Inter-annual wind speed variability on the North Sea

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Abstract

In 2016 Garrad Hassan and Partners Ltd (DNV GL) published a report on the inter-annual variability (IAV) of wind in UK offshore waters [1]. The main conclusion of this study, commissioned by The Crown Estate (TCE), was that the current industrial standard of 6 % for the IAV is too conservative for UK offshore waters: a range of 4.0-5.5% was suggested. Using data from the KNMI North Sea Wind (KNW) atlas [2], we studied the IAV for the Dutch Economic Exclusive Zone (DEEZ) and found that also for the DEEZ the IAV is (much) lower than the British industrial standard of 6 %.

Objectives

We aimed to assess the IAV of the wind speed in the DEEZ of the North Sea at heights relevant for wind energy applications. The IAV is determined for a number of locations near or in the DEEZ (Fig. 1).

Methods and Results

As in the report of DNGV GL, the IAV of the wind speed is based on calendar years and defined as the standard deviation of the average mean wind speed divided by the long term mean wind speed. Where DNV GL used MERRA-2 data to derive IAV values, we used data from the KNW atlas. For this study KNW wind speeds at 40, 60, 100 and 200 m were used because they were either closest to the 50 m used in the study of DNV GL or close to the hub and tip height of modern wind turbines.

Table 1: IAV values for offshore locations

<table>
<thead>
<tr>
<th>Station Name</th>
<th>IAV 40 m</th>
<th>IAV 60 m</th>
<th>IAV 100 m</th>
<th>IAV 200 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteomast</td>
<td>3.90</td>
<td>3.85</td>
<td>3.83</td>
<td>3.99</td>
</tr>
<tr>
<td>Ijmuiden</td>
<td>3.82</td>
<td>3.79</td>
<td>3.75</td>
<td>3.92</td>
</tr>
<tr>
<td>K14</td>
<td>3.79</td>
<td>3.75</td>
<td>3.72</td>
<td>3.91</td>
</tr>
<tr>
<td>K13</td>
<td>3.68</td>
<td>3.68</td>
<td>3.70</td>
<td>3.88</td>
</tr>
<tr>
<td>P11</td>
<td>3.55</td>
<td>3.55</td>
<td>3.56</td>
<td>3.73</td>
</tr>
<tr>
<td>F3</td>
<td>3.78</td>
<td>3.74</td>
<td>3.71</td>
<td>3.79</td>
</tr>
<tr>
<td>Huibergast</td>
<td>4.48</td>
<td>4.41</td>
<td>4.32</td>
<td>4.31</td>
</tr>
<tr>
<td>Oosterschelde</td>
<td>4.29</td>
<td>4.25</td>
<td>4.24</td>
<td>4.3</td>
</tr>
<tr>
<td>Vlakte van de Raam</td>
<td>4.36</td>
<td>4.31</td>
<td>4.27</td>
<td>4.35</td>
</tr>
<tr>
<td>Lichtenland</td>
<td>4.18</td>
<td>4.14</td>
<td>4.14</td>
<td>4.26</td>
</tr>
</tbody>
</table>

Table 1 shows that the horizontal variation of the IAV is between 3.5 and 4.0 % for North Sea measurement sites north of P11 and between 4.0 and 4.5% for sites south of P11. They compare well to the values found by DNV GL for UK offshore waters based on 36 years (1980-2015) of MERRA-2 data. Figure 2 shows annual mean wind speeds at four heights at K13 for 1979-2013 based on the KNW atlas. There are periods where the annual mean wind speeds vary a lot, but also periods where successive annual means are more “clustered”. This shows the need to base IAV on data for periods much longer than these clusters (much longer than 10 years). IAV-values based on periods that are too short may be under- or overestimated. The size of this error is shown in figure 3 with running averages (5, 10 and 20 years) of IAV for K13 at 100 m height . The range of IAV values decreases dramatically when increasing the length of the period. The 10 year IAV values show fluctuations with time that are twice as large as the spatial variation of the 35 year IAV in table 1 and are in that respect significant.

Conclusions

The aim of this study was to quantify the inter-annual variability (IAV) of the wind speed at a number of sites in the DEEZ. Wind speeds were extracted from the KNW-atlas for each year and each site and used to calculate the annual mean wind speeds. These were then used to calculate the IAV at each site. In agreement with the results obtained by DNV GL we find that for the DEEZ the IAV is (much) lower than the British industrial standard of 6 %. It appears that the annual means are approximately normally distributed, with typical values for the IAV that range between 3.5 and 4.0 % for sites in the northern part of the DEEZ and between 4.0 and 4.5% in the southern part of the DEEZ. An analysis at K13 shows that more than 20 years are required to make the IAV fluctuations at 100 m height smaller than the spatial variations of the IAV on the North Sea.

References

1) DNV GL, 2016: a study on UK offshore wind variability. DNV GL report nr L2C124303-UKBR-R-01, Issue B, 67 pp
2) http://projects.knmi.nl/KNW/