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Design Basis for the Feasibility Evaluation of Four Different Floater Designs

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Abstract

Floating wind turbines are gaining focus as the technology is advancing and more and more demonstration projects are being deployed. The key aspects for this development are maturing the technology towards cost effective solutions for commercialization. In this context, the European Union funding for the research project LIFEs50+ as part of Horizon2020 framework becomes more and more relevant for the development / commercialization of floating wind turbines / wind farm. To obtain cost effective designs, it is important to characterize the correct site environmental conditions such as wind, waves, current, etc.. Based on these site conditions, appropriate design concepts are chosen. Once a specific design concept is chosen, relevant design methodologies as per the existing standards shall be agreed upon as there are several parties such as met-ocean experts, foundation designer, wind turbine supplier, certification agencies, etc., are involved. As the design methodologies are clearly defined, all the experts can initiate the design process in parallel. In general, the above mentioned process (the environmental conditions and design methodology including the design load case table) is documented, which is termed as Design Basis. In this paper, the focus is given to the development of a generalized design basis, which categorizes three different sites along with design methodologies for the design concepts along with the process followed for the development of the generic design basis. By this way, different interested parties can make use of the design basis to fill in the relevant data and to understand how these data would influence the global design.

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1. Nomenclature

The nomenclature and abbreviations used in this paper are detailed below:

Nomenclature

AEP	Annual Energy Production
ALS	Accident Limit State
DLC	Design Load Case
DTU	Technical University of Denmark
ECD	Extreme Coherent gust with Direction change
EOG	Extreme Operating Gust
EU	European Union
FLS	Fatigue Limit State
KPI	Key Performance Indicator
O&M	Operation and Maintenance
PLF	Partial Load Factor
RNA	Rotor Nacelle Assembly
SLS	Serviceability Limit State
TLP	Tension Leg Platform
TRL	Technology Readiness Level
ULS	Ultimate Limit State

2. Introduction

Floating wind turbines are becoming popular and the developments are reaching the level of commercial deployment, once such example is the first pilot floating wind farm off the Scottish coast [1]. In this context, as part of Horizon2020 framework, the European Union has granted funding for the research project LIFEs50+ in order to reduce production, installation, and O&M costs for water depths of more than 50 m [2]. The objectives of the project are to optimize and qualify to a technology readiness level TRL of 5 (which is a requirement set out by the LIFEs50+ consortium for commercialization of floater designs), two innovative substructure designs for 10MW turbines, and to develop a streamlined and key performance indicator (KPI) –based methodology for evaluation and qualification process of floating substructures. For the project three generic sites viz. Site A (mild sea state), Site B (moderate sea state), and Site C (severe sea state) are considered with four floater concepts viz. Semi-submersible by Olav Olsen, Tension Leg Platform (TLP) by Iberdrola, Semi-submersible by Nautilus, and a moon-pool barge type concept by Ideol. Details of the sites and floater concepts are described in [3]. All the floaters will be mounted with DTU 10MW reference wind turbine [4].

Since floating wind turbines consist of several components and multi-disciplinary technologies, there are several parties involved for the design of a concept such as the wind turbines (RNA and tower), floater, station-keeping system, anchoring system, flexible power cables etc.. All these components and systems are subjected to site-specific environmental conditions such as wind, waves, current, tidal variations, wind/wave misalignments etc.. These environmental conditions are in general divided into operational conditions (which determines the Fatigue Limit State (FLS) design) and extreme conditions (used for the Ultimate Limit State (ULS) design). A design basis serves as an interface between the site-specific environmental data and the concept design.

In the present paper, the site conditions described in [5] for the three sites investigated in LIFEs50+ project are summarized. The focus is given to the four floater concepts mentioned above and the scope of the analysis is the feasibility study of the concepts (e.g. first design iteration). Starting from the site conditions, it is detailed how to obtain simplified conservative values for the first design iteration (as it is not practical to have the comprehensive