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Modelling and Sizing of a Hybrid Power Plant using Airborne Wind Energy Systems

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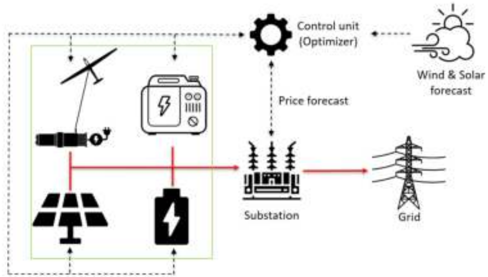
Currently, in remote off-grid locations, electricity is primarily generated using diesel generators, which is expensive and has significant carbon emissions. Alternatively, these remote locations have a huge potential for utilizing renewable energy sources. In such locations, airborne wind energy (AWE) systems could have an advantage over conventional wind turbines. Since, the AWE systems operate at higher altitudes, stronger and more consistent wind energy can be harnessed. Moreover, they are more compact and have higher mobility, which can reduce installation, operation, and maintenance costs. A possible architecture of a hybrid power plant (HPP) using AWE systems is shown in Figure 1. The centralized controller of the HPP optimizes the energy sources' dispatch based on the resource and demand forecasts.

Due to the anti-correlation between the wind and solar resources, electricity can be generated more constantly on a daily and seasonal scale [1]. The batteries can be smaller, and diesel generators rarely need to be used. The stronger the anti-correlation between the wind and solar resources, the better the HPP performs.

The model of the HPP uses wind, solar, and load data as inputs. The hourly energy production is calculated, and combined with the load data, the battery capacity is determined. To find the optimal number of kites, modules, battery capacity, different combinations of kites and modules are put in the model. The Levelized Cost of Electricity (LCoE) is evaluated for each configuration. The model's output is the minimal LCoE with the corresponding capacity of the different components.

The model is used to evaluate multiple case studies, which resulted in the following key findings. HPPs have a stronger case in off-grid markets than utility-scale grid-connected markets. The cost reduction by sharing the infrastructure is minimal. The security of the power supply is better maximized at lower costs than standalone installations. The LCoE has become so competitive that the use of diesel can almost wholly be replaced in suitable locations, which results in a significant reduction in carbon emissions.



Possible architecture of a Hybrid Power Plant using Airborne Wind Energy, Solar PV, batteries, and diesel generators.

References:

[1] Bett, P. and Thornton, H. (2016). The climatological relationships between wind and solar energy supply in Britain. Renewable Energy, 87(1), 96–110. doi:10.1016/j.renene.2015.10.006