Maurneset – Wind energy study

-estimated production with turbine SWT – 2.3-113

StormGeo for Vindkraft Nord

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Oslo (Bergen), 11.05.11

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This report includes data with estimates of production with the turbine SWT-2.3-113, and also some comparison with the turbine SWT-3.0-101.

The estimates show a large increase in estimated production using the turbine SWT-2.3-113, around 15-20%.

For extensive interpretation of the data, see earlier report.

SWT 2.3MW-113 turbines/ SWT 3.0MW-101 turbines

	P50	P75	P90	P99
Net energy (REG)	**32902**/ 28334	**29968**/ 25266	**27859**/ 23680	**23765**/ 20227
Net energy (GEV)	**31860**/ 27692	**28793**/ 24734	**26361**/ 23350	**22572**/ 19684
Net energy (REG)	+16%	+19%	+18%	+17%
Net energy (GEV)	+15%	+16%	+13%	+15%

Park layout - Siemens SWT 2.3MW-113 turbines - 100 m hubheight

Long term correlated data : Linear regression method

Long term correlated data : GEV correlation method

Verification summary

Estimated yearly gross energy procuction with Siemens SWT 2.3MW-113 turbines

	P99	P90	P75	P50
MWh/year (REG)	26406	30954	33298	36557
MWh/year (GEV)	25080	29290	31993	35400

Estimated yearly net energy procuction with Siemens SWT 2.3MW-113 turbines

	P99	P90	P75	P50
MWh/year (REG)	23765	27859	29968	32902
MWh/year (GEV)	22572	26361	28793	31860

Parameter explanation

	Explanation
AEP1	Annual energy production (MWh/yr) calculated from weibull distribution
AEP2	Annual energy production (MWh/yr) calculated from hourly wind data
AEP3	Annual energy production (MWh/yr) calculated from hourly wind data, density corrected
AEP1_c	As AEP1, but based on long term corrected data (averaged over ERA INTERIM period)
AEP2_c	As AEP2, but based on long term corrected data (averaged over ERA INTERIM period)
AEP3_c	As AEP3, but based on long term corrected data (averaged over ERA INTERIM period)
lambda	Weibull distribution scale parameter (for WRF data)
k	Weibull distribution shape parameter (for WRF data)
lambda_c	Weibull distribution scale parameter (for long term corrected data)
k_c	Weibull distribution shape parameter (for long term corrected data)
MEAN	Wind speed mean (for WRF data)
MEAN_c	Wind speed mean (after long term correction)
Part_down	Part of the year with to much or to less wind to produce energy

Estimated procuction from hindcast period with Siemens SWT 2.3MW-113 turbines

	AEP1	AEP2	AEP3
Gross	33756	33525	34055
Net	30381	30172	30650

Estimated procuction from year to year with Siemens SWT 2.3MW-113 turbines - USING LINEAR REGRESSION

	Year	AEP1_c	AEP2_c	AEP3_c
1	1989	34350	33694	34375
2	1990	36707	36100	36773
3	1991	34095	33594	34338
4	1992	34784	34275	35067
5	1993	34472	33577	34320
6	1994	31661	31450	32255
7	1995	33502	33135	33948
8	1996	30209	29999	30846
9	1997	32814	32197	32925
10	1998	32651	32427	33369
11	1999	31701	31310	32003
12	2000	31353	31189	31936
13	2001	31445	31084	31823
14	2002	27654	27511	28219
15	2003	28812	28601	29332
16	2004	30506	30392	31151
17	2005	33459	33259	34031
18	2006	33601	33299	34050
19	2007	33114	32813	33561
20	2008	29931	29639	30405
21	2009	31389	31248	32130

Estimated production from year to year with Siemens SWT 2.3MW-113 turbines - USING GEV CORRELATION

	Year	AEP1_c	AEP2_c	AEP3_c
1	1989	33801	32479	33054
2	1990	35825	35293	35798
3	1991	33369	32596	33185
4	1992	34316	33304	33911
5	1993	33931	32332	32927
6	1994	30758	30313	30966
7	1995	32657	32112	32725
8	1996	29339	28303	28930
9	1997	32323	30813	31383
10	1998	31809	31667	32437
11	1999	30485	29857	30395
12	2000	30859	30776	31342
13	2001	30395	30040	30587
14	2002	26826	26271	26842
15	2003	28017	27172	27742
16	2004	30132	29751	30378
17	2005	32782	32881	33497
18	2006	33328	32682	33251
19	2007	32357	31964	32545
20	2008	29255	28745	29401
21	2009	30552	30553	31262

AEP percentile results for each location with Siemens SWT 2.3MW-113 turbines (MWh/year) - USING LINEAR REGRESSION

	P99	P90	P75	P50
Turbine 1	6495	7235	7786	8130
Turbine 2	6687	7412	7973	8309
Turbine 3	6734	7452	8008	8354
Turbine 4	6489	7226	7778	8108

AEP percentile results for each location with Siemens SWT 2.3MW-113 turbines (MWh/year) - USING GEV CORRELATION

	P99	P90	P75	P50
Turbine 1	6138	6814	7446	7831
Turbine 2	6340	7001	7642	8034
Turbine 3	6422	7086	7728	8109
Turbine 4	6179	6847	7494	7886

Wind data for last available year (REG) - 2010-02-01 00:00:00 to 2011-02-01 00:00:00

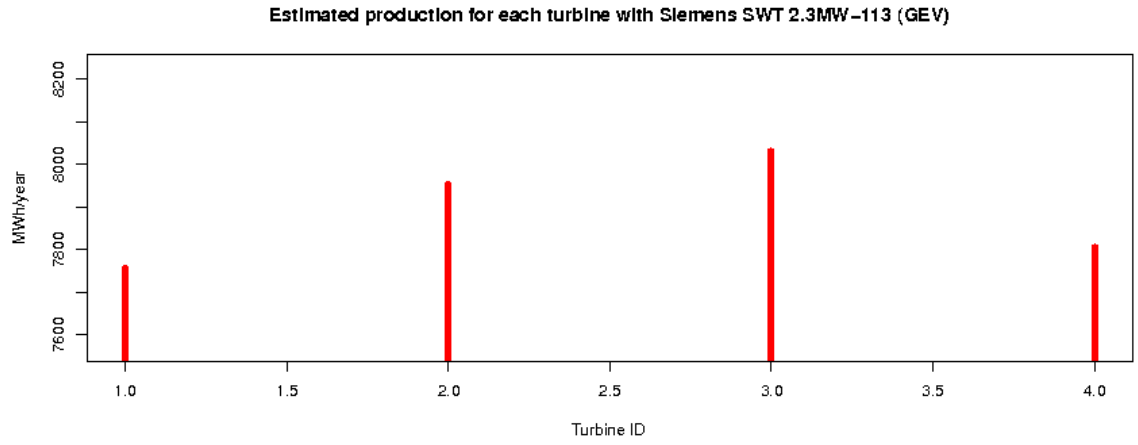
	lambda	k	MEAN
Turbine 1	6.960	2.006	6.298
Turbine 2	7.099	2.032	6.417
Turbine 3	7.112	2.058	6.440
Turbine 4	6.974	2.019	6.319

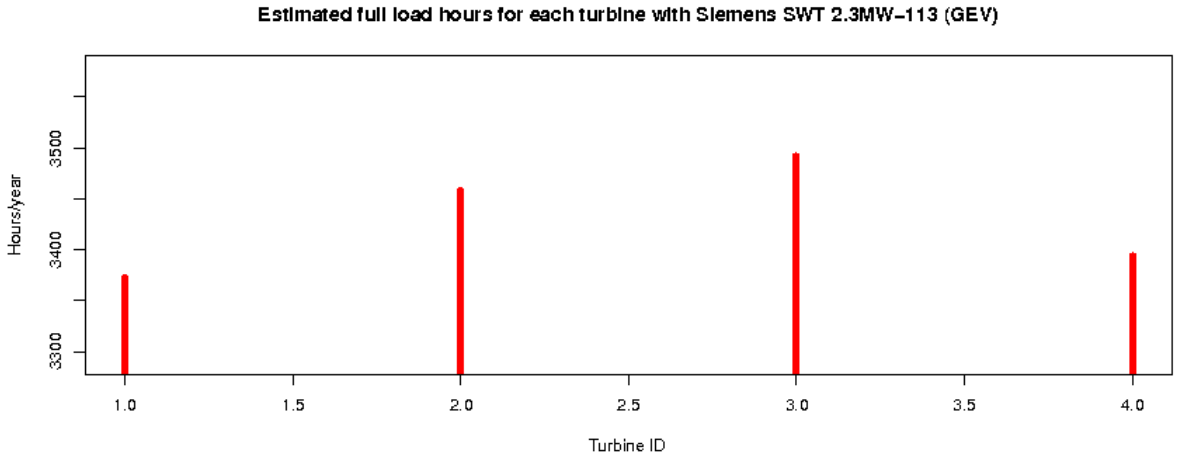
Wind data for last available year (GEV) - 2010-02-01 00:00:00 to 2011-02-01 00:00:00

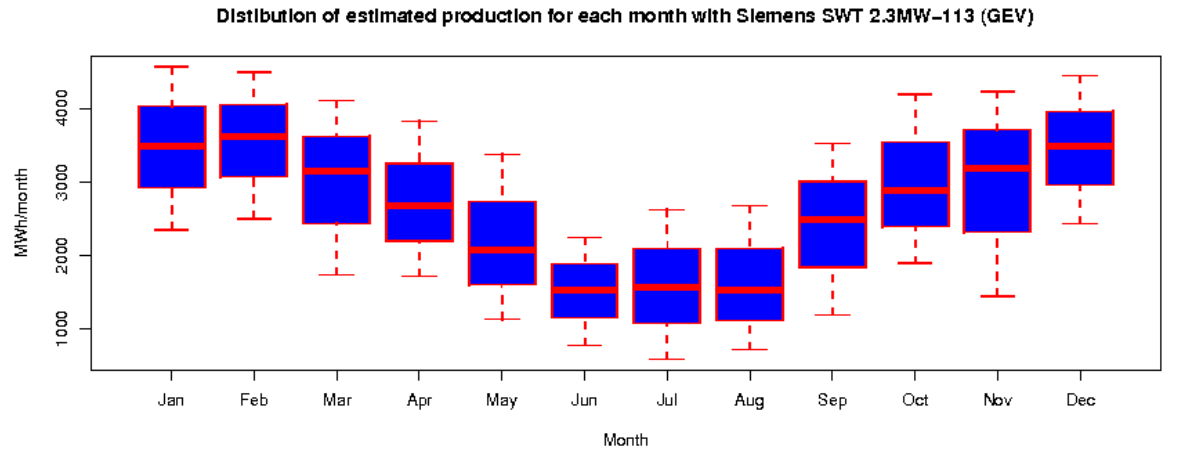
	lambda	k	MEAN
Turbine 1	6.869	1.441	6.237
Turbine 2	7.005	1.465	6.355
Turbine 3	7.034	1.456	6.345
Turbine 4	6.882	1.449	6.217

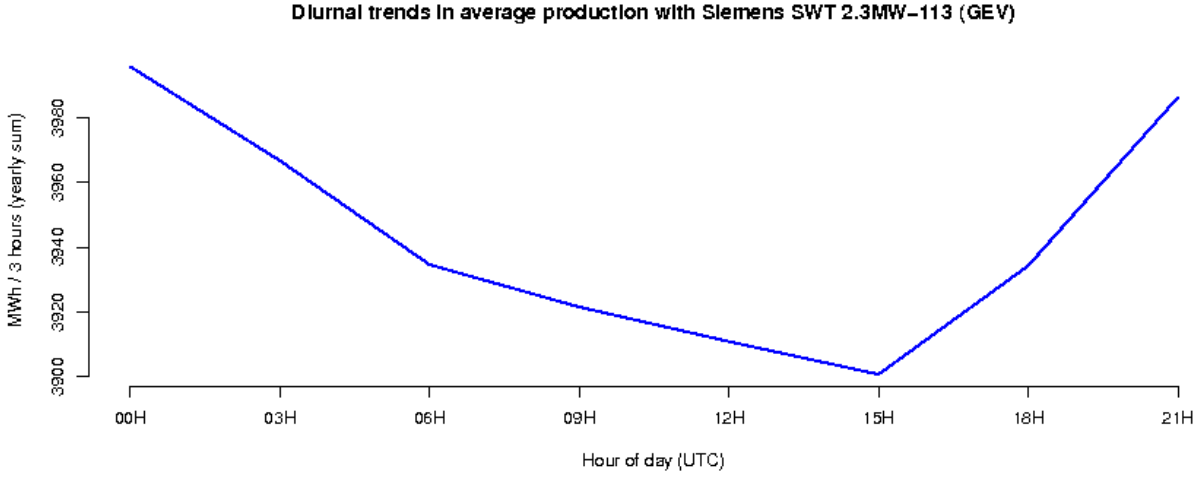
Coordinates for each turbine location

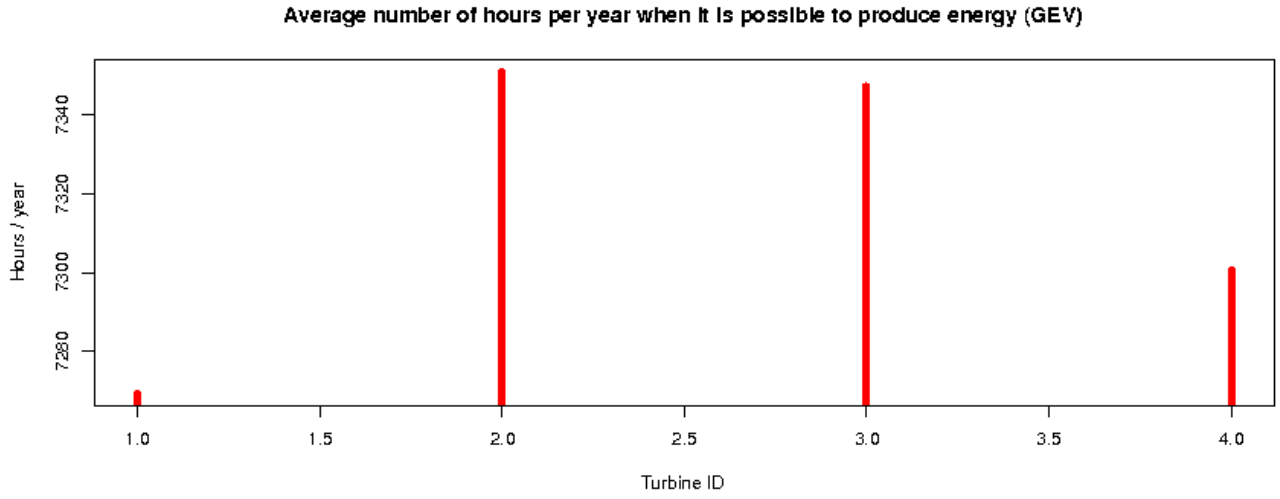
	Lon	Lat	Altitude
Turbine 1	21.0577	69.9551	150
Turbine 2	21.0646	69.9530	95
Turbine 3	21.0480	69.9536	105
Turbine 4	21.0569	69.9488	90



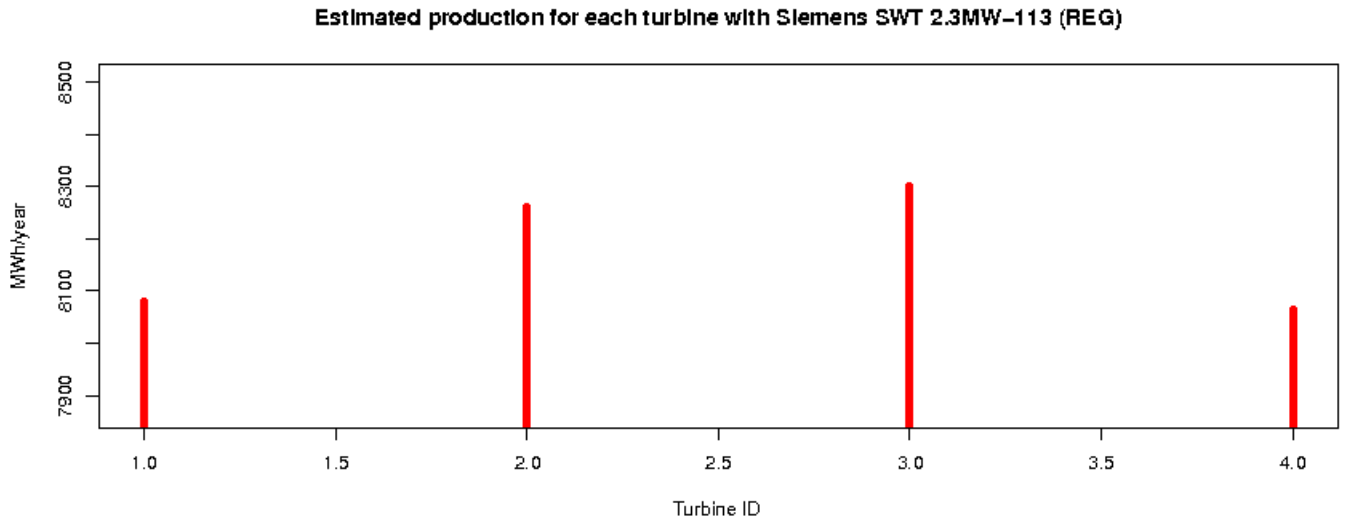

Estimated full load hours for each turbine with Siemens SWT 2.3MW–113 (GEV)
Hours/year
3300
3400
3500
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Turbine ID

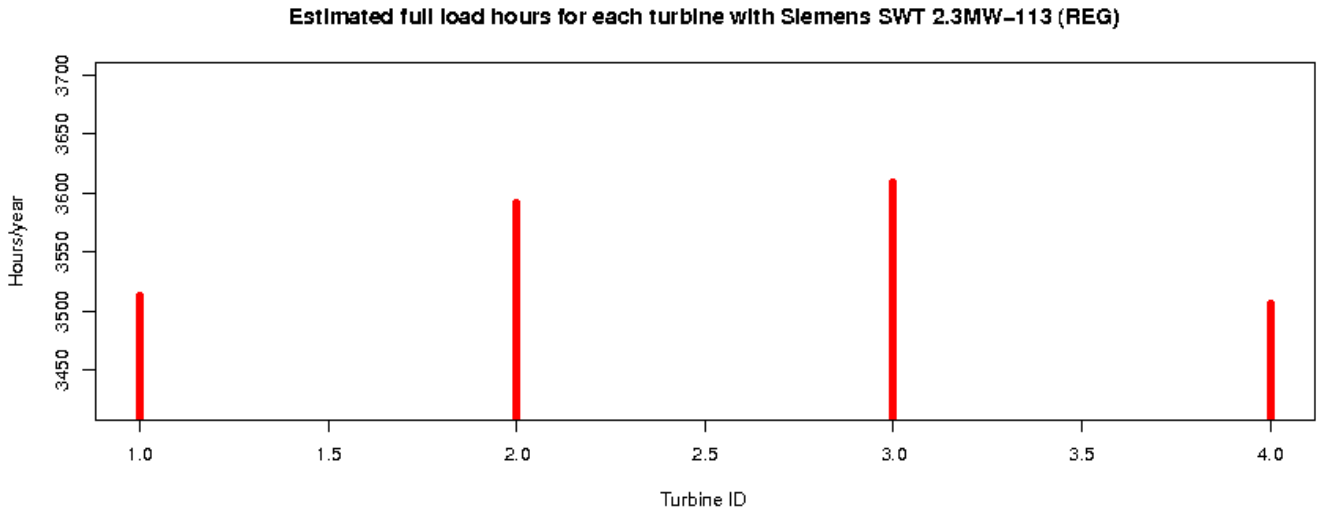

Distibution of estimated production for each month with Siemens SWT 2.3MW–113 (GEV)
MWh/month
1000
2000
3000
4000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

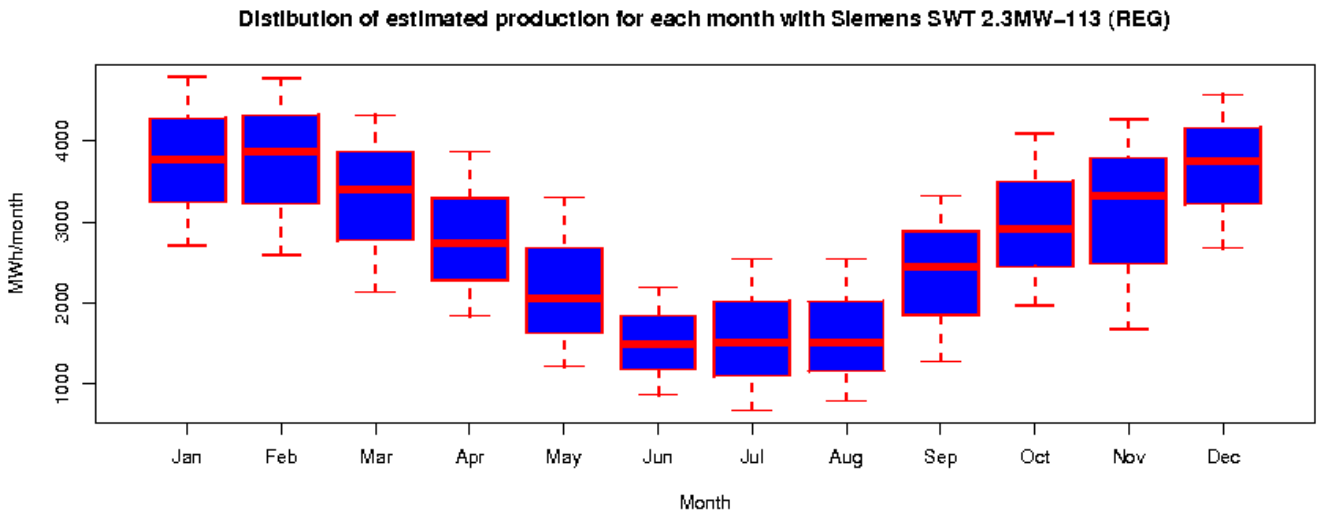

Diurnal trends in average production with Siemens SWT 2.3MW–113 (GEV)
MWh / 3 hours (yearly sum)
3900
3920
3940
3960
3980
00H
03H
06H
09H
12H
15H
18H
21H
Hour of day (UTC)

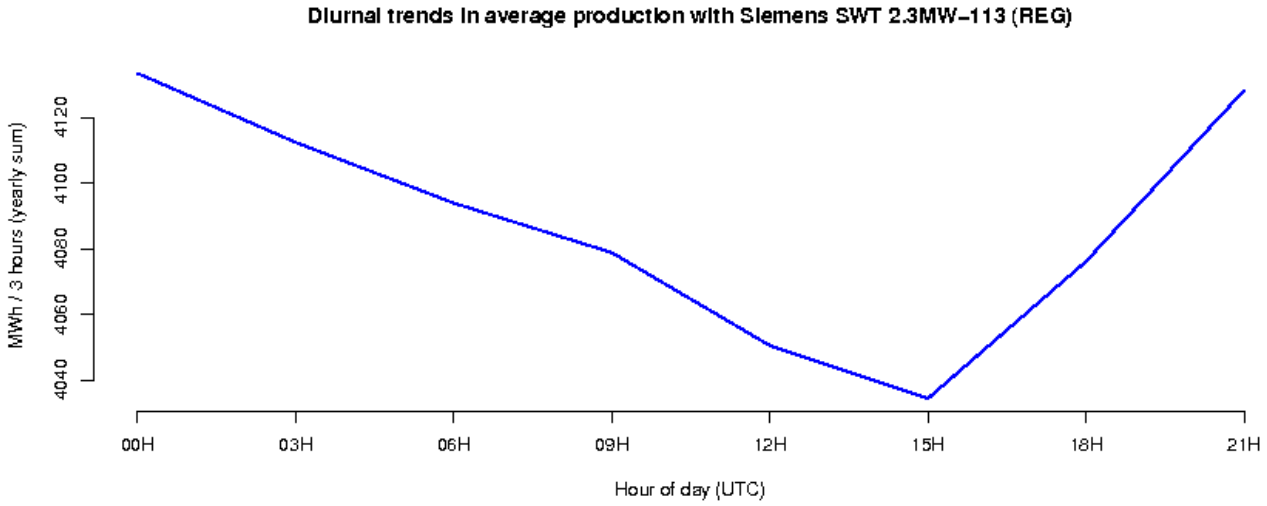

Average number of hours per year when it is possible to produce energy (GEV)
Hours / year
7280
7300
7320
7340
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Turbine ID

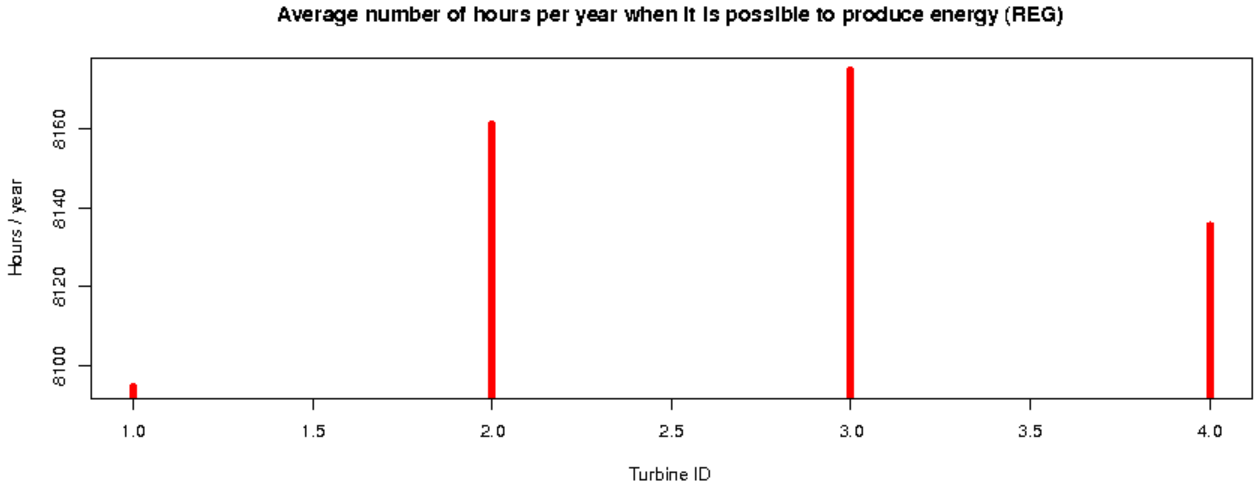

Yearly estimated total production (REG)
GWh/year
28
30
32
34
36
38
1990
1995
2000
2005
Year

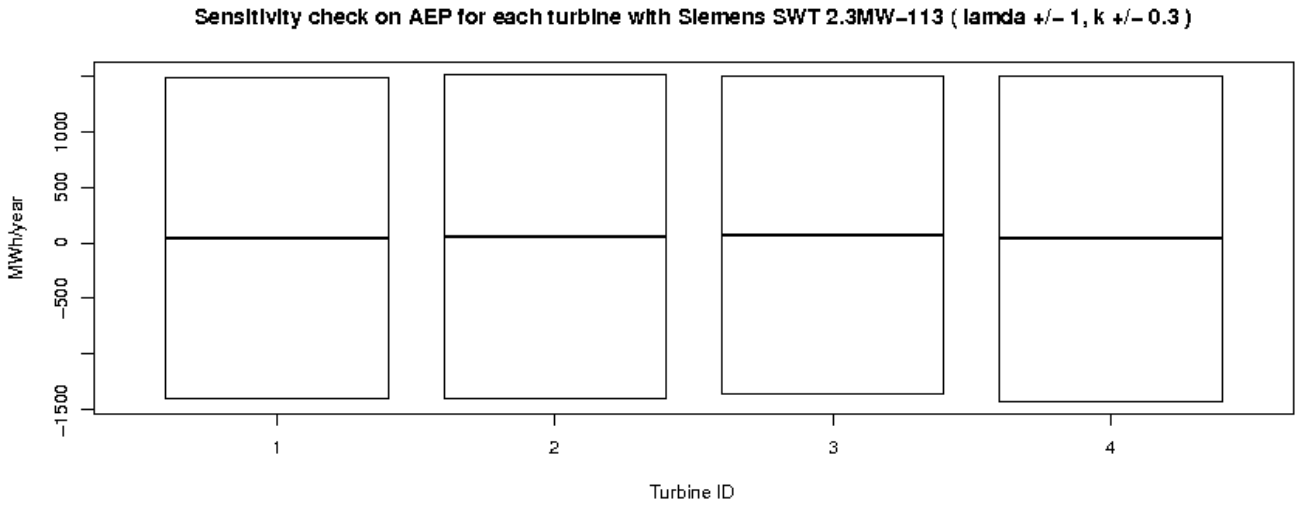

Estimated production for each turbine with Siemens SWT 2.3MW-113 (REG)
MWh/year
7900
8100
8300
8500
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Turbine ID

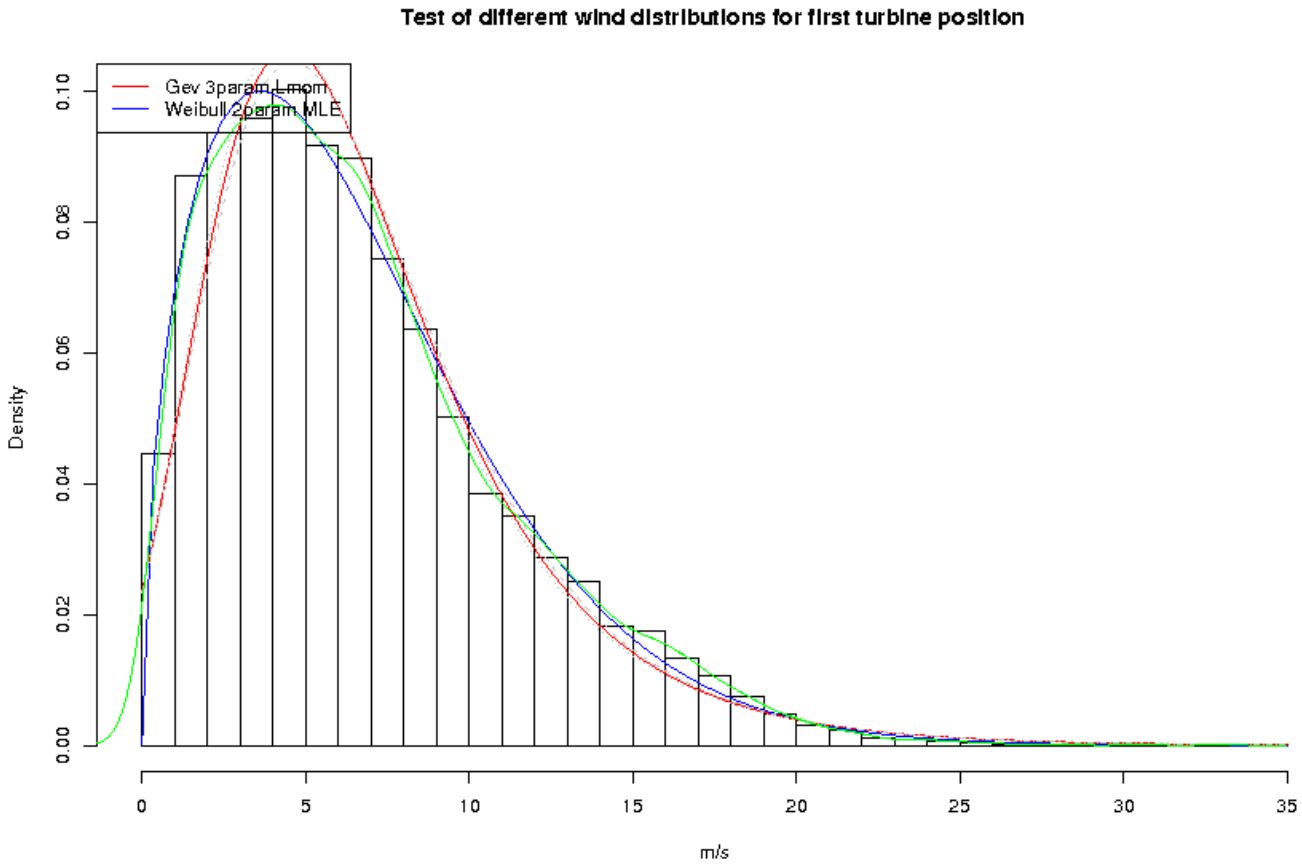

Estimated full load hours for each turbine with Siemens SWT 2.3MW-113 (REG)
Hours/year
3450
3500
3550
3600
3650
3700
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Turbine ID

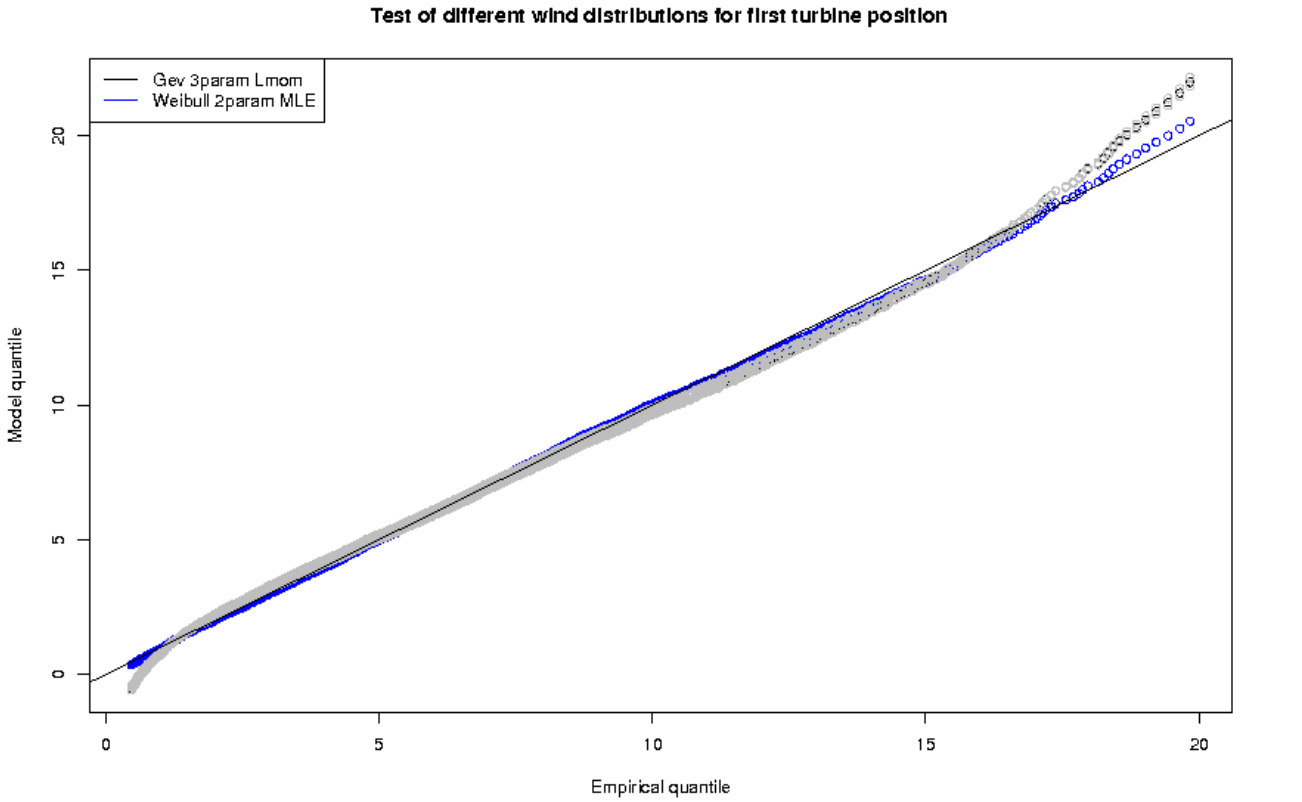

Distibution of estimated production for each month with Siemens SWT 2.3MW-113 (REG)
MWh/month
1000
2000
3000
4000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

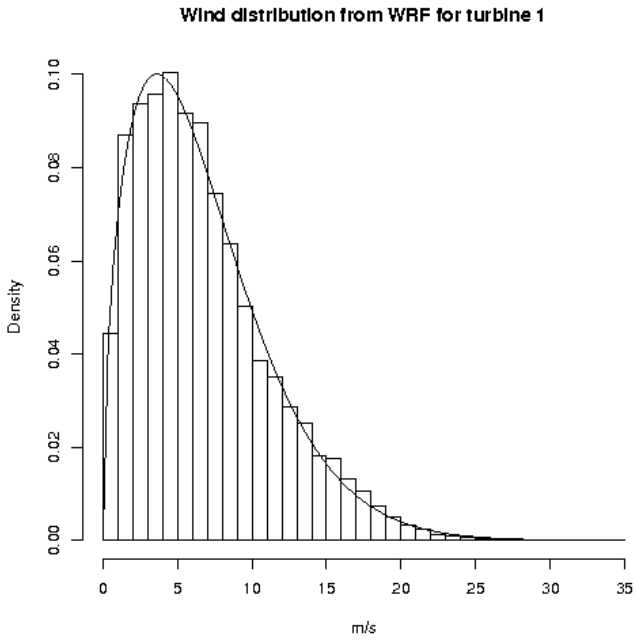

Diurnal trends in average production with Siemens SWT 2.3MW-113 (REG)
MWh / 3 hours (yearly sum)
4040
4060
4080
4100
4120
00H
03H
06H
09H
12H
15H
18H
21H
Hour of day (UTC)

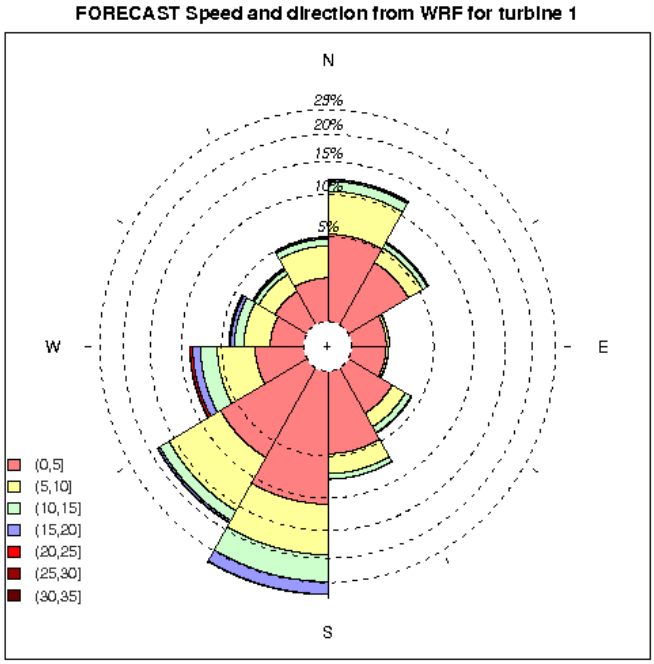

Average number of hours per year when it is possible to produce energy (REG)
Hours / year
8100
8120
8140
8160
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Turbine ID

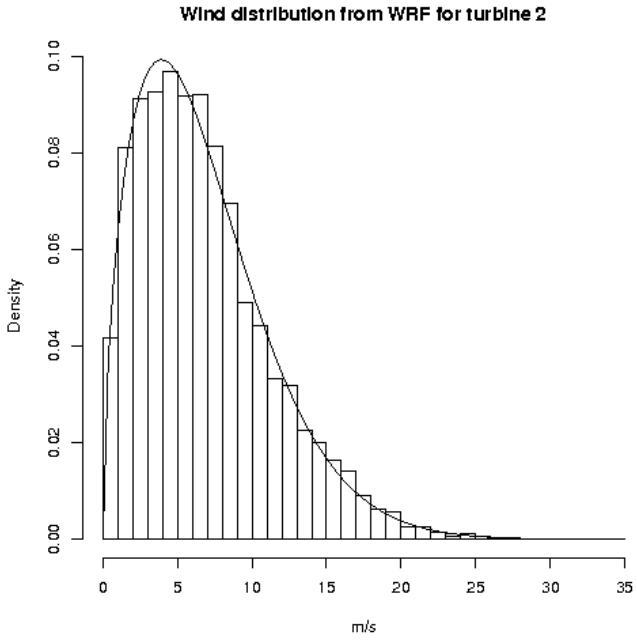

Sensitivity check on AEP for each turbine with Siemens SWT 2.3MW-113 (lamda +/- 1, k +/- 0.3)
MWh/year
−1500
−500
0
500
1000
1
2
3
4
Turbine ID

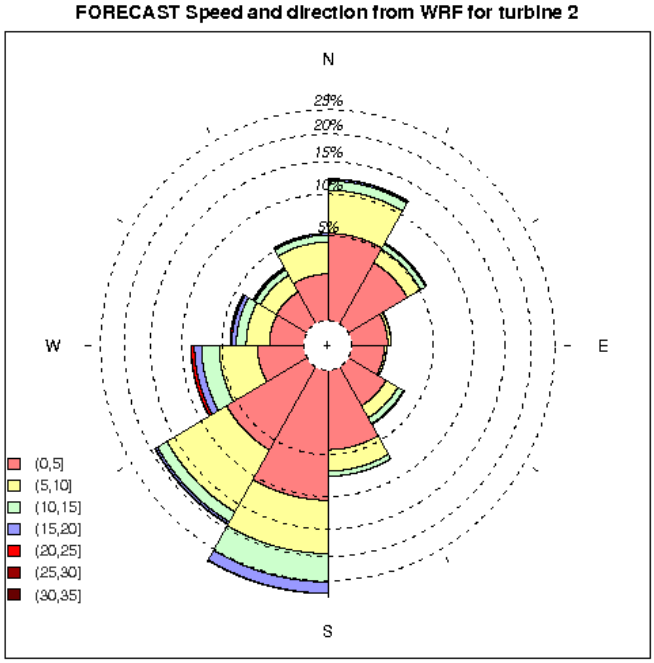

Test of different wind distributions for first turbine position
Gev 3param Lmom
Weibull 2param MLE
Density
0.00
0.02
0.04
0.06
0.08
0.10
0
5
10
15
20
25
30
35
m/s

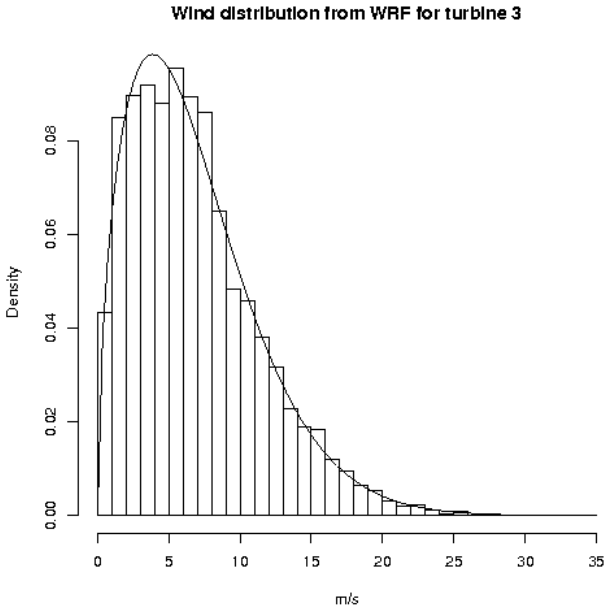

Test of different wind distributions for first turbine position
Gev 3param Lmom
Weibull 2param MLE
Model quantile
0
5
10
15
20
Empirical quantile

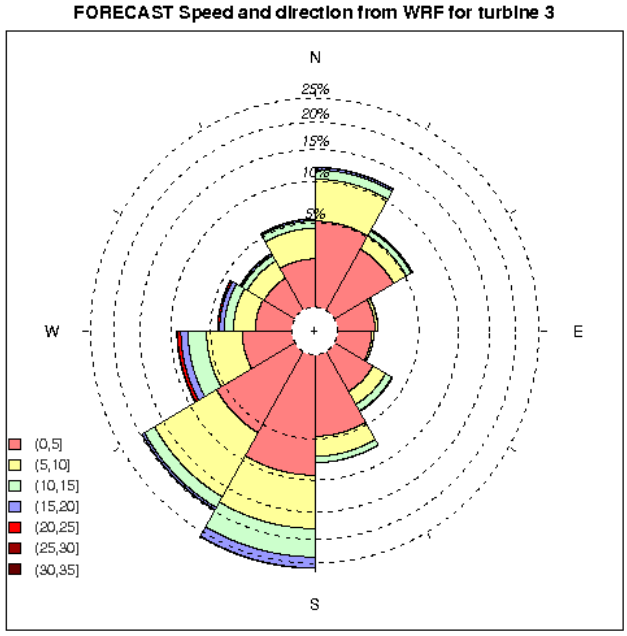

Wind distribution from WRF for turbine 1
Density
0.00
0.02
0.04
0.06
0.08
0.10
0
5
10
15
20
25
30
35
m/s

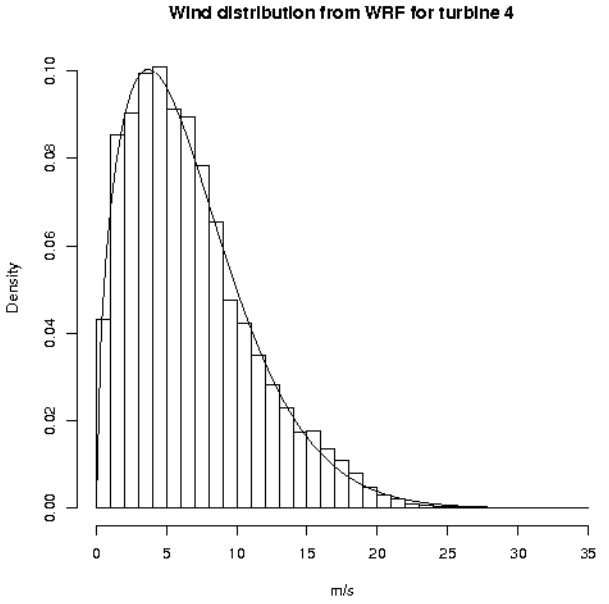

FORECAST Speed and direction from WRF for turbine 1
N
E
S
W
25%
20%
15%
10%
5%
(0,5]
(5,10]
(10,15]
(15,20]
(20,25]
(25,30]
(30,35]

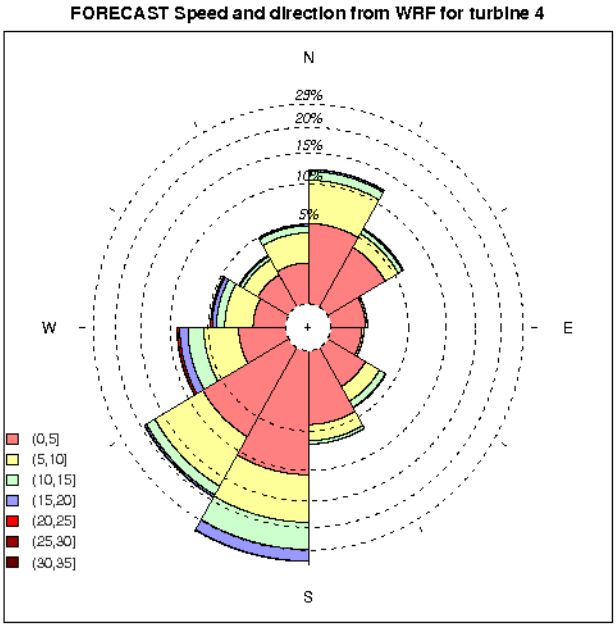

Wind distribution from WRF for turbine 2
Density
0.00
0.02
0.04
0.06
0.08
0.10
0
5
10
15
20
25
30
35
m/s


FORECAST Speed and direction from WRF for turbine 2
N
E
S
W
25%
20%
15%
10%
5%
(0,5]
(5,10]
(10,15]
(15,20]
(20,25]
(25,30]
(30,35]


Wind distribution from WRF for turbine 3
Density
0.00
0.02
0.04
0.06
0.08
0
5
10
15
20
25
30
35
m/s


FORECAST Speed and direction from WRF for turbine 3
N
E
S
W
5%
10%
15%
20%
25%
(0,5]
(5,10]
(10,15]
(15,20]
(20,25]
(25,30]
(30,35]


Wind distribution from WRF for turbine 4
Density
0.00
0.02
0.04
0.06
0.08
0.10
0
5
10
15
20
25
30
35
m/s


FORECAST Speed and direction from WRF for turbine 4
N
E
S
W
5%
10%
15%
20%
25%
(0,5]
(5,10]
(10,15]
(15,20]
(20,25]
(25,30]
(30,35]