship electrical system.
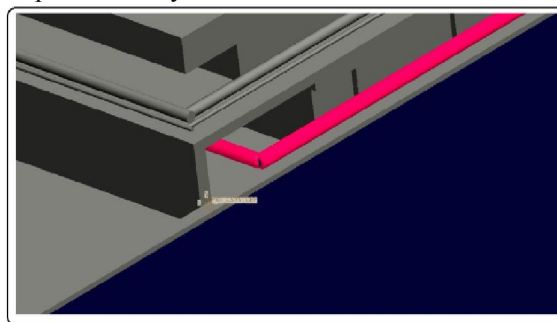

Figure 6: Cable to auxiliary engine.

First and foremost, the tethered wind turbine - based power needs to get onboard via cables. In some cases, particularly container ships, Roll-on/Roll-off and car carriers, the cable is installed on the ship, and lowered via a spool or drum, where it is connected. The tethered wind turbine connection panel contains a circuit breaker, a protection relay, physical electrical connection and a control interface with the ship integrated automation system, or power management system. These systems allow the incoming power to be synchronized with the ship diesel auxiliary engines before the load is transferred. This Medium-voltage equipment needs to be installed in a dedicated room that can be locked.

On ships that use conventional mechanical propulsion (in which the diesel engines directly power the ship propellers, as opposed to diesel electric propulsion), the ship low-voltage auxiliary power system – typically 400 to 690 volts – requires a transformer to receive the 11kV to 6.6 kV power supply from wind turbine. This transformer is relatively large and bulky, but– it can be installed in the engine room, or any other suitable location onboard. In a few years, you may see scores of giant Air rotor over stern deck. It not

your typical turbine. This extremely mobile energy generators. It will float high the air at altitudes ranging from 600 to 1,000 feet (183 to 305 meters).Tethered wind turbine not only for easy deployment, but also for easy maintenance.
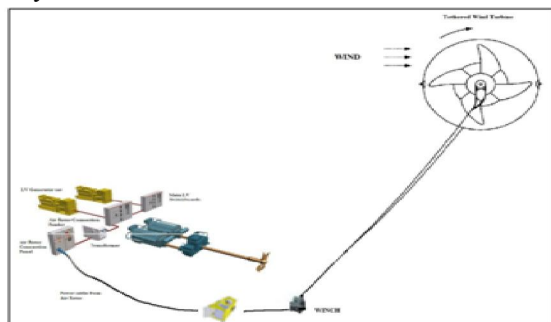

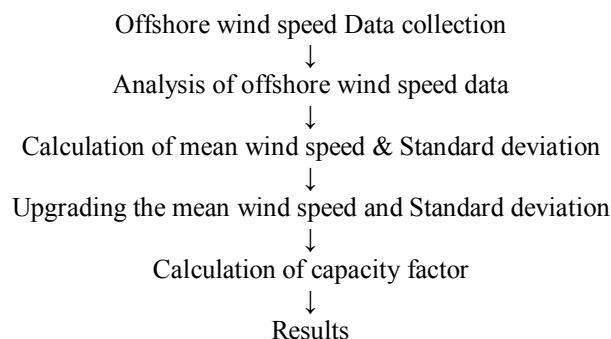Figure 7: wind turbine and ship auxiliary electrical system connection.

Methodology for Determination of Capacity Factors.
The methodology for the selection of the optimum wind turbine is based on the capacity factors (CF) of the available wind turbine. The long term wind speed data recorded at different hours of the day for many years is used. The particular steps used to determine CF for the mean wind speeds for at different hours of the day are generated with the manufacturer's specifications. The wind turbine with the highest capacity factor specific the optimum one and to be recommended. [6]

Calculation of Mean Wind Speeds
The mean wind speed for a typical day of a month need to be generated by averaging all the recorded wind speeds for regular interval of long term data of the wind speeds for the particular site to be considered.

Steps to calculate the capacity factor

Offshore wind speed Data collection
↓
Analysis of offshore wind speed data
↓
Calculation of mean wind speed & Standard deviation
↓
Upgrading the mean wind speed and Standard deviation
↓
Calculation of capacity factor
↓
Results

The mean wind speed is then calculated using the equation below

$$V_i = \left(\frac{\sum_{j=1}^{N_j} V_j^3}{N_j} \right)^{1/3}$$

Where
V_j =observed wind speed
N_j =number of wind speed observations
V_i =mean wind speed

> **Upgrading the Mean Wind Speed**

$$V_z = V_i \left(\frac{Z}{Z_i} \right)^x$$

Where
V_z = mean wind speed at projected height, Z
V_i = mean wind speed at reference height, Z
Z= projected height (or hub height)
x=power law exponent depends upon the roughness of the surface.

> **Generation of the Wind Speed Probability Density Functions**

$$f(v) = \left(\frac{v}{C_i^2} \right) \exp\left(-\left(\frac{v}{2C_i^2} \right) \right)$$

Where
$C_i = v_i/1.253$
V = wind speed

The Weibull probability density function is represented by

$$f(v) = \left(\frac{k}{c} \right) \cdot \left(\frac{v}{c} \right)^{k-1} \exp\left(-\left(\frac{v}{c} \right)^k \right)$$

Where
c=scale factor, unit of speed
k=shape factor, dimensionless
v=wind speed

The Weibull parameters c and k can be found using the following acceptable approximations

$$k = \left(\frac{\sigma}{v} \right)^{-1.086} \qquad 1 \le k \le 10$$

$$c = \frac{v}{\Gamma\left(1 + \frac{1}{k} \right)}$$

In both the probability density functions, the wind speed v will be the mean wind speed V, calculated at hub height

> **Calculation of Capacity Factors**

The average power output from a wind turbine is the power produced at each wind speed multiplied by fraction of the time that wind speed is, experienced integrated over all possible wind speeds.

$$P_a = \int_0^\infty P_w \cdot f(v) \cdot dv$$

Capacity factor can be defined as the ratio between average power output and rated power of the wind turbine can be obtained from the manufacturer's details.

$$P_w = \begin{cases} P \cdot \dfrac{v^k - v_c^{\,k}}{v_R^{\,k} - v_c^{\,k}} & for \ \ v_c \le v \le v_R \\ P & for \ \ v_R \le v \le v_f \\ 0 & elsewhere \end{cases}$$

Where
P is the rated electrical power,
v_c is the cut in wind speed,
v_R is the rated wind speed
v_f is the cut off wind speed
k is the Weibull shape parameter, the relationship between power and wind speed is as under,

$$P = \frac{1}{2} C_p \cdot \rho \cdot A \cdot v^3 \eta$$

For which considering value of air density factor
$\rho = 3.485 \ P/T$
Where P=101.3 kpa and T=273K the power equation thus can be written as

$$P = 0.646 \ C_p. \ A \ . \ v^3.\eta$$

Thus the capacity factor defined above can be expressed as

$$CF = \frac{1}{P_r} \int P(v) \cdot f(v) \cdot dv$$

> ➢ **Choice of the Optimum Wind Turbine Based on Capacity Factor**

The capacity factors of different turbines are computed from the wind speeds (v_c, v_R, v_f) and rated power data obtained from manufacturer details.
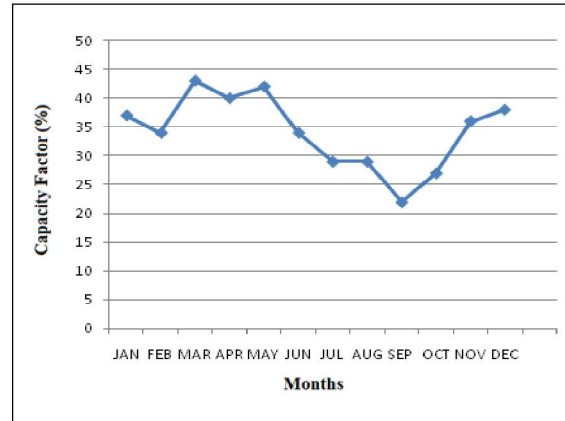
RESULTS

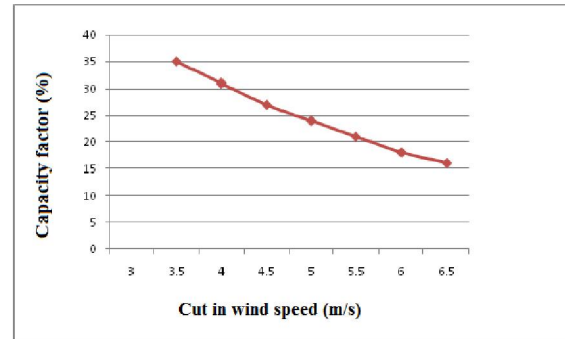Figure 8: Capacity factor Vs Months

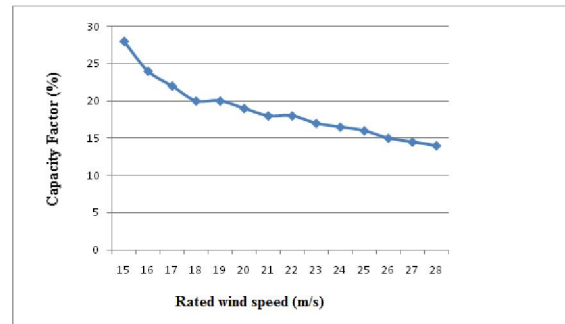Figure 9: Capacity factor Vs Cut in wind speed

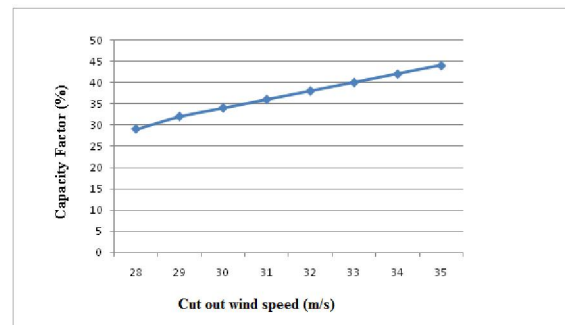Figure 10: Capacity factor Vs Rated wind speed

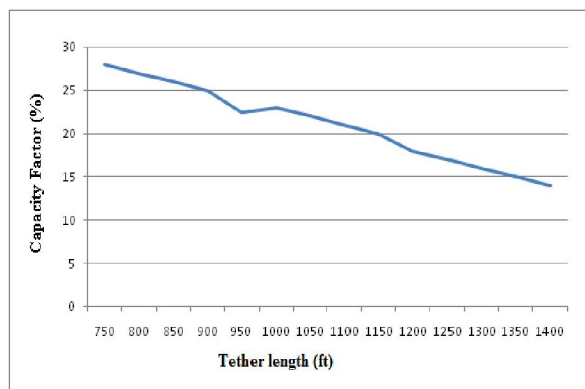Figure 11: Capacity factor Vs Cut out wind speed

Figure 12: Capacity factor Vs Tether length

COST ANALYSIS

For the offshore windmill turbine itself, the largest costs components are the rotor blades, the tower and the gearbox. These three items account for around 50% to 60% of the turbine cost. The generator, transformer and power converter account for about 13% of the turbine costs with the balance of "other" costs being made up miscellaneous costs associated with the tower, such as the rotor hub, cabling and rotor shaft. Overall, the turbine accounts for between 64% to as much as 84% of the total installed costs with the grid connection, civil works and other costs accounting for the rest. The reality is that the share of different cost components varies by country and project, depending on turbine costs, site requirements, and competitiveness of the local wind industry where the project is being developed.
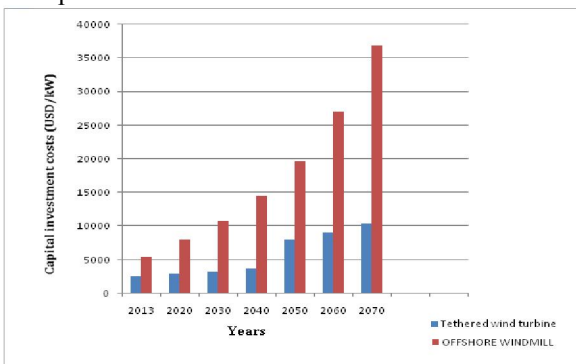

Figure 13: Comparison of Capital Investment Cost for Tethered Wind Turbine and Offshore Windmill:

The reasons for these price increases are several, and include:

The rapidly rising cost of commodities in general, steel and copper prices in particular. In offshore projects, copper and steel alone can account for as much as 20% to 40% of the total project cost.

The shift to offshore developments may be raising average installed costs in Europe. This is being accelerated by the shift from a shallow water market driven by Denmark to deeper water projects in the United Kingdom and Germany.

Growing pains and more sophisticated systems. Market demand grew so rapidly that the supply chain and human capacity required had difficulty keeping up with demand and shortages in certain components – notably, wind turbines, gear boxes, blades, bearings and towers – and led to higher costs. The increasing sophistication of turbine design, component integration and grid interaction also pushed up prices. Tethered wind turbine can be raised from 400-ft to 1,000-ft above surface of deck are possible, without having to build an expensive tower, or use a crane to perform maintenance. So capital expensive is low.

Figure 14: Power generation costs by energy source

Energy Type	Electricity Generation Costs in INR/kWh (USD/kWh)66
Coal	1–2 (0.02–0.04)
Nuclear	2–3 (0.04–0.06)
Large Hydro	3–4 (0.06–0.08)
Gas	4–6 (0.08–0.12)
Diesel	10+ (0.20+)
Wind (on-shore)	3–4.5 (0.06–0.09)
Small Hydro	3–4 (0.06–0.08)
Biomass	4–5 (0.06–0.10)
Solar (CSP)	10–15 (0.20–0.30)
Solar (PV)	12–20 (0.24–0.40)
Tethered wind turbine	**1.5–2.25.5 (0.03–0.045)**

PASSENGER SPACE

When the ship is at risk this tethered wind turbine also act emergency rescue passenger space for life saving. The floating power station is used as both power generation system and emergency rescue passenger space in the event of a disaster aboard a ship. Airborne body is tethered with passenger space to ascend. It is a floating body without an internal supporting framework, or a keel.
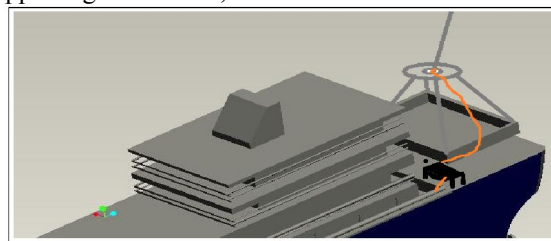

Figure 14: Passenger Space

This airborne body is a medium sized (55 feet diameter, 125 feet length) helium-filled balloon with a

volume of 250000 cubic foot tethered to the passenger space. It has buoyant tendency and high payload. Airborne body comprises of generator to convert mechanical energy to electrical energy. Initially the power transfers inside the tether. Using switchgear equipments power transmission is stopped. While we use emergency rescue passenger space generator is eliminate from airborne body to decrease the weight.

Figure 15: passenger space Lock

A winch, mechanical device is used to pull in (wind up) or let out (wind out) or otherwise adjust the tension of a rope or wire rope (also called cable or wire cable). In its simplest form it consists of a spool and attached hand crank. Winch is available to drop down the airborne body and then remove the generator. We can add additional payload. The rectangle shaped open structure passenger space carries all of its passengers within. Passenger space is connected by the hook in the lock which is fixed with ship deck. By unlocking the passenger space hook from the ship deck, the whole passenger space is freed from the ship. Normally one end of the tether (round disk) is fixed with the winch and other end is adjustable to increase or decrease the altitude of airborne body. The fixed end is connected with the electrical cable system of the ship. Whenever the ship is at risk the fixed end of the tether removes from the winch to make the total passenger space completely free from the ship.
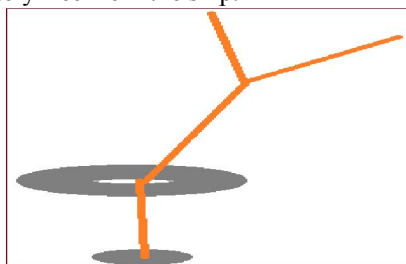

Figure 16: Passenger space and Airborne body joint

The fixed end of the tether (round disk) automatically goes up (due to buoyant lift) to the hollow disk like joint at the top of the passenger space. This joint is connected to the four ends of the passenger space by a tether. The diameter of the round shaped disk must be greater than the inner diameter of the hollow disk. Then only it can carry the passenger space from the ship. When the Helium filled Airborne body is lifted up,

the tethered passenger space is also lifted along with the passengers. Thus the passengers' lives are saved from the evacuated ship.
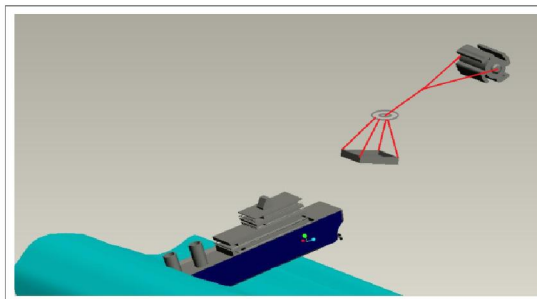

Figure 17: passenger space raised when the ship at risk

The items checked for passenger space safety are:
- ✓ Navigation lights.
- ✓ Compass.
- ✓ Sound producing devices/bell.
- ✓ Life jackets and throwable flotation devices.
- ✓ Fire extinguishers.
- ✓ Visual distress signals.
- ✓ Backfire flame control.
- ✓ Overall passenger space condition.
- ✓ Life Jackets.
- ✓ MARPOL trash placards (garbage dumping restriction).
- ✓ Drinking water.
- ✓ Navigation Rules book.
- ✓ State and/or local requirements.

Other recommended equipment
- ✓ VHF-FM Marine Radio with Digital Selective Calling System
- ✓ Mounted Fire Extinguishers
- ✓ Anchor and Line
- ✓ First Aid Kit
- ✓ Person-in-Water (PIW) Kit

APPLICATIONS

Major emissions coming from ships auxiliary engines include nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOC) and diesel particulate matter (PM) are reduced to 10% to 15%.
- ✓ Emergency rescue passenger space will save number of passenger's life.
- ✓ Tethered wind turbine is less expensive per unit of actual electrical energy output - under 20 cents per kWh versus 50 cents to 99 cents per kWh for diesel.
- ✓ Tethered wind turbine will deliver time-averaged output much closer to its rated capacity than the capacity factor typical with conventional designs. This turbine efficiency will be 25 to 60 percent. This is hugely important, since doubling capacity factor cuts the cost of each delivered watt by half.

- ✓ Wide range of wind speeds - 3 meters/second to more than 28 meters/second.
- ✓ Tethered wind turbine can be raised to higher altitudes, thus capitalizing on higher winds aloft. Altitudes from 400-ft to 1,000-ft above Ship deck are possible, without having to build an expensive tower, or use a crane to perform maintenance.
- ✓ Constant electricity can be produce over a period of time. Birds, bat friendly and lower noise.

Conclusion

This paper presented a new approach for ship to generate Eco friendly electric power. Therefore the fuel consumption perhaps reduced and the energy efficiency of the ship will improved. The proposed modeling approaches will also reduce the environmental impact of commercial ship. During sailing of ship the wind turbine will get additional Magnus effect. These kinds of proposal are necessary for ship to compensating the increase in present power consumption. Floating power station has also the potential to act as a emergency rescue passenger space whenever the ship is at risk, by which passengers can utilize the passenger space to save their life.

3/12/2013

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