

South Fork RFP Deepwater Offshore Wind Proposal EFOR Analysis

Background and Assumptions

The Selection Committee has considered Deepwater Wind's nominal 90 MW¹ Offshore wind proposal connecting at the East Hampton substation in the portfolio analysis for Phase III. Due to the intermittent nature of the wind resource, this proposal has a UCAP of 33 MW representing the average capacity that the wind project could provide on a summer season basis. However, the wind project will vary in output and cannot be expected to provide a firm 33 MW during the South Fork peak load period 1PM-9PM. Therefore, the Selection Committee has considered coupling this wind proposal to LI Energy Storage's 33 MW battery storage proposal to use off-peak wind energy to charge the battery and discharge the stored energy--minus losses--during the peak hours.

This assessment is a simplification of the two options in isolation (i.e. without assessment of other generation resources or customer load) during the Peak Period May through September. The following describes the assessment and comparison of estimated peak period unavailability (or equivalent forced outage rate) of the offshore wind project option (Wind Only option) and the combination of offshore wind and battery option (Wind+Battery option).

The source of wind resource data for this assessment is the P50 annual hourly wind output data (App 9-1 Deepwater ONE - 8760.xlsx) and P90 annual hourly wind output data (L-T_MDM-8760_Scaled_to_P90_WS_Unlocked-Deliver~.xlsx). This data is a representation of hourly wind farm output for a given year adjusted to the long term average. According to Deepwater Wind: "The project energy production was estimated for each hour of the year using the input wind speed dataset, density-adjusted turbine power curve, and estimated project losses." **Deepwater Wind estimates that the overall uncertainty in the wind resource is 7%.**

We make the following common assumptions in this assessment:

- The assessment is performed on a daily basis where there are two main periods: Peak and Off-Peak.
- The Peak Hours are 1PM to 9PM.
- The Peak Period is May through September during Peak Hours (a total of 1224 hours per year)
- The Off-Peak Hours are 9PM to 1PM.
- To be 100% available during Peak Hours, the Offshore wind project will be required to produce 264 MWh (33 MW x 8 hours).

For the Wind Only option, we assumed:

- Any daily shortfall of wind energy during the Peak Period is attributed to unavailability (or equivalent forced outage rate, EFOR).

For the Wind+Battery option, we assumed:

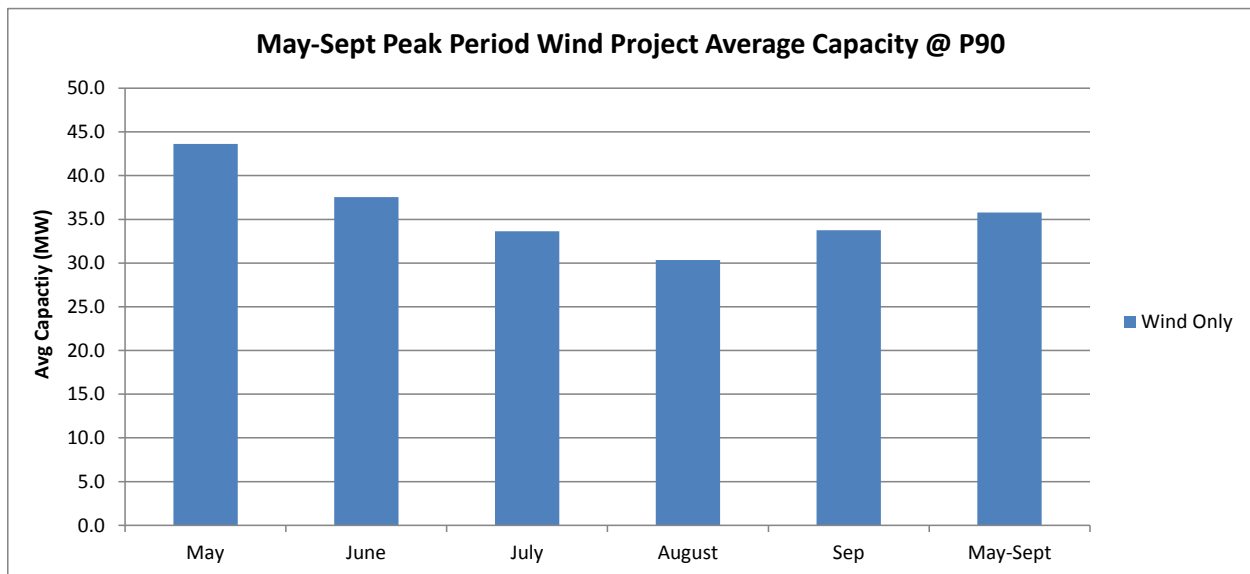
¹ According to the Deepwater Wind proposal (DWW100), the maximum capacity output from the export facility of the wind farm will be 75 MW. This maximum is reflected in the wind data where the maximum hourly energy production is 75 MWh.

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- The Off-Peak wind output from 9PM the previous evening through 1PM of the present day charges the battery; no other energy source charges the battery
- The battery charges at a cycle efficiency of 89% (as indicated in the LIE400 proposal) with a goal of a full load charge of 264 MWh.
- The Peak Period wind is accepted first, and then the battery is discharged to fill the remaining required energy.
- Unused battery energy at the end of the daily Peak Period is carried over to next day.
- For simplification, the battery is assumed to be 100% available.
- Any daily shortfall of energy during the Peak Period is attributed to unavailability.

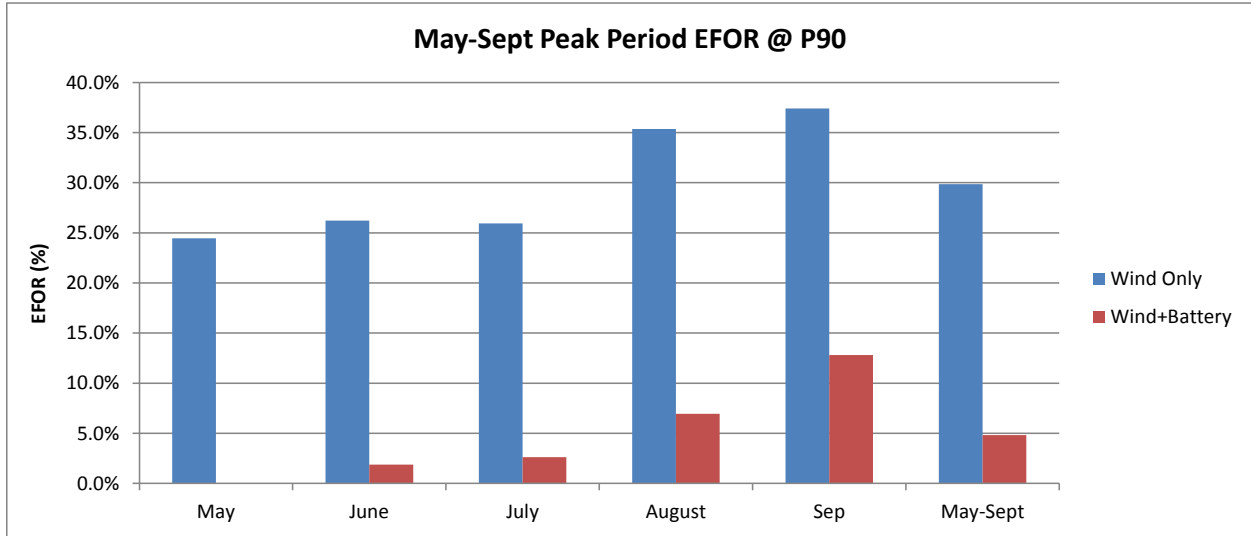
Unavailability at P90 Probability Level

Based on this P90 wind resource data and the assumptions above, Deepwater Wind’s offshore wind project has a May through September Peak Period average capacity of 35.8 MW without the assistance of LI Energy Storage battery (shown in the figure below). Although this average capacity during the Peak Period is greater than 35.8 MW, there are many Peak Periods when the wind resource is not sufficient and encounters a shortfall.



An accumulation of these shortfalls on an energy basis shows that Deepwater Wind’s offshore wind project at P90 probability level would have a May through September Peak Period unavailability (or EFOR) of 29.9% without the assistance of LI Energy Storage battery (as shown in the figure below). When the battery resource is coupled to the wind project, the off-peak wind energy charges the battery and that energy is discharged during the Peak Period. The EFOR of the Wind+Battery option is estimated to be an average of 4.8% at the P90 wind resource probability level.

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Without the battery, shortfalls occur on 77 of the 152 Peak Period days, or about 50% of the days. With the battery, shortfalls occur on 19 of the 152 Peak Period days, or about 12%. Most of the Peak Period unavailability occurs in August and September. Based on the representative data, there are 7 days in both August and September that have shortfalls. The assessment shows:

- The 77 days of Wind Only shortfall means that the battery will be called upon at least 77 times during the 152 day Peak Period.
- There are periods of up to 4 consecutive days where Wind+Battery shortfalls are occurring in August and September.
- Some Peak Periods see shortfalls across the full 8 hours.
- The average number of shortfall hours during the 8 hour peak period is 4.7 hours (i.e. the first three hours are covered by the battery and the last five hours are in shortfall).
- Typically, the hourly shortfalls occur at the end of the Peak Period after the battery has been fully discharged.

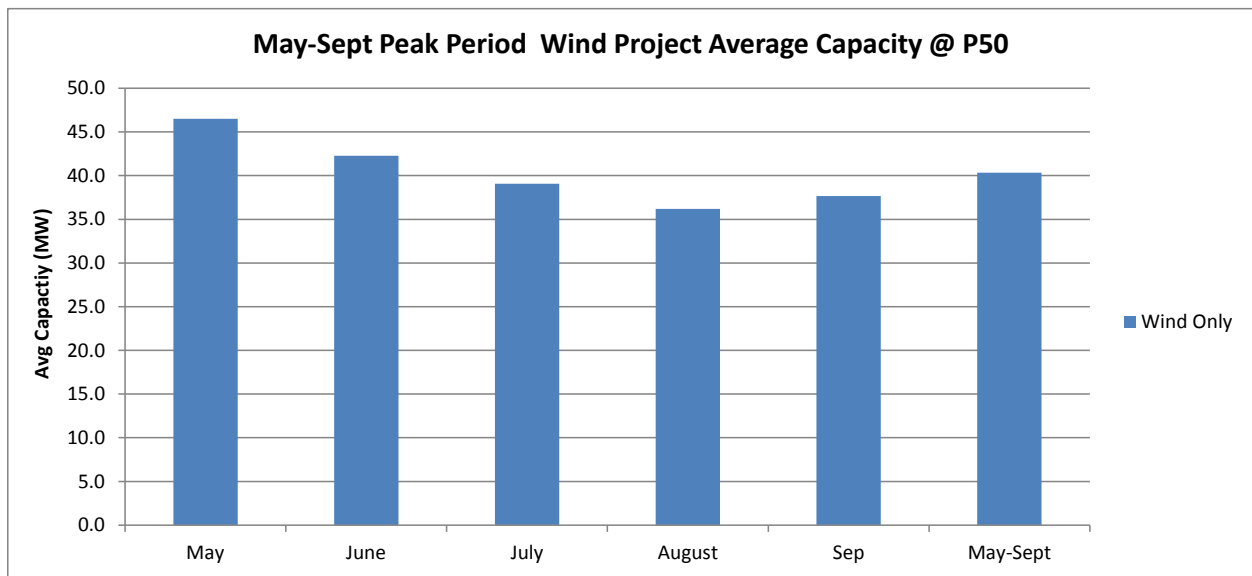
Table 1 – EFOR and Shortfalls of Wind Only Option and Wind+Battery Option at P90

| Month | Wind Only | | | | Wind+Battery | | | |
|----------------|--------------|--|---|---|--------------|--|---|---|
| | EFOR | Number of Days with Peak Period Shortfalls | Average Unavailable Capacity during Shortfalls (MW) | Average Duration during Shortfalls (Hour) | EFOR | Number of Days with Peak Period Shortfalls | Average Unavailable Capacity during Shortfalls (MW) | Average Duration during Shortfalls (Hour) |
| May | 24.5% | 10 | 25.0 | 5.8 | 0.0% | 0 | 0.0 | 0.0 |
| June | 26.2% | 13 | 20.0 | 4.7 | 1.9% | 2 | 9.3 | 3.5 |
| July | 25.9% | 18 | 14.7 | 5.2 | 2.6% | 3 | 8.9 | 3.7 |
| August | 35.4% | 20 | 18.1 | 6.5 | 6.9% | 7 | 10.1 | 4.6 |
| Sep | 37.4% | 16 | 23.2 | 6.5 | 12.8% | 7 | 18.1 | 5.7 |
| May-Sep | 29.9% | 77 | 19.6 | 5.7 | 4.8% | 19 | 12.8 | 4.7 |

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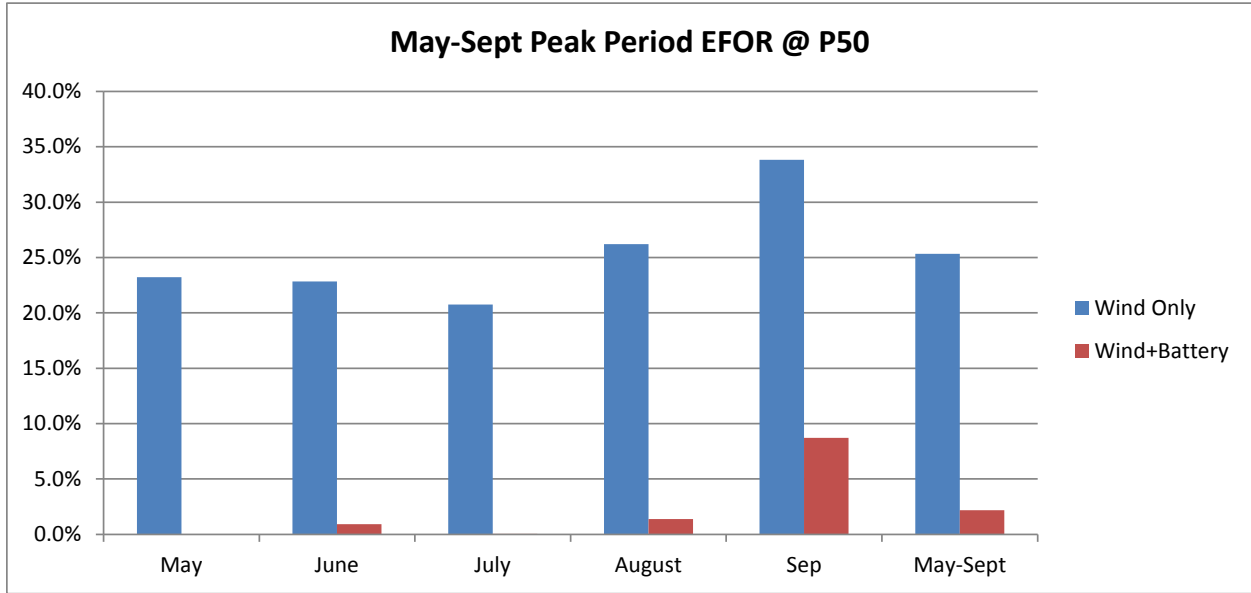
Unavailability at P50 Probability Level

Based on this P50 wind resource data and the assumptions above, Deepwater Wind’s offshore wind project has a May through September Peak Period average capacity of 40.3 MW without the assistance of LI Energy Storage battery (shown in the figure below). Although this average capacity during the Peak Period is greater than 40.3 MW, there are many Peak Periods when the wind resource is not sufficient and encounters a shortfall.



An accumulation of these shortfalls on an energy basis shows that Deepwater Wind’s offshore wind project at P50 probability level would have a May through September Peak Period unavailability (or EFOR) of 25.3% without the assistance of LI Energy Storage battery (as shown in the figure below). When the battery resource is coupled to the wind project, the off-peak wind energy charges the battery and that energy is discharged during the Peak Period. The EFOR of the Wind+Battery option is estimated to be an average of 2.2% at the P50 wind resource probability level.

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Without the battery, shortfalls occur on 65 of the 152 Peak Period days, or about 42% of the days. With the battery, shortfalls occur on 8 of the 152 Peak Period days, or about 5%. Most of the Peak Period unavailability occurs in September. Based on the representative data, there are 4 days in September that have shortfalls. The assessment shows:

- The 65 days of Wind Only shortfall means that the battery will be called upon at least 65 times during the 152 day Peak Period.
- There are periods of up to 2 consecutive days where Wind+Battery shortfalls are occurring in August and September.
- Some Peak Periods see shortfalls across the full 8 hours.
- The average number of shortfall hours during the 8 hour peak period is 4.9 hours (i.e. the first three hours are covered by the battery and the last five hours are in shortfall).
- Typically, the hourly shortfalls occur at the end of the Peak Period after the battery has been fully discharged.

Table 2 – EFOR and Shortfalls of Wind Only Option and Wind+Battery Option at P50

| Month | Wind Only | | | | Wind+Battery | | | |
|----------------|--------------|--|---|---|--------------|--|---|---|
| | EFOR | Number of Days with Peak Period Shortfalls | Average Unavailable Capacity during Shortfalls (MW) | Average Duration during Shortfalls (Hour) | EFOR | Number of Days with Peak Period Shortfalls | Average Unavailable Capacity during Shortfalls (MW) | Average Duration during Shortfalls (Hour) |
| May | 23.2% | 11 | 21.6 | 5.8 | 0.0% | 0 | 0.0 | 0.0 |
| June | 22.8% | 11 | 20.6 | 4.4 | 0.9% | 1 | 9.0 | 4.0 |
| July | 20.7% | 11 | 19.3 | 4.5 | 0.0% | 1 | 0.5 | 2.0 |
| August | 26.2% | 16 | 16.8 | 5.6 | 1.4% | 2 | 7.0 | 4.0 |
| Sep | 33.8% | 16 | 20.9 | 6.5 | 8.7% | 4 | 21.6 | 6.5 |
| May-Sep | 25.3% | 65 | 19.7 | 5.3 | 2.2% | 8 | 13.7 | 4.9 |

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Observations for the Wind+Battery Option

Based on this initial assessment, the simplified Wind+Battery option is estimated to reduce the unavailability of the Wind Only option during the Peak Period between 84% and 91% for the P90 and P50 resource probability levels, respectively. Without the battery, the Wind Only option is estimated to experience unavailability of over 25% during the Peak Period and therefore, is not a viable option for the South Fork RFP needs. However, the assessment estimated the Peak Period average EFOR of the simplified Wind+Battery option to be between 2.2% and 4.8%. This EFOR is within the range of typical EFOR for a conventional generating unit. Furthermore, the combined resources would not realistically be required for the full defined five month Peak Period and would only be needed during days of highest demand.

The EFOR of the Wind+Battery option may be further alleviated with appropriate Off-Peak charging of the battery using existing generation or other new generation. Although the estimated shortfalls are concentrated in July, August and September when the South Fork peak customer load has the highest probability of occurring, the flexibility of using other generation to charge the battery is a significant benefit to this resource combination. Therefore, from a conceptual perspective, the Wind+Battery option is a reasonable resource option for detailed evaluation in Portfolio scenarios.