The ‘dragonfly approach’ to stabilising floating wind turbines

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Floating wind turbines are receiving more interest due to their merits of easy installation and applicability to various water depths. But unlike wind turbines installed on fixed foundations, the power generation efficiency of a floating turbine is not only dependent on the efficiency of its control, but depends on a stable floating foundation. This project has developed a new stable floating foundation for off-shore wind turbines based on the separate muscles used by a dragon fly to maneuver in flight and maintain stability. The technology works in a variety of environmental conditions, resulting in about 50% increase in stability.
Key Facts about floating wind turbines:

• The installed capacity of offshore wind in the UK will increase from the present 5.07GW to 10GW by 2020, which will attract £16-21bn more investment in the UK from across the world.

• Off-shore wind turbines are expected to be massively deployed in the coming years in less than 35m water depth, where turbines can be supported using fixed foundation.

• The extensive application of fixed foundations significantly increases the cost of energy of offshore wind power due to the costly manufacturing, transportation and installation. This requires a cost-effective solution for supporting off-shore wind turbines.

What did the project seek to find out?

Develop a new concept of floating foundation dedicated to supporting off-shore wind turbines installed in shallow water

While stabilising systems exist for floating wind turbines they are not satisfactory at reducing platform motions and responding to instantaneous changes of winds and waves, nor inexpensive for wider application. The research proved a new biomimetic concept for floating wind turbines that stabilises the platform similar to the actions of a dragon fly’s wings.

Test the ‘dragon fly stabiliser’ using a numerical model and hydro-lab experiments

Modelling gives insight into how well the stabiliser performs in various wind and wave conditions, while lab experiments demonstrate the actual performances of the stabiliser in different ‘offshore environments’. By testing the stabiliser in Newcastle University’s hydro-lab it shows how much the proposed biomimetic concept can improve the motion stability of floating off-shore wind turbines in different offshore environmental conditions.

Insights from the project:

• A new motion stabilisation system for floating wind turbines was invented.

• The stabiliser greatly suppresses the motion of the floating wind turbine caused by wind and waves by about 50% in 50m depth water.

• Enable the floating offshore wind turbine to have stable motion under harsh sea and weather conditions.

• Improve the turbine’s power generation efficiency and minimise the risk of catastrophic sink in extreme weather.

• The effect of the stabiliser was demonstrated in a hydro-laboratory under multiple conditions, proving the concept (see Figure 8).

• The floating wind turbine shows more stable pitch motion with the stabiliser over a wide range of offshore environmental conditions.

• A review of three offshore floating wind turbines was undertaken: Hywind, WindFloat and PelaStar, revealing the pros and cons of the designs.

• These designs were found to be either only applicable to deep water, less stable, extremely expensive or requiring intensive maintenance.

• The dragon fly stabiliser is low in capital cost and stable in motion in shallow water.

• The technique for stabilising off-shore wind turbines demonstrated is applicable to seakeeping which is essential to installation of offshore wind turbines supported by fixed foundations.

• Stabilising off-shore wind turbines using this technique reaches the desired stability without sacrificing power generation efficiency.

• Superior to the current approach that stabilises floating wind turbines via blade pitch control.

This research project was supported by an Institute for Sustainability Responsive Mode grant, “Concept design of a motion-stable floating foundation dedicated to offshore wind turbines”.

Further info: http://www.ncl.ac.uk/sustainability/funding/awardedprojects/floatingfoundation/

Figure 8: Laboratory testing results

(a) Pitch motion stabilisation result when ‘lock-in’ occurs under pure wave conditions.

(b) Pitch motion stabilisation result under pure wave conditions.

(c) Pitch motion stabilisation result under wave-current combined conditions.

(d) Pitch motion stabilisation result under wind-wave-current combined combinations.

(e) Heave motion stabilisation result under pure wave conditions.

(f) Heave motion stabilisation result under wave-current combined conditions.

(g) Heave motion stabilisation result under wave-current combined conditions.