

Project:

Wind Resource Map Hiiumaa

Description:

Calculation are based on local wind statistic based on 8 month measurements long term corrected with a factor 1.15 based partly on NCAR data, partly on the WTG production data.

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Energi- og Miljødata

Niels Jernesvej 10

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Tlf.: 9635 4444

Per Nielsen

Calculated:

26-03-2002 16:44/2.3.0.0

WASP interface - Main Result

Calculation: 150 kW WTG at Tahkuna

Name WASP Calc Tahkuna
Site Coordinates Local East: 418,915 North: 6,550,965
Air density 1.270 kg/m³

Calculation is based on "WASP Calc Tahkuna", using WASP (WASP5XL 16-12-1998 13:40) to convert the wind statistics and the terrain classification to a site specific wind speed distribution. Using the selected power curve, the expected annual energy production is calculated.

Wind statistics EE 18,0 m Hiiumaa_Tuula_long termcorrected.

Regional Correction Factor 1.15

Based on NCAR-data and existing WTG production indicates 80-88 % of nergy level in measure period, 87% is chosen - this gives 1,15 in correction factor.



Scale 1:50,000

Site Data

Terrain classification

Sector	Roughness classification (Roughness class)											
	Roughness at WTG	Distance to 1. change	Roughness after 1. change	Distance to 2. change	Roughness after 2. change	Distance to 3. change	Roughness after 3. change	D 4	R 4	D 5	R 5	
	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]	
0 N	2.8	244	0.0									
1 NNE	2.7	209	0.0									
2 ENE	2.8	170	0.0									
3 E	2.8	171	0.0									
4 ESE	2.8	204	0.6	681	2.8	1,425	1.0	2,300	2.8	6,713	0.0	
5 SSE	2.8	9,469	2.0	12,444	2.9	15,252	2.3	27,633	1.1			
6 S	2.8	575	2.0	975	2.5	6,711	2.7	26,007	1.8			
7 SSW	2.6	182	0.0	8,853	1.0	20,753	0.7	21,868	2.4	25,384	0.0	
8 WSW	2.7	120	0.0									
9 W	2.8	111	0.0									
10 WNW	2.7	119	0.0									
11 NNW	2.6	180	0.0									

Calculation Results

Key results for height 50.0 m above ground level

Wind energy: 4,063 kWh/m²; Mean wind speed: 7.1 m/s; Mean roughness: 0.6

Key results for height 40.0 m above ground level

Wind energy: 3,735 kWh/m²; Mean wind speed: 6.9 m/s; Mean roughness: 0.6

Calculated Annual Energy

WTG type		Power curve					Annual Energy			
Valid	Manufact.	Type	Power	Diam.	Height	Creator	Name	Result	Result-10%	Mean wind speed
			[kW]	[m]	[m]			[MWh]	[MWh]	[m/s]
No	VIND-SYSSEL		150	21.8	30.0	EMD	Tripod Jerlsev 86	339.5	306	6.5

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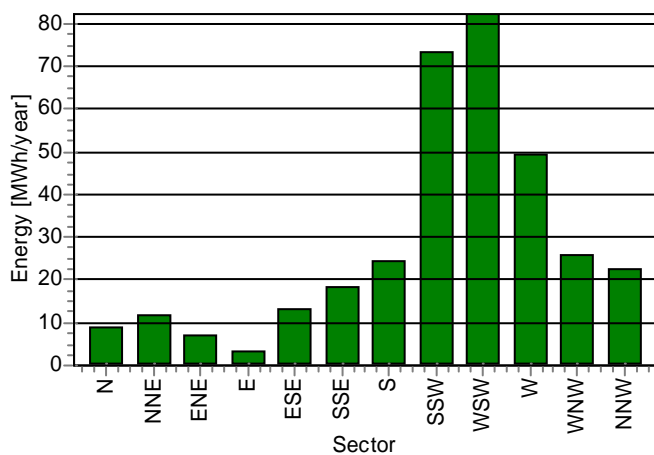
WASP interface - Production Analysis

Calculation: 150 kW WTG at Tahkuna **WTG:** VIND-SYSSEL 150 21.8 !O!, Hub height: 30.0 m, Air density: 1.270 kg/m3

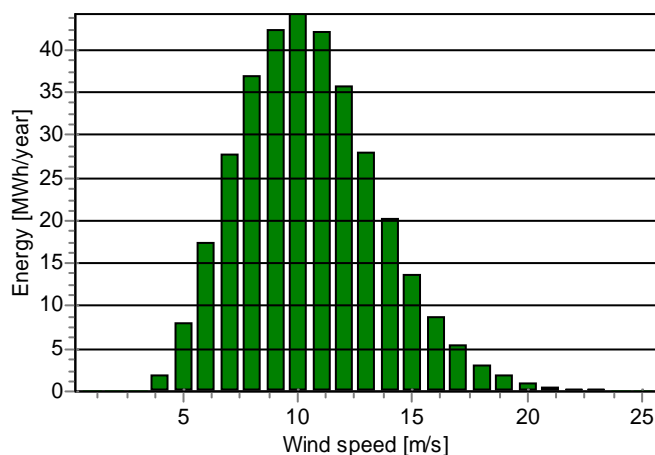
Directional Analysis

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	10.7	11.6	7.0	3.2	15.1	22.1	29.7	75.0	82.0	49.8	27.4	24.1	357.7
-Decrease due to obstacles	[MWh]	1.6	0.0	0.0	0.0	1.8	3.2	4.8	2.0	0.6	0.5	1.2	1.4	17.2
+Increase due to hills	[MWh]	-0.1	0.0	0.1	0.0	-0.3	-0.7	-0.6	0.2	0.8	0.2	-0.3	-0.4	-1.0
Resulting energy	[MWh]	9.0	11.6	7.1	3.1	13.0	18.2	24.3	73.2	82.2	49.5	25.9	22.3	339.5
Specific energy	[kWh/m2]													909
Specific energy	[kWh/kW]													2,263
Decrease due to obstacles	[%]	14.5	0.2	0.0	1.1	12.1	14.7	16.3	2.7	0.7	1.0	4.4	5.9	4.8
Increase due to hills	[%]	-1.4	0.4	1.4	0.6	-1.7	-3.0	-2.0	0.3	1.0	0.4	-1.1	-1.7	-0.3
Directional Distribution	[%]	2.7	3.4	2.1	0.9	3.8	5.4	7.2	21.6	24.2	14.6	7.6	6.6	100.0
Utilization	[%]	31.7	32.5	31.1	30.2	32.0	29.6	31.5	26.4	27.9	30.5	31.3	26.7	28.8
Operational	[Hours/year]	340	264	212	186	348	591	920	997	1,064	653	417	407	6,401
Full Load Equivalent	[Hours/year]	60	77	47	21	87	121	162	488	548	330	173	149	2,263
A- parameter	[m/s]	5.3	6.6	5.7	5.0	6.1	5.3	5.3	8.1	8.3	8.3	7.6	6.9	6.9
Mean wind speed	[m/s]	4.7	5.8	5.1	4.4	5.4	4.7	4.7	7.2	7.4	7.4	6.7	6.1	6.1
k- parameter		1.82	2.11	1.74	2.20	1.93	1.53	1.78	1.89	2.08	2.33	2.20	1.65	1.79
Frequency	[%]	5.3	4.1	3.3	2.9	5.4	9.2	14.4	15.6	16.6	10.2	6.5	6.4	100.0
Power density	[W/m2]													371

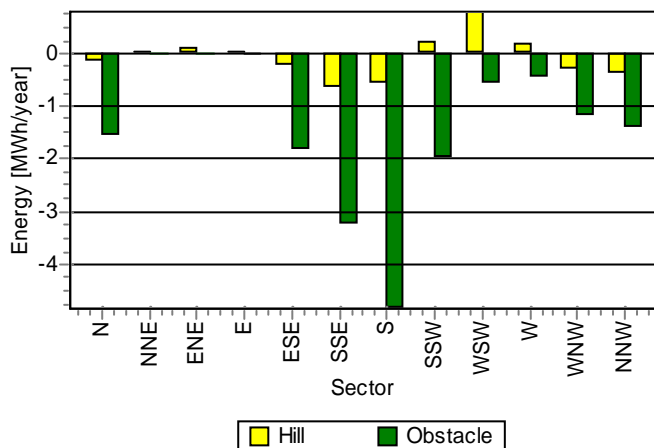
Energy vs. sector



Energy vs. wind speed



Impact of hills and obstacles vs. sector



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Per Nielsen

Calculated:

26-03-2002 16:44/2.3.0.0

WASP interface - Power Curve Analysis

Calculation: 150 kW WTG at Tahkuna WTG: VIND-SYSSEL 150 21.8 !O! Tripod Jerlsev 86 1.225 25.00 0.60, Hub height: 30.0 m

Name: Tripod Jerlsev 86 1.225 25.00 0.60

Source: Tripod Jerlsev 86

Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type
EMD	09-08-1996	15-11-2000	25.0	Stall	Standard stall

Power curve

Original data from Windcat, Air density: 1.225 kg/m3

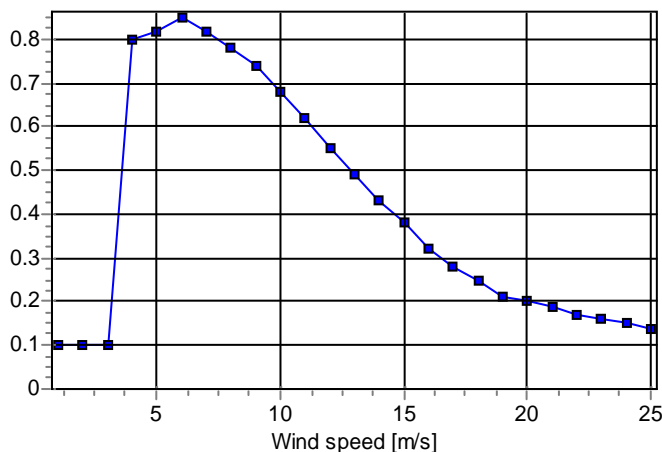
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3.6	0.0	0.00	1.0	0.10
4.7	3.6	0.15	2.0	0.10
5.6	11.5	0.29	3.0	0.10
6.5	21.0	0.33	4.0	0.80
7.4	34.7	0.37	5.0	0.82
8.4	52.7	0.39	6.0	0.85
9.5	74.4	0.38	7.0	0.82
10.4	97.2	0.38	8.0	0.78
11.4	118.4	0.35	9.0	0.74
12.5	135.9	0.30	10.0	0.68
13.4	147.7	0.27	11.0	0.62
14.3	151.8	0.23	12.0	0.55
15.4	153.1	0.18	13.0	0.49
16.4	151.6	0.15	14.0	0.43
17.0	148.0	0.13	15.0	0.38
18.0	142.0	0.11	16.0	0.32
19.0	136.0	0.09	17.0	0.28
20.0	130.0	0.07	18.0	0.25
			19.0	0.21
			20.0	0.20
			21.0	0.19
			22.0	0.17
			23.0	0.16
			24.0	0.15
			25.0	0.14
			26.0	0.13
			27.0	0.12
			28.0	0.11
			29.0	0.10

Power, Efficiency and energy vs. wind speed

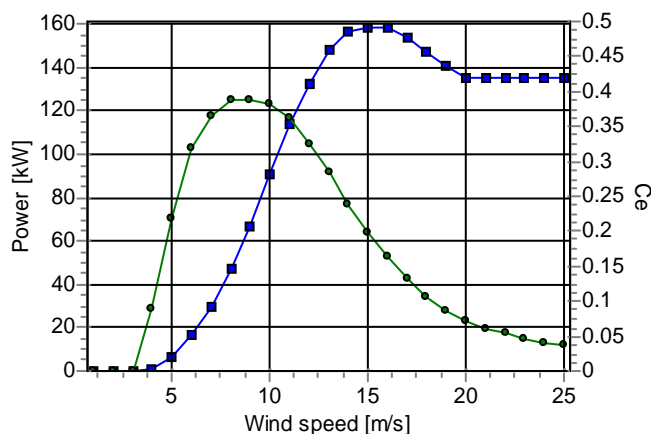
Data used in calculation, Air density: 1.270 kg/m3

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50- 1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50- 2.50	0.0	0.0	0.0
3.0	0.0	0.00	2.50- 3.50	0.0	0.0	0.0
4.0	1.4	0.09	3.50- 4.50	1.8	1.8	0.5
5.0	6.5	0.22	4.50- 5.50	8.0	9.8	2.9
6.0	16.3	0.32	5.50- 6.50	17.3	27.2	8.0
7.0	29.7	0.36	6.50- 7.50	27.6	54.8	16.1
8.0	47.2	0.39	7.50- 8.50	36.9	91.7	27.0
9.0	66.9	0.39	8.50- 9.50	42.2	134.0	39.5
10.0	90.3	0.38	9.50- 10.50	44.2	178.1	52.5
11.0	114.0	0.36	10.50- 11.50	42.1	220.2	64.9
12.0	132.6	0.32	11.50- 12.50	35.8	256.0	75.4
13.0	147.7	0.28	12.50- 13.50	28.0	284.1	83.7
14.0	156.0	0.24	13.50- 14.50	20.3	304.4	89.7
15.0	158.2	0.20	14.50- 15.50	13.7	318.1	93.7
16.0	157.8	0.16	15.50- 16.50	8.8	326.8	96.3
17.0	153.4	0.13	16.50- 17.50	5.4	332.2	97.9
18.0	147.2	0.11	17.50- 18.50	3.2	335.4	98.8
19.0	141.0	0.09	18.50- 19.50	1.8	337.2	99.3
20.0	134.8	0.07	19.50- 20.50	1.0	338.2	99.6
21.0	134.8	0.06	20.50- 21.50	0.6	338.8	99.8
22.0	134.8	0.05	21.50- 22.50	0.3	339.2	99.9
23.0	134.8	0.05	22.50- 23.50	0.2	339.3	100.0
24.0	134.8	0.04	23.50- 24.50	0.1	339.4	100.0
25.0	134.8	0.04	24.50- 25.50	0.0	339.5	100.0

Ct curve



Power and Ce curve
Data used in calculation



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WASP interface - Terrain

Calculation: 150 kW WTG at Tahkuna **Site Data:** A - WASP Calc Tahkuna

Terrain classification

Sector	Roughness classification (Roughness class)										
	Roughness at WTG	Distance to 1. change [m]	Roughness after 1. change	Distance to 2. change [m]	Roughness after 2. change	Distance to 3. change [m]	Roughness after 3. change	D 4 [m]	R 4	D 5 [m]	R 5
0 N	2.8	244	0.0								
1 NNE	2.7	209	0.0								
2 ENE	2.8	170	0.0								
3 E	2.8	171	0.0								
4 ESE	2.8	204	0.6	681	2.8	1,425	1.0	2,300	2.8	6,713	0.0
5 SSE	2.8	9,469	2.0	12,444	2.9	15,252	2.3	27,633	1.1		
6 S	2.8	575	2.0	975	2.5	6,711	2.7	26,007	1.8		
7 SSW	2.6	182	0.0	8,853	1.0	20,753	0.7	21,868	2.4	25,384	0.0
8 WSW	2.7	120	0.0								
9 W	2.8	111	0.0								
10 WNW	2.7	119	0.0								
11 NNW	2.6	180	0.0								

Obstacles:

5 Obstacles used within a radius of 2,000 m

Roughness:

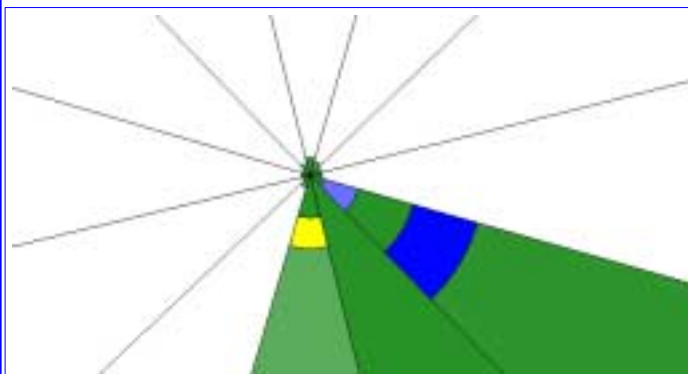
Orography:

Calculation uses following MAP files:

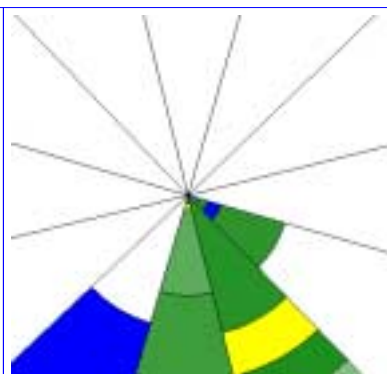
C:\My Documents\WindPRO Data\PROJECTS\Baltic\Hiiumaa_ORO_1_No_Z_values.wpo

Min X: 387,085, Max X: 449,538, Min Y: 6,506,070, Max Y: 6,551,338, Width: 62,453 m, Height: 45,268 m

Limited by a square on 10.0 km x 10.0 km around the current site



Roughness rose, Scale 1:100,000



Roughness rose Scale 1:500,000

- Rough. Class 0
- Rough. Class 1
- Rough. Class 2
- Rough. Class 3
- Rough. Class 4

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WASP interface - Wind Data Analysis

Calculation: 150 kW WTG at Tahkuna **Wind data:** A - WASP Calc Tahkuna; Hub height: 30.0

Site Coordinates

Local East: 418,915 North: 6,550,965

Origin

Wind statistics EE 18,0 m Hiiumaa_Tuula_long term corrected

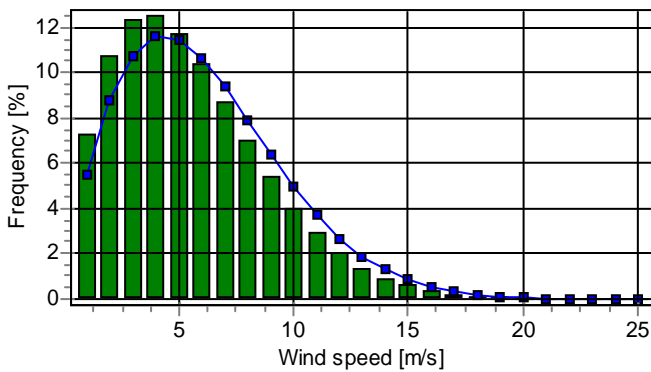
Regional Correction Factor 1.15

Based on NCAR-data and existing WTG production indicates 80-88 % of energy level in measure period, 87% is chosen - this gives 1,15 in correction factor.

Weibull Data

Direction	Current site parameter [m/s]	Current site speed [m/s]	Current site k-parameter	Current site Frequency [%]	Reference parameter [m/s]	Reference k-parameter	Reference Frequency [%]
0 N	5.33	4.74	1.820	5.3	4.43	1.798	5.2
1 NNE	6.60	5.85	2.110	4.1	5.21	1.870	4.0
2 ENE	5.68	5.06	1.740	3.3	4.17	1.515	3.3
3 E	4.98	4.41	2.200	2.9	4.34	1.663	3.2
4 ESE	6.10	5.41	1.930	5.4	6.74	1.785	5.9
5 SSE	5.25	4.73	1.530	9.2	7.26	1.508	8.6
6 S	5.28	4.70	1.780	14.4	6.68	1.800	14.9
7 SSW	8.08	7.17	1.890	15.6	6.67	1.747	16.2
8 WSW	8.34	7.39	2.080	16.6	6.53	1.930	16.2
9 W	8.32	7.37	2.330	10.2	6.50	2.126	9.3
10 WNW	7.59	6.72	2.200	6.5	5.93	1.868	6.5
11 NNW	6.86	6.13	1.650	6.4	5.29	1.435	6.6
All	6.88	6.48	1.790	100.0	6.21	1.698	100.0

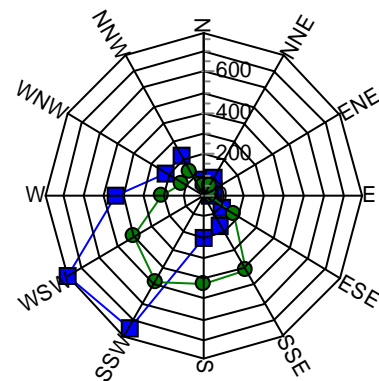
Weibull Distribution



Reference: A=6.21;k=1.698;V mean=5.5 m/s
 Current site: A=6.88;k=1.790;V mean=6.5 m/s

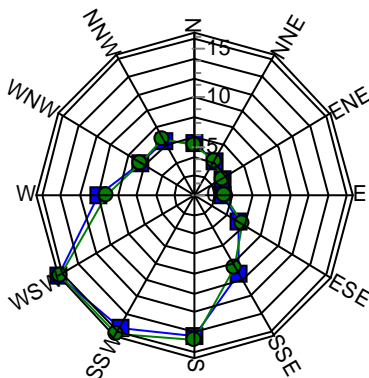
Reference: Roughness class 1

Energy Rose (kWh/m2/year)



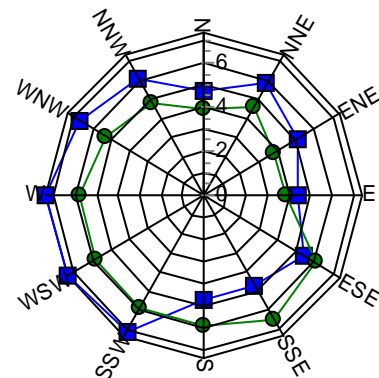
Current site Reference

Frequency (%)



Current site Reference

Mean wind speed (m/s)



Current site Reference

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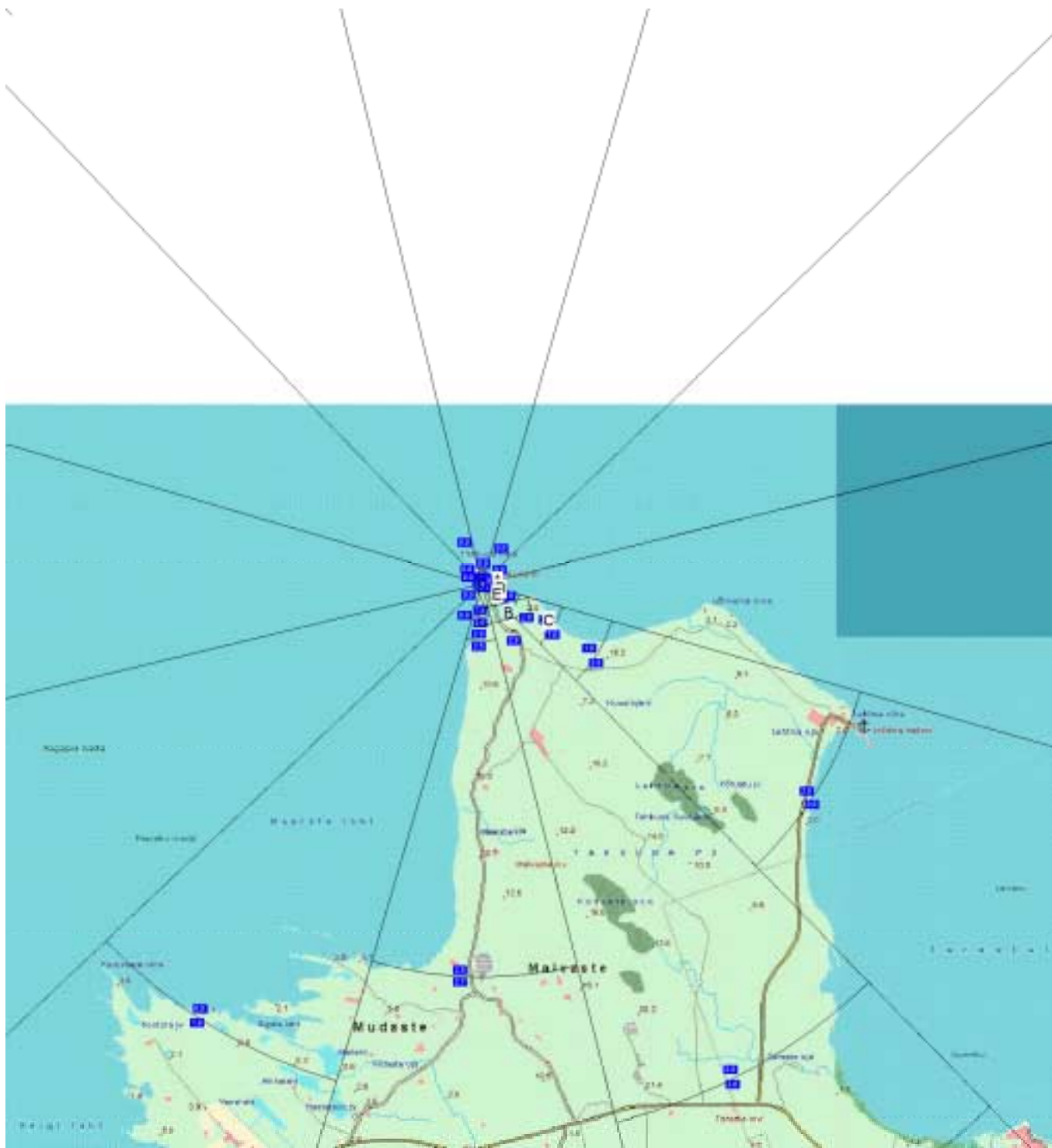
Per Nielsen

Calculated:

26-03-2002 16:44/2.3.0.0

WASP interface - Hiiumaa_50K

Calculation: 150 kW WTG at Tahkuna **File:** Hiiumaa_50K.bmi



0 1 2 3 4 km

Map: Hiiumaa_50K, Print scale 1:100,000, Map center Local East: 419,288 North: 6,550,706

Site Data

Obstacle