CALCULATION OF EFFECTIVE FORCED OUTAGE RATE OF OFFSHORE WIND (DWW100) AND OFFSHORE WIND PLUS BATTERY (DWW100+LIE400)

Introduction

This document describes the calculations performed to determine the statistical effective forced outage rate of the DWW100 offshore wind resource, and this wind resource combined with a 33 MW × 8 hour (264 MWh) battery.

The DWW100 offshore wind resource consists of fifteen 6 MW wind turbines, yielding an aggregate nameplate capacity of 90 MW, collector system and transmission losses not considered. The maximum output of the plant, at the onshore point of interconnection is proposed to be limited to 75 MW by means of wind turbine curtailment.

The goal of the South Fork RFP process is to obtain resources that can serve as an alternative to transmission capacity in order to cover transmission contingencies during high loading conditions. Wind generation is inherently variable, however, and its local capacity contribution must be determined by statistical analysis.[1] The key metric is the effective forced outage rate (EFOR), which is the weighted probability that the resource is not available at the time it is needed.

The LIE400 battery has been proposed for the same location as the DWW100 point of interconnection, introducing the possibility of using this battery to "firm" the offshore wind resource to yield a greater local capacity contribution.

Data Source

The DWW100 wind data are based on a historical year's meteorological data, from which the DWW100 proposer's wind resource consultant (AWSTruePower) has "back-casted" wind turbine hourly output. These data were provided to WESC in the spreadsheet "App 9-1 Deepwater ONE - 8760_Equivalent FOR_rms v01.xlsx".

Analysis Methodology

The EFOR analysis was limited to the months of May to September. For the analysis of the wind resource alone, the analysis was further limited to the hours from 2 pm to 9 pm each day, which correspond to the peak hours of the South Fork area load curve. A target local capacity contribution P_t was selected. For each peak-period hour h, the per-unit unserved energy $E_{us}(h)$ was calculated as:

[1] The local capacity contribution is different than the effective contribution to system-wide generation capacity (UCAP).

$$if\left(P_W \geq P_t\right), E_{us}(h) = 0$$
$$else\left(E_{us}(h) = 1 - {P_W(h)}/{P_t} \right)$$

where $P_W(h)$ is the average wind power output for the respective hour.

The EFOR is the average value of $E_{us}(h)$ over the peak-period hours in the peak season. The target capacity contribution P_t was varied over a range to define the relationship of EFOR to the capacity contribution.

The calculation of EFOR for the wind resource combined with the "firming" battery is more complex as it requires modeling the battery state of charge. This analysis is performed on a 24-hour per day basis within the peak season. At each non-peak hour, the entire wind resource output is used to increase the battery's state of charge, unless the wind resource output is greater than the battery power rating (33 MW) or if the battery maximum state of charge (264 MWh) has been reached. If the wind output is greater than 33 MW, then 33 MW is devoted to the battery charging (unless the maximum state of charge has been reached), and the remainder flows into the grid. If the battery maximum state of charge has been reached, then all wind production flows to the grid during non-peak hours.

During peak hours, the battery is used to supplement the wind resource output to the extent that the total of wind plus battery output is 33 MW, provided sufficient battery state of charge exists. If the battery has been discharged to zero state of charge, then the output is limited to that of the wind alone. The combined output of the wind and battery in each peak hour is P_W and the formula above is used to calculate the hourly unserved energy, which is then averaged to determine the EFOR. As in the case of the wind resource alone, the target capacity contribution P_t was varied over a range to define the relationship of EFOR to the capacity contribution.

This analysis did not include battery losses, so the results are slightly optimistic.

EFOR Calculation Results

The methodology described above was used to calculate the EFOR for the DWW100 wind resource alone, and the DWW100 wind resource combined with the LIE400 battery. The results are displayed in Figure 1.

Conventional generation resources typically have an EFOR of around 5%. Therefore, this value has been used as the basis to define the capacity contribution of these resources. The 5% EFOR is shown by the green dashed line in Figure 1. It intersects with the wind resource alone curve at 2 MW, and the combined wind and battery resource at approximately 40 MW. On the basis of a desired EFOR of 5%, the wind alone has a very small effective capacity due to the distinct statistical possibility that it may have very low available power output at the time of a peak-period contingency.

Provided the transmission system has the capacity to recharge the battery during off-peak periods, the battery alone provides an effective capacity equal to its 33 MW rating. Combining the wind and battery shows a small amount of synergy between the resources because the 5% EFOR capacity is 40 MW, which is slightly greater than the sum of the 2 MW wind capacity contribution and 33 MW battery capacity contribution.

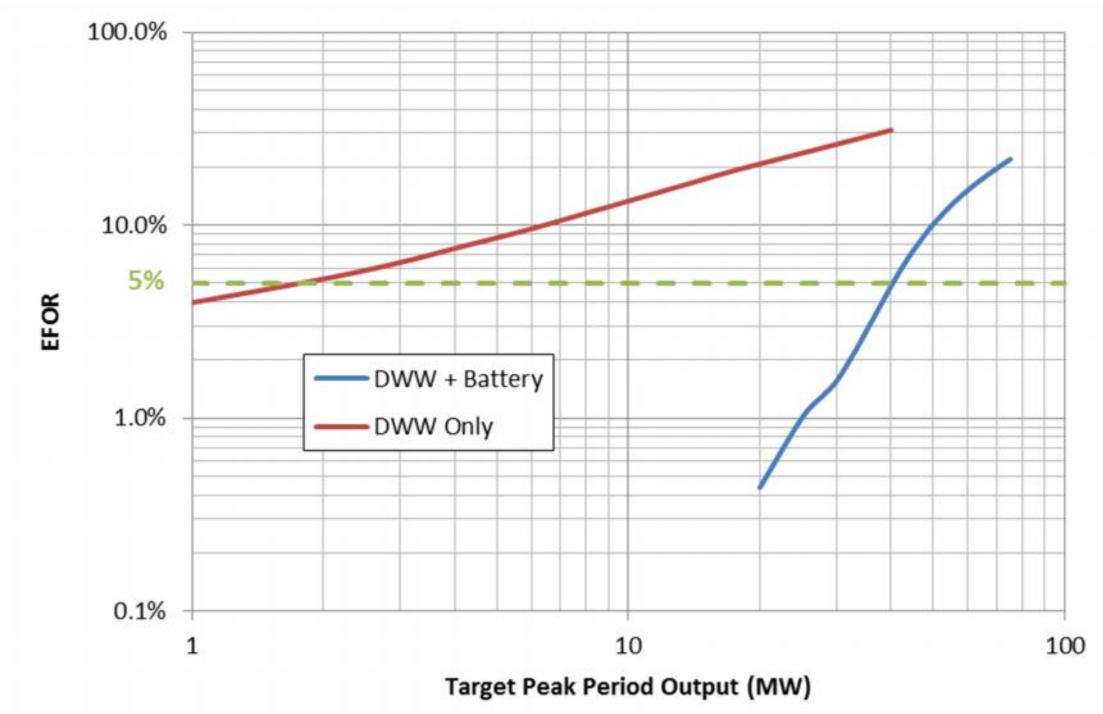

Figure 1 Effective forced outage rate (EFOR) for DWW 100 wind resource alone and combined with the LIE400 33 MW battery.