

Study Committee B1

Insulated Cables

10882_2022

Optimal energy management of offshore wind farms considering the combination of overplanting and dynamic rating

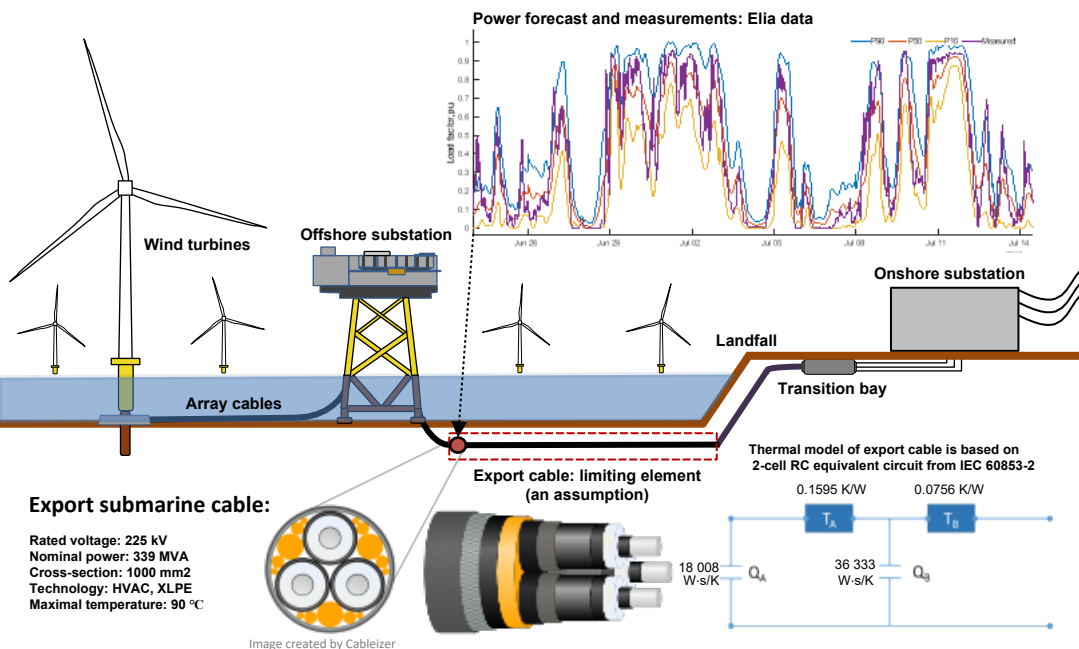
Ildar DAMINOV¹, Anne BLAVETTE^{2,3}, Salvy BOURGUET³, Thomas SOULARD⁴, Didier TRICHET⁵, Guillaume WASSELYNCK³, Hamid BEN AHMED³, Laurent DUPONT⁵, Pierre WARLOP⁶
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Motivation:

Offshore wind farms started having a greater installed capacity than their transmission infrastructure. Such a design is known as "overplanting". This allows increasing the energy generation revenues while requiring some curtailments of power output during the windiest periods. In addition, export cables may have high thermal inertia. So they can be fully loaded for several days before the cable reaches the maximum permissible temperature (usually 90°C for XLPE cables). Hence, some Transmission System Operators allow offshore wind farm managers to export more power than the transmission infrastructure may deliver in steady-state conditions. This is known as the «dynamic thermal rating» (DTR). DTR combined with overplanting can lead to a significant reduction in the Levelized Cost of Energy (LCOE) of offshore wind farms.

Goals:

The paper's goal is to investigate the optimal commitment strategy of overplanted offshore wind farms considering the effects of the imbalance prices. Specifically, we examine the benefits of improving the electricity production commitment strategies against business-as-usual approaches based on the 50% quantile, called P50. In this perspective, a theoretical case is investigated, where the day-ahead and imbalance prices would be known in advance to define an optimized power production commitment. This theoretical case intends to determine the upper bound on the annual revenue that could be gained by enhanced forecasts on both the production of overplanted offshore wind farm and the day-ahead and real-time energy prices at the market.

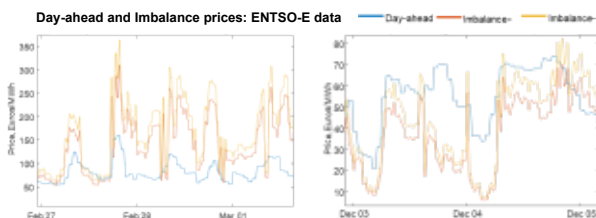


Performed studies:

Limit of export cable : STR vs DTR

Commitment strategy : P50 vs Optimal Power Profile

Overplanting rate : 0 % - 200 % of wind farm's installed capacity



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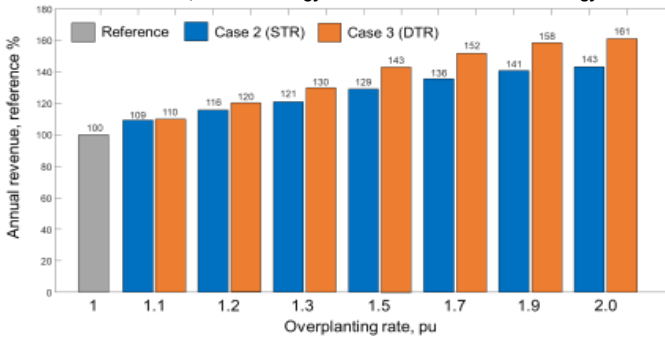
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Main results:

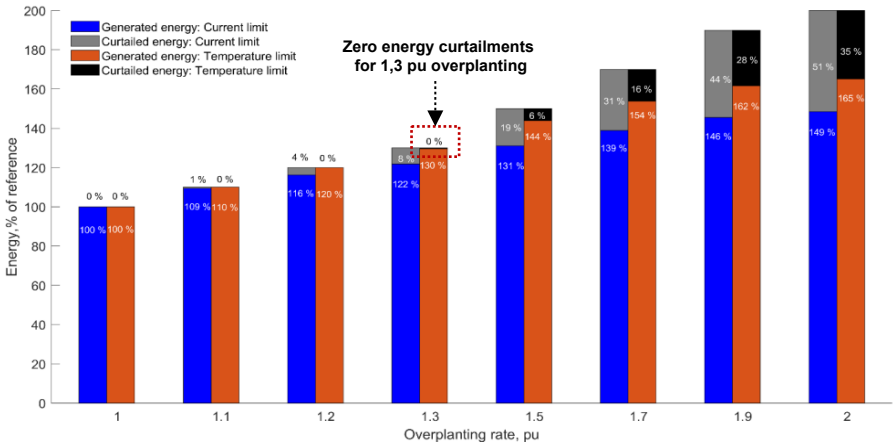
Annual revenue as a function of the overplanting rate for the STR and DTR cases. In all cases, the P50 strategy is used as the commitment strategy



Annual revenue in % as a function of overplanting rate for the two commitment strategies with STR and DTR

Cable limit	Commitment strategy	Overplanting rate (pu)							
		1	1.1	1.2	1.3	1.5	1.7	1.9	2
STR	P50	100	109	116	121	129	136	141	143
	P _{OptimProfile}	121	132	141	148	161	172	182	187
DTR	P50	100	110	120	130	143	152	156	161
	P _{OptimProfile}	121	133	145	157	175	188	199	204

Annual generated and curtailed energy as a function of the overplanting rate



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Conclusions:

- The revenue increased in the same proportion as the overplanting rate (up to 130%), in case the business as usual strategy (P50) strategy is used and that dynamic rating is applied. This means that no curtailment is done in this case which can be deemed as economically viable.
- If the optimal strategy is used, the revenue increase is always greater than the overplanting rate, therefore suggesting also an economically viable case.
- The commitment strategies and the export cable's rating (STR or DTR) have an important influence on the value of the optimal overplanting rate.
- A large margin exists for improving commitment strategies if the forecast tools become sufficient to exploit the events when the variations of imbalances prices compared to the day-ahead price may lead to small costs for a deficit of energy / high rewards for an excess of energy.
- Enhancing the forecasting quality on day-ahead and imbalance energy prices, in complement to having good wind generation forecasts, could result in significant benefits. As mentioned in the paper, these cases are theoretical as energy prices are considered as known in advance, but it suggests that sufficient knowledge of these prices may have an important influence on the selection of an optimal overplanting rate. Research works are starting to emerge in the area of imbalance price forecasting.
- Future work may investigate the level of forecast quality above which this knowledge would play a significant role in the annual revenue increase.

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