Smart Blue Regions
Output 4.3 - Transnational blue growth cooperation projects

Project theme: Multi Rotor System for Off-shore Wind Turbines

Challenge to be addressed:

Multi Rotor system proved (in laboratory tests) to be efficient way to increase turbine power and to minimise risk of one turbine system damage.
The current technology drive regarding off-shore wind turbines requires a development of innovative substructure concepts. One of the main objectives that the engineering community sets out is to minimise the wind and wave-induced platform motions to provide stable operational environment to wind turbine rotor. The second group of objectives targets mass as well as installation, operational and maintenance (IO&M) costs reduction.

The present prototypes of wind turbines operating at sea are classical three-bladed wind turbines. These turbines are known for their superior efficiency and performance for on-land based applications. In fact, at present, on land and on shallow sea waters, a 3-bladed HAWT is able to generate up to 8 MW of power (e.g. Vestas V-164). This is a direct result of increasing the rotor size. However, with rotor size increase, the generator mass and hence the nacelle to house it reach gigantic dimensions. The so called Top Head Mass (THM) of the Rotor Nacelle Assembly (RNA) can reach 500 tonnes (e.g. Vestas V-164). An application of even larger wind turbines at sea (also deep sea where floating turbines are necessary) requires a modified approach: with growing size while maintaining productivity, turbines weight and loads must not scale exponentially. Technologically, by further upscaling of turbines, one runs the risk of increased forces and moments acting on the RNA at substantial heights above the water surface. On the cost side, large RNAs create tremendous problems in terms of transportation (towing to an operational site) and installation by dedicated vessels and cranes. Hence, a new approach is suggested: an advanced multi rotor system creating a wind turbine. By combining few smaller designs it is possible to decrease the IO&M costs, use existing turbine designs and testing facilities, while simplifying the manufacturing, towing, and maintenance process, being able to keep competitive or even superior energy efficiency.

Expected results:

1. Installation of the multi rotor system in a prototype turbine.
2. Development of R&D lab ready to progress the development of materials, methods and processes for the developed MRS.
3. To develop a reliable, low-cost, long lifetime modular support for a Multi Rotor System wind turbine using innovative materials and substructure concepts.
4. To develop a mooring system to carry the load of innovative MRS wind turbine integrated floating structure allowing for:
   a) mitigation of dynamic loads acting on support structure and compensation of the wide range of hostile environmental loads
   b) potential cost-reduction when up-scaled due to insensitivity to site conditions
   c) enhancement and integration of tools for the design of structures at deep-water sites due to broad experimental data obtained during the final prototype test campaign
5. Design a reliable low-weight (low THM-Top Head Mass) wind turbine for off-shore operation allowing:
   a) >20 years in harsh conditions
   b) Maximise single turbine power production ($P_{avg}>350\ W/m^2$)
   c) Power-to-Weight ratio kW/kg (obtain $P/W > 0.02\ kW/kg$)
6. Develop MRS of rotors allowing for:

   a) minimal wind shear influence due to reduced rotor size
   b) reduction of substructure size and complexity due to distributed mass of rotor array compared to classical nacelle with a concentrated THM
   c) novel, active control strategies for cancellation of wind/wave induced motions being inherent feature of modular design allowing for control work parameters of individual rotors
   d) reduced investments costs due to modular design, mass production possibilities, simplified towing and transport procedures
   e) reduced operational costs due to inherent redundancy and improved maintenance schemes
7. Prove the concept of technology by performing:
   a) the survivability test as described in code of standards
   b) Integrate the technology and perform evaluation testing including scaled model tests in realistic conditions,
   c) estimate the cost and efficiency as well as environmental impact of an up scaled version of the prototype.

Target groups:

- Turbine manufacturers,
- Turbine subcomponent producers,
- R&D Centers for material testing
- Academics
- OWF operators,
- ?

Main activities and timeframe:

The project would entail the development of:

WP1: Innovative Structure as First Part of MRS Concept
WP2: Innovative Yaw System as Second Part of Substructure Concept
WP3: Rotor Nacelle Assembly (RNA) Design and Control strategy of a Single Rotor
WP4: Design of modular MRS and Development of Innovative Control Strategy
WP5: Technology Integration and Proof of Concept

Each WPs is broken into research and development areas where the consortium possesses knowledge and expertise.

Partnership:

Idea proposed by:

- Maciej Karczewski and Piotr Domagalski (SME)

Organisations that expressed their interest at the workshop in Gdańsk 26th April 2018:

- Aluship Technology Sp. z o. o.

Additional organizations identified as wanting to join:

- University of Strathclyde (prof. Peter Jamieson), Scotland
- Fachhochschule Hamburg (prof. Peter Dalhoff), Germany
- GSG Towers Sp z o.o., Gdansk, Poland
- IWES Fraunhofer, Bremerhaven, Germany
- NTNU Trondheim (prof. Lars Saetran), Norway

Estimated budget:

3-10 mln EUR

Financing sources:

H2020, Eurostars, transnational and national financing schemes available for SMEs and consortiums involving R&D centres, financing rounds available for start-ups in Baltic Sea region

Other remarks for further project development

Expected impacts

The off-shore wind energy sector is still at a very early stage of development, especially at deep-water and in order to achieve commercial and large-scale deployment, the sector must overcome technical, economic and political challenges associated with energy dependence from outside EU markets. Proposed work plan starting with TRL 2 and finishing with scaled prototype survivability test at TRL4 and beyond to TRL5 ready protoype site-tested together with optimal consortium consisting of top level research institutions augmented by industrial partners ensures the detailed identification of out-of-the-box or advanced innovative ideas that will provide new input to technology pathways as well as in-depth analysis of solutions found during the project and possible issues.

That presents precious knowledge for all the players concerned, policy makers, regulatory authorities, and interest groups representing civil society, as due to off-shore renewable sector immaturity not only technical components are required for optimal development, but also sociological factors are seen more and more important nowadays. Last but not least, deep offshore designs and know-how constitute an export opportunity. European companies, including those at Baltic Sea region, being close to the most maritime of all continents can build its strength on potential for or innovation and green-blue growth. As deep offshore capacity increases, expertise, skills and technologies developed in Europe can be exported across the globe, initially to US and potentially to Japan rendering the parties engaged in this project as innovation leaders with knowledge-based facilities and products.

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