MEMO

TITEL	Vurdering af mølleplacering i Høje Taastrup Kommune
DATO	01. Juni 2015
TIL	Steen Olesen
KOPI	
FRA	SAJ
PROJEKTNR	A053246

1 Indledning

Dette memo indeholder en analyse af en mulig mølleplacering i Høje Taastrup Kommune (HTK). Den undersøgte placering er udpeget af HTK og er lokaliseret i det nordvestlige hjørne af containerområdet ved Litauen Allé 9.

I analysen bliver en række forhold i relation til de relevante områder og bygninger omkring mølleplaceringen belyst. Det er vurderet om vindmøllen kan opfylde krav til støj, skygge og afstand i forhold til beboelse.

En Nordex S77 1.5 MW vindmølle er benyttet til beregningerne. Vindmøllen har en rotor diameter på 61.5 m og en navhøjde på 77 m hvilket resulterer i en totalhøjde på 100 m. Endvidere er netto årsproduktion for den nævnte mølle beregnet og sikkerhedsaspekter i forhold til isnedfald/vingekast er belyst.

2 Afstand fra vindmølle til nærmeste beboelser

Den potentielle vindmølleplacering er på forhånd udpeget af HTK. Vindmølleplaceringen kan ses i Figur 1, markeret med en gul cirkel. Endvidere er oversigt over boliger (røde cirkler) omkring vindmølleområdet hentet fra BBR bolig databasen fra Miljøministeriet/MiljøGIS. I Tabel 1 er afstanden mellem vindmølleplaceringen og de fire nærmeste boliger præsenteret. Afstandskravet om minimum 4 x møllehøjde til nærmeste beboelse overholdes.

Figur 1: Oversigt over boliger (røde punkter) i nærhed af den undersøgte vindmølleplacering (gul cirkel). Data er hentet fra BBR bolig databasen fra Miljøministeriet/MiljøGIS. De fire boliger der er tættest på er nummereret.

Bolig nummer	Afstand mellem potentiel vindmølle og beboelse [m]
1	578
2	531
3	820
4	819

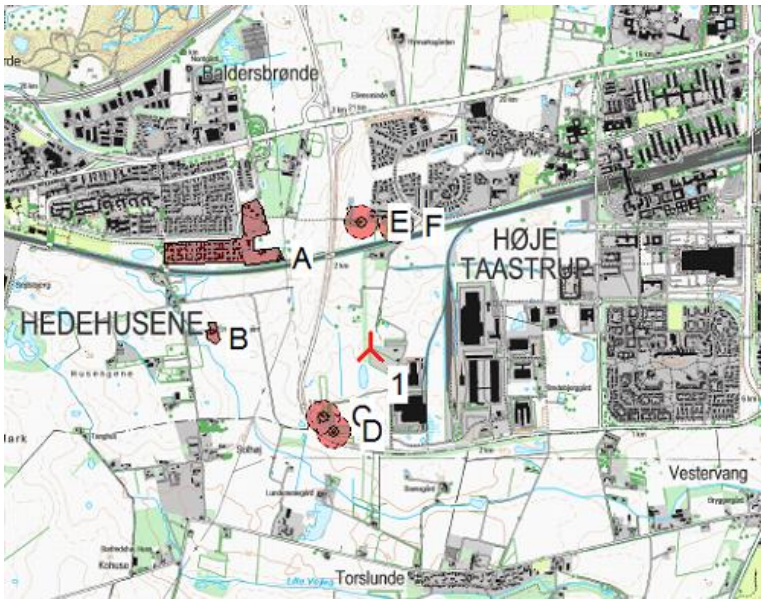
Tabel 1: Afstand mellem potentiel vindmølle og nærmeste beboelse.

3 Afklaring af status for områder omkring mølleplacering

For at vurdere om støjkrav overholdes er typen af de nærmeste beboelsesområder vurderet og det er afklaret hvilke støjkrav der skal være gældende for de enkelte boligområder.

Sydvest for vindmølleplaceringen findes der to bygninger der benyttes til beboelse (se punkt 1 og punkt 2 i Figur 1). De to beboelser klassificeres som beboelse i det åbne land. Længere sydvest for vindmølleplaceringen ved Solhøjvej og Lille Solhøjvej er der flere beboelser samlet i et mindre område hvilket klassificeres som støjfølsomt område. I retning vest for mølleplaceringen findes der enkeltbeboelser, endvidere findes der i nordlig retning på den anden side af toglinjen beboelsesområder som klassificeres som støjfølsomt areal. Øst for vindmølleplaceringen er præget af industriområder, hvor der ikke findes beboelser hvor støjpåvirkning kan være relevant.

De støjbelastede punkter/beboelsesområderne der er benyttet til støjberegningerne er præsenteret i Figur 2. Punkternes/områdernes status og gældende støjkrav for hvert punkt/område er præsenteret i Tabel 2.



Figur 2: Støjbelastede punkter omkring vindmølle.

I henhold til bekendtgørelsen om støj fra vindmøller "Bekendtgørelse nr. 1284 af 15. december 2011" fra Energistyrelsen må den samlede støjbelastning fra vindmøller ikke overstige følgende grænseværdier:

1) I det mest støjbelastede punkt ved udendørs opholdsareal højst 15 meter fra beboelse i det åbne land:

- 42 dB(A) ved en vindhastighed på 6 m/s.
- 44 dB(A) ved en vindhastighed på 8 m/s.

2) I det mest støjbelastede punkt i områder til støjfølsom arealanvendelse:

- 37 dB(A) ved en vindhastighed på 6 m/s.
- 39 dB(A) ved en vindhastighed på 8 m/s.

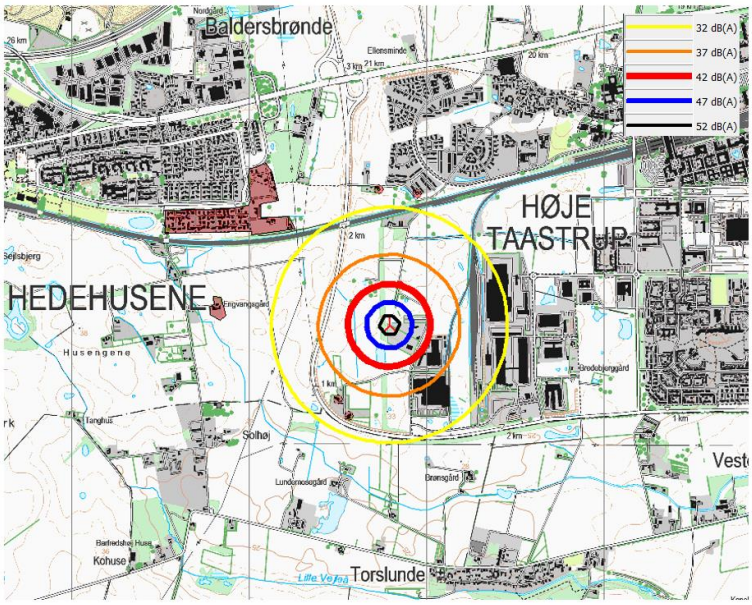
3) Den samlede lavfrekvente støj fra vindmøller må indendørs i beboelse i det åbne land eller indendørs i områder til støjfølsom arealanvendelse ikke overstige 20 dB ved en vindhastighed på 6 m/s og 8 m/s.

Støjbelastet punkt/område	Status	Gældende støjkrav ved 6 m/s / 8 m/s [dB(A)]	Gældende støjkrav for lavfrekvent støj [dB(A)]
A	Støjfølsomt område	37 / 39	20
B	Beboelse i åbent land	42 / 44	20
C	Beboelse i åbent land	42 / 44	20
D	Beboelse i åbent land	42 / 44	20
E	Støjfølsomt område	37 / 39	20
F	Støjfølsomt område	37 / 39	20

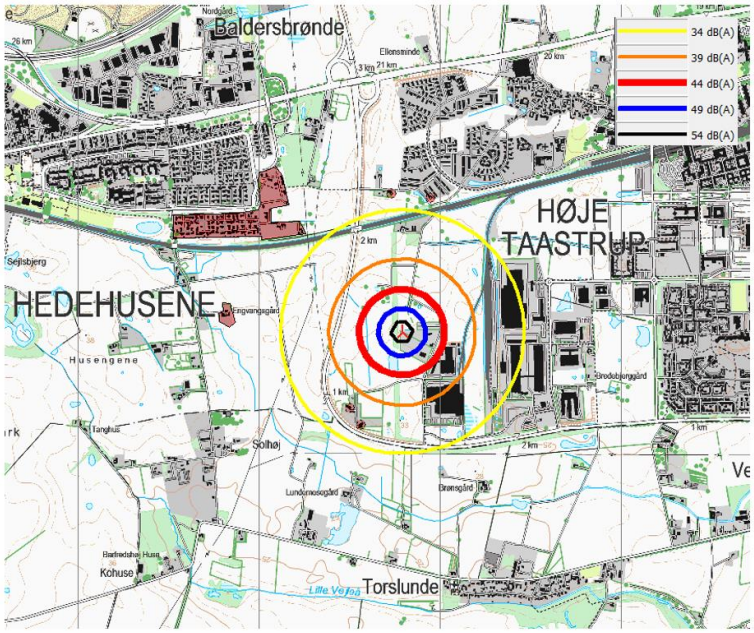
Tabel 2: Status og støjgrænser ved relevante støjbelastede punkt/områder.

4 Støjudbredelse fra Nordex S77 1.5 MW mølle

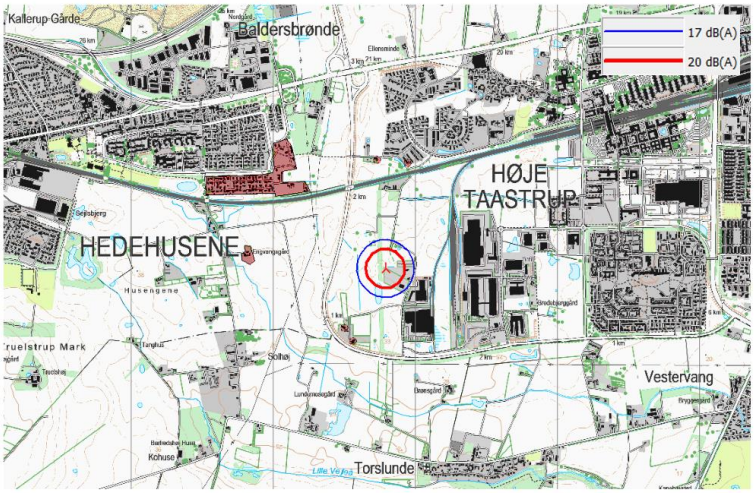
Resultaterne fra støjberegningerne for møllen er vist grafisk i Figur 3 og Figur 4 for henholdsvis 6 m/s og 8 m/s. Endvidere er resultaterne for de lavfrekvente støjberegninger vist i Figur 5 og Figur 6.



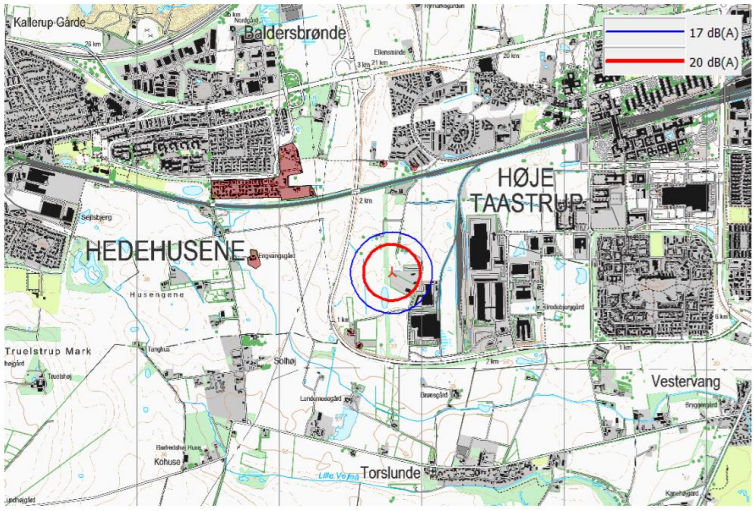
Figur 3: Støjudbredelse fra Nordex S77 1.5 MW ved 6 m/s.



Figur 4: Støjudbredelse fra Nordex S77 1.5 MW ved 8 m/s.



Figur 5: Lavfrekvent støjudbredelse fra Nordex S77 1.5 MW ved 6 m/s.



Figur 6: Lavfrekvent støjudbredelse fra Nordex S77 1.5 MW ved 8 m/s.

Resultaterne fra støjberegningerne er opsummeret i Tabel 3.

Støjbelastet punkt	Støjkrav 6 m/s / 8 m/s [dB(A)]	Støjkrav lavfrekvent 6 m/s / 8 m/s [dB(A)]	Støj fra potentiel vindmølle ved støjfølsomt punkt 6 / 8 m/s [dB(A)]	Lavfrekvent støj fra potentiel vindmølle ved støjfølsomt punkt 6 / 8 m/s [dB(A)]
A	37 / 39	20 / 20	30.6 / 32.7	5.7 / 8.6
B	42 / 44	20 / 20	28.6 / 30.7	4.0 / 6.9
C	42 / 44	20 / 20	34.7 / 36.8	9.2 / 12.1
D	42 / 44	20 / 20	33.6 / 35.8	8.3 / 11.2
E	37 / 39	20 / 20	30.6 / 32.7	5.7 / 8.6
F	37 / 39	20 / 20	30.7 / 32.8	5.8 / 8.7

Tabel 3: Estimeret støj ved støjfølsomme punkter som følge af opstilling af en Nordex S77 1.5 MW mølle på den udpegede mølleplacering.

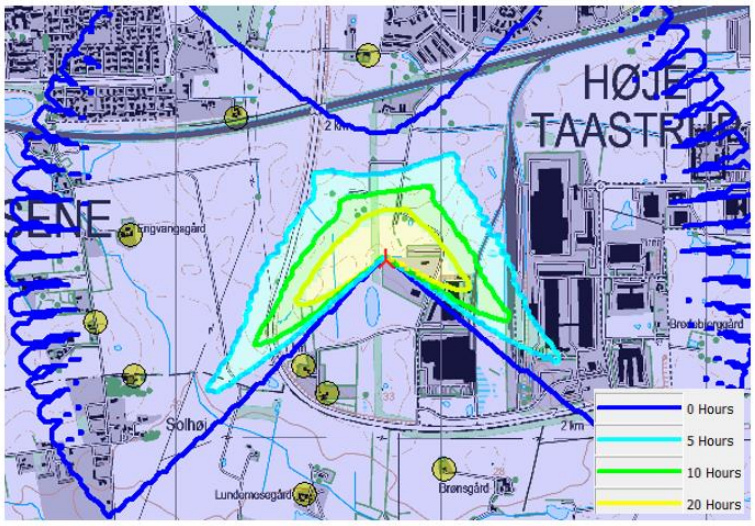
Fra støjberegningerne fremgår det at det vil være muligt at placere en Nordex S77 1.5 MW vindmølle i den foreslåede position uden at overskride støjgrænsen ved de nærmeste beboelsesområder. Støjgrænserne er overholdt med god margin.

Bemærk at grundet manglende data for støjudsendelse for den specifikke mølle er møllens kildestøjsniveauer estimeret fra generelle data fra Miljøstyrelsens vejledning nr. 1, 2012 "Støj fra vindmøller". De generelle støjdata vurderes at være konservative.

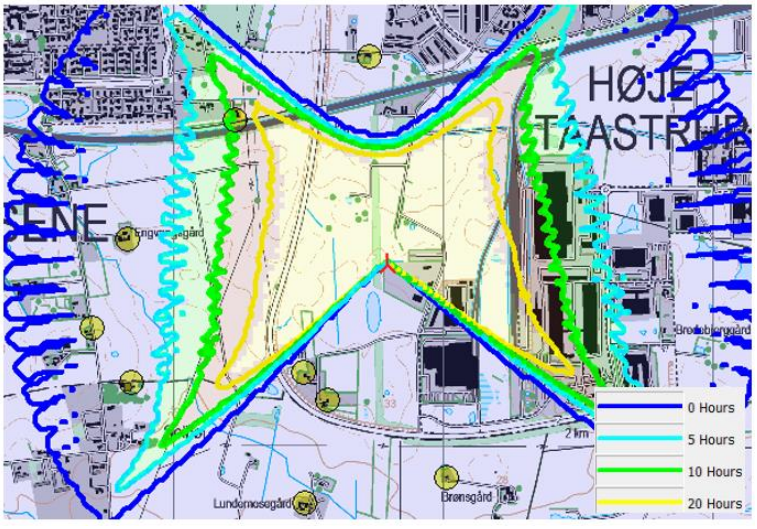
5 Skyggekast fra mølle

I "Vejledning om planlægning for og landzonetilladelse til opstilling af vindmøller" fra Miljø og Energiministeriet anbefales det at naboer højst udsættes for rotorskygge i 10 timers "reel-værdi " årlig.

En beregning er udført både for "worst-case" og "real-case/reel-værdi ". I "worst-case" scenariet regnes det med samtlige timer hvor solen står bag møllens rotor der vender mod solen, uden at tage hensyn til om solen skinner eller møllen kører. For "real-case" scenariet indregnes det at det kan være vindstille, at solen ikke alltid skinner og at rotoren ikke står kontinuerlig vinkelret på sollyset.



Figur 7: Skyggepåvirkning/flicker fra en Nordex S77 1.5 MW vindmølle, real case.



Figur 8: Skyggepåvirkning/flicker fra en Nordex S77 1.5 MW vindmølle, worst case.

For "real-case" bliver ingen beboelser berørt af rotorskygge i mere end 10 timer / årlig. Regner man med "worst-case" scenariet resulterer det i en overskridelse af de 10 timer / årlig for en enkelt beboelse ved Mølleager, nordvest for vindmøllen.

6 Netto årlig energiproduktion fra vindmølle

Beregningerne for de nye møller er udført i WindPRO 3.0/WAsP 6-9, hvor det danske vindatlas er benyttet som det vindstatistiske grundlag.

I Tabel 4 præsenteres energiproduktionsresultaterne for møllescenariet med en enkelt Nordex S77 1.5 MW med navhøjde 61.5 m. Der er indregnet et totalt energitab på 5.0 % for den nye foreslåede mølle. Dette estimat dækker energitab, som resultat af nedsat mølletilgængelighed, elektriske tab samt tab i forbindelse med møllens effektkurve.

Nye møller	Årlig brutto energi produktion [MWh/år]	Skygge tab [%]	Energitab [%]	Årlig netto energi produktion [MWh/år]	Kapacitets-faktor[1] [%]	Fuldlast-timer[2] [timer/år]
1 x Nordex S77 1.5 MW, navhøjde 61.5 m	3570.1	0.0	5.0	3391.6	25.8	2261.1

Tabel 4: Årlig netto energiproduktion for en Nordex S77 1.5 MW med navhøjde 61.5 m. Der er ikke foretaget "godheds"-korrektion af model eller energiproduktionsresultater da der ikke findes tilstrækkeligt grundlag (relevante eksisterende møller) for korrektion.

[1] Kapacitetsfaktor = 100 * (Årlig netto energiproduktion / installeret kapacitet) / 8760

[2] Fuldlasttimer = Årlig netto energiproduktion / installeret kapacitet

7 Relevante sikkerhedsaspekter (vingekast)

I anbefalingen "Afstandskrav mellem vindmøller og veje og jernbaner" fra 2010, udarbejdet af en arbejdsgruppe bestående af Miljøministeriet, Energistyrelsen, DTU-Risø, Transportministeriet og Banedanmark, præsenteres en forenklet beregningsmodel for at estimere en risikocirkel for isnedfald fra vindmøllevinger for vindmøller i drift og for stillestående vindmøller. Den præsenterede model er benyttet til at estimere risikocirkelens radius d for en Nordex S77 1.5 MW vindmølle.

Simplificeret beregningsmodel til bestemmelse af en "risikocirkel", med radius d, for isnedfald fra vindmøllevinger for en vindmølle i drift:

$$d = (D + H)\ x\ 1.5$$

Simplificeret beregningsmodel til bestemmelse af en "risikocirkel", med radius d, for isnedfald fra vindmøllevinger for en stillestående vindmølle:

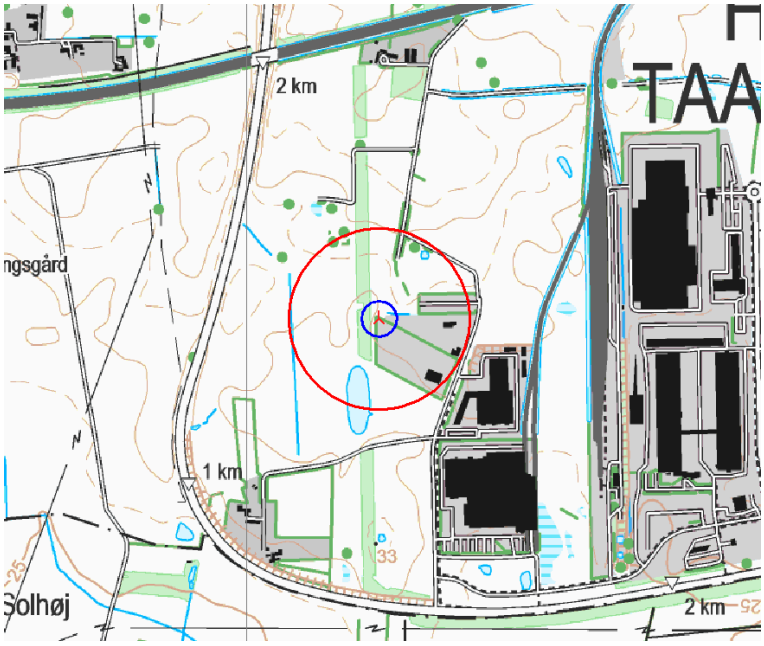
$$d = \frac{V\left(\frac{D}{2} + H\right)}{15}$$

Hvor D er vindmøllens rotordiameter, H er vindmøllens navhøjde og V er vindhastighed ved navhøjde.

Der er foretaget beregninger med en Nordex S77 1.5 MW mølle med navhøjde 61.5 m og rotor diameter på 77 m. Årsmiddelvind i navhøjde (U) er estimeret til 6.1 m/s. Beregningsmodel er ikke beregnet for ekstremtilfælde.

For en Nordex S77 1.5 MW mølle med navhøjde 61.5 m og rotor diameter på 77 m resulterer det i en risikocirkel med radius 209 m for møllen i drift. For den samme mølle i stillestående operation er risikocirkelens radius 41 m.

Risikocirkler er vist grafisk i Figur 9. Under normale omstændigheder er der ingen fare for at isnedfald rammer de nærmeste boliger. Dog kan der være fare for isnedfald ved containerområdet samt ved vejen som går fra nord til syd, tættest på vindmølleområdet.



Figur 9: Risikocirkler for isnedfald fra vingeblader, rød cirkel viser risikosone ved vindmølle i drift, blå cirkel viser risikosone ved stillestående vindmølle.

Bilag A – WindPRO DECIBEL

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DK-2800 Kgs. Lyngby

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Calculated:
29-05-2015 15:00/3.0.578

DECIBEL - Main Result

Calculation: Nordex S77, 62.5 m HH incl. existing

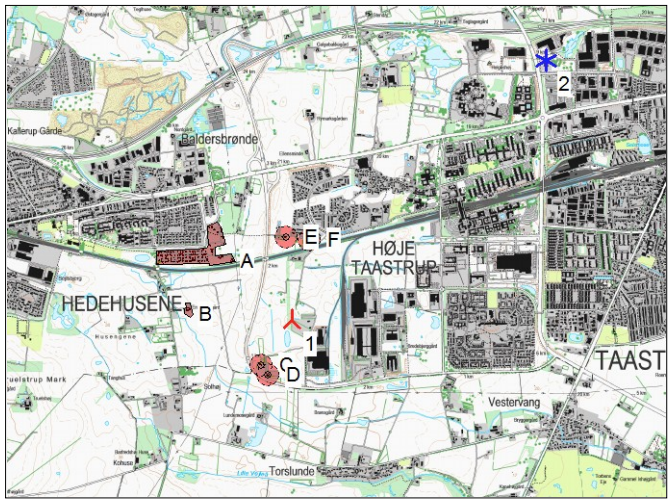
Noise calculation model:

Danish 2011

The calculation is based on the "Bekendtgørelse nr. 1284 af 15. december 2011" from the Danish Environmental Agency.

The noise impact from WTGs are not allowed to exceed the following limits: (Wind speeds in 10 m height)
1) At outdoor areas maximum 15 m from neighbor settlements in the open land.
a) 44 db(A) at wind speed 8 m/s.
b) 42 db(A) at wind speed 6 m/s.
2) At outdoor areas in residential or recreational areas.
a) 39 db(A) at wind speed 8 m/s in residential areas.
b) 37 db(A) at wind speed 6 m/s in residential areas.
The low frequency noise impact from WTGs are not allowed to exceed 20 dB indoor at wind speeds 8 and 6 m/s
The limits are not to be taken into acount for houses belonging to WTG owner

All coordinates are in
UTM (north)-WGS84 Zone: 33



Scale 1:75,000

New WTG | Existing WTG | Noise sensitive area

WTGs

	Easting	Northing	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Noise data Creator	Name	First wind speed	LwaRef		Last wind speed	LwaRef		Pure tones
			[m]					[kW]	[m]	[m]			[m/s]	[dB(A)]		[m/s]	[dB(A)]		
1	326,414	6,169,429	28.5	NORDEX S77 1500 77.0 !-! hu...	Yes	NORDEX	S77-1,500	1,500	77.0	61.5	EMD	Level 0 - official - - 04-2005	6.0	100.7	b	8.0	102.9	b	No
2	329,139	6,171,782	22.9	570715000000107078: 850 k...	Yes	VESTAS	V52-850	850	52.0	54.0	EMD	Level 0 - - 104.2 dB(A) - 07-2006	6.0	101.0	b	8.0	103.9	b	No

b) Data from Danish Environmental Agency

Calculation Results

Sound Level

Noise sensitive area No.	Name	Easting	Northing	Z	Imission height	Wind speed	Demands Noise	Sound Level From WTGs	Distance to noise demand	Demands fulfilled ? Noise
				[m]	[m]	[m/s]	[dB(A)]	[dB(A)]	[m]	
A	NSA 2	325,901	6,170,057	30.0	1.5	6.0	37.0	30.6	387	Yes
A						8.0	39.0	32.7	382	Yes
B	NSA 3	325,440	6,169,573	30.0	1.5	6.0	42.0	28.6	737	Yes
B						8.0	44.0	30.7	734	Yes
C	Noise sensitive point: Danish 2007 - Open land (5)	326,072	6,169,013	26.1	1.5	6.0	42.0	34.7	292	Yes
C						8.0	44.0	36.8	289	Yes
D	Noise sensitive point: Danish 2007 - Open land (6)	326,125	6,168,907	24.9	1.5	6.0	42.0	33.6	351	Yes
D						8.0	44.0	35.8	348	Yes
E	Noise sensitive point: Danish 2007 - Residential areas (7)	326,420	6,170,247	30.0	1.5	6.0	37.0	30.6	393	Yes
E						8.0	39.0	32.7	388	Yes
F	Noise sensitive point: Danish 2007 - Residential areas (8)	326,647	6,170,204	30.0	1.5	6.0	37.0	30.7	384	Yes
F						8.0	39.0	32.8	379	Yes

Distances (m)

	WTG	
NSA	1	2
A	811	3619
B	985	4268
C	539	4132
D	598	4166
E	818	3122
F	809	2949

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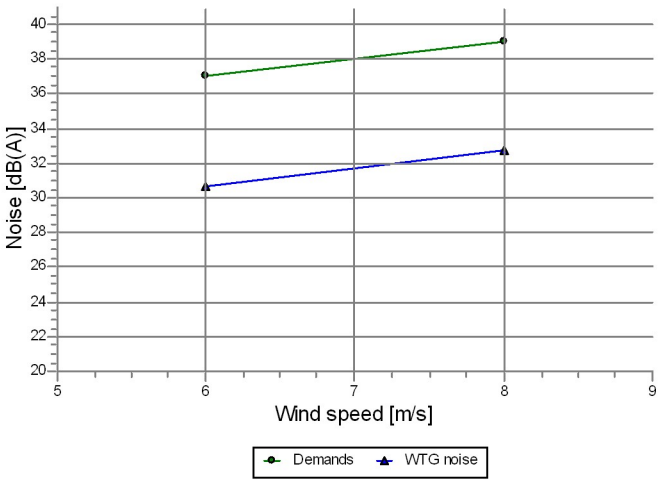
DECIBEL - Detailed results

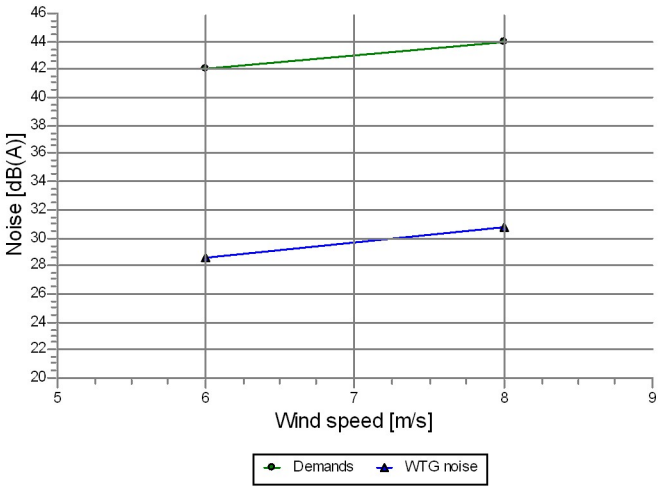
Calculation: Nordex S77, 62.5 m HH incl. existingNoise calculation model: Danish 2011

NSA 2 (A)



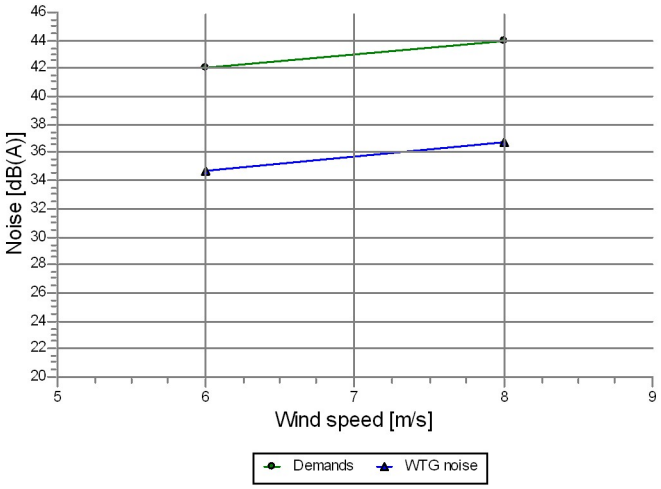
	Sound Level		
Wind speed [m/s]	Demands [dB(A)]	WTG noise [dB(A)]	Demands fulfilled ?
6.0	37.0	30.6	Yes
8.0	39.0	32.7	Yes

NSA 3 (B)



	Sound Level		
Wind speed [m/s]	Demands [dB(A)]	WTG noise [dB(A)]	Demands fulfilled ?
6.0	42.0	28.6	Yes
8.0	44.0	30.7	Yes

Noise sensitive point: Danish 2007 - Open land (5) (C)



	Sound Level		
Wind speed [m/s]	Demands [dB(A)]	WTG noise [dB(A)]	Demands fulfilled ?
6.0	42.0	34.7	Yes
8.0	44.0	36.8	Yes

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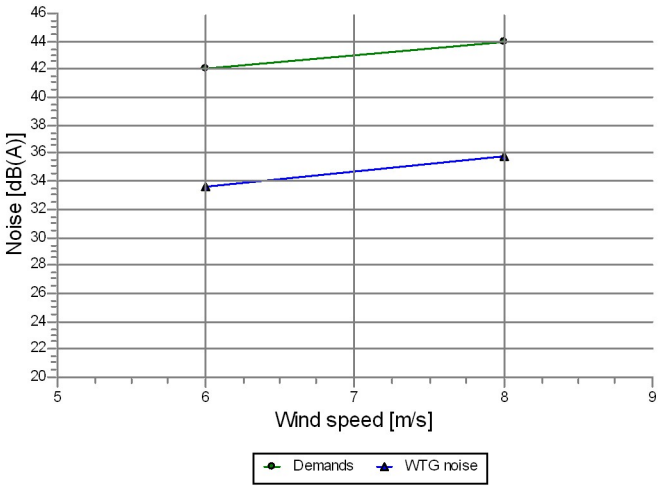
DECIBEL - Detailed results

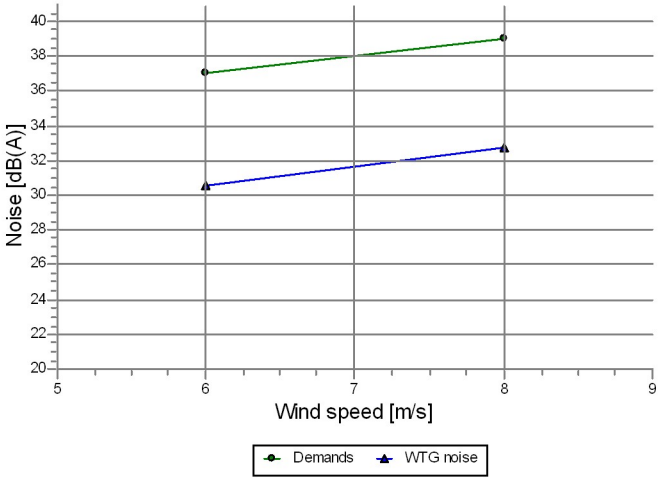
Calculation: Nordex S77, 62.5 m HH incl. existingNoise calculation model: Danish 2011

Noise sensitive point: Danish 2007 - Open land (6) (D)



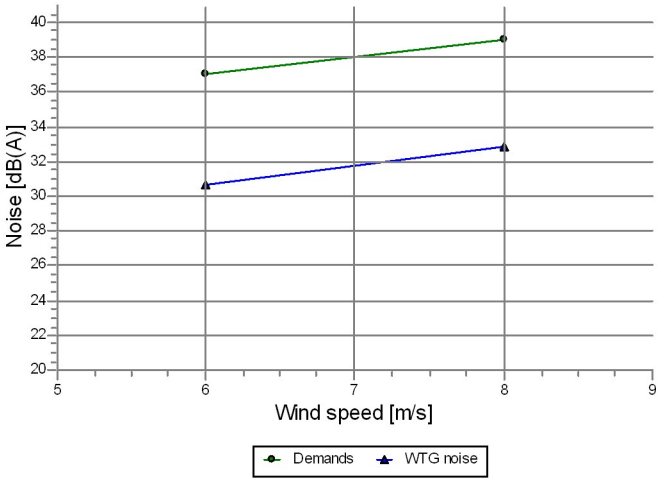
Wind speed [m/s]	Sound Level Demands [dB(A)]	WTG noise [dB(A)]	Demands fulfilled ?
6.0	42.0	33.6	Yes
8.0	44.0	35.8	Yes

Noise sensitive point: Danish 2007 - Residential areas (7) (E)



Wind speed [m/s]	Sound Level Demands [dB(A)]	WTG noise [dB(A)]	Demands fulfilled ?
6.0	37.0	30.6	Yes
8.0	39.0	32.7	Yes

Noise sensitive point: Danish 2007 - Residential areas (8) (F)



Wind speed [m/s]	Sound Level Demands [dB(A)]	WTG noise [dB(A)]	Demands fulfilled ?
6.0	37.0	30.7	Yes
8.0	39.0	32.8	Yes

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Calculated:
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DECIBEL - Assumptions for noise calculation

Calculation: Nordex S77, 62.5 m HH incl. existingNoise calculation model: Danish 2011

Noise calculation model:
Danish 2011
Wind speed:
6.0 m/s - 8.0 m/s, step 2.0 m/s
Terrain reduction:
-1.5 dB(A) Onshore
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure tone penalty are added to demand: 5.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Octave data required
Air absorption

63	125	250	500	1,000	2,000	4,000	8,000
[db/km]	[db/km]	[db/km]	[db/km]	[db/km]	[db/km]	[db/km]	[db/km]
0.1	0.4	1.0	2.0	3.6	8.8	29.0	104.5

WTG: NORDEX S77 1500 77.0 !-!
Noise: Level 0 - official - - 04-2005

Source	Source/Date	Creator	Edited
Manufacturer	21-04-2005	EMD	21-11-2005 16:18

						Octave data							
Status	Hub height	Wind speed	LwA,ref	Pure tones		63	125	250	500	1000	2000	4000	8000
	[m]	[m/s]	[dB(A)]			[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
Data from Danish Environmental Agency	61.5	6.0	100.7	No	Generic data	84.0	90.9	94.1	93.8	93.5	93.1	89.8	82.8
Data from Danish Environmental Agency	61.5	8.0	102.9	No	Generic data	86.5	92.9	96.3	95.8	95.6	95.2	92.3	85.2

WTG: VESTAS V52 850 52.0 !O!
Noise: Level 0 - - 104.2 dB(A) - 07-2006

Source	Source/Date	Creator	Edited
Manufacturer	20-07-2006	EMD	14-09-2010 13:48

Data based on document 946506.R9 2006-07-20.
Measurement standard IEC 61400-11 ed. 2 2002
Max. turbulence at 10 meter height: 16%
Inflow angle (vertical): 0 ± 2°
Air density: 1.225 kg/m3.
Please note that the sound power level may differ marginally at other hub heights.

						Octave data							
Status	Hub height	Wind speed	LwA,ref	Pure tones		63	125	250	500	1000	2000	4000	8000
	[m]	[m/s]	[dB(A)]			[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
Data from Danish Environmental Agency	54.0	6.0	101.0	No	Generic data	79.4	88.3	92.4	95.1	95.2	93.1	91.1	81.7
Data from Danish Environmental Agency	54.0	8.0	103.9	No	Generic data	83.6	91.1	96.1	97.9	97.2	96.7	93.9	84.2

NSA: NSA 2-A
Predefined calculation standard: Residential areas
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
37.0 dB(A)	39.0 dB(A)

No distance demand

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DECIBEL - Assumptions for noise calculation

Calculation: Nordex S77, 62.5 m HH incl. existingNoise calculation model: Danish 2011

NSA: NSA 3-B
Predefined calculation standard: Open land
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Open land (5)-C
Predefined calculation standard: Open land
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Open land (6)-D
Predefined calculation standard: Open land
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
42.0 dB(A)	44.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Residential areas (7)-E
Predefined calculation standard: Residential areas
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
37.0 dB(A)	39.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Residential areas (8)-F
Predefined calculation standard: Residential areas
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
37.0 dB(A)	39.0 dB(A)

No distance demand

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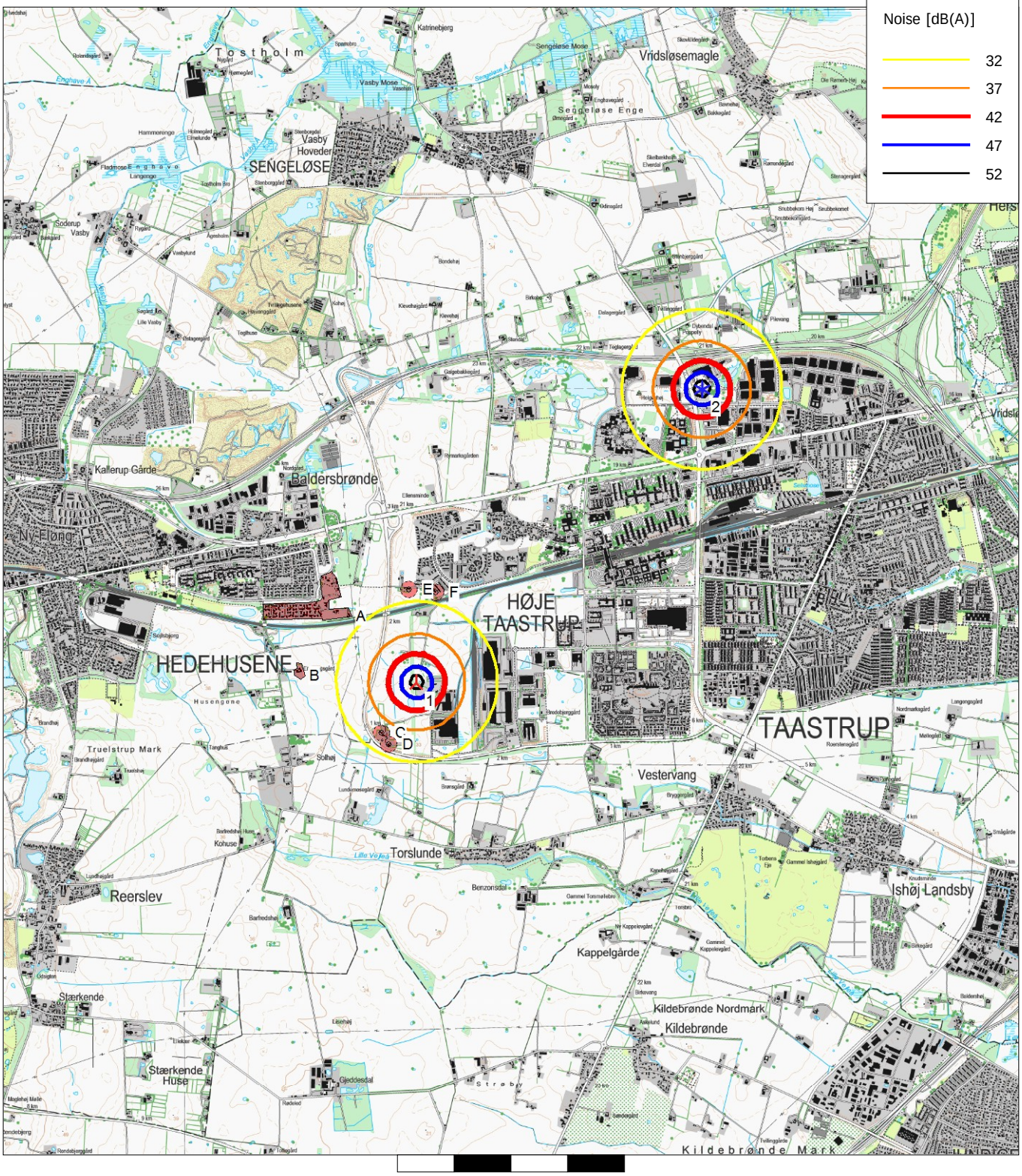
Calculated:
29-05-2015 15:00/3.0.578

DECIBEL - Map 6.0 m/s

Calculation: Nordex S77, 62.5 m HH incl. existingNoise calculation model: Danish 2011



Map: Kort25-1110_6200_700 6200_700, Print scale 1:50,000, Map center UTM (north)-WGS84 Zone: 33 East: 327,777 North: 6,170,606

New WTG Existing WTG Noise sensitive area

Noise calculation model: Danish 2011. Wind speed: 6.0 m/s
Height above sea level from active line object

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DK-2800 Kgs. Lyngby

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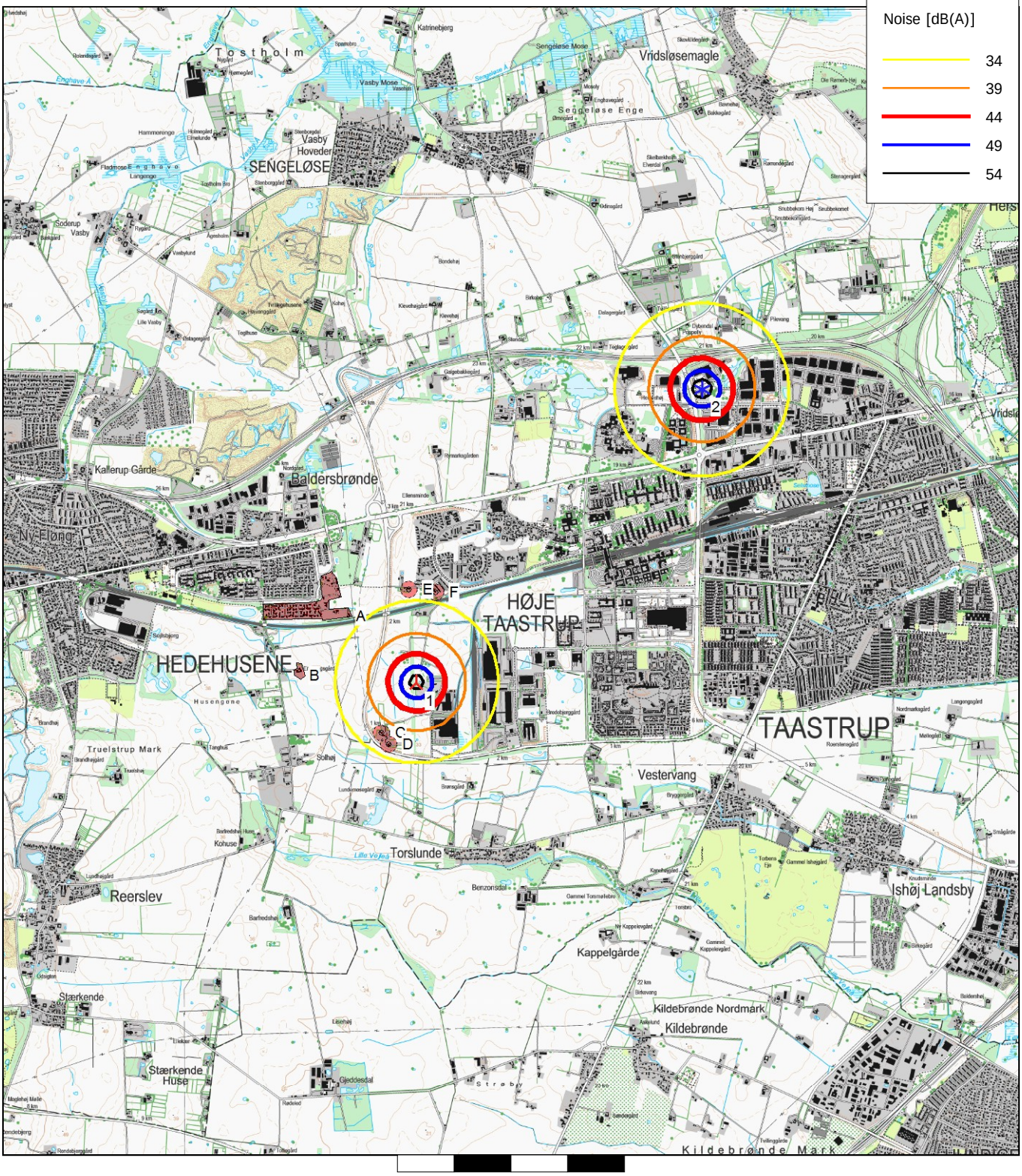
Calculated:
29-05-2015 15:00/3.0.578

DECIBEL - Map 8.0 m/s

Calculation: Nordex S77, 62.5 m HH incl. existingNoise calculation model: Danish 2011



Map: Kort25-1110_6200_700 6200_700, Print scale 1:50,000, Map center UTM (north)-WGS84 Zone: 33 East: 327,777 North: 6,170,606

New WTG Existing WTG Noise sensitive area

Noise calculation model: Danish 2011. Wind speed: 8.0 m/s
Height above sea level from active line object

Bilag B – WindPRO DECIBEL Lavfrekvent

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Calculated:
29-05-2015 12:32/3.0.578

DECIBEL - Main Result

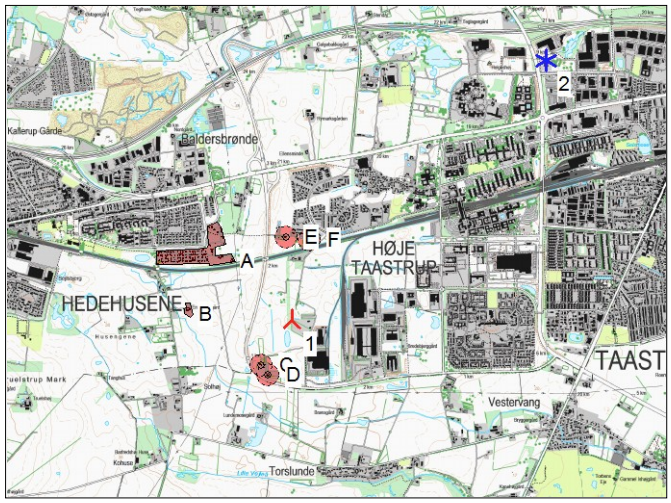
Calculation: Nordex S77, 62.5 m HH incl. existing Lavfrekvent

Noise calculation model:
Danish 2011 Low frequency

The calculation is based on the "Bekendtgørelse nr. 1284 af 15. december 2011" from the Danish Environmental Agency.

The noise impact from WTGs are not allowed to exceed the following limits: (Wind speeds in 10 m height)
1) At outdoor areas maximum 15 m from neighbor settlements in the open land.
a) 44 db(A) at wind speed 8 m/s.
b) 42 db(A) at wind speed 6 m/s.
2) At outdoor areas in residential or recreational areas.
a) 39 db(A) at wind speed 8 m/s in residential areas.
b) 37 db(A) at wind speed 6 m/s in residential areas.
The low frequency noise impact from WTGs are not allowed to exceed 20 dB indoor at wind speeds 8 and 6 m/s
The limits are not to be taken into acount for houses belonging to WTG owner
Den lavfrekvente støj beregnes indendøre og må ikke overstige 20 dB ved vindhastigheder på 6 og 8 m/s i 10 m højde

All coordinates are in
UTM (north)-WGS84 Zone: 33



Scale 1:75,000

New WTG | Existing WTG | Noise sensitive area

WTGs

	Easting	Northing	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Noise data Creator	Name	First wind speed	LwaRef		Last wind speed	LwaRef	
			[m]					[kW]	[m]	[m]			[m/s]	[dB(A)]		[m/s]	[dB(A)]	
1	326,414	6,169,429	28.5	NORDEX S77 1500 77.0 !-! h...	Yes	NORDEX	S77-1,500	1,500	77.0	61.5	EMD	Level 0 - official - - 04-2005	6.0	91.7	b	8.0	93.9	b
2	329,139	6,171,782	22.9	570715000000107078: 850 ...	Yes	VESTAS	V52-850	850	52.0	54.0	EMD	Level 0 - - 104.2 dB(A) - 07-2006	6.0	88.9	b	8.0	91.9	b

b) Data from Danish Environmental Agency

Calculation Results

Sound Level

Noise sensitive area No.	Name	Easting	Northing	Z	Imission height	Wind speed	Demands Noise	Sound Level From WTGs	Distance to noise demand	Demands fulfilled ? Noise
				[m]	[m]	[m/s]	[dB(A)]	[dB(A)]	[m]	
A	NSA 2 LF	325,901	6,170,057	30.0	1.5	6.0	20.0	5.7	664	Yes
A						8.0	20.0	8.6	600	Yes
B	NSA 3 LF	325,440	6,169,573	30.0	1.5	6.0	20.0	4.0	839	Yes
B						8.0	20.0	6.9	774	Yes
C	Noise sensitive point: Danish 2007 - Open land LF	326,072	6,169,013	26.1	1.5	6.0	20.0	9.2	393	Yes
C						8.0	20.0	12.1	328	Yes
D	Noise sensitive point: Danish 2007 - Open land LF	326,125	6,168,907	24.9	1.5	6.0	20.0	8.3	452	Yes
D						8.0	20.0	11.2	387	Yes
E	Noise sensitive point: Danish 2007 - Residential areas LF	326,420	6,170,247	30.0	1.5	6.0	20.0	5.7	672	Yes
E						8.0	20.0	8.6	607	Yes
F	Noise sensitive point: Danish 2007 - Residential areas LF	326,647	6,170,204	30.0	1.5	6.0	20.0	5.8	660	Yes
F						8.0	20.0	8.7	598	Yes

Distances (m)

	WTG	
NSA	1	2
A	811	3619
B	985	4268
C	539	4132
D	598	4166
E	818	3122
F	809	2949

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DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
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DECIBEL - Assumptions for noise calculation

Calculation: Nordex S77, 62.5 m HH incl. existing Lavfrekvent

Noise calculation model:
Danish 2011 Low frequency
Wind speed:
6.0 m/s - 8.0 m/s, step 2.0 m/s
Ground attenuation:
None
Meteorological coefficient, C0:
0.0 dB
Type of demand in calculation:
1: WTG noise is compared to demand (DK, DE, SE, NL etc.)
Noise values in calculation:
All noise values are mean values (Lwa) (Normal)
Pure tones:
Pure tone penalty are added to demand: 0.0 dB(A)
Height above ground level, when no value in NSA object:
1.5 m Don't allow override of model height with height from NSA object
Deviation from "official" noise demands. Negative is more restrictive, positive is less restrictive.:
0.0 dB(A)
Low frequency calculation
?Ls

10.0 Hz	12.5 Hz	16.0 Hz	20.0 Hz	25.0 Hz	31.5 Hz	40.0 Hz	50.0 Hz	63.0 Hz	80.0 Hz	100.0 Hz	125.0 Hz	160.0 Hz
[db]	[db]	[db]	[db]	[db]	[db]	[db]	[db]	[db]	[db]	[db]	[db]	[db]
4.9	5.9	4.6	6.6	8.4	10.8	11.4	13.0	16.6	19.7	21.2	20.2	21.2

WTG: NORDEX S77 1500 77.0 !-!
Noise: Level 0 - official - - 04-2005

Source	Source/Date	Creator	Edited
Manufacturer	21-04-2005	EMD	21-11-2005 16:18

				Low frequency data												
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	10.0 Hz [dB]	12.5 Hz [dB]	16.0 Hz [dB]	20.0 Hz [dB]	25.0 Hz [dB]	31.5 Hz [dB]	40.0 Hz [dB]	50.0 Hz [dB]	63.0 Hz [dB]	80.0 Hz [dB]	100.0 Hz [dB]	125.0 Hz [dB]	160.0 Hz [dB]
Data from Danish Environmental Agency	61.5	6.0	91.7	37.6	44.1	50.3	57.1	62.1	65.7	70.2	75.2	78.9	81.4	83.9	86.3	87.4
Data from Danish Environmental Agency	61.5	8.0	93.9	42.3	47.8	53.0	59.4	65.9	70.9	75.7	77.8	81.2	84.1	86.9	88.3	89.0

WTG: VESTAS V52 850 52.0 !O!
Noise: Level 0 - - 104.2 dB(A) - 07-2006

Source	Source/Date	Creator	Edited
Manufacturer	20-07-2006	EMD	14-09-2010 13:48

Data based on document 946506.R9 2006-07-20.
Measurement standard IEC 61400-11 ed. 2 2002
Max. turbulence at 10 meter height: 16%
Inflow angle (vertical): 0 ± 2°
Air density: 1.225 kg/m3.
Please note that the sound power level may differ marginally at other hub heights.

				Low frequency data												
Status	Hub height [m]	Wind speed [m/s]	LwA,ref [dB(A)]	10.0 Hz [dB]	12.5 Hz [dB]	16.0 Hz [dB]	20.0 Hz [dB]	25.0 Hz [dB]	31.5 Hz [dB]	40.0 Hz [dB]	50.0 Hz [dB]	63.0 Hz [dB]	80.0 Hz [dB]	100.0 Hz [dB]	125.0 Hz [dB]	160.0 Hz [dB]
Data from Danish Environmental Agency	54.0	6.0	88.9	37.8	40.9	47.7	52.9	58.1	62.0	67.5	72.6	73.0	76.9	81.3	82.0	85.8
Data from Danish Environmental Agency	54.0	8.0	91.9	42.6	46.4	52.5	58.2	63.5	67.5	71.3	76.8	77.9	80.8	83.6	85.6	88.5

NSA: NSA 2 LF-A
Predefined calculation standard: Indoor
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
20.0 dB(A)	20.0 dB(A)

No distance demand

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DECIBEL - Assumptions for noise calculation

Calculation: Nordex S77, 62.5 m HH incl. existing Lavfrekvent

NSA: NSA 3 LF-B
Predefined calculation standard: Indoor
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
20.0 dB(A)	20.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Open land LF-C
Predefined calculation standard: Indoor
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
20.0 dB(A)	20.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Open land LF-D
Predefined calculation standard: Indoor
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
20.0 dB(A)	20.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Residential areas LF-E
Predefined calculation standard: Indoor
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
20.0 dB(A)	20.0 dB(A)

No distance demand

NSA: Noise sensitive point: Danish 2007 - Residential areas LF-F
Predefined calculation standard: Indoor
Imission height(a.g.l.): Use standard value from calculation model

Noise demand:

6.0 [m/s]	8.0 [m/s]
20.0 dB(A)	20.0 dB(A)

No distance demand

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Calculated:
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DECIBEL - Map 6.0 m/s

Calculation: Nordex S77, 62.5 m HH incl. existing Lavfrekvent

Map: Kort25-1110_6200_700 6200_700, Print scale 1:50,000, Map center UTM (north)-WGS84 Zone: 33 East: 327,777 North: 6,170,606

New WTG Existing WTG Noise sensitive area

Noise calculation model: Danish 2011 Low frequency. Wind speed: 6.0 m/s

Height above sea level from active line object

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Calculated:
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DECIBEL - Map 8.0 m/s

Calculation: Nordex S77, 62.5 m HH incl. existing Lavfrekvent

Map: Kort25-1110_6200_700 6200_700, Print scale 1:50,000, Map center UTM (north)-WGS84 Zone: 33 East: 327,777 North: 6,170,606

New WTG Existing WTG Noise sensitive area

Noise calculation model: Danish 2011 Low frequency. Wind speed: 8.0 m/s

Height above sea level from active line object

Bilag B – WindPRO SHADOW

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Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Main Result

Calculation: Shadow flicker

Assumptions for shadow calculations

Maximum distance for influence
Calculate only when more than 20 % of sun is covered by the blade
Please look in WTG table

Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational hours are calculated from WTGs in calculation and wind distribution:
For PARK

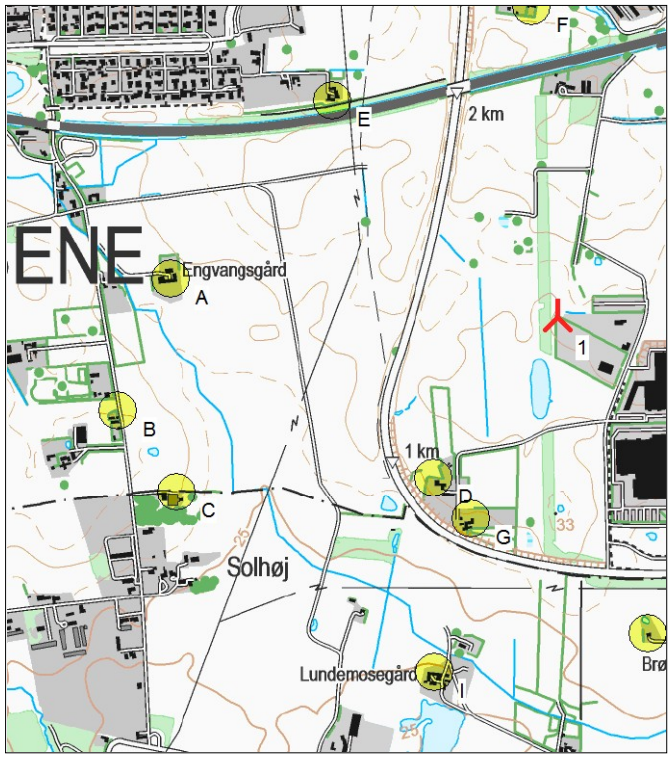
Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: HCL - SRTM
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10.0 m

All coordinates are in
UTM (north)-WGS84 Zone: 33



Scale 1:20,000

New WTG Shadow receptor

WTGs

	Easting	Northing	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Shadow data Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
1	326,414	6,169,429	28.5	NORDEX S77 1500 77.0 !-! hub: 61.5 ...	Yes	NORDEX	S77-1,500	1,500	77.0	61.5	1,505	17.3

Shadow receptor-Input

No.	Name	Easting	Northing	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	Shadow Receptor 1	325,406	6,169,617	30.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
B	Shadow Receptor 2	325,236	6,169,283	30.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
C	Shadow Receptor 3	325,372	6,169,055	29.5	1.0	1.0	1.0	0.0	90.0	"Green house mode"
D	Shadow Receptor 4	326,050	6,169,034	26.3	1.0	1.0	1.0	0.0	90.0	"Green house mode"
E	Shadow Receptor 5	325,870	6,170,049	30.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
F	Shadow Receptor 6	326,417	6,170,251	30.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
G	Shadow Recepter 7	326,139	6,168,916	24.9	1.0	1.0	1.0	0.0	90.0	"Green house mode"
H	Shadow Receptor 8	326,578	6,168,574	20.5	1.0	1.0	1.0	0.0	90.0	"Green house mode"
I	Shadow Receptor 9	326,010	6,168,522	21.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow, expected values Shadow hours per year [h/year]
A	Shadow Receptor 1	2:54	18	0:15	0:31
B	Shadow Receptor 2	1:50	16	0:11	0:27
C	Shadow Receptor 3	3:08	22	0:14	0:54
D	Shadow Receptor 4	0:00	0	0:00	0:00
E	Shadow Receptor 5	11:19	46	0:23	1:02

To be continued on next page...

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Calculated:
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SHADOW - Main Result

Calculation: Shadow flicker

...continued from previous page

No.	Name	Shadow, worst case Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow, expected values Shadow hours per year [h/year]
F	Shadow Receptor 6	0:00	0	0:00	0:00
G	Shadow Recepter 7	0:00	0	0:00	0:00
H	Shadow Receptor 8	0:00	0	0:00	0:00
I	Shadow Receptor 9	0:00	0	0:00	0:00

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]	Expected [h/year]
1	NORDEX S77 1500 77.0 !-! hub: 61.5 m (TOT: 100.0 m) (37)	19:11	2:56

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Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: A - Shadow Receptor 1

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March		April	May	June	July	August	September		October		November	December
1	08:41	08:07	07:05		06:45	05:31	04:37	04:32	05:16	06:15		07:13	07:40 (1)	07:15	08:15
	15:49	16:44	17:45		19:48	20:48	21:42	21:58	21:19	20:08		18:49	2 07:42 (1)	16:34	15:45
2	08:41	08:05	07:02		06:43	05:29	04:36	04:33	05:17	06:17		07:14		07:18	08:17
	15:50	16:47	17:47		19:50	20:50	21:44	21:58	21:17	20:05		18:47		16:32	15:45
3	08:40	08:03	07:00		06:40	05:27	04:35	04:33	05:19	06:19		07:16		07:20	08:18
	15:52	16:49	17:49		19:52	20:52	21:45	21:57	21:15	20:03		18:44		16:30	15:44
4	08:40	08:01	06:57		06:37	05:25	04:34	04:34	05:21	06:21		07:18		07:22	08:20
	15:53	16:51	17:51		19:54	20:54	21:46	21:57	21:13	20:00		18:42		16:28	15:43
5	08:40	07:59	06:55		06:35	05:22	04:33	04:35	05:23	06:22		07:20		07:24	08:21
	15:54	16:53	17:53		19:56	20:56	21:48	21:56	21:11	19:57		18:39		16:26	15:42
6	08:39	07:57	06:52		06:32	05:20	04:32	04:36	05:25	06:24		07:22		07:26	08:23
	15:56	16:55	17:55		19:58	20:58	21:49	21:55	21:09	19:55		18:37		16:24	15:42
7	08:39	07:55	06:50		06:30	05:18	04:31	04:37	05:27	06:26		07:24		07:28	08:24
	15:57	16:57	17:57		20:00	21:00	21:50	21:55	21:07	19:52		18:34		16:22	15:41
8	08:38	07:53	06:47		06:27	05:16	04:31	04:38	05:29	06:28		07:26		07:30	08:26
	15:59	16:59	17:59		20:02	21:02	21:51	21:54	21:05	19:50		18:31		16:20	15:41
9	08:37	07:51	06:45		06:25	05:14	04:30	04:40	05:30	06:30		07:28		07:32	08:27
	16:00	17:02	18:01		20:04	21:03	21:52	21:53	21:03	19:47		18:29		16:18	15:40
10	08:36	07:49	06:42		06:22	05:12	04:30	04:41	05:32	06:32		07:30		07:34	08:28
	16:02	17:04	18:03		20:06	21:05	21:53	21:52	21:00	19:44		18:26		16:16	15:40
11	08:36	07:47	06:40		06:19	05:10	04:29	04:42	05:34	06:34		07:32		07:36	08:29
	16:03	17:06	18:05		20:08	21:07	21:54	21:51	20:58	19:42		18:24		16:14	15:39
12	08:35	07:45	06:37		06:17	05:08	04:29	04:43	05:36	06:36		07:34		07:39	08:31
	16:05	17:08	18:07		20:10	21:09	21:54	21:50	20:56	19:39		18:21		16:12	15:39
13	08:34	07:42	06:35		06:59 (1)	06:14	05:06	04:28	04:45	05:38		06:38		07:36	07:41	08:32
	16:07	17:10	18:09	4	07:03 (1)	20:12	21:11	21:55	21:49	20:54		19:37		18:19	16:10	15:39
14	08:33	07:40	06:32		06:57 (1)	06:12	05:04	04:28	04:46	05:40		06:40		07:38	07:43	08:33
	16:09	17:12	18:11	7	07:04 (1)	20:14	21:13	21:56	21:48	20:52		19:34		18:16	16:09	15:39
15	08:32	07:38	06:29		06:54 (1)	06:09	05:02	04:28	04:47	05:42		06:42		07:40	07:45	08:34
	16:10	17:15	18:13	9	07:03 (1)	20:16	21:15	21:57	21:47	20:49		19:31		18:14	16:07	15:39
16	08:31	07:36	06:27		06:52 (1)	06:07	05:01	04:27	04:49	05:44		06:44		07:42	07:47	08:35
	16:12	17:17	18:15	12	07:04 (1)	20:18	21:17	21:57	21:45	20:47		19:29		18:11	16:05	15:39
17	08:30	07:33	06:24		06:49 (1)	06:04	04:59	04:27	04:50	05:46		06:45		07:44	07:49	08:36
	16:14	17:19	18:18	14	07:03 (1)	20:20	21:18	21:58	21:44	20:45		19:26		18:09	16:04	15:39
18	08:28	07:31	06:22		06:46 (1)	06:02	04:57	04:27	04:52	05:48		06:47		07:46	07:51	08:36
	16:16	17:21	18:20	15	07:01 (1)	20:22	21:20	21:58	21:43	20:42		19:24		18:07	16:02	15:39
19	08:27	07:29	06:19		06:47 (1)	05:59	04:55	04:27	04:53	05:50		06:49		07:48	07:53	08:37
	16:18	17:23	18:22	14	07:01 (1)	20:24	21:22	21:59	21:41	20:40		19:21		18:04	16:00	15:39
20	08:26	07:27	06:16		06:48 (1)	05:57	04:54	04:27	04:55	05:52		06:51		07:51	07:55	08:38
	16:20	17:25	18:24	10	06:58 (1)	20:26	21:24	21:59	21:40	20:37		19:18		18:02	15:59	15:40
21	08:25	07:24	06:14		06:52 (1)	05:55	04:52	04:27	04:56	05:53		06:53		07:53	07:57	08:38
	16:22	17:28	18:26	2	06:54 (1)	20:28	21:25	21:59	21:38	20:35		19:16		17:59	15:57	15:40
22	08:23	07:22	06:11			05:52	04:50	04:27	04:58	05:55		06:55		07:55	07:59	08:39
	16:24	17:30	18:28			20:30	21:27	21:59	21:37	20:33		19:13		17:57	15:56	15:41
23	08:22	07:19	06:09			05:50	04:49	04:28	05:00	05:57		06:57	07:34 (1)	07:57	08:01	08:39
	16:26	17:32	18:30			20:32	21:29	22:00	21:35	20:30		19:10	8 07:42 (1)	17:55	15:55	15:41
24	08:20	07:17	06:06			05:47	04:47	04:28	05:01	05:59		06:59	07:31 (1)	07:59	08:02	08:40
	16:28	17:34	18:32			20:34	21:30	22:00	21:34	20:28		19:08	13 07:44 (1)	17:52	15:53	15:42
25	08:19	07:15	06:03			05:45	04:46	04:28	05:03	06:01		07:01	07:29 (1)	07:01	08:04	08:40
	16:30	17:36	18:34			20:36	21:32	22:00	21:32	20:25		19:05	15 07:44 (1)	16:50	15:52	15:42
26	08:17	07:12	06:01			05:43	04:44	04:29	05:05	06:03		07:03	07:30 (1)	07:03	08:06	08:41
	16:32	17:38	18:36			20:38	21:34	22:00	21:30	20:23		19:03	14 07:44 (1)	16:48	15:51	15:43
27	08:15	07:10	05:58			05:40	04:43	04:29	05:07	06:05		07:05	07:32 (1)	07:05	08:08	08:41
	16:34	17:40	18:38			20:40	21:35	21:59	21:28	20:20		19:00	12 07:44 (1)	16:45	15:50	15:44
28	08:14	07:07	05:56			05:38	04:42	04:30	05:08	06:07		07:07	07:34 (1)	07:07	08:10	08:41
	16:36	17:42	18:40			20:42	21:37	21:59	21:27	20:18		18:57	10 07:44 (1)	16:43	15:48	15:45
29	08:12		06:53			05:36	04:40	04:30	05:10	06:09		07:09	07:36 (1)	07:09	08:11	08:41
	16:38		19:42			20:44	21:38	21:59	21:25	20:15		18:55	8 07:44 (1)	16:41	15:47	15:46
30	08:10		06:50			05:33	04:39	04:31	05:12	06:11		07:11	07:38 (1)	07:11	08:13	08:41
	16:40		19:44			20:46	21:40	21:59	21:23	20:13		18:52	5 07:43 (1)	16:39	15:46	15:47
31	08:09		06:48				04:38		05:14	06:13				07:13		08:41
	16:42		19:46				21:41		21:21	20:10				16:36		15:48
Potential sun hours	240	268	366		424	503	522	523	466	384		325		251	222	
Total, worst case				87							85		2			
Sun reduction				0.31							0.40		0.31			
Oper. time red.				0.84							0.84		0.84			
Wind dir. red.				0.63							0.63		0.63			
Total reduction				0.16							0.21		0.16			
Total, real				14							18		0			

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: B - Shadow Receptor 2

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April		May	June	July	August		September		October	November	December
1	08:41	08:07	07:05	06:45		05:31	04:37	04:32	05:16		06:15	06:44 (1)	07:13	07:15	08:15
	15:49	16:44	17:45	19:48		20:48	21:42	21:58	21:19		20:08 10	06:54 (1)	18:50	16:34	15:46
2	08:41	08:05	07:02	06:43		05:29	04:36	04:33	05:17		06:17	06:45 (1)	07:14	07:18	08:17
	15:50	16:47	17:47	19:50		20:50	21:44	21:58	21:17		20:05 8	06:53 (1)	18:47	16:32	15:45
3	08:40	08:03	07:00	06:40		05:27	04:35	04:33	05:19		06:19	06:47 (1)	07:16	07:20	08:18
	15:52	16:49	17:49	19:52		20:52	21:45	21:57	21:15		20:03 6	06:53 (1)	18:44	16:30	15:44
4	08:40	08:01	06:57	06:37		05:25	04:34	04:34	05:21		06:21	06:49 (1)	07:18	07:22	08:20
	15:53	16:51	17:51	19:54		20:54	21:46	21:57	21:13		20:00 4	06:53 (1)	18:42	16:28	15:43
5	08:40	07:59	06:55	06:35		05:22	04:33	04:35	05:23		06:22	06:51 (1)	07:20	07:24	08:21
	15:54	16:53	17:53	19:56		20:56	21:48	21:56	21:11		19:57 1	06:52 (1)	18:39	16:26	15:42
6	08:39	07:57	06:52	06:32		05:20	04:32	04:36	05:25		06:24		07:22	07:26	08:23
	15:56	16:55	17:55	19:58		20:58	21:49	21:55	21:09		19:55		18:37	16:24	15:42
7	08:38	07:55	06:50	06:30	06:54 (1)	05:18	04:32	04:37	05:27		06:26		07:24	07:28	08:24
	15:57	16:57	17:57	20:00 1	06:55 (1)	21:00	21:50	21:55	21:07		19:52		18:34	16:22	15:41
8	08:38	07:53	06:47	06:27	06:52 (1)	05:16	04:31	04:38	05:29		06:28		07:26	07:30	08:26
	15:59	16:59	17:59	20:02 4	06:56 (1)	21:02	21:51	21:54	21:05		19:50		18:31	16:20	15:41
9	08:37	07:51	06:45	06:25	06:49 (1)	05:14	04:30	04:40	05:30		06:30		07:28	07:32	08:27
	16:00	17:02	18:01	20:04 6	06:55 (1)	21:03	21:52	21:53	21:03		19:47		18:29	16:18	15:40
10	08:36	07:49	06:42	06:22	06:47 (1)	05:12	04:30	04:41	05:32		06:32		07:30	07:34	08:28
	16:02	17:04	18:03	20:06 8	06:55 (1)	21:05	21:53	21:52	21:00		19:45		18:26	16:16	15:40
11	08:36	07:47	06:40	06:19	06:44 (1)	05:10	04:29	04:42	05:34		06:34		07:32	07:36	08:29
	16:03	17:06	18:05	20:08 10	06:54 (1)	21:07	21:54	21:51	20:58		19:42		18:24	16:14	15:39
12	08:35	07:45	06:37	06:17	06:42 (1)	05:08	04:29	04:43	05:36		06:36		07:34	07:39	08:31
	16:05	17:08	18:07	20:10 11	06:53 (1)	21:09	21:54	21:50	20:56		19:39		18:21	16:12	15:39
13	08:34	07:42	06:35	06:14	06:42 (1)	05:06	04:28	04:45	05:38		06:38		07:36	07:41	08:32
	16:07	17:10	18:09	20:12 10	06:52 (1)	21:11	21:55	21:49	20:54		19:37		18:19	16:10	15:39
14	08:33	07:40	06:32	06:12	06:44 (1)	05:04	04:28	04:46	05:40		06:40		07:38	07:43	08:33
	16:09	17:12	18:11	20:14 5	06:49 (1)	21:13	21:56	21:48	20:52		19:34		18:16	16:09	15:39
15	08:32	07:38	06:29	06:09		05:02	04:28	04:47	05:42		06:42		07:40	07:45	08:34
	16:10	17:15	18:13	20:16		21:15	21:57	21:47	20:49		19:31		18:14	16:07	15:39
16	08:31	07:36	06:27	06:07		05:01	04:27	04:49	05:44		06:44		07:42	07:47	08:35
	16:12	17:17	18:15	20:18		21:17	21:57	21:45	20:47		19:29		18:11	16:05	15:39
17	08:30	07:33	06:24	06:04		04:59	04:27	04:50	05:46		06:45		07:44	07:49	08:36
	16:14	17:19	18:18	20:20		21:18	21:58	21:44	20:45		19:26		18:09	16:04	15:39
18	08:28	07:31	06:22	06:02		04:57	04:27	04:52	05:48		06:47		07:46	07:51	08:36
	16:16	17:21	18:20	20:22		21:20	21:58	21:43	20:42		19:24		18:07	16:02	15:39
19	08:27	07:29	06:19	05:59		04:55	04:27	04:53	05:50		06:49		07:48	07:53	08:37
	16:18	17:23	18:22	20:24		21:22	21:59	21:41	20:40		19:21		18:04	16:00	15:40
20	08:26	07:27	06:16	05:57		04:54	04:27	04:55	05:52		06:51		07:51	07:55	08:38
	16:20	17:25	18:24	20:26		21:24	21:59	21:40	20:37		19:18		18:02	15:59	15:40
21	08:25	07:24	06:14	05:55		04:52	04:27	04:57	05:54		06:53		07:53	07:57	08:38
	16:22	17:28	18:26	20:28		21:25	21:59	21:38	20:35		19:16		17:59	15:57	15:40
22	08:23	07:22	06:11	05:52		04:50	04:27	04:58	05:55		06:55		07:55	07:59	08:39
	16:24	17:30	18:28	20:30		21:27	21:59	21:37	20:33		19:13		17:57	15:56	15:41
23	08:22	07:19	06:09	05:50		04:49	04:28	05:00	05:57		06:57		07:57	08:00	08:39
	16:26	17:32	18:30	20:32		21:29	22:00	21:35	20:30		19:10		17:55	15:55	15:41
24	08:20	07:17	06:06	05:47		04:47	04:28	05:01	05:59		06:59		07:59	08:02	08:40
	16:28	17:34	18:32	20:34		21:30	22:00	21:34	20:28		19:08		17:52	15:53	15:42
25	08:19	07:15	06:03	05:45		04:46	04:28	05:03	06:01		07:01		07:01	08:04	08:40
	16:30	17:36	18:34	20:36		21:32	22:00	21:32	20:25		19:05		16:50	15:52	15:42
26	08:17	07:12	06:01	05:43		04:44	04:29	05:05	06:03		07:03		07:03	08:06	08:41
	16:32	17:38	18:36	20:38		21:34	22:00	21:30	20:23		19:03		16:48	15:51	15:43
27	08:15	07:10	05:58	05:40		04:43	04:29	05:07	06:05		07:05		07:05	08:08	08:41
	16:34	17:40	18:38	20:40		21:35	21:59	21:28	20:20		19:00		16:45	15:50	15:44
28	08:14	07:07	05:56	05:38		04:42	04:30	05:08	06:07		07:07		07:07	08:10	08:41
	16:36	17:42	18:40	20:42		21:37	21:59	21:27	20:18		18:57		16:43	15:49	15:45
29	08:12		06:53	05:36		04:41	04:30	05:10	06:09	06:45 (1)	07:09		07:09	08:11	08:41
	16:38		19:42	20:44		21:38	21:59	21:25	20:15 5	06:50 (1)	18:55		16:41	15:47	15:46
30	08:10		06:50	05:33		04:39	04:31	05:12	06:11	06:42 (1)	07:11		07:11	08:13	08:41
	16:40		19:44	20:46		21:40	21:59	21:23	20:13 10	06:52 (1)	18:52		16:39	15:46	15:47
31	08:09		06:48			04:38		05:14	06:13	06:42 (1)			07:13		08:41
	16:42		19:46			21:41		21:21	20:10 11	06:53 (1)			16:36		15:48
Potential sun hours	240	268	366	424		503	522	523	466		384		325	251	222
Total, worst case					55					26		29			
Sun reduction					0.43					0.50		0.40			
Oper. time red.					0.84					0.84		0.84			
Wind dir. red.					0.68					0.68		0.68			
Total reduction					0.24					0.28		0.23			
Total, real					13					7		7			

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: C - Shadow Receptor 3

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April		May		June	July	August		September	October	November	December
1	08:41	08:07	07:05	06:45		05:31	05:58 (1)	04:37	04:32	05:16		06:15	07:13	07:15	08:15
	15:49	16:44	17:45	19:48		20:48	10 06:08 (1)	21:42	21:58	21:19		20:08	18:50	16:34	15:46
2	08:41	08:05	07:02	06:43		05:29	05:56 (1)	04:36	04:33	05:17		06:17	07:14	07:18	08:16
	15:50	16:47	17:47	19:50		20:50	12 06:08 (1)	21:44	21:58	21:17		20:05	18:47	16:32	15:45
3	08:40	08:03	07:00	06:40		05:27	05:54 (1)	04:35	04:33	05:19		06:19	07:16	07:20	08:18
	15:52	16:49	17:49	19:52		20:52	14 06:08 (1)	21:45	21:57	21:15		20:03	18:44	16:30	15:44
4	08:40	08:01	06:57	06:37		05:25	05:53 (1)	04:34	04:34	05:21		06:21	07:18	07:22	08:20
	15:53	16:51	17:51	19:54		20:54	14 06:07 (1)	21:46	21:57	21:13		20:00	18:42	16:28	15:43
5	08:40	07:59	06:55	06:35		05:22	05:54 (1)	04:33	04:35	05:23		06:22	07:20	07:24	08:21
	15:54	16:53	17:53	19:56		20:56	12 06:06 (1)	21:48	21:56	21:11		19:57	18:39	16:26	15:42
6	08:39	07:57	06:52	06:32		05:20	05:55 (1)	04:32	04:36	05:25	06:07 (1)	06:24	07:22	07:26	08:23
	15:56	16:55	17:55	19:58		20:58	9 06:04 (1)	21:49	21:55	21:09	5 06:12 (1)	19:55	18:37	16:24	15:42
7	08:38	07:55	06:50	06:30		05:18	05:59 (1)	04:32	04:37	05:27	06:04 (1)	06:26	07:24	07:28	08:24
	15:57	16:57	17:57	20:00		21:00	1 06:00 (1)	21:50	21:55	21:07	10 06:14 (1)	19:52	18:34	16:22	15:41
8	08:38	07:53	06:47	06:27		05:16		04:31	04:39	05:29	06:03 (1)	06:28	07:26	07:30	08:25
	15:59	16:59	17:59	20:02		21:02		21:51	21:54	21:05	12 06:15 (1)	19:50	18:31	16:20	15:41
9	08:37	07:51	06:45	06:25		05:14		04:30	04:40	05:30	06:02 (1)	06:30	07:28	07:32	08:27
	16:00	17:02	18:01	20:04		21:03		21:52	21:53	21:03	14 06:16 (1)	19:47	18:29	16:18	15:40
10	08:36	07:49	06:42	06:22		05:12		04:30	04:41	05:32	06:04 (1)	06:32	07:30	07:34	08:28
	16:02	17:04	18:03	20:06		21:05		21:53	21:52	21:00	13 06:17 (1)	19:44	18:26	16:16	15:40
11	08:36	07:47	06:40	06:19		05:10		04:29	04:42	05:34	06:06 (1)	06:34	07:32	07:36	08:29
	16:03	17:06	18:05	20:08		21:07		21:54	21:51	20:58	12 06:18 (1)	19:42	18:24	16:14	15:39
12	08:35	07:45	06:37	06:17		05:08		04:29	04:43	05:36	06:07 (1)	06:36	07:34	07:38	08:31
	16:05	17:08	18:07	20:10		21:09		21:54	21:50	20:56	10 06:17 (1)	19:39	18:21	16:12	15:39
13	08:34	07:42	06:35	06:14		05:06		04:28	04:45	05:38	06:09 (1)	06:38	07:36	07:41	08:32
	16:07	17:10	18:09	20:12		21:11		21:55	21:49	20:54	8 06:17 (1)	19:37	18:19	16:10	15:39
14	08:33	07:40	06:32	06:12		05:04		04:28	04:46	05:40	06:11 (1)	06:40	07:38	07:43	08:33
	16:09	17:12	18:11	20:14		21:13		21:56	21:48	20:51	6 06:17 (1)	19:34	18:16	16:09	15:39
15	08:32	07:38	06:29	06:09		05:02		04:28	04:47	05:42	06:13 (1)	06:42	07:40	07:45	08:34
	16:10	17:15	18:13	20:16		21:15		21:57	21:47	20:49	4 06:17 (1)	19:31	18:14	16:07	15:39
16	08:31	07:36	06:27	06:07		05:01		04:27	04:49	05:44	06:14 (1)	06:44	07:42	07:47	08:35
	16:12	17:17	18:15	20:18		21:17		21:57	21:45	20:47	1 06:15 (1)	19:29	18:11	16:05	15:39
17	08:30	07:33	06:24	06:04		04:59		04:27	04:50	05:46		06:45	07:44	07:49	08:36
	16:14	17:19	18:18	20:20		21:18		21:58	21:44	20:45		19:26	18:09	16:04	15:39
18	08:28	07:31	06:22	06:02		04:57		04:27	04:52	05:48		06:47	07:46	07:51	08:36
	16:16	17:21	18:20	20:22		21:20		21:58	21:43	20:42		19:24	18:07	16:02	15:39
19	08:27	07:29	06:19	05:59		04:55		04:27	04:53	05:50		06:49	07:48	07:53	08:37
	16:18	17:23	18:22	20:24		21:22		21:59	21:41	20:40		19:21	18:04	16:00	15:40
20	08:26	07:27	06:16	05:57		04:54		04:27	04:55	05:52		06:51	07:51	07:55	08:38
	16:20	17:25	18:24	20:26		21:24		21:59	21:40	20:37		19:18	18:02	15:59	15:40
21	08:25	07:24	06:14	05:55		04:52		04:27	04:57	05:54		06:53	07:53	07:57	08:38
	16:22	17:28	18:26	20:28		21:25		21:59	21:38	20:35		19:16	17:59	15:57	15:40
22	08:23	07:22	06:11	05:52		04:50		04:27	04:58	05:55		06:55	07:55	07:59	08:39
	16:24	17:30	18:28	20:30		21:27		21:59	21:37	20:33		19:13	17:57	15:56	15:41
23	08:22	07:19	06:09	05:50		04:49		04:28	05:00	05:57		06:57	07:57	08:00	08:39
	16:26	17:32	18:30	20:32		21:29		21:59	21:35	20:30		19:10	17:55	15:55	15:41
24	08:20	07:17	06:06	05:47		04:47		04:28	05:01	05:59		06:59	07:59	08:02	08:40
	16:28	17:34	18:32	20:34		21:30		22:00	21:34	20:28		19:08	17:52	15:53	15:42
25	08:19	07:15	06:03	05:45		04:46		04:28	05:03	06:01		07:01	07:01	08:04	08:40
	16:30	17:36	18:34	20:36		21:32		22:00	21:32	20:25		19:05	16:50	15:52	15:42
26	08:17	07:12	06:01	05:43		04:44		04:29	05:05	06:03		07:03	07:03	08:06	08:41
	16:32	17:38	18:36	20:38		21:34		22:00	21:30	20:23		19:03	16:48	15:51	15:43
27	08:15	07:10	05:58	05:40	06:07 (1)	04:43		04:29	05:07	06:05		07:05	07:05	08:08	08:41
	16:34	17:40	18:38	20:40	2 06:09 (1)	21:35		21:59	21:28	20:20		19:00	16:45	15:50	15:44
28	08:14	07:07	05:56	05:38	06:05 (1)	04:42		04:30	05:08	06:07		07:07	07:07	08:10	08:41
	16:36	17:42	18:40	20:42	4 06:09 (1)	21:37		21:59	21:27	20:18		18:57	16:43	15:49	15:45
29	08:12		06:53	05:36	06:03 (1)	04:41		04:30	05:10	06:09		07:09	07:09	08:11	08:41
	16:38		19:42	20:44	6 06:09 (1)	21:38		21:59	21:25	20:15		18:55	16:41	15:47	15:46
30	08:10		06:50	05:33	06:00 (1)	04:39		04:31	05:12	06:11		07:11	07:11	08:13	08:41
	16:40		19:44	20:46	9 06:09 (1)	21:40		21:59	21:23	20:13		18:52	16:39	15:46	15:47
31	08:09		06:48			04:38			05:14	06:13			07:13		08:41
	16:42		19:46			21:41			21:21	20:10			16:36		15:48
Potential sun hours	240	268	366	424		503		522	523	466		384	325	251	222
Total, worst case					21		72				95				
Sun reduction					0.43		0.51				0.50				
Oper. time red.					0.84		0.84				0.84				
Wind dir. red.					0.70		0.70				0.70				
Total reduction					0.25		0.30				0.29				
Total, real					5		21				28				

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: D - Shadow Receptor 4

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:41	08:07	07:05	06:45	05:31	04:37	04:32	05:16	06:15	07:12	07:15	08:15
	15:49	16:44	17:44	19:48	20:48	21:42	21:58	21:19	20:08	18:49	16:34	15:45
2	08:41	08:05	07:02	06:42	05:29	04:36	04:33	05:17	06:17	07:14	07:18	08:16
	15:50	16:46	17:47	19:50	20:50	21:44	21:58	21:17	20:05	18:47	16:32	15:45
3	08:40	08:03	07:00	06:40	05:27	04:35	04:33	05:19	06:19	07:16	07:20	08:18
	15:52	16:49	17:49	19:52	20:52	21:45	21:57	21:15	20:03	18:44	16:30	15:44
4	08:40	08:01	06:57	06:37	05:25	04:34	04:34	05:21	06:20	07:18	07:22	08:20
	15:53	16:51	17:51	19:54	20:54	21:46	21:57	21:13	20:00	18:42	16:28	15:43
5	08:39	07:59	06:55	06:35	05:22	04:33	04:35	05:23	06:22	07:20	07:24	08:21
	15:54	16:53	17:53	19:56	20:56	21:47	21:56	21:11	19:57	18:39	16:26	15:42
6	08:39	07:57	06:52	06:32	05:20	04:32	04:36	05:25	06:24	07:22	07:26	08:23
	15:56	16:55	17:55	19:58	20:58	21:49	21:55	21:09	19:55	18:37	16:24	15:42
7	08:38	07:55	06:50	06:30	05:18	04:31	04:37	05:27	06:26	07:24	07:28	08:24
	15:57	16:57	17:57	20:00	21:00	21:50	21:55	21:07	19:52	18:34	16:22	15:41
8	08:38	07:53	06:47	06:27	05:16	04:31	04:38	05:29	06:28	07:26	07:30	08:25
	15:59	16:59	17:59	20:02	21:01	21:51	21:54	21:05	19:50	18:31	16:20	15:41
9	08:37	07:51	06:45	06:24	05:14	04:30	04:40	05:30	06:30	07:28	07:32	08:27
	16:00	17:02	18:01	20:04	21:03	21:52	21:53	21:03	19:47	18:29	16:18	15:40
10	08:36	07:49	06:42	06:22	05:12	04:30	04:41	05:32	06:32	07:30	07:34	08:28
	16:02	17:04	18:03	20:06	21:05	21:53	21:52	21:00	19:44	18:26	16:16	15:40
11	08:36	07:47	06:40	06:19	05:10	04:29	04:42	05:34	06:34	07:32	07:36	08:29
	16:03	17:06	18:05	20:08	21:07	21:54	21:51	20:58	19:42	18:24	16:14	15:39
12	08:35	07:45	06:37	06:17	05:08	04:29	04:43	05:36	06:36	07:34	07:38	08:30
	16:05	17:08	18:07	20:10	21:09	21:54	21:50	20:56	19:39	18:21	16:12	15:39
13	08:34	07:42	06:34	06:14	05:06	04:28	04:45	05:38	06:38	07:36	07:41	08:32
	16:07	17:10	18:09	20:12	21:11	21:55	21:49	20:54	19:37	18:19	16:10	15:39
14	08:33	07:40	06:32	06:12	05:04	04:28	04:46	05:40	06:40	07:38	07:43	08:33
	16:09	17:12	18:11	20:14	21:13	21:56	21:48	20:51	19:34	18:16	16:09	15:39
15	08:32	07:38	06:29	06:09	05:02	04:28	04:47	05:42	06:42	07:40	07:45	08:34
	16:10	17:15	18:13	20:16	21:15	21:57	21:47	20:49	19:31	18:14	16:07	15:39
16	08:31	07:36	06:27	06:07	05:01	04:27	04:49	05:44	06:43	07:42	07:47	08:35
	16:12	17:17	18:15	20:18	21:17	21:57	21:45	20:47	19:29	18:11	16:05	15:39
17	08:30	07:33	06:24	06:04	04:59	04:27	04:50	05:46	06:45	07:44	07:49	08:35
	16:14	17:19	18:17	20:20	21:18	21:58	21:44	20:44	19:26	18:09	16:04	15:39
18	08:28	07:31	06:22	06:02	04:57	04:27	04:52	05:48	06:47	07:46	07:51	08:36
	16:16	17:21	18:19	20:22	21:20	21:58	21:43	20:42	19:23	18:06	16:02	15:39
19	08:27	07:29	06:19	05:59	04:55	04:27	04:53	05:50	06:49	07:48	07:53	08:37
	16:18	17:23	18:22	20:24	21:22	21:58	21:41	20:40	19:21	18:04	16:00	15:39
20	08:26	07:26	06:16	05:57	04:54	04:27	04:55	05:52	06:51	07:50	07:55	08:38
	16:20	17:25	18:24	20:26	21:24	21:59	21:40	20:37	19:18	18:02	15:59	15:40
21	08:24	07:24	06:14	05:55	04:52	04:27	04:56	05:53	06:53	07:53	07:57	08:38
	16:22	17:28	18:26	20:28	21:25	21:59	21:38	20:35	19:16	17:59	15:57	15:40
22	08:23	07:22	06:11	05:52	04:50	04:27	04:58	05:55	06:55	07:55	07:59	08:39
	16:24	17:30	18:28	20:30	21:27	21:59	21:37	20:33	19:13	17:57	15:56	15:41
23	08:22	07:19	06:09	05:50	04:49	04:28	05:00	05:57	06:57	07:57	08:00	08:39
	16:26	17:32	18:30	20:32	21:29	21:59	21:35	20:30	19:10	17:55	15:55	15:41
24	08:20	07:17	06:06	05:47	04:47	04:28	05:01	05:59	06:59	07:59	08:02	08:40
	16:28	17:34	18:32	20:34	21:30	22:00	21:34	20:28	19:08	17:52	15:53	15:42
25	08:19	07:15	06:03	05:45	04:46	04:28	05:03	06:01	07:01	07:01	08:04	08:40
	16:30	17:36	18:34	20:36	21:32	22:00	21:32	20:25	19:05	16:50	15:52	15:42
26	08:17	07:12	06:01	05:43	04:44	04:29	05:05	06:03	07:03	07:03	08:06	08:40
	16:32	17:38	18:36	20:38	21:34	21:59	21:30	20:23	19:02	16:48	15:51	15:43
27	08:15	07:10	05:58	05:40	04:43	04:29	05:07	06:05	07:05	07:05	08:08	08:41
	16:34	17:40	18:38	20:40	21:35	21:59	21:28	20:20	19:00	16:45	15:50	15:44
28	08:14	07:07	05:55	05:38	04:42	04:30	05:08	06:07	07:07	07:07	08:10	08:41
	16:36	17:42	18:40	20:42	21:37	21:59	21:27	20:18	18:57	16:43	15:48	15:45
29	08:12		06:53	05:36	04:40	04:30	05:10	06:09	07:09	07:09	08:11	08:41
	16:38		19:42	20:44	21:38	21:59	21:25	20:15	18:55	16:41	15:47	15:46
30	08:10		06:50	05:33	04:39	04:31	05:12	06:11	07:11	07:11	08:13	08:41
	16:40		19:44	20:46	21:40	21:59	21:23	20:13	18:52	16:39	15:46	15:47
31	08:08		06:48		04:38		05:14	06:13		07:13		08:41
	16:42		19:46		21:41		21:21	20:10		16:36		15:48
Potential sun hours	240	268	366	424	503	522	523	466	384	325	251	222
Total, worst case												
Sun reduction												
Oper. time red.												
Wind dir. red.												
Total reduction												
Total, real												

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: E - Shadow Receptor 5

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January		February	March	April	May	June	July	August	September	October	November		December	
1	08:41		08:07	07:05	06:45	05:31	04:37	04:32	05:15	06:15	07:12	07:15		08:15	08:53 (1)
	15:49		16:44	17:44	19:48	20:48	21:42	21:58	21:19	20:08	18:49	16:34		15:45	8 09:01 (1)
2	08:41		08:05	07:02	06:42	05:29	04:36	04:33	05:17	06:17	07:14	07:18		08:17	08:55 (1)
	15:50		16:46	17:47	19:50	20:50	21:44	21:58	21:17	20:05	18:47	16:32		15:45	6 09:01 (1)
3	08:40		08:03	07:00	06:40	05:27	04:35	04:33	05:19	06:19	07:16	07:20		08:18	08:56 (1)
	15:52		16:49	17:49	19:52	20:52	21:45	21:57	21:15	20:03	18:44	16:30		15:44	4 09:00 (1)
4	08:40		08:01	06:57	06:37	05:25	04:34	04:34	05:21	06:20	07:18	07:22		08:20	08:58 (1)
	15:53		16:51	17:51	19:54	20:54	21:46	21:57	21:13	20:00	18:42	16:28		15:43	3 09:01 (1)
5	08:40		07:59	06:55	06:35	05:22	04:33	04:35	05:23	06:22	07:20	07:24		08:21	09:00 (1)
	15:54		16:53	17:53	19:56	20:56	21:48	21:56	21:11	19:57	18:39	16:26		15:42	1 09:01 (1)
6	08:39		07:57	06:52	06:32	05:20	04:32	04:36	05:25	06:24	07:22	07:26		08:23	
	15:56		16:55	17:55	19:58	20:58	21:49	21:55	21:09	19:55	18:37	16:24		15:42	
7	08:39	09:15 (1)	07:55	06:50	06:30	05:18	04:31	04:37	05:27	06:26	07:24	07:28		08:24	
	15:57	1 09:16 (1)	16:57	17:57	20:00	21:00	21:50	21:55	21:07	19:52	18:34	16:22		15:41	
8	08:38	09:14 (1)	07:53	06:47	06:27	05:16	04:31	04:38	05:29	06:28	07:26	07:30		08:26	
	15:59	2 09:16 (1)	16:59	17:59	20:02	21:02	21:51	21:54	21:05	19:50	18:31	16:20		15:41	
9	08:37	09:13 (1)	07:51	06:45	06:24	05:14	04:30	04:40	05:30	06:30	07:28	07:32		08:27	
	16:00	4 09:17 (1)	17:02	18:01	20:04	21:03	21:52	21:53	21:03	19:47	18:29	16:18		15:40	
10	08:36	09:12 (1)	07:49	06:42	06:22	05:12	04:29	04:41	05:32	06:32	07:30	07:34		08:28	
	16:02	6 09:18 (1)	17:04	18:03	20:06	21:05	21:53	21:52	21:00	19:44	18:26	16:16		15:40	
11	08:36	09:11 (1)	07:47	06:40	06:19	05:10	04:29	04:42	05:34	06:34	07:32	07:36		08:29	
	16:03	8 09:19 (1)	17:06	18:05	20:08	21:07	21:54	21:51	20:58	19:42	18:24	16:14		15:39	
12	08:35	09:10 (1)	07:45	06:37	06:17	05:08	04:28	04:43	05:36	06:36	07:34	07:38		08:31	
	16:05	10 09:20 (1)	17:08	18:07	20:10	21:09	21:54	21:50	20:56	19:39	18:21	16:12		15:39	
13	08:34	09:08 (1)	07:42	06:34	06:14	05:06	04:28	04:45	05:38	06:38	07:36	07:41		08:41 (1)	08:32
	16:07	12 09:20 (1)	17:10	18:09	20:12	21:11	21:55	21:49	20:54	19:37	18:19	16:10	9	08:50 (1)	15:39
14	08:33	09:07 (1)	07:40	06:32	06:12	05:04	04:28	04:46	05:40	06:40	07:38	07:43		08:40 (1)	08:33
	16:08	14 09:21 (1)	17:12	18:11	20:14	21:13	21:56	21:48	20:51	19:34	18:16	16:09	13	08:53 (1)	15:39
15	08:32	09:06 (1)	07:38	06:29	06:09	05:02	04:27	04:47	05:42	06:42	07:40	07:45		08:38 (1)	08:34
	16:10	16 09:22 (1)	17:15	18:13	20:16	21:15	21:57	21:47	20:49	19:31	18:14	16:07	16	08:54 (1)	15:39
16	08:31	09:04 (1)	07:36	06:27	06:07	05:01	04:27	04:49	05:44	06:43	07:42	07:47		08:37 (1)	08:35
	16:12	17 09:21 (1)	17:17	18:15	20:18	21:17	21:57	21:45	20:47	19:29	18:11	16:05	18	08:55 (1)	15:39
17	08:30	09:03 (1)	07:33	06:24	06:04	04:59	04:27	04:50	05:46	06:45	07:44	07:49		08:38 (1)	08:36
	16:14	19 09:22 (1)	17:19	18:17	20:20	21:18	21:58	21:44	20:45	19:26	18:09	16:04	19	08:57 (1)	15:39
18	08:28	09:02 (1)	07:31	06:22	06:02	04:57	04:27	04:52	05:48	06:47	07:46	07:51		08:37 (1)	08:36
	16:16	21 09:23 (1)	17:21	18:20	20:22	21:20	21:58	21:43	20:42	19:24	18:06	16:02	21	08:58 (1)	15:39
19	08:27	09:00 (1)	07:29	06:19	05:59	04:55	04:27	04:53	05:50	06:49	07:48	07:53		08:36 (1)	08:37
	16:18	23 09:23 (1)	17:23	18:22	20:24	21:22	21:59	21:41	20:40	19:21	18:04	16:00	22	08:58 (1)	15:39
20	08:26	09:01 (1)	07:27	06:16	05:57	04:54	04:27	04:55	05:52	06:51	07:51	07:55		08:36 (1)	08:38
	16:20	23 09:24 (1)	17:25	18:24	20:26	21:24	21:59	21:40	20:37	19:18	18:02	15:59	22	08:58 (1)	15:40
21	08:25	09:01 (1)	07:24	06:14	05:55	04:52	04:27	04:56	05:53	06:53	07:53	07:57		08:36 (1)	08:38
	16:22	23 09:24 (1)	17:27	18:26	20:28	21:25	21:59	21:38	20:35	19:16	17:59	15:57	23	08:59 (1)	15:40
22	08:23	09:01 (1)	07:22	06:11	05:52	04:50	04:27	04:58	05:55	06:55	07:55	07:59		08:37 (1)	08:39
	16:24	22 09:23 (1)	17:30	18:28	20:30	21:27	21:59	21:37	20:33	19:13	17:57	15:56	23	09:00 (1)	15:41
23	08:22	09:02 (1)	07:19	06:09	05:50	04:49	04:28	05:00	05:57	06:57	07:57	08:00		08:37 (1)	08:39
	16:26	22 09:24 (1)	17:32	18:30	20:32	21:29	22:00	21:35	20:30	19:10	17:54	15:55	23	09:00 (1)	15:41
24	08:20	09:03 (1)	07:17	06:06	05:47	04:47	04:28	05:01	05:59	06:59	07:59	08:02		08:39 (1)	08:40
	16:28	21 09:24 (1)	17:34	18:32	20:34	21:30	22:00	21:34	20:28	19:08	17:52	15:53	21	09:00 (1)	15:42
25	08:19	09:04 (1)	07:15	06:03	05:45	04:46	04:28	05:03	06:01	07:01	07:01	08:04		08:41 (1)	08:40
	16:30	19 09:23 (1)	17:36	18:34	20:36	21:32	22:00	21:32	20:25	19:05	16:50	15:52	19	09:00 (1)	15:42
26	08:17	09:04 (1)	07:12	06:01	05:43	04:44	04:29	05:05	06:03	07:03	07:03	08:06		08:43 (1)	08:41
	16:32	18 09:22 (1)	17:38	18:36	20:38	21:34	22:00	21:30	20:23	19:03	16:48	15:51	18	09:01 (1)	15:43
27	08:15	09:06 (1)	07:10	05:58	05:40	04:43	04:29	05:07	06:05	07:05	07:05	08:08		08:45 (1)	08:41
	16:34	15 09:21 (1)	17:40	18:38	20:40	21:35	21:59	21:28	20:20	19:00	16:45	15:50	16	09:01 (1)	15:44
28	08:14	09:07 (1)	07:07	05:55	05:38	04:42	04:30	05:08	06:07	07:07	07:07	08:10		08:47 (1)	08:41
	16:36	13 09:20 (1)	17:42	18:40	20:42	21:37	21:59	21:27	20:18	18:57	16:43	15:48	14	09:01 (1)	15:45
29	08:12	09:09 (1)		06:53	05:36	04:40	04:30	05:10	06:09	07:09	07:09	08:11		08:49 (1)	08:41
	16:38	9 09:18 (1)		19:42	20:44	21:38	21:59	21:25	20:15	18:55	16:41	15:47	12	09:01 (1)	15:46
30	08:10			06:50	05:33	04:39	04:31	05:12	06:11	07:11	07:11	08:13		08:51 (1)	08:41
	16:40			19:44	20:46	21:40	21:59	21:23	20:13	18:52	16:39	15:46	10	09:01 (1)	15:47
31	08:09			06:48		04:38		05:14	06:13		07:13				08:41
	16:42			19:46		21:41		21:21	20:10		16:36				15:48
Potential sun hours	240		268	366	424	503	522	523	466	384	325	251		222	
Total, worst case		338											319		22
Sun reduction		0.17											0.23		0.16
Oper. time red.		0.84											0.84		0.84
Wind dir. red.		0.55											0.55		0.55
Total reduction		0.08											0.11		0.08
Total, real		27											34		2

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: F - Shadow Receptor 6

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:41	08:07	07:05	06:45	05:31	04:37	04:32	05:15	06:15	07:12	07:15	08:15
	15:49	16:44	17:44	19:48	20:48	21:42	21:58	21:19	20:08	18:49	16:34	15:45
2	08:41	08:05	07:02	06:42	05:29	04:36	04:33	05:17	06:17	07:14	07:18	08:16
	15:50	16:46	17:47	19:50	20:50	21:44	21:58	21:17	20:05	18:47	16:32	15:44
3	08:40	08:03	07:00	06:40	05:27	04:35	04:33	05:19	06:19	07:16	07:20	08:18
	15:52	16:49	17:49	19:52	20:52	21:45	21:57	21:15	20:03	18:44	16:30	15:44
4	08:40	08:01	06:57	06:37	05:25	04:34	04:34	05:21	06:20	07:18	07:22	08:20
	15:53	16:51	17:51	19:54	20:54	21:46	21:57	21:13	20:00	18:42	16:28	15:43
5	08:40	07:59	06:55	06:35	05:22	04:33	04:35	05:23	06:22	07:20	07:24	08:21
	15:54	16:53	17:53	19:56	20:56	21:48	21:56	21:11	19:57	18:39	16:26	15:42
6	08:39	07:57	06:52	06:32	05:20	04:32	04:36	05:25	06:24	07:22	07:26	08:23
	15:56	16:55	17:55	19:58	20:58	21:49	21:55	21:09	19:55	18:37	16:24	15:42
7	08:38	07:55	06:50	06:30	05:18	04:31	04:37	05:27	06:26	07:24	07:28	08:24
	15:57	16:57	17:57	20:00	21:00	21:50	21:55	21:07	19:52	18:34	16:22	15:41
8	08:38	07:53	06:47	06:27	05:16	04:31	04:38	05:28	06:28	07:26	07:30	08:26
	15:59	16:59	17:59	20:02	21:01	21:51	21:54	21:05	19:50	18:31	16:20	15:40
9	08:37	07:51	06:45	06:24	05:14	04:30	04:40	05:30	06:30	07:28	07:32	08:27
	16:00	17:02	18:01	20:04	21:03	21:52	21:53	21:03	19:47	18:29	16:18	15:40
10	08:36	07:49	06:42	06:22	05:12	04:29	04:41	05:32	06:32	07:30	07:34	08:28
	16:02	17:04	18:03	20:06	21:05	21:53	21:52	21:00	19:44	18:26	16:16	15:40
11	08:36	07:47	06:40	06:19	05:10	04:29	04:42	05:34	06:34	07:32	07:36	08:29
	16:03	17:06	18:05	20:08	21:07	21:54	21:51	20:58	19:42	18:24	16:14	15:39
12	08:35	07:45	06:37	06:17	05:08	04:28	04:43	05:36	06:36	07:34	07:38	08:31
	16:05	17:08	18:07	20:10	21:09	21:54	21:50	20:56	19:39	18:21	16:12	15:39
13	08:34	07:42	06:34	06:14	05:06	04:28	04:45	05:38	06:38	07:36	07:41	08:32
	16:07	17:10	18:09	20:12	21:11	21:55	21:49	20:54	19:37	18:19	16:10	15:39
14	08:33	07:40	06:32	06:12	05:04	04:28	04:46	05:40	06:40	07:38	07:43	08:33
	16:08	17:12	18:11	20:14	21:13	21:56	21:48	20:51	19:34	18:16	16:09	15:39
15	08:32	07:38	06:29	06:09	05:02	04:27	04:47	05:42	06:42	07:40	07:45	08:34
	16:10	17:15	18:13	20:16	21:15	21:57	21:47	20:49	19:31	18:14	16:07	15:39
16	08:31	07:36	06:27	06:07	05:00	04:27	04:49	05:44	06:43	07:42	07:47	08:35
	16:12	17:17	18:15	20:18	21:17	21:57	21:45	20:47	19:29	18:11	16:05	15:39
17	08:30	07:33	06:24	06:04	04:59	04:27	04:50	05:46	06:45	07:44	07:49	08:36
	16:14	17:19	18:17	20:20	21:18	21:58	21:44	20:45	19:26	18:09	16:03	15:39
18	08:28	07:31	06:22	06:02	04:57	04:27	04:52	05:48	06:47	07:46	07:51	08:36
	16:16	17:21	18:19	20:22	21:20	21:58	21:43	20:42	19:23	18:06	16:02	15:39
19	08:27	07:29	06:19	05:59	04:55	04:27	04:53	05:50	06:49	07:48	07:53	08:37
	16:18	17:23	18:21	20:24	21:22	21:59	21:41	20:40	19:21	18:04	16:00	15:39
20	08:26	07:26	06:16	05:57	04:54	04:27	04:55	05:51	06:51	07:50	07:55	08:38
	16:20	17:25	18:24	20:26	21:24	21:59	21:40	20:37	19:18	18:02	15:59	15:40
21	08:25	07:24	06:14	05:55	04:52	04:27	04:56	05:53	06:53	07:53	07:57	08:38
	16:22	17:27	18:26	20:28	21:25	21:59	21:38	20:35	19:16	17:59	15:57	15:40
22	08:23	07:22	06:11	05:52	04:50	04:27	04:58	05:55	06:55	07:55	07:59	08:39
	16:24	17:30	18:28	20:30	21:27	21:59	21:37	20:33	19:13	17:57	15:56	15:41
23	08:22	07:19	06:08	05:50	04:49	04:28	05:00	05:57	06:57	07:57	08:00	08:39
	16:26	17:32	18:30	20:32	21:29	22:00	21:35	20:30	19:10	17:54	15:55	15:41
24	08:20	07:17	06:06	05:47	04:47	04:28	05:01	05:59	06:59	07:59	08:02	08:40
	16:28	17:34	18:32	20:34	21:30	22:00	21:34	20:28	19:08	17:52	15:53	15:42
25	08:19	07:15	06:03	05:45	04:46	04:28	05:03	06:01	07:01	07:01	08:04	08:40
	16:30	17:36	18:34	20:36	21:32	22:00	21:32	20:25	19:05	16:50	15:52	15:42
26	08:17	07:12	06:01	05:43	04:44	04:29	05:05	06:03	07:03	07:03	08:06	08:41
	16:32	17:38	18:36	20:38	21:34	22:00	21:30	20:23	19:02	16:47	15:51	15:43
27	08:15	07:10	05:58	05:40	04:43	04:29	05:06	06:05	07:05	07:05	08:08	08:41
	16:34	17:40	18:38	20:40	21:35	21:59	21:28	20:20	19:00	16:45	15:50	15:44
28	08:14	07:07	05:55	05:38	04:42	04:30	05:08	06:07	07:07	07:07	08:10	08:41
	16:36	17:42	18:40	20:42	21:37	21:59	21:27	20:18	18:57	16:43	15:48	15:45
29	08:12		06:53	05:36	04:40	04:30	05:10	06:09	07:09	07:09	08:11	08:41
	16:38		19:42	20:44	21:38	21:59	21:25	20:15	18:55	16:41	15:47	15:46
30	08:10		06:50	05:33	04:39	04:31	05:12	06:11	07:10	07:11	08:13	08:41
	16:40		19:44	20:46	21:40	21:59	21:23	20:13	18:52	16:38	15:46	15:47
31	08:08		06:48		04:38		05:14	06:13		07:13		08:41
	16:42		19:46		21:41		21:21	20:10		16:36		15:48
Potential sun hours	240	268	366	424	503	522	523	466	384	325	251	222
Total, worst case												
Sun reduction												
Oper. time red.												
Wind dir. red.												
Total reduction												
Total, real												

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: G - Shadow Recepter 7

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:41	08:07	07:05	06:45	05:31	04:37	04:32	05:16	06:15	07:12	07:15	08:15
	15:49	16:44	17:44	19:48	20:48	21:42	21:58	21:19	20:08	18:49	16:34	15:45
2	08:41	08:05	07:02	06:42	05:29	04:36	04:33	05:17	06:17	07:14	07:18	08:16
	15:50	16:46	17:47	19:50	20:50	21:44	21:58	21:17	20:05	18:47	16:32	15:45
3	08:40	08:03	07:00	06:40	05:27	04:35	04:33	05:19	06:19	07:16	07:20	08:18
	15:52	16:49	17:49	19:52	20:52	21:45	21:57	21:15	20:03	18:44	16:30	15:44
4	08:40	08:01	06:57	06:37	05:25	04:34	04:34	05:21	06:20	07:18	07:22	08:20
	15:53	16:51	17:51	19:54	20:54	21:46	21:57	21:13	20:00	18:42	16:28	15:43
5	08:39	07:59	06:55	06:35	05:22	04:33	04:35	05:23	06:22	07:20	07:24	08:21
	15:54	16:53	17:53	19:56	20:56	21:47	21:56	21:11	19:57	18:39	16:26	15:42
6	08:39	07:57	06:52	06:32	05:20	04:32	04:36	05:25	06:24	07:22	07:26	08:23
	15:56	16:55	17:55	19:58	20:58	21:49	21:55	21:09	19:55	18:37	16:24	15:42
7	08:38	07:55	06:50	06:30	05:18	04:31	04:37	05:27	06:26	07:24	07:28	08:24
	15:57	16:57	17:57	20:00	21:00	21:50	21:55	21:07	19:52	18:34	16:22	15:41
8	08:38	07:53	06:47	06:27	05:16	04:31	04:38	05:29	06:28	07:26	07:30	08:25
	15:59	16:59	17:59	20:02	21:01	21:51	21:54	21:05	19:50	18:31	16:20	15:41
9	08:37	07:51	06:45	06:24	05:14	04:30	04:40	05:30	06:30	07:28	07:32	08:27
	16:00	17:02	18:01	20:04	21:03	21:52	21:53	21:03	19:47	18:29	16:18	15:40
10	08:36	07:49	06:42	06:22	05:12	04:30	04:41	05:32	06:32	07:30	07:34	08:28
	16:02	17:04	18:03	20:06	21:05	21:53	21:52	21:00	19:44	18:26	16:16	15:40
11	08:36	07:47	06:40	06:19	05:10	04:29	04:42	05:34	06:34	07:32	07:36	08:29
	16:03	17:06	18:05	20:08	21:07	21:54	21:51	20:58	19:42	18:24	16:14	15:39
12	08:35	07:45	06:37	06:17	05:08	04:29	04:43	05:36	06:36	07:34	07:38	08:30
	16:05	17:08	18:07	20:10	21:09	21:54	21:50	20:56	19:39	18:21	16:12	15:39
13	08:34	07:42	06:34	06:14	05:06	04:28	04:45	05:38	06:38	07:36	07:40	08:32
	16:07	17:10	18:09	20:12	21:11	21:55	21:49	20:54	19:37	18:19	16:10	15:39
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	16:09	17:12	18:11	20:14	21:13	21:56	21:48	20:51	19:34	18:16	16:09	15:39
15	08:32	07:38	06:29	06:09	05:02	04:28	04:47	05:42	06:42	07:40	07:45	08:34
	16:10	17:15	18:13	20:16	21:15	21:56	21:47	20:49	19:31	18:14	16:07	15:39
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	16:12	17:17	18:15	20:18	21:17	21:57	21:45	20:47	19:29	18:11	16:05	15:39
17	08:30	07:33	06:24	06:04	04:59	04:27	04:50	05:46	06:45	07:44	07:49	08:35
	16:14	17:19	18:17	20:20	21:18	21:58	21:44	20:44	19:26	18:09	16:04	15:39
18	08:28	07:31	06:22	06:02	04:57	04:27	04:52	05:48	06:47	07:46	07:51	08:36
	16:16	17:21	18:19	20:22	21:20	21:58	21:43	20:42	19:23	18:06	16:02	15:39
19	08:27	07:29	06:19	05:59	04:55	04:27	04:53	05:50	06:49	07:48	07:53	08:37
	16:18	17:23	18:22	20:24	21:22	21:58	21:41	20:40	19:21	18:04	16:00	15:39
20	08:26	07:26	06:16	05:57	04:54	04:27	04:55	05:52	06:51	07:50	07:55	08:38
	16:20	17:25	18:24	20:26	21:24	21:59	21:40	20:37	19:18	18:02	15:59	15:40
21	08:24	07:24	06:14	05:55	04:52	04:27	04:56	05:53	06:53	07:53	07:57	08:38
	16:22	17:28	18:26	20:28	21:25	21:59	21:38	20:35	19:16	17:59	15:57	15:40
22	08:23	07:22	06:11	05:52	04:50	04:27	04:58	05:55	06:55	07:55	07:59	08:39
	16:24	17:30	18:28	20:30	21:27	21:59	21:37	20:33	19:13	17:57	15:56	15:41
23	08:22	07:19	06:09	05:50	04:49	04:28	05:00	05:57	06:57	07:57	08:00	08:39
	16:26	17:32	18:30	20:32	21:29	21:59	21:35	20:30	19:10	17:55	15:55	15:41
24	08:20	07:17	06:06	05:47	04:47	04:28	05:01	05:59	06:59	07:59	08:02	08:40
	16:28	17:34	18:32	20:34	21:30	22:00	21:33	20:28	19:08	17:52	15:53	15:42
25	08:19	07:15	06:03	05:45	04:46	04:28	05:03	06:01	07:01	07:01	08:04	08:40
	16:30	17:36	18:34	20:36	21:32	22:00	21:32	20:25	19:05	16:50	15:52	15:42
26	08:17	07:12	06:01	05:43	04:44	04:29	05:05	06:03	07:03	07:03	08:06	08:40
	16:32	17:38	18:36	20:38	21:34	21:59	21:30	20:23	19:02	16:48	15:51	15:43
27	08:15	07:10	05:58	05:40	04:43	04:29	05:07	06:05	07:05	07:05	08:08	08:41
	16:34	17:40	18:38	20:40	21:35	21:59	21:28	20:20	19:00	16:45	15:50	15:44
28	08:14	07:07	05:55	05:38	04:42	04:30	05:08	06:07	07:07	07:07	08:10	08:41
	16:36	17:42	18:40	20:42	21:37	21:59	21:27	20:18	18:57	16:43	15:48	15:45
29	08:12		06:53	05:36	04:40	04:30	05:10	06:09	07:09	07:09	08:11	08:41
	16:38		19:42	20:44	21:38	21:59	21:25	20:15	18:55	16:41	15:47	15:46
30	08:10		06:50	05:33	04:39	04:31	05:12	06:11	07:10	07:11	08:13	08:41
	16:40		19:44	20:46	21:40	21:59	21:23	20:13	18:52	16:39	15:46	15:47
31	08:08		06:48		04:38		05:14	06:13		07:13		08:41
	16:42		19:46		21:41		21:21	20:10		16:36		15:48
Potential sun hours	240	268	366	424	503	522	523	466	384	325	251	222
Total, worst case												
Sun reduction												
Oper. time red.												
Wind dir. red.												
Total reduction												
Total, real												

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: H - Shadow Receptor 8

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:41	08:07	07:05	06:45	05:31	04:37	04:32	05:15	06:15	07:12	07:15	08:15
	15:49	16:44	17:44	19:48	20:48	21:42	21:58	21:19	20:08	18:49	16:34	15:45
2	08:40	08:05	07:02	06:42	05:29	04:36	04:33	05:17	06:17	07:14	07:17	08:16
	15:50	16:46	17:47	19:50	20:50	21:44	21:58	21:17	20:05	18:47	16:32	15:45
3	08:40	08:03	07:00	06:40	05:27	04:35	04:33	05:19	06:19	07:16	07:20	08:18
	15:52	16:49	17:49	19:52	20:52	21:45	21:57	21:15	20:03	18:44	16:30	15:44
4	08:40	08:01	06:57	06:37	05:25	04:34	04:34	05:21	06:20	07:18	07:22	08:20
	15:53	16:51	17:51	19:54	20:54	21:46	21:57	21:13	20:00	18:42	16:28	15:43
5	08:39	07:59	06:55	06:35	05:22	04:33	04:35	05:23	06:22	07:20	07:24	08:21
	15:54	16:53	17:53	19:56	20:56	21:47	21:56	21:11	19:57	18:39	16:26	15:42
6	08:39	07:57	06:52	06:32	05:20	04:32	04:36	05:25	06:24	07:22	07:26	08:23
	15:56	16:55	17:55	19:58	20:58	21:49	21:55	21:09	19:55	18:37	16:24	15:42
7	08:38	07:55	06:50	06:30	05:18	04:31	04:37	05:27	06:26	07:24	07:28	08:24
	15:57	16:57	17:57	20:00	20:59	21:50	21:55	21:07	19:52	18:34	16:22	15:41
8	08:38	07:53	06:47	06:27	05:16	04:31	04:38	05:29	06:28	07:26	07:30	08:25
	15:59	16:59	17:59	20:02	21:01	21:51	21:54	21:05	19:50	18:31	16:20	15:41
9	08:37	07:51	06:45	06:24	05:14	04:30	04:40	05:30	06:30	07:28	07:32	08:27
	16:00	17:02	18:01	20:04	21:03	21:52	21:53	21:03	19:47	18:29	16:18	15:40
10	08:36	07:49	06:42	06:22	05:12	04:30	04:41	05:32	06:32	07:30	07:34	08:28
	16:02	17:04	18:03	20:06	21:05	21:53	21:52	21:00	19:44	18:26	16:16	15:40
11	08:36	07:47	06:40	06:19	05:10	04:29	04:42	05:34	06:34	07:32	07:36	08:29
	16:03	17:06	18:05	20:08	21:07	21:53	21:51	20:58	19:42	18:24	16:14	15:39
12	08:35	07:44	06:37	06:17	05:08	04:29	04:43	05:36	06:36	07:34	07:38	08:30
	16:05	17:08	18:07	20:10	21:09	21:54	21:50	20:56	19:39	18:21	16:12	15:39
13	08:34	07:42	06:34	06:14	05:06	04:28	04:45	05:38	06:38	07:36	07:40	08:32
	16:07	17:10	18:09	20:12	21:11	21:55	21:49	20:54	19:37	18:19	16:10	15:39
14	08:33	07:40	06:32	06:12	05:04	04:28	04:46	05:40	06:40	07:38	07:43	08:33
	16:09	17:12	18:11	20:14	21:13	21:56	21:48	20:51	19:34	18:16	16:09	15:39
15	08:32	07:38	06:29	06:09	05:02	04:28	04:47	05:42	06:42	07:40	07:45	08:34
	16:10	17:15	18:13	20:16	21:15	21:56	21:46	20:49	19:31	18:14	16:07	15:39
16	08:31	07:36	06:27	06:07	05:01	04:27	04:49	05:44	06:43	07:42	07:47	08:35
	16:12	17:17	18:15	20:18	21:16	21:57	21:45	20:47	19:29	18:11	16:05	15:39
17	08:30	07:33	06:24	06:04	04:59	04:27	04:50	05:46	06:45	07:44	07:49	08:35
	16:14	17:19	18:17	20:20	21:18	21:58	21:44	20:44	19:26	18:09	16:04	15:39
18	08:28	07:31	06:21	06:02	04:57	04:27	04:52	05:48	06:47	07:46	07:51	08:36
	16:16	17:21	18:19	20:22	21:20	21:58	21:43	20:42	19:23	18:06	16:02	15:39
19	08:27	07:29	06:19	05:59	04:55	04:27	04:53	05:50	06:49	07:48	07:53	08:37
	16:18	17:23	18:21	20:24	21:22	21:58	21:41	20:40	19:21	18:04	16:00	15:39
20	08:26	07:26	06:16	05:57	04:54	04:27	04:55	05:52	06:51	07:50	07:55	08:38
	16:20	17:25	18:24	20:26	21:24	21:59	21:40	20:37	19:18	18:02	15:59	15:40
21	08:24	07:24	06:14	05:55	04:52	04:27	04:56	05:53	06:53	07:52	07:57	08:38
	16:22	17:27	18:26	20:28	21:25	21:59	21:38	20:35	19:16	17:59	15:57	15:40
22	08:23	07:22	06:11	05:52	04:50	04:27	04:58	05:55	06:55	07:55	07:58	08:39
	16:24	17:30	18:28	20:30	21:27	21:59	21:37	20:33	19:13	17:57	15:56	15:41
23	08:22	07:19	06:08	05:50	04:49	04:28	05:00	05:57	06:57	07:57	08:00	08:39
	16:26	17:32	18:30	20:32	21:29	21:59	21:35	20:30	19:10	17:54	15:55	15:41
24	08:20	07:17	06:06	05:47	04:47	04:28	05:01	05:59	06:59	07:59	08:02	08:40
	16:28	17:34	18:32	20:34	21:30	21:59	21:33	20:28	19:08	17:52	15:53	15:42
25	08:19	07:15	06:03	05:45	04:46	04:28	05:03	06:01	07:01	07:01	08:04	08:40
	16:30	17:36	18:34	20:36	21:32	21:59	21:32	20:25	19:05	16:50	15:52	15:42
26	08:17	07:12	06:01	05:43	04:44	04:29	05:05	06:03	07:03	07:03	08:06	08:40
	16:32	17:38	18:36	20:38	21:34	21:59	21:30	20:23	19:02	16:48	15:51	15:43
27	08:15	07:10	05:58	05:40	04:43	04:29	05:07	06:05	07:05	07:05	08:08	08:41
	16:34	17:40	18:38	20:40	21:35	21:59	21:28	20:20	19:00	16:45	15:50	15:44
28	08:14	07:07	05:55	05:38	04:42	04:30	05:08	06:07	07:07	07:07	08:10	08:41
	16:36	17:42	18:40	20:42	21:37	21:59	21:27	20:18	18:57	16:43	15:48	15:45
29	08:12		06:53	05:36	04:40	04:30	05:10	06:09	07:09	07:09	08:11	08:41
	16:38		19:42	20:44	21:38	21:59	21:25	20:15	18:55	16:41	15:47	15:46
30	08:10		06:50	05:33	04:39	04:31	05:12	06:11	07:10	07:11	08:13	08:41
	16:40		19:44	20:46	21:40	21:59	21:23	20:13	18:52	16:39	15:46	15:47
31	08:08		06:48		04:38		05:14	06:13		07:13		08:41
	16:42		19:46		21:41		21:21	20:10		16:36		15:48
Potential sun hours	240	268	366	424	503	522	523	466	384	325	251	222
Total, worst case												
Sun reduction												
Oper. time red.												
Wind dir. red.												
Total reduction												
Total, real												

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar

Calculation: Shadow flickerShadow receptor: I - Shadow Receptor 9

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:41	08:07	07:05	06:45	05:31	04:37	04:32	05:16	06:15	07:12	07:15	08:15
	15:49	16:44	17:44	19:48	20:48	21:42	21:58	21:19	20:08	18:49	16:34	15:45
2	08:40	08:05	07:02	06:42	05:29	04:36	04:33	05:17	06:17	07:14	07:18	08:16
	15:50	16:47	17:47	19:50	20:50	21:44	21:58	21:17	20:05	18:47	16:32	15:45
3	08:40	08:03	07:00	06:40	05:27	04:35	04:33	05:19	06:19	07:16	07:20	08:18
	15:52	16:49	17:49	19:52	20:52	21:45	21:57	21:15	20:03	18:44	16:30	15:44
4	08:40	08:01	06:57	06:37	05:25	04:34	04:34	05:21	06:20	07:18	07:22	08:20
	15:53	16:51	17:51	19:54	20:54	21:46	21:57	21:13	20:00	18:42	16:28	15:43
5	08:39	07:59	06:55	06:35	05:22	04:33	04:35	05:23	06:22	07:20	07:24	08:21
	15:54	16:53	17:53	19:56	20:56	21:47	21:56	21:11	19:57	18:39	16:26	15:42
6	08:39	07:57	06:52	06:32	05:20	04:32	04:36	05:25	06:24	07:22	07:26	08:23
	15:56	16:55	17:55	19:58	20:58	21:49	21:55	21:09	19:55	18:37	16:24	15:42
7	08:38	07:55	06:50	06:30	05:18	04:32	04:37	05:27	06:26	07:24	07:28	08:24
	15:57	16:57	17:57	20:00	21:00	21:50	21:55	21:07	19:52	18:34	16:22	15:41
8	08:38	07:53	06:47	06:27	05:16	04:31	04:38	05:29	06:28	07:26	07:30	08:25
	15:59	16:59	17:59	20:02	21:01	21:51	21:54	21:05	19:50	18:31	16:20	15:41
9	08:37	07:51	06:45	06:24	05:14	04:30	04:40	05:30	06:30	07:28	07:32	08:27
	16:00	17:02	18:01	20:04	21:03	21:52	21:53	21:03	19:47	18:29	16:18	15:40
10	08:36	07:49	06:42	06:22	05:12	04:30	04:41	05:32	06:32	07:30	07:34	08:28
	16:02	17:04	18:03	20:06	21:05	21:53	21:52	21:00	19:44	18:26	16:16	15:40
11	08:36	07:47	06:40	06:19	05:10	04:29	04:42	05:34	06:34	07:32	07:36	08:29
	16:03	17:06	18:05	20:08	21:07	21:54	21:51	20:58	19:42	18:24	16:14	15:39
12	08:35	07:45	06:37	06:17	05:08	04:29	04:43	05:36	06:36	07:34	07:38	08:30
	16:05	17:08	18:07	20:10	21:09	21:54	21:50	20:56	19:39	18:21	16:12	15:39
13	08:34	07:42	06:34	06:14	05:06	04:28	04:45	05:38	06:38	07:36	07:40	08:32
	16:07	17:10	18:09	20:12	21:11	21:55	21:49	20:54	19:37	18:19	16:10	15:39
14	08:33	07:40	06:32	06:12	05:04	04:28	04:46	05:40	06:40	07:38	07:43	08:33
	16:09	17:12	18:11	20:14	21:13	21:56	21:48	20:51	19:34	18:16	16:09	15:39
15	08:32	07:38	06:29	06:09	05:02	04:28	04:47	05:42	06:42	07:40	07:45	08:34
	16:10	17:15	18:13	20:16	21:15	21:56	21:47	20:49	19:31	18:14	16:07	15:39
16	08:31	07:36	06:27	06:07	05:01	04:27	04:49	05:44	06:43	07:42	07:47	08:35
	16:12	17:17	18:15	20:18	21:17	21:57	21:45	20:47	19:29	18:11	16:05	15:39
17	08:30	07:33	06:24	06:04	04:59	04:27	04:50	05:46	06:45	07:44	07:49	08:35
	16:14	17:19	18:17	20:20	21:18	21:58	21:44	20:44	19:26	18:09	16:04	15:39
18	08:28	07:31	06:22	06:02	04:57	04:27	04:52	05:48	06:47	07:46	07:51	08:36
	16:16	17:21	18:19	20:22	21:20	21:58	21:43	20:42	19:23	18:06	16:02	15:39
19	08:27	07:29	06:19	05:59	04:55	04:27	04:53	05:50	06:49	07:48	07:53	08:37
	16:18	17:23	18:22	20:24	21:22	21:58	21:41	20:40	19:21	18:04	16:00	15:40
20	08:26	07:26	06:16	05:57	04:54	04:27	04:55	05:52	06:51	07:50	07:55	08:38
	16:20	17:25	18:24	20:26	21:24	21:59	21:40	20:37	19:18	18:02	15:59	15:40
21	08:24	07:24	06:14	05:55	04:52	04:27	04:57	05:53	06:53	07:53	07:57	08:38
	16:22	17:28	18:26	20:28	21:25	21:59	21:38	20:35	19:16	17:59	15:57	15:40
22	08:23	07:22	06:11	05:52	04:50	04:27	04:58	05:55	06:55	07:55	07:58	08:39
	16:24	17:30	18:28	20:30	21:27	21:59	21:37	20:33	19:13	17:57	15:56	15:41
23	08:22	07:19	06:09	05:50	04:49	04:28	05:00	05:57	06:57	07:57	08:00	08:39
	16:26	17:32	18:30	20:32	21:29	21:59	21:35	20:30	19:10	17:55	15:55	15:41
24	08:20	07:17	06:06	05:47	04:47	04:28	05:01	05:59	06:59	07:59	08:02	08:40
	16:28	17:34	18:32	20:34	21:30	21:59	21:33	20:28	19:08	17:52	15:53	15:42
25	08:19	07:15	06:03	05:45	04:46	04:28	05:03	06:01	07:01	07:01	08:04	08:40
	16:30	17:36	18:34	20:36	21:32	21:59	21:32	20:25	19:05	16:50	15:52	15:42
26	08:17	07:12	06:01	05:43	04:44	04:29	05:05	06:03	07:03	07:03	08:06	08:40
	16:32	17:38	18:36	20:38	21:34	21:59	21:30	20:23	19:03	16:48	15:51	15:43
27	08:15	07:10	05:58	05:40	04:43	04:29	05:07	06:05	07:05	07:05	08:08	08:41
	16:34	17:40	18:38	20:40	21:35	21:59	21:28	20:20	19:00	16:45	15:50	15:44
28	08:14	07:07	05:55	05:38	04:42	04:30	05:08	06:07	07:07	07:07	08:10	08:41
	16:36	17:42	18:40	20:42	21:37	21:59	21:27	20:18	18:57	16:43	15:49	15:45
29	08:12		06:53	05:36	04:41	04:30	05:10	06:09	07:09	07:09	08:11	08:41
	16:38		19:42	20:44	21:38	21:59	21:25	20:15	18:55	16:41	15:47	15:46
30	08:10		06:50	05:33	04:39	04:31	05:12	06:11	07:11	07:11	08:13	08:41
	16:40		19:44	20:46	21:40	21:59	21:23	20:13	18:52	16:39	15:46	15:47
31	08:08		06:48		04:38		05:14	06:13		07:13		08:41
	16:42		19:46		21:41		21:21	20:10		16:36		15:48
Potential sun hours	240	268	366	424	503	522	523	466	384	325	251	222
Total, worst case												
Sun reduction												
Oper. time red.												
Wind dir. red.												
Total reduction												
Total, real												

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker Last time (hh:mm) with flicker	(WTG causing flicker first time) (WTG causing flicker last time)

Licensed user:
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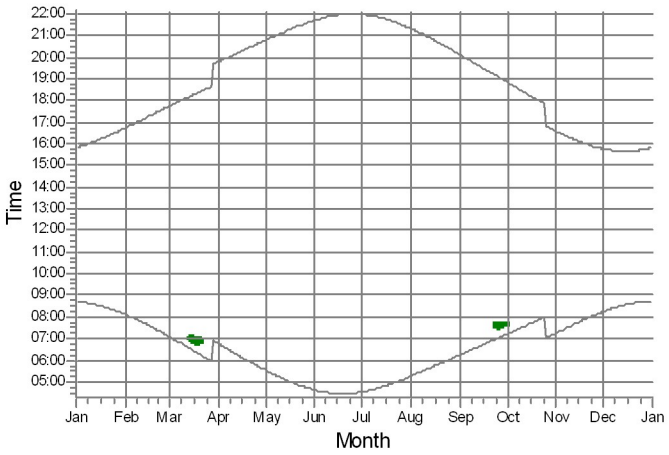
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

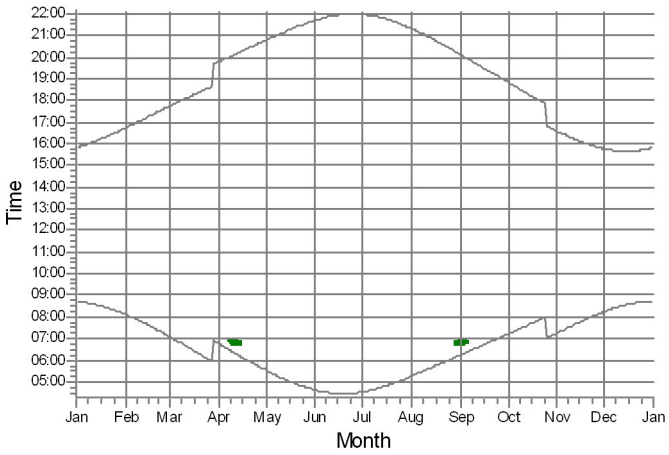
SHADOW - Calendar, graphical

Calculation: Shadow flicker

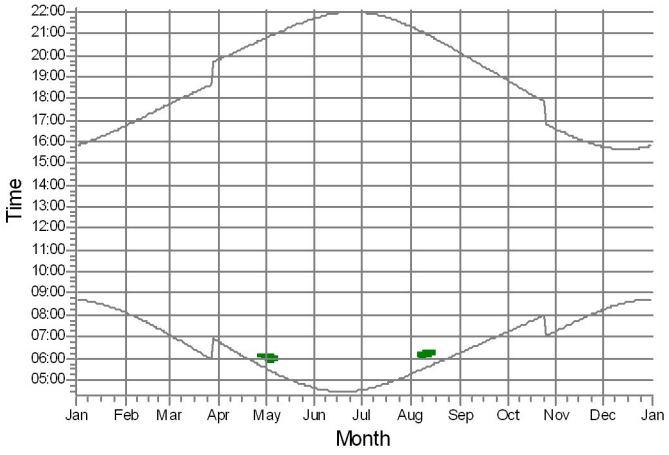
A: Shadow Receptor 1



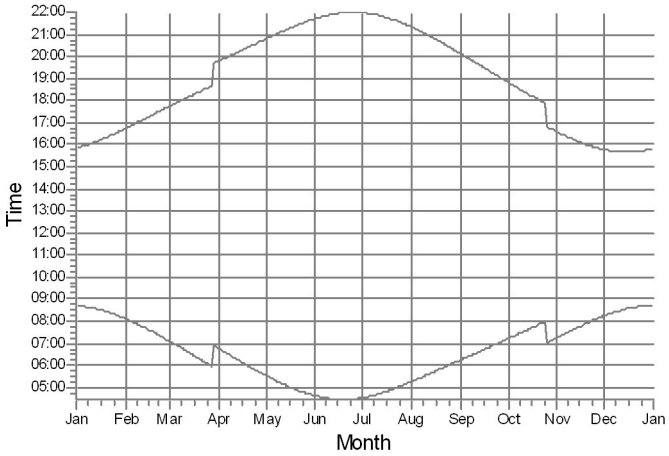
B: Shadow Receptor 2



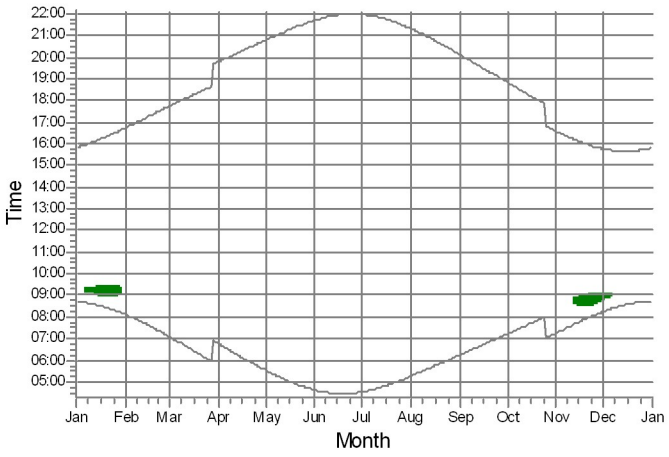
C: Shadow Receptor 3



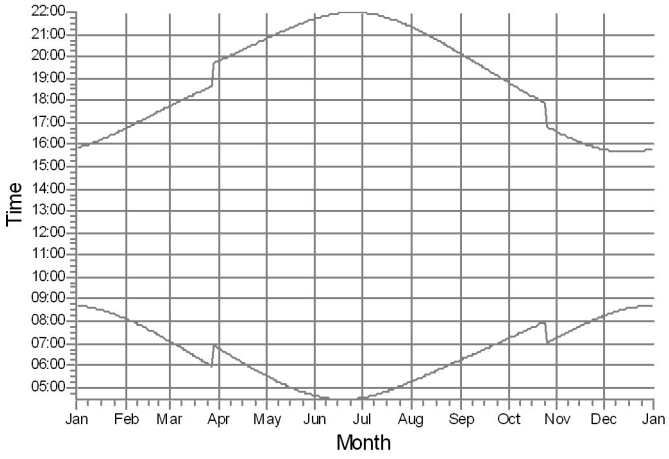
D: Shadow Receptor 4



E: Shadow Receptor 5



F: Shadow Receptor 6



WTGs

1: NORDEX S77 1500 77.0 !-! hub: 61.5 m (TOT: 100.0 m) (37)

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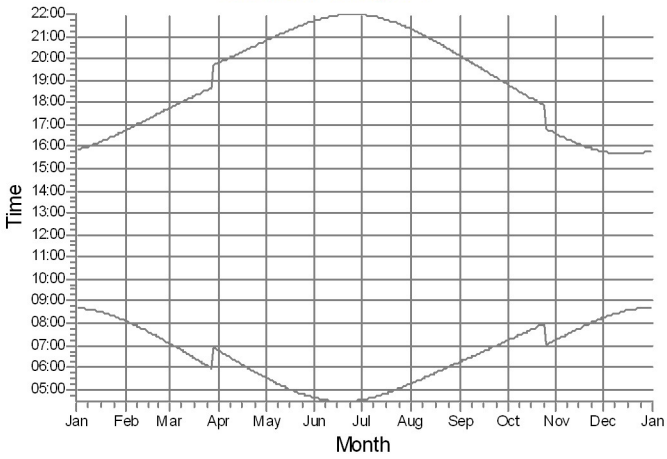
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

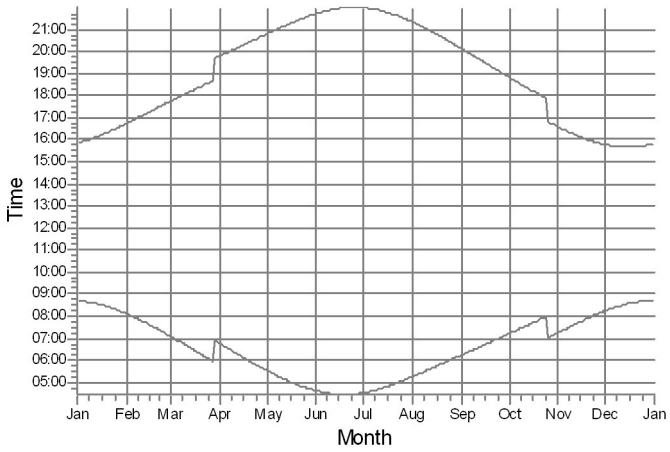
SHADOW - Calendar, graphical

Calculation: Shadow flicker

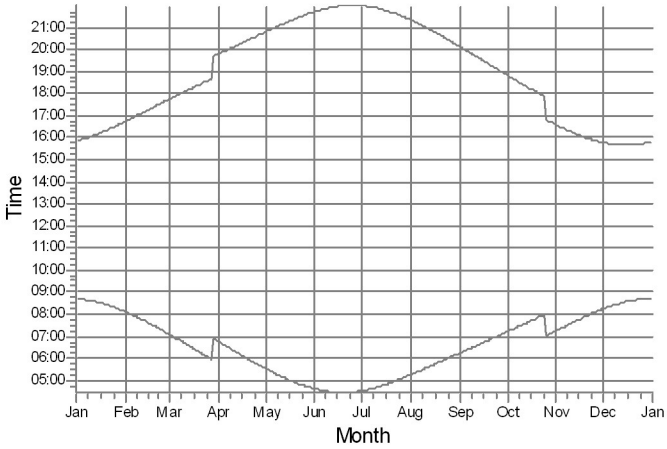
G: Shadow Recepter 7



H: Shadow Receptor 8



I: Shadow Receptor 9



WTGs

SHADOW - Calendar per WTG

Calculation: Shadow flickerWTG: 1 - NORDEX S77 1500 77.0 !-! hub: 61.5 m (TOT: 100.0 m) (37)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June
1	08:41	08:07	07:05	06:45	05:31 05:58-06:08/10	04:37
	15:49	16:44	17:44	19:48	20:48	21:42
2	08:41	08:05	07:02	06:42	05:29 05:56-06:08/12	04:36
	15:50	16:46	17:47	19:50	20:50	21:44
3	08:40	08:03	07:00	06:40	05:27 05:54-06:08/14	04:35
	15:52	16:49	17:49	19:52	20:52	21:45
4	08:40	08:01	06:57	06:37	05:25 05:53-06:07/14	04:34
	15:53	16:51	17:51	19:54	20:54	21:46
5	08:39	07:59	06:55	06:35	05:22 05:54-06:06/12	04:33
	15:54	16:53	17:53	19:56	20:56	21:47
6	08:39	07:57	06:52	06:32	05:20 05:55-06:04/9	04:32
	15:56	16:55	17:55	19:58	20:58	21:49
7	08:38 09:15-09:16/1	07:55	06:50	06:30 06:54-06:55/1	05:18 05:59-06:00/1	04:31
	15:57	16:57	17:57	20:00	21:00	21:50
8	08:38 09:14-09:16/2	07:53	06:47	06:27 06:52-06:56/4	05:16	04:31
	15:59	16:59	17:59	20:02	21:01	21:51
9	08:37 09:13-09:17/4	07:51	06:45	06:24 06:49-06:55/6	05:14	04:30
	16:00	17:02	18:01	20:04	21:03	21:52
10	08:36 09:12-09:18/6	07:49	06:42	06:22 06:47-06:55/8	05:12	04:29
	16:02	17:04	18:03	20:06	21:05	21:53
11	08:36 09:11-09:19/8	07:47	06:40	06:19 06:44-06:54/10	05:10	04:29
	16:03	17:06	18:05	20:08	21:07	21:54
12	08:35 09:10-09:20/10	07:45	06:37	06:17 06:42-06:53/11	05:08	04:28
	16:05	17:08	18:07	20:10	21:09	21:54
13	08:34 09:08-09:20/12	07:42	06:34 06:59-07:03/4	06:14 06:42-06:52/10	05:06	04:28
	16:07	17:10	18:09	20:12	21:11	21:55
14	08:33 09:07-09:21/14	07:40	06:32 06:57-07:04/7	06:12 06:44-06:49/5	05:04	04:28
	16:08	17:12	18:11	20:14	21:13	21:56
15	08:32 09:06-09:22/16	07:38	06:29 06:54-07:03/9	06:09	05:02	04:27
	16:10	17:15	18:13	20:16	21:15	21:57
16	08:31 09:04-09:21/17	07:36	06:27 06:52-07:04/12	06:07	05:00	04:27
	16:12	17:17	18:15	20:18	21:17	21:57
17	08:30 09:03-09:22/19	07:33	06:24 06:49-07:03/14	06:04	04:59	04:27
	16:14	17:19	18:17	20:20	21:18	21:58
18	08:28 09:02-09:23/21	07:31	06:22 06:46-07:01/15	06:02	04:57	04:27
	16:16	17:21	18:19	20:22	21:20	21:58
19	08:27 09:00-09:23/23	07:29	06:19 06:47-07:01/14	05:59	04:55	04:27
	16:18	17:23	18:21	20:24	21:22	21:58
20	08:26 09:01-09:24/23	07:26	06:16 06:48-06:58/10	05:57	04:54	04:27
	16:20	17:25	18:24	20:26	21:24	21:59
21	08:24 09:01-09:24/23	07:24	06:14 06:52-06:54/2	05:55	04:52	04:27
	16:22	17:27	18:26	20:28	21:25	21:59
22	08:23 09:01-09:23/22	07:22	06:11	05:52	04:50	04:27
	16:24	17:30	18:28	20:30	21:27	21:59
23	08:22 09:02-09:24/22	07:19	06:08	05:50	04:49	04:28
	16:26	17:32	18:30	20:32	21:29	21:59
24	08:20 09:03-09:24/21	07:17	06:06	05:47	04:47	04:28
	16:28	17:34	18:32	20:34	21:30	22:00
25	08:19 09:04-09:23/19	07:15	06:03	05:45	04:46	04:28
	16:30	17:36	18:34	20:36	21:32	22:00
26	08:17 09:04-09:22/18	07:12	06:01	05:43	04:44	04:29
	16:32	17:38	18:36	20:38	21:34	21:59
27	08:15 09:06-09:21/15	07:10	05:58	05:40 06:07-06:09/2	04:43	04:29
	16:34	17:40	18:38	20:40	21:35	21:59
28	08:14 09:07-09:20/13	07:07	05:55	05:38 06:05-06:09/4	04:42	04:30
	16:36	17:42	18:40	20:42	21:37	21:59
29	08:12 09:09-09:18/9		06:53	05:36 06:03-06:09/6	04:40	04:30
	16:38		19:42	20:44	21:38	21:59
30	08:10		06:50	05:33 06:00-06:09/9	04:39	04:31
	16:40		19:44	20:46	21:40	21:59
31	08:08		06:48		04:38	
	16:42		19:46		21:41	
Potential sun hours	240	268	366	424	503	522
Sum of minutes with flicker	338	0	87	76	72	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Licensed user:
COWI A/S
Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 15:29/3.0.578

SHADOW - Calendar per WTG

Calculation: Shadow flickerWTG: 1 - NORDEX S77 1500 77.0 !-! hub: 61.5 m (TOT: 100.0 m) (37)

Assumptions for shadow calculations

Sunshine probability S (Average daily sunshine hours) [COPENHAGEN / TAAST RUP]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.34	2.21	3.64	6.02	8.24	8.34	7.86	7.48	5.08	3.27	1.95	1.18

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
267	390	481	578	651	426	634	950	1,161	969	514	296	7,316

Idle start wind speed: Cut in wind speed from power curve

	July	August		September		October		November		December	
1	04:32	05:15		06:15	06:44-06:54/10	07:12	07:40-07:42/2	07:15		08:15	08:53-09:01/8
	21:58	21:19		20:08		18:49		16:34		15:45	
2	04:33	05:17		06:17	06:45-06:53/8	07:14		07:18		08:16	08:55-09:01/6
	21:58	21:17		20:05		18:47		16:32		15:45	
3	04:33	05:19		06:19	06:47-06:53/6	07:16		07:20		08:18	08:56-09:00/4
	21:57	21:15		20:03		18:44		16:30		15:44	
4	04:34	05:21		06:20	06:49-06:53/4	07:18		07:22		08:20	08:58-09:01/3
	21:57	21:13		20:00		18:42		16:28		15:43	
5	04:35	05:23		06:22	06:51-06:52/1	07:20		07:24		08:21	09:00-09:01/1
	21:56	21:11		19:57		18:39		16:26		15:42	
6	04:36	05:25	06:07-06:12/5	06:24		07:22		07:26		08:23	
	21:55	21:09		19:55		18:37		16:24		15:42	
7	04:37	05:27	06:04-06:14/10	06:26		07:24		07:28		08:24	
	21:55	21:07		19:52		18:34		16:22		15:41	
8	04:38	05:29	06:03-06:15/12	06:28		07:26		07:30		08:25	
	21:54	21:05		19:50		18:31		16:20		15:41	
9	04:40	05:30	06:02-06:16/14	06:30		07:28		07:32		08:27	
	21:53	21:03		19:47		18:29		16:18		15:40	
10	04:41	05:32	06:04-06:17/13	06:32		07:30		07:34		08:28	
	21:52	21:00		19:44		18:26		16:16		15:40	
11	04:42	05:34	06:06-06:18/12	06:34		07:32		07:36		08:29	
	21:51	20:58		19:42		18:24		16:14		15:39	
12	04:43	05:36	06:07-06:17/10	06:36		07:34		07:38		08:30	
	21:50	20:56		19:39		18:21		16:12		15:39	
13	04:45	05:38	06:09-06:17/8	06:38		07:36		07:40	08:41-08:50/9	08:32	
	21:49	20:54		19:37		18:19		16:10		15:39	
14	04:46	05:40	06:11-06:17/6	06:40		07:38		07:43	08:40-08:53/13	08:33	
	21:48	20:51		19:34		18:16		16:09		15:39	
15	04:47	05:42	06:13-06:17/4	06:42		07:40		07:45	08:38-08:54/16	08:34	
	21:47	20:49		19:31		18:14		16:07		15:39	
16	04:49	05:44	06:14-06:15/1	06:43		07:42		07:47	08:37-08:55/18	08:35	
	21:45	20:47		19:29		18:11		16:05		15:39	
17	04:50	05:46		06:45		07:44		07:49	08:38-08:57/19	08:35	
	21:44	20:44		19:26		18:09		16:03		15:39	
18	04:52	05:48		06:47		07:46		07:51	08:37-08:58/21	08:36	
	21:43	20:42		19:23		18:06		16:02		15:39	
19	04:53	05:50		06:49		07:48		07:53	08:36-08:58/22	08:37	
	21:41	20:40		19:21		18:04		16:00		15:39	
20	04:55	05:52		06:51		07:50		07:55	08:36-08:58/22	08:38	
	21:40	20:37		19:18		18:02		15:59		15:40	
21	04:56	05:53		06:53		07:53		07:57	08:36-08:59/23	08:38	
	21:38	20:35		19:16		17:59		15:57		15:40	
22	04:58	05:55		06:55		07:55		07:59	08:37-09:00/23	08:39	
	21:37	20:33		19:13		17:57		15:56		15:41	
23	05:00	05:57		06:57	07:34-07:42/8	07:57		08:00	08:37-09:00/23	08:39	
	21:35	20:30		19:10		17:54		15:55		15:41	
24	05:01	05:59		06:59	07:31-07:44/13	07:59		08:02	08:39-09:00/21	08:40	
	21:34	20:28		19:08		17:52		15:53		15:42	
25	05:03	06:01		07:01	07:29-07:44/15	07:01		08:04	08:41-09:00/19	08:40	
	21:32	20:25		19:05		16:50		15:52		15:42	
26	05:05	06:03		07:03	07:30-07:44/14	07:03		08:06	08:43-09:01/18	08:40	
	21:30	20:23		19:02		16:48		15:51		15:43	
27	05:07	06:05		07:05	07:32-07:44/12	07:05		08:08	08:45-09:01/16	08:41	
	21:28	20:20		19:00		16:45		15:50		15:44	
28	05:08	06:07		07:07	07:34-07:44/10	07:07		08:10	08:47-09:01/14	08:41	
	21:27	20:18		18:57		16:43		15:48		15:45	
29	05:10	06:09	06:45-06:50/5	07:09	07:36-07:44/8	07:09		08:11	08:49-09:01/12	08:41	
	21:25	20:15		18:55		16:41		15:47		15:46	
30	05:12	06:11	06:42-06:52/10	07:10	07:38-07:43/5	07:11		08:13	08:51-09:01/10	08:41	
	21:23	20:13		18:52		16:39		15:46		15:47	
31	05:14	06:13	06:42-06:53/11			07:13				08:41	
	21:21	20:10				16:36				15:48	
Potential sun hours	523	466		384		325		251		222	
Sum of minutes with flicker	0	121		114		2		319		22	

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

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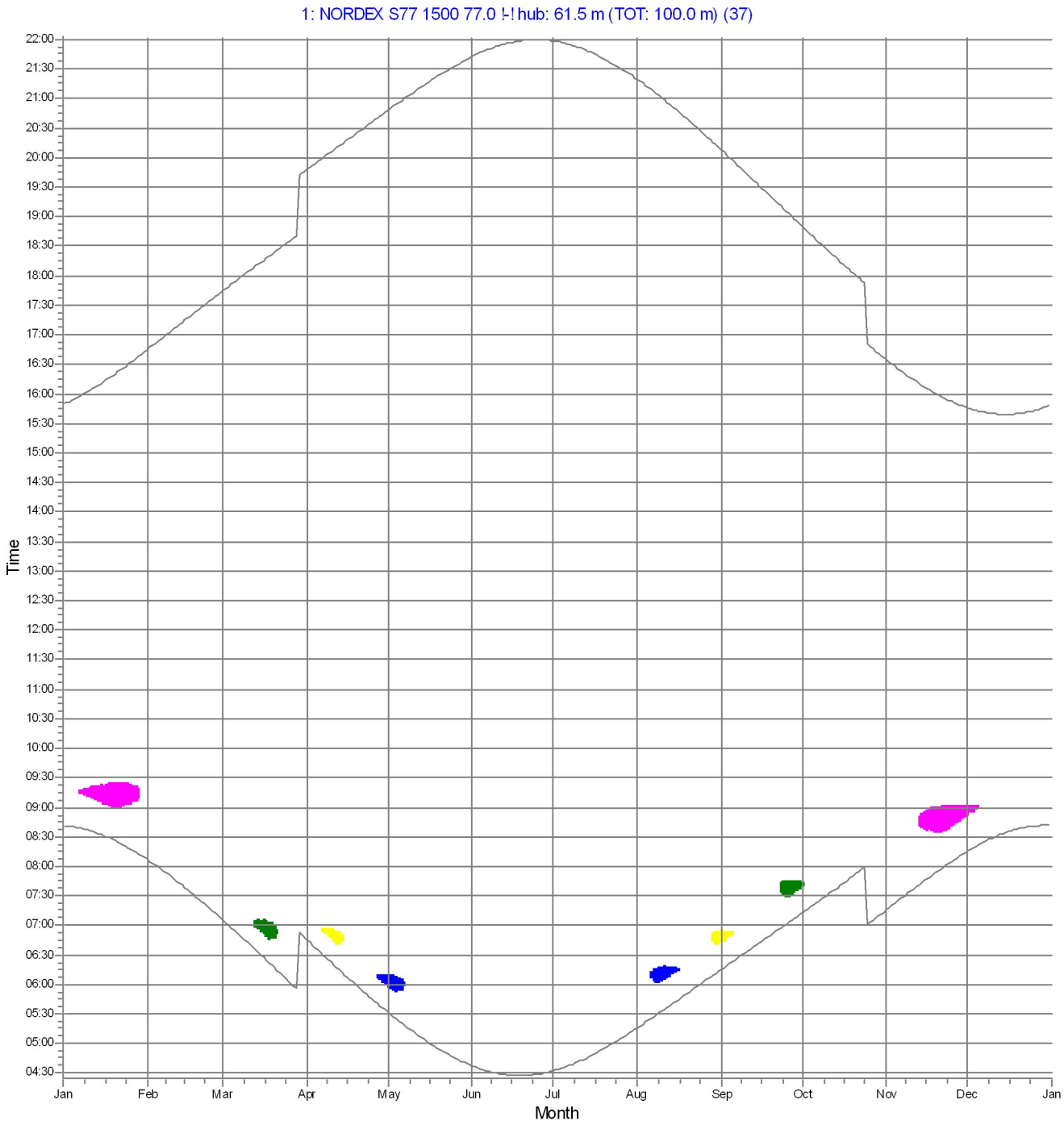
SHADOW - Calendar per WTG, graphical

Calculation: Shadow flickerWTG: 1 - NORDEX S77 1500 77.0 !-! hub: 61.5 m (TOT: 100.0 m) (37)

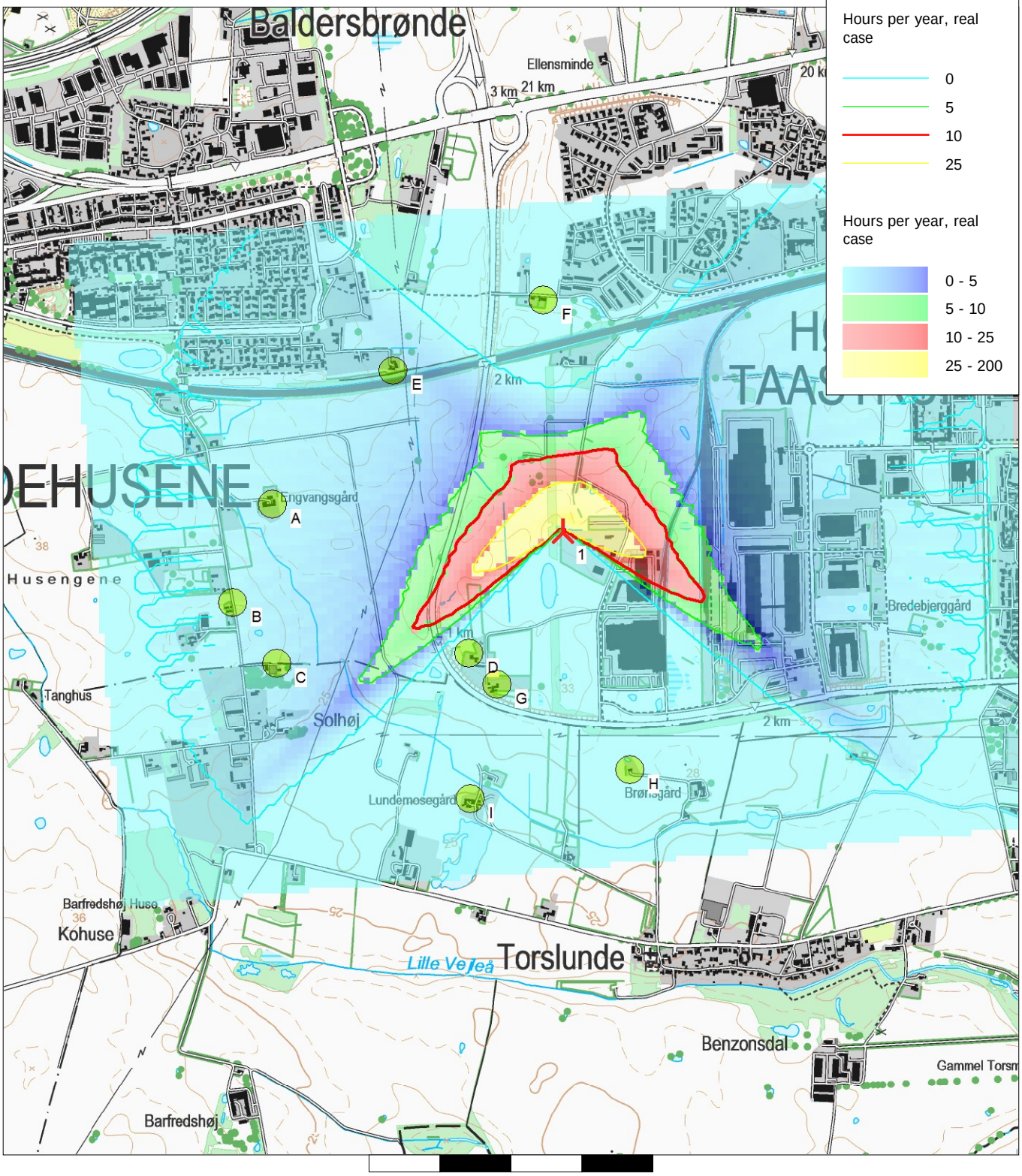


Shadow receptors

A: Shadow Receptor 1	C: Shadow Receptor 3
B: Shadow Receptor 2	E: Shadow Receptor 5

SHADOW - Map

Calculation: Shadow flickerWTG: 1 - NORDEX S77 1500 77.0 !-! hub: 61.5 m (TOT: 100.0 m) (37)



Map: Kort25-1110_6200_700 6200_700, Print scale 1:20,000, Map center UTM (north)-WGS84 Zone: 33 East: 326,400 North: 6,169,420

New WTG Shadow receptor

Flicker map level: HCL - SRTM

Bilag C – WindPRO PARK

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PARK - Main Result

Calculation: Park - Nordex S77, hub height 61.5 m

Wake Model	N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	1.246 kg/m³ to 1.248 kg/m³
Air density relative to standard	101.7 % to 101.8 %
Hub altitude above sea level (asl)	76.9 m to 90.0 m
Annual mean temperature at hub alt.	7.1 °C to 7.2 °C
Pressure at WTGs	1,002.2 hPa to 1,003.8 hPa

Wake Model Parameters

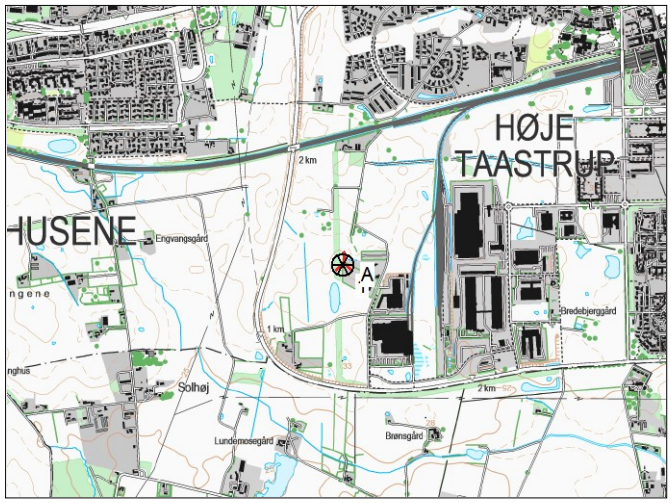
From angle [°]	To angle [°]	Terrain type	Wake decay constant
-180.0	180.0	Open farmland	0.075

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	DK DANMARK '07.wws
Regional Correction Factor	0.91
WAsP version	WAsP 6-9 RVEA0011.dll 1, 0, 0, 13



Scale 1:40,000

New WTG Site Data

Key results for height 50.0 m above ground level

Terrain UTM (north)-WGS84 Zone: 33

	Easting	Northing	Name of wind distribution	Type	Mean wind speed [m/s]	Equivalent roughness
A	326,412	6,169,414	For PARK	WAsP (WAsP 6-9 RVEA0011.dll 1, 0, 0, 13)	5.8	2.4

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @hub height [m/s]
				Specific results¤)			
Wind farm	3,570.1	3,570.7	100.0	27.2	3,570.1	2,380	6.1

¤) Based on wake reduced results, but no other losses included

Calculated Annual Energy for each of 1 new WTGs with total 1.5 MW rated power

Links	WTG type Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve Creator	Name	Annual Energy Result [MWh]	Park Efficiency [%]	Capacity factor [%]	Mean wind speed [m/s]
1 A	Yes	NORDEX	S77-1,500	1,500	77.0	61.5	0.0	EMD	Level 0 - official - LKG04R3 - 06-2005	3,570.1	99.98	27.2	6.11

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

UTM (north)-WGS84 Zone: 33

	Easting	Northing	Z [m]	Row data/Description
1 New	326,414	6,169,429	28.5	NORDEX S77 1500 77.0 !-! hub: 61.5 m (TOT: 100.0 m) (37)

*) Included in array losses is influence from 1 WTG(s) in the neighborhood, which has status as "Reference WTGs", see separate report to identify these.

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PARK - Reference WTGs

Calculation: Park - Nordex S77, hub height 61.5 m

Wake Model	N.O. Jensen (RISØ/EMD)

Calculation Settings

Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	1.246 kg/m³ to 1.248 kg/m³
Air density relative to standard	101.7 % to 101.8 %
Hub altitude above sea level (asl)	76.9 m to 90.0 m
Annual mean temperature at hub alt.	7.1 °C to 7.2 °C
Pressure at WTGs	1,002.2 hPa to 1,003.8 hPa

Wake Model Parameters

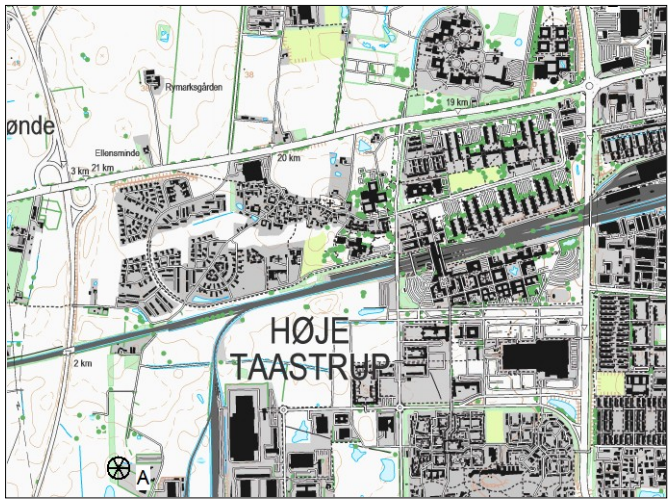
From angle [°]	To angle [°]	Terrain type	Wake decay constant
-180.0	180.0	Open farmland	0.075

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	DK DANMARK '07.wws
Regional Correction Factor	0.91
WAsP version	WAsP 6-9 RVEA0011.dll 1, 0, 0, 13



Scale 1:40,000

New WTG Existing WTG Site Data

Key results for height 50.0 m above ground level

Terrain UTM (north)-WGS84 Zone: 33

	Easting	Northing	Name of wind distribution	Type	Mean wind speed [m/s]	Equivalent roughness
A	326,412	6,169,414	For PARK	WAsP (WAsP 6-9 RVEA0011.dll 1, 0, 0, 13)	5.8	2.4

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @hub height [m/s]
				Specific results¤)			
Wind farm	3,570.1	3,570.7	100.0	27.2	3,570.1	2,380	6.1

¤) Based on wake reduced results, but no other losses included

Calculated Annual Energy for each of 1 reference WTGs with total 0.9 MW rated power

Links	WTG type Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve Creator	Name	Calculated prod. without new WTGs [MWh]	Actual wind corrected energy [MWh]	Goodness Factor [%]
2 A	Yes	VESTAS	V52-850	850	52.0	54.0	0.0	EMD	Level 0 - calculated - 104.2 dB(A) - 07-2006	1,508.5	1,256.0	83

WTG siting

UTM (north)-WGS84 Zone: 33

	Easting	Northing	Z [m]	Row data/Description	Production source	Statistical basis for normalized production: [Months]
2	329,139	6,171,782	22.9	570715000000107078: 850 kW Vestas - Høje-Taastrup	EMD-indeks ver.13 region 7	40

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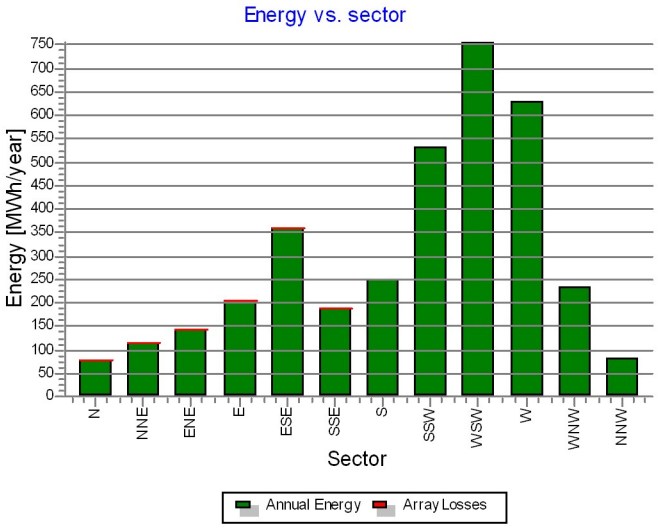
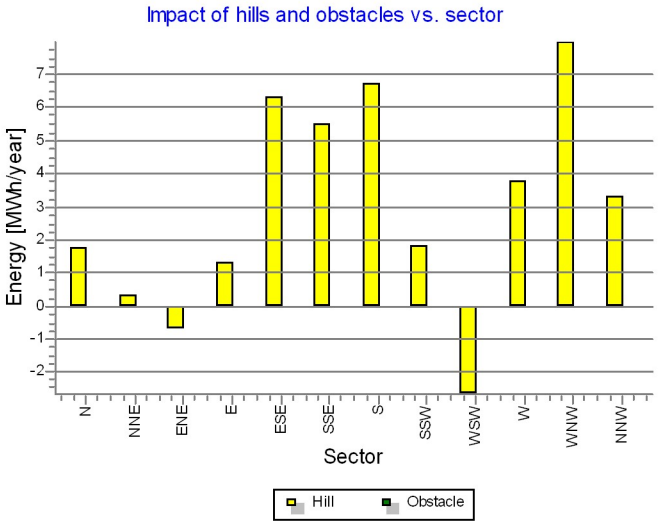
PARK - Production Analysis

Calculation: Park - Nordex S77, hub height 61.5 mWTG: All new WTGs, Air density varies with WTG position 1.248 kg/m³ - 1.249 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]	76.0	115.8	144.7	201.5	353.3	183.4	243.0	531.2	758.8	625.0	225.7	76.8	3,535.2
+Increase due to hills	[MWh]	1.8	0.3	-0.7	1.3	6.3	5.5	6.7	1.8	-2.7	3.8	8.0	3.3	35.5
-Decrease due to array losses	[MWh]	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Resulting energy	[MWh]	77.8	116.1	143.5	202.8	359.6	188.9	249.7	533.0	756.1	628.8	233.6	80.1	3,570.1
Specific energy	[kWh/m²]													767
Specific energy	[kWh/kW]													2,380
Increase due to hills	[%]	2.3	0.3	-0.5	0.6	1.8	3.0	2.8	0.3	-0.4	0.6	3.5	4.3	1.00
Decrease due to array losses	[%]	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
Utilization	[%]	35.2	34.8	31.7	37.3	34.1	34.5	35.4	32.4	32.6	32.2	33.8	34.3	33.4
Operational	[Hours/year]	267	389	476	578	653	427	636	951	1,162	970	515	297	7,320
Full Load Equivalent	[Hours/year]	52	77	96	135	240	126	166	355	504	419	156	53	2,380





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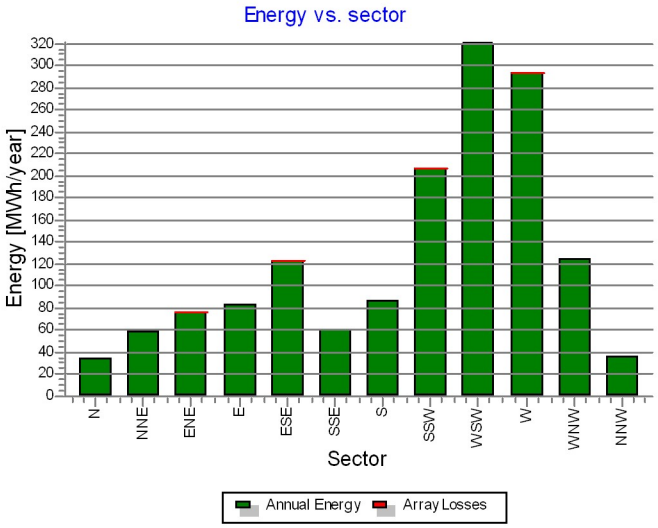
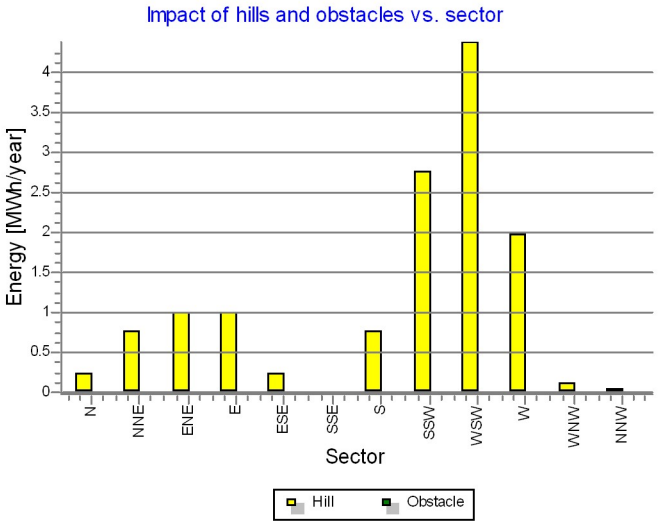
PARK - Production Analysis

Calculation: Park - Nordex S77, hub height 61.5 mWTG: All existing WTGs, Air density varies with WTG position 1.248 kg/m³ - 1.249 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]	35.1	57.7	75.7	83.2	122.5	61.4	86.0	204.4	317.1	290.8	125.0	36.4	1,495.3
+Increase due to hills	[MWh]	0.2	0.8	1.0	1.0	0.2	0.0	0.8	2.8	4.4	2.0	0.1	0.0	13.2
-Decrease due to array losses	[MWh]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.4	0.0	0.0	0.0	2.5
Resulting energy	[MWh]	35.4	58.4	76.7	84.2	122.7	61.4	86.7	207.1	319.0	292.8	125.1	36.4	1,506.0
Specific energy	[kWh/m²]													709
Specific energy	[kWh/kW]													1,772
Increase due to hills	[%]	0.6	1.3	1.3	1.2	0.2	0.0	0.9	1.3	1.4	0.7	0.1	0.1	0.89
Decrease due to array losses	[%]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.17
Utilization	[%]	39.7	38.8	35.0	42.1	41.2	41.1	41.5	39.5	38.6	37.2	37.0	38.7	38.8
Operational	[Hours/year]	253	378	462	561	621	392	604	928	1,127	927	489	278	7,020
Full Load Equivalent	[Hours/year]	42	69	90	99	144	72	102	244	375	344	147	43	1,772





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PARK - Power Curve Analysis

Calculation: Park - Nordex S77, hub height 61.5 mWTG: 1 - NORDEX S77 1500 77.0 !-! Level 0 - official - LKG04R3 - 06-2005, Hub height: 61.5 m

Name: Level 0 - official - LKG04R3 - 06-2005
Source: Manufacturer

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m²
03-06-2005	EMD	21-11-2005	21-11-2005	25.0	Pitch	Standard pitch	Variable	0.32

Power curve is based on measurement
WT Grevenbroich LK 02 001 B1 A6

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]	2,384	3,662	4,913	6,040	6,998	7,770
NORDEX S77 1500 77.0 !-! Level 0 - official - LKG04R3 - 06-2005	[MWh]	2,173	3,395	4,619	5,741	6,704	7,483
Check value	[%]	10	8	6	5	4	4

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/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

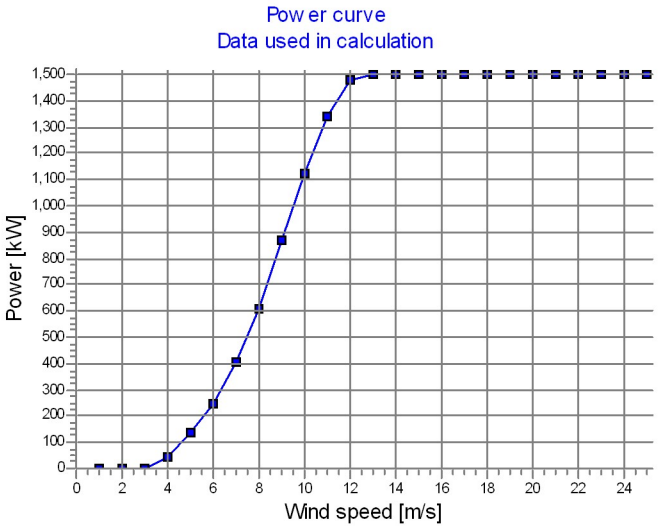
Original data from Windcat, Air density: 1.225 kg/m³

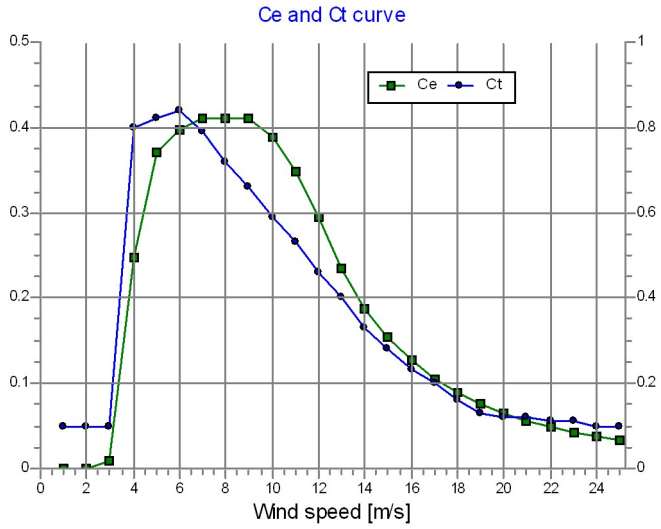
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
2.0	0.0	0.00	1.0	0.10
3.0	0.0	0.00	2.0	0.10
4.0	44.0	0.24	3.0	0.10
5.0	131.0	0.37	4.0	0.80
6.0	244.0	0.40	5.0	0.82
7.0	400.0	0.41	6.0	0.84
8.0	600.0	0.41	7.0	0.79
9.0	854.0	0.41	8.0	0.72
10.0	1,111.0	0.39	9.0	0.66
11.0	1,331.0	0.35	10.0	0.59
12.0	1,475.0	0.30	11.0	0.53
13.0	1,500.0	0.24	12.0	0.46
14.0	1,500.0	0.19	13.0	0.40
15.0	1,500.0	0.16	14.0	0.33
16.0	1,500.0	0.13	15.0	0.28
17.0	1,500.0	0.11	16.0	0.23
18.0	1,500.0	0.09	17.0	0.20
19.0	1,500.0	0.08	18.0	0.16
20.0	1,500.0	0.07	19.0	0.13
21.0	1,500.0	0.06	20.0	0.12
22.0	1,500.0	0.05	21.0	0.12
23.0	1,500.0	0.04	22.0	0.11
24.0	1,500.0	0.04	23.0	0.11
25.0	1,500.0	0.03	24.0	0.10

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 1.246 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	0.0	0.0	0.0
3.0	0.7	0.01	2.50- 3.50	11.1	11.1	0.3
4.0	45.9	0.25	3.50- 4.50	59.5	70.6	2.0
5.0	134.1	0.37	4.50- 5.50	152.1	222.7	6.2
6.0	249.1	0.40	5.50- 6.50	269.6	492.2	13.8
7.0	407.7	0.41	6.50- 7.50	389.0	881.2	24.7
8.0	611.3	0.41	7.50- 8.50	486.5	1,367.7	38.3
9.0	867.8	0.41	8.50- 9.50	533.7	1,901.4	53.3
10.0	1,125.8	0.39	9.50-10.50	509.9	2,411.3	67.5
11.0	1,343.2	0.35	10.50-11.50	423.5	2,834.8	79.4
12.0	1,477.5	0.29	11.50-12.50	306.1	3,140.9	88.0
13.0	1,500.0	0.24	12.50-13.50	195.0	3,335.8	93.4
14.0	1,500.0	0.19	13.50-14.50	113.4	3,449.3	96.6
15.0	1,500.0	0.15	14.50-15.50	61.8	3,511.1	98.3
16.0	1,500.0	0.13	15.50-16.50	31.7	3,542.7	99.2
17.0	1,500.0	0.11	16.50-17.50	15.3	3,558.0	99.7
18.0	1,500.0	0.09	17.50-18.50	7.0	3,565.0	99.9
19.0	1,500.0	0.08	18.50-19.50	3.0	3,568.0	99.9
20.0	1,500.0	0.06	19.50-20.50	1.2	3,569.3	100.0
21.0	1,500.0	0.06	20.50-21.50	0.5	3,569.8	100.0
22.0	1,500.0	0.05	21.50-22.50	0.2	3,570.0	100.0
23.0	1,500.0	0.04	22.50-23.50	0.1	3,570.0	100.0
24.0	1,500.0	0.04	23.50-24.50	0.0	3,570.1	100.0
25.0	1,500.0	0.03	24.50-25.50	0.0	3,570.1	100.0





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PARK - Terrain

Calculation: Park - Nordex S77, hub height 61.5 mSite Data: A - For PARK

Obstacles:
0 Obstacles used

Roughness:
Calculation uses following MAP files:
C:\Users\todl\Desktop\Høje Taastrup\Hoje Taastrup WindPRO Project TODL\ROUGHNESSLINE_28082012_BEBI_Taastrup_01_0.wpo
Min X: 312,813, Max X: 354,909, Min Y: 6,146,184, Max Y: 6,193,281, Width: 42,096 m, Height: 47,097 m
Limited by a square on 40.0 km x 40.0 km around the current site

Orography:
Calculation uses following MAP files:
C:\Users\todl\Desktop\Høje Taastrup\Hoje Taastrup WindPRO Project TODL\CONTOURLINE_ONLINEDATA_0.wpo
Min X: 317,879, Max X: 343,862, Min Y: 6,156,622, Max Y: 6,180,598, Width: 25,983 m, Height: 23,976 m
Limited by a square on 14.0 km x 14.0 km around the current site

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Parallelvej 2
DK-2800 Kgs. Lyngby

Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 11:11/3.0.578

PARK - Wind Data Analysis

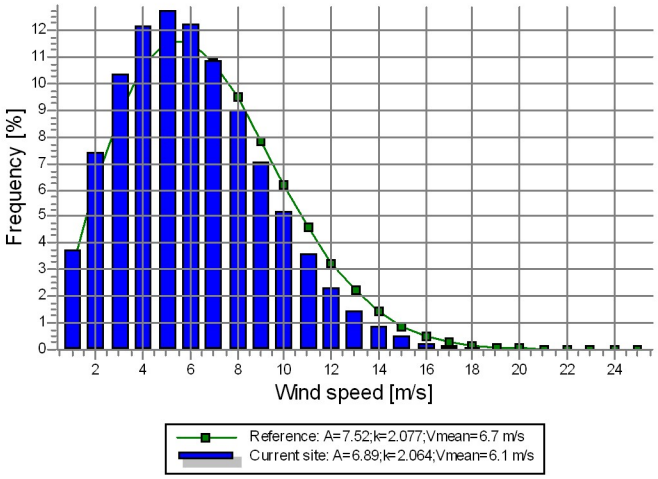
Calculation: Park - Nordex S77, hub height 61.5 mWind data: A - For PARK; Hub height: 61.5

Site coordinates
UTM (north)-WGS84 Zone: 33
East: 326,412 North: 6,169,414
Wind statistics
DK DANMARK '07.wws
Regional Correction Factor
1.00

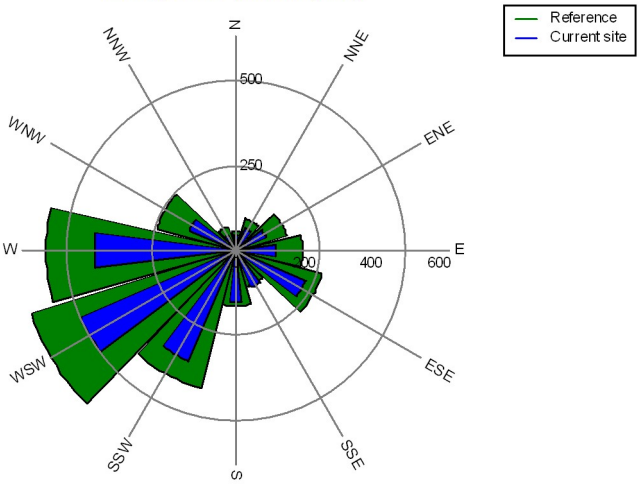
Weibull Data

Sector	Current site A-parameter [m/s]	Current site Wind speed [m/s]	Current site k-parameter	Current site Frequency [%]	Reference: Roughness class 1 A-parameter [m/s]	Reference: Roughness class 1 k-parameter	Reference: Roughness class 1 Frequency [%]
0 N	5.43	4.83	1.814	3.6	5.86	1.826	3.5
1 NNE	5.46	4.85	1.787	5.3	6.23	1.892	5.2
2 ENE	5.25	4.72	1.549	6.5	6.18	1.547	6.4
3 E	6.13	5.43	2.283	7.9	7.38	2.339	7.7
4 ESE	7.36	6.52	2.350	8.9	7.76	2.340	8.9
5 SSE	6.64	5.88	2.100	5.8	6.55	2.012	5.5
6 S	6.32	5.59	2.092	8.7	6.46	2.082	8.7
7 SSW	7.42	6.57	2.186	13.0	7.92	2.189	12.6
8 WSW	8.00	7.09	2.439	15.9	8.62	2.432	16.0
9 W	7.98	7.08	2.393	13.2	8.70	2.415	13.8
10 WNW	6.69	5.93	2.053	7.0	7.77	2.100	7.4
11 NNW	5.15	4.60	1.670	4.1	5.76	1.673	4.2
All	6.89	6.10	2.064	100.0	7.52	2.077	100.0

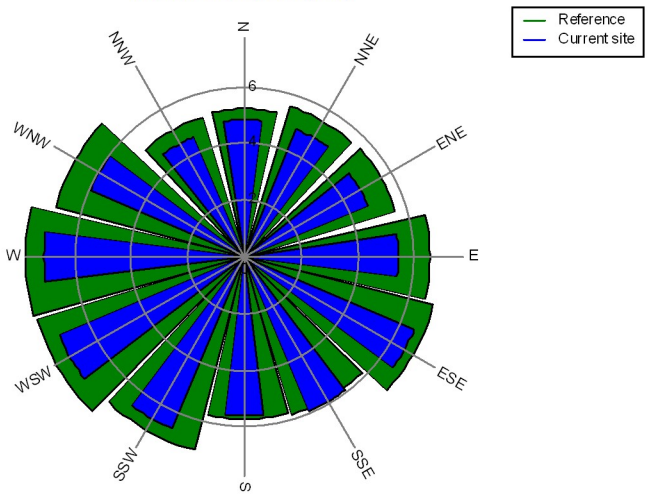
Weibull Distribution



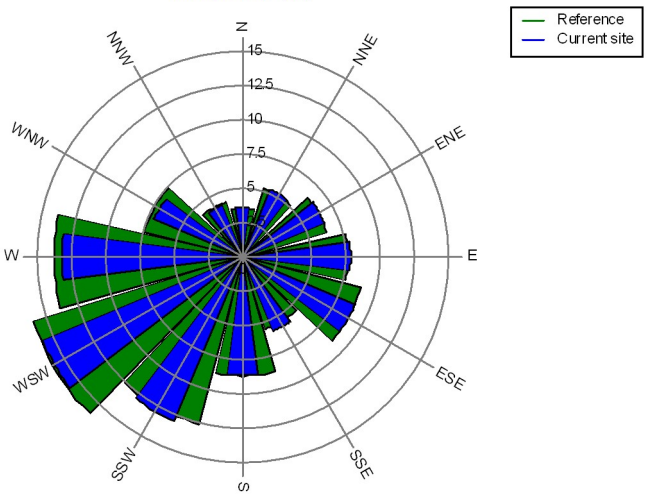
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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DK-2800 Kgs. Lyngby

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Calculated:
29-05-2015 11:11/3.0.578

PARK - Wind Data Analysis

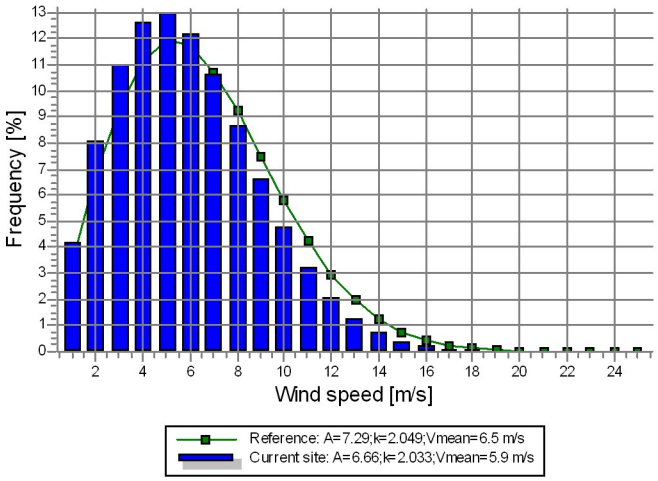
Calculation: Park - Nordex S77, hub height 61.5 mWind data: A - For PARK; Hub height: 54.0

Site coordinates
UTM (north)-WGS84 Zone: 33
East: 326,412 North: 6,169,414
Wind statistics
DK DANMARK '07.wws
Regional Correction Factor
1.00

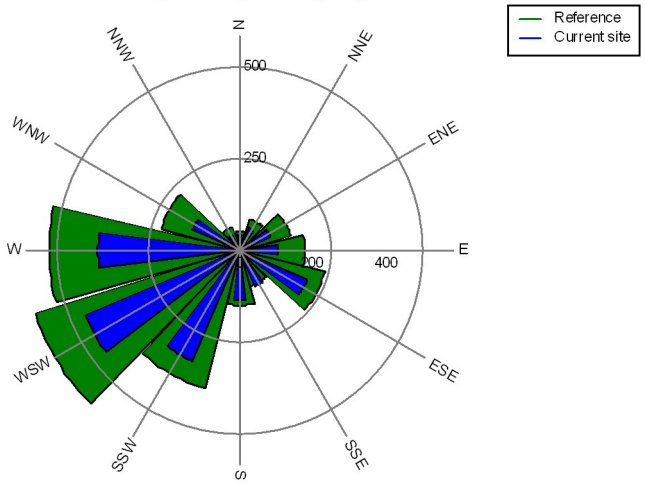
Weibull Data

Sector	Current site A-parameter [m/s]	Current site Wind speed [m/s]	Current site k-parameter	Current site Frequency [%]	Reference: Roughness class 1 A-parameter [m/s]	Reference: Roughness class 1 k-parameter	Reference: Roughness class 1 Frequency [%]
0 N	5.24	4.67	1.779	3.7	5.67	1.805	3.5
1 NNE	5.23	4.65	1.752	5.3	6.02	1.868	5.2
2 ENE	5.09	4.59	1.518	6.5	5.98	1.527	6.4
3 E	5.91	5.23	2.229	7.9	7.14	2.311	7.7
4 ESE	7.08	6.27	2.326	8.9	7.51	2.312	8.9
5 SSE	6.40	5.67	2.104	5.9	6.33	1.988	5.5
6 S	6.08	5.39	2.072	8.7	6.24	2.058	8.7
7 SSW	7.19	6.37	2.146	13.0	7.69	2.159	12.6
8 WSW	7.76	6.88	2.396	15.8	8.38	2.400	16.0
9 W	7.75	6.87	2.350	13.2	8.46	2.381	13.8
10 WNW	6.51	5.77	2.014	7.1	7.54	2.072	7.4
11 NNW	4.97	4.45	1.639	4.1	5.57	1.655	4.2
All	6.66	5.90	2.033	100.0	7.29	2.049	100.0

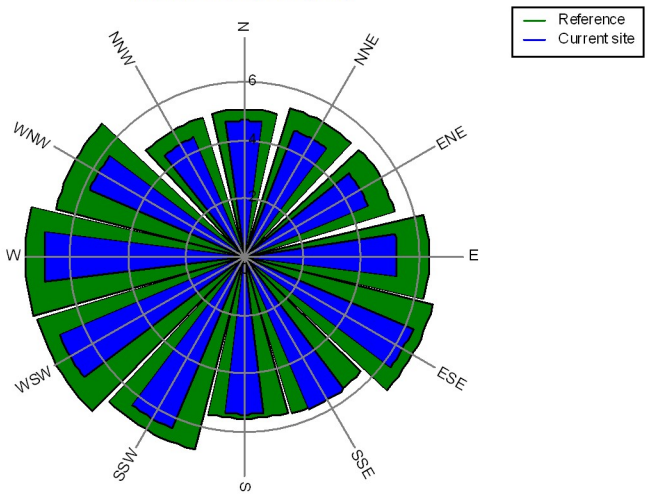
Weibull Distribution



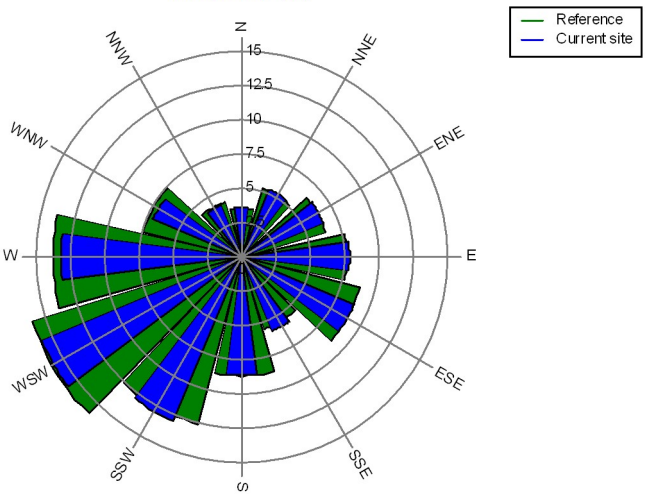
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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Calculated:
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PARK - Wind Data Analysis

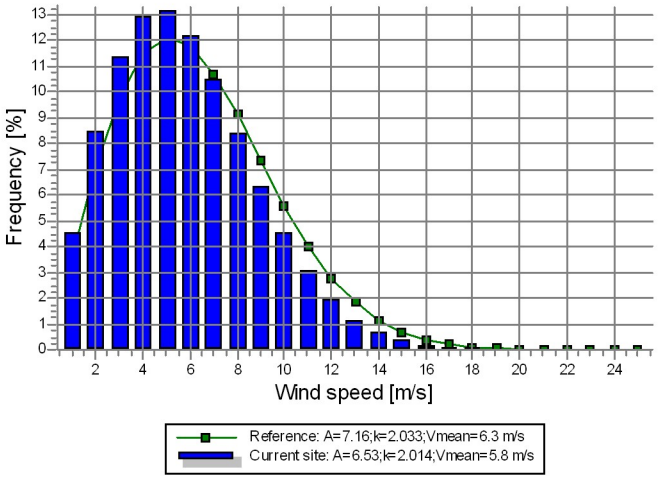
Calculation: Park - Nordex S77, hub height 61.5 mWind data: A - For PARK; Hub height: 50.0

Site coordinates
UTM (north)-WGS84 Zone: 33
East: 326,412 North: 6,169,414
Wind statistics
DK DANMARK '07.wws
Regional Correction Factor
1.00

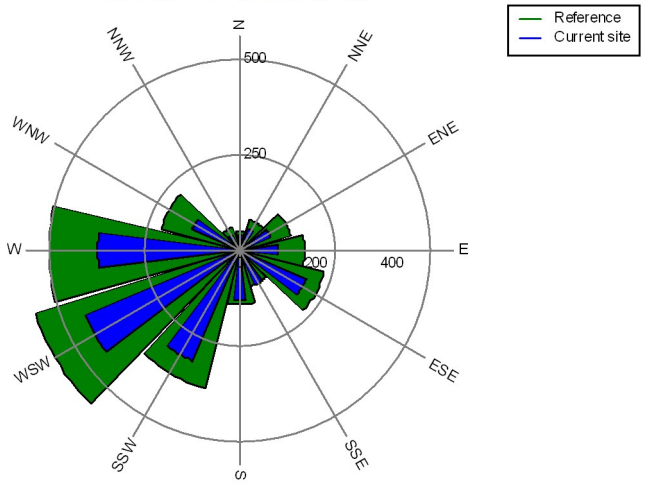
Weibull Data

Sector	Current site A-parameter [m/s]	Current site Wind speed [m/s]	Current site k-parameter	Current site Frequency [%]	Reference: Roughness class 1 A-parameter [m/s]	Reference: Roughness class 1 k-parameter	Reference: Roughness class 1 Frequency [%]
0 N	5.13	4.57	1.760	3.7	5.55	1.793	3.5
1 NNE	5.09	4.54	1.729	5.3	5.90	1.854	5.2
2 ENE	5.00	4.51	1.498	6.5	5.87	1.514	6.4
3 E	5.78	5.12	2.193	7.9	6.99	2.294	7.7
4 ESE	6.92	6.13	2.311	8.9	7.36	2.295	8.9
5 SSE	6.26	5.54	2.104	5.9	6.20	1.974	5.5
6 S	5.95	5.27	2.057	8.7	6.11	2.044	8.7
7 SSW	7.05	6.25	2.123	13.0	7.55	2.141	12.6
8 WSW	7.62	6.76	2.373	15.8	8.24	2.381	16.0
9 W	7.62	6.75	2.322	13.2	8.32	2.361	13.8
10 WNW	6.41	5.68	1.990	7.1	7.41	2.055	7.4
11 NNW	4.87	4.36	1.623	4.1	5.45	1.643	4.2
All	6.53	5.79	2.014	100.0	7.16	2.033	100.0

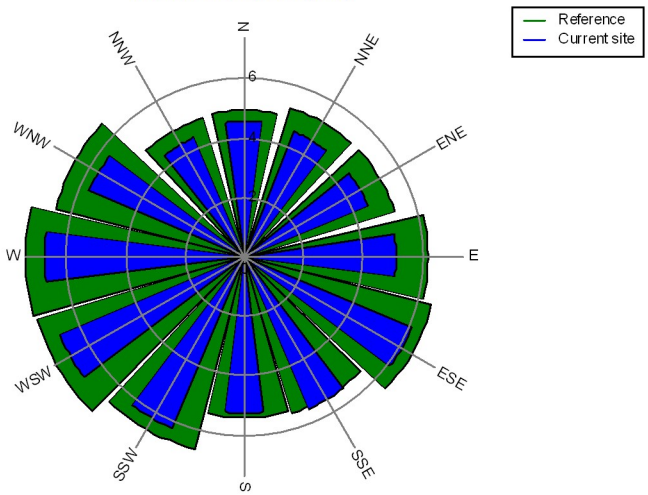
Weibull Distribution



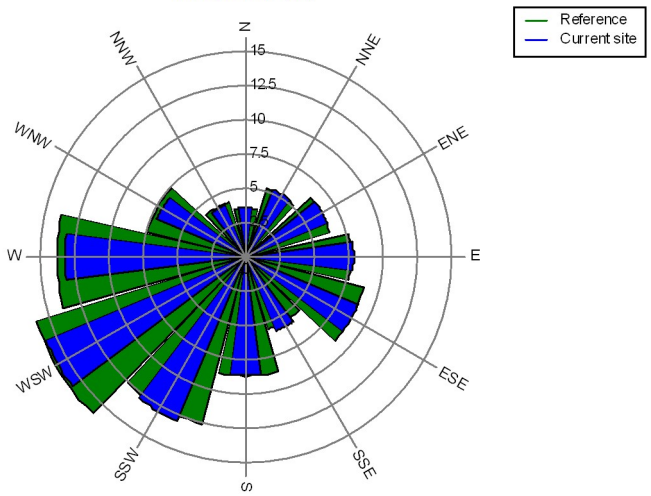
Energy Rose (kWh/m²/year)



Mean wind speed (m/s)



Frequency (%)



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Calculated:
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PARK - Park power curve

Calculation: Park - Nordex S77, hub height 61.5 m

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	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	36	36	36	36	36	36	36	36	36	36	36	36	36	36
4.5	137	137	137	137	137	137	137	137	137	137	136	137	137	137
5.5	289	289	289	289	288	289	289	289	289	289	288	289	289	289
6.5	495	494	495	494	493	495	495	495	495	494	492	495	495	495
7.5	766	766	766	766	764	766	766	766	766	766	763	766	766	766
8.5	1,110	1,109	1,110	1,110	1,107	1,110	1,110	1,110	1,110	1,110	1,107	1,110	1,110	1,110
9.5	1,496	1,495	1,496	1,496	1,492	1,496	1,496	1,496	1,496	1,496	1,492	1,496	1,496	1,496
10.5	1,860	1,859	1,860	1,860	1,856	1,860	1,860	1,860	1,860	1,860	1,857	1,860	1,860	1,860
11.5	2,140	2,140	2,140	2,140	2,138	2,140	2,140	2,140	2,140	2,140	2,138	2,140	2,140	2,140
12.5	2,281	2,281	2,281	2,281	2,281	2,281	2,281	2,281	2,281	2,281	2,280	2,281	2,281	2,281
13.5	2,327	2,327	2,327	2,327	2,327	2,327	2,327	2,327	2,327	2,327	2,326	2,327	2,327	2,327
14.5	2,342	2,342	2,342	2,342	2,342	2,342	2,342	2,342	2,342	2,342	2,342	2,342	2,342	2,342
15.5	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348	2,348
16.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
17.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
18.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
19.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
20.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
21.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
22.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
23.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
24.5	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350	2,350
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.

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DK-2800 Kgs. Lyngby

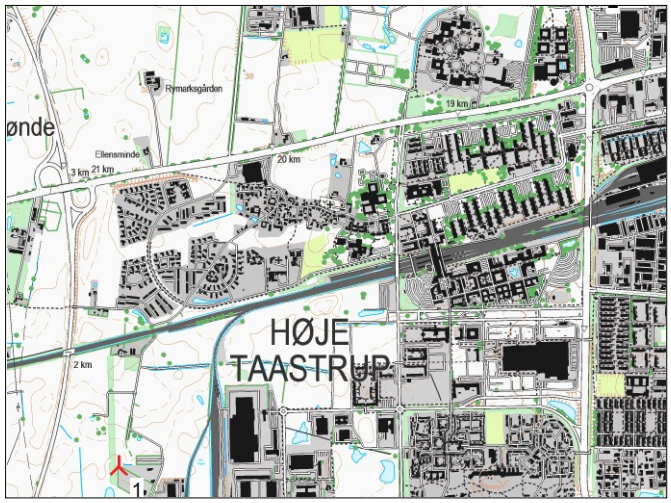
Torkel Dyrkorn Løland / todl@cowi.dk
Calculated:
29-05-2015 11:11/3.0.578

PARK - WTG distances

Calculation: Park - Nordex S77, hub height 61.5 m

WTG distances

	Z	Nearest WTG	Z	Horizontal distance	Distance in|rotor diameters	Distance in|rotor diameters
	[m]		[m]	[m]	(max)	(min)
1	28.5	2	22.9	3,600	69.2	46.8
2	22.9	1	28.5	3,600	69.2	46.8
Min	22.9		22.9	3,600	69.2	46.8
Max	28.5		28.5	3,600	69.2	46.8



Scale 1:40,000

New WTG Existing WTG

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DK-2800 Kgs. Lyngby

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Calculated:
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PARK - Wind statistics info

Calculation: Park - Nordex S77, hub height 61.5 m

Main data for wind statistic

File	C:\Users\todl\Desktop\Høje Taastrup\Hoje Taastrup WindPRO Project TODL\DK DANMARK '07.wws
Name	DANMARK '07
Country	Denmark
Source	EM0
Created	04-07-2000
Edited	12-10-2007
Sectors	12
WAsP version	

The used wind statistic is generated from an older windPRO version (before 2.8) or from another tool (WAsP) – therefore not all detailed informations are available.

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.

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Calculated:
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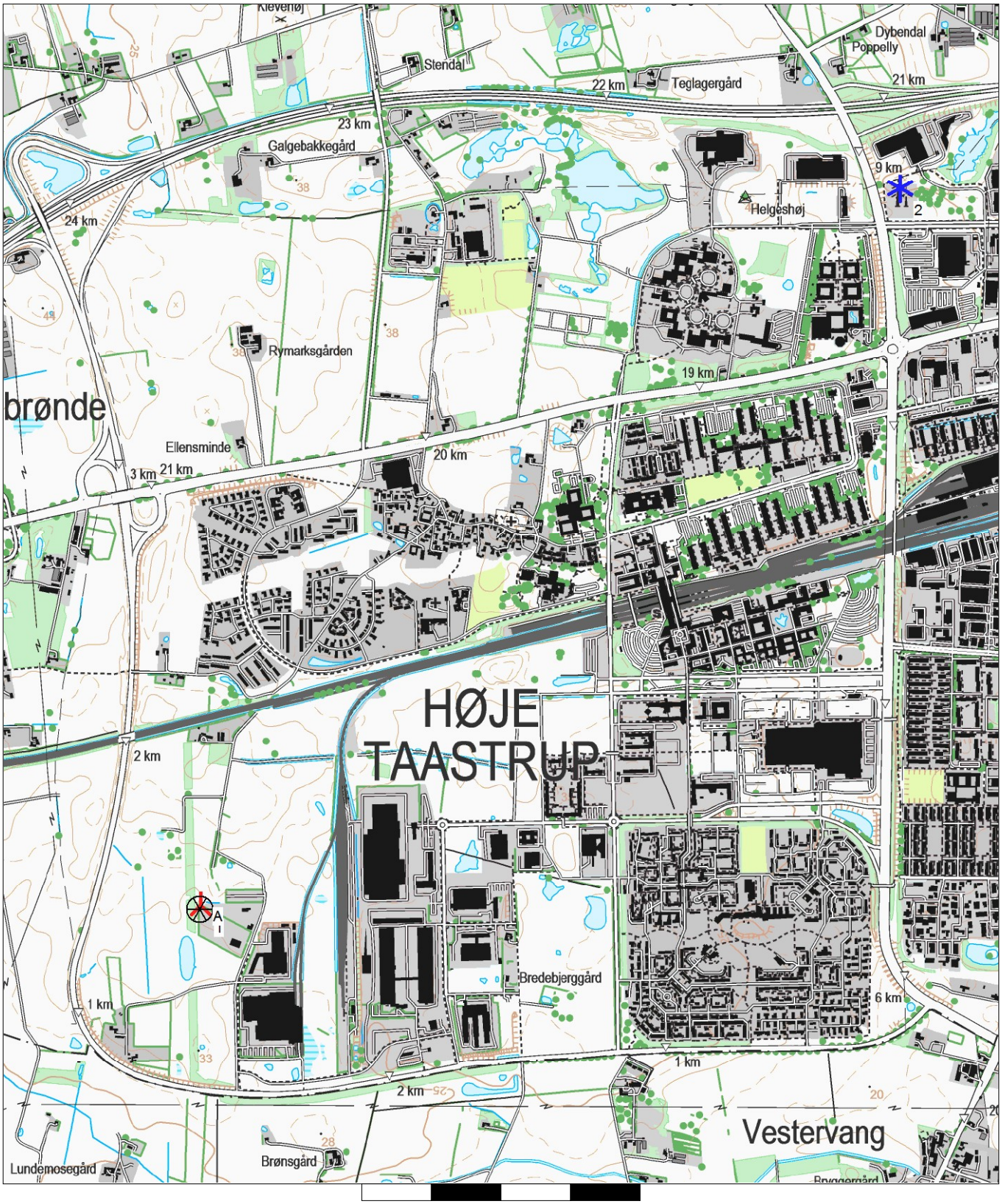
PARK - Map

Calculation: Park - Nordex S77, hub height 61.5 m



Map: Kort25-1110_6200_700 6200_700, Print scale 1:20,000, Map center UTM (north)-WGS84 Zone: 33 East: 327,775 North: 6,170,598

New WTG Existing WTG Site Data