Analysis of transmission options for offshore wind farms

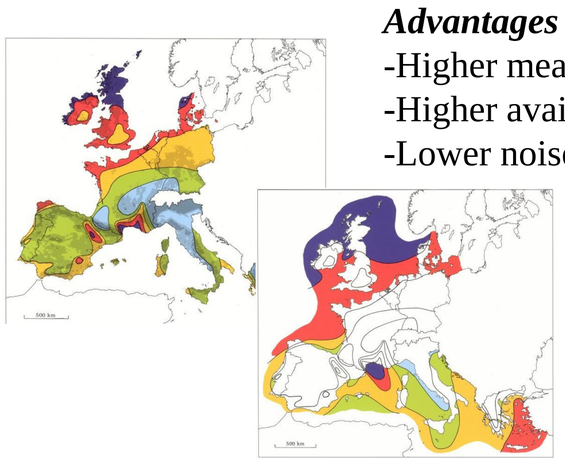
David Berenguel-Centeno (IREC), Lluís Trilla-Romero (IREC), Oriol Gomis-Bellmunt (IREC, CITCEA-UPC)
Electrical Engineering Research Area
IREC Institut de Recerca en Energia de Catalunya – Jardins de les Dones de Negre, 1, 2ª pl. 08930 Sant Adrià del Besòs, Barcelona
CITCEA-UPC Centre d'Innovació Tecnològica en Convertidors Estàtics i Accionaments – Av. Diagonal 647, ETSEIB, Barcelona

Abstract

This project focuses on the study and evaluation of different transmission options for offshore wind farms. The first step consists on a optimization procedure for components design which is implemented considering both technical and economical aspects. In a second step different scheme controls are proposed to test the steady-state and dynamic response of the new HVDC links, considering different power flow exchanges. These tests provide information about the system behaviour when a fault ocurrs in the onshore/offshore grid or the transmission link.

Why offshore wind?

In comparison with onshore wind, offshore wind power plants provides :



Source: European Wind Atlas

Advantages
-Higher mean wind speed and more constant
-Higher available areas.
-Lower noise and visual impact

Disadvantages
-Higher investments and maintenance costs

*Better locations are situated far away from the coast, therefore transmission distance are expected to be large.

AC or DC for offshore wind farms?

Traditional High Voltage AC topology for onshores wind farm applied to offshore are **limited** due to the **reactive power generation** from the HVAC submarines cables. For higher power ratings and voltages the limitation is even greater for HVAC schemes.

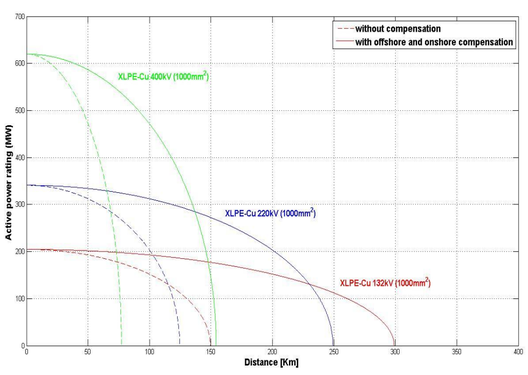


Fig 1: AC active power transmission vs distance

DC transmission

- No transmission length limitations
- Lower losses for long distances
- Ancilliary services

Economical issues

Economic aspects has to be evaluated in order to find the proper solution, mainly based on two key aspects:

- The cost [€/Km] of the submarine HVAC cables are higher than the HVDC cables.
- The cost [€] of HVDC converter stations have higher initial investment cost.

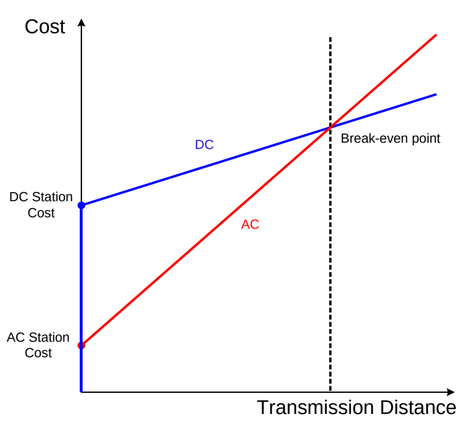
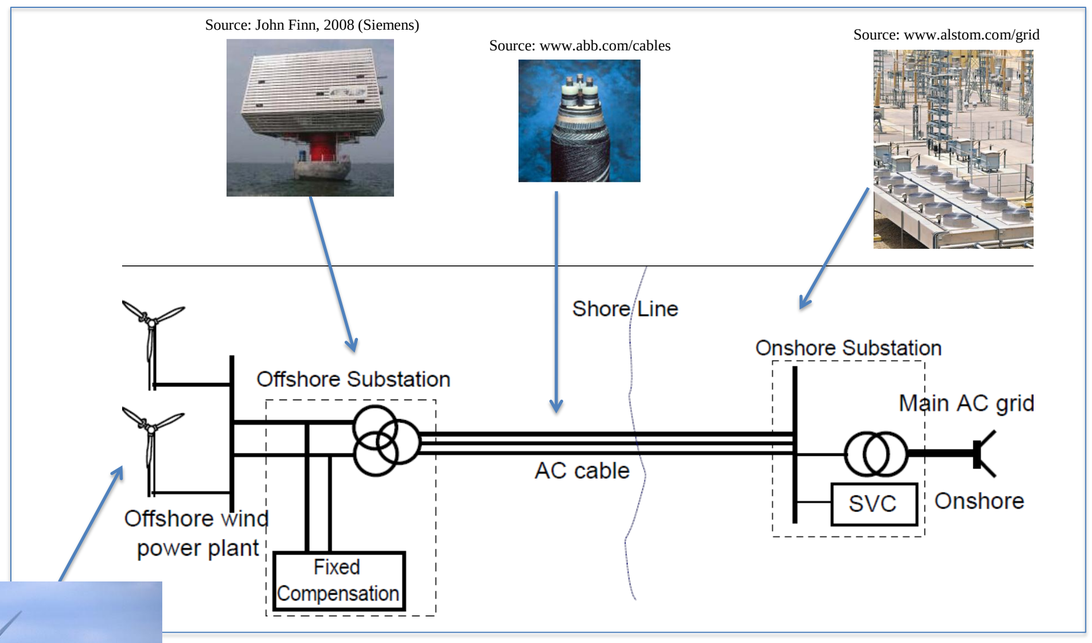


Fig 2: Ac vs DC. Break even point

Considered transmission options

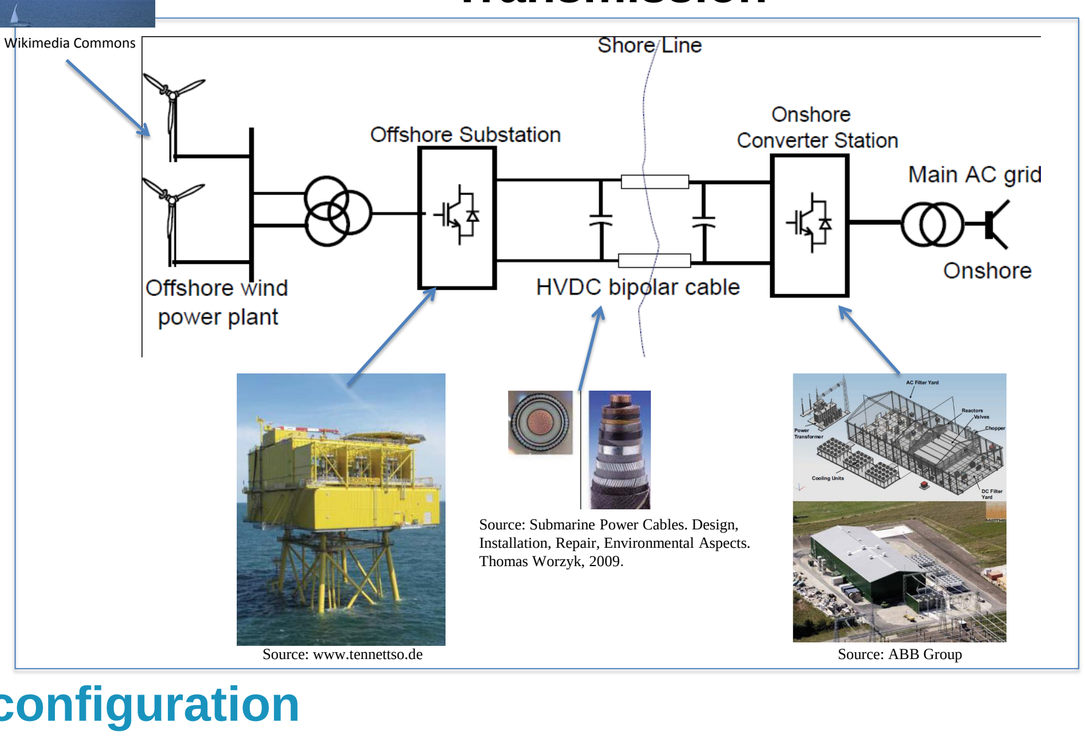
The options considered are the HVAC and HVDC-VSC transmissions. Although others may be used in a very specific situations, such as MVAC.

High Voltage AC (HVAC) Transmission



Source: Less Salty . Wikimedia Commons

High Voltage DC (HVDC) Transmission



Source: www.tennettso.de

Source: Submarine Power Cables. Design, Installation, Repair, Environmental Aspects. Thomas Worzyk, 2009.

Source: ABB Group

Optimization of the proper configuration

The project objective is to evaluate the optimal transmission scheme depending on the different input variables, such as the power to be transmitted, distance of the transmission link or ancilliary services that the wind farm must provide.

Optimization objective functions

Power losses

Costs

Conclusions

Offshore wind farms are expected to be an important energy source in the future. As these wind power plants have to be placed further from the shore their design and installation becomes more challenging. In this project several aspects regarding different types of technology are considered in order to optimize the total cost of the plant and improve its efficiency. As a result, given a specification of a project, an optimal design of the transmission system is obtained, its cost and power losses can be checked and its performance when facing different situations such as grid faults can be tested.