DEMOGRAVI3

Figure 1. DEMOGRAVI3 towing the wind turbine with foundations

Summary description

The DEMOGRAVI3 project is focused on designing, building, assembling, transporting, installing and demonstrating a full scale foundation, equipped with a 2 MW offshore wind turbine, in a consented and grid connected demonstration site.
Additionally, the project will undertake further technology development for improved design and perform an in depth evaluation of the technology's future industrialization, competitiveness and bankability.
In particular, the DEMOGRAVI3 project will demonstrate an innovative hybrid concrete-steel, self-buoyant bottom standing gravity based foundation (GBF) for offshore wind farms positioned in water depths between 35 and 60m. The complete unit (turbine and foundation) will be built and assembled onshore and towed while floating to the deployment site, where it will be submerged by an innovative patented process on a controlled way without the need for external support or heavy lift vessels.
The project is funded by the European Union under the framework of the Horizon 2020 call with a total budget of approx. 25 M € (with most part devoted for the design and development of the solution). The members that took part in the consortium are world-leading companies from the different engineering sectors: TYPSA (as designer and owner of the patent), EDPR (as electrical company), Global Maritime (Marine Warranty Surveyor), HRL-UPM (lab test facility), ASM (steel manufacturer) and CYES (construction company), among others.

Figure 2. Offshore windmills construction site

Reason of interest for MAESTRALE

Offshore wind energy is one of the pillars of the energy market in the North of Europe, particularly in the North Sea. In the case of the Mediterranean Sea, the number of offshore wind farms is very limited. This is explained by the higher water depths of this sea in comparison with the North Sea. The typical foundations used in the past, mainly jackets and monopiles, were economically viable for water depths less than 40. However the GBS, such as the GRAVI3, opens a new market, since these foundations are recommended for water depths between 30 and 60 m. On this sense, Gravi3 can be of particular interest for this project.

GENERAL INFORMATION	
Type of Blue energy source	Offshore wind energy
Type of energy output	Electricity
Type of project/plant	Prototype
Status	Under realization

Location	41.68 N, -9.10 E Atlantic Ocean Aguçadoura, Portugal
Involved actors	The project is funded by the European Comission under the Horizon 2020 call. The patent is hold by TYPSA and EDPR is the electrical company that will provide the wind turbine. In the project, other relevant companies will also participate: HRL-UPM, Wavec and Fraunhofer, among others.
Nominal power	Turbine of 2MW: 17520 MWh/year
Annual productivity	It will depend on the number of hours with full wind. For an offshore location it is expected around 4000 hours/years, which would produce 8000 MWh/year
Size	The structure is comprised of 3 caissons with dimensions of 25 m aprox. The total space occupied is approx 5000 m2.
Year	Desing period: 2016, Construction period: 2017 (ongoing), Deployment: late 2017/early 2018, Decommisioning: 2019
Implementation cost	Not applicable at this stage, although the unit cost is described below
Payback period	Once commercialised it is expected to be between 7-10 years (depends on the number of hours)
Key words	Offshore Wind Energy, Gravity Based Solution, Self-bouyant structure, wind turbine, intermediate water depth
Web link	http://demogravi3.com/

4.8.1 BACKGROUND

Energy policies framework

Renewable Energy

- Directive 2009/28/EC — promoting the use of energy from renewable sources

The EU's Renewable energy directive sets a binding target of 20% final energy consumption from renewable sources by 2020. To achieve this, EU countries have committed to reaching their own national renewables targets ranging from 10% in Malta to 49% in Sweden. They are also each required to have at least 10% of their transport fuels come from renewable sources by 2020.

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Energy 2020 A

strategy for competitive, sustainable and secure energy. The new EU energy strategy will require significant efforts in technical innovation and investment. It will foster a dynamic and competitive market and lead to a major strengthening of institutional arrangements to monitor and guide these developments.

Integrated Maritime Policy

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An Integrated Maritime Policy for the European Union. The Integrated Maritime Policy seeks to provide a more coherent approach to maritime issues, with increased coordination between different policy areas

Offshore Wind Energy

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Offshore Wind Energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond. In the context of the second strategic energy review carried out in November 2008, the Commission issued a communication on 13 November 2013 entitled 'Offshore Wind Energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond, with the aim of promoting the development of maritime and offshore wind energy in the EU.

Legal and administrative background

Recommendations

IEC 61400-3:2009 Design requirements for offshore wind turbines

DNV-OS-J101 Design of Offshore Wind Turbine Structures

EU Legislation

*** Regulation (EU) No 1255/2011 of the European Parliament and of the Council of 30 November 2011 establishing a Program to support the further development of an Integrated Maritime Policy**

*** Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. It seeks to contribute to ensuring biodiversity in the European Union by the conservation of natural habitats, and wild fauna and flora species.**

Links with spatial planning instrument

Maritime Spatial Planning

Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning

Competition for maritime space – for renewable energy equipment, aquaculture and other uses – has highlighted the need to manage our waters more coherently. Maritime spatial planning (MSP) works across borders and sectors to ensure human activities at sea take place in an efficient, safe and sustainable way. That is why the European Parliament and the Council have adopted legislation to create a common framework for maritime spatial planning in Europe.

This case study is a research project so just a wind turbine was deployed for its development, and therefore not a significant impact was found on the maritime spatial planning. If a full

plant is installed, the definition of the deployment area must be agreed with the key players of the Mediterranean Sea, e.g. tranport companies, main sea routes; so as to reduce the impact on other sectors.

4.8.2 TECHNOLOGICAL ISSUES

Applied technology

The GRAVI3 concept consists on a mixed concrete-steel self-buoyant GBS made by three concrete caissons supporting a steel tripod. Design is suitable for deep water locations. It has been evaluated for depths between 35m and 60m, with WTG up to 8 MW. of HLV during all phases of project's deployment. The concrete caissons are built using slip-forming systems inshore (floating docks with high construction rates) and, therefore, there are no special needs for onshore construction yard, minimizing use of port area for construction and storage.

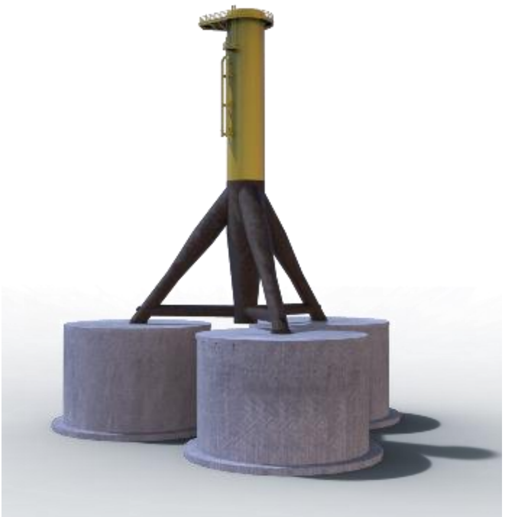

Figure 3. Turbine foundations

Figure 4. Turbine schematics

Innovation aspects

This three-leg concept provides the following advantages: multi-hull design for naval stability and navigation and a better support allowing WTG transportation. This also improves the behaviour of structure against overturning, and maximized the contact area to minimize the load transmitted to soil. Transportation shall be made by towing with normal tugs. After installation is done, no solid ballast is needed as only filling with water the caissons shall suffice, which induces savings in the operations.
Other advantages:
Efficient construction rates of concrete structures by means of slip-forming methods.
As the ballasting is done with water, decommissioning or re-floating can be carried out if necessary.
Minimization of the use of port area for construction and storage.

Transport of the wind turbine assembled on the GBS.
No noise or pile driving. Environmentally friendly.
Low loads transmitted to the terrain. Adapted to large range of soil conditions.

Quantitative information

The three caissons are 19 m height and 24 m width. The vortex are chamfered in order to improve the hydrodynamic behaviour.
On the top of the caissons, it is found the steel tripod, with a height of approx 50m. The sections are variable, according to the position. For instance, the shaft has a diameter of 4 m, and the legs approx. 2 m.
The shaft of the tripod ends up in a deck that connects the wind turbine with the the foundation.

Background information

The wind resource in the Mediterranean Sea is found to be sufficient to justify the installation of an offshore wind farm. Actually, the wind intensity and the number of hours per year in certain areas is equivalent to the resource found in the North of Europe. A value adopted for offshore wind is more than 3000 hours per year of full wind.

The areas with the highest resource such as the South of France or the East of Greece, among others, are perfect locations for the deployment of this kind of wind farms. Actually, they present advantages against the Europe Atlantic façade as the wave climate is milder and thus, the O&M operations and installation and decommissioning have larger weather windows.

Assessment tools & methods

As this was a research project that was installed for a year, it was not necessary to conduct such studies. However, the potential impacts on the environment brought about by the device were considered and mitigated, as will be described in the following section.

Environmental & Landscape impacts

One of the main impacts induced by an offshore wind farm is the visual impact, especially if the adjacent coast is a touristic place. To mitigate these impacts, ad hoc studies are instrumental to determine the minimum distance for the deployment of the turbines from the coast to avoid a significant visual impact. Generally, a distance around 5 km from the coastline is adopted as a recommended minimum distance. However, this can vary as a function of the boundary conditions of the area.
Another relevant impact is the mammal's collision. In this case, as the project consists in the demonstration of a prototype is not that relevant since just one foundation will be deployed. For wind farms, acoustic signals are sent in order to minimize the collision risks.

Socio-economic impacts

Apart of the clear positive impact brought about by the presence of the wind farm and the associated electricity generation, the impacts induced by a wind farm supported by Gravi3 foundations are numerous. First, during the construction and installation the number of players involved is very large, greater than monopiles or jackets foundations since the assembly in this kind of projects is conducted offshore. In this case, all the operations are carried out in the port, which has a positive effect in the economy of the area. Furthermore, these platforms can constitute the perfect location for harnessing other resources: aquaculture or wave energy, among others.

4.8.3 IMPLEMENTATION ISSUES

Implementation cost

This will depend on the scale economy, the distance between the port and the installation area and the water depth. But approximately the unit cost of a fully deployed device with the wind turbine is between 15 and 20 M € for water depth not larger than 60 m.

Financial sources

The funds are provided by the EU under the framework of the Horizon 2020. The call that granted the demonstration of this prototype was:

- **COMPETITIVE LOW-CARBON ENERGY H2020-LCE-2015-2**
- **Sub call: H2020-LCE-2014-2015**
- **Topic: LCE-03-2015 Demonstration of renewable electricity and heating/cooling technologies**

Problems and obstacles

One of the main restrictions found in this project was the high energetic conditions of the area, which limited the number of available weather windows for the transport and deployment of the Gravi3 prototype. The coast of Portugal is characterized by high waves, and the lack of protection, which is the opposite case to the Mediterranean or North Sea. On this sense, the distance between the assembly port and the installation area (in front of Viana do Castelo) was optimized. Then, the port of Vigo was chosen for carrying out all the operations. The distance between the port and the installation point is 20 nautical miles, which is approx. 1 day of transport plus one day of ballasting. This was additionally overcome with the definition of accurate forecast systems for the weather window analysis, which allows the consortium to choose the best frame of time for the transport and installation.

Success factors

The key of the success of this project is related to the application of the port technology to the offshore wind sector. The caisson construction take advantage of the very mature and well developed caisson building approach that is conducted in the port engineering sector. Then, the fabrication of the caissons is optimized and the costs can be reduced. In this sense, TYPSA and EDPR are leaders and pioneer in the sector as they deployed in 2014 the first gravity based meteorological mast (self-buoyant during transport). This project constitutes the next step in the transference of the port knowledge into the offshore wind sector.

Transferability in the MAESTRALE area

The implementation of the offshore wind energy in the Mediterranean Sea has been slower than in other European areas such as the North Sea because the water depth restrictions associated to the morphological features of the coast. The mediterranean sea is deeper than these areas, and the typical foundations that have been built there cannot be applied. However, the new scenario with the presence of foundations such as Gravi3, which are particularly effective in terms of loads and costs for these larger water depths (40-60 m) enhance the viability of offshore wind farms in areas like the Mediterranean Sea.
This step is very important since the resource (intensity and number of hours) is sufficient to justify the installation of a wind farm in the Mediterranean Sea. Regarding the seafloor conditions, the harder the material of the seabed, the better for the foundation. The Mediterranean Sea is very diverse and it is difficult to generalize, but the soils are mainly characterized by sands, which can provide the perfect support for the foundation.

Notes/Comments

1) http://gravi3.com/
2) Zountouridou EI, Kiokes GC, Chakalis S, Georgilakis PS, Hatziargyriou ND. Offshore floating wind parks in the deep waters of Mediterranean Sea. Renewable and Sustainable Energy Reviews. 2015 Nov 30;51:433-48.