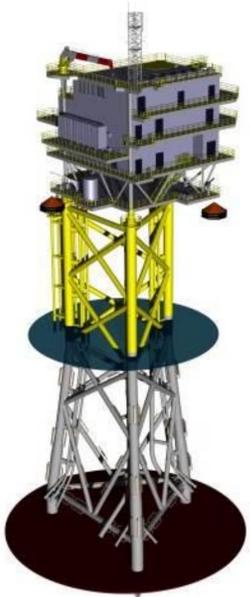


Abstract



The distributed substation is part of an effort to prepare more modular and cost-effective solutions for the future in terms of array cable expenditure, electrical losses and substation installation & fabrication costs.

The distributed substation approach offers a number of opportunities to merge offshore substation and WTG foundation installation and fabrication contracts, ultimately reducing both development cost (DEVEX) and project cost (CAPEX). The main savings are identified in the joint installation of WTG foundations and the substations as well as the development of a standard foundation suitable for both WTGs and substation topsides.

The distributed substation has a single transformer and is rated at ~200 MW.

Traditional OSS substation designed, fabricated and installed by individual supply chain



Distributed substation as developed in the present project

Objectives

- Investigate whether the WTG foundation could be used as substructure for a smaller topside
- Utilise the existing WTG foundation design, fabrication and installation supply chain for the offshore substation as well
- Eliminate individual OSS supply chains to the extent possible
- Topside weight below 1,000 tonnes
- Solution to be robust in terms of HSE performance, WTG independence, supply chain, time schedule, structural and electrical performance

Methods

Design

- Reuse in-house WTG foundation design
- Develop conceptual design for topside with one transformer, one reactor and a topside maximum weight 1,000 tonnes
- Optimisation of electrical design and grid layout



DONG Energy WTG foundation design

Fabrication

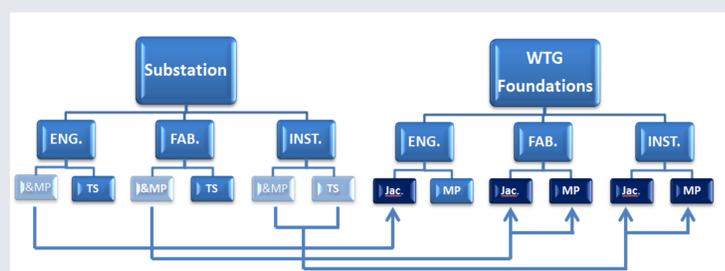
- Distributed substation jacket to be part of WTG foundation contract
- Distributed substation topside to be separate contract



Installation of BKR01 suction bucket jacket foundation, August 2014

Installation

- Distributed substation jacket installation part of WTG foundation installation work
- Distributed substation topside potentially part of WTG foundation installation work as well

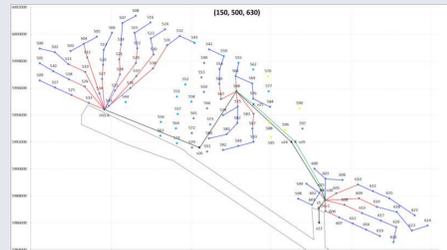


Existing supply chain (dark blue) utilised for delivery of the distributed substation. Eliminated supply chain elements shown in light blue.

Results

Main results

- Concept has been matured to be ready for project implementation
- Substructure design, supply and installation now driven by WTG foundation supply chain
- Elimination of separate substation jacket fabrication
- Elimination of separate heavy lift vessel for substation
- The solution is robust in many ways including:
 - HSE performance in operations phase
 - static reactor for compensation of export cable
 - business interruption risk improved compared to OSS
 - independent of WTG supply
- An attractive business case has been demonstrated on a project



Conceptual park layout for Distributed Substation Solution

The feasibility of the electrical concept was demonstrated on a UK project. The electrical concept is described in more detail in a EWEA Offshore 2015 paper.

Due to the single transformer concept a grid code user variation request was applied for and granted by the UK National Grid on a project specific basis.

The feasibility of the structural concept and supply chain was demonstrated on the same UK project.

The elements affecting the business case contributed in the following way:

Site independent

Substation fabrication	positive
Substation installation	positive

Site specific

Array cable reduction	positive
Electrical loss reduction	positive
Extra length export cable	negative

Only complete implementation will give the full benefit from the concept.



Installation of BKR01 suction bucket jacket foundation, August 2014



Monopile version



Topside layout with one transformer and one reactor

Further potential upsides exist; they are mainly related to substation design and fabrication, ie.

- OFTO shared rooms
- OFTO shared services
- reduction of systems onboard
- reduction of topside weight
- monopile

Conclusions

The project presented here has succeeded in designing a fully functional compact low-weight offshore substation utilising the existing supply chain. The concept presented has been matured to a level that allows for implementation as base case in a project.

The concept is independent of wind turbine manufacturer and therefore supports competition for the WTG contract which typically accounts for 40-45% of the project CAPEX.

The business case evaluation includes all major electrical system aspects in addition to the aspects related to structures, installation and O&M. Therefore the business case is found robust. HSE issues are covered and resolved to full extent considering the relevant offshore conditions for the platform.

It is found that the concept presented offers a solid and robust solution as aimed for in the project objectives.

