Heuristics-based design and optimization of offshore wind farms collection systems

A parallel-based algorithmic framework for automated design of Offshore Wind Farms (OWFs) collection systems is proposed in this paper. The framework consists basically on five algorithms executed simultaneously and independently, followed by a combined analysis aiming to generate the best results in terms of different objective functions. The main inputs of the framework are the location coordinates of the Wind Turbines (WTs) and the Offshore Substation (OSS), wind power production time series, and the set cables considered for the collection system design. Four heuristics and one metaheuristic algorithm are considered. The heuristics are based on modified versions of well-known graph-theory algorithms: Kruskal, Prim, Esau-Williams, and Vogel's Approximation Method; all of them coded in a unified framework with quartic time complexity. The metaheuristic is built upon a Genetic Algorithm designed using a hierarchical-restricted penalization system. Comparisons between all of these methods are performed from different perspectives, taking into consideration the particular constraints treated for OWFs practical applications.

In general, primal solutions from heuristics lead to faster and better results when only a single cable is available, and provide collection systems with lower electrical power losses for multiple cables choice, whilst the Genetic Algorithm shows better results when the initial investment is prioritized and several cable types are considered.
Improved Method for Calculating Power-Transfer Capability Curves of Offshore Wind Farms Cables

The power-transfer capability curve is widely used by Offshore Wind Farms (OWFs) planner when designing their grid connection. An improved method for calculating power-transfer capability curves of OWFs cables is presented in this paper. What differentiates this method compared to the traditional approach, is the consideration of the high power variability and low capacity factors of OWFs, instead of assuming continuous nominal conditions. The method is based on an iterative approach, aiming to determine the maximum total installed power of an OWF, that a cable can support in function of its total length (effective length from the Offshore Substation, OSS, to the Onshore Connection Point, OCP); in order to do so, operational constraints such as: voltage swing limit, Surge Impedance Limit (SIL), and thermal limit are taken into account. By means of this strategy, is possible to estimate more accurately and realistically the power limits and binding constraints, hence exploiting the cables’ capacities under particular installation and operating conditions. The translation from rated conditions towards dynamic behaviours, permits the inclusion of more realistic states of the system, for instance, accounting not only for the wind speeds fluctuations, but also the variation of boundary temperatures (seabed), and other thermal parameters which have strong influence over buried cables’ thermal performance. The transmission cables are modelled considering a uniform distribution of their electrical parameters, inductance and capacitance, by means of the attenuation constant and characteristic impedance. Likewise, A Thermo-Electrical Equivalent Model (TEE) is applied for the thermal analysis given its good solution quality-computation time balance. The proposed methodology is applied to a 800 mm2 cable, with the results showing an estimated increase of OWF total installed power of 110% for a total length of 120 km, when compared to the traditional method.

Lifetime estimation and performance evaluation for offshore wind farms transmission cables

A novel methodology for life estimation and performance evaluation of offshore wind farms high voltage AC export cables is presented. The method applies Dynamic Temperature Prediction (DTP) analysis using a Thermo-Electrical Equivalent model (TEE). Furthermore, it is suggested how the cable lifetime might be inferred based on the accumulated ageing effects. Afterwards, a sensitivity analysis of the seabed temperature variations is performed. Finally, a holistic procedure for calculating more accurately the electrical power losses of the cable is presented. Results show that an important increase of the total installed power, or cross-section reduction, can be achieved compared to traditional sizing methods.
Metaheuristic-based Design and Optimization of Offshore Wind Farms Collection Systems
An optimization framework for automated design of offshore wind farms collection systems is proposed in this paper. The core of the framework consists of a metaheuristic algorithm, namely a Genetic Algorithm (GA). The GA is designed for searching high-quality feasible solutions in terms of the capital expenditure (CAPEXcs); a subsequent step runs a power flow in order to calculate electrical power losses for estimating the collection systems share on the Levelized Cost of Energy (LCOEcs). Finally, after several executions of the full framework, the feasible solution bringing the cheapest LCOEcs is selected. The main inputs are the coordinate’s location of the wind turbines and the offshore substation (OSS), wind power production time series, and the set of considered cables for the collection system design. The proposed approach offers a full search space exploration for feasible solutions, while taking into account cables capacities and disallowing for cable crossings. The results show that this framework can find feasible solutions improving benchmark methods by 8%.

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Heuristics-based design and optimization of offshore wind farms collection systems
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Juan-Andrés Pérez-Rúa (Guest lecturer)
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Latest advancements on algorithms for designing the collection systems in large-scale offshore wind farms
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CITCEA Polytechnic University of Catalonia
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Juan-Andrés Pérez-Rúa (Guest lecturer)
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**Related external organisation**
State of Green and Region Skåne
Activity: Talks and presentations › Conference presentations

**Prizes:**

**Scholarship for EMMC STEPS studies**
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Prize: Prizes, scholarships, distinctions