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Wind Tracing Rotational Semi-Submerged Raft For Multi-Turbine Wind Power Generation

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Abstract

Introduction

An innovative semi-submerged raft supporting multiple turbines and self orientates to facing the wind is presented herein. Spacing between wind facing turbines is taken as 2.2D so that two rows of turbines can be placed with the wind wakes of front row of turbines project to the empty space between the aft row turbines, provided that the raft can turn along with the wind direction changes, i.e., wind tracing. A triangular raft supporting three turbines and a trapezoidal raft supporting five turbines are proposed here. Using an eccentric rotation center, the raft will always orientate to wind facing pose by itself.

Approach

To create a floating multiple-turbine raft without wind wake suffering, all turbines have to face into incoming wind thereby requiring the raft turns along with the wind tracing. By allocating Rotation Center (R.C.) eccentric from the C.G. towards the windward side or the leeward side, the raft settles only after wind force resultant passes through the R.C. and the C.G. In this orientation all turbines are wind facing, hence Wind Tracing. Support raft is submerged to depth that waves have insignificant effects on the raft beams. Beam weight is balanced by buoyancy, and the raft is made with concrete/prestressed concrete using bridge engineering skills for its construction.

Main body of abstract

Use a semi-submerged triangular raft with floaters located at the vertices supporting 3 turbines as an example. Submerged beams connect the floater bottom at depth greater than 14m wherein waves have little effects on the beams. The beam self weight is balanced by its buoyancy so that the floatation is from the floaters. A cable is attached to the bottom end of each floater, and merges to a node away from the C.G. into the windward side along the bisector of the triangle. The node is tied down by a mooing line to a seabed anchor to form a single tensioned leg structure. The rotation is by twisting of the mooring line. Power output cable is attached to one cable line and runs down the mooring line onto seabed with sufficient slackness in loosened coils to allow limited twisting. If needed, the raft performs active turn by pointing the rotor into wind for generating torque to turn back the raft to release the twisted cable and mooing line. Two turbines are in the front and the 3rd in the aft between the two front turbines. Wakes cast in the empty space behind. Wind force resultant is fluctuating around the C.G. since wind is not perfectly uniform. If rotation center is the at C.G., the raft will oscillate due to changing sign of the torque. With the rotation center eccentric from the C.G., the fluctuating force produces torque to turn the raft until the force resultant passes through both centers. The suggested construction method is by using the precast prestressed segmental concrete units to be joined whilst floating in a harbour.

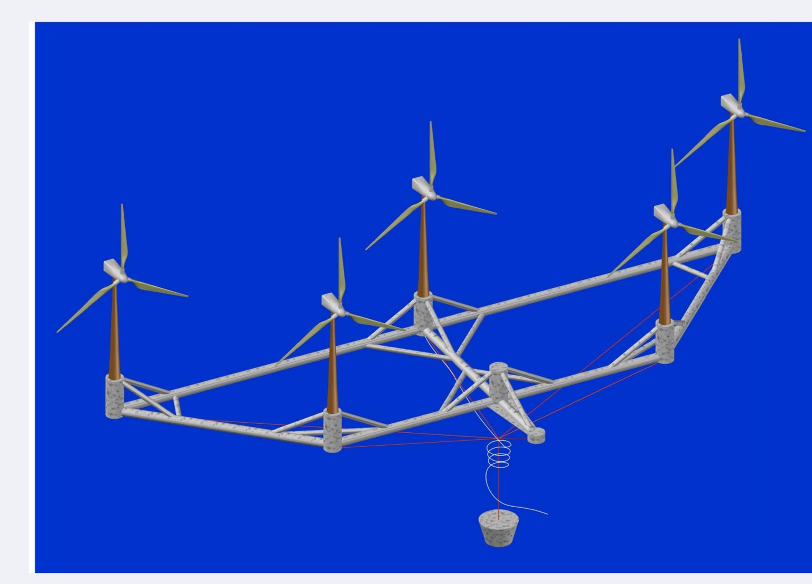
Objectives and key technical innovation

Objectives

- To create a floating platform for multi-turbine and;
- To create a simple turning mechanism for the floating platform such that;
- The platform turns following the wind direction.

Key technical innovation

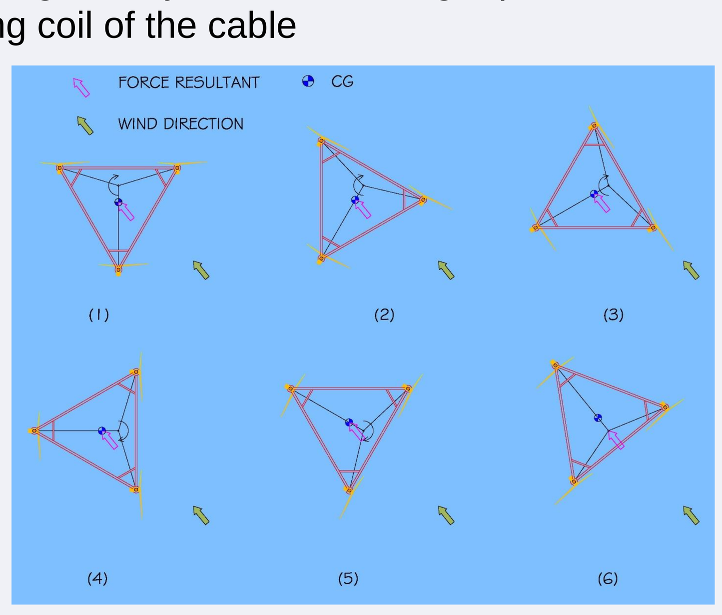
- Using prestressed concrete replacing steel for floating wind turbine support.
- Submerged raft members suspended at a water depth to avoid the action of the waves.
- Using multi-turbine raft instead of single turbine floating support.
- Creating a giant turbine from aggregated sweeping areas of the rotors.
- Eccentric rotation center to create a wind tracing mechanism.
- Using cabling system to form a flexible rotation axis.
- Using cabling system to generate a tensioned leg floating platfrom.

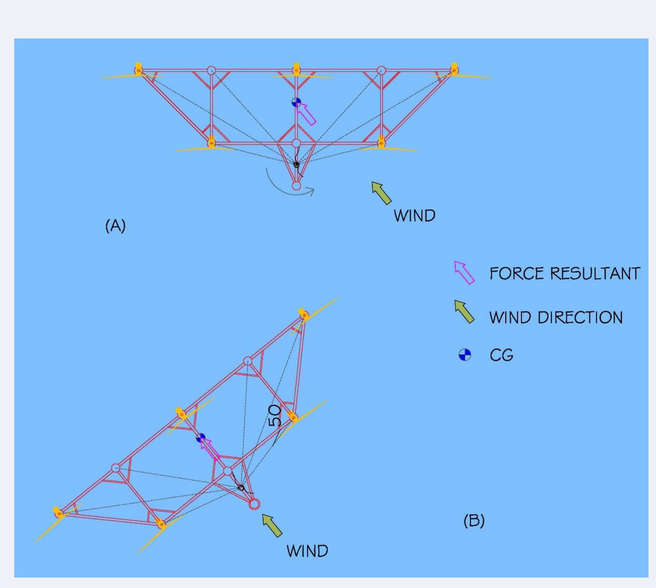


Methods

How it works

1. Discrete turbines connected by raft ➔ very stable
2. Raft members suspended in water ➔ stress free ➔ concrete structure a better option (weight/buoyancy balance)
3. Raft members suspended at a depth > wave height ➔ wave load small ➔ great span possible
4. Turning axis eccentric from the C.G. ➔
   A) wind force resultant produces a torque about turning axis to turn the raft unless;
   B) the wind force resultant passes through the Rotation Center (R.C.) and the C.G. ➔;
   C) the raft is always settled at the orientation that the line joining the R.C. and C.G. coincides with the action line of the wind ➔;
   D) Wind turbines set at this orientation are always facing the wind at the end of wind direction change.
5. Turning axis by flexible mooring rope. Power output cable turns by closing and opening of several stacking coil of the cable





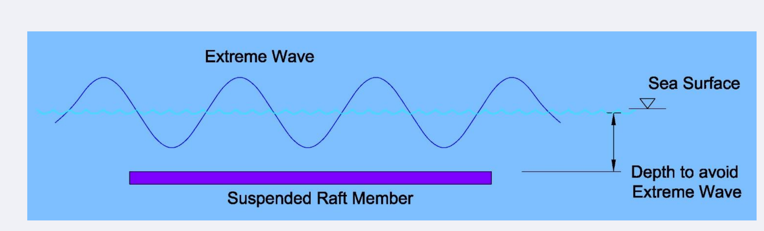
TURNING MECHANISM

Wind at 90D initial state

turning

turning

Settled wind facing state



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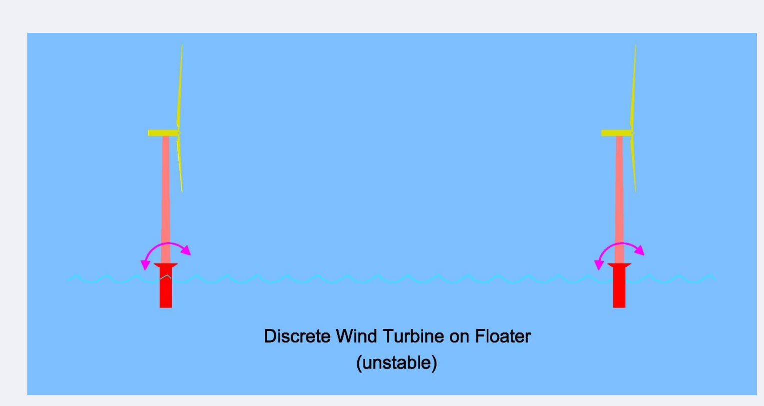

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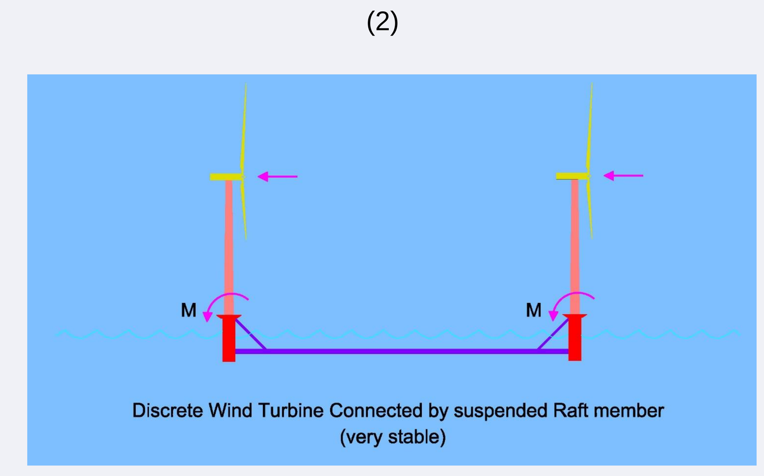

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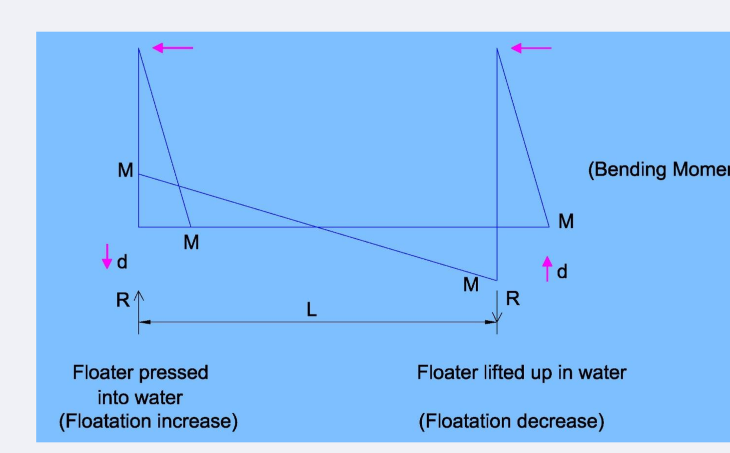

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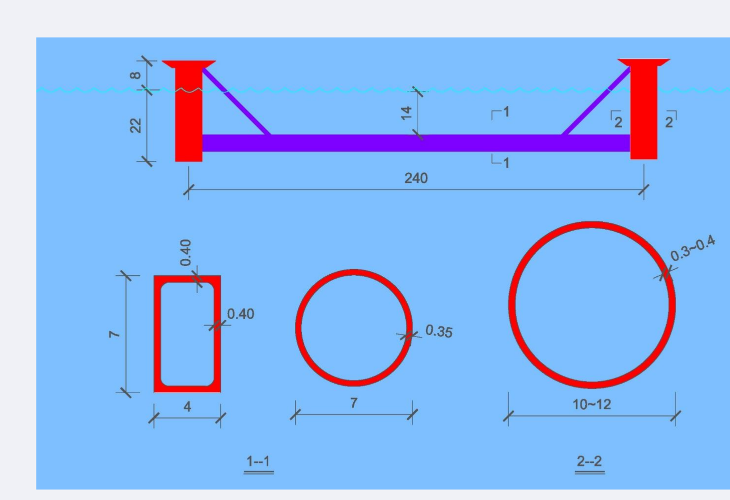

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Suggested Dimension

Working state

Turbine tower rotation = Rigid body rotational θ_1 + Elastic deformation θ_2
Rigid body rotation = d/L. In the current setup, since L is large, rotation θ_1 is small. Elastic deformation θ_2 is reduced by the diagonal strut. Compare with single floating platform , the rotation of is dominated by the rigid body rotation which is large due to small L, hence the current setup is much more stable than the single floating platform.

Extreme Weather

Use multi-point mooring system by dropping from each floater a ship anchor to tie the raft in position preventing it from turning wildly causing damages.

Conclusions

- The patent pending invention is very stable due to its large base, and very economical due to use of prestressed concrete, and reliable due to simple turning mechanism.
- Can last over 100 years without major maintenance.
- The same raft can support 4 generations turbines within its design life, the life-long costing is even less.
- It can be viewed as a giant wind turbine.
- It reduces the length of marine power cable.
- Using bridge construction skills the raft can be precast in segments and assembled in a harbor.
- The turning mechanism without the expensive turret further reduces the cost.
- At the present Chinese market, the installation cost is estimated to be at the upper band of that for inland turbine, making it very competitive.
- It can be used in water depth 50m or over in the far shore sea.

References

1. Wind tracing rotational semi-submerged raft for wind power generation and the construction method.PCT/CN2014/094666 (patent pending).
2. 半潜筏式随风转向水上风力发电设备.CHINA. 201410323537.1 (patent pending).