Midterm Presentation 2: Offshore Wind Turbine

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11-12-13

Matt Robertson

Overview

- Brief Review
- Final design selection
- Technological Approach
- Procurement of Material/ Manufacturing
- Future Plans and Possible Modifications

Matt Robertson

Brief Review

- The Floating Wind Turbine team has been tasked with designing the following:
- An innovative original way of designing a floating wind turbine for use in commercial power production.
- Cost reduction of the design is the main focus.
- Ideation and innovation has become the priority.
- The current design uses autonomous guide technology and a self erecting tower to give the design turn key capability.
- Combining these concepts will allow the turbine to be launched from port and make its way to a predetermined destination where it will begin producing utility scale power without needing manpower for installation.

Nick Smith

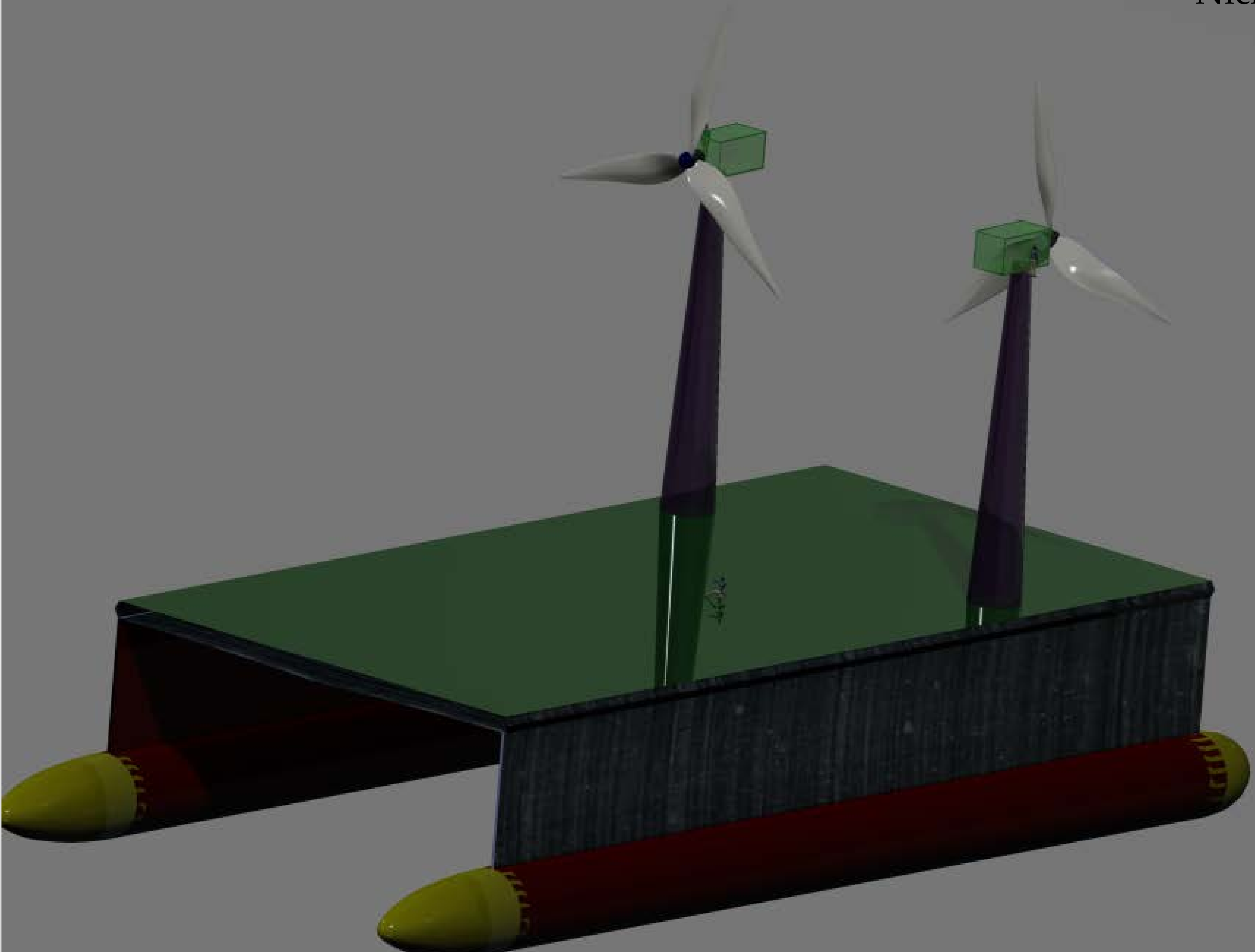
Final Design

- Catamaran Style Foundation
- Two 20m tall turbines
- 100 kW output

- The following slides will show analysis on towers, blades, thrusters, generators, and foundation.

Nick Smith

Nick Smith



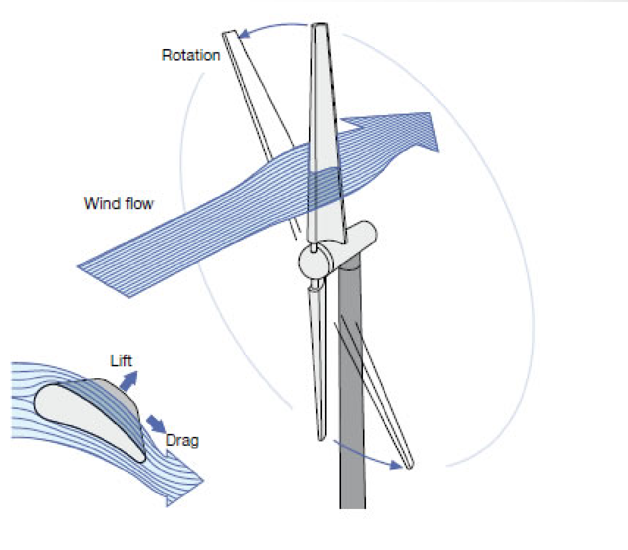
Creo Parametric - OWT SWATH CATAMARAN CONCEPT

Nick Smith

Turbine Blade Details

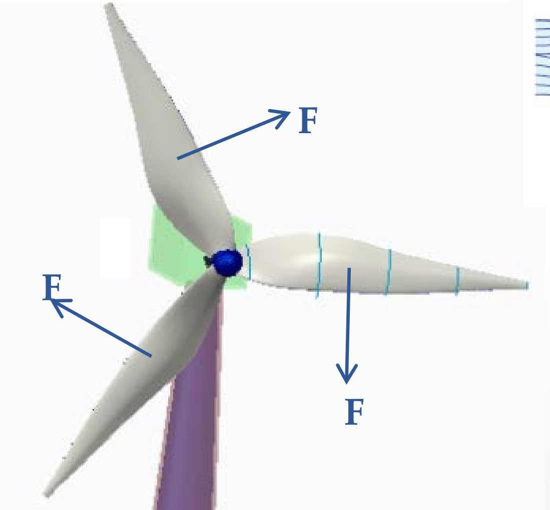
- Three-Blade Configuration

Property	Value
Max rotational speed	19 rpm
Blade composition	Epoxy glass fiber + carbon fiber
Length per blade	9 m
Mass per blade	1,200 kg



- Blade Forces

Force	Design
214 N	Per one blade
642 N	Per three blades



Nick Smith

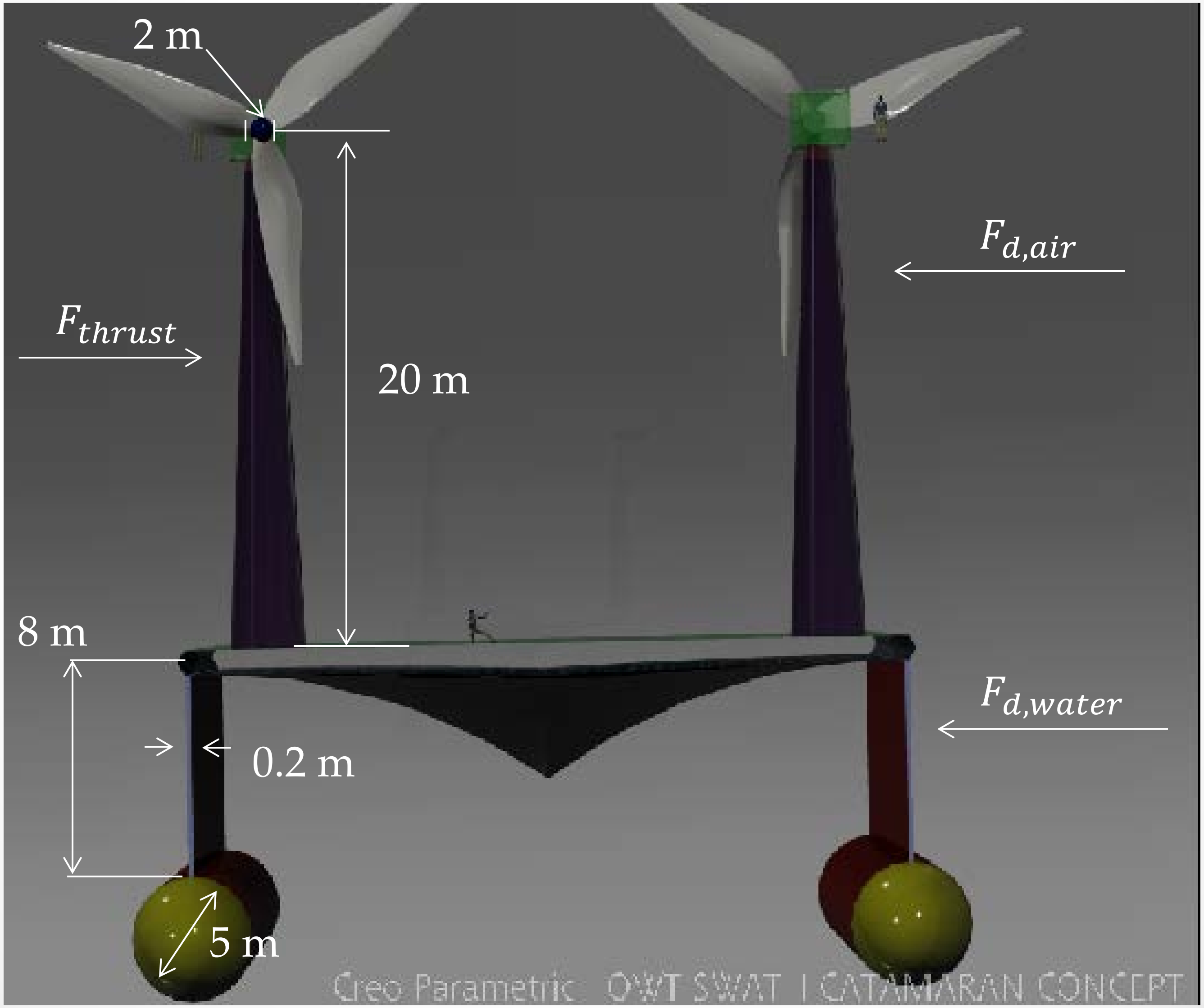
Generator

- Power Output – 100 Kw
- Start up speed – 3 m/s
- Max wind speed – 25 m/s
- Rated rotational speed – 50 rpm
- Optimal wind speed – 12 m/s
- Survival speed – 40 m/s
- Weight – 2400 Kg
-

Rotor Size and Maximum Power Output	
Rotor Diameter (meters)	Power Output (kW)
10	25
17	100
27	225
33	300
40	500
44	600
48	750
54	1000
64	1500
72	2000
80	2500
Sources: Danish Wind Industry Association, American Wind Energy Association	

Thrust Analysis

Kevin Foppe



Kevin Foppe

Analysis/Calculations

$\sum F_x = 0 = F_{thrust} - F_{d,air} - F_{d,water}$

$F_{thrust} = F_{d,air} + F_{d,water}$ where F_{air}, $F_{d,air} = F_{d,blade} + F_{d,tower}$

For $F_{d,air}$,

$F_{d,air} = \frac{1}{2} C_d v^2 A_c p_{\ air}$ $p_{\ air} = 1.23\ \frac{kg}{m^3}$ $C_d = 0.5$ $v = 4.5\frac{m}{s}$

$A_c = A_{tower} + A_{blades}$

$A_c = 2(Tower\ Height\ * Tower\ Width) + 2(\%Blade\ in\ Sweep\ Area)$

$A_c = 2(20m\ * 2m) + 2[0.1\pi(10m)^2]$

$A_c = 142.8\ m^2 \approx 145\ m^2$

Therefore,

$F_{d,air} = 903\ \text{N}\ \approx 905\ N$

Kevin Foppe

Calculations Cont'd

For F_{water},

$F_{water} = \frac{1}{2} C_d v^2 A_c p_{\ water}$ $\quad p_{\ water} = 1000\ \frac{kg}{m^3}$ $\quad C_d = 0.295$ $\quad v = 4.5\,\frac{m}{s}$

$A_c = A_{pontoon} + A_{structure}$

$A_c = 2[\left(\frac{\pi(5m)^2}{4}\right) + (0.2m)(8m)]$

$A_c = 42.5\ m^2$

Therefore,

$F_{water} = 126{,}942\text{ N} \approx 127\ kN$

$F_{thrust} = F_{air} + F_{water} \approx 128\ kN$

$$Power = \frac{Energy}{time} = \frac{J}{s} = \frac{N * m}{s} = F_{thrust} * v$$

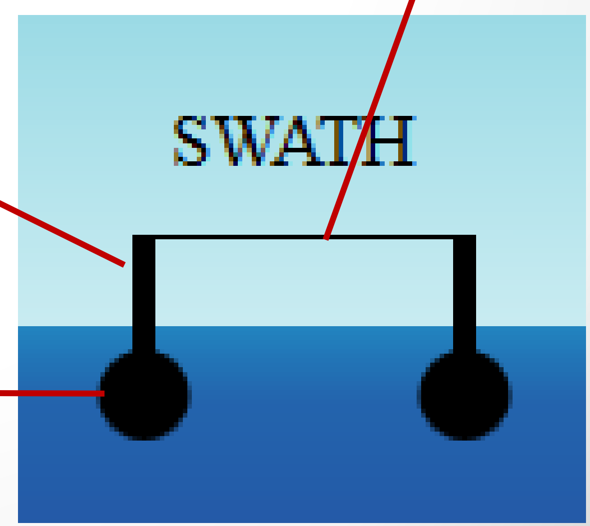
$$Power\ Required = (128\ kN)\left(4.5\,\frac{m}{s}\right) = 575\text{ W} \approx 770\ hp \approx Two\ 385\ hp\ Motors$$

Project Procurement

- No long lead items
- Smaller model size – Tabletop
- Going forward, 3-D print blades
  - Complex geometries

Foundation

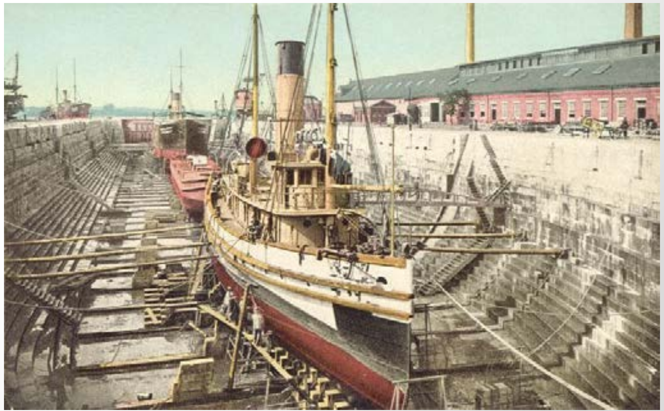
- Small-Waterplane-Area Hull (SWATH)
- L:W ratio = 2:1
- Displacement Mass: Foundation Mass 2:1
- Buoyancy = (Mass of Displaced Fluid – Mass Structure)
- Displaced Fluid = 2.4 x10^6 kg.
- Foundation = 1.2 x 10^6 kg.
- Ballasted Hulls



Mark Price

Manufacturing Process: Full Scale

- Pontoon Sections
- Thruster and Steel Components (Supporting Structure) will be imported and built offsite
- Fiberglass components (Visual Structure)
- will be cast on site
- Stream Line Assembly will occur in Dry Dock

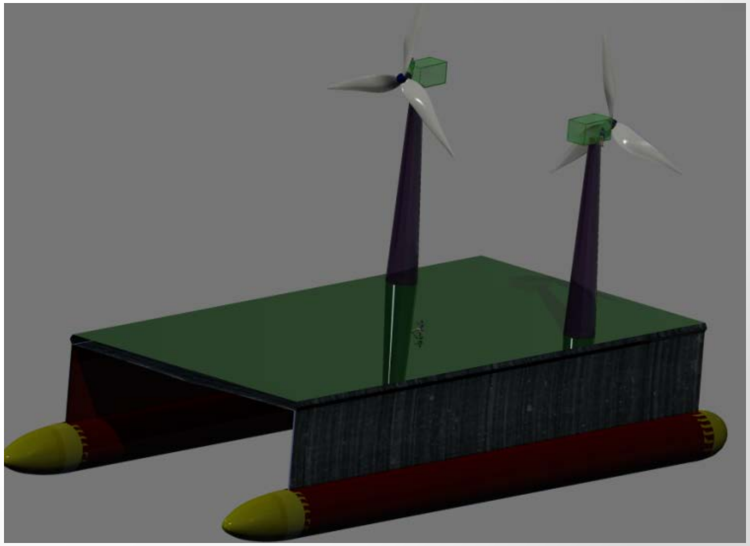


Mark Price

Manufacturing Process: Small Scale

Approximately 1/60 scale

- Hull – 3D Printer
- Tower- utilize piping from home depot
- Blades – 3D Printer
- Generator – Buy from
- Thruster – will be bought from hobby shop
- Sealer/Friction Reducer/ Rust preventative



Nick Smith

Technological Approach to Design

- **<u>Hardware/Software</u>**
  - AutoCAD
  - Creo
  - ComSol
  - Code Warrior
  - GPS
  - Motorcontroller
  - Basic Computer
  - USB interface

Challenges

- Making sure it floats and maintains its upright position.
- Material selection.
  -Strength to weight
- Cost effectiveness.
- The autonomous aspect will be developed with the assumption that technology will advance and become more viable and eliminate future designs from reliance on mooring lines.

Future Plans

- Possible concepts include
  - Autonomous
    - Programming controllers
  - Self Erecting Tower
  - Market Needs
  - Motor Selection

References

- 1) “Value Breakdown for the Offshore Wind Sector.” *A Report Commissioned by the Renewables Advisory Board*. Feb. 2010
- 2) "Vertical Axis Wind Turbines vs Horizontal Axis Wind Turbines." *Small Wind Tips RSS*. N.p., Jan. 2013. Web. 21 Oct. 2013.
- 3) **“Model Development and Loads Analysis of an Offshore Wind Turbine on a Tension Leg Platform, with a Comparison to Other Floating Turbine Concepts”** Matha, Denis. *NREL: Wind Research Home Page*. University of Colorado-Boulder, Feb. 2010. Web. 22 Oct. 2013. <http://www.nrel.gov/wind/>.

Questions