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Comparative Levelized Cost of Energy Analysis

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Abstract

To estimate the economic feasibility of floating and bottom-fixed substructures at various offshore sites, a generally applicable calculation tool has been developed. With this "LCOE calculation tool" it is possible to optimize the design and reduce the costs of deep offshore wind farms, by analyzing key aspects already during the planning and pre-design phase. Hereby the conducted breakdown of the several cost categories assists identifying main cost-drivers prior a final investment decision. Whereas the influence of varying site specific, technological and financial parameters on the cost-effectiveness is investigated in a sensitivity analysis. To validate and enlarge the tool's dataset, the tool was applied to a real floating concept with the aim to compare the cost-effectiveness of floating solutions with their bottom-fixed counterparts.

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1. Introduction

The global market for floating offshore wind turbines (FOWTs) shows a great potential [1]. Technical feasibility of FOWTs has been demonstrated in various simulations and prototypes. On the pathway to commercialization, economic feasibility seems to be the key challenge which has to be mastered.

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Promoters and engineering companies strongly rely on having tools, judging the cost-effectiveness of wind farms in different locations, to support their planning and decision making process. Currently there is a tendency in the offshore industry to move into greater water depths further away from shore and to install turbines with a higher rated power [2][3]. This trend leads to more complex infrastructures which makes the planning, installation and operation process even more challenging. Due to the fact that the deep offshore wind industry and the floating wind sector in particular are still in its infancies, there is a lack of this kind of tools. To address these existing shortcomings, a so called "Levelized Cost of Energy (LCOE) calculation tool" based on an extensive database compiled from publicly available sources has been developed and through a sensitivity analysis, parameters offering cost reduction potential were identified.

1.1. Objectives

The main objective of the LCOE calculation tool is to optimize the design and reduce the costs of deep offshore wind farms, by analyzing key aspects already during the planning and pre-design phase. As a case study, the competitiveness of a new FOWT concept is judged and compared to other floating concepts and bottom-fixed systems.

The conceptual design of this new solution, which results from a joint research project named "Alternative floating offshore substructures for offshore wind farms" (AFOSP) carried out by KIC InnoEnergy, Gas Natural Fenosa, the University of Stuttgart and Universitat Politècnica de Catalunya. The main differentiating aspect with respect to other FOWT concepts is the monolithic nature of the whole structure, including both, platform and tower, as well as the utilization of post tensioned concrete as main material.

2. The LCOE calculation tool

The developed tool analyzes and compares different offshore wind solutions in deep waters from a techno-economic perspective.

2.1. Methodology

Offshore wind farms are capital-intensive projects which will accumulate revenues over a long period of time, before reaching their break-even points. When evaluating long term investment projects, quantification of expenses in different phases of the project becomes important due to capital costs and risk placement. Therefore a Life Cycle Cost Analysis (LCCA) is conducted for each of the regarded substructure types. Hence all costs occurring through different life cycle phases of a wind farm are considered; from wind farm development, manufacturing, acquisition and installation of components to operation and maintenance of the wind farm and finally decommissioning. Total costs are discounted to values at equal points of time and assigned to expected wind farm energy production, to find costs per produced unit of energy, so called Levelized Cost of Energy (LCOE). The LCOE calculation tool includes all capital-, operational- and decommissioning expenditure (CAPEX, OPEX and DECEX) incurred over the lifetime of a project. The result is a constant unit cost per kWh of a payment stream that has the same present value as the total cost of a generating plant over its lifetime. Simplified the presented calculation tool is based on the following, general approach [4]:

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{el}}{(1+i)^t}} \quad (1)$$

$LCOE$:	Levelized cost of electricity in €ct/kWh	i:	Weighted average cost of capital (WACC) in %
I_0:	Capital expenditure (CAPEX) in €ct	n:	Operational lifetime in years
A_t:	Annual operating costs (OPEX) in year t	t:	Individual year of lifetime (1,2,…n)
M_{el}:	Produced electricity in the corresponding year in kWh		