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MBSA model to evaluate and analyse the production availability of an offshore wind farm

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Estimating the production availability of an offshore wind farm is a new challenge. In order to perform these calculations as well as possible, work is carried out within TotalEnergies using the GRIF software suite. A synthesis is proposed in this article and will be presented at ESREL 2023.

Keywords: Wind, Offshore, Petri nets, Monte-Carlo simulation, MBSA, Maintenance, O&M, Production availability, Weather, GRIF

1. Introduction

Preparing for the energy transition is one of the major concerns of the French government, which enacted the Energy Transition Law for Green Growth (LTECV) on 17 August 2015 to limit global warming effects (ecologie.gouv.fr., 2017). To meet this challenge, the French energy supermajor Total became TotalEnergies in 2021 to make the group a major player in the energy transition and to achieve, jointly with society, carbon neutrality by 2050. To achieve this, the company has set itself the following objectives:

(i) Reduce greenhouse gas emissions as much as possible, primarily on its different sites operated in Europe and elsewhere in the world that are under its direct responsibility
(ii) Offset all remaining emissions, for example through CO_2 capture projects
(iii) At the same time, propose an energy mix that is less and less carbon intensive with the development of renewable energies (solar, hydrogen, onshore and offshore wind, etc.).

To enhance energy mix, from 2022 onwards, new offshore wind farm projects will emerge close to consumption grids and raise new questions which the Offshore Wind industry is preparing to meet the objectives of the LTECV law. To this end, Reliability Availability Maintainability (RAM) studies can provide decision-aid support to define the best Operation and Maintenance (O&M) strategy, i.e. the one allowing to obtain the optimum between OPerating EXpenditure (OPEX) and production availability (ISO 20815:2018) for a given farm.

2. Issues

The complexity of the O&M model of an offshore wind farm relies on the accuracy of the simulation model, especially on the way the weather impact and the maintenance strategy are to be considered. Indeed, all effects induced on intervention vessel mobilization times, power of turbines and logistic delays are to be addressed properly as they can have a significant impact on final results. By simply considering the wind speed and wave height, it quickly becomes clear that the availability and accessibility of human resources and maritime transport are variable. Moreover, the structures, machines and technologies present in an offshore wind farm are continuously increasing in size. This makes it difficult to access reliability data and feedback on different O&M strategies.

Faced with such constraints and following a benchmark of existing software and methods, it appears that a Model Based Safety Assessment (MBSA) modelling technique is the best solution. By definition, in the context of system safety analysis, MBSA is an approach that consists of building high-level models that are closer to the descriptions of functional and physical architectures of systems, while remaining assessable by the tools for calculating safety indicators (Batteux, 2017).

This type of methodology has already been conducted for oil & gas industry through Petro module of the GRIF software suite (GRIF, 2023), technology of TotalEnergies, which supports the MBSA approach (Batteux, 2016). However, this module does not properly address all offshore wind market specificities, and that is why it is needed to propose an alternative with the Flex module also available in the GRIF simulation package based on Petri nets with predicates and assertions associated to Monte-Carlo Simulation.

3. Methodology

The purpose of this new tool is to consider in a same integrated model (non-exhaustive list):

- Curative maintenance interventions further to random failures
- Planned events (inspection, preventive maintenance, testing, etc.)
- Weather impact (wind and wave) and all associated effects on the system
- System architecture and design capacities
- Logistics (maintenance resources, intervention vessels, mobilization times, spare part strategy, procurement times, etc.).

To do so, the Flex methodology put in place consists in:

(i) In GRIF-Petri12 (dedicated graphical interface for the realization of Petri nets with Predictions and Assertions)
(a) Create a library of generic Petri nets (components, resources)
(b) Define flow propagation for generic components

(ii) In GRIF-Flex
(a) Model the system from its definition by assigning the corresponding generic Petri nets for each block created
(b) Enter a source and a target of the flow (mono or multi) that will circulate through the system components according to flow definitions.

To illustrate the use of Flex module, the figure below allows to see a simple model composed of two turbines and an offshore sub-station).

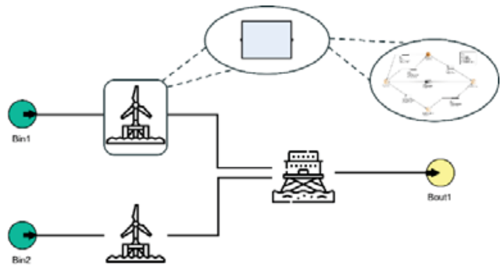

Fig. 1.Flex model and methodology illustration

4. Perspectives

The aim of the research is to create a MBSA model with Flex according to a test case. Further results will be provided during the presentation at ESREL 2023.

References

ecologie.gouv.fr. (2017).Loi de transition énergétique pour la croissance verte. https://www.ecologie.gouv.fr/loi-transition-energetique-croissance-verte

ISO 20815:2018(fr).Industries du pétrole, de la pétrochimie et du gaz naturel — Assurance production et gestion de la fiabilité.

Batteux, M., Prosvirnova, T. (2022).Analyses de Sûreté de Fonctionnement basées modèles - Model-Based Safety Assessment (MBSA). *IMdR Info n°47*.

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Batteux, M., Prosvirnova, T., Rauzy, A. (2016).A Reasoned Introduction to Model-Based Risk and Safety Assessments. *IMdR Lambda-Mu 16.*

DOI:10.3390/jmse10071000 - "Availability Analysis of an Offshore Wind Turbine Subjected to Age-Based Preventive Maintenance by Petri Nets"

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IEC 62551:2012.Analysis techniques for dependability - Petri net techniques