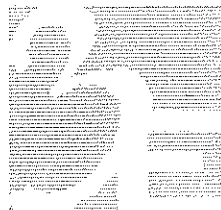


Annexe 4 : Etude de vent - 2006



EVALUATION PRÉLIMINAIRE DU POTENTIEL ÉOLIEN DE GESVES

Rapport

Client: WindVision
Personne de contact: Jaap Jan Ferweda
Référence 3E: BWE 497
Auteur: Pierre-Antoine Mali
Date: 28/07/2006

INFORMATION QUALITÉ

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29/07/2006
Signature:

Approuvé par:
Luc Dewilde
29/07/2006
Signature:



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2 MÉTHODOLOGIE

Pour estimer le productible du parc éolien, il est nécessaire de connaître le régime local du vent à hauteur d'axe de chaque éolienne qu'on combine ensuite avec sa courbe de puissance.

Le logiciel WAsP a été utilisé pour reconstruire le régime de vent à l'emplacement et à la hauteur souhaitée (extrapolation horizontale et verticale des vitesses).

Le principe de WAsP est schématisé à la Figure 2. WAsP utilise les données météorologiques d'une station de référence nettoyée des effets locaux pour calculer le vent géostrophique, représentatif du vent régional. Le vent sur site est ensuite reconstruit en appliquant au vent régional les caractéristiques du terrain. Les effets locaux pris en compte par WAsP sont le relief, la rugosité et les obstacles.

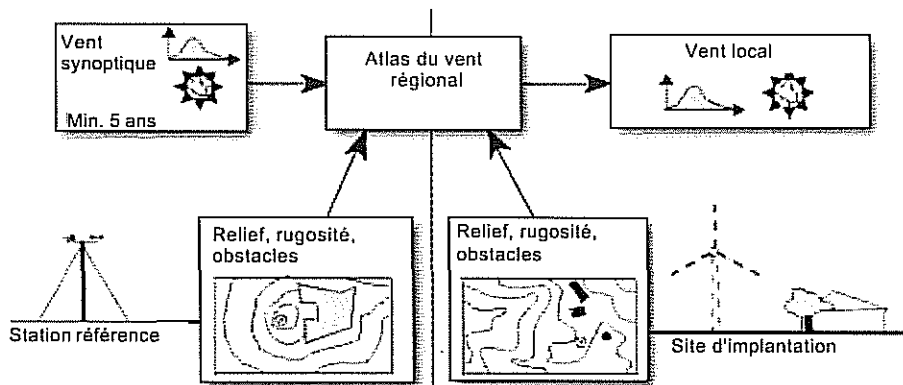


Figure 2 Méthode WAsP

WAsP nécessite donc en entrée des données météorologiques plus des données numériques de relief, de rugosité et des obstacles.

3 DESCRIPTION DU PROJET

WindVision développe un projet de 12 éoliennes sur la commune de Gesves, dans la province de Namur. La carte de la Figure 3 reprend la configuration du parc éolien et les coordonnées Lambert des éoliennes sont données au tableau 1.

WindVision envisage d'y installer des éoliennes d'un diamètre de rotor compris entre 82 et 94 mètres et d'une hauteur d'axe de 100 mètres. La distance minimale qui sépare deux éoliennes s'élève à 440 mètres, soit 4.7 fois le diamètre du rotor de 94 mètres.

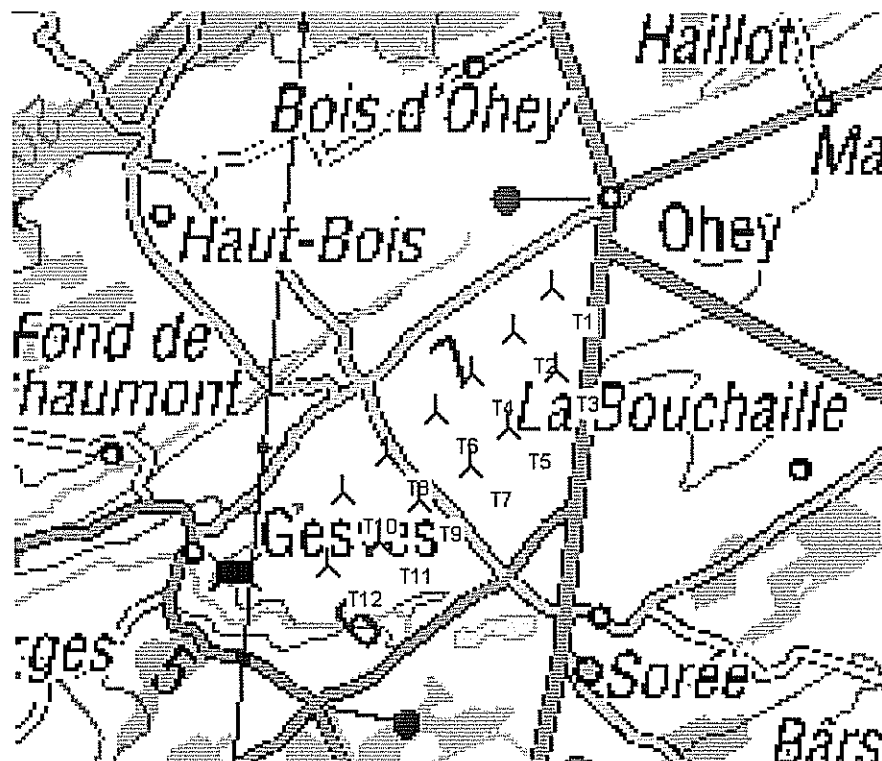


Figure 3 Configuration du parc éolien de Gesves

Tableau 1 Coordonnées Lambert et altitude des éoliennes

	x	y	Altitude (m)
T1	202334	122863	260.1
T2	202624	122413	260.5
T3	201931	122506	259.4
T4	202197	122137	264.5
T5	201563	122191	261.3
T6	201866	121789	265.0
T7	201443	121595	265.0
T8	203313	123885	260.9
T9	202999	123534	265.0
T10	203340	123203	255.2

T11	202641	123181	265.0
T12	202947	122726	260.9

7 CONCLUSION

Les estimations de production ont été calculées à partir des données météorologiques de Beauvechain et Florennes et du logiciel WASP.

A 100 m d'altitude, la vitesse moyenne du vent sur site s'élève à 6.6 m/s et les vents dominants proviennent du secteur sud-ouest.

Les résultats de production sont repris au tableau suivant pour trois types d'éoliennes et s'appuient sur les courbes de puissance adaptées à la densité de l'air du site.

Les prévisions de production ne prennent pas en compte les pertes électriques et les périodes d'indisponibilité de l'éolienne.

Table 5 Prévisions de production pour le parc éolien de Gesves

	MM92	E82	GE 2.3
Hauteur axe (m)	100	98	100
Diamètre rotor (m)	92.5	82	94
Puissance installée (MW)	24	24	27.6
Puissance nominale unitaire (MW)	2	2	2.3
Production annuelle (MWh)	64330	59505	67050
Pertes sillages (%)	8.2	8.2	8.4
Pertes électriques (%)	0	0	0
Indisponibilité technique (%)	0	0	0
Facteur capacité (h)	2680	2480	2430

ANNEXE A: COURBES DE PUISSANCE

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PARK - Power Curve Analysis

Calculation: 12 E82 h 98m, Stat Florennes & Beauvechain 92-01 WTG: 1 - ENERCON E-82 2000 82.0 (0) Calculated powercurve January 2005. Hub height: 98.0 m

Name: Calculated powercurve January 2005
 Source: Enercon

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type
01/01/2005	USER	14/03/2003	26/05/2006	25.0	Pitch	User defined

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

Vmean	[m/s]	5	6	7	8	9	10
HP value	[MWh]	2,447	3,991	5,587	7,138	8,444	9,602
ENERCON E-82 2000 82.0 (0) hub: 98.0 m (2)	[MWh]	2,995	4,688	6,386	7,937	9,273	10,365
Check value	[%]	-18	-15	-13	-10	-9	-7

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTG's performs quite similar - only specific power loading (kW/m²) at 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 from Windcat, Air density: 1.225 kg/m³

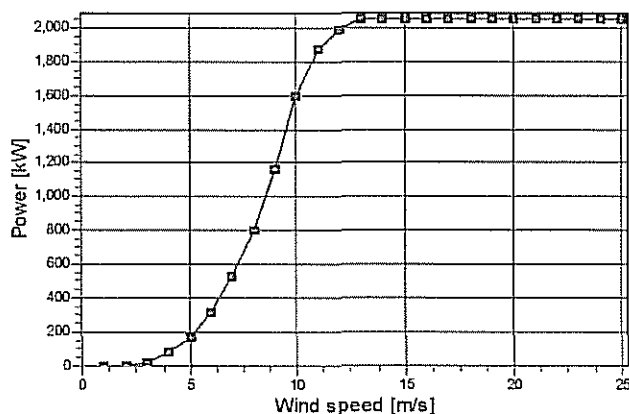
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
1.0	0.0	0.00	1.0	0.00
2.0	3.0	0.12	2.0	0.79
3.0	25.0	0.29	3.0	0.78
4.0	82.0	0.40	4.0	0.78
5.0	174.0	0.43	5.0	0.78
6.0	321.0	0.46	6.0	0.78
7.0	532.0	0.48	7.0	0.78
8.0	815.0	0.49	8.0	0.78
9.0	1,180.0	0.50	9.0	0.78
10.0	1,612.0	0.50	10.0	0.78
11.0	1,890.0	0.44	11.0	0.78
12.0	2,000.0	0.36	12.0	0.78
13.0	2,050.0	0.29	13.0	0.68
14.0	2,050.0	0.23	14.0	0.47
15.0	2,050.0	0.19	15.0	0.37
16.0	2,050.0	0.16	16.0	0.29
17.0	2,050.0	0.13	17.0	0.24
18.0	2,050.0	0.11	18.0	0.20
19.0	2,050.0	0.09	19.0	0.17
20.0	2,050.0	0.08	20.0	0.15
21.0	2,050.0	0.07	21.0	0.13
22.0	2,050.0	0.06	22.0	0.11
23.0	2,050.0	0.05	23.0	0.10
24.0	2,050.0	0.05	24.0	0.09
25.0	2,050.0	0.04	25.0	0.08

Power, Efficiency and energy vs. wind speed

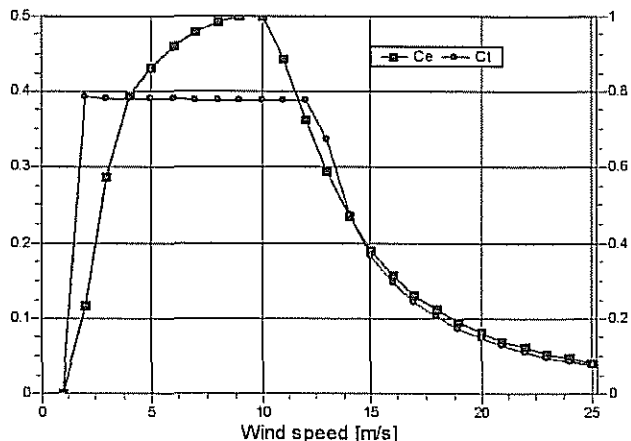
Data used in calculation, Air density: 1.206 kg/m³

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50-1.50	0.2	0.2	0.0
2.0	3.0	0.12	1.50-2.50	4.1	4.3	0.1
3.0	24.6	0.29	2.50-3.50	25.6	29.9	0.6
4.0	80.7	0.40	3.50-4.50	84.7	114.6	2.3
5.0	171.3	0.43	4.50-5.50	198.8	305.4	6.3
6.0	316.0	0.46	5.50-6.50	335.1	640.5	13.1
7.0	523.7	0.48	6.50-7.50	489.1	1,129.6	23.2
8.0	802.3	0.49	7.50-8.50	618.5	1,748.0	35.6
9.0	1,161.6	0.50	8.50-9.50	697.3	2,445.3	50.1
10.0	1,591.0	0.50	9.50-10.50	693.5	3,138.8	64.3
11.0	1,873.6	0.44	10.50-11.50	593.2	3,732.1	76.5
12.0	1,991.3	0.36	11.50-12.50	442.4	4,174.5	85.6
13.0	2,050.0	0.29	12.50-13.50	298.8	4,473.3	91.7
14.0	2,050.0	0.23	13.50-14.50	186.3	4,659.6	95.5
15.0	2,050.0	0.19	14.50-15.50	108.1	4,767.7	97.7
16.0	2,050.0	0.16	15.50-16.50	58.6	4,826.3	98.9
17.0	2,050.0	0.13	16.50-17.50	29.5	4,855.8	99.5
18.0	2,050.0	0.11	17.50-18.50	13.8	4,869.6	99.8
19.0	2,050.0	0.09	18.50-19.50	6.0	4,875.6	99.9
20.0	2,050.0	0.08	19.50-20.50	2.4	4,877.9	100.0
21.0	2,050.0	0.07	20.50-21.50	0.9	4,878.8	100.0
22.0	2,050.0	0.06	21.50-22.50	0.3	4,879.1	100.0
23.0	2,050.0	0.05	22.50-23.50	0.1	4,879.2	100.0
24.0	2,050.0	0.05	23.50-24.50	0.0	4,879.2	100.0
25.0	2,050.0	0.04	24.50-25.50	0.0	4,879.2	100.0

Power curve
Data used in calculation



Ce and Ct curve



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PARK - Power Curve Analysis

Calculation: 12 MM92 h 100m, Stat Florennes & Beauvechain 92-01 WTG: 1 - REpower MM 92 2000 92.5 IO! Measured PC (WICO255LK80502); Hub height: 100.0 m

Name: Measured PC (WICO255LK80502)
 Source: WindConsult

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type
19/12/2005	USER	7/08/2003	28/07/2006	20.0	Pitch	Standard pitch

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

Vmean [m/s]	5	6	7	8	9	10
HP value [MWh]	0	0	0	0	0	0
REpower MM 92 2000 92.5 IO! hub: 100.0 m (2) [MWh]	3,223	5,014	6,738	8,225	9,385	10,189
Check value [%]						

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTG's performs quite similar - only specific power loading (kW m⁻²) 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

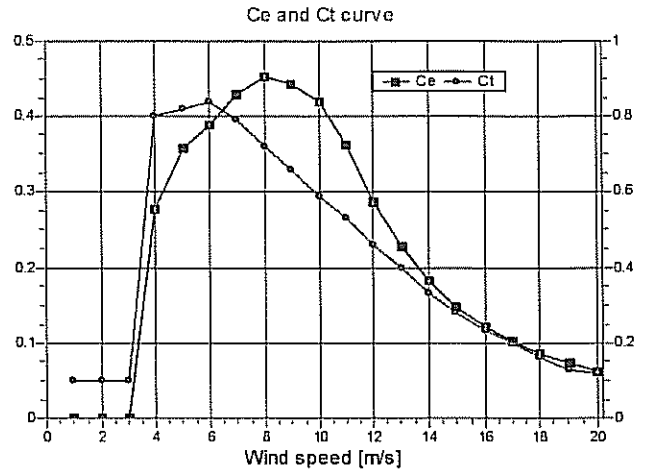
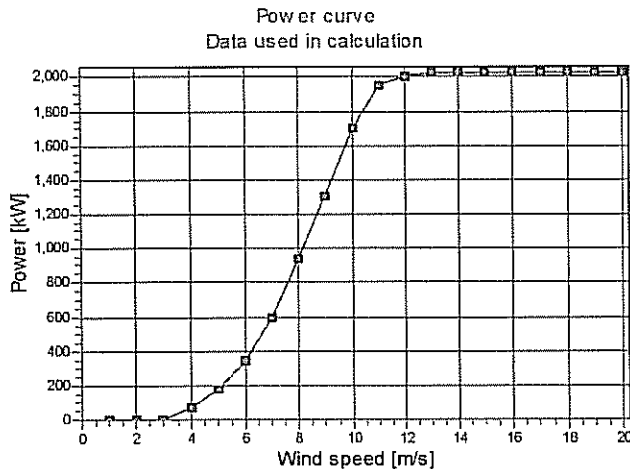
Original data from Windcal, Air density: 1.225 kg/m³

Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
2.6	-25.5	0.00	1.0	0.10
3.0	-1.1	0.00	2.0	0.10
3.5	28.2	0.16	3.0	0.10
4.0	75.4	0.28	4.0	0.80
4.5	121.4	0.32	5.0	0.82
5.0	178.3	0.35	6.0	0.84
5.5	267.4	0.39	7.0	0.79
6.0	346.4	0.39	8.0	0.72
6.5	464.5	0.41	9.0	0.66
7.0	607.8	0.43	10.0	0.59
7.5	766.4	0.44	11.0	0.53
8.0	944.2	0.45	12.0	0.46
8.5	1,147.6	0.45	13.0	0.40
9.0	1,322.0	0.44	14.0	0.33
9.5	1,564.7	0.45	15.0	0.28
10.0	1,719.0	0.42	16.0	0.23
10.6	1,894.6	0.39	17.0	0.20
11.0	1,970.6	0.36	18.0	0.16
11.5	2,004.4	0.33	19.0	0.13
12.0	2,014.1	0.29	20.0	0.12
12.5	2,025.0	0.26	21.0	0.12
13.0	2,025.1	0.23	22.0	0.11
13.5	2,024.0	0.20	23.0	0.11
13.9	2,021.0	0.19	24.0	0.10
14.5	2,021.0	0.16		
15.0	2,020.0	0.15		
15.4	2,020.0	0.14		
20.0	2,020.0	0.06		

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1.206 kg/m³

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50- 1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50- 2.50	0.0	0.0	0.0
3.0	0.0	0.00	2.50- 3.50	11.7	11.7	0.2
4.0	71.6	0.28	3.50- 4.50	70.4	82.1	1.6
5.0	181.7	0.36	4.50- 5.50	194.7	276.8	5.3
6.0	339.3	0.39	5.50- 6.50	362.6	639.4	12.1
7.0	595.5	0.43	6.50- 7.50	549.5	1,189.0	22.6
8.0	940.3	0.45	7.50- 8.50	710.5	1,899.4	36.1
9.0	1,305.8	0.44	8.50- 9.50	796.1	2,695.6	51.2
10.0	1,701.6	0.42	9.50-10.50	769.5	3,465.0	65.8
11.0	1,953.3	0.36	10.50-11.50	632.9	4,097.9	77.8
12.0	2,006.7	0.29	11.50-12.50	456.8	4,554.7	86.5
13.0	2,025.0	0.23	12.50-13.50	302.3	4,857.0	92.3
14.0	2,021.0	0.18	13.50-14.50	187.5	5,044.5	95.8
15.0	2,020.1	0.15	14.50-15.50	109.1	5,153.6	97.9
16.0	2,020.0	0.12	15.50-16.50	59.3	5,212.9	99.0
17.0	2,020.0	0.10	16.50-17.50	30.0	5,242.8	99.6
18.0	2,020.0	0.09	17.50-18.50	14.0	5,256.9	99.9
19.0	2,020.0	0.07	18.50-19.50	6.1	5,263.0	100.0
20.0	2,020.0	0.06	19.50-20.50	1.8	5,264.7	100.0



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PARK - Power Curve Analysis

Calculation: 12 GE2.3 h 100m, Stat Florennes & Beauvechain 92-01 WTG: 1 - GE WIND ENERGY GE 2.3 2300 94.0 101 Man. 10-2003, Hub height: 100.0 m

Name: Man. 10-2003
Source: Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type
02/10/2003	EMD	5/11/2003	5/11/2003	25.0	Pitch	Standard pitch

According to document: 2.3_PCD_allComp_GE45.7xx dated 2/10-2003

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

Vmean [m/s]	HP value [MWh]	GE WIND ENERGY GE 2.3 2300 94.0 101 hub: 100.0 m (2) [MWh]	Check value [%]
5	3,199	3,322	-4
6	5,054	5,240	-4
7	6,967	7,156	-3
8	8,803	8,902	-1
9	10,321	10,404	-1
10	11,680	11,630	0

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTG's performs quite similar - only specific power loading (kW/m²) at 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 from Windcat, Air density: 1.225 kg/m³

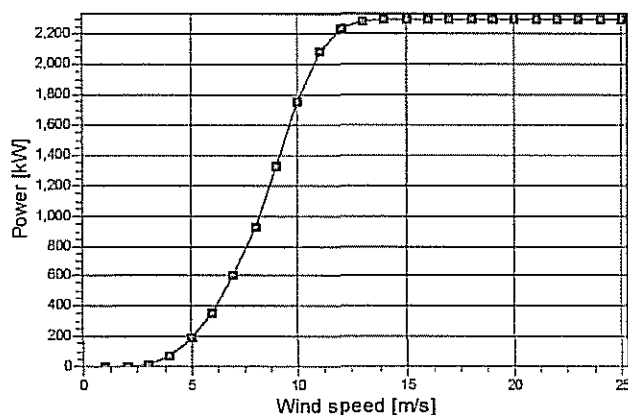
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3.0	8.0	0.07	1.0	0.10
4.0	71.0	0.26	2.0	0.10
5.0	187.0	0.35	3.0	0.10
6.0	363.0	0.40	4.0	0.80
7.0	609.0	0.42	5.0	0.82
8.0	934.0	0.43	6.0	0.84
9.0	1,352.0	0.44	7.0	0.79
10.0	1,780.0	0.42	8.0	0.72
11.0	2,113.0	0.38	9.0	0.66
12.0	2,259.0	0.31	10.0	0.59
13.0	2,295.0	0.25	11.0	0.53
14.0	2,300.0	0.20	12.0	0.46
15.0	2,300.0	0.16	13.0	0.40
16.0	2,300.0	0.13	14.0	0.33
17.0	2,300.0	0.11	15.0	0.28
18.0	2,300.0	0.09	16.0	0.23
19.0	2,300.0	0.08	17.0	0.20
20.0	2,300.0	0.07	18.0	0.16
21.0	2,300.0	0.06	19.0	0.13
22.0	2,300.0	0.05	20.0	0.12
23.0	2,300.0	0.05	21.0	0.12
24.0	2,300.0	0.04	22.0	0.11
25.0	2,300.0	0.04	23.0	0.11
			24.0	0.10

Power, Efficiency and energy vs. wind speed

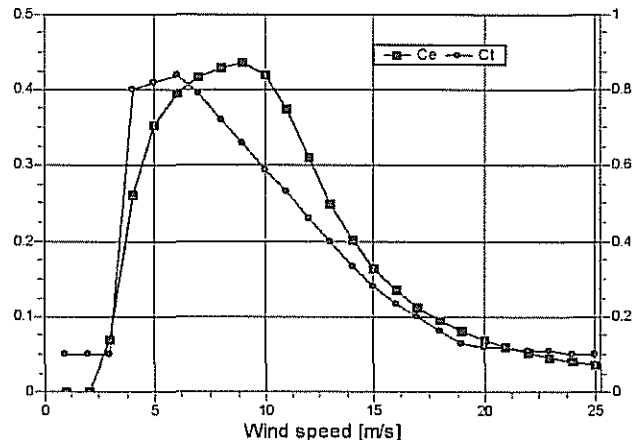
Data used in calculation, Air density: 1.206 kg/m³

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc. Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50-1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50-2.50	0.0	0.0	0.0
3.0	7.9	0.07	2.50-3.50	15.8	15.8	0.3
4.0	69.9	0.26	3.50-4.50	78.6	94.5	1.7
5.0	184.0	0.35	4.50-5.50	203.9	298.4	5.4
6.0	357.3	0.40	5.50-6.50	376.3	674.7	12.3
7.0	599.4	0.42	6.50-7.50	557.9	1,232.6	22.5
8.0	919.3	0.43	7.50-8.50	709.1	1,941.7	35.4
9.0	1,330.7	0.44	8.50-9.50	792.8	2,734.4	49.8
10.0	1,755.6	0.42	9.50-10.50	778.6	3,513.1	64.0
11.0	2,091.3	0.38	10.50-11.50	667.2	4,180.2	76.2
12.0	2,243.5	0.31	11.50-12.50	501.6	4,681.8	85.3
13.0	2,287.1	0.25	12.50-13.50	339.4	5,021.3	91.5
14.0	2,300.0	0.20	13.50-14.50	212.3	5,233.5	95.4
15.0	2,300.0	0.16	14.50-15.50	123.8	5,357.4	97.7
16.0	2,300.0	0.13	15.50-16.50	67.3	5,424.7	98.9
17.0	2,300.0	0.11	16.50-17.50	34.0	5,458.7	99.5
18.0	2,300.0	0.09	17.50-18.50	16.0	5,474.7	99.8
19.0	2,300.0	0.08	18.50-19.50	6.9	5,481.6	99.9
20.0	2,300.0	0.07	19.50-20.50	2.8	5,484.4	100.0
21.0	2,300.0	0.06	20.50-21.50	1.0	5,485.4	100.0
22.0	2,300.0	0.05	21.50-22.50	0.3	5,485.7	100.0
23.0	2,300.0	0.05	22.50-23.50	0.1	5,485.8	100.0
24.0	2,300.0	0.04	23.50-24.50	0.0	5,485.9	100.0
25.0	2,300.0	0.04	24.50-25.50	0.0	5,485.9	100.0

Power curve
Data used in calculation



Ce and Ct curve



ANNEXE B : CALCULS DE PRODUCTION

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PARK - Main Result

Calculation: 12 E82 h 98m, Stat Florennes & Beauvechain 92-01

Wake Model N.O. Jensen (RISØ/EMD)

Calculation Settings

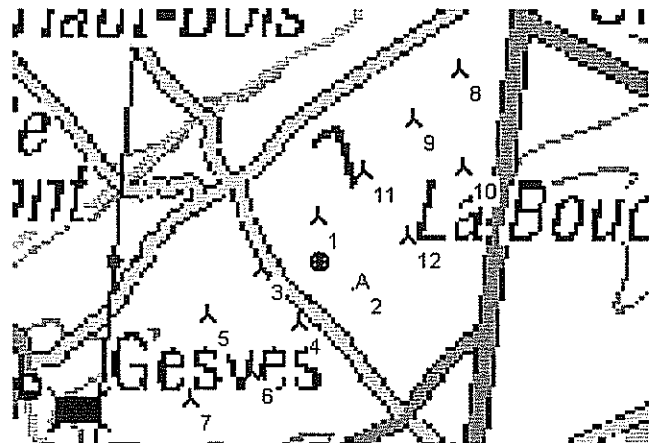
Air density calculation mode Individual per WTG
Result for WTG at hub altitude 1.206 kg/m³ to 1.207 kg/m³
Hub altitude above sea level (asl) 353.2 m to 363.0 m
Annual mean temperature at hub alt. 7.0 °C to 7.0 °C
Pressure at WTGs 959.5 hPa to 970.7 hPa

Wake Model Parameters

Wake Decay Constant 0.075

Wind data

Wind statistics	Distance [km]	Weight [%]
BE 10.00 m Beauvechain 1992-2001.lib	45	45
BE 10.00m Florennes 1992-2001 .lib	36	55



Scale 1:50,000
New WTG Site Data

Key results for height 98.0 m above ground level

Terrain Lambert (BE)

East	North	Name of wind distribution	Type	Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	202,337	122,550	Gesves	WASP (RVEAD011 1, 0, 0, 11)	2,583	6.6

Calculated Annual Energy for Wind Farm

WTG combination	Annual Energy		Park Efficiency [%]	Mean WTG energy [MWh]	Capacity Factor for	
	Result [MWh]	Result-10.0% [MWh]			Result [%]	Result-10.0% [%]
Wind farm	59,504.0	53,553.6	91.8	4,958.7	28.3	25.5

Calculated Annual Energy for each of 12 new WTG's with total 24.0 MW rated power

WTG type	Terrain	Valid	Manufact.	Type	Power [kW]	Diam. [m]	Height [m]	Power curve Creator	Annual Energy		Park Efficiency [%]	Mean wind speed [m/s]
									Result [MWh]	Result-10.0% [MWh]		
1 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,879.2	4,391	90.2	6.5
2 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,957.3	4,462	90.4	6.6
3 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,847.4	4,363	90.4	6.5
4 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,950.1	4,455	90.6	6.6
5 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,998.1	4,498	95.3	6.5
6 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	5,050.0	4,545	92.9	6.6
7 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	5,200.3	4,680	97.4	6.5
8 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,964.4	4,468	92.1	6.5
9 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,899.5	4,410	91.0	6.5
10 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	5,002.0	4,502	91.8	6.6
11 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,878.1	4,390	89.8	6.6
12 A	Yes	ENERCON	E-82	2,000	82.0	98.0	USER	Calculated powercurve January 2005	4,877.6	4,390	89.8	6.6

WTG siting

Lambert (BE)

	East	North	Z [m]	Row data/Description
1 New	202,334	122,863	264	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (2)
2 New	202,624	122,413	265	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (3)
3 New	201,931	122,506	261	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (4)
4 New	202,197	122,137	265	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (5)
5 New	201,563	122,191	255	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (6)

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PARK - Main Result

Calculation: 12 E82 h 98m, Stat Florennes & Beauvechain 92-01

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Lambert (BE)

	East	North	Z	Row data/Description
			[m]	
6 New	201,866	121,789	265	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (7)
7 New	201,443	121,595	261	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (8)
8 New	203,313	123,885	260	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (9)
9 New	202,999	123,534	261	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (10)
10 New	203,340	123,203	259	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (11)
11 New	202,641	123,181	265	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (12)
12 New	202,947	122,726	261	ENERCON E-82 2000 82.0 IOI hub: 98.0 m (13)

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PARK - Main Result

Calculation: 12 GE2.3 h 100m, Stat Florennes & Beauvechain 92-01

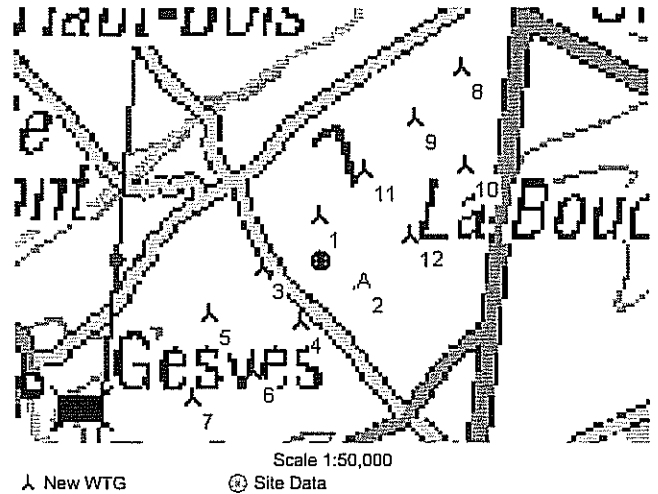
Wake Model N.O. Jensen (RISØ/EMD)

Calculation Settings
Air density calculation mode Individual per WTG
Result for WTG at hub altitude 1.206 kg/m³ to 1.207 kg/m³
Hub altitude above sea level (asl) 355.2 m to 365.0 m
Annual mean temperature at hub alt. 6.9 °C to 7.0 °C
Pressure at WTGs 969.3 hPa to 970.5 hPa

Wake Model Parameters
Wake Decay Constant 0.075

Wind data

Wind statistics	Distance [km]	Weight [%]
BE 10.00 m Beauvechain 1992-2001.lib	45	45
BE 10.00m Florennes 1992-2001 .lib	36	55



Key results for height 98.0 m above ground level

Terrain Lambert (BE)		East	North	Name of wind distribution	Type	Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	202,337	122,550	Gesves	WASP (RVEA0011 1, 0, 0, 11)	2,583	6.6	2.2	

Calculated Annual Energy for Wind Farm

WTG combination	Annual Energy		Park Efficiency [%]	Mean WTG energy [MWh]	Capacity Factor for	
	Result [MWh]	Result-10.0% [MWh]			Result [%]	Result-10.0% [%]
Wind farm	67,051.5	60,346.4	91.6	5,587.6	27.7	24.9

Calculated Annual Energy for each of 12 new WTG's with total 27.6 MW rated power

Terrain	WTG type		Type	Power [kW]	Diam. [m]	Height [m]	Power curve Creator	Name	Annual Energy		Park Efficiency [%]	Mean wind speed [m/s]
	Valid	Manufact.							Result [MWh]	Result-10.0% [MWh]		
1 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,485.9	4,937	89.8	6.6
2 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,590.8	5,032	90.3	6.6
3 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,473.9	4,927	90.4	6.5
4 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,600.9	5,041	90.7	6.6
5 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,617.9	5,056	94.8	6.5
6 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,710.3	5,139	93.0	6.6
7 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,854.8	5,269	97.1	6.5
8 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,585.3	5,027	91.8	6.6
9 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,503.5	4,953	90.5	6.6
10 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,640.0	5,076	91.7	6.6
11 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,485.6	4,937	89.5	6.6
12 A	Yes	GE WIND ENERGY	GE 2.3	2,300	94.0	100.0	EMD	Man. 10-2003	5,502.5	4,952	89.8	6.6

WTG siting

Lambert (BE)				
East	North	Z [m]	Row data/Description	
1 New	202,334	122,863	264	GE WIND ENERGY GE 2.3 2300 94.0 100.0 hub: 100.0 m (2)
2 New	202,624	122,413	265	GE WIND ENERGY GE 2.3 2300 94.0 100.0 hub: 100.0 m (3)
3 New	201,931	122,506	261	GE WIND ENERGY GE 2.3 2300 94.0 100.0 hub: 100.0 m (4)
4 New	202,197	122,137	265	GE WIND ENERGY GE 2.3 2300 94.0 100.0 hub: 100.0 m (5)

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Lambert (BE)

	East	North	Z	Row data/Description
			[m]	
5 New	201,563	122,191	255	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (6)
6 New	201,866	121,789	265	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (7)
7 New	201,443	121,595	261	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (8)
8 New	203,313	123,885	260	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (9)
9 New	202,999	123,534	261	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (10)
10 New	203,340	123,203	259	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (11)
11 New	202,641	123,181	265	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (12)
12 New	202,947	122,726	261	GE WIND ENERGY GE 2.3 2300 94.0 IO! hub: 100.0 m (13)

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PARK - Main Result
Calculation: 12 MM92 h 100m, Stat Florennes & Beauvechain 92-01

Wake Model N.O. Jensen (RISØ/EMD) Calculation Settings Air density calculation mode: Individual per WTG Result for WTG at hub altitude: 1.206 kg/m ³ to 1.207 kg/m ³ Hub altitude above sea level (asl): 355.2 m to 365.0 m Annual mean temperature at hub ell.: 6.9 °C to 7.0 °C Pressure at WTGs: 969.3 hPa to 970.5 hPa Wake Model Parameters Wake Decay Constant: 0.075 Wind data Wind statistics BE 10.00 m Beauvechain 1992-2001.lib: Distance 45 km, Weight 45 % BE 10.00m Florennes 1992-2001 .lib: Distance 36 km, Weight 55 %	
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Key results for height 100.0 m above ground level

Terrain	Lambert (BE)	East	North	Name of wind distribution	Type	Wind energy [kWh/m ²]	Mean wind speed [m/s]	Equivalent roughness
A	202,337	122,550	Gesves	WAsP (RVEA0011 1, 0, 0, 11)	2,614	6.6	2.2	

Calculated Annual Energy for Wind Farm

WTG combination	Annual Energy		Park Efficiency [%]	Mean WTG energy [MWh]	Capacity Factor for	
	Result [MWh]	Result-10.0% [MWh]			Result [%]	Result-10.0% [%]
Wind farm	64,331.5	57,898.3	91.8	5,361.0	30.6	27.5

Calculated Annual Energy for each of 12 new WTG's with total 24.0 MW rated power

WTG type	Terrain	Valid	Manufact.	Type	Power [kW]	Diam. [m]	Height [m]	Circle radius [m]	Power curve Creator	Name	Annual Energy		Park Efficiency [%]	Mean wind speed [m/s]
											Result [MWh]	Result-10.0% [MWh]		
1 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,264.7	4,738	90.1	6.6	
2 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,362.2	4,826	90.6	6.6	
3 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,252.4	4,727	90.6	6.5	
4 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,370.8	4,834	91.0	6.6	
5 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,365.4	4,847	94.8	6.5	
6 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,476.9	4,929	93.2	6.6	
7 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,608.9	5,048	97.1	6.5	
8 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,364.9	4,828	92.2	6.6	
9 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,285.4	4,757	90.8	6.6	
10 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,409.3	4,868	91.9	6.6	
11 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,268.1	4,741	89.7	6.6	
12 A	No	REpower	MM 92	2,000	92.5	100.0	350.0	USER	Measured PC (WICO255LK805/02)	5,282.6	4,754	90.1	6.6	

WTG siting

	Lambert (BE)			Row data/Description [m]
	East	North	Z	
1 New	202,334	122,863	265	REpower MM 92 2000 92.5 IOI hub: 100.0 m (2)
2 New	202,624	122,413	265	REpower MM 92 2000 92.5 IOI hub: 100.0 m (3)
3 New	201,931	122,506	261	REpower MM 92 2000 92.5 IOI hub: 100.0 m (4)
4 New	202,197	122,137	265	REpower MM 92 2000 92.5 IOI hub: 100.0 m (5)
5 New	201,563	122,191	255	REpower MM 92 2000 92.5 IOI hub: 100.0 m (6)

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PARK - Main Result**Calculation: 12 MM92 h 100m, Stat Florennes & Beauvechain 92-01**

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Lambert (BE)

	East	North	Z	Row data/Description
			[m]	
6 New	201,866	121,789	265	REpower MM 92 2000 92.5 IOI hub: 100.0 m (7)
7 New	201,443	121,595	261	REpower MM 92 2000 92.5 IOI hub: 100.0 m (8)
8 New	203,313	123,885	260	REpower MM 92 2000 92.5 IOI hub: 100.0 m (9)
9 New	202,999	123,534	261	REpower MM 92 2000 92.5 IOI hub: 100.0 m (10)
10 New	203,340	123,203	259	REpower MM 92 2000 92.5 IOI hub: 100.0 m (11)
11 New	202,641	123,181	265	REpower MM 92 2000 92.5 IOI hub: 100.0 m (12)
12 New	202,947	122,726	261	REpower MM 92 2000 92.5 IOI hub: 100.0 m (13)