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EXTREME WIND CONDITIONS IN
DIGERNESSUNDET, STORD
PRELIMINARY REPORT

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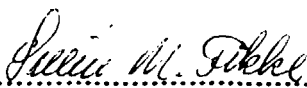
AKER STORD

OPPDRAGSNR.

SAMMENDRAG

Extreme wind conditions are evaluated for 8 directions and 2 seasons based on analysis of 23 years of wind recordings from Utsira and nearly 2 years of recordings from Digernessundet.

UNDERSKRIFT



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EXTREME WIND CONDITIONS IN DIGERNESSUNDET, STORD

PRELIMINARY REPORT

1. INTRODUCTION

The Norwegian Meteorological Institute in cooperation with The Norwegian Research Institute of Electricity Supply has performed an analysis of the extreme wind conditions in Diger-nessundet south of the island Stord. The project is funded by Aker Stord A/S.

In this preliminary report a survey of the method and the conclusions so far will be given. A couple of reservations are taken with respect to the final report, but they will probably not seriously affect the conclusions.

2. METHOD

The analysis is carried out according to the following steps:

- A. Cases with strong winds in Digernessundet are found from nearly 2 years of wind records near Digernessundet.
- B. The above cases are compared with records from the regular weather station Utsira lighthouse, and reduction factors are calculated for different sectors. Directional deviations are found as well.
- C. 23 years of wind records from Utsira lighthouse are examined, and seasonal extremes for 10 min. mean wind and (3-5s) gust wind speeds are found for 8 directions and 2 seasons: September-April and May-August.

- 2 -
- D. The "all-direction" - extremes are analysed according to Gumbel's 1. distribution of extremes.
- E. The directional distribution of extreme values with different return periods are determined as follows:

Return period 2 and 5 years:

The 50 and 20 percentiles of the recorded maxima of each sector are used.

Return periods of 10 year or more:

The "alldirection" value are fixed to the most exposed sector(s) and weighted for the other directions according to the averages of the 5 highest values recorded for each sector.

- F. The extreme values thus found for Utsira are reduced to Digernessundet by means of the functions found under B.

3. RESULTS

Table 1 give the time series for the seasonal maxima of 10 min. mean wind speeds for Utsira. Minor homogeneity breaks may occur in the data, but this will be discussed in the final report.

The investigation of the homogeneity is not finished and some changes may be done in table 1.

The values of table 1 are sorted in decreasing order in table 2.

The value 0.0 in tables 1 and 2 means that no value higher than 10 m/s are found. This limit was chosen due to the amount of work and has probably no effects on the results.

The extreme values calculated for Utsira according to the method described under E above, are shown in table 3.

It should be noted that the "all direction" extremes are somewhat higher than the highest value for each sector for the return periods 2 and 5 years. This is found logical since for short return periods the seasonal extremes may occur from several directions. The "all-direction" value must therefore represent a longer return period for each of these sectors alone.

Longer return periods (10 years or more) give higher wind speeds and it is reasonable that these strong winds are restricted to one or two sectors (see table 2). However, the directional extremes in table 3 for long return periods are probably on the conservative side. Due to high standard deviations of the recorded directional maxima, the Gumbel distribution gave unrealistic values when applied on each sector separately.

Table 4, has been computed by method F. Gust factors was calculated for the Stord-data, and applied to the extremes of the 10 min mean values in this table. The 3-5s gust wind speed extremes thus found are presented in Table 5.

The directions are referred to Utsira. By comparing the short data set at Stord with the Utsira records we found the typical veering at Stord. This veering is somewhat dependent at the wind direction, and is highest (50°) for northwesterly and easterly winds at Utsira, and lowest for southerly to southwesterly winds (20-25°).

The high summer extremes in tables 4 and 5 for long return periods should be mentioned. The normal summer conditions are weak winds, illustrated by low values for the short return periods. However, a strong storm may blow up, but has a long return period. This happened for example 21 May 1979, when maximum value of the 10 min mean speed at Utsira, was 31 m/s, and the probable value at Stord was 24 m/s.

TABLE 1. EXTREMES OF 10 MIN. MEAN WIND FOR 8 DIRECTIONS AND 2 SEASONS FOR UTSIRA
 THE VALUE 0.0 MEANS THAT NO VALUE GREATER THAN = 10 M/S IS FOUND.
 UNIT: M/S.

YEAR	SEPTEMBER - APRIL								MAY - AUGUST								MAX-WINT.	MAX-SUM.
	N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW		
1962-1963	21.0	16.5	15.8	25.8	24.5	25.5	26.7	19.0	13.3	11.0	0.0	21.0	21.0	11.0	16.0	18.7	26.7	21.0
1963-1964	25.0	18.3	18.5	20.3	25.5	28.5	27.5	23.5	15.0	0.0	14.0	17.5	16.5	21.0	22.5	21.5	28.5	22.5
1964-1965	29.0	13.3	14.5	28.3	26.0	19.0	29.5	15.0	16.7	16.7	18.3	17.0	16.0	15.5	14.0	17.5	29.5	18.3
1965-1966	23.3	18.5	20.0	22.5	20.0	20.0	26.0	23.0	19.0	10.0	18.3	18.3	21.0	13.3	0.0	23.0	26.0	23.0
1966-1967	19.5	22.5	16.0	25.0	27.5	25.0	22.5	22.5	15.5	0.0	15.8	16.0	17.5	21.5	15.5	14.0	27.5	21.5
1967-1968	30.6	18.5	14.0	25.0	23.0	19.0	26.7	26.7	16.1	0.0	11.7	14.6	19.0	13.6	15.1	13.6	30.6	19.0
1968-1969	23.3	13.0	17.0	23.5	23.5	20.5	20.5	19.5	20.0	9.5	11.5	16.0	17.5	13.3	14.5	17.5	23.5	20.0
1969-1970	30.0	20.0	20.0	25.0	25.5	22.5	30.0	33.0	20.0	0.0	18.3	16.5	19.3	15.0	18.3	22.5	33.0	22.5
1970-1971	26.7	12.5	22.5	27.5	22.0	23.3	24.0	26.7	16.7	13.0	14.5	15.0	16.7	15.5	14.0	21.0	27.5	21.0
1971-1972	17.5	16.7	22.5	26.7	21.7	27.0	29.0	23.5	17.4	0.0	0.0	17.4	15.0	0.0	0.0	0.0	29.0	17.4
1972-1973	21.7	15.0	11.7	19.0	26.0	25.0	29.0	21.0	19.0	0.0	11.7	15.7	22.5	26.0	27.5	17.8	29.0	27.5
1973-1974	31.5	17.5	19.0	30.0	23.3	21.0	22.5	27.5	17.0	0.0	0.0	15.0	20.0	13.5	14.0	13.0	31.5	20.0
1974-1975	23.3	14.0	12.5	25.0	26.7	23.3	25.0	30.0	22.0	0.0	0.0	13.3	16.5	14.0	12.5	21.0	30.0	22.0
1975-1976	29.0	17.5	13.0	23.3	24.0	23.5	26.5	30.0	19.0	0.0	0.0	15.0	18.3	0.0	19.0	20.0	30.0	20.0
1976-1977	23.5	17.0	18.3	31.5	23.3	16.7	20.0	20.0	21.0	14.0	0.0	13.0	14.0	0.0	0.0	14.5	31.5	21.0
1977-1978	20.0	17.0	19.0	24.5	23.0	19.0	26.0	28.3	18.3	0.0	0.0	0.0	16.5	0.0	16.0	16.0	28.3	18.3
1978-1979	21.6	17.0	15.4	19.3	25.5	25.7	28.0	24.4	20.1	0.0	12.6	21.6	30.9	18.5	16.5	16.7	28.0	30.9
1979-1980	24.4	11.1	21.1	27.8	28.6	25.2	21.9	31.6	24.2	0.0	15.9	11.8	18.5	11.1	18.5	18.3	31.6	24.2
1980-1981	27.5	16.2	15.9	20.6	26.8	19.5	29.3	31.9	18.5	0.0	16.5	15.4	17.7	12.3	19.3	12.9	31.9	19.3
1981-1982	28.6	12.9	19.5	27.8	26.5	19.3	21.6	32.4	16.7	18.8	15.2	21.3	17.2	21.6	22.9	18.0	32.4	22.9
1982-1983	14.1	22.1	24.4	27.3	27.3	27.0	23.9	28.6	16.2	0.0	15.9	18.3	14.4	14.1	11.3	14.1	28.6	18.3
1983-1984	23.7	18.8	19.5	30.6	24.7	27.3	30.9	27.8	21.1	0.0	0.0	0.0	11.1	0.0	0.0	15.2	30.9	21.1
1984-1985	25.7	18.5	12.3	22.6	23.7	23.7	21.6	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.7	0.0
NO. OF OBS.:	23	23	23	23	23	23	23	23	22	7	14	20	22	17	18	21	23	22
MEAN:	24.4	16.7	17.5	25.2	24.7	22.9	25.6	25.5	18.3	13.3	15.0	16.5	18.0	15.9	17.1	17.5	29.2	21.4
ST. DEV.:	4.40	2.95	3.55	3.48	2.11	3.31	3.31	4.95	2.56	3.49	2.45	2.67	3.85	4.27	4.08	3.18	2.38	3.12

TABLE 2. EXTREMES OF 10 MIN. MEAN WIND FD 8 DIRECTIONS AND 2 SEASONS FOR UTSIRA
SORTED IN DECREASING ORDER. UNIT: M/S
0.0 MEANS MAXIMA LESS THAN 10 M/S.

	SEPTEMBER - APRIL								MAY - AUGUST								MAX-WINT.	MAX-SUM.
	N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW		
1	31.5	22.5	24.4	31.5	28.6	28.5	30.9	33.0	24.2	18.8	18.3	21.6	30.9	26.0	27.5	23.0	33.0	30.9
2	30.6	22.1	22.5	30.6	27.5	27.3	30.0	32.4	22.0	16.7	18.3	21.3	22.5	21.6	22.9	22.5	32.4	27.5
3	30.0	20.0	22.5	30.0	27.3	27.0	29.5	31.9	21.1	14.0	18.3	21.0	21.0	21.5	22.5	21.5	31.9	24.2
4	29.0	18.8	21.1	28.3	26.8	27.0	29.3	31.6	21.0	13.0	16.5	18.3	21.0	21.0	19.3	21.0	31.6	23.0
5	29.0	18.5	20.0	27.8	26.7	25.7	29.0	30.0	20.1	11.0	15.9	18.3	20.0	18.5	19.0	21.0	31.5	22.9
6	28.6	18.5	20.0	27.8	26.5	25.5	29.0	30.0	20.0	10.0	15.9	17.5	19.3	15.5	18.5	20.0	31.5	22.5
7	27.5	18.5	19.5	27.5	26.0	25.2	28.0	28.6	20.0	9.5	15.8	17.4	19.0	15.5	18.3	18.7	30.9	22.5
8	26.7	18.3	19.5	27.3	26.0	25.0	27.5	28.3	19.0	0.0	15.2	17.0	18.5	15.0	16.5	18.3	30.6	22.0
9	25.7	17.5	19.0	26.7	25.5	25.0	26.7	27.8	19.0	0.0	14.5	16.5	18.3	14.1	16.0	18.0	30.0	21.5
10	25.0	17.5	19.0	25.8	25.5	23.7	26.7	27.5	19.0	0.0	14.0	16.0	17.7	14.0	16.0	17.8	30.0	21.1
11	24.4	17.0	18.5	25.0	25.5	23.5	26.5	26.7	18.5	0.0	12.6	16.0	17.5	13.6	15.5	17.5	29.5	21.0
12	23.7	17.0	18.3	25.0	24.7	23.3	26.0	26.7	18.3	0.0	11.7	15.7	17.5	13.5	15.1	17.5	29.0	21.0
13	23.5	17.0	17.0	25.0	24.5	23.3	26.0	24.4	17.4	0.0	11.7	15.4	17.2	13.3	14.5	16.7	29.0	21.0
14	23.3	16.7	16.0	25.0	24.0	22.5	25.0	23.5	17.0	0.0	11.5	15.0	16.7	13.3	14.0	16.0	28.6	20.0
15	23.3	16.5	15.9	24.5	23.7	21.0	24.0	23.5	16.7	0.0	0.0	15.0	16.5	12.3	14.0	15.2	28.5	20.0
16	23.3	16.2	15.8	23.5	23.5	20.5	23.9	23.0	16.7	0.0	0.0	15.0	16.5	11.1	14.0	14.5	28.3	20.0
17	21.7	15.0	15.4	23.3	23.3	20.0	22.5	22.5	16.7	0.0	0.0	14.6	16.5	11.0	12.5	14.1	28.0	19.3
18	21.6	14.0	14.5	22.6	23.3	19.5	22.5	21.0	16.2	0.0	0.0	13.3	16.0	0.0	11.3	14.0	27.5	19.0
19	21.0	13.3	14.0	22.5	23.0	19.3	21.9	20.6	16.1	0.0	0.0	13.0	15.0	0.0	0.0	13.6	27.5	18.3
20	20.0	13.0	13.0	20.6	23.0	19.0	21.6	20.0	15.5	0.0	0.0	11.8	14.4	0.0	0.0	13.0	26.7	18.3
21	19.5	12.9	12.5	20.3	22.0	19.0	21.6	19.5	15.0	0.0	0.0	0.0	14.0	0.0	0.0	12.9	26.0	18.3
22	17.5	12.5	12.3	19.3	21.7	19.0	20.5	19.0	13.3	0.0	0.0	0.0	11.1	0.0	0.0	0.0	25.7	17.4
23	14.1	11.1	11.7	19.0	20.0	16.7	20.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5	0.0

MEANS OF THE 5 HIGHEST VALUES:

30.0 20.4 22.1 29.6 27.4 27.1 29.7 31.8 21.7 14.7 17.5 20.1 23.1 21.7 22.2 21.8

RELATIVE TO THE STRONGEST SECTOR:

0.94 0.64 0.70 0.93 0.86 0.85 0.94 1.00 0.94 0.64 0.76 0.87 1.00 0.94 0.96 0.94

TABLE 3. EXTREME WIND SPEEDS FOR UTSIRA LIGHTHOUSE

The extremes for the 8 different sectors are calculated according to the following procedure:

- Return period 2 and 5 years - 50 and 20 percentiles of 23 years of data.
- Return periods 10 years or more - the extreme value for all directions calculated according to Gumbel's 1. distributions of extremes are fixed to the most wind exposed sector. For the other sectors, this value are weighted after the average of the 5 highest recorded speeds of each sector.

Unit: m/s.

Return periode (years)	SEPTEMBER - APRIL								MAY - AUGUST								All directions	
	N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW	Winter	Summer
	10 MIN. MEAN WIND SPEEDS																	
2	24	17	18	25	25	23	26	27	18	8	12	16	18	14	15	18	29	21
5	29	19	21	28	27	26	29	31	21	12	16	18	21	20	19	21	32	23
10	31	21	23	31	28	28	31	33	25	17	20	23	26	25	25	25	33	26
50	34	23	26	34	31	31	34	37	29	20	24	27	31	29	30	29	37	31
100	36	24	27	36	33	32	36	38	31	21	25	29	33	31	32	31	38	33

TABLE 4. EXTREME VALUES OF 10 MIN. MEAN WIND SPEED FOR 8 SECTORS AND ALL DIRECTION, WINTER AND SUMMER AT DIGERNESSUNDET, STORD. THE SECTORS ARE REFERRED TO UTSIRA AND VEERED TO REPRESENT THE CONDITIONS IN DIGERNESSUNDET. UNIT: M/S.

		SEPTEMBER - APRIL								MAY - AUGUST									
Direction UTSIRA:		N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW	All directions	
Direction STORD:		W-NW	N-NE	NE	E	SE-S	S-SW	SW	W	W-NW	N-NE	NE	E	SE-S	S-SW	SW	W	Wint.	Sum.
Return period:																			
	2	10	9	13	13	20	18	21	16	7	4	8	8	14	11	12	11	21	14
	5	12	10	15	14	22	21	23	19	8	6	11	10	17	16	15	13	23	17
	10	13	11	16	16	23	23	25	20	10	9	14	12	21	20	20	15	25	21
	50	14	12	18	17	25	25	27	22	12	10	17	14	24	23	23	17	27	24
	100	15	13	19	18	26	26	29	23	13	11	18	15	26	25	26	19	29	26

TABLE 5. EXTREME VALUES OF 3-5 S. GUST WIND SPEED FOR 8 SECTORS AND ALL DIRECTION, WINTER AND SUMMER AT DIGERNESSUNDET, STORD. THE SECTORS ARE REFERRED TO UTSIRA AND VEERED TO REPRESENT THE CONDITIONS IN DIGERNESSUNDET. UNIT: M/S.

		SEPTEMBER - APRIL								MAY - AUGUST									
Direction UTSIRA:		N	NE	E	SE	S	SW	W	NW	N	NE	E	SE	S	SW	W	NW	All directions	
Direction STORD:		W-NW	N-NE	NE	E	SE-S	S-SW	SW	W	W-NW	N-NE	NE	E	SE-S	S-SW	SW	W	Wint.	Sum.
Return period:																			
	2	19	18	23	29	30	25	34	29	13	8	14	18	21	15	19	20	34	21
	5	22	20	26	32	33	29	37	33	16	12	20	21	26	22	24	23	37	26
	10	25	22	29	34	35	32	40	36	19	17	25	26	32	28	32	27	40	32
	50	27	24	32	37	38	35	43	39	22	20	31	31	38	32	38	31	43	38
	100	29	26	34	40	39	36	46	41	25	22	32	33	39	35	42	34	46	42