



Duurzame oplossingen in
energie, klimaat en milieu

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Documenttitel	Productieberekeningen P50 en P90 Windpark De Kookepan
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PRODUCTIEBEREKENINGEN P50 EN P90

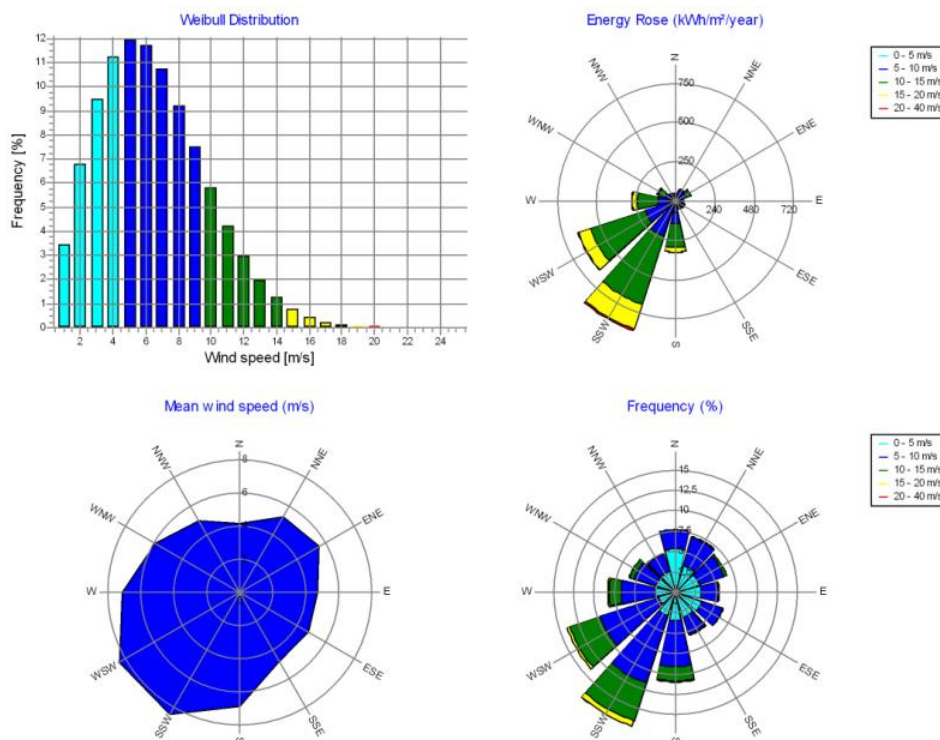
WINDPARK DE KOOKEPAN

Windklimaat Windpark De Kookepan

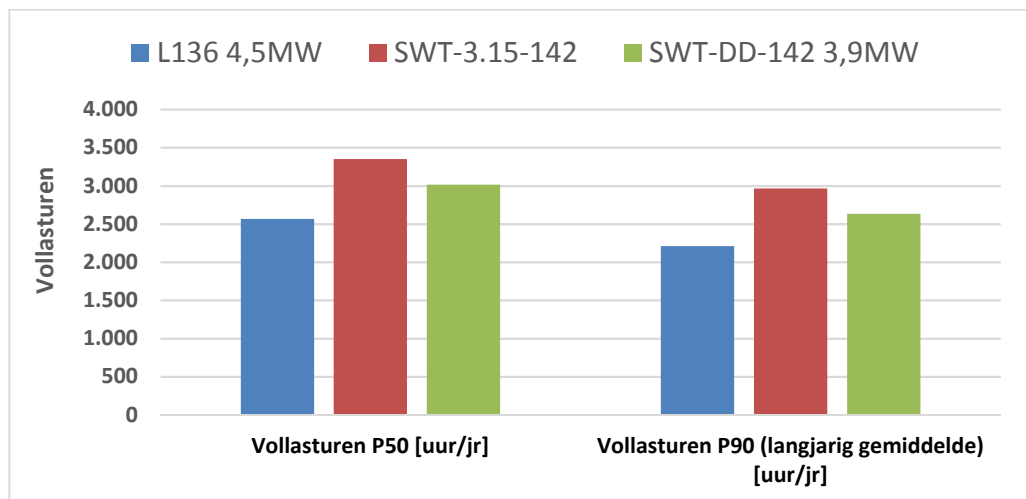
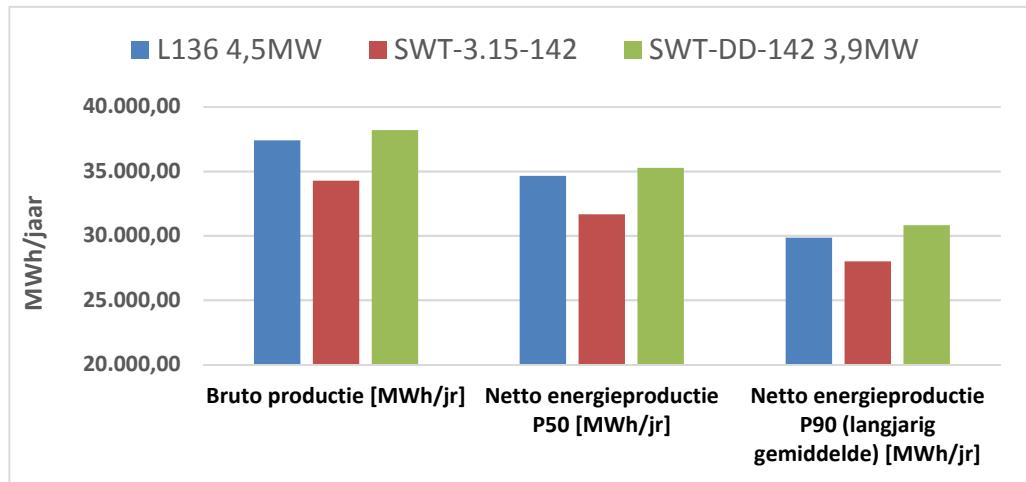
Het windklimaat voor de P50 en P90 productieberekeningen voor Windpark De Kookepan werd bepaald aan de hand van twee datasets: windmetingen van KNMI-meetstation Eil (1999-2017) en SCADA bruto-productiegegevens van 4 windturbines van Windpark Neer. Samengevat zijn de volgende stappen genomen bij het bepalen van het langjarig windklimaat:

- Eerst werd het windklimaat van KNMI-meetstation Eil geschaald met een schaaftactor om zo goed mogelijk de bruto productie van 2012-2015 na te bootsen op ashoogte en locatie van de vier windturbines van Windpark Neer
- Het geschaalde windklimaat werd vervolgens gecorrigeerd naar een langjarig gemiddelde windklimaat gebaseerd op windmetingen van 1 august 1999 tot en met 14 december 2017.
- Het geschaalde en gecorrigeerde windklimaat is met WindPRO en WAsP vertaald naar een langjarig representatief windklimaat voor Windpark De Kookepan

Windklimaat op 132 m ashoogte Windpark De Kookepan



Resultaten Productieberekeningen P50 en P90 Windpark De Kookepan



Productieverliezen Windpark De Kookepan

Verliespost	Bepaling effect	L136 4,5MW	SWT-3.15-142 3,15MW	SWT-DD-142 3,9MW
Wake-effecten	Berekening	- 1,7%	- 1,9%	- 2,0%
Niet beschikbaar				
- Windturbine	Inschatting	- 2,5%	- 2,5%	- 2,5%
- Balance of plant	Inschatting	0%	0%	0%
- Grid	Inschatting	0%	0%	0%
- Overig (onderhoud)	Gegeven	0%	0%	0%
Elektrisch				
- Netverliezen	Inschatting	- 1,0%	- 1,0%	- 1,0%
- Eigen gebruik	Inschatting	0%	0%	0%
Omgeving				
- Bladdegradatie	Aanname	- 0,5%	- 0,5%	- 0,5%
- Icing maatregelen	Aanname	- 0,5%	- 0,5%	- 0,5%
- Site toegang beperkingen	Aanname	0%	0%	0%
- Extreme weersomstandigheden	Aanname	0%	0%	0%
- Bosaangroei	Aanname	0%	0%	0%
- Overig		0%	0%	0%
Prestaties				
- High wind hysteresis	Inschatting	- 0,5%	- 0,5%	- 0,5%
- Power curve-	Inschatting	0%	0%	0%
Inkorting				
- Geluid	n.v.t.	0%	0%	0%
- Schaduw	Berekening	- 0,9%	- 0,9%	- 0,9%
- Vogels / Vleermuizen	n.v.t.	0%	0%	0%
- Externe veiligheid	n.v.t.	0%	0%	0%
- Overig	n.v.t.	0%	0%	0%
Overig	n.v.t.	0%	0%	0%
Verliezen totaal		- 7,4%	- 7,6%	- 7,6%

Onzekerheden in de windmetingen bij windklimaatbepaling

Onzekerheid in windmetingen	Commentaar	L136 4,5MW	SWT-3.15-142	SWT-DD-142 3,9MW
Windmetingen	Gebaseerd op productiedata Windpark Neer	4,0 %	4,0 %	4,0 %
Lange termijn correctie	Gebaseerd op correctiefactor naar langjarig gemiddeld	3,3 %	3,3 %	3,3 %
Jaarlijkse variabiliteit	Berekend door MCP analyse	4,6 %	4,6 %	4,6 %
Verticale extrapolatie	Windklimaat geschaald op basis van verschil in ashoogte tussen Windpark Neer en Windpark De Kookepan	1,0 %	0,9 %	0,9 %
Horizontale extrapolatie	Windklimaat geschaald op basis van afstand tussen Windpark Neer en Windpark De Kookepan	1,5 %	1,5 %	1,5 %

Onzekerheden in de gemiddelde jaarlijkse bruto productie

Onzekerheden in de productie	L136 4,5MW	SWT-3.15-142	SWT-DD-142 3,9MW
Gevoeligheid %Productie / %Windsnelheid	1,9	1,6	1,7
Vermogenscurve	2,0 %	2,0 %	2,0 %
Windmetingen:			
- Windmetingen	7,6 %	6,3%	6,9 %
- Lange termijn correctie	6,2 %	5,2 %	5,7 %
- Jaarlijkse variabiliteit	8,7 %	7,2 %	7,9 %
- Verticale extrapolatie	1,9 %	1,5 %	1,6 %
- Horizontale extrapolatie	2,8 %	2,4 %	2,6 %
Onzekerheden in de verliezen:			
- Wake-effect	0,5 %	0,6 %	0,6 %
- Niet-beschikbaarheid	0,5 %	0,5 %	0,5 %
- High wind hysteresis	0,1 %	0,1 %	0,1 %
- Elektrische verliezen	0,2 %	0,2 %	0,2 %
- Bladdegradatie niet door ijsvorming	0,1 %	0,1 %	0,1 %
- Bladdegradatie door ijsvorming	0,1 %	0,1 %	0,1 %
- Slagschaduwinkorting	0,1 %	0,2 %	0,2 %
1 jaar gemiddelde P90 onzekerheid	13,7%	11,4%	12,5%
Langjarig (20 jaar) gemiddelde P90 onzekerheid	10,8%	9,0%	9,8%

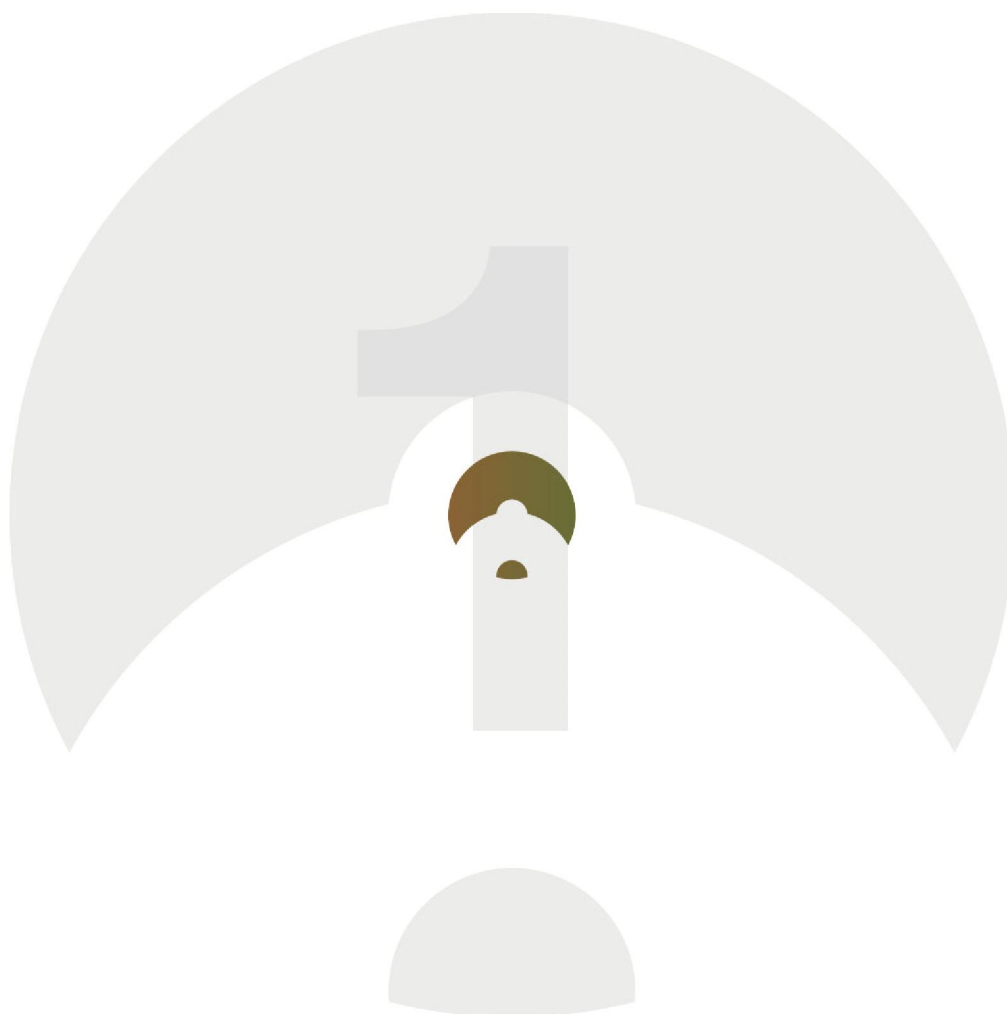
Resultaten P50 en P90 productieberekeningen Windpark De Kookepan

Algemene uitgangspunten			
Windturbintypes	L136 4,5MW; SWT-3.15-142; SWT-DD-142		
Wake-vervalconstante	Berekend met N.O. Jensen (EMD) 2005 model en een wake-vervalconstante 0,065		
Gebruikte winddata	Voor windrichting en verdeling: KNMI-meetstation EII (1999-2017)		
Windklimaat schaling en correcties	Windklimaat geschaald naar Windpark Neer productiedata (2012-2015) en gecorrigeerd naar langjarig klimaat (1999-2017)		
Luchtdichtheid [kg/m ³]	1,225 kg/m ³		
Specifieke uitgangspunten	L136 4,5MW	SWT-3.15-142	SWT-DD-142
Rotordiameter [m]	136	142	142
Ashoogte [m]	132	129	129
Geïnstalleerd vermogen [MW]	13,5	9,4	11,7
Aantal windturbines	3	3	3
Uitkomsten	L136 4,5MW	SWT-3.15-142	SWT-DD-142
Gemiddelde windsnelheid op ashoogte RVO Windviewer [m/s]	6,81	6,76	6,76
Gemiddelde windsnelheid op ashoogte [m/s]	6,4 m/s	6,4 m/s	6,4 m/s
Bruto productie [MWh/jr]	37.401,9	34.278,4	38.189,9
Wake-effect verliezen [%]	1,7 %	1,9 %	2,0 %
Verliezen totaal [%]	7,4 %	7,6 %	7,6 %
Verliezen totaal [MWh/jr]	2759,3	2611,6	2919,6
Netto energieproductie P50 [MWh/jr]	34.642,6	31.666,8	35.270,3
Vollasturen P50 [uur/jr]	2.566	3.351	3.015
Langjarig gemiddelde onzekerheid [%]	10,8 %	9,0 %	9,8 %
Netto energieproductie P90 (langjarig gemiddelde) [MWh/jr]	29.859,9	28.013,6	30.825,6
Vollasturen P90 (langjarig gemiddelde) [uur/jr]	2.212	2.964	2.635

BIJLAGE 1

INVOER EN RESULTATEN

MODEL PRODUCTIEBEREKENINGEN



Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:45/3.1.617

PARK - Main Result

Calculation: WP De Kookepan L136 4,5MW HH132

Wake Model N.O. Jensen (EMD) : 2005

Include mirror wakes

Calculation Settings

Air density calculation mode Individual per WTG
Result for WTG at hub altitude 1,224 kg/m³ to 1,228 kg/m³
Air density relative to standard 99,9 % to 100,2 %
Hub altitude above sea level (asl) 126,7 m to 162,0 m
Annual mean temperature at hub alt. 9,7 °C to 9,9 °C
Pressure at WTGs 993,6 hPa to 997,9 hPa

Wake Model Parameters

Terrain type Wake decay constant
HH:100m Mixed farmland 0,065

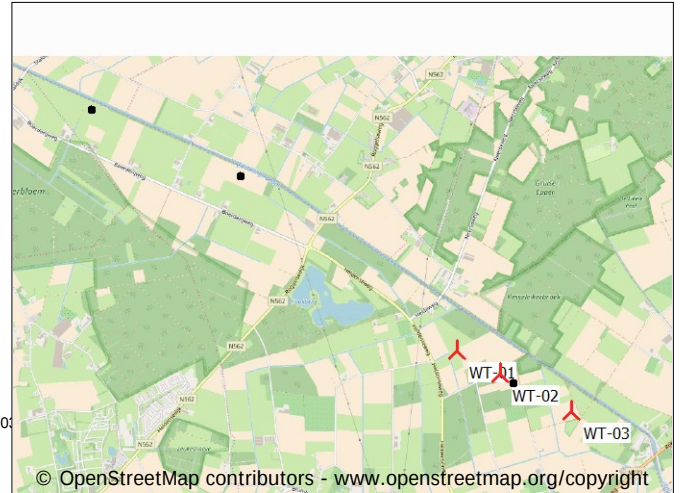
Displacement heights from objects

Wake calculation settings

Angle [°] Wind speed [m/s]
start end step start end step
0,5 360,0 1,0 0,5 30,5 1,0

Wind statistics KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.027

WASP version WASP 11 Version 11.06.0012



New WTG

Scale 1:75.000

Site Data

Key results for height 100,0 m above ground level

Terrain Dutch Stereo-RD/NAP 2000

X (east) Y (north) Name of wind distribution Type

					Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	192.765	368.713	WP NEER1	WASP (WASP 11 Version 11.06.0012)	1.985	5,9	2,0
B	194.261	368.067	WP NEER2	WASP (WASP 11 Version 11.06.0012)	2.022	5,9	1,9
C	196.989	366.031	De Kookepan	WASP (WASP 11 Version 11.06.0012)	2.035	5,9	2,0

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results ^{a)}			Mean wind speed @hub height [m/s]
				Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	
Wind farm	36.775,7	37.401,9	98,3	31,1	12.258,6	2.724	6,4

^{a)} Based on wake reduced results, but no other losses included

Calculated Annual Energy for each of 3 new WTGs with total 13,5 MW rated power

WTG type	Links	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Power curve Creator	Name	Annual Energy Result	Park Efficiency	Capacity factor	Free mean wind speed
WT-01 C	Yes	LAGERWEY	L136-4.5MW-4.500	4.500	136,0	132,0	USER	Standard	L136-4.5MW PV-curve	12.177,8	98,47	30,9	6,40
WT-02 C	Yes	LAGERWEY	L136-4.5MW-4.500	4.500	136,0	132,0	USER	Standard	L136-4.5MW PV-curve	12.166,0	97,53	30,8	6,43
WT-03 C	Yes	LAGERWEY	L136-4.5MW-4.500	4.500	136,0	132,0	USER	Standard	L136-4.5MW PV-curve	12.431,9	98,98	31,5	6,45

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

WTG siting

Dutch Stereo-RD/NAP 2000

X (east) Y (north) Z Row data/Description [m]

WT-01 New	196.420	366.350	27,7	LAGERWEY L136-4.5MW 4500	136,0	!-! hub: 132,0 m (TOT: 200,0 m) (
WT-02 New	196.853	366.126	30,0	LAGERWEY L136-4.5MW 4500	136,0	!-! hub: 132,0 m (TOT: 200,0 m) (
WT-03 New	197.562	365.760	27,4	LAGERWEY L136-4.5MW 4500	136,0	!-! hub: 132,0 m (TOT: 200,0 m) (

^{*}) Included in array losses is influence from 5 WTG(s) in the neighborhood, which has status as "Reference WTGs", see separate report to identify these.

PARK - Reference WTGs

Calculation: WP De Kookepan L136 4,5MW HH132

Wake Model N.O. Jensen (EMD) : 2005

Include mirror wakes

Calculation Settings

Calculation Settings	
Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	1,224 kg/m ³ to 1,228 kg/m ³
Air density relative to standard	99.9 % to 100.2 %
Hub altitude above sea level (asl)	126.7 m to 162.0 m
Annual mean temperature at hub alt.	9.7 °C to 9.9 °C
Pressure at WTGs	993.6 hPa to 997.9 hPa

Wake Model Parameters

Terrain type	Wake decay constant
HH:100m Mixed farmland	0,065

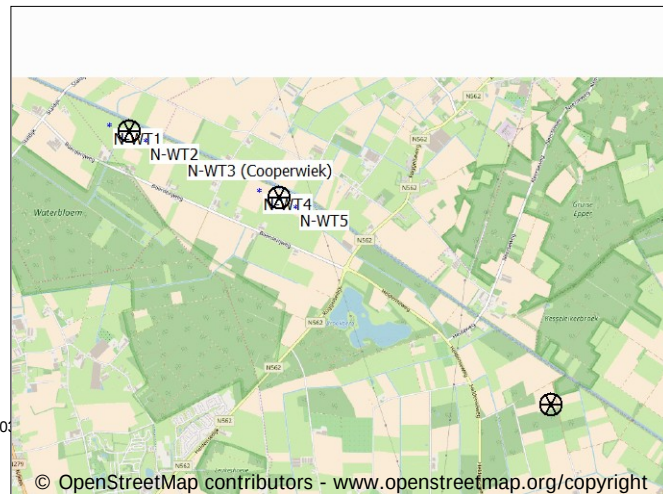
Displacement heights from objects

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0,5	360,0	1,0	0,5	30,5	1,0

Wind statistics KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.027

WASP version WASP 11 Version 11.06.0012



Scale 1:75.000

 New WTG

* Existing WTG

 Site Data

Key results for height 100,0 m above ground level

Terrain Dutch Stereo-RD/NAP 2000

X (east)	Y (north)	Name of wind distribution	Type
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	X (east)	Y (north)	Name of wind distribution	Type	Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	192.765	368.713	WP NEER1	WASP (WASP 11 Version 11.06.0012)	1.985	5.9	2.0
B	194.261	368.067	WP NEER2	WASP (WASP 11 Version 11.06.0012)	2.022	5.9	1.9
C	196.989	366.031	De Kookepan	WASP (WASP 11 Version 11.06.0012)	2.035	5.9	2.0

Calculated Annual Energy for reference WTGs

Overall results			Specific results				Overall results		
Calculated prod. without new WTGs	GROSS (no loss) Free WTGs	Park efficiency	Capacity factor	Mean WTG result	Full load hours	Mean wind speed @hub height	Actual wind corrected energy	Goodness Factor	
[MWh]	[MWh/y]	[%]	[%]	[MWh/y]	[Hours/year]	[m/s]	[MWh]	[%]	
22.292.8	22.766.6	97.9	21.6	4.458.6	1.897	5.9	0.0	0.0	

Calculated Annual Energy for each of 5 reference WTGs with total 11,8 MW rated power

	Links	WTG type			Power, rated	Rotor diameter	Hub height	Power curve		Calculated prod. without new WTGs	Goodness Factor
		Valid	Manufact.	Type-generator				Creator	Name		
N-WT3 (Cooperwiek)	N-WT1 A	Yes	ENERCON	E-82 E4-2.350	[kW]	[m]	[m]	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.370,3	0
	N-WT2 A	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.262,3	0
	N-WT3 (Cooperwiek) A	Yes	ENERCON	E-92 2,3 MW-2.350	2.350	92,0	98,4	EMD	Level 0 - official - 2350kW - 02/2014	4.953,1	0
	N-WT4 B	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.341,6	0
	N-WT5 B	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.365,3	0

WTG siting

Dutch Stereo-RD/NAP 2000

X (east)	Y (north)	Z	Row data/Description
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Product
source

Statistical basis for normalized production: [Months]

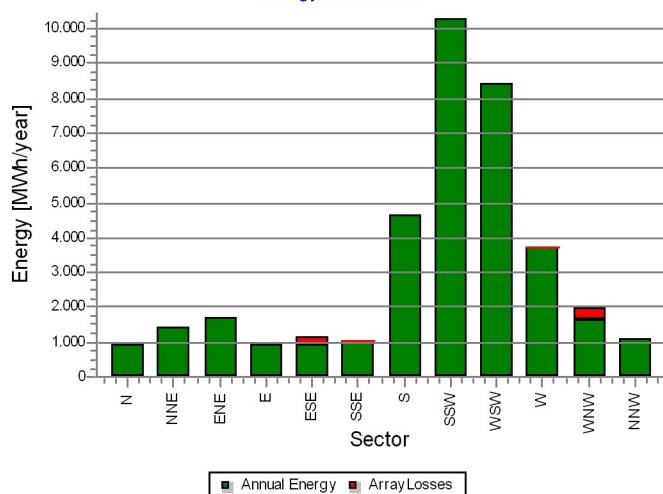
		[m]			
	N-WT1	192.568	368.782	29,0	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (6)
	N-WT2	192.935	368.624	28,9	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (7)
N-WT3 (Cooperwiek)		193.303	368.468	29,7	ENERCON E-92 2,3 MW 2350 92.0 !-! hub: 98,4 m (TOT: 144,4 m) (10)
	N-WT4	194.064	368.140	28,4	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (8)
	N-WT5	194.430	367.980	30,7	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (9)

PARK - Production Analysis

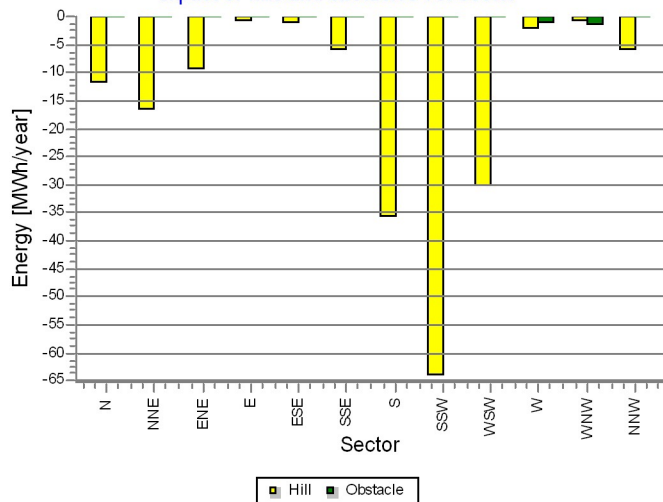
Calculation: WP De Kookepan L136 4,5MW HH132WTG: All new WTGs, Air density varies with WTG position 1,224 kg/m³ - 1,228 kg/m³
Directional Analysis

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]	953,0	1.465,2	1.700,8	972,4	1.164,4	1.067,4	4.690,9	10.343,9	8.469,5	3.732,6	1.949,9	1.083,3	37.593,5
-Decrease due to obstacles [MWh]	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,3	0,4	1,5	1,7	0,4	4,5
+Increase due to hills [MWh]	-11,8	-16,8	-9,4	-1,2	-1,2	-6,2	-36,0	-64,2	-30,5	-2,5	-1,1	-6,1	-187,1
-Decrease due to array losses [MWh]	0,0	0,0	0,0	15,0	243,1	0,0	0,0	0,0	0,0	34,5	333,6	0,0	626,2
Resulting energy [MWh]	941,2	1.448,3	1.691,4	956,2	920,0	1.061,3	4.654,9	10.279,4	8.438,6	3.694,1	1.613,4	1.076,8	36.775,7
Specific energy [kWh/m ²]													844
Specific energy [kWh/kW]													2.724
Decrease due to obstacles [%]	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,01
Increase due to hills [%]	-1,2	-1,1	-0,6	-0,1	-0,1	-0,6	-0,8	-0,6	-0,4	-0,1	-0,1	-0,6	-0,50
Decrease due to array losses [%]	0,0	0,0	0,0	1,5	20,9	0,0	0,0	0,0	0,0	0,9	17,1	0,0	1,67
Utilization [%]	44,5	44,0	40,2	42,1	34,4	42,2	33,1	28,2	30,0	31,6	29,7	42,3	31,8
Operational [Hours/year]	630	579	537	438	505	451	899	1.404	1.135	679	490	410	8.158
Full Load Equivalent [Hours/year]	70	107	125	71	68	79	345	761	625	274	120	80	2.724

Energy vs. sector



Impact of hills and obstacles vs. sector

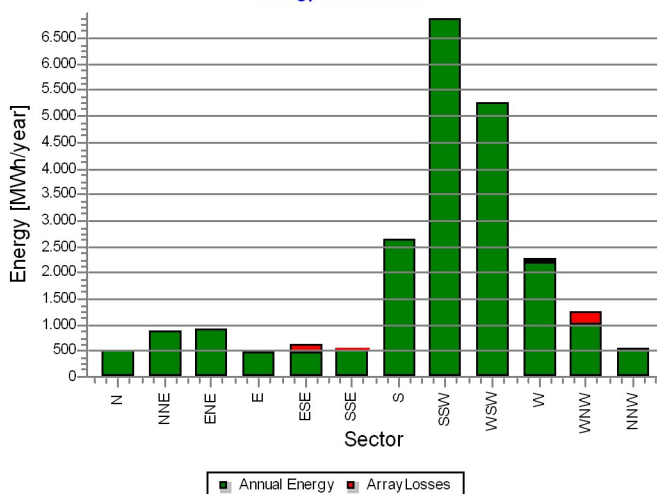


PARK - Production Analysis

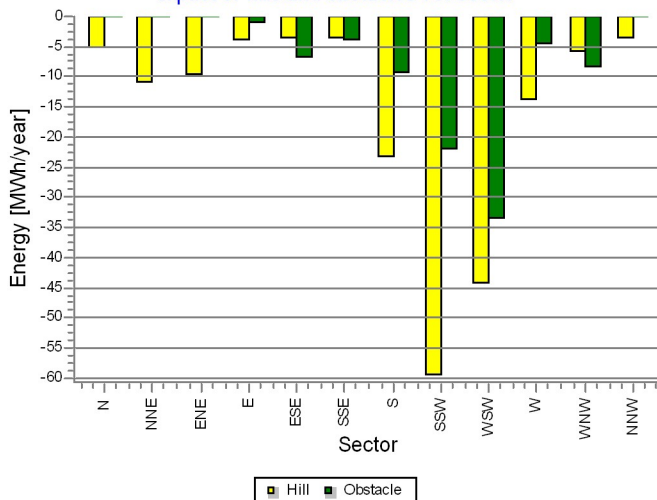
Calculation: WP De Kookepan L136 4,5MW HH132WTG: All existing WTGs, Air density varies with WTG position 1,224 kg/m³ - 1,228 kg/m³
 Directional Analysis

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]	513,5	884,5	927,7	501,5	631,2	548,6	2.663,2	6.952,3	5.326,6	2.277,8	1.251,4	569,7	23.048,0
-Decrease due to obstacles	[MWh]	0,0	0,0	0,0	1,2	7,1	4,1	9,5	22,4	33,6	4,9	8,7	0,4	91,9
+Increase due to hills	[MWh]	-5,5	-11,1	-9,8	-4,0	-3,7	-3,8	-23,4	-59,7	-44,6	-14,0	-5,9	-3,9	-189,5
-Decrease due to array losses	[MWh]	0,0	0,0	0,0	22,4	161,6	0,0	0,0	0,0	0,0	73,0	237,0	0,0	494,1
Resulting energy	[MWh]	508,0	873,4	917,8	473,8	458,9	540,7	2.630,4	6.870,2	5.248,4	2.185,9	999,7	565,3	22.272,5
Specific energy	[kWh/m ²]													802
Specific energy	[kWh/kW]													1.896
Decrease due to obstacles	[%]	0,0	0,0	0,0	0,2	1,1	0,8	0,4	0,3	0,6	0,2	0,7	0,1	0,40
Increase due to hills	[%]	-1,1	-1,3	-1,1	-0,8	-0,6	-0,7	-0,9	-0,9	-0,8	-0,6	-0,5	-0,7	-0,82
Decrease due to array losses	[%]	0,0	0,0	0,0	4,5	26,0	0,0	0,0	0,0	0,0	3,2	19,2	0,0	2,17
Utilization	[%]	44,8	46,5	45,9	43,7	34,1	45,9	43,6	38,6	41,4	40,4	35,0	46,2	40,8
Operational	[Hours/year]	660	613	564	460	531	475	966	1.483	1.186	711	520	431	8.598
Full Load Equivalent	[Hours/year]	43	74	78	40	39	46	224	585	447	186	85	48	1.896

Energy vs. sector



Impact of hills and obstacles vs. sector



PARK - Power Curve Analysis

Calculation: WP De Kookepan L136 4,5MW HH132WTG: WT-01 - LAGERWEY L136-4.5MW 4500 136.0 !O! Standard L136-4.5MW PV-curve, Hub height: 132,0 m

Name: Standard L136-4.5MW PV-curve

Source: Document number: SD202ENR2

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m ²
27-11-2017	USER	27-11-2017	27-11-2017	25,0	Pitch	User defined	Variable	0,31

Document number: SD202ENR2

Toegevoegd op 27-11-2017 door Haydar H.

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, variable speed (2013)	[MWh]	7.402	11.306	15.095	18.482	21.345	23.641
LAGERWEY L136-4.5MW 4500 136.0 !O! Standard L136-4.5MW PV-curve	[MWh]	7.406	11.094	14.715	17.993	20.792	23.041
Check value	[%]	0	2	3	3	3	3

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

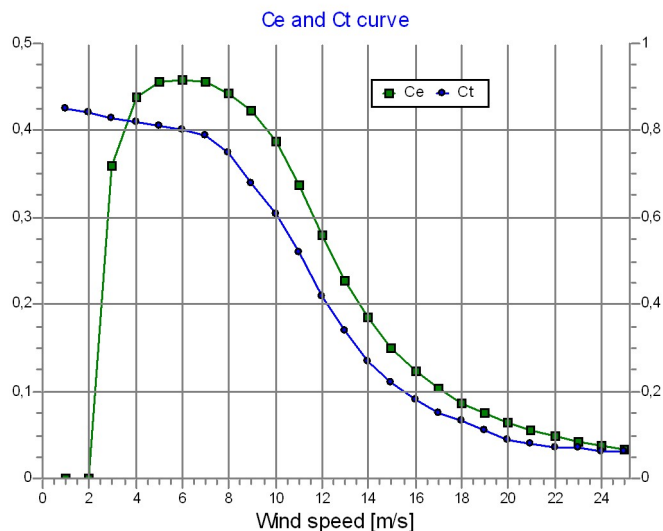
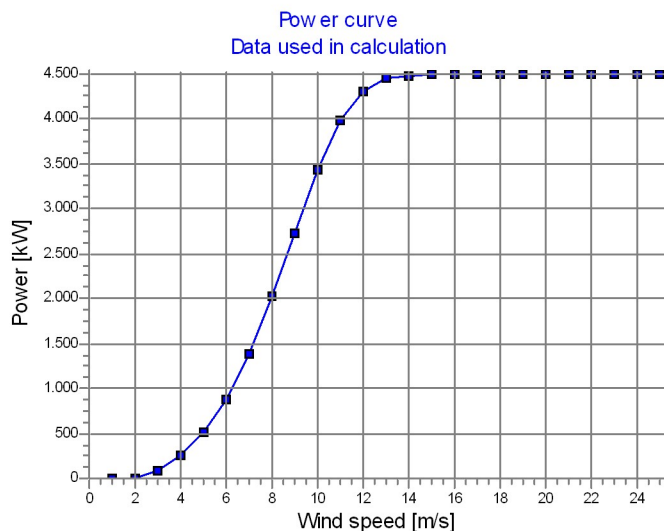
Original data, Air density: 1,225 kg/m³

Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3,0	86,0	0,36	3,0	0,83
4,0	250,0	0,44	4,0	0,82
5,0	507,0	0,46	5,0	0,81
6,0	881,0	0,46	6,0	0,80
7,0	1.389,0	0,46	7,0	0,79
8,0	2.020,0	0,44	8,0	0,75
9,0	2.734,0	0,42	9,0	0,68
10,0	3.440,0	0,39	10,0	0,61
11,0	3.995,0	0,34	11,0	0,52
12,0	4.314,0	0,28	12,0	0,42
13,0	4.447,0	0,23	13,0	0,34
14,0	4.487,0	0,18	14,0	0,27
15,0	4.500,0	0,15	15,0	0,22
16,0	4.500,0	0,12	16,0	0,18
17,0	4.500,0	0,10	17,0	0,15
18,0	4.500,0	0,09	18,0	0,13
19,0	4.500,0	0,07	19,0	0,11
20,0	4.500,0	0,06	20,0	0,09
21,0	4.500,0	0,05	21,0	0,08
22,0	4.500,0	0,05	22,0	0,07
23,0	4.500,0	0,04	23,0	0,07
24,0	4.500,0	0,04	24,0	0,06
25,0	4.500,0	0,03	25,0	0,06

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1,224 kg/m³ New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

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	1,4	1,4	0,0
3,0	86,0	0,36	2,50- 3,50	83,3	84,7	0,7
4,0	250,0	0,44	3,50- 4,50	291,0	375,8	3,1
5,0	507,0	0,46	4,50- 5,50	590,6	966,4	7,9
6,0	881,0	0,46	5,50- 6,50	944,2	1.910,6	15,7
7,0	1.389,0	0,46	6,50- 7,50	1.274,2	3.184,8	26,2
8,0	2.020,0	0,44	7,50- 8,50	1.510,5	4.695,3	38,6
9,0	2.734,0	0,42	8,50- 9,50	1.609,6	6.304,9	51,8
10,0	3.440,0	0,39	9,50-10,50	1.552,8	7.857,7	64,5
11,0	3.995,0	0,34	10,50-11,50	1.351,2	9.208,8	75,6
12,0	4.314,0	0,28	11,50-12,50	1.060,0	10.268,8	84,3
13,0	4.447,0	0,23	12,50-13,50	756,6	11.025,4	90,5
14,0	4.487,0	0,18	13,50-14,50	498,0	11.523,4	94,6
15,0	4.500,0	0,15	14,50-15,50	304,9	11.828,3	97,1
16,0	4.500,0	0,12	15,50-16,50	174,2	12.002,5	98,6
17,0	4.500,0	0,10	16,50-17,50	92,8	12.095,3	99,3
18,0	4.500,0	0,09	17,50-18,50	46,1	12.141,4	99,7
19,0	4.500,0	0,07	18,50-19,50	21,4	12.162,8	99,9
20,0	4.500,0	0,06	19,50-20,50	9,2	12.172,0	100,0
21,0	4.500,0	0,05	20,50-21,50	3,7	12.175,7	100,0
22,0	4.500,0	0,05	21,50-22,50	1,4	12.177,1	100,0
23,0	4.500,0	0,04	22,50-23,50	0,5	12.177,6	100,0
24,0	4.500,0	0,04	23,50-24,50	0,2	12.177,8	100,0
25,0	4.500,0	0,03	24,50-25,50	0,0	12.177,8	100,0



Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:45/3.1.617

PARK - Terrain

Calculation: WP De Kookepan L136 4,5MW HH132Site Data: C - De Kookepan

Obstacles:

17 Obstacles used

Roughness:

Terrain data files used in calculation:

P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\ROUGHNESSLINE_ONLINEDATA_0.wpo
Min X: 164.636, Max X: 227.062, Min Y: 334.874, Max Y: 398.555, Width: 62.426 m, Height: 63.681 m

Orography:

Terrain data files used in calculation:

P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\717130 Productie_EMDGrid_0.wpg
Min X: 176.541, Max X: 216.980, Min Y: 346.612, Max Y: 386.959, Width: 40.438 m, Height: 40.347 m

PARK - Wind Data Analysis

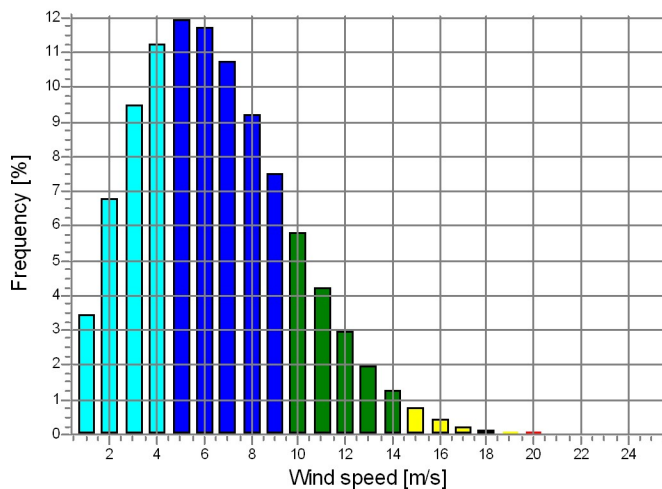
Calculation: WP De Kookepan L136 4,5MW HH132Wind data: C - De Kookepan; Hub height: 132,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 197.562 North: 365.760
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

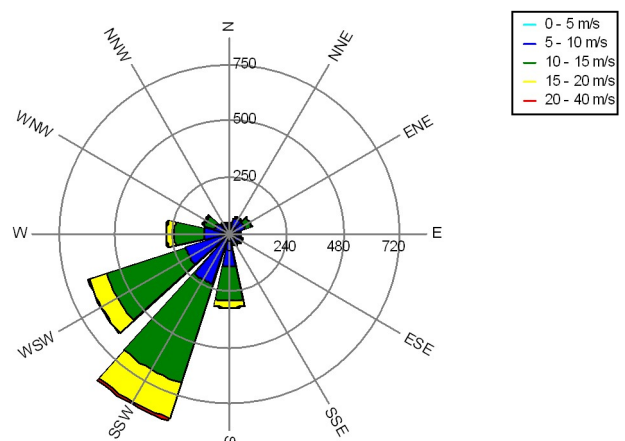
Weibull Data

Sector	Current site		k- parameter	Frequency [%]
	A- parameter [m/s]	Wind speed [m/s]		
0 N	4,68	4,15	2,486	7,7
1 NNE	5,86	5,21	2,717	7,1
2 ENE	6,23	5,52	2,225	6,6
3 E	5,28	4,67	2,229	5,4
4 ESE	5,45	4,83	2,443	6,2
5 SSE	5,37	4,75	2,182	5,5
6 S	7,74	6,86	2,248	11,0
7 SSW	9,52	8,45	2,568	17,2
8 WSW	9,45	8,41	2,818	14,0
9 W	8,05	7,13	2,256	8,3
10 WNW	6,70	5,94	2,072	6,0
11 NNW	5,62	4,98	2,342	5,0
All	7,28	6,45	2,045	100,0

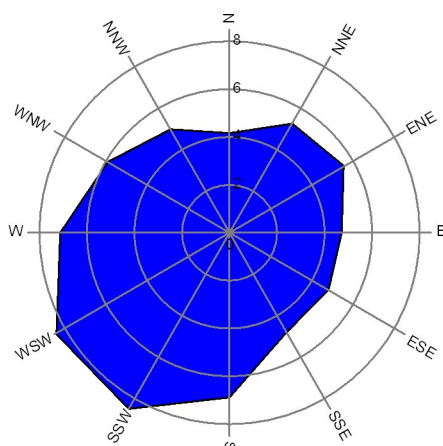
Weibull Distribution



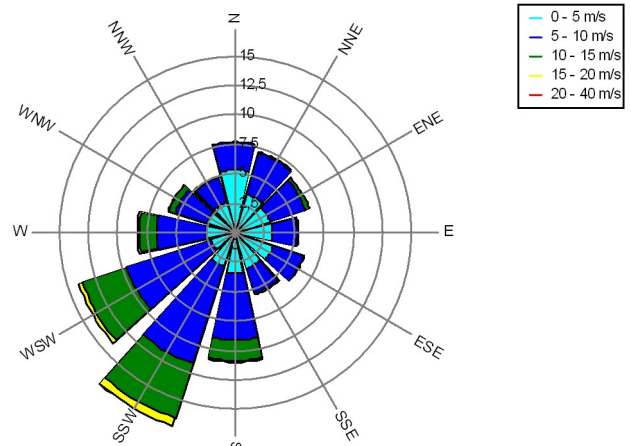
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Wind Data Analysis

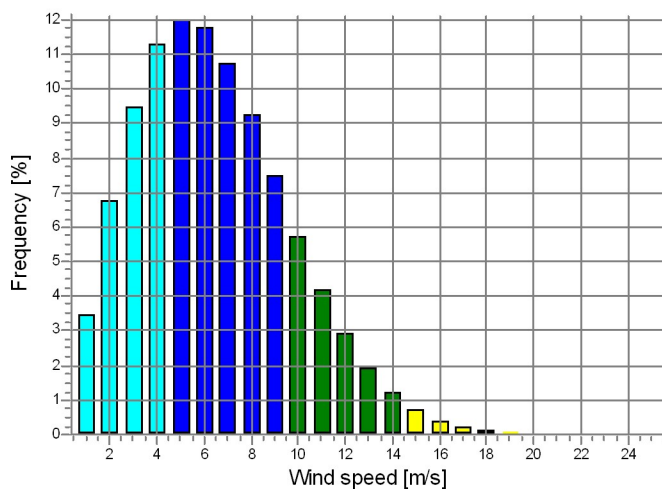
Calculation: WP De Kookepan L136 4,5MW HH132Wind data: C - De Kookepan; Hub height: 132,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 196.853 North: 366.126
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

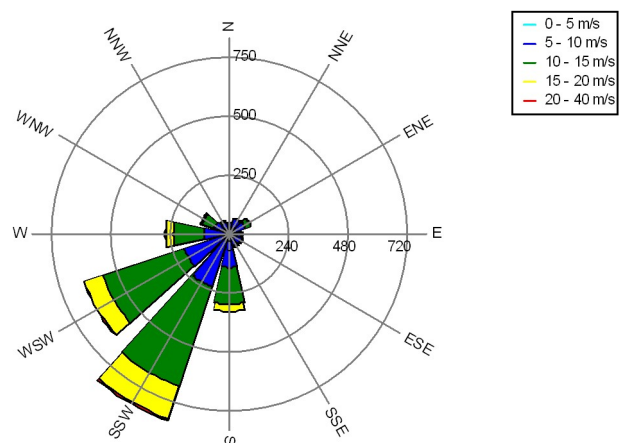
Weibull Data

Sector	Current site			
	A- parameter [m/s]	Wind speed [m/s]	k- parameter	Frequency [%]
0 N	4,75	4,21	2,479	7,7
1 NNE	5,63	5,00	2,701	7,1
2 ENE	6,11	5,42	2,225	6,5
3 E	5,35	4,74	2,225	5,4
4 ESE	5,52	4,89	2,443	6,2
5 SSE	5,47	4,84	2,162	5,6
6 S	7,75	6,86	2,252	11,1
7 SSW	9,41	8,36	2,576	17,2
8 WSW	9,44	8,41	2,814	13,8
9 W	7,98	7,07	2,256	8,3
10 WNW	6,76	5,98	2,072	6,0
11 NNW	5,79	5,13	2,322	5,1
All	7,26	6,43	2,053	100,0

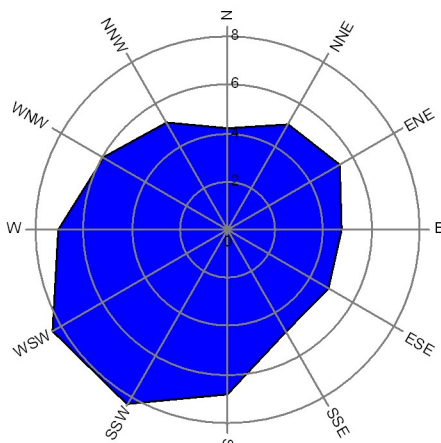
Weibull Distribution



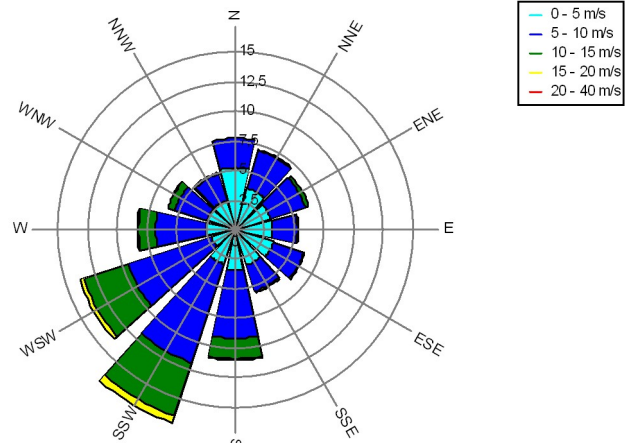
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Wind Data Analysis

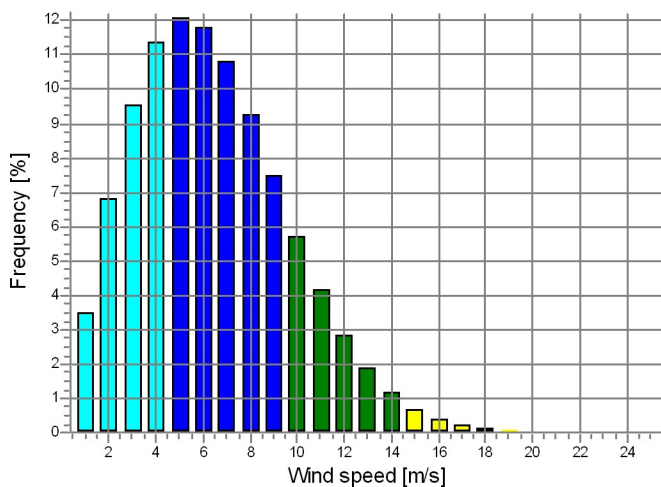
Calculation: WP De Kookepan L136 4,5MW HH132Wind data: C - De Kookepan; Hub height: 132,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 196.420 North: 366.350
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

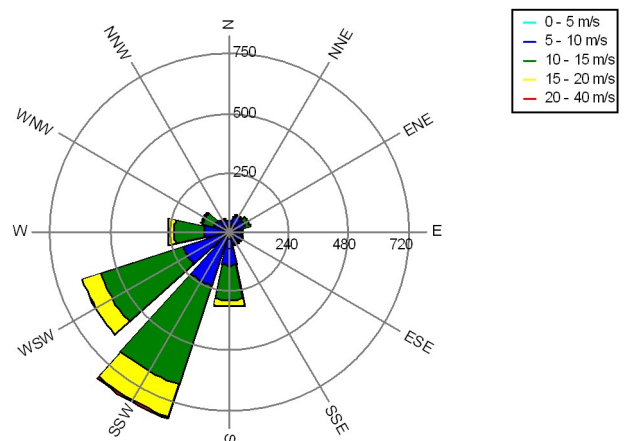
Weibull Data

Sector	Current site		k- parameter	Frequency
	A- parameter [m/s]	Wind speed [m/s]		
0 N	4,77	4,23	2,479	7,7
1 NNE	5,73	5,10	2,709	7,1
2 ENE	5,97	5,29	2,225	6,6
3 E	5,33	4,72	2,225	5,4
4 ESE	5,49	4,87	2,443	6,2
5 SSE	5,41	4,79	2,178	5,5
6 S	7,65	6,78	2,252	11,0
7 SSW	9,37	8,32	2,580	17,3
8 WSW	9,43	8,40	2,814	13,9
9 W	7,88	6,98	2,248	8,3
10 WNW	6,67	5,91	2,072	6,0
11 NNW	5,75	5,09	2,322	5,0
All	7,22	6,40	2,057	100,0

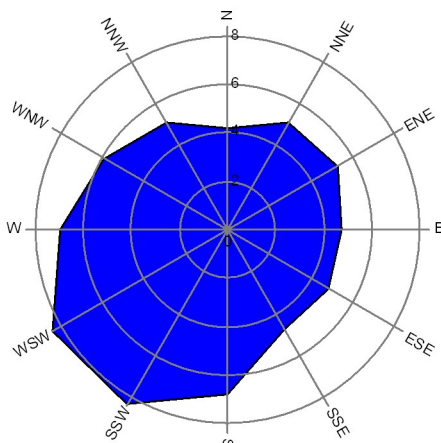
Weibull Distribution



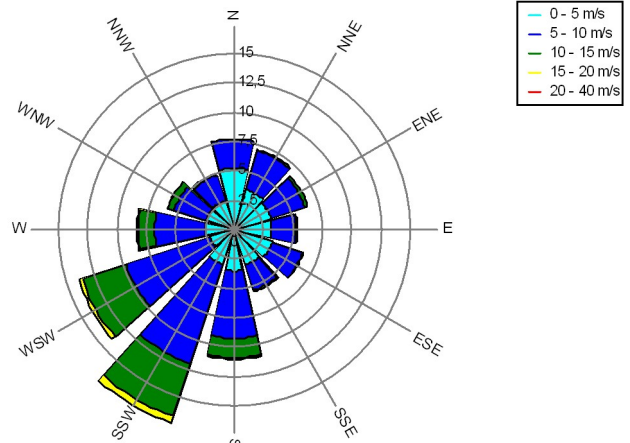
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Park power curve

Calculation: WP De Kookepan L136 4,5MW HH132

Power														
Wind speed	Free	Park	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
[m/s]	WTGs [kW]	WTGs [kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]
0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,5	12	11	12	12	12	10	5	12	12	12	12	10	3	12
3,5	504	482	504	504	504	492	341	504	504	504	504	492	328	504
4,5	1.135	1.097	1.135	1.135	1.135	1.113	859	1.135	1.135	1.135	1.135	1.113	838	1.135
5,5	2.081	2.015	2.081	2.081	2.081	2.043	1.602	2.081	2.081	2.081	2.081	2.043	1.563	2.081
6,5	3.404	3.299	3.404	3.404	3.404	3.344	2.650	3.404	3.404	3.404	3.404	3.344	2.582	3.404
7,5	5.112	4.963	5.112	5.112	5.112	5.030	4.036	5.112	5.112	5.112	5.112	5.030	3.937	5.112
8,5	7.128	6.943	7.128	7.128	7.128	7.032	5.779	7.128	7.128	7.128	7.128	7.032	5.657	7.128
9,5	9.258	9.059	9.258	9.258	9.258	9.163	7.799	9.258	9.258	9.258	9.258	9.163	7.669	9.258
10,5	11.149	10.975	11.149	11.149	11.149	11.076	9.855	11.149	11.149	11.149	11.149	11.077	9.748	11.149
11,5	12.461	12.349	12.461	12.461	12.461	12.423	11.610	12.461	12.461	12.461	12.461	12.423	11.562	12.461
12,5	13.140	13.092	13.140	13.140	13.140	13.127	12.764	13.140	13.140	13.140	13.140	13.127	12.755	13.140
13,5	13.401	13.387	13.401	13.401	13.401	13.397	13.293	13.401	13.401	13.401	13.401	13.397	13.287	13.401
14,5	13.480	13.477	13.480	13.480	13.480	13.479	13.455	13.480	13.480	13.480	13.480	13.479	13.453	13.480
15,5	13.500	13.500	13.500	13.500	13.500	13.500	13.496	13.500	13.500	13.500	13.500	13.500	13.496	13.500
16,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
17,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
18,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
19,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
20,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
21,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
22,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
23,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
24,5	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500	13.500
25,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in windPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in windPRO (PPV-model).

Note:

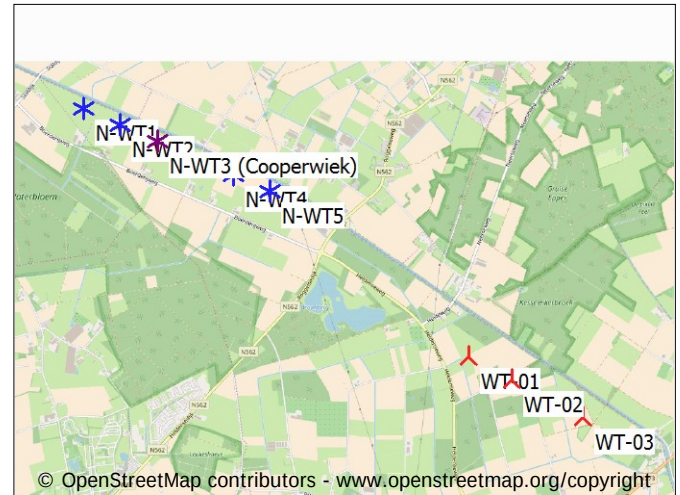
From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

PARK - WTG distances

Calculation: WP De Kookepan L136 4,5MW HH132

WTG distances

	Z	Nearest WTG	Z	Horizontal distance	Distance in rotor diameters (max)	Distance in rotor diameters (min)
	[m]		[m]	[m]		
N-WT1	29,0	N-WT2	28,9	400	4,9	4,9
N-WT2	28,9	N-WT1	29,0	400	4,9	4,9
N-WT3 (Cooperwiek)	29,7	N-WT2	28,9	400	4,9	4,3
N-WT4	28,7	N-WT5	30,4	400	4,9	4,9
N-WT5	30,4	N-WT4	28,7	400	4,9	4,9
WT-01	27,7	WT-02	30,0	488	3,6	3,6
WT-02	30,0	WT-01	27,7	488	3,6	3,6
WT-03	27,4	WT-02	30,0	798	5,9	5,9
Min	27,4		27,7	400	3,6	3,6
Max	30,4		30,4	798	5,9	5,9



Scale 1:75.000
 New WTG
 Existing WTG

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:45/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan L136 4,5MW HH132

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WASP version	WASP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WASP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WASP CFD should always use WASP CFD calculated wind statistics.

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:45/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan L136 4,5MW HH132

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WASP version	WASP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
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Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WASP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WASP CFD should always use WASP CFD calculated wind statistics.

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:45/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan L136 4,5MW HH132

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WASP version	WASP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

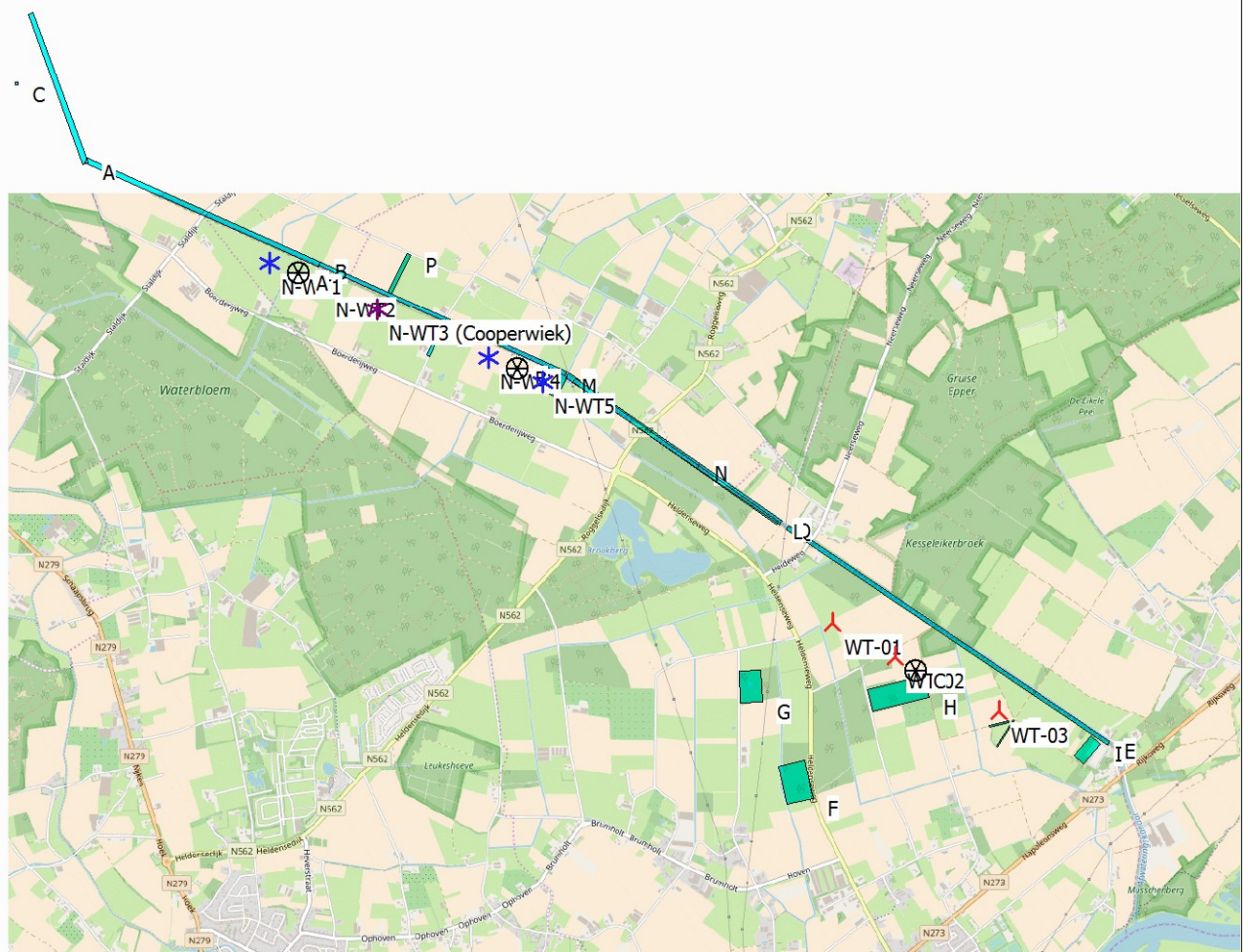
Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WASP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WASP CFD should always use WASP CFD calculated wind statistics.

PARK - Map

Calculation: WP De Kookepan L136 4,5MW HH132



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0 500 1000 1500 2000 m

Map: Open Street Map 001, Print scale 1:50.000, Map center Dutch Stereo-RD/NAP 2000 East: 194.481 North: 367.787

New WTG Existing WTG Site Data Obstacle

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:52/3.1.617

PARK - Main Result

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129

Wake Model N.O. Jensen (EMD) : 2005

Include mirror wakes

Calculation Settings

Air density calculation mode Individual per WTG
Result for WTG at hub altitude 1,224 kg/m³ to 1,228 kg/m³
Air density relative to standard 99,9 % to 100,2 %
Hub altitude above sea level (asl) 126,7 m to 159,0 m
Annual mean temperature at hub alt. 9,7 °C to 9,9 °C
Pressure at WTGs 994,0 hPa to 997,9 hPa

Wake Model Parameters

Terrain type Wake decay constant
HH:100m Mixed farmland 0,065

Displacement heights from objects

Wake calculation settings

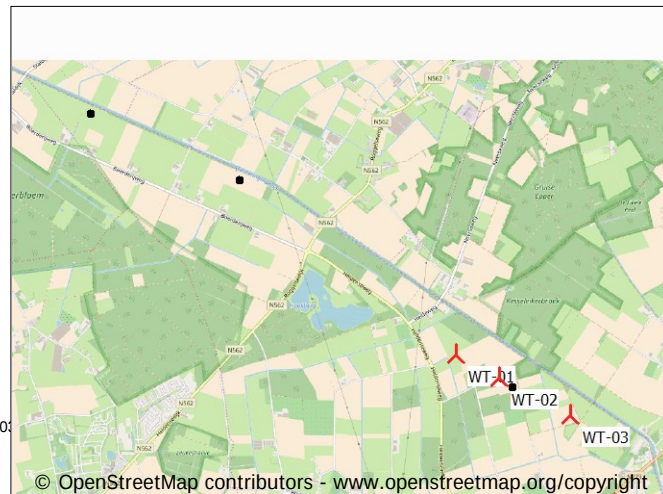
Angle [°] Wind speed [m/s]
start end step start end step
0,5 360,0 1,0 0,5 30,5 1,0

Wind statistics

KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.0

WASP version

WASP 11 Version 11.06.0012



Scale 1:75.000
New WTG

Site Data

Key results for height 100,0 m above ground level

Terrain Dutch Stereo-RD/NAP 2000

X (east) Y (north) Name of wind distribution Type

					Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	192.765	368.713	WP NEER1	WASP (WASP 11 Version 11.06.0012)	1.985	5,9	2,0
B	194.261	368.067	WP NEER2	WASP (WASP 11 Version 11.06.0012)	2.022	5,9	1,9
C	196.989	366.031	De Kookepan	WASP (WASP 11 Version 11.06.0012)	2.035	5,9	2,0

Calculated Annual Energy for Wind Farm

WTG combination	Result		GROSS (no loss) Free WTGs	Park efficiency	Specific results ^{a)}			Mean wind speed @hub height
	PARK [MWh/y]				Capacity factor	Mean WTG result	Full load hours	
			[MWh/y]	[%]	[%]	[MWh/y]	[Hours/year]	[m/s]
Wind farm	33.614,3		34.278,4	98,1	40,6	11.204,8	3.557	6,4

^{a)} Based on wake reduced results, but no other losses included

Calculated Annual Energy for each of 3 new WTGs with total 9,4 MW rated power

WTG type		Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Power curve		Annual Energy Result	Park Efficiency	Capacity factor	Free mean wind speed
Links	Links							Creator	Name				
WT-01 C	Yes	Siemens	SWT-3.15-142-3.150	3.150	142,0	129,0	EMD	Level 0 - Calculated - Std.	104.9dB - 05-2016	11.142,4	98,14	40,4	6,35
WT-02 C	Yes	Siemens	SWT-3.15-142-3.150	3.150	142,0	129,0	EMD	Level 0 - Calculated - Std.	104.9dB - 05-2016	11.112,7	97,15	40,2	6,38
WT-03 C	Yes	Siemens	SWT-3.15-142-3.150	3.150	142,0	129,0	EMD	Level 0 - Calculated - Std.	104.9dB - 05-2016	11.359,2	98,90	41,1	6,41

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

WTG siting

Dutch Stereo-RD/NAP 2000

X (east) Y (north) Z Row data/Description
[m]

WT-01 New	196.420	366.350	27,7	Siemens SWT-3.15-142 3150	142,0	129,0	EMD	Level 0 - Calculated - Std.	104.9dB - 05-2016	!O! hub: 129,0 m (TOT: 200,0 m) (12)
WT-02 New	196.853	366.126	30,0	Siemens SWT-3.15-142 3150	142,0	129,0	EMD	Level 0 - Calculated - Std.	104.9dB - 05-2016	!O! hub: 129,0 m (TOT: 200,0 m) (11)
WT-03 New	197.562	365.760	27,4	Siemens SWT-3.15-142 3150	142,0	129,0	EMD	Level 0 - Calculated - Std.	104.9dB - 05-2016	!O! hub: 129,0 m (TOT: 200,0 m) (10)

^{*}) Included in array losses is influence from 5 WTG(s) in the neighborhood, which has status as "Reference WTGs", see separate report to identify these.

PARK - Reference WTGs

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129

Wake Model N.O. Jensen (EMD) : 2005

Include mirror wakes

Calculation Settings

Calculation Settings	
Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	1,224 kg/m³ to 1,228 kg/m³
Air density relative to standard	99,9 % to 100,2 %
Hub altitude above sea level (asl)	126,7 m to 159,0 m
Annual mean temperature at hub alt.	9,7 °C to 9,9 °C
Pressure at WTGs	994,0 hPa to 997,9 hPa

Wake Model Parameters

Terrain type	Wake decay constant
HH:100m Mixed farmland	0.065

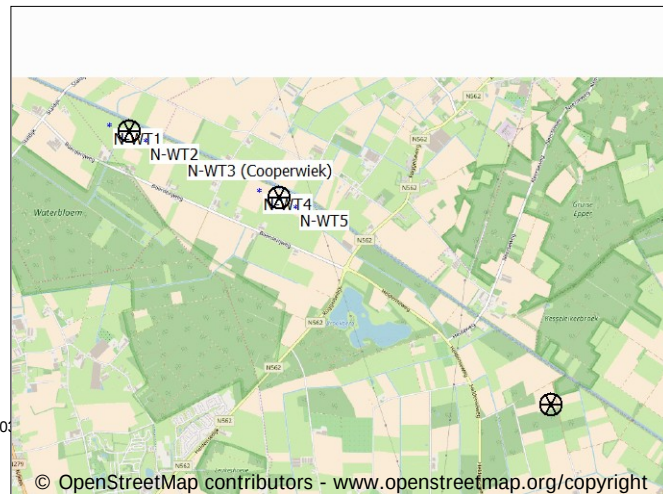
Displacement heights from objects

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0.5	360.0	1.0	0.5	30.5	1.0

Wind statistics KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.027

WASP version WASP 11 Version 11.06.0012



Scale 1:75 000

 New WTG

* Existing WTG

 Site Data

Key results for height 100,0 m above ground level

Terrain Dutch Stereo-RD/NAP 2000

X (east)	Y (north)	Name of wind distribution	Type
----------	-----------	---------------------------	------

	X (east)	Y (north)	Name of wind distribution	Type	Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	192.765	368.713	WP NEER1	WASP (WASP 11 Version 11.06.0012)	1.985	5,9	2,0
B	194.261	368.067	WP NEER2	WASP (WASP 11 Version 11.06.0012)	2.022	5,9	1,9
C	196.989	366.031	De Kookepan	WASP (WASP 11 Version 11.06.0012)	2.035	5,9	2,0

Calculated Annual Energy for reference WTGs

Overall results			Specific results				Overall results		
Calculated prod. without new WTGs	GROSS (no loss) Free WTGs	Park efficiency	Capacity factor	Mean WTG result	Full load hours	Mean wind speed @hub height	Actual wind corrected energy	Goodness Factor	
[MWh]	[MWh/y]	[%]	[%]	[MWh/y]	[Hours/year]	[m/s]	[MWh]	[%]	
22.292.8	22.766.6	97.9	21.6	4.458.6	1.897	5.9	0.0	0.0	

Calculated Annual Energy for each of 5 reference WTGs with total 11,8 MW rated power

	Links	WTG type			Power, rated	Rotor diameter	Hub height	Power curve		Calculated prod. without new WTGs	Goodness Factor
		Valid	Manufact.	Type-generator				Creator	Name		
N-WT3 (Cooperwiek)	N-WT1 A	Yes	ENERCON	E-82 E4-2.350	[kW]	[m]	[m]	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.370,3	0
	N-WT2 A	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.262,3	0
	N-WT3 (Cooperwiek) A	Yes	ENERCON	E-92 2,3 MW-2.350	2.350	92,0	98,4	EMD	Level 0 - official - 2350kW - 02/2014	4.953,1	0
	N-WT4 B	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.341,6	0
	N-WT5 B	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.365,3	0

WTG siting

Dutch Stereo-RD/NAP 2000

X (east)	Y (north)	Z	Row data/Description
----------	-----------	---	----------------------

Product
source

Statistical
basis for
normalized
production:
[Months]

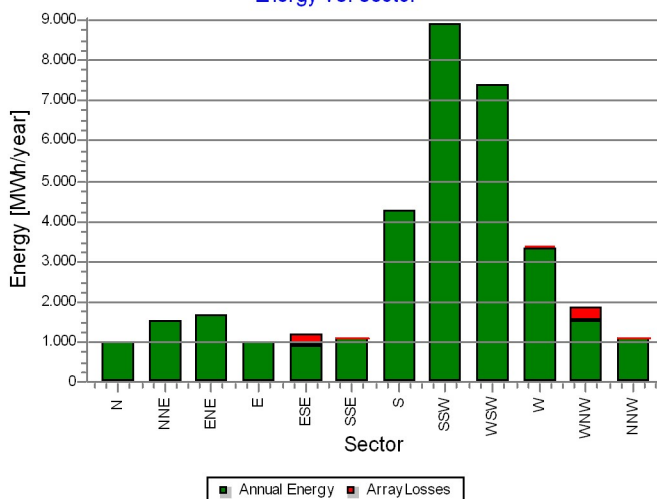
		[m]			
	N-WT1	192.568	368.782	29,0	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (6)
	N-WT2	192.935	368.624	28,9	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (7)
N-WT3 (Cooperwiek)		193.303	368.468	29,7	ENERCON E-92 2,3 MW 2350 92.0 !-! hub: 98,4 m (TOT: 144,4 m) (10)
	N-WT4	194.064	368.140	28,4	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (8)
	N-WT5	194.430	367.980	30,7	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (9)

PARK - Production Analysis

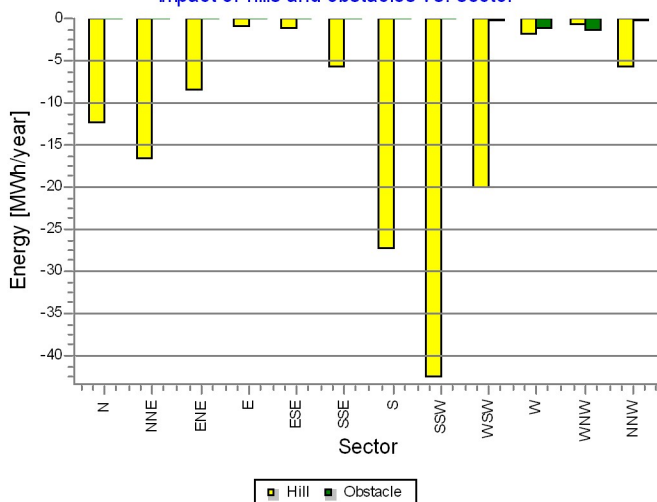
Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129WTG: All new WTGs, Air density varies with WTG position 1,224 kg/m³ - 1,228 kg/m³
 Directional Analysis

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]	994,4	1.510,4	1.678,5	993,1	1.199,2	1.082,1	4.293,1	8.954,2	7.405,8	3.379,2	1.842,2	1.096,2	34.428,4
-Decrease due to obstacles [MWh]	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,2	0,4	1,3	1,7	0,4	4,2
+Increase due to hills [MWh]	-12,6	-16,9	-8,6	-1,2	-1,3	-6,0	-27,5	-42,7	-20,2	-2,0	-1,0	-5,9	-145,9
-Decrease due to array losses [MWh]	0,0	0,0	0,0	19,3	280,3	0,1	0,0	0,0	0,0	35,7	328,7	0,1	664,1
Resulting energy [MWh]	981,9	1.493,5	1.670,0	972,6	917,5	1.076,1	4.265,5	8.911,3	7.385,2	3.340,2	1.510,9	1.089,8	33.614,3
Specific energy [kWh/m ²]													708
Specific energy [kWh/kW]													3.557
Decrease due to obstacles [%]	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,01
Increase due to hills [%]	-1,3	-1,1	-0,5	-0,1	-0,1	-0,6	-0,6	-0,5	-0,3	-0,1	-0,1	-0,5	-0,42
Decrease due to array losses [%]	0,0	0,0	0,0	1,9	23,4	0,0	0,0	0,0	0,0	1,1	17,9	0,0	1,94
Utilization [%]	43,5	42,6	37,1	40,1	32,1	40,0	28,4	22,9	24,6	26,8	26,1	40,1	27,3
Operational [Hours/year]	630	578	537	438	505	451	899	1.403	1.134	678	490	410	8.152
Full Load Equivalent [Hours/year]	104	158	177	103	97	114	451	943	782	353	160	115	3.557

Energy vs. sector



Impact of hills and obstacles vs. sector

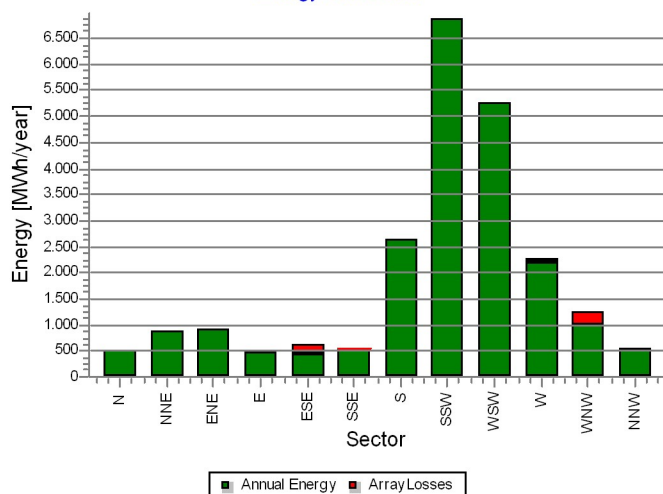


PARK - Production Analysis

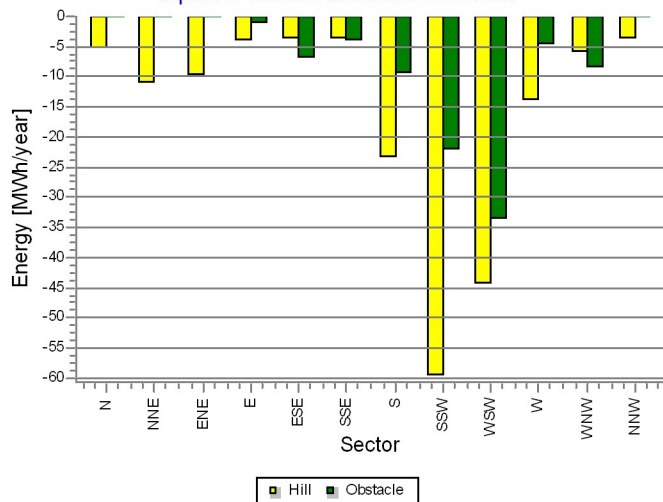
Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129WTG: All existing WTGs, Air density varies with WTG position 1,224 kg/m³ - 1,228 kg/m³
 Directional Analysis

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]	513,5	884,5	927,7	501,5	631,2	548,6	2.663,2	6.952,3	5.326,6	2.277,8	1.251,4	569,7	23.048,0
-Decrease due to obstacles	[MWh]	0,0	0,0	0,0	1,2	7,1	4,1	9,5	22,4	33,6	4,9	8,7	0,4	91,9
+Increase due to hills	[MWh]	-5,5	-11,1	-9,8	-4,0	-3,7	-3,8	-23,4	-59,7	-44,6	-14,0	-5,9	-3,9	-189,5
-Decrease due to array losses	[MWh]	0,0	0,0	0,0	22,4	165,3	0,0	0,0	0,0	0,0	73,0	237,0	0,0	497,8
Resulting energy	[MWh]	508,0	873,4	917,8	473,8	455,2	540,7	2.630,4	6.870,2	5.248,4	2.185,9	999,7	565,3	22.268,8
Specific energy	[kWh/m ²]													802
Specific energy	[kWh/kW]													1.895
Decrease due to obstacles	[%]	0,0	0,0	0,0	0,2	1,1	0,8	0,4	0,3	0,6	0,2	0,7	0,1	0,40
Increase due to hills	[%]	-1,1	-1,3	-1,1	-0,8	-0,6	-0,7	-0,9	-0,9	-0,8	-0,6	-0,5	-0,7	-0,82
Decrease due to array losses	[%]	0,0	0,0	0,0	4,5	26,6	0,0	0,0	0,0	0,0	3,2	19,2	0,0	2,19
Utilization	[%]	44,8	46,5	45,9	43,7	33,8	45,9	43,6	38,6	41,4	40,4	35,0	46,2	40,8
Operational	[Hours/year]	660	613	564	460	531	475	966	1.483	1.186	711	520	431	8.598
Full Load Equivalent	[Hours/year]	43	74	78	40	39	46	224	585	447	186	85	48	1.895

Energy vs. sector



Impact of hills and obstacles vs. sector



Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:52/3.1.617

PARK - Terrain

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129Site Data: C - De Kookepan

Obstacles:

17 Obstacles used

Roughness:

Terrain data files used in calculation:

P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\ROUGHNESSLINE_ONLINEDATA_0.wpo

Min X: 164.636, Max X: 227.062, Min Y: 334.874, Max Y: 398.555, Width: 62.426 m, Height: 63.681 m

Orography:

Terrain data files used in calculation:

P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\717130 Productie_EMDGrid_0.wpg

Min X: 176.541, Max X: 216.980, Min Y: 346.612, Max Y: 386.959, Width: 40.438 m, Height: 40.347 m

PARK - Wind Data Analysis

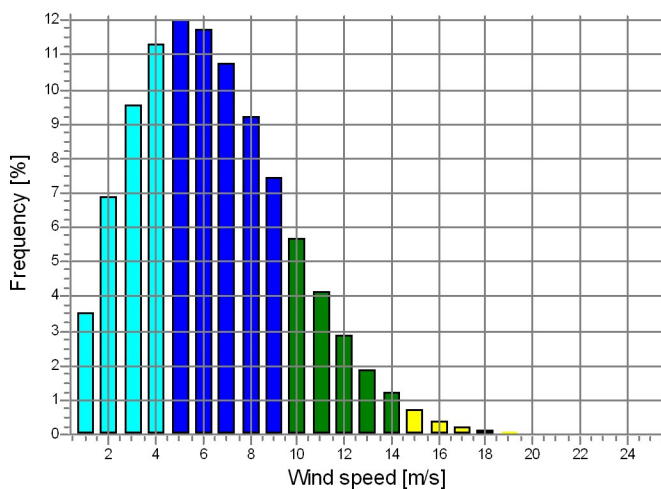
Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129 Wind data: C - De Kookepan; Hub height: 129,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 197.562 North: 365.760
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (10)
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

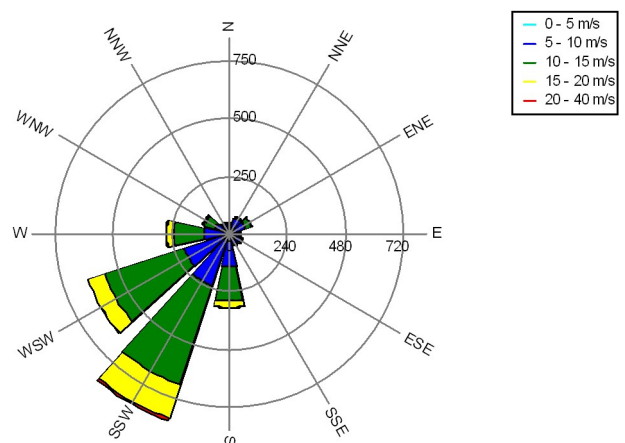
Weibull Data

Sector	Current site		k- parameter	Frequency
	A- parameter	Wind speed		
	[m/s]	[m/s]		[%]
0 N	4,64	4,12	2,490	7,7
1 NNE	5,82	5,17	2,721	7,1
2 ENE	6,19	5,48	2,225	6,6
3 E	5,24	4,64	2,232	5,4
4 ESE	5,41	4,80	2,447	6,2
5 SSE	5,33	4,72	2,186	5,5
6 S	7,69	6,81	2,252	11,0
7 SSW	9,45	8,39	2,568	17,2
8 WSW	9,38	8,36	2,822	14,0
9 W	7,99	7,08	2,260	8,3
10 WNW	6,66	5,90	2,076	6,0
11 NNW	5,58	4,94	2,346	5,0
All	7,23	6,41	2,045	100,0

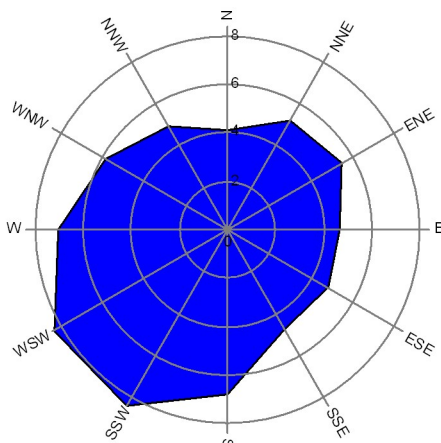
Weibull Distribution



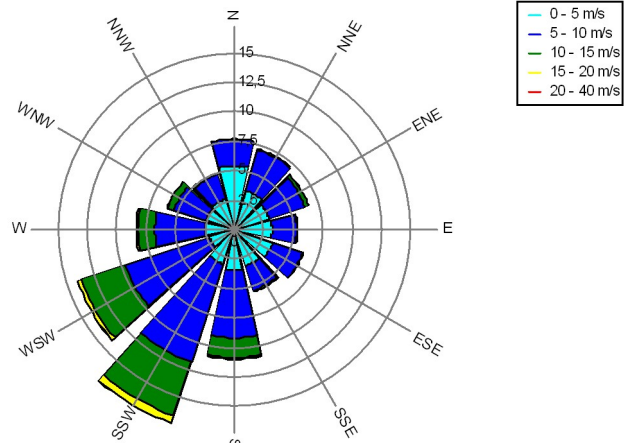
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Wind Data Analysis

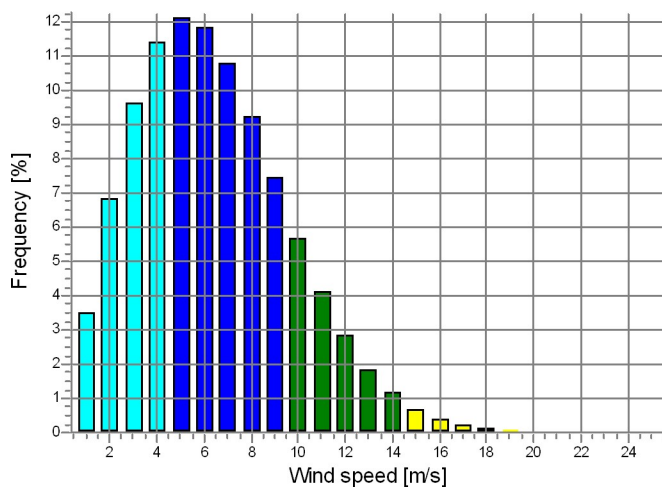
Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129 Wind data: C - De Kookepan; Hub height: 129,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 196.853 North: 366.126
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (11)
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

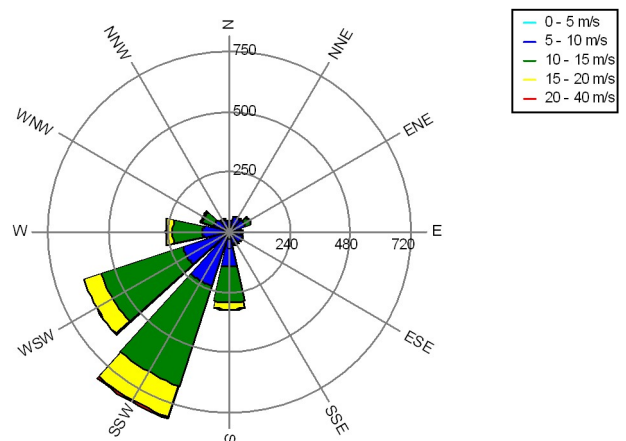
Weibull Data

Sector	Current site		k- parameter	Frequency [%]
	A- parameter [m/s]	Wind speed [m/s]		
0 N	4,72	4,18	2,482	7,7
1 NNE	5,58	4,96	2,705	7,1
2 ENE	6,07	5,38	2,225	6,5
3 E	5,31	4,71	2,229	5,4
4 ESE	5,48	4,86	2,447	6,2
5 SSE	5,44	4,82	2,166	5,6
6 S	7,70	6,82	2,256	11,1
7 SSW	9,34	8,30	2,580	17,2
8 WSW	9,38	8,35	2,818	13,8
9 W	7,93	7,02	2,260	8,3
10 WNW	6,71	5,94	2,076	6,0
11 NNW	5,75	5,10	2,326	5,1
All	7,21	6,38	2,057	100,0

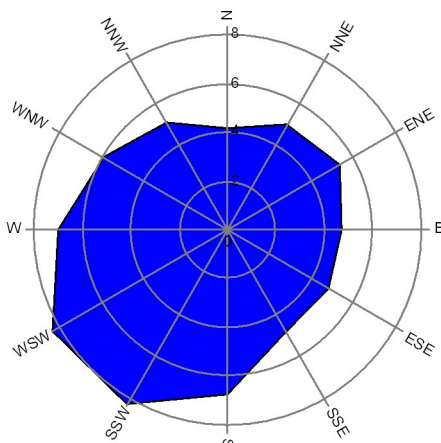
Weibull Distribution



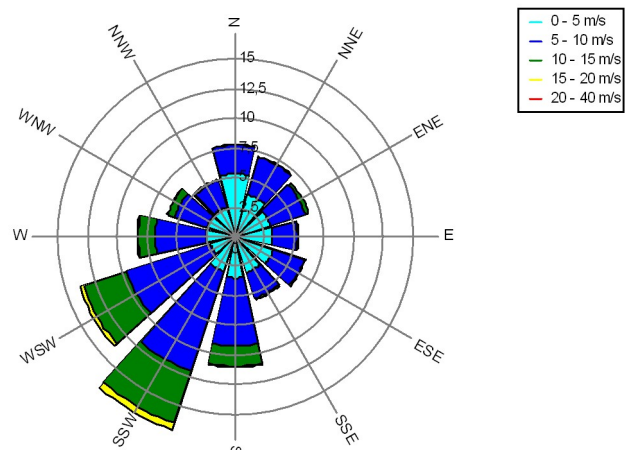
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Wind Data Analysis

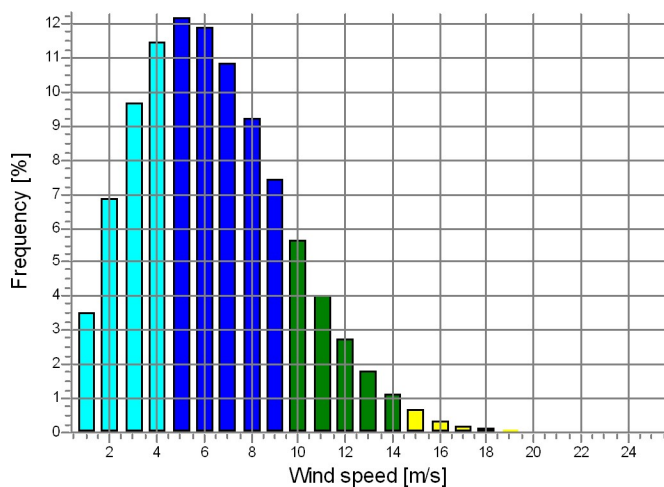
Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129 Wind data: C - De Kookepan; Hub height: 129,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 196.420 North: 366.350
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (12)
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

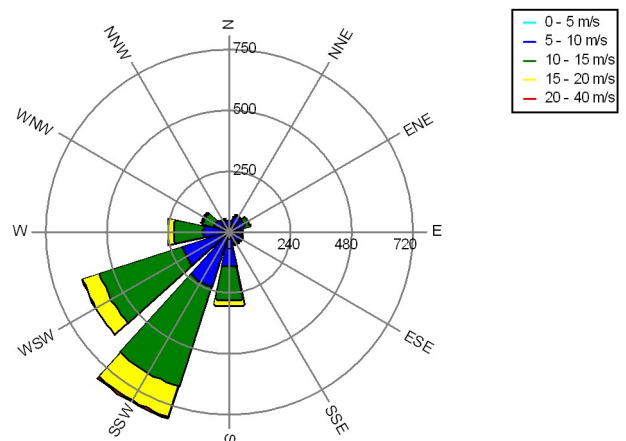
Weibull Data

Sector	Current site		k- parameter	Frequency [%]
	A- parameter [m/s]	Wind speed [m/s]		
0 N	4,73	4,20	2,482	7,7
1 NNE	5,69	5,06	2,713	7,1
2 ENE	5,93	5,25	2,229	6,6
3 E	5,30	4,69	2,229	5,4
4 ESE	5,46	4,85	2,447	6,2
5 SSE	5,38	4,76	2,178	5,5
6 S	7,60	6,73	2,256	11,0
7 SSW	9,31	8,27	2,584	17,3
8 WSW	9,36	8,34	2,818	13,9
9 W	7,82	6,93	2,252	8,3
10 WNW	6,62	5,87	2,076	6,0
11 NNW	5,71	5,06	2,326	5,0
All	7,17	6,35	2,061	100,0

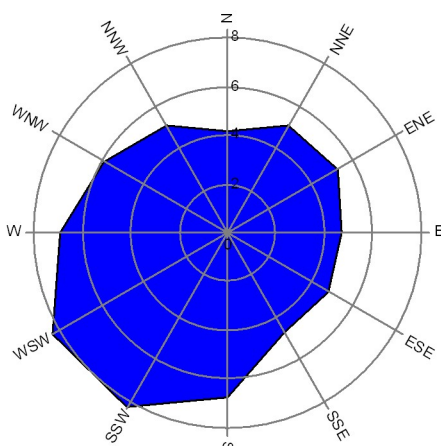
Weibull Distribution



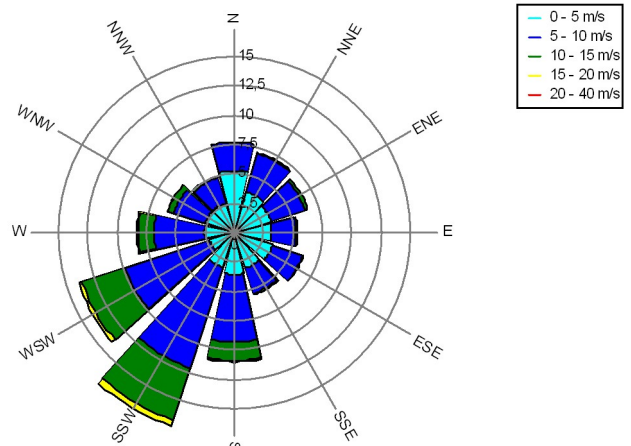
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Park power curve

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129

Wind speed [m/s]	Power													
	Free WTGs [kW]	Park WTGs [kW]	N [kW]	NNE [kW]	ENE [kW]	E [kW]	ESE [kW]	SSE [kW]	S [kW]	SSW [kW]	WSW [kW]	W [kW]	WNW [kW]	NNW [kW]
0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,5	83	80	82	82	82	81	66	82	82	82	82	81	63	82
3,5	441	420	441	441	441	425	287	441	441	441	441	425	280	441
4,5	1.182	1.132	1.182	1.182	1.182	1.148	821	1.182	1.182	1.182	1.182	1.148	796	1.182
5,5	2.276	2.189	2.275	2.275	2.275	2.220	1.652	2.275	2.275	2.275	2.275	2.220	1.609	2.275
6,5	3.735	3.602	3.735	3.735	3.735	3.650	2.781	3.735	3.735	3.735	3.735	3.650	2.711	3.735
7,5	5.586	5.402	5.586	5.586	5.586	5.472	4.254	5.586	5.586	5.586	5.586	5.472	4.157	5.586
8,5	7.527	7.323	7.527	7.527	7.527	7.419	6.024	7.527	7.527	7.527	7.527	7.419	5.928	7.527
9,5	8.859	8.715	8.859	8.859	8.859	8.807	7.757	8.859	8.859	8.859	8.859	8.808	7.710	8.859
10,5	9.353	9.306	9.353	9.353	9.353	9.343	8.965	9.352	9.353	9.353	9.353	9.344	8.991	9.352
11,5	9.443	9.438	9.443	9.443	9.443	9.442	9.409	9.443	9.443	9.443	9.443	9.442	9.404	9.443
12,5	9.450	9.450	9.450	9.450	9.450	9.450	9.448	9.450	9.450	9.450	9.450	9.450	9.448	9.450
13,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
14,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
15,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
16,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
17,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
18,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
19,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
20,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
21,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
22,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
23,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
24,5	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450	9.450
25,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in windPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in windPRO (PPV-model).

Note:

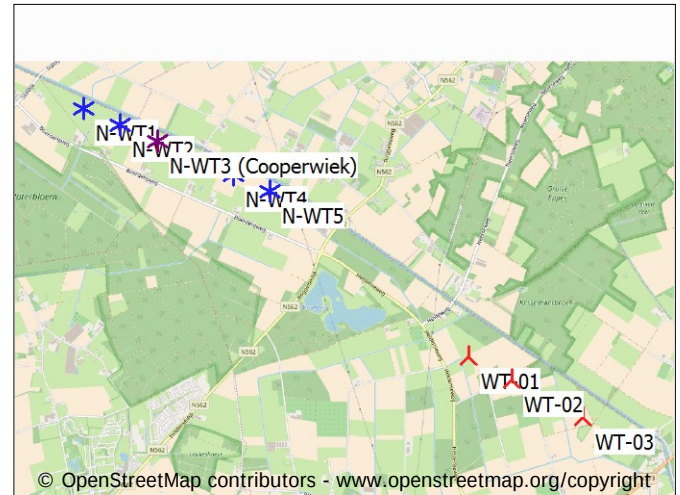
From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

PARK - WTG distances

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129

WTG distances

	Z	Nearest WTG	Z	Horizontal distance	Distance in rotor diameters (max)	Distance in rotor diameters (min)
	[m]		[m]	[m]		
N-WT1	29,0	N-WT2	28,9	400	4,9	4,9
N-WT2	28,9	N-WT1	29,0	400	4,9	4,9
N-WT3 (Cooperwiek)	29,7	N-WT2	28,9	400	4,9	4,3
N-WT4	28,7	N-WT5	30,4	400	4,9	4,9
N-WT5	30,4	N-WT4	28,7	400	4,9	4,9
WT-01	27,7	WT-02	30,0	488	3,4	3,4
WT-02	30,0	WT-01	27,7	488	3,4	3,4
WT-03	27,4	WT-02	30,0	798	5,6	5,6
Min	27,4		27,7	400	3,4	3,4
Max	30,4		30,4	798	5,6	5,6



Scale 1:75.000
 New WTG
 Existing WTG

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:52/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WAsP version	WAsP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WAsP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WAsP CFD should always use WAsP CFD calculated wind statistics.

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 16:52/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WASP version	WASP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WASP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WASP CFD should always use WASP CFD calculated wind statistics.

PARK - Wind statistics info

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WASP version	WASP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

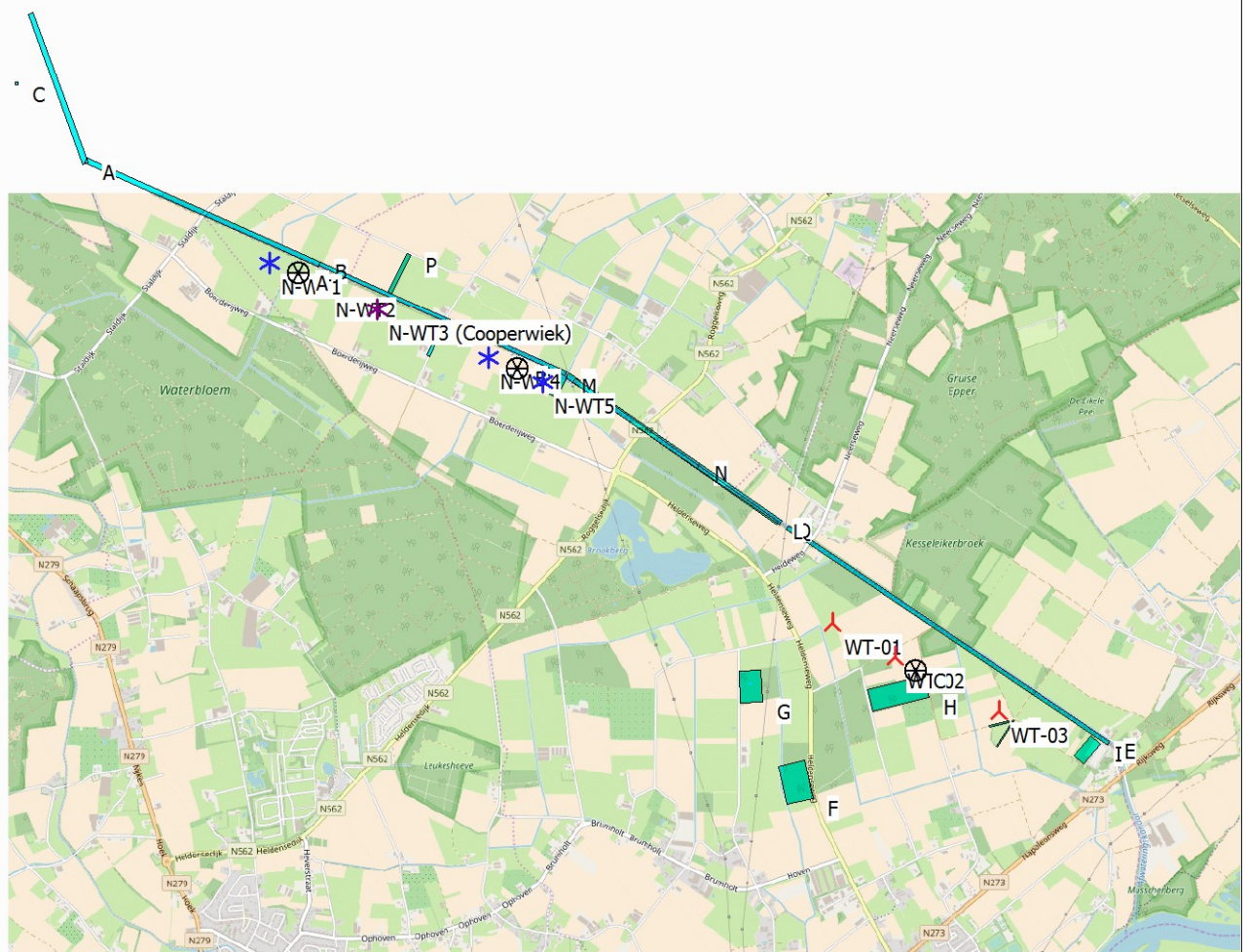
Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WASP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WASP CFD should always use WASP CFD calculated wind statistics.

PARK - Map

Calculation: WP De Kookepan SWT-3.15-142 3,15MW HH129



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0 500 1000 1500 2000 m

Map: Open Street Map 001, Print scale 1:50.000, Map center Dutch Stereo-RD/NAP 2000 East: 194.481 North: 367.787

New WTG Existing WTG Site Data Obstacle

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 17:01/3.1.617

PARK - Main Result

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129

Wake Model N.O. Jensen (EMD) : 2005

Include mirror wakes

Calculation Settings

Air density calculation mode Individual per WTG
Result for WTG at hub altitude 1,224 kg/m³ to 1,228 kg/m³
Air density relative to standard 99,9 % to 100,2 %
Hub altitude above sea level (asl) 126,7 m to 159,0 m
Annual mean temperature at hub alt. 9,7 °C to 9,9 °C
Pressure at WTGs 994,0 hPa to 997,9 hPa

Wake Model Parameters

Terrain type Wake decay constant
HH:100m Mixed farmland 0,065

Displacement heights from objects

Wake calculation settings

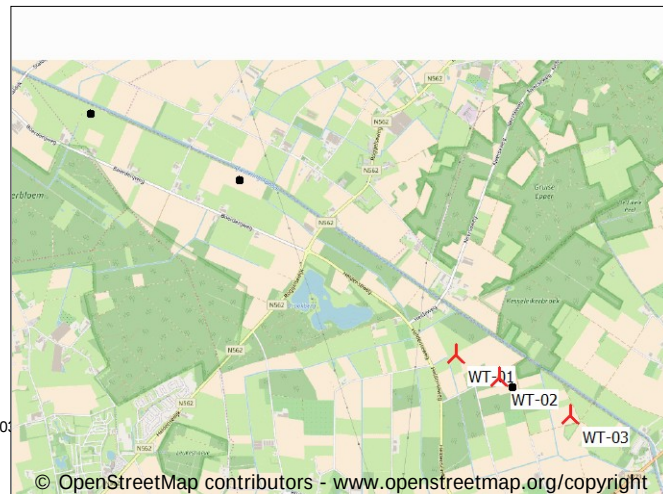
Angle [°] Wind speed [m/s]
start end step start end step
0,5 360,0 1,0 0,5 30,5 1,0

Wind statistics

KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.0

WASP version

WASP 11 Version 11.06.0012



Scale 1:75.000

New WTG

Site Data

Key results for height 100,0 m above ground level

Terrain Dutch Stereo-RD/NAP 2000

X (east) Y (north) Name of wind distribution Type

					Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	192.765	368.713	WP NEER1	WASP (WASP 11 Version 11.06.0012)	1.985	5,9	2,0
B	194.261	368.067	WP NEER2	WASP (WASP 11 Version 11.06.0012)	2.022	5,9	1,9
C	196.989	366.031	De Kookepan	WASP (WASP 11 Version 11.06.0012)	2.035	5,9	2,0

Calculated Annual Energy for Wind Farm

WTG combination	Result		GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results ^{a)}			Mean wind speed @hub height [m/s]
	PARK				Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	
Wind farm	37.444,7		38.190,0	98,0	36,5	12.481,6	3.200	6,4

^{a)} Based on wake reduced results, but no other losses included

Calculated Annual Energy for each of 3 new WTGs with total 11,7 MW rated power

Links	WTG type		Type-generator	Power, rated	Rotor diameter	Hub height	Power curve		Annual Energy Result	Park Efficiency	Capacity factor	Free mean wind speed
	Valid	Manufact.					Creator	Name				
				[kW]	[m]	[m]			[MWh]	[%]	[%]	[m/s]
WT-01 C	Yes	Siemens	SWT-DD-142-3.900	3.900	142,0	129,0	EMD	Mode 1 - Calculated - Std. 107dB - 9-2017	12.408,4	98,18	36,3	6,35
WT-02 C	Yes	Siemens	SWT-DD-142-3.900	3.900	142,0	129,0	EMD	Mode 1 - Calculated - Std. 107dB - 9-2017	12.375,9	97,11	36,2	6,38
WT-03 C	Yes	Siemens	SWT-DD-142-3.900	3.900	142,0	129,0	EMD	Mode 1 - Calculated - Std. 107dB - 9-2017	12.660,4	98,86	37,0	6,41

Annual Energy results do not include any losses apart from wake losses. For expected NET AEP (expected sold production), see report Loss & Uncertainty.

WTG siting

Dutch Stereo-RD/NAP 2000

X (east) Y (north) Z Row data/Description
[m]

WT-01 New	196.420	366.350	27,7	Siemens SWT-DD-142 3900	142,0	!O! hub: 129,0 m (TOT: 200,0 m) (15)
WT-02 New	196.853	366.126	30,0	Siemens SWT-DD-142 3900	142,0	!O! hub: 129,0 m (TOT: 200,0 m) (14)
WT-03 New	197.562	365.760	27,4	Siemens SWT-DD-142 3900	142,0	!O! hub: 129,0 m (TOT: 200,0 m) (13)

^{*}) Included in array losses is influence from 5 WTG(s) in the neighborhood, which has status as "Reference WTGs", see separate report to identify these.

PARK - Reference WTGs

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129

Wake Model N.O. Jensen (EMD) : 2005

Include mirror wakes

Calculation Settings

Calculation Settings	
Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	1,224 kg/m ³ to 1,228 kg/m ³
Air density relative to standard	99,9 % to 100,2 %
Hub altitude above sea level (asl)	126,7 m to 159,0 m
Annual mean temperature at hub alt.	9,7 °C to 9,9 °C
Pressure at WTGs	994,0 hPa to 997,9 hPa

Wake Model Parameters

Terrain type	Wake decay constant
HH:100m Mixed farmland	0,065

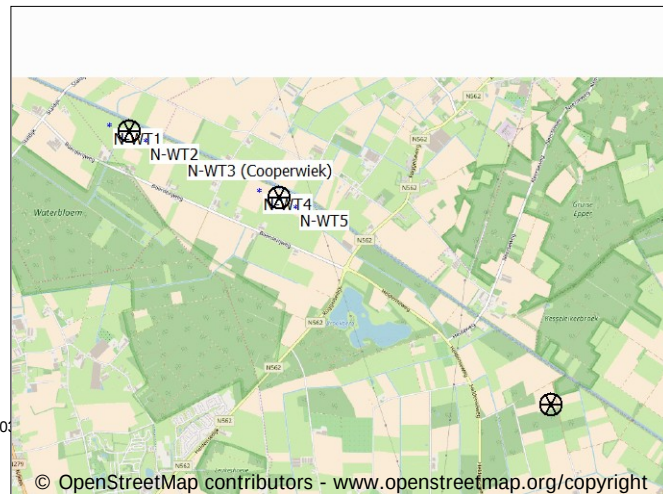
Displacement heights from objects

Wake calculation settings

Angle [°]			Wind speed [m/s]		
start	end	step	start	end	step
0,5	360,0	1,0	0,5	30,5	1,0

Wind statistics KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.027

WASP version WASP 11 Version 11.06.0012



Scale 1:75.000

 New WTG

* Existing WTG

 Site Data

Key results for height 100,0 m above ground level

Terrain Dutch Stereo-RD/NAP 2000

X (east)	Y (north)	Name of wind distribution	Type
----------	-----------	---------------------------	------

	X (east)	Y (north)	Name of wind distribution	Type	Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	192.765	368.713	WP NEER1	WASP (WASP 11 Version 11.06.0012)	1.985	5,9	2,0
B	194.261	368.067	WP NEER2	WASP (WASP 11 Version 11.06.0012)	2.022	5,9	1,9
C	196.989	366.031	De Kookepan	WASP (WASP 11 Version 11.06.0012)	2.035	5,9	2,0

Calculated Annual Energy for reference WTGs

Overall results			Specific results				Overall results		
Calculated prod. without new WTGs	GROSS (no loss) Free WTGs	Park efficiency	Capacity factor	Mean WTG result	Full load hours	Mean wind speed @hub height	Actual wind corrected energy	Goodness Factor	
[MWh]	[MWh/y]	[%]	[%]	[MWh/y]	[Hours/year]	[m/s]	[MWh]	[%]	
22.292.8	22.766.6	97.9	21.6	4.458.6	1.897	5.9	0.0	0.0	

Calculated Annual Energy for each of 5 reference WTGs with total 11,8 MW rated power

	Links	WTG type			Power, rated	Rotor diameter	Hub height	Power curve		Calculated prod. without new WTGs	Goodness Factor
		Valid	Manufact.	Type-generator				Creator	Name		
					[kW]	[m]	[m]			[MWh]	[%]
N-WT3 (Cooperwiek)	N-WT1 A	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.370,3	0
	N-WT2 A	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.262,3	0
	N-WT3 (Cooperwiek) A	Yes	ENERCON	E-92 2,3 MW-2.350	2.350	92,0	98,4	EMD	Level 0 - official - 2350kW - 02/2014	4.953,1	0
	N-WT4 B	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.341,6	0
	N-WT5 B	Yes	ENERCON	E-82 E4-2.350	2.350	82,0	98,0	EMD	Level 0 - 2350kW - official - OM 0 - 2350kW - 06/2015	4.365,3	0

WTG siting

Dutch Stereo-RD/NAP 2000

X (east)	Y (north)	Z	Row data/Description
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Product
source

Statistical
basis for
normalized
production:
[Months]

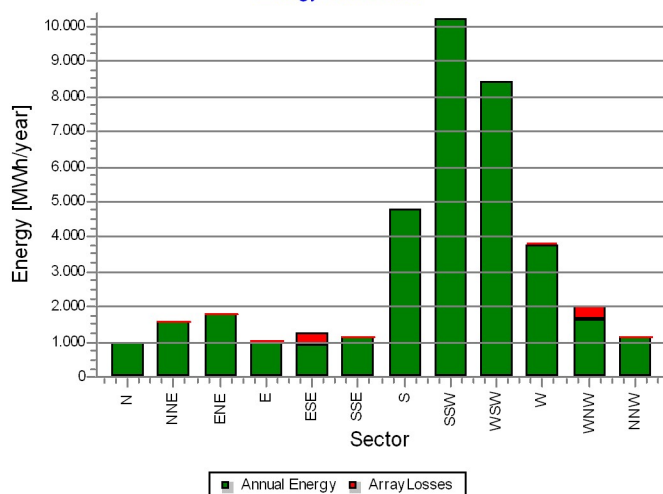
		[m]			
	N-WT1	192.568	368.782	29,0	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (6)
	N-WT2	192.935	368.624	28,9	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (7)
N-WT3 (Cooperwiek)		193.303	368.468	29,7	ENERCON E-92 2,3 MW 2350 92.0 !-! hub: 98,4 m (TOT: 144,4 m) (10)
	N-WT4	194.064	368.140	28,4	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (8)
	N-WT5	194.430	367.980	30,7	ENERCON E-82 E4 2350 82.0 !O! hub: 98,0 m (TOT: 139,0 m) (9)

PARK - Production Analysis

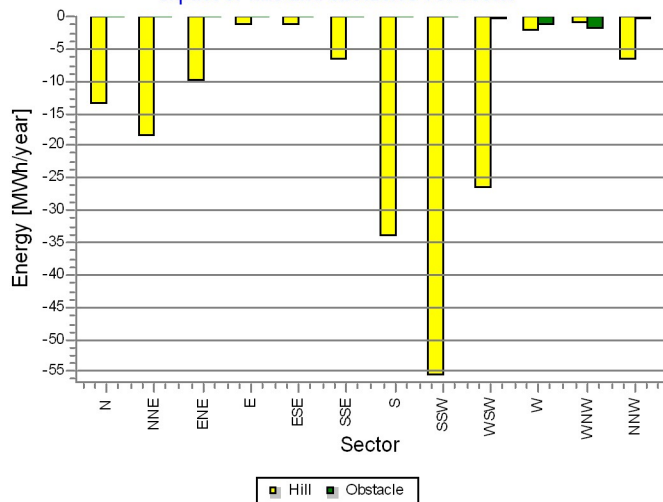
Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129WTG: All new WTGs, Air density varies with WTG position 1,224 kg/m³ - 1,228 kg/m³
Directional Analysis

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]	1.013,5	1.578,1	1.804,3	1.041,4	1.253,3	1.141,5	4.801,9	10.278,6	8.479,8	3.796,9	2.025,0	1.159,4	38.373,7
-Decrease due to obstacles	[MWh]	0,0	0,0	0,0	0,0	0,2	0,0	0,1	0,3	0,5	1,6	2,0	0,5	5,1
+Increase due to hills	[MWh]	-13,5	-18,8	-9,9	-1,3	-1,4	-6,7	-34,1	-55,7	-26,6	-2,5	-1,2	-6,7	-178,6
-Decrease due to array losses	[MWh]	0,0	0,0	0,0	21,0	302,4	0,1	0,0	0,0	0,0	42,7	379,1	0,1	745,3
Resulting energy	[MWh]	1.000,0	1.559,3	1.794,4	1.019,0	949,3	1.134,7	4.767,7	10.222,6	8.452,7	3.750,1	1.642,8	1.152,1	37.444,7
Specific energy	[kWh/m ²]													788
Specific energy	[kWh/kW]													3.200
Decrease due to obstacles	[%]	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,01
Increase due to hills	[%]	-1,3	-1,2	-0,6	-0,1	-0,1	-0,6	-0,7	-0,5	-0,3	-0,1	-0,1	-0,6	-0,47
Decrease due to array losses	[%]	0,0	0,0	0,0	2,0	24,2	0,0	0,0	0,0	0,0	1,1	18,7	0,0	1,95
Utilization	[%]	44,3	44,5	39,9	42,0	33,2	42,2	31,8	26,2	28,1	30,1	28,3	42,4	30,4
Operational	[Hours/year]	630	578	537	438	505	451	899	1.403	1.134	678	490	410	8.152
Full Load Equivalent	[Hours/year]	85	133	153	87	81	97	407	874	722	321	140	98	3.200

Energy vs. sector



Impact of hills and obstacles vs. sector

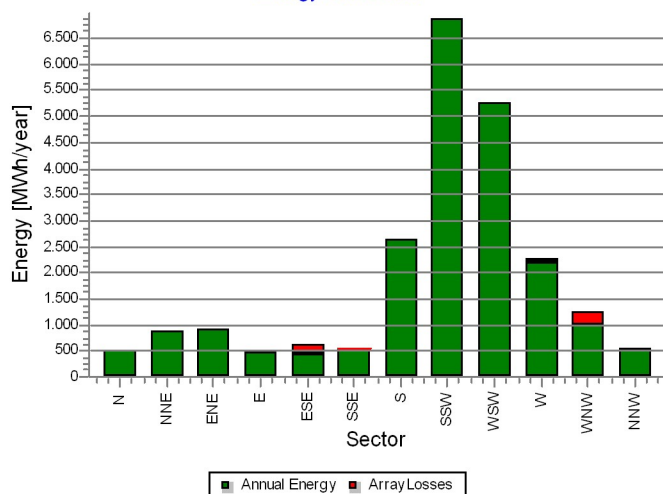


PARK - Production Analysis

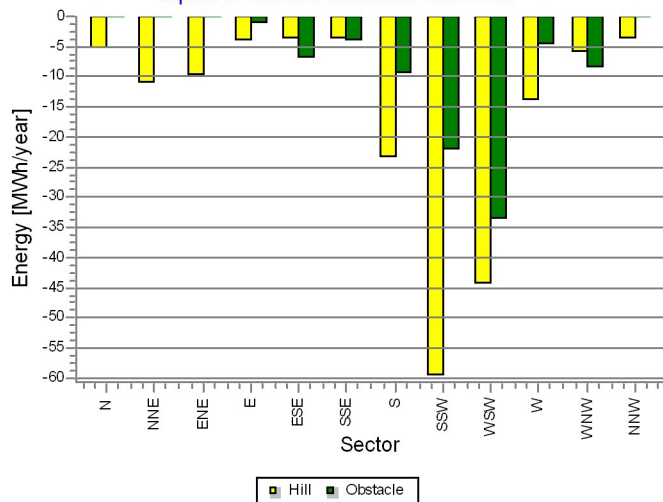
Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129WTG: All existing WTGs, Air density varies with WTG position 1,224 kg/m³ - 1,228 kg/m³
Directional Analysis

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]	513,5	884,5	927,7	501,5	631,2	548,6	2.663,2	6.952,3	5.326,6	2.277,8	1.251,4	569,7	23.048,0
-Decrease due to obstacles	[MWh]	0,0	0,0	0,0	1,2	7,1	4,1	9,5	22,4	33,6	4,9	8,7	0,4	91,9
+Increase due to hills	[MWh]	-5,5	-11,1	-9,8	-4,0	-3,7	-3,8	-23,4	-59,7	-44,6	-14,0	-5,9	-3,9	-189,5
-Decrease due to array losses	[MWh]	0,0	0,0	0,0	22,4	165,0	0,0	0,0	0,0	0,0	73,0	237,0	0,0	497,5
Resulting energy	[MWh]	508,0	873,4	917,8	473,8	455,4	540,7	2.630,4	6.870,2	5.248,4	2.185,9	999,7	565,3	22.269,1
Specific energy	[kWh/m ²]													802
Specific energy	[kWh/kW]													1.895
Decrease due to obstacles	[%]	0,0	0,0	0,0	0,2	1,1	0,8	0,4	0,3	0,6	0,2	0,7	0,1	0,40
Increase due to hills	[%]	-1,1	-1,3	-1,1	-0,8	-0,6	-0,7	-0,9	-0,9	-0,8	-0,6	-0,5	-0,7	-0,82
Decrease due to array losses	[%]	0,0	0,0	0,0	4,5	26,6	0,0	0,0	0,0	0,0	3,2	19,2	0,0	2,19
Utilization	[%]	44,8	46,5	45,9	43,7	33,8	45,9	43,6	38,6	41,4	40,4	35,0	46,2	40,8
Operational	[Hours/year]	660	613	564	460	531	475	966	1.483	1.186	711	520	431	8.598
Full Load Equivalent	[Hours/year]	43	74	78	40	39	46	224	585	447	186	85	48	1.895

Energy vs. sector



Impact of hills and obstacles vs. sector



PARK - Power Curve Analysis

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129WTG: WT-01 - Siemens SWT-DD-142 3900 142.0 !O! Mode 1 - Calculated - Std. 107dB - 9-2017, Hub height: 129,0 m

Name: Mode 1 - Calculated - Std. 107dB - 9-2017

Source: Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m ²
8-9-2017	EMD	3-5-2017	8-9-2017	26,0	Pitch	User defined	Variable	0,25

Power Curve Rev. 0.

Siemens Wind Power and its affiliates reserve the right to change the above specifications without prior notice.

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value PWT, variable speed (2013)	[MWh]	7.717	11.382	14.769	17.682	20.076	21.948
Siemens SWT-DD-142 3900 142.0 !O! Mode 1 - Calculated - Std. 107dB - 9-2017	[MWh]	7.951	11.599	14.945	17.784	20.044	21.713
Check value	[%]	-3	-2	-1	-1	0	1

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m²) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.

For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.

The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.

Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

Original data, Air density: 1,225 kg/m³

Wind speed Power Ce Wind speed Ct curve

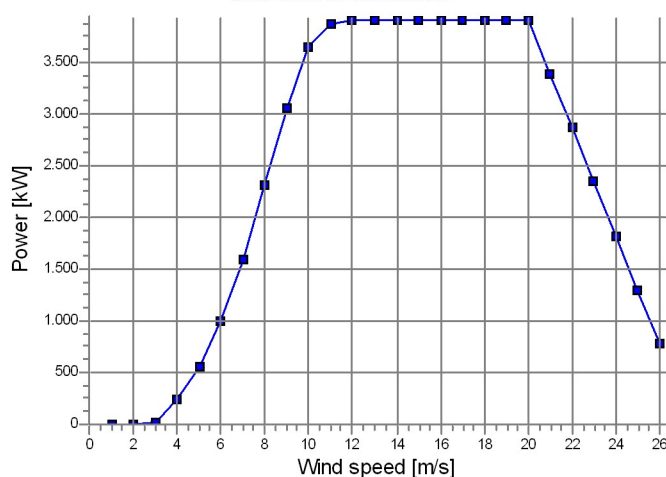
[m/s]	[kW]		[m/s]	
2,0	0,0	0,00	2,0	0,00
3,0	20,4	0,08	3,0	0,86
4,0	235,4	0,38	4,0	0,86
5,0	555,9	0,46	5,0	0,86
6,0	994,1	0,47	6,0	0,85
7,0	1.581,5	0,48	7,0	0,84
8,0	2.306,1	0,46	8,0	0,79
9,0	3.057,9	0,43	9,0	0,71
10,0	3.646,3	0,38	10,0	0,61
11,0	3.863,1	0,30	11,0	0,48
12,0	3.897,0	0,23	12,0	0,36
13,0	3.899,8	0,18	13,0	0,27
14,0	3.900,0	0,15	14,0	0,21
15,0	3.900,0	0,12	15,0	0,17
16,0	3.900,0	0,10	16,0	0,14
17,0	3.900,0	0,08	17,0	0,12
18,0	3.900,0	0,07	18,0	0,10
19,0	3.900,0	0,06	19,0	0,09
20,0	3.900,0	0,05	20,0	0,07
21,0	3.380,0	0,04	21,0	0,06
22,0	2.860,0	0,03	22,0	0,04
23,0	2.340,0	0,02	23,0	0,03
24,0	1.820,0	0,01	24,0	0,02
25,0	1.300,0	0,01	25,0	0,02
26,0	780,0	0,00	26,0	0,01

Power, Efficiency and energy vs. wind speed

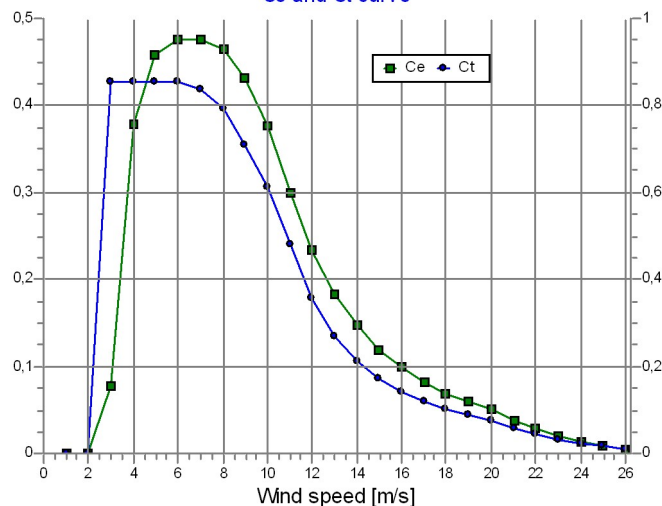
Data used in calculation, Air density: 1,224 kg/m³ New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

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	3,7	3,7	0,0
3,0	20,4	0,08	2,50- 3,50	66,6	70,3	0,6
4,0	235,4	0,38	3,50- 4,50	282,9	353,1	2,8
5,0	555,9	0,46	4,50- 5,50	647,1	1.000,2	8,1
6,0	994,1	0,47	5,50- 6,50	1.064,7	2.065,0	16,6
7,0	1.581,5	0,48	6,50- 7,50	1.444,8	3.509,8	28,3
8,0	2.306,1	0,46	7,50- 8,50	1.700,6	5.210,4	42,0
9,0	3.057,9	0,43	8,50- 9,50	1.762,8	6.973,2	56,2
10,0	3.646,3	0,38	9,50-10,50	1.606,4	8.579,6	69,1
11,0	3.863,1	0,30	10,50-11,50	1.293,2	9.872,8	79,6
12,0	3.897,0	0,23	11,50-12,50	945,6	10.818,4	87,2
13,0	3.899,8	0,18	12,50-13,50	646,1	11.464,4	92,4
14,0	3.900,0	0,15	13,50-14,50	415,3	11.879,8	95,7
15,0	3.900,0	0,12	14,50-15,50	250,4	12.130,2	97,8
16,0	3.900,0	0,10	15,50-16,50	141,1	12.271,2	98,9
17,0	3.900,0	0,08	16,50-17,50	74,1	12.345,3	99,5
18,0	3.900,0	0,07	17,50-18,50	36,2	12.381,5	99,8
19,0	3.900,0	0,06	18,50-19,50	16,5	12.398,0	99,9
20,0	3.900,0	0,05	19,50-20,50	6,9	12.404,9	100,0
21,0	3.380,0	0,04	20,50-21,50	2,5	12.407,4	100,0
22,0	2.860,0	0,03	21,50-22,50	0,8	12.408,2	100,0
23,0	2.340,0	0,02	22,50-23,50	0,2	12.408,4	100,0
24,0	1.820,0	0,01	23,50-24,50	0,1	12.408,4	100,0
25,0	1.300,0	0,01	24,50-25,50	0,0	12.408,4	100,0
26,0	780,0	0,00	25,50-26,50	0,0	12.408,4	100,0

Power curve
Data used in calculation



Ce and Ct curve



Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 17:01/3.1.617

PARK - Terrain

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129Site Data: C - De Kookepan

Obstacles:

17 Obstacles used

Roughness:

Terrain data files used in calculation:

P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\ROUGHNESSLINE_ONLINEDATA_0.wpo

Min X: 164.636, Max X: 227.062, Min Y: 334.874, Max Y: 398.555, Width: 62.426 m, Height: 63.681 m

Orography:

Terrain data files used in calculation:

P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\717130 Productie_EMDGrid_0.wpg

Min X: 176.541, Max X: 216.980, Min Y: 346.612, Max Y: 386.959, Width: 40.438 m, Height: 40.347 m

PARK - Wind Data Analysis

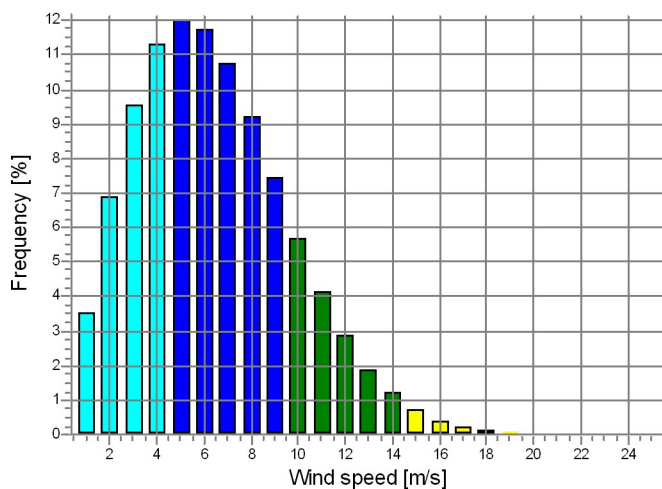
Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129Wind data: C - De Kookepan; Hub height: 129,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 197.562 North: 365.760
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (13)
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

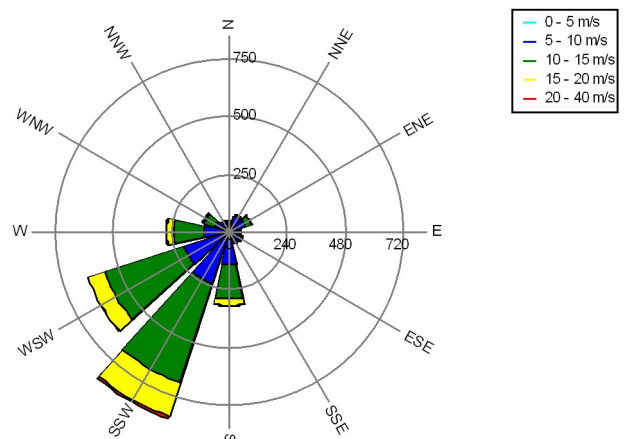
Weibull Data

Sector	Current site		k- parameter	Frequency
	A- parameter [m/s]	Wind speed [m/s]		
0 N	4,64	4,12	2,490	7,7
1 NNE	5,82	5,17	2,721	7,1
2 ENE	6,19	5,48	2,225	6,6
3 E	5,24	4,64	2,232	5,4
4 ESE	5,41	4,80	2,447	6,2
5 SSE	5,33	4,72	2,186	5,5
6 S	7,69	6,81	2,252	11,0
7 SSW	9,45	8,39	2,568	17,2
8 WSW	9,38	8,36	2,822	14,0
9 W	7,99	7,08	2,260	8,3
10 WNW	6,66	5,90	2,076	6,0
11 NNW	5,58	4,94	2,346	5,0
All	7,23	6,41	2,045	100,0

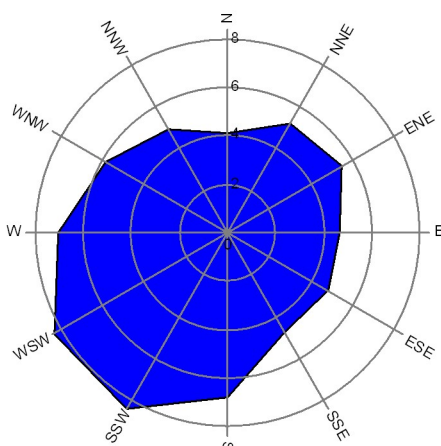
Weibull Distribution



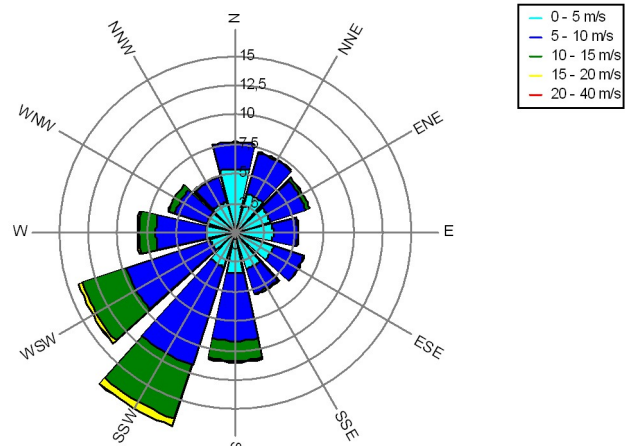
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Wind Data Analysis

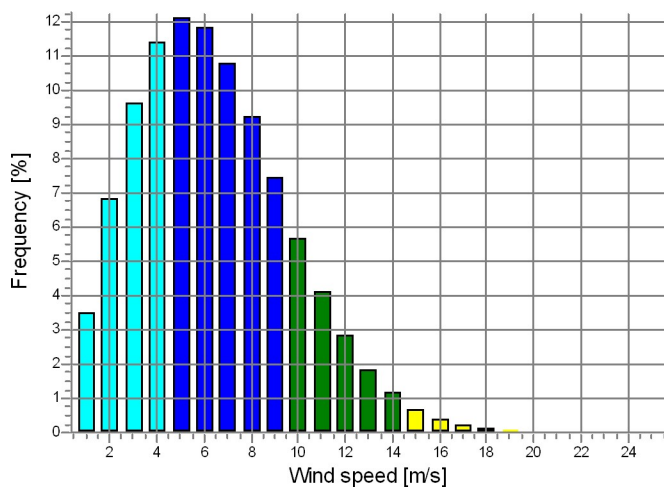
Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129Wind data: C - De Kookepan; Hub height: 129,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 196.853 North: 366.126
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (14)
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

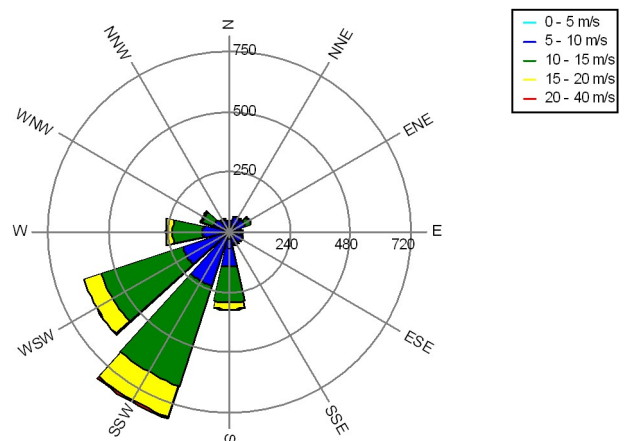
Weibull Data

Sector	Current site		k- parameter	Frequency
	A- parameter [m/s]	Wind speed [m/s]		
0 N	4,72	4,18	2,482	7,7
1 NNE	5,58	4,96	2,705	7,1
2 ENE	6,07	5,38	2,225	6,5
3 E	5,31	4,71	2,229	5,4
4 ESE	5,48	4,86	2,447	6,2
5 SSE	5,44	4,82	2,166	5,6
6 S	7,70	6,82	2,256	11,1
7 SSW	9,34	8,30	2,580	17,2
8 WSW	9,38	8,35	2,818	13,8
9 W	7,93	7,02	2,260	8,3
10 WNW	6,71	5,94	2,076	6,0
11 NNW	5,75	5,10	2,326	5,1
All	7,21	6,38	2,057	100,0

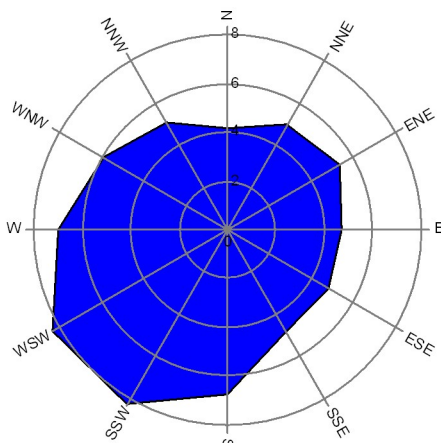
Weibull Distribution



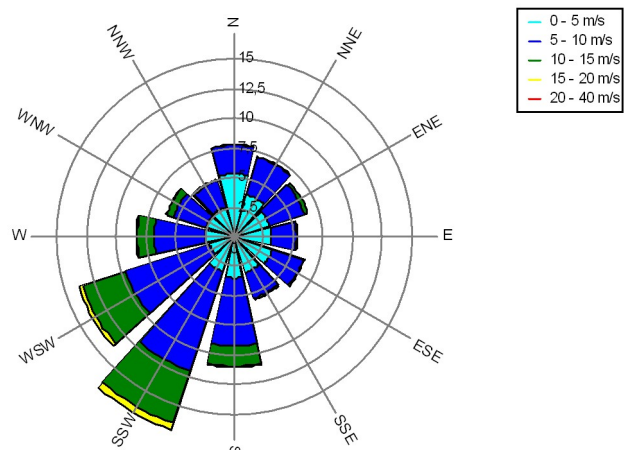
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Wind Data Analysis

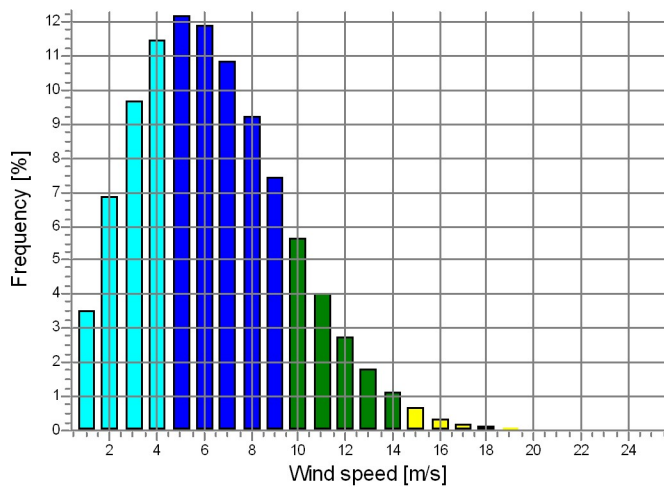
Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129Wind data: C - De Kookepan; Hub height: 129,0

Site coordinates
Dutch Stereo-RD/NAP 2000
East: 196.420 North: 366.350
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (15)
Wind statistics
KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws

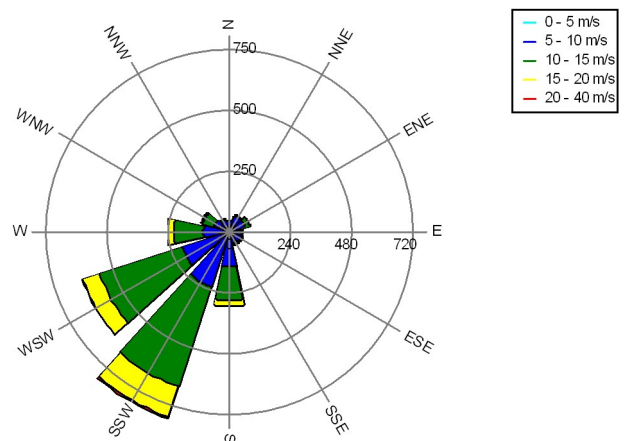
Weibull Data

Sector	Current site		k- parameter	Frequency [%]
	A- parameter [m/s]	Wind speed [m/s]		
0 N	4,73	4,20	2,482	7,7
1 NNE	5,69	5,06	2,713	7,1
2 ENE	5,93	5,25	2,229	6,6
3 E	5,30	4,69	2,229	5,4
4 ESE	5,46	4,85	2,447	6,2
5 SSE	5,38	4,76	2,178	5,5
6 S	7,60	6,73	2,256	11,0
7 SSW	9,31	8,27	2,584	17,3
8 WSW	9,36	8,34	2,818	13,9
9 W	7,82	6,93	2,252	8,3
10 WNW	6,62	5,87	2,076	6,0
11 NNW	5,71	5,06	2,326	5,0
All	7,17	6,35	2,061	100,0

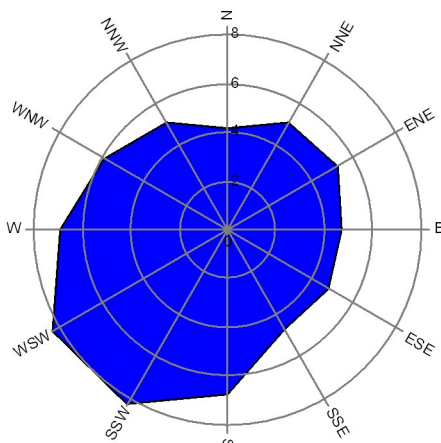
Weibull Distribution



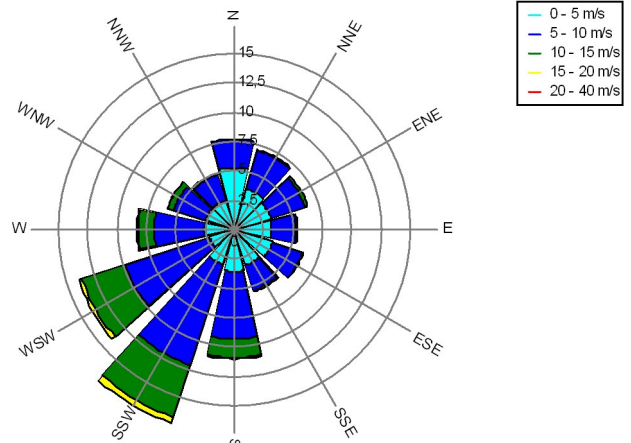
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



PARK - Park power curve

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129

Power															
Wind speed	Free	Park	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	
[m/s]	WTGs	WTGs	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]	
0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2,5	31	30	31	31	31	30	25	31	31	31	31	30	23	31	
3,5	384	360	384	384	384	365	218	384	384	384	384	365	210	384	
4,5	1.187	1.134	1.187	1.187	1.187	1.152	802	1.187	1.187	1.187	1.187	1.152	776	1.187	
5,5	2.325	2.236	2.325	2.325	2.325	2.268	1.683	2.325	2.325	2.325	2.325	2.268	1.637	2.325	
6,5	3.863	3.726	3.863	3.863	3.863	3.775	2.876	3.863	3.863	3.863	3.863	3.776	2.802	3.863	
7,5	5.831	5.639	5.831	5.831	5.831	5.712	4.440	5.831	5.831	5.831	5.831	5.712	4.334	5.831	
8,5	8.046	7.816	8.046	8.046	8.046	7.916	6.368	8.046	8.046	8.046	8.046	7.917	6.249	8.046	
9,5	10.056	9.842	10.056	10.056	10.056	9.954	8.465	10.056	10.056	10.056	10.056	9.955	8.362	10.056	
10,5	11.264	11.136	11.264	11.264	11.264	11.223	10.276	11.264	11.264	11.264	11.264	11.225	10.245	11.264	
11,5	11.640	11.606	11.640	11.640	11.640	11.634	11.347	11.640	11.640	11.640	11.640	11.635	11.379	11.640	
12,5	11.695	11.692	11.695	11.695	11.695	11.695	11.672	11.695	11.695	11.695	11.695	11.695	11.671	11.695	
13,5	11.700	11.700	11.700	11.700	11.700	11.700	11.699	11.700	11.700	11.700	11.700	11.700	11.698	11.700	
14,5	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	
15,5	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	
16,5	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	
17,5	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	
18,5	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	
19,5	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	11.700	
20,5	10.920	10.950	10.920	10.920	10.920	10.935	11.137	10.920	10.920	10.920	10.920	10.935	11.162	10.920	
21,5	9.360	9.384	9.360	9.360	9.360	9.372	9.533	9.360	9.360	9.360	9.360	9.372	9.556	9.360	
22,5	7.800	7.819	7.800	7.800	7.800	7.809	7.935	7.800	7.800	7.800	7.800	7.809	7.957	7.800	
23,5	6.240	6.255	6.240	6.240	6.240	6.247	6.345	6.240	6.240	6.240	6.240	6.247	6.365	6.240	
24,5	4.680	4.692	4.680	4.680	4.680	4.685	4.760	4.680	4.680	4.680	4.680	4.685	4.779	4.680	
25,5	3.120	3.127	3.120	3.120	3.120	3.124	3.175	3.120	3.120	3.120	3.120	3.124	3.175	3.120	
26,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Description:

The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.

Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in windPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in windPRO (PPV-model).

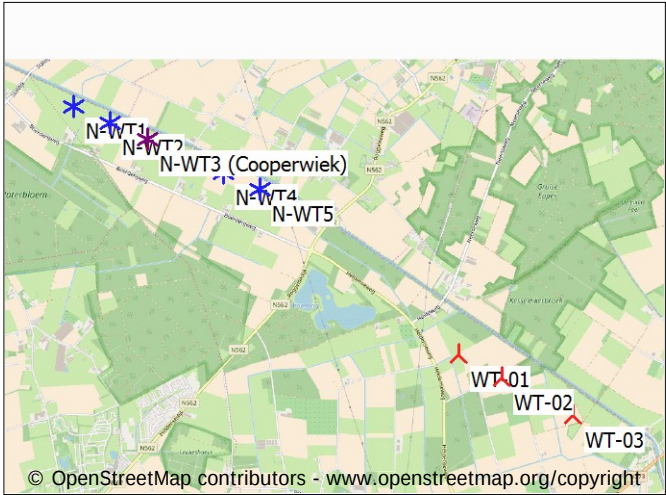
Note:

From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

PARK - WTG distances

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129
WTG distances

	Z	Nearest WTG	Z	Horizontal distance	Distance in rotor diameters (max)	Distance in rotor diameters (min)
	[m]		[m]	[m]		
N-WT1	29,0	N-WT2	28,9	400	4,9	4,9
N-WT2	28,9	N-WT1	29,0	400	4,9	4,9
N-WT3 (Cooperwiek)	29,7	N-WT2	28,9	400	4,9	4,3
N-WT4	28,7	N-WT5	30,4	400	4,9	4,9
N-WT5	30,4	N-WT4	28,7	400	4,9	4,9
WT-01	27,7	WT-02	30,0	488	3,4	3,4
WT-02	30,0	WT-01	27,7	488	3,4	3,4
WT-03	27,4	WT-02	30,0	798	5,6	5,6
Min	27,4		27,7	400	3,4	3,4
Max	30,4		30,4	798	5,6	5,6



Scale 1:75.000
New WTG
Existing WTG

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 17:01/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WAsP version	WAsP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WAsP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WAsP CFD should always use WAsP CFD calculated wind statistics.

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 17:01/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WASP version	WASP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WASP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WASP CFD should always use WASP CFD calculated wind statistics.

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 17:01/3.1.617

PARK - Wind statistics info

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129

Main data for wind statistic

File	P:\Extern\2017\717130 AKO SS VIS WP De Kookepan te Neer\TO\WP\KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033.wws
Name	KNMI ELL juni2012-oktober2015 - 10,00 m-Corr1.027-Corr1.033
Country	Netherlands
Source	User
Mast coordinates	Dutch Stereo-RD/NAP 2000 East: 181.267 North: 356.578
Created	15-12-2017
Edited	15-12-2017
Sectors	12
WASP version	WASP 11 Version 11.06.0012
Displacement height	None

Additional info for wind statistic

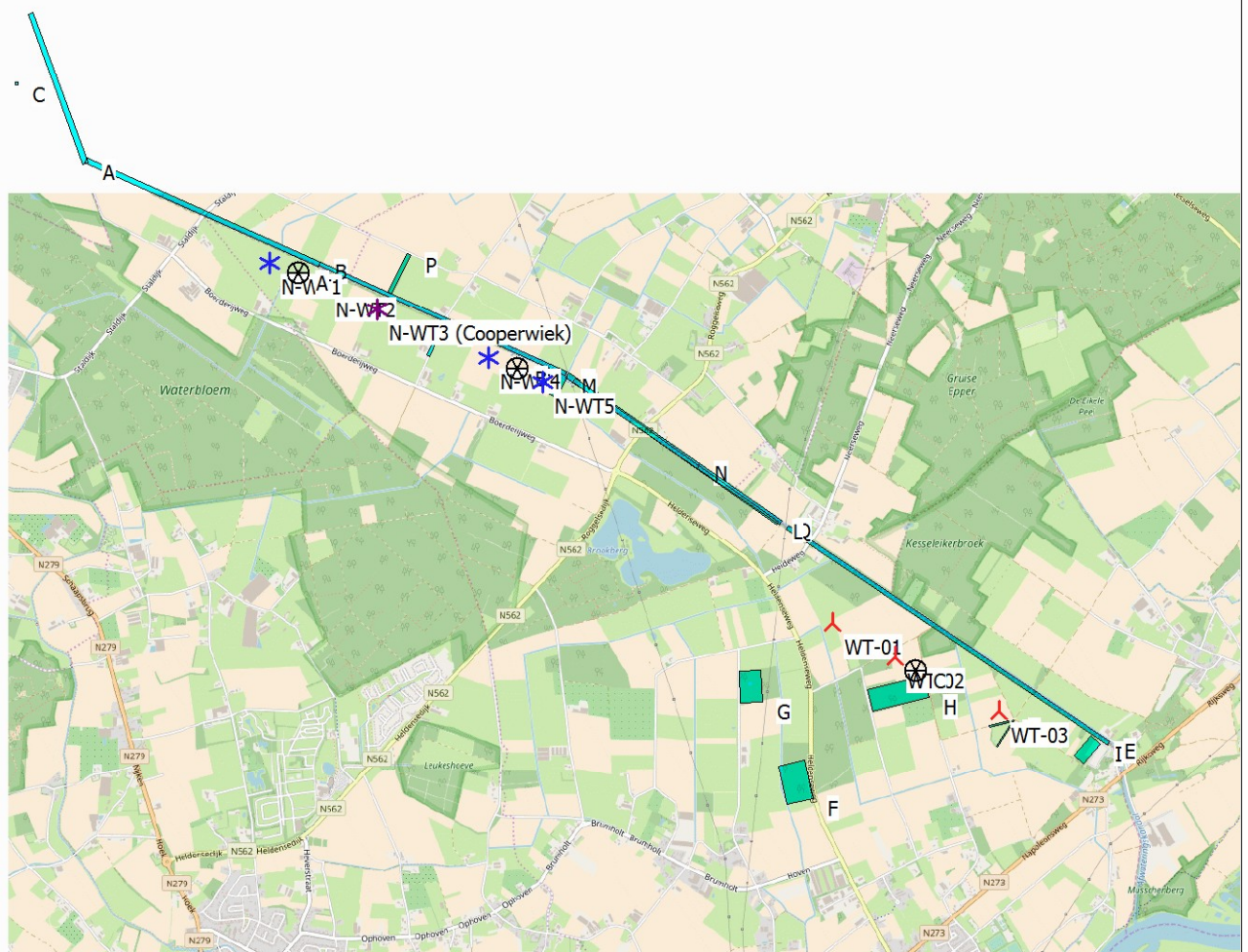
Source data	KNMI ELL juni2012-oktober2015
Data from	1-6-2012
Data to	31-10-2015
Measurement length	41,0 Months
Recovery rate	98,4 %
Effective measurement length	40,3 Months

Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WASP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WASP CFD should always use WASP CFD calculated wind statistics.

PARK - Map

Calculation: WP De Kookepan SWT-DD-142 3,9MW HH129



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0 500 1000 1500 2000 m

Map: Open Street Map 001, Print scale 1:50.000, Map center Dutch Stereo-RD/NAP 2000 East: 194.481 North: 367.787

New WTG Existing WTG Site Data Obstacle

BIJLAGE 2

INVOER EN RESULTATEN

MODEL VERLIEZEN



Loss&Uncertainty - Main result

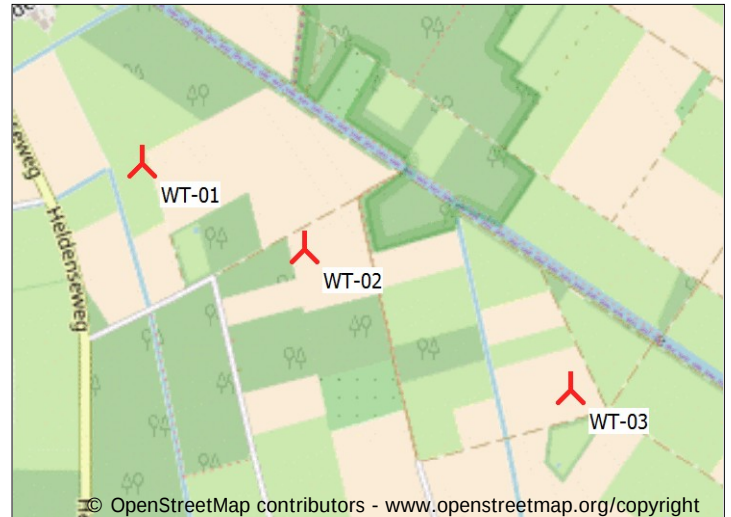
Calculation: L136 4,5MW HH132

Main data for PARK

PARK calculation 3.1.617: WP De Kookepan L136 4,5MW HH132
Count 3
Rated power 13,5 MW
Mean wind speed 6,4 m/s at hub height
Sensitivity 1,9 %AEP / %Mean Wind Speed
Expected lifetime 20 Years

RESULTS

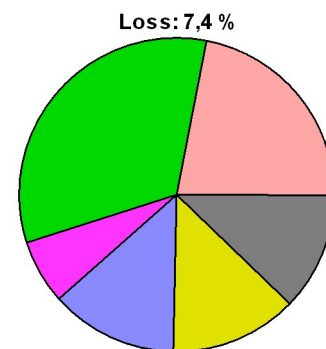
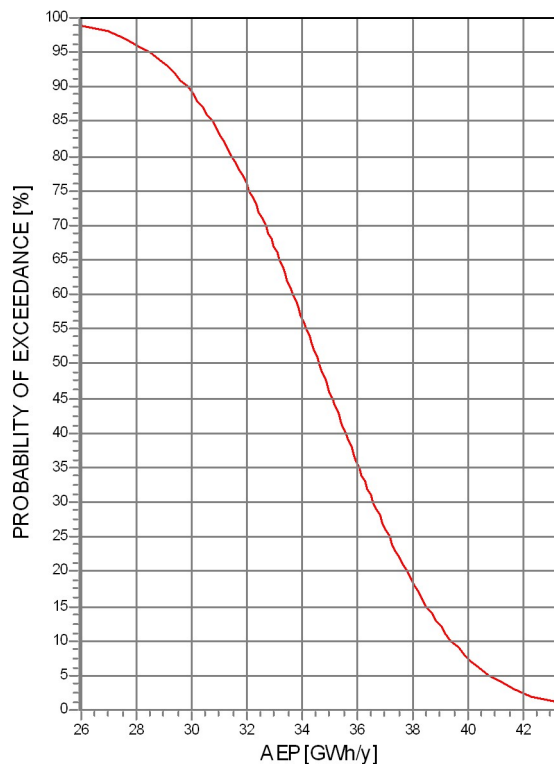
		P50	P85	P90
NET AEP	[GWh/y]	34,6	30,8	29,9
Capacity factor	[%]	29,3	26,0	25,2
Full load hours	[h/y]	2.566	2.280	2.212



Scale: 20.000

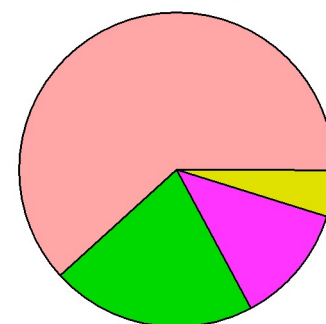
Result details

	P50	Uncertainty
GROSS AEP *)	37,4 GWh/y	10,7 %
Bias correction	0,0 GWh/y	0,0 %
Loss correction	-2,8 GWh/y	-7,4 %
Wake loss	-1,7 %	
Other losses	-5,8 %	
NET AEP	34,6 GWh/y	10,8 %



1. Wake effects	1,7 %	2. Availability	2,5 %
3. Turbine performance	0,5 %	4. Electrical	1,0 %
5. Environmental	1,0 %	6. Curtailment	0,9 %
7. Other	0,0 %		

Uncertainty: 10,8 %



A. Wind data	10,0 %	B. Wind model	3,4 %
C. Power conversion	2,0 %	D. BIAS	0,0 %
E. LOSS	0,8 %		

*) Calculated Annual Energy Production before any bias or loss corrections
Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

Loss&Uncertainty - Assumptions and results

Calculation: L136 4,5MW HH132
ASSUMPTIONS

LOSS		Method *)	Loss [%]	Loss [GWh/y]	Std dev**) [%]	Comment
1.	Wake effects					
	Wake effects, all WTGs	Calculation	1,7	0,6	30,0	0,5% onzekerheid op de AEP
2.	Availability					
	Turbine availability	Estimate	2,5	0,9	20,0	0,5% onzekerheid op de AEP
3.	Turbine performance					
	High wind hysteresis	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
4.	Electrical					
	Electrical losses	Estimate	1,0	0,4	20,0	0,2% onzekerheid op de AEP
5.	Environmental					
	Performance degradation not due to icing	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
	Performance degradation due to icing	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
6.	Curtailment					
	Flicker	Calculation	0,9	0,3	20,0	0,1% onzekerheid op de AEP
7.	Other					No input
	LOSS, total		7,4	2,8	0,8	
UNCERTAINTY		Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment	
A.	Wind data					
	Wind measurement/Wind data	Estimate	4,0	7,6		KNMI 2012-2015
	Long term correction	Estimate	3,3	6,2		Correctiefactor van 3,3%
	Year-to-year variability	Estimate	4,6	8,7		4,6% berekend door MCP
	Future climate					
	Other wind related					
B.	Wind model					
	Vertical extrapolation	Calculation	1,0	1,9		Windklimaat geschaald naar locatie productiedata
	Horizontal extrapolation	Calculation	1,5	2,8		Windklimaat geschaald naar locatie productiedata
	Other wind model related					
C.	Power conversion					
	Power curve uncertainty	Estimate		2,0		Conservatieve aanname
	Metering uncertainty					
	Other AEP related uncertainties					
D.	BIAS, total uncertainty			0,0		
E.	LOSS, total uncertainty			0,8		
	UNCERTAINTY, total (1y average)			13,7		
	UNCERTAINTY, total (20y average)			10,8		
VARIABILITY		Years	Variability (std dev) [%]	Total std dev [%]		
		1	8,69	13,7		
		5	3,89	11,3		
		10	2,75	10,9		
		20	1,94	10,8		

RESULTS

AEP versus exceedance level / time horizon

PXX [%]	1 y [MWh/y]	5 y [MWh/y]	10 y [MWh/y]	20 y [MWh/y]
50	34.643	34.643	34.643	34.643
75	31.441	32.005	32.085	32.125
84	29.922	30.754	30.871	30.931
90	28.559	29.632	29.783	29.860
95	26.835	28.212	28.405	28.504

*) Calculation means that a calculation method available in the windPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

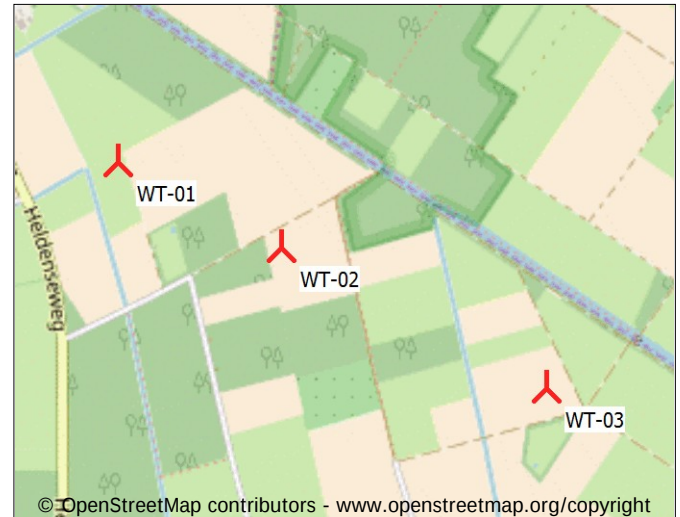
**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

Loss&Uncertainty - WTG results

Calculation: L136 4,5MW HH132

Main data for PARK

PARK calculation 3.1.617: WP De Kookepan L136 4,5MW HH132
 Count 3
 Rated power 13,5 MW
 Mean wind speed 6,4 m/s at hub height
 Sensitivity 1,9 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 20.000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	User label	Calculated GROSS*)	Bias	Loss	Unc.	20 years averaging		
						P50	P85	P90
		[MWh/y]	[%]	[%]	[%]	[MWh/y]	[MWh/y]	[MWh/y]
1 LAGERWEY L136-4.5MW 4500 136.0 !O! hub: 132,0 m (TOT: 200,0 m) (3)	WT-01	12.366,8	0,0	8,2	10,8	11.354,8	10.078,3	9.776,5
2 LAGERWEY L136-4.5MW 4500 136.0 !O! hub: 132,0 m (TOT: 200,0 m) (2)	WT-02	12.474,5	0,0	7,8	10,8	11.495,9	10.211,1	9.907,2
3 LAGERWEY L136-4.5MW 4500 136.0 !O! hub: 132,0 m (TOT: 200,0 m) (1)	WT-03	12.560,6	0,0	6,1	10,7	11.791,9	10.484,7	10.175,6
PARK		37.401,9	0,0	7,4	10,8	34.642,6	30.774,6	29.859,9

Loss&Uncertainty - Vertical extrapolation

Calculation: L136 4,5MW HH132

Vertical extrapolation uncertainty

WTG

	Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	0,50	0,30	29,3	98,0	-1,6	34,0	1,9
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	0,50	0,30	29,3	98,0	0,7	34,0	1,9
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	0,50	0,30	29,3	98,0	-1,9	34,0	1,9

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 18:41/3.1.617

Loss&Uncertainty - Horizontal extrapolation

Calculation: L136 4,5MW HH132

Horizontal extrapolation uncertainty

WTG

	Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	0,30	0,0	0,0	5,0	2,9
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	0,30	0,0	0,0	5,0	2,8
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	0,30	0,0	0,0	5,0	2,8

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 18:41/3.1.617

Loss&Uncertainty - Flicker

Calculation: L136 4,5MW HH132

Calculated losses due to shadow (flicker) loss.

Used SHADOW calculation: 3.1.617: L136

Assumptions:

Advanced stop (light sensors etc. included). Reduced to: 35 % AEP reduction relative to worst case.

Result

WTG	Calculated AEP GROSS [MWh]	Loss [MWh]	Percent of AEP [%]
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	12.366,8	239,6	1,94
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	12.474,5	77,7	0,62
LAGERWEY L136-4.5MW 4500 136.0 !-! hub: 132,0 m (TOT: 200,0 m) (	12.560,6	30,7	0,24
TOTAL	37.401,9	348,0	0,93

Loss&Uncertainty - Main result

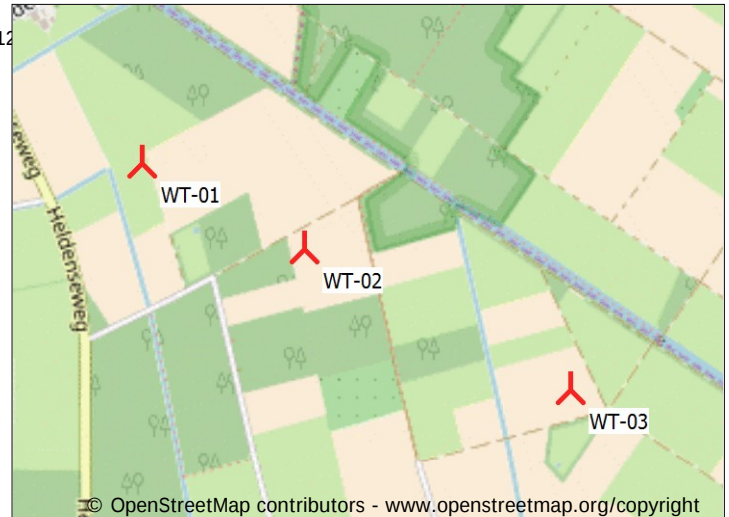
Calculation: SWT-3.15-142 HH129

Main data for PARK

PARK calculation 3.1.617: WP De Kookepan SWT-3.15-142 3,15MW HH129
Count 3
Rated power 9,4 MW
Mean wind speed 6,4 m/s at hub height
Sensitivity 1,6 %AEP / %Mean Wind Speed
Expected lifetime 20 Years

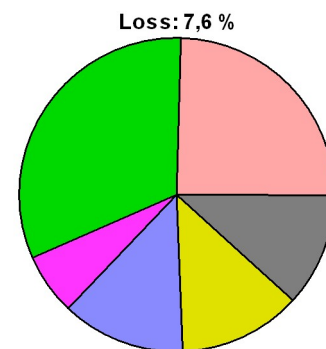
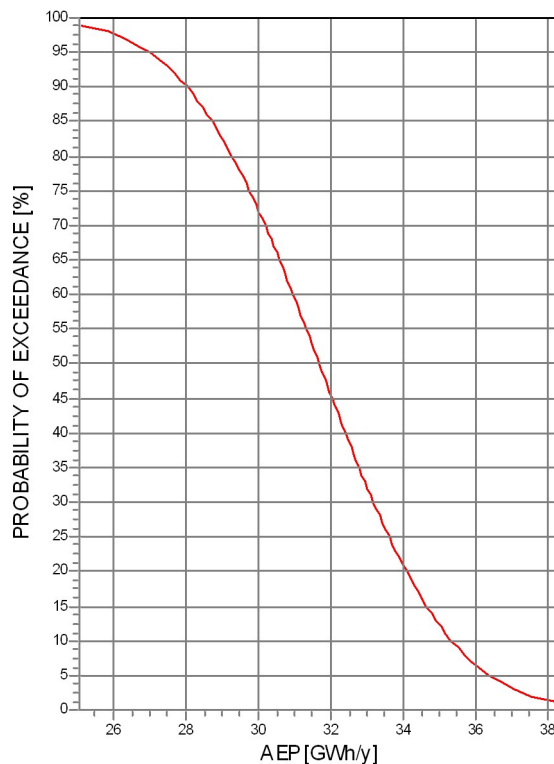
RESULTS

		P50	P85	P90
NET AEP	[GWh/y]	31,7	28,7	28,0
Capacity factor	[%]	38,3	34,7	33,8
Full load hours	[h/y]	3.351	3.038	2.964

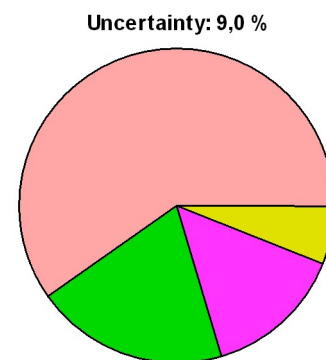


Result details

	P50	Uncertainty
GROSS AEP *)	34,3 GWh/y	9,0 %
Bias correction	0,0 GWh/y	0,0 %
Loss correction	-2,6 GWh/y	-7,6 %
Wake loss	-1,9 %	
Other losses	-5,8 %	
NET AEP	31,7 GWh/y	9,0 %



1. Wake effects	1,9 %	2. Availability	2,5 %
3. Turbine performance	0,5 %	4. Electrical	1,0 %
5. Environmental	1,0 %	6. Curtailment	0,9 %
7. Other	0,0 %		



A. Wind data	8,3 %	B. Wind model	2,8 %
C. Power conversion	2,0 %	D. BIAS	0,0 %
E. LOSS	0,8 %		

*) Calculated Annual Energy Production before any bias or loss corrections
Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

Loss&Uncertainty - Assumptions and results

Calculation: SWT-3.15-142 HH129

ASSUMPTIONS

LOSS	Method *)	Loss [%]	Loss [GWh/y]	Std dev**) [%]	Comment
1. Wake effects					
Wake effects, all WTGs	Calculation	1,9	0,7	30,0	0,6% onzekerheid op de AEP
2. Availability					
Turbine availability	Estimate	2,5	0,9	20,0	0,5% onzekerheid op de AEP
3. Turbine performance					
High wind hysteresis	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
4. Electrical					
Electrical losses	Estimate	1,0	0,3	20,0	0,2% onzekerheid op de AEP
5. Environmental					
Performance degradation not due to icing	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
Performance degradation due to icing	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
6. Curtailment					
Flicker	Calculation	0,9	0,3	20,0	0,2% onzekerheid op de AEP
7. Other					No input
LOSS, total		7,6	2,6	0,8	

UNCERTAINTY	Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment
A. Wind data				
Wind measurement/Wind data	Estimate	4,0	6,3	KNMI 2012-2015
Long term correction	Estimate	3,3	5,2	Correctiefactor van 3,3%
Year-to-year variability	Estimate	4,6	7,2	4,6% berekend door MCP
Future climate				
Other wind related				
B. Wind model				
Vertical extrapolation	Calculation	0,9	1,5	Windklimaat geschaald naar locatie productiedata
Horizontal extrapolation	Calculation	1,5	2,4	Windklimaat geschaald naar locatie productiedata
Other wind model related				
C. Power conversion				
Power curve uncertainty	Estimate		2,0	Conservatieve aanname
Metering uncertainty				
Other AEP related uncertainties				
D. BIAS, total uncertainty			0,0	
E. LOSS, total uncertainty			0,8	
UNCERTAINTY, total (1y average)			11,4	
UNCERTAINTY, total (20y average)			9,0	

VARIABILITY

Years	Variability (std dev) [%]	Total std dev [%]
1	7,21	11,4
5	3,22	9,4
10	2,28	9,1
20	1,61	9,0

RESULTS

AEP versus exceedance level / time horizon

PXX [%]	1 y [MWh/y]	5 y [MWh/y]	10 y [MWh/y]	20 y [MWh/y]
50	31.667	31.667	31.667	31.667
75	29.228	29.654	29.714	29.744
84	28.070	28.699	28.787	28.832
90	27.032	27.842	27.955	28.014
95	25.718	26.758	26.903	26.978

*) Calculation means that a calculation method available in the windPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

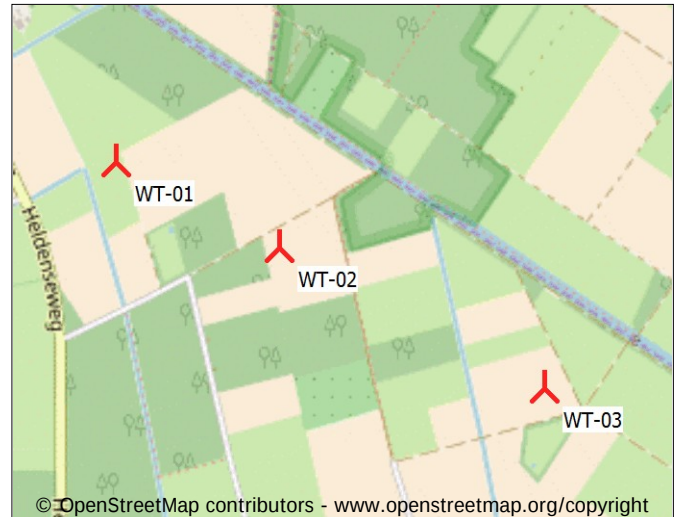
**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

Loss&Uncertainty - WTG results

Calculation: SWT-3.15-142 HH129

Main data for PARK

PARK calculation 3.1.617: WP De Kookepan SWT-3.15-142 3,15MW HH129
 Count 3
 Rated power 9,4 MW
 Mean wind speed 6,4 m/s at hub height
 Sensitivity 1,6 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 20.000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	User label	Calculated GROSS*) [MWh/y]	Bias [%]	Loss [%]	20 years averaging			
					Unc. [%]	P50 [MWh/y]	P85 [MWh/y]	P90 [MWh/y]
1 Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (12)	WT-01	11.353,7	0,0	8,5	9,1	10.392,6	9.414,8	9.183,6
2 Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (11)	WT-02	11.439,1	0,0	8,2	9,0	10.502,2	9.520,1	9.287,8
3 Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (10)	WT-03	11.485,7	0,0	6,2	8,9	10.772,2	9.776,8	9.541,3
PARK		34.278,4	0,0	7,6	9,0	31.666,8	28.712,4	28.013,6

Loss&Uncertainty - Vertical extrapolation

Calculation: SWT-3.15-142 HH129

Vertical extrapolation uncertainty

WTG

	Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (12)	0,50	0,30	29,3	98,0	-1,6	31,0	1,5
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (11)	0,50	0,30	29,3	98,0	0,7	31,0	1,5
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (10)	0,50	0,30	29,3	98,0	-1,9	31,0	1,5

Loss&Uncertainty - Horizontal extrapolation

Calculation: SWT-3.15-142 HH129

Horizontal extrapolation uncertainty

WTG

	Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (12)	0,30	0,0	0,0	5,0	2,4
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (11)	0,30	0,0	0,0	5,0	2,4
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (10)	0,30	0,0	0,0	5,0	2,3

Loss&Uncertainty - Flicker

Calculation: SWT-3.15-142 HH129

Calculated losses due to shadow (flicker) loss.

Used SHADOW calculation: 3.1.617: SWT-3.15

Assumptions:

Advanced stop (light sensors etc. included). Reduced to: 35 % AEP reduction relative to worst case.

Result

WTG	Calculated AEP GROSS [MWh]	Loss [MWh]	Percent of AEP [%]
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (12)	11.353,7	216,5	1,91
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (11)	11.439,1	69,5	0,61
Siemens SWT-3.15-142 3150 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (10)	11.485,7	30,4	0,26
TOTAL	34.278,4	316,5	0,92

Loss&Uncertainty - Main result

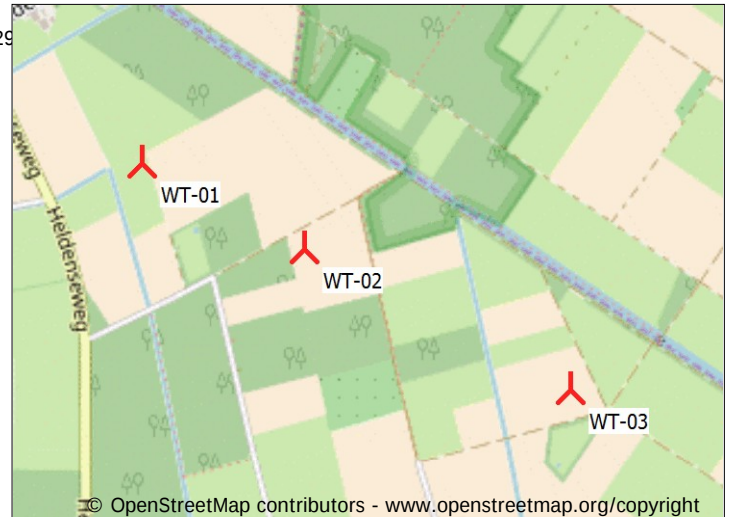
Calculation: SWT-DD-142 3,9MW HH129

Main data for PARK

PARK calculation 3.1.617: WP De Kookepan SWT-DD-142 3,9MW HH129
Count 3
Rated power 11,7 MW
Mean wind speed 6,4 m/s at hub height
Sensitivity 1,7 %AEP / %Mean Wind Speed
Expected lifetime 20 Years

RESULTS

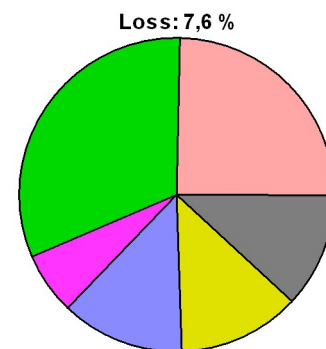
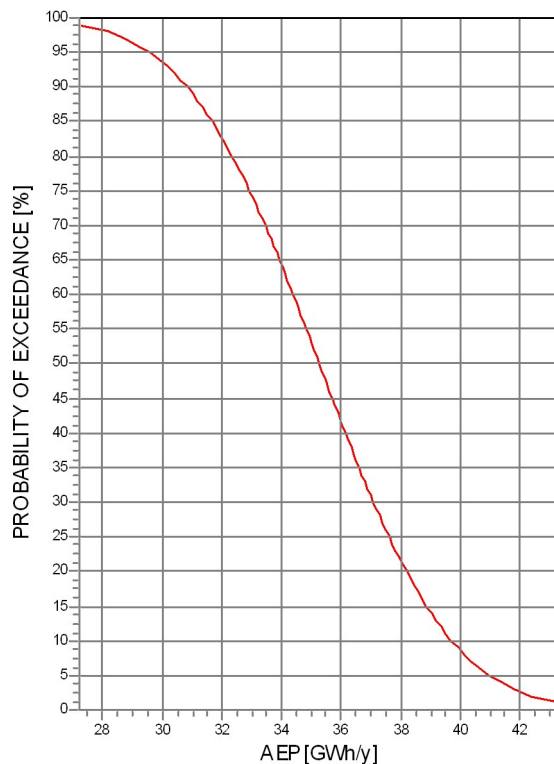
		P50	P85	P90
NET AEP	[GWh/y]	35,3	31,7	30,8
Capacity factor	[%]	34,4	30,9	30,1
Full load hours	[h/y]	3.015	2.707	2.635



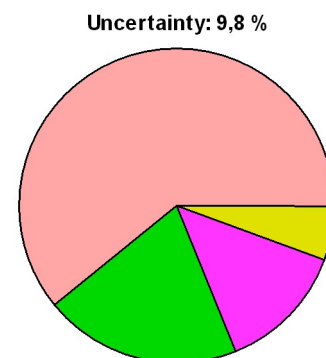
Scale: 20.000

Result details

	P50	Uncertainty
GROSS AEP *)	38,2 GWh/y	9,8 %
Bias correction	0,0 GWh/y	0,0 %
Loss correction	-2,9 GWh/y	-7,6 %
Wake loss	-2,0 %	
Other losses	-5,8 %	
NET AEP	35,3 GWh/y	9,8 %



1. Wake effects	2,0 %	2. Availability	2,5 %
3. Turbine performance	0,5 %	4. Electrical	1,0 %
5. Environmental	1,0 %	6. Curtailment	0,9 %
7. Other	0,0 %		



A. Wind data	9,1 %	B. Wind model	3,0 %
C. Power conversion	2,0 %	D. BIAS	0,0 %
E. LOSS	0,8 %		

*) Calculated Annual Energy Production before any bias or loss corrections
Assumptions: Uncertainty and percentiles (PXX values) are calculated for the expected lifetime

Loss&Uncertainty - Assumptions and results

Calculation: SWT-DD-142 3,9MW HH129

ASSUMPTIONS

LOSS	Method *)	Loss [%]	Loss [GWh/y]	Std dev**) [%]	Comment
1. Wake effects					
Wake effects, all WTGs	Calculation	2,0	0,7	30,0	0,6% onzekerheid op de AEP
2. Availability					
Turbine availability	Estimate	2,5	1,0	20,0	0,5% onzekerheid op de AEP
3. Turbine performance					
High wind hysteresis	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
4. Electrical					
Electrical losses	Estimate	1,0	0,4	20,0	0,2% onzekerheid op de AEP
5. Environmental					
Performance degradation not due to icing	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
Performance degradation due to icing	Estimate	0,5	0,2	20,0	0,1% onzekerheid op de AEP
6. Curtailment					
Flicker	Calculation	0,9	0,4	20,0	0,2% onzekerheid op de AEP
7. Other					No input
LOSS, total		7,6	2,9	0,8	

UNCERTAINTY	Method *)	Std dev, wind speed [%]	Std dev, AEP [%]	Comment
A. Wind data				
Wind measurement/Wind data	Estimate	4,0	6,9	KNMI 2012-2015
Long term correction	Estimate	3,3	5,7	Correctiefactor van 3,3%
Year-to-year variability	Estimate	4,6	7,9	4,6% berekend door MCP
Future climate				
Other wind related				
B. Wind model				
Vertical extrapolation	Calculation	0,9	1,6	Windklimaat geschaald naar locatie productiedata
Horizontal extrapolation	Calculation	1,5	2,6	Windklimaat geschaald naar locatie productiedata
Other wind model related				
C. Power conversion				
Power curve uncertainty	Estimate		2,0	Conservatieve aanname
Metering uncertainty				
Other AEP related uncertainties				
D. BIAS, total uncertainty			0,0	
E. LOSS, total uncertainty			0,8	
UNCERTAINTY, total (1y average)			12,5	
UNCERTAINTY, total (20y average)			9,8	

VARIABILITY

Years	Variability (std dev) [%]	Total std dev [%]
1	7,92	12,5
5	3,54	10,3
10	2,50	10,0
20	1,77	9,8

RESULTS

AEP versus exceedance level / time horizon

PXX [%]	1 y [MWh/y]	5 y [MWh/y]	10 y [MWh/y]	20 y [MWh/y]
50	35.270	35.270	35.270	35.270
75	32.297	32.820	32.893	32.931
84	30.886	31.658	31.766	31.821
90	29.621	30.615	30.754	30.826
95	28.019	29.295	29.474	29.566

*) Calculation means that a calculation method available in the windPRO software is used. This still typically involve a user judgement and user data where the quality of those decides the accuracy. If calculation method is used, the values will often be different from turbine to turbine, here the average is shown, but at page "WTG results" the individual turbine results are shown.

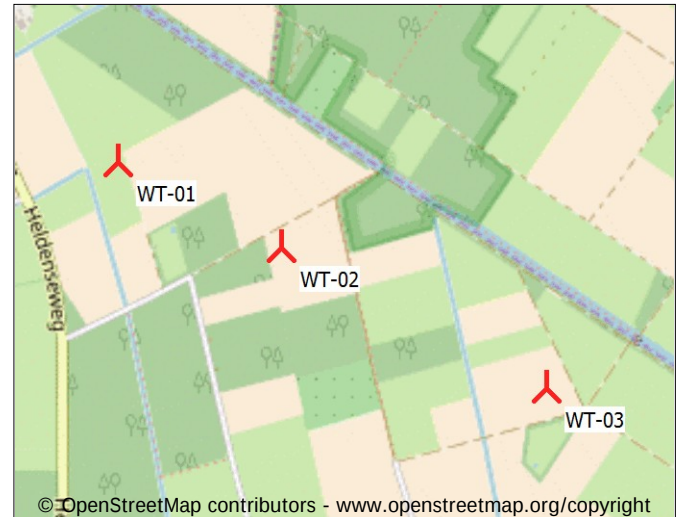
**) For totals the std dev refers to the full AEP, otherwise std dev refers to the bias or loss component which is a fraction of the total AEP.

Loss&Uncertainty - WTG results

Calculation: SWT-DD-142 3,9MW HH129

Main data for PARK

PARK calculation 3.1.617: WP De Kookepan SWT-DD-142 3,9MW HH129
 Count 3
 Rated power 11,7 MW
 Mean wind speed 6,4 m/s at hub height
 Sensitivity 1,7 %AEP / %Mean Wind Speed
 Expected lifetime 20 Years



Scale: 20.000

Expected AEP per WTG including bias, loss and uncertainty evaluation

Description	User label	Calculated GROSS*) [MWh/y]	Bias [%]	Loss [%]	20 years averaging			
					Unc. [%]	P50 [MWh/y]	P85 [MWh/y]	P90 [MWh/y]
1 Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (15)	WT-01	12.638,2	0,0	8,5	9,9	11.568,2	10.379,5	10.098,4
2 Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (14)	WT-02	12.744,8	0,0	8,2	9,9	11.694,8	10.500,4	10.217,9
3 Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (13)	WT-03	12.807,0	0,0	6,2	9,7	12.007,4	10.795,1	10.508,4
PARK		38.189,9	0,0	7,6	9,8	35.270,3	31.675,7	30.825,6

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
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0031742489940

Calculated:

15-12-2017 18:59/3.1.617

Loss&Uncertainty - Vertical extrapolation

Calculation: SWT-DD-142 3,9MW HH129

Vertical extrapolation uncertainty

WTG

	Uncertainty input elevation difference [%/10m]	Uncertainty input height difference [%/10m]	Measure elevation [m a.s.l.]	Measure height [m a.g.l.]	Delta elevation [m]	Delta height [m]	Result (std dev AEP) [%]
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (15)	0,50	0,30	29,3	98,0	-1,6	31,0	1,6
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (14)	0,50	0,30	29,3	98,0	0,7	31,0	1,6
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (13)	0,50	0,30	29,3	98,0	-1,9	31,0	1,6

Project:

717130 Productie

Licensed user:

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0031742489940

Calculated:

15-12-2017 18:59/3.1.617

Loss&Uncertainty - Horizontal extrapolation

Calculation: SWT-DD-142 3,9MW HH129

Horizontal extrapolation uncertainty

WTG

	Uncertainty input, distance [%/km]	Lower threshold value [km]	Upper threshold value [km]	Distance [km]	Result (std dev AEP) [%]
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (15)	0,30	0,0	0,0	5,0	2,6
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (14)	0,30	0,0	0,0	5,0	2,6
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (13)	0,30	0,0	0,0	5,0	2,6

Project:

717130 Productie

Licensed user:

Pondera Consult B.V.
Welbergweg 49
NL-7556 PE Hengelo
0031742489940

Calculated:

15-12-2017 18:59/3.1.617

Loss&Uncertainty - Flicker

Calculation: SWT-DD-142 3,9MW HH129

Calculated losses due to shadow (flicker) loss.

Used SHADOW calculation: 3.1.617: SWT-DD-142

Assumptions:

Advanced stop (light sensors etc. included). Reduced to: 35 % AEP reduction relative to worst case.

Result

WTG	Calculated AEP GROSS [MWh]	Loss [MWh]	Percent of AEP [%]
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (15)	12.638,2	246,7	1,95
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (14)	12.744,8	78,7	0,62
Siemens SWT-DD-142 3900 142.0 !O! hub: 129,0 m (TOT: 200,0 m) (13)	12.807,0	32,6	0,25
TOTAL	38.189,9	358,0	0,94