Dynamically positioned wind turbine

Investigation of a dynamically positioned floating offshore wind turbine

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Outline

Motivation

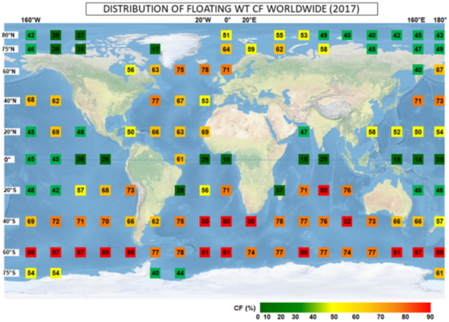
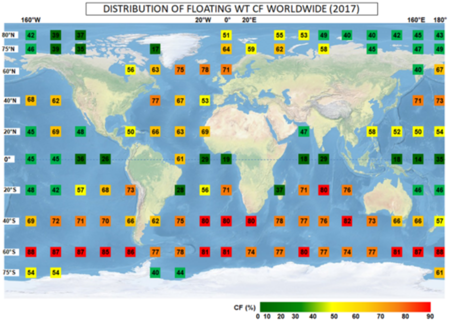


Figure: Stationary wind turbine capacity factor [1].

Motivation

1. High wind potential.



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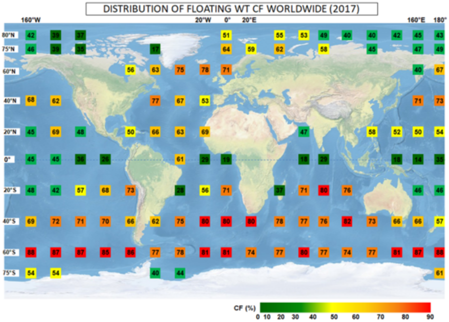

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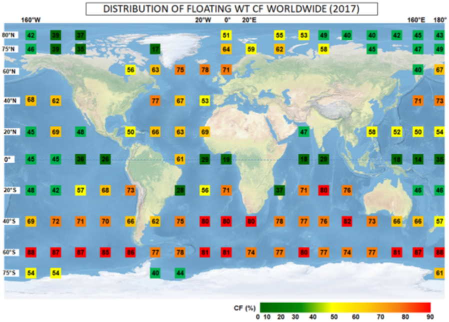

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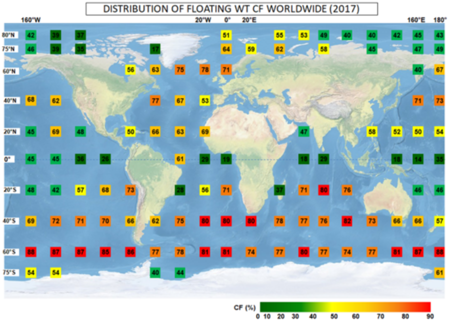
   - CF up to 80% [1].
2. High installation and maintenance cost [3].



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Concept description

Vidal's Patent

- Patented in 1983.

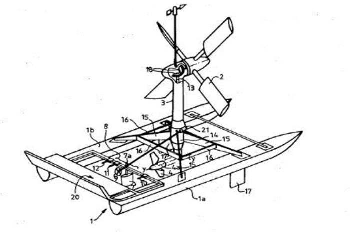

Figure: Jean-Pierre Vidal's concept [5].

Concept description

Vidal's Patent

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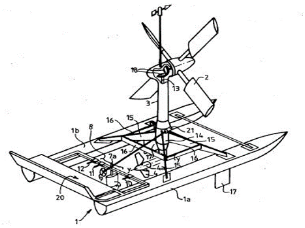
- Wind energy is used to sail upwind.



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Dynamically Positioned Wind Turbine

- Barge platform equipped with a wind turbine and propellers.

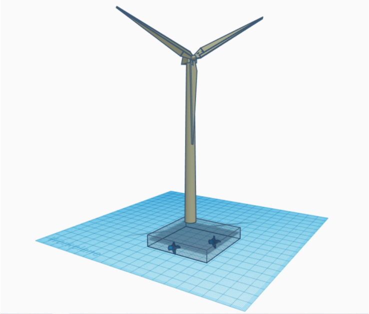

Figure: Artist view of a dynamically positioned wind turbine.

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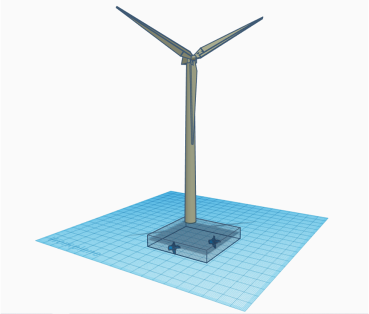

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Concept description

Dynamically Positioned Wind Turbine

- Barge platform equipped with a wind turbine and propellers.
- Dynamical positioning by the propellers.
- On-board storage (e.g. Electrolyzers and Hydrogen tanks, Batteries, etc.).

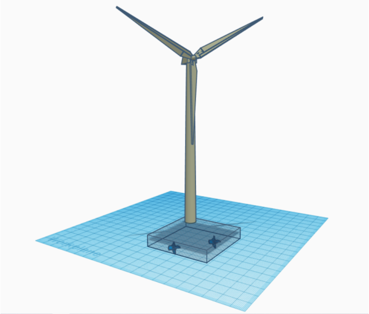

Figure: Artist view of a dynamically positioned wind turbine.

Aims and objectives

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Feasibility of the dynamically positioned floating wind turbine.

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Objectives

- Velocity and Power Prediction Program (VPPP).

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Feasibility of the dynamically positioned floating wind turbine.

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- Velocity and Power Prediction Program (VPPP).
- Design parameters effects.
- Environmental conditions effects.

Outline

Equation of motion

Assumptions

1. Small static angle [4].

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Equation of Motion

$$T_T + F_d + T_P = 0$$

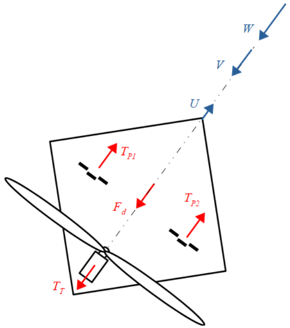


Figure: Force diagram.

Wind turbine mathematical model

Momentum Theory

Thrust force:

$$T_T = \begin{cases} \frac{1}{2}\rho_a A_T C_T V^2 & \text{if} \quad V_{\text{cut-in}} \leq V < V_{\text{cut-out}} \\ 0 & \text{otherwise} \end{cases}$$

Generated power:

$$P_T = \eta_T \times 2\rho A_T f_c a(1-a)^2 V^3$$

Wind turbine mathematical model

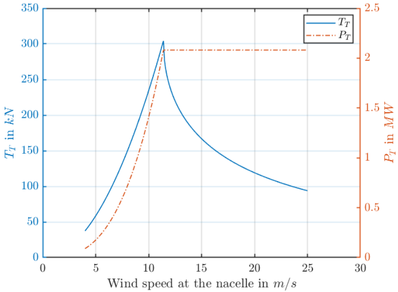


Figure: Thrust force and electric power of a 78 m rotor wind turbine.

Mean wave drift mathematical model

Potential Theory

Irregular waves:

$$F_d = \int_0^\infty \Phi(h)S(f)df$$

Equivalent regular wave:

$$F_{d,eq} = \Phi(h)A^2$$

Mean wave drift mathematical model

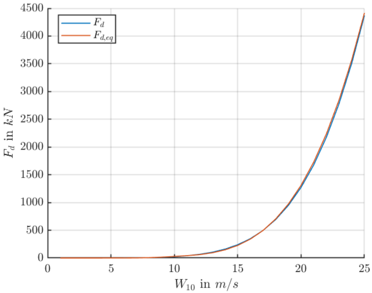


Figure: Mean wave drift force.

Propellers mathematical model

Wageningen B-series screw propellers

Thrust force:

$$T_P = \rho_w n^2 D_P^4 \left(K_{T,P1} + K_{T,P2}\right)$$

Consumend power:

$$P_P = 2\pi n Q_{P1} + 2\pi n Q_{P2}$$

Propellers mathematical model

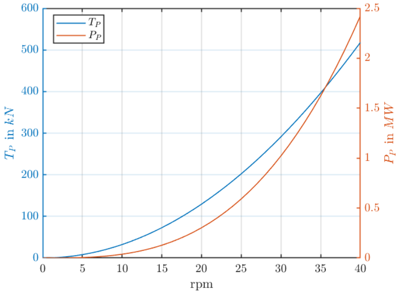
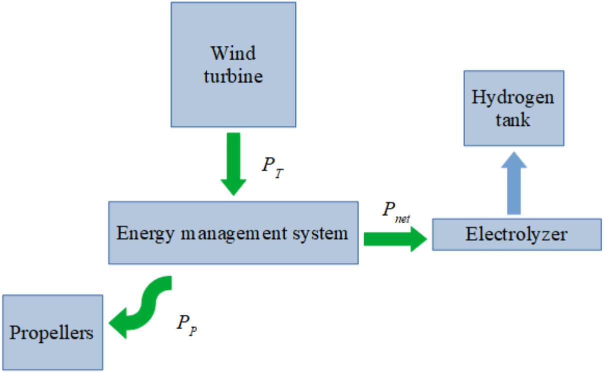


Figure: Propellers thrust force and consumed power for an inflow velocity of 0 m/s.

Power diagram

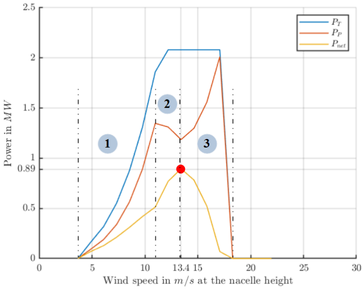


Outline

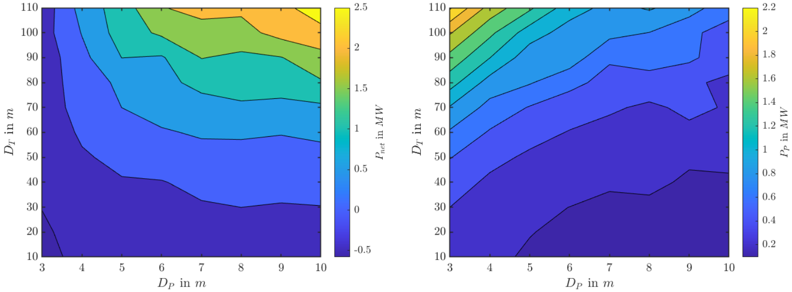
Power curve

Observation

- Maximum Power of 0.89 MW at 13.4 m/s.
- Regions 1, 2 and 3, $F_d \nearrow$.
- Region 1, $T_T \nearrow$.
- Regions 2 and 3, $T_T \searrow$.



Sensitivity study



Capacity factor

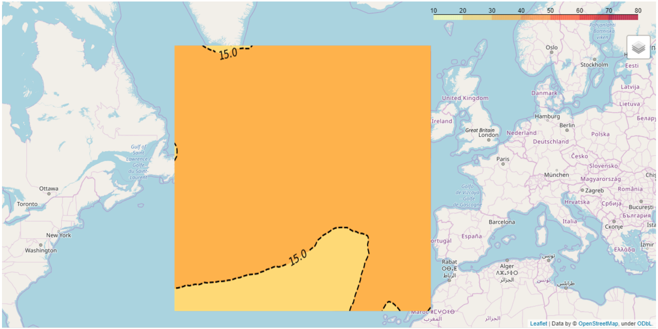


Figure: Mean CF of a dynamically positioned wind turbine deployed in the North Atlantic ocean - From 2015 to 2017.

Capacity factor

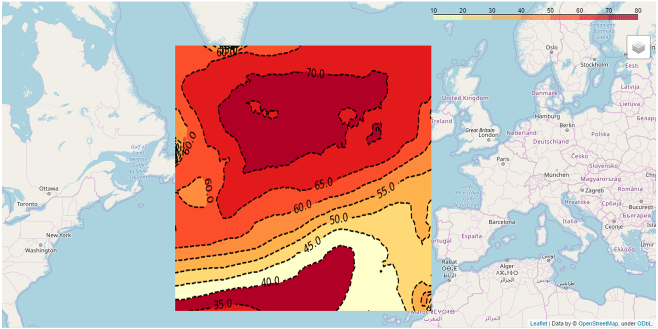


Figure: Mean CF of a stationary wind turbine deployed in the North Atlantic ocean - From 2015 to 2017.

Outline

1. Introduction
   - Motivation
   - Concept description
   - Aims and objectives
2. Methods
   - Equation of motion
   - Mathematical models
3. Results
   - Power curve
   - Sensitivity study
   - Capacity factor
4. Conclusion
   - Conclusion and perspectives

Conclusion and perspectives

For the proposed design:

- Max $P_{net} = 0.89\ MW$ at a wind velocity of 13.4 m/s.

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Greater CF

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Greater CF

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- Consider other platform types.
- Consider other design parameters.

Thank You for Your Attention

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