Design of offshore power grid to collect offshore wind power

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The energy transition requires an important development of offshore wind farms. For example, in the coming years, France is projected to develop large capabilities in offshore wind power (see [1]). In order to collect the energy produced by those wind farms, they need to be connected to the onshore grid. This responsibility falls upon Transmission System Operators, such as RTE in France, which must optimize both the design and operational costs of connecting offshore wind farms to onshore grids. In this context, we address the complexity of this optimization problem using a Mixed Integer Quadratic Programming (MIQP) formulation.

The design phase involves critical decisions, including the selection of the number and capacity of substations, the establishment of connections among land, substations, and wind turbines, and the determination of their respective capacities. Operational costs comes from penalties for untransported energy, and are incurred when the offshore grid struggles to accommodate energy production due to capacity constraints or equipment failures. The core challenge lies in the variability of equipment failure rates, introducing a design-dependent dimension to the probability of failure and the consequent penalties incurred. This intricate relationship engenders a complex optimization problem. Specifically, the quadratic nature of the problem arises from the interplay between failure probabilities and resulting penalties. This relationship involves the multiplication of boolean values representing the presence (for failure probability) and the capacity of the equipment (for computing untransported energy). Recognizing the pivotal role of redundancy in shaping resilient system designs, our objective is to develop an approach that systematically integrates these considerations.

The goal of this talk is present the approach we developped this subject. The presentation unfolds in three parts: firstly, we provide contextual insights into the offshore grid optimization problem; secondly, we detail the MIQP model with a focus on key simplifications; and thirdly, we present a solving algorithm and outlining future developments in the formulation.

Our work aims to contribute to the efficient and cost-effective development of offshore wind farm grids, aligning with the growing importance of renewable energy sources in the global energy landscape.

References

[1] RTE. Futurs énergétiques 2050. https://www.rte-france.com/analyses-tendances-et-prospectives/bilan-previsionnel-2050-futurs-energetiques, 2021.