Appendix F

WindPro Shadow Flicker Results

Project:
SF_V112_94HH

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HDR
701 Xenia Av. So. Suite 600
US-MINNEAPOLI MN 55416

Anjali Malhotra / Anjali.Malhotra@hdrinc.com

Calculated:
12/1/2010 2:26 PM/2.7.473

SHADOW - Main Result

Calculation: Vestas V112 94HH

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
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) [BISMARCK]

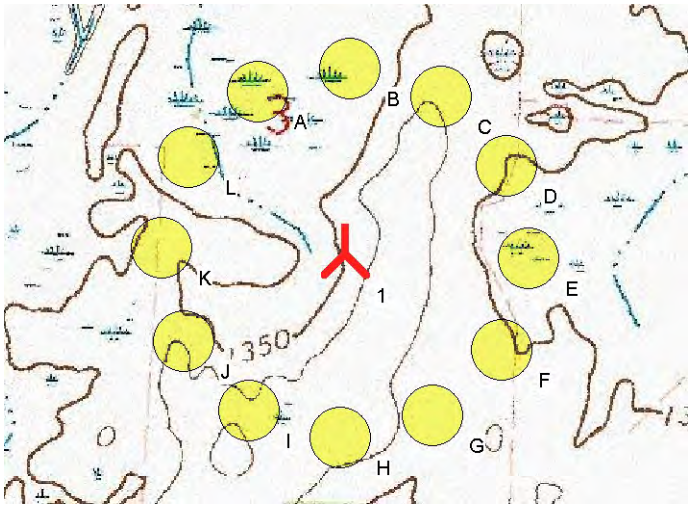
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.92	5.13	7.45	8.03	10.20	11.21	11.69	10.35	8.68	5.69	4.02	3.69

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
817	449	416	498	873	941	956	515	418	782	1,014	1,081	8,760

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: Height Contours: Contour_m.wpo (6)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:12,500
New WTG Shadow receptor

WTGs

UTM NAD83 Zone: 15

	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	RPM
	UTM NAD83 Zone: 15		[m]					[kW]	[m]	[m]	[RPM]
1	339,085.16	5,058,695.19	412.5	VESTAS V112 3000 112.0 !O! hub:...	Yes	VESTAS	V112-3,000	3,000	112.0	94.0	12.8

Shadow receptor-Input

UTM NAD83 Zone: 15

No.	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
			[m]	[m]	[m]	[m]	[°]	[°]	
A	338,939.97	5,058,963.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
B	339,093.34	5,058,999.84	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
C	339,244.51	5,058,954.82	414.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
D	339,352.98	5,058,840.37	412.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
E	339,389.82	5,058,687.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
F	339,344.80	5,058,535.83	413.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
G	339,230.35	5,058,427.36	414.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
H	339,076.98	5,058,390.52	414.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
I	338,925.81	5,058,435.54	416.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
J	338,817.34	5,058,549.99	413.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
K	338,780.50	5,058,703.36	411.8	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
L	338,825.52	5,058,854.53	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

	Shadow, worst case			Shadow, expected values
No.	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]
A	146:30	114	1:28	48:19

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Project:
SF_V112_94HH

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Calculated:
12/1/2010 2:26 PM/2.7.473

SHADOW - Main Result

Calculation: Vestas V112 94HH

...continued from previous page

No.	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]
B	86:51	76	1:24	24:51
C	143:57	112	1:29	37:26
D	115:41	111	1:22	36:48
E	137:49	135	1:22	62:28
F	15:06	31	0:37	7:59
G	0:00	0	0:00	0:00
H	0:00	0	0:00	0:00
I	0:00	0	0:00	0:00
J	17:58	34	0:41	7:31
K	136:57	134	1:22	62:00
L	115:07	109	1:22	46:24

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	VESTAS V112 3000 112.0 !O! hub: 94.0 m (1)	915:55	333:51

Project:
SF_V112_94HH

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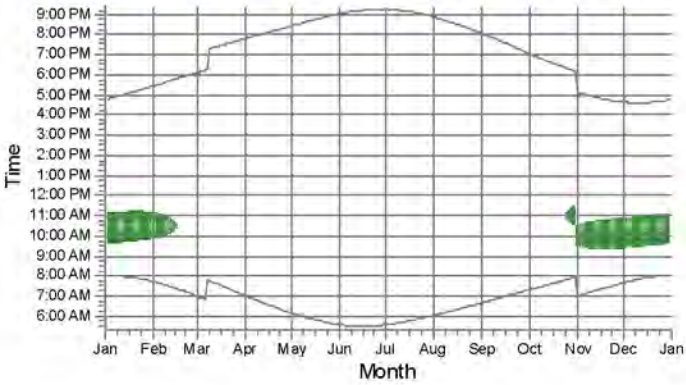
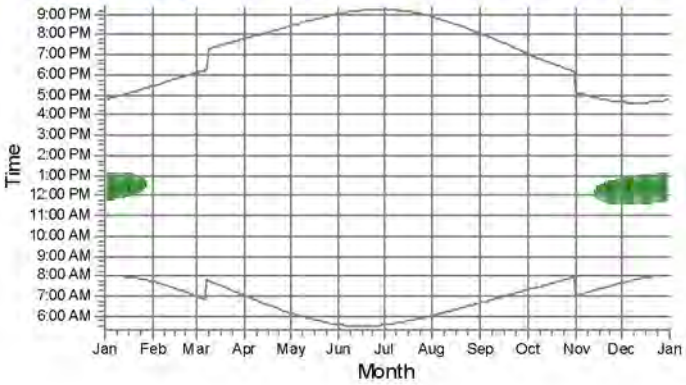
SHADOW - Calendar, graphical

Calculation: Vestas V112 94HH

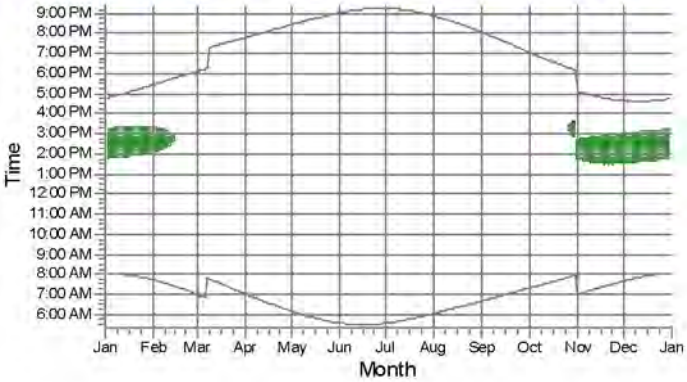
A: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (2)



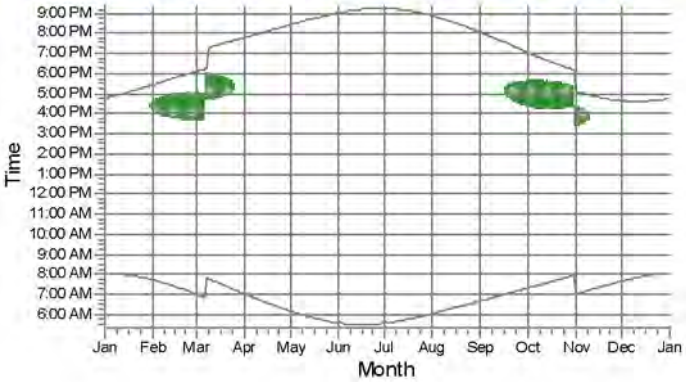
B: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (3)



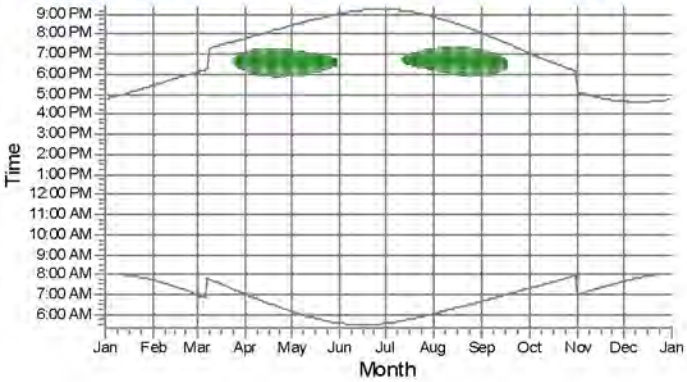
C: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (4)



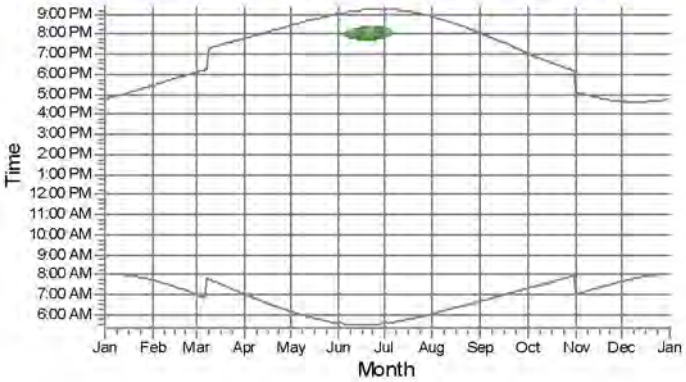
D: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (5)



E: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (6)



F: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (7)



WTGs

1: VESTAS V112 3000 112.0 !O! hub: 94.0 m (1)

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SF_V112_94HH

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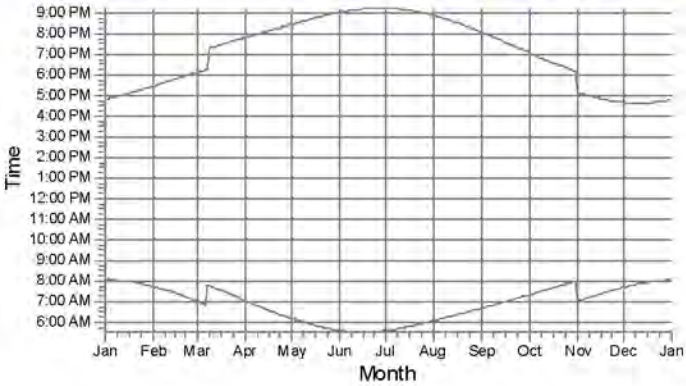
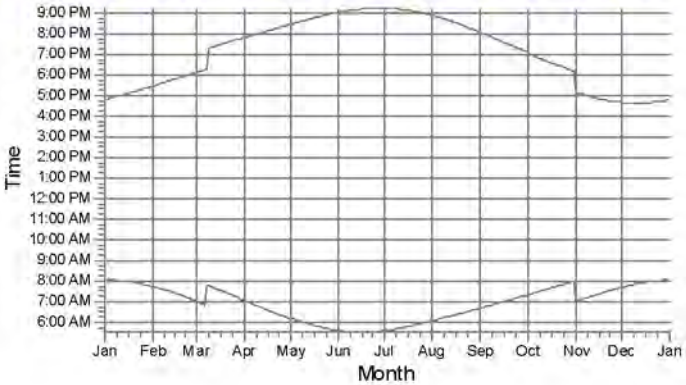
SHADOW - Calendar, graphical

Calculation: Vestas V112 94HH

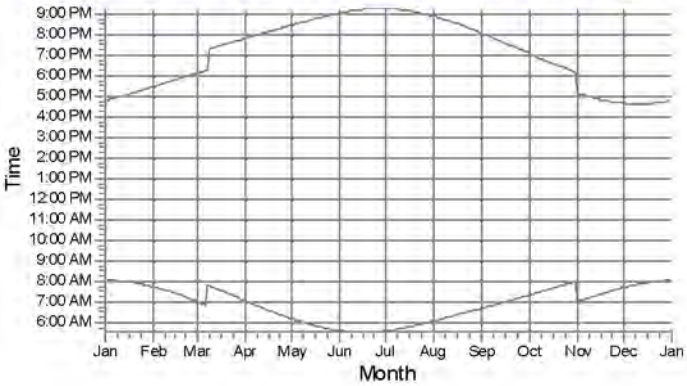
G: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (8)



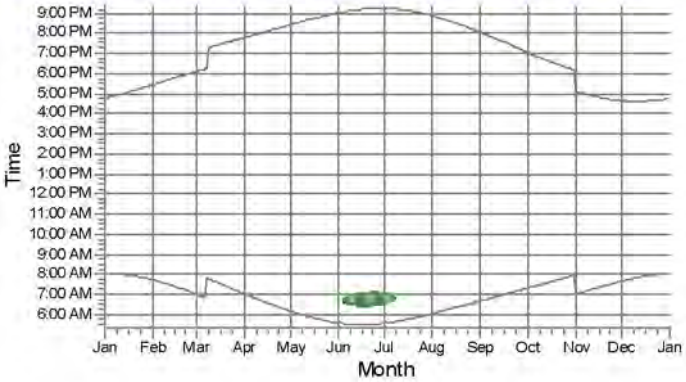
H: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (9)



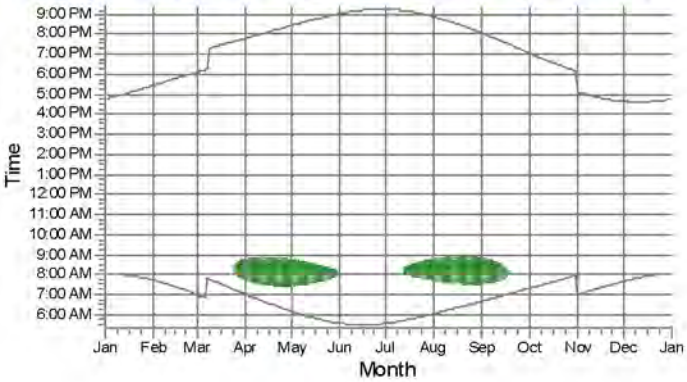
I: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (10)



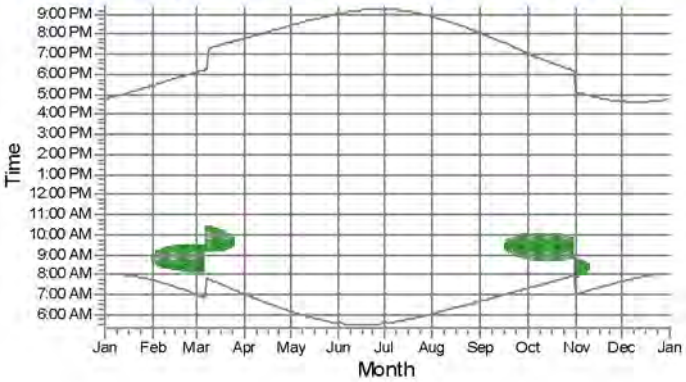
J: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (11)



K: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (12)



L: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (13)



WTGs

1: VESTAS V112 3000 112.0 !O! hub: 94.0 m (1)

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SF_V112_84HH

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Calculated:
12/1/2010 12:03 PM/2.7.473

SHADOW - Main Result

Calculation: V112, HH84, RD 112m_new

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
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) [BISMARCK]

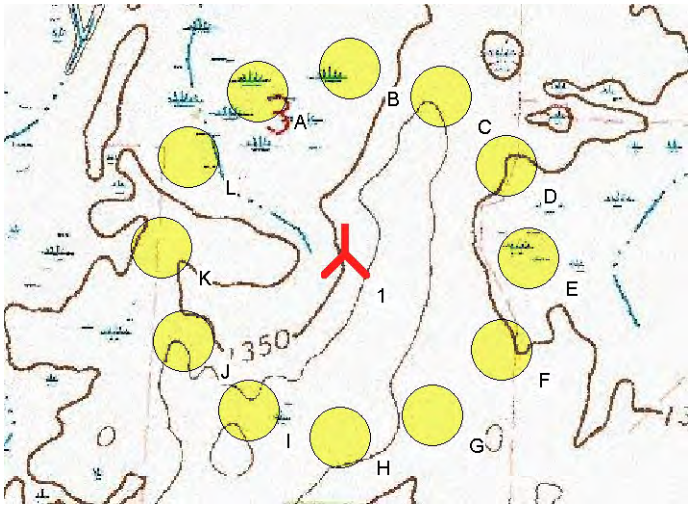
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.92	5.13	7.45	8.03	10.20	11.21	11.69	10.35	8.68	5.69	4.02	3.69

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
817	449	416	498	873	941	956	515	418	782	1,014	1,081	8,760

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: Height Contours: Contour_m.wpo (6)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:12,500
New WTG
Shadow receptor

WTGs

UTM NAD83 Zone: 15

	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	RPM
	UTM NAD83 Zone: 15		[m]					[kW]	[m]	[m]	[RPM]
1	339,085.16	5,058,695.19	412.5	VESTAS V112 3000 112.0 !O! hub:...	Yes	VESTAS	V112-3,000	3,000	112.0	84.0	12.8

Shadow receptor-Input

UTM NAD83 Zone: 15

No.	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
			[m]	[m]	[m]	[m]	[°]	[°]	
A	338,939.97	5,058,963.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
B	339,093.34	5,058,999.84	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
C	339,244.51	5,058,954.82	414.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
D	339,352.98	5,058,840.37	412.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
E	339,389.82	5,058,687.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
F	339,344.80	5,058,535.83	413.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
G	339,230.35	5,058,427.36	414.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
H	339,076.98	5,058,390.52	414.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
I	338,925.81	5,058,435.54	416.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
J	338,817.34	5,058,549.99	413.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
K	338,780.50	5,058,703.36	411.8	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
L	338,825.52	5,058,854.53	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

	Shadow, worst case			Shadow, expected values
No.	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]
A	135:10	106	1:30	44:23

To be continued on next page...

Project:
SF_V112_84HH

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Calculated:
12/1/2010 12:03 PM/2.7.473

SHADOW - Main Result

Calculation: V112, HH84, RD 112m_new

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No.	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]
B	64:50	64	1:16	18:23
C	131:47	104	1:30	34:08
D	122:28	115	1:23	37:53
E	133:44	129	1:23	60:05
F	38:12	51	0:57	20:21
G	0:00	0	0:00	0:00
H	0:00	0	0:00	0:00
I	0:00	0	0:00	0:00
J	41:04	53	0:59	17:17
K	133:12	128	1:23	59:47
L	121:54	115	1:23	47:47

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	VESTAS V112 3000 112.0 !O! hub: 94.0 m (1)	922:21	340:09

Project:
SF_V112_84HH

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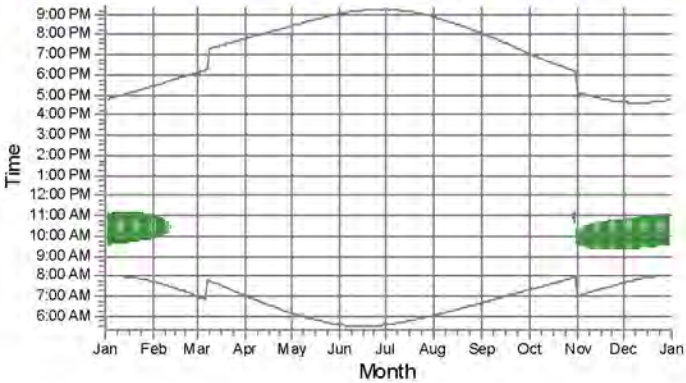
Calculated:
12/1/2010 12:03 PM/2.7.473

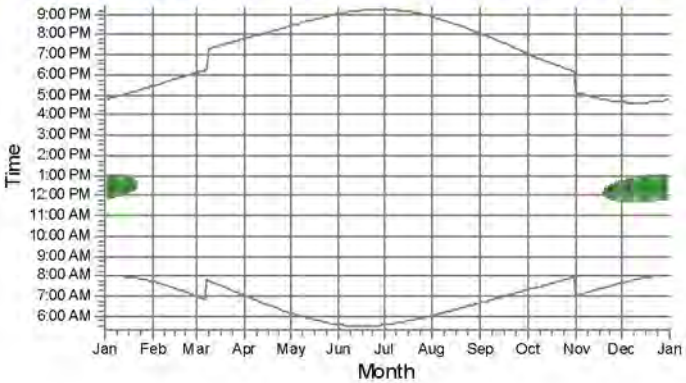
SHADOW - Calendar, graphical

Calculation: V112, HH84, RD 112m_new

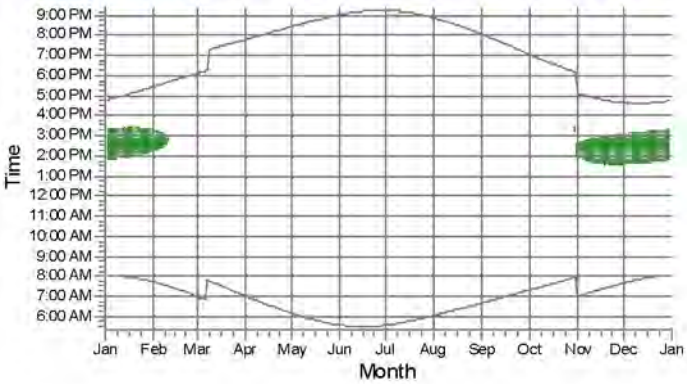
A: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (2)



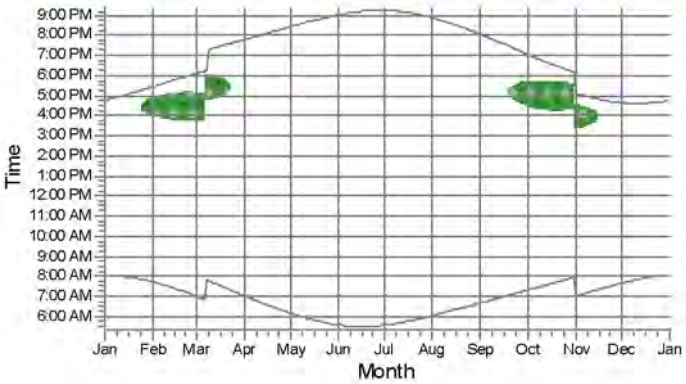
B: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (3)



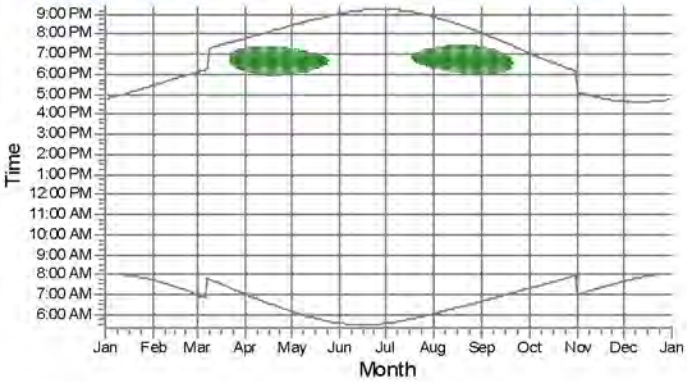
C: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (4)



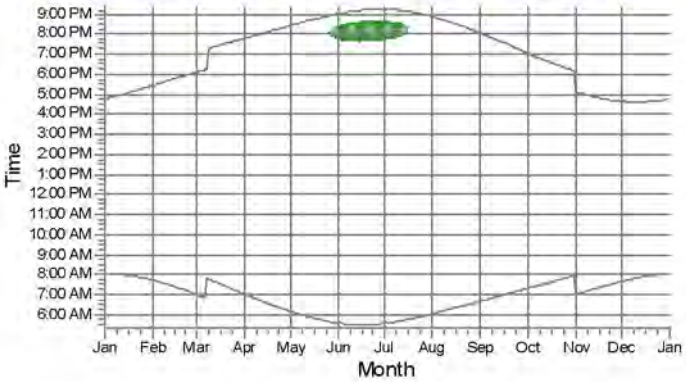
D: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (5)



E: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (6)



F: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (7)



WTGs

1: VESTAS V112 3000 112.0 !O! hub: 94.0 m (1)

Project:
SF_V112_84HH

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Calculated:
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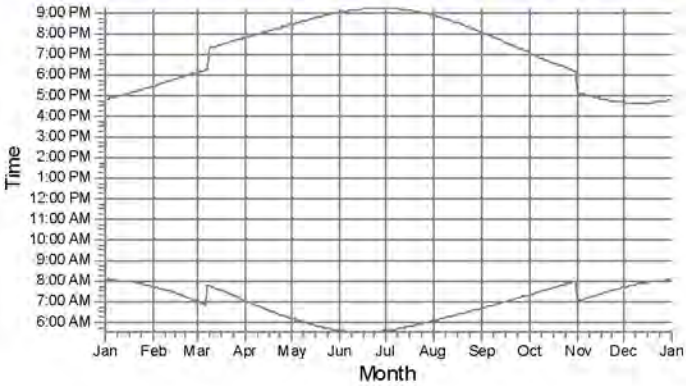
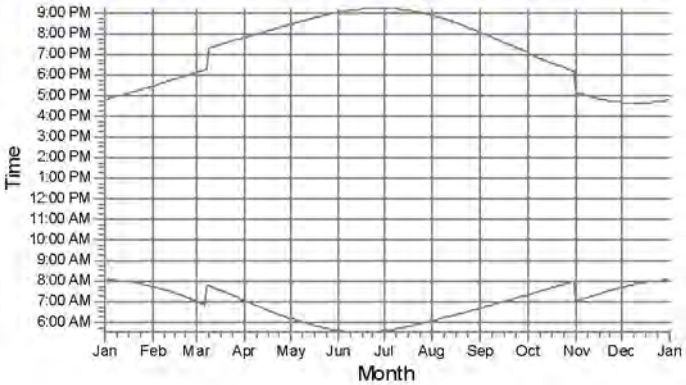
SHADOW - Calendar, graphical

Calculation: V112, HH84, RD 112m_new

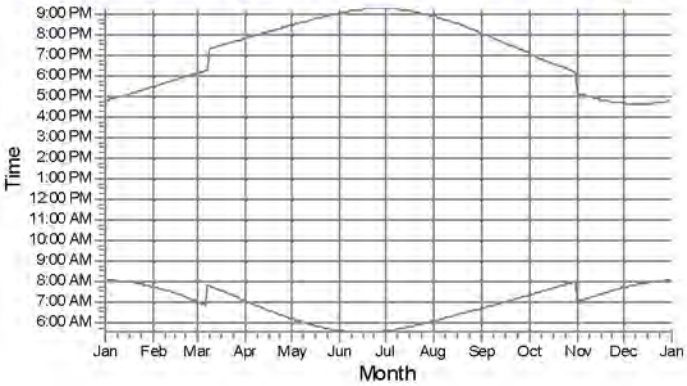
G: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (8)



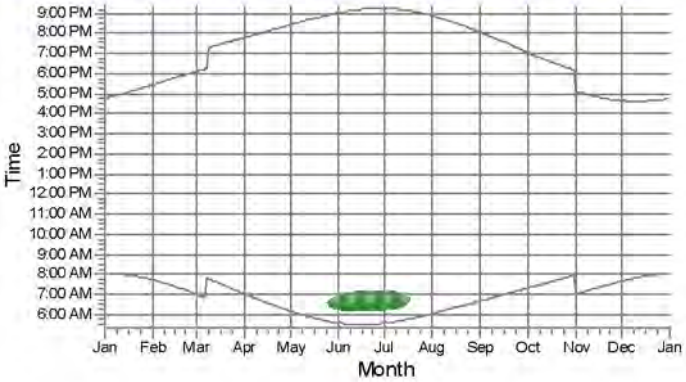
H: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (9)



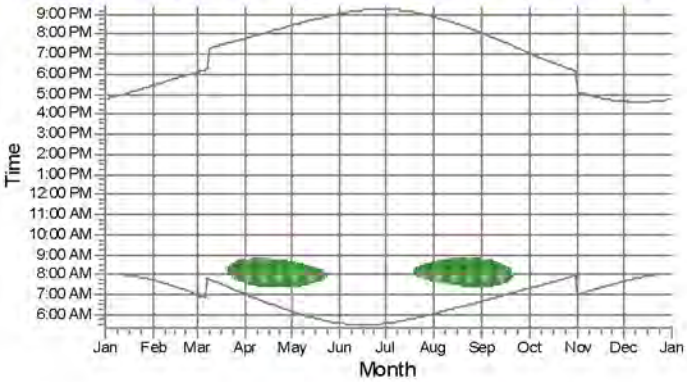
I: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (10)



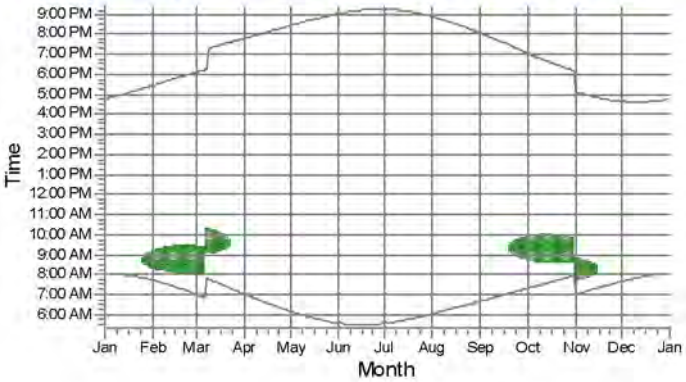
J: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (11)



K: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (12)



L: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (13)



WTGs

1: VESTAS V112 3000 112.0 !O! hub: 94.0 m (1)

Project:
SF_V90_95HH

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Calculated:
12/1/2010 12:24 PM/2.7.473

SHADOW - Main Result

Calculation: Vestas V90, 95 HH, RD 90

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
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) [BISMARCK]

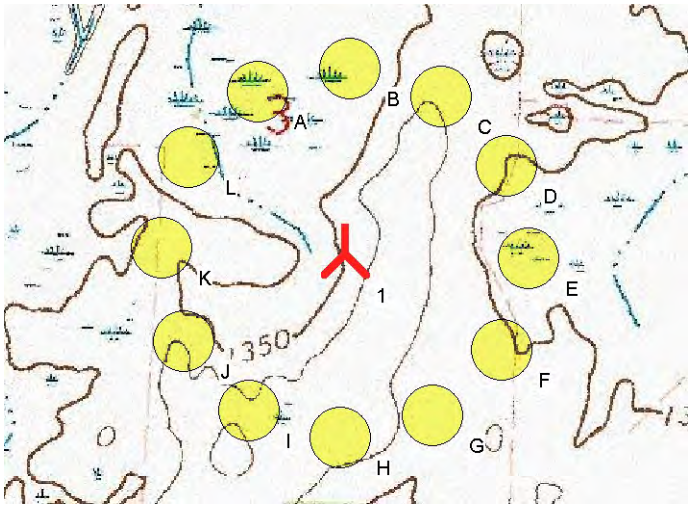
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.92	5.13	7.45	8.03	10.20	11.21	11.69	10.35	8.68	5.69	4.02	3.69

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
817	449	416	498	873	941	956	515	418	782	1,014	1,081	8,760

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: Height Contours: Contour_m.wpo (6)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:12,500
New WTG
Shadow receptor

WTGs

	UTM NAD83 Zone: 15 East	North	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	RPM
	UTM NAD83 Zone: 15		[m]					[kW]	[m]	[m]	[RPM]
1	339,085.16	5,058,695.19	412.5	VESTAS V90 1800 90.0 !O! hub: 9...	Yes	VESTAS	V90-1,800	1,800	90.0	95.0	14.9

Shadow receptor-Input

UTM NAD83 Zone: 15

No.	East	North	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
A	338,939.97	5,058,963.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
B	339,093.34	5,058,999.84	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
C	339,244.51	5,058,954.82	414.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
D	339,352.98	5,058,840.37	412.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
E	339,389.82	5,058,687.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
F	339,344.80	5,058,535.83	413.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
G	339,230.35	5,058,427.36	414.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
H	339,076.98	5,058,390.52	414.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
I	338,925.81	5,058,435.54	416.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
J	338,817.34	5,058,549.99	413.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
K	338,780.50	5,058,703.36	411.8	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
L	338,825.52	5,058,854.53	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	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	108:17	104	1:11	35:34

To be continued on next page...

Project:
SF_V90_95HH

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Calculated:
12/1/2010 12:24 PM/2.7.473

SHADOW - Main Result

Calculation: Vestas V90, 95 HH, RD 90

...continued from previous page

No.	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]
B	55:29	64	1:05	15:45
C	106:12	102	1:11	27:32
D	73:35	87	1:06	23:33
E	86:34	104	1:06	39:01
F	0:00	0	0:00	0:00
G	0:00	0	0:00	0:00
H	0:00	0	0:00	0:00
I	0:00	0	0:00	0:00
J	0:00	0	0:00	0:00
K	86:05	103	1:06	38:45
L	73:19	87	1:06	29:44

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	VESTAS V90 1800 90.0 !O! hub: 95.0 m (1)	589:31	209:56

Project:
SF_V90_95HH

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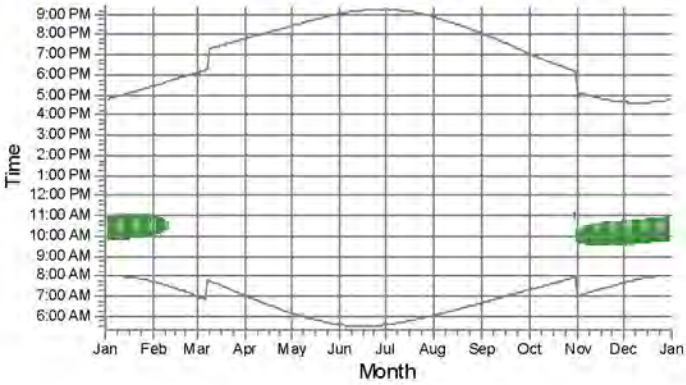
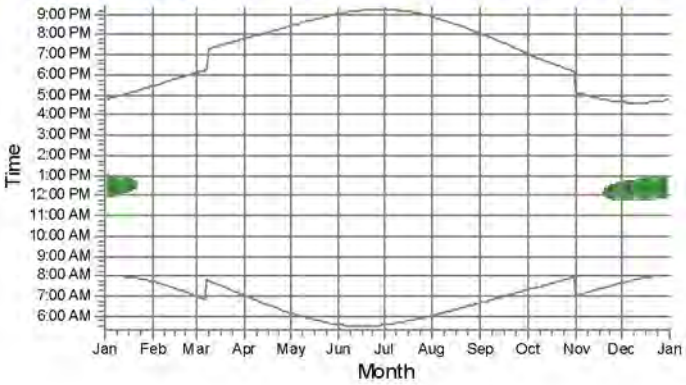
SHADOW - Calendar, graphical

Calculation: Vestas V90, 95 HH, RD 90

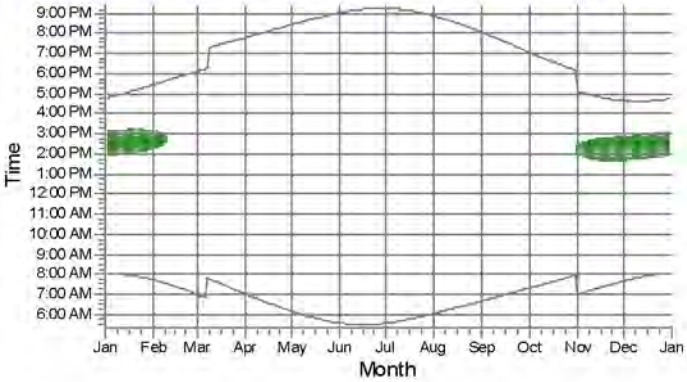
A: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (2)



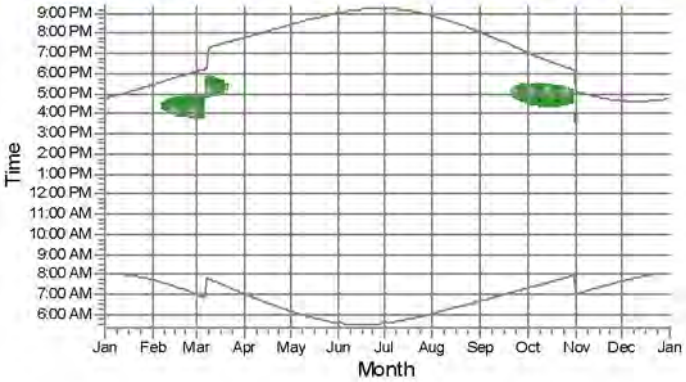
B: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (3)



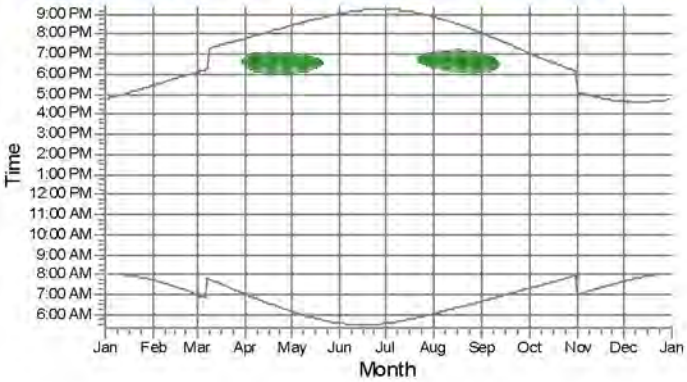
C: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (4)



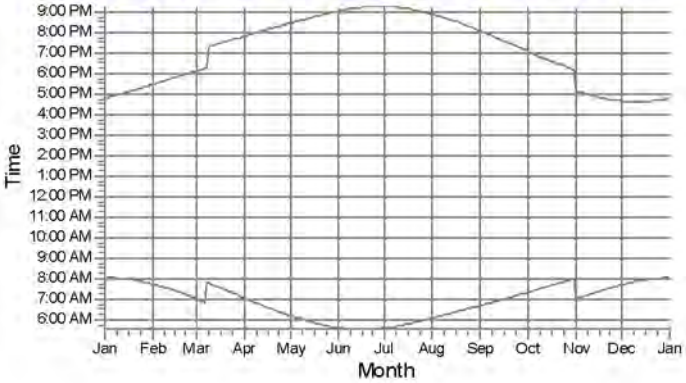
D: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (5)



E: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (6)



F: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (7)



WTGs

1: VESTAS V90 1800 90.0 !O! hub: 95.0 m (1)

Project:
SF_V90_95HH

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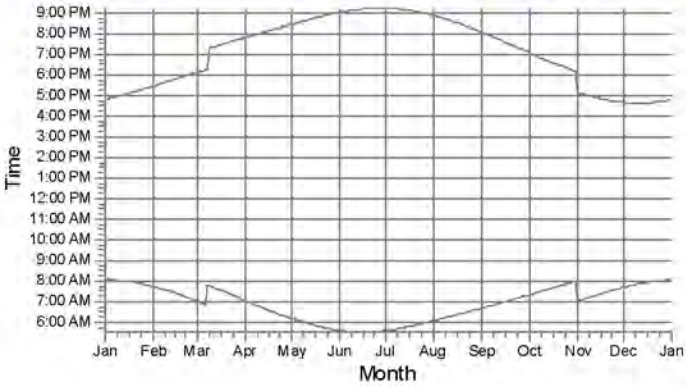
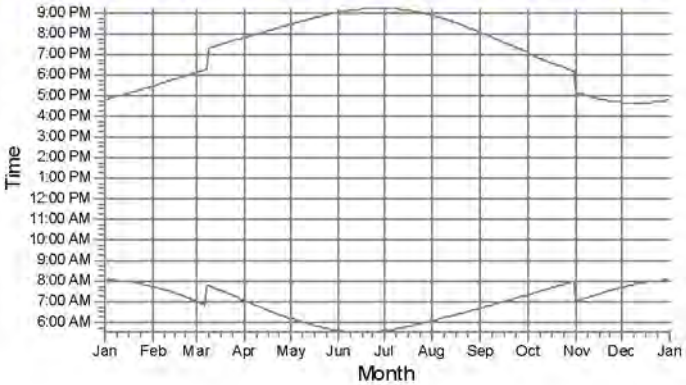
SHADOW - Calendar, graphical

Calculation: Vestas V90, 95 HH, RD 90

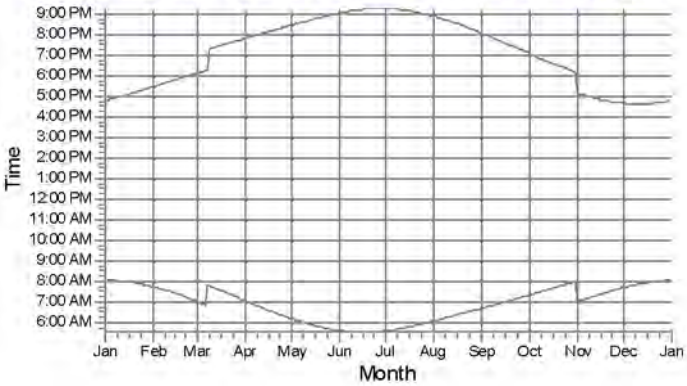
G: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (8)



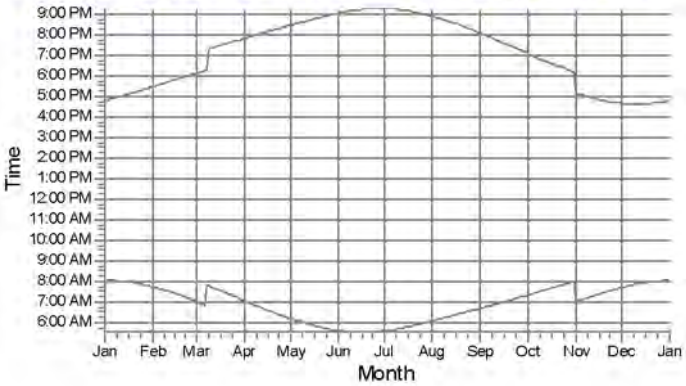
H: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (9)



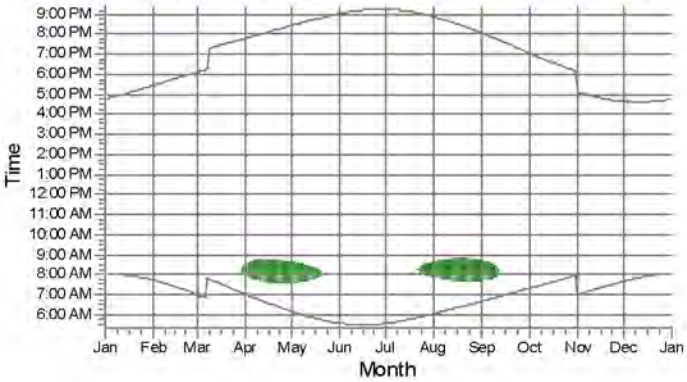
I: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (10)



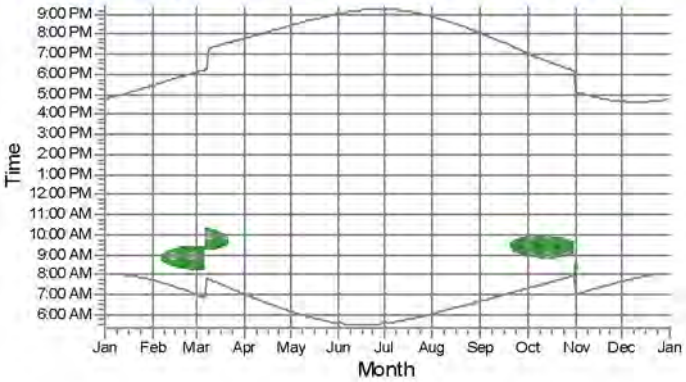
J: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (11)



K: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (12)



L: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (13)



WTGs

1: VESTAS V90 1800 90.0 !O! hub: 95.0 m (1)

Project:
SF_V90_80HH

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Calculated:
12/1/2010 1:59 PM/2.7.473

SHADOW - Main Result

Calculation: Vestas V90, 80 HH, RD 90

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
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) [BISMARCK]

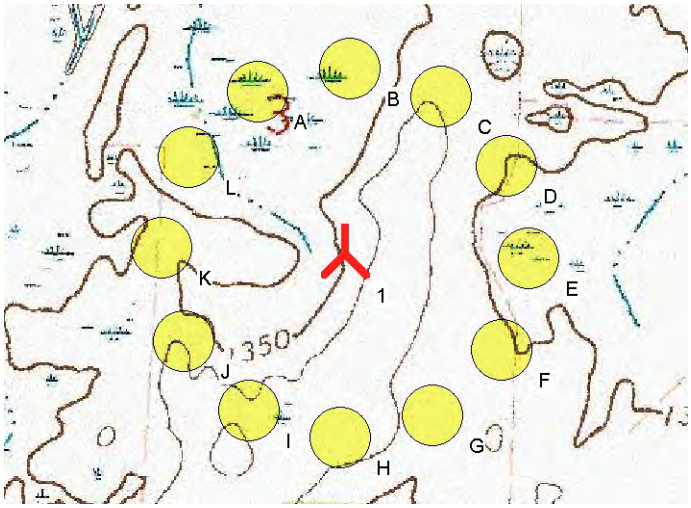
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.92	5.13	7.45	8.03	10.20	11.21	11.69	10.35	8.68	5.69	4.02	3.69

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
817	449	416	498	873	941	956	515	418	782	1,014	1,081	8,760

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: Height Contours: Contour_m.wpo (6)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:12,500
New WTG
Shadow receptor

WTGs

	UTM NAD83 Zone: 15 East	North	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	RPM
	UTM NAD83 Zone: 15		[m]					[kW]	[m]	[m]	[RPM]
1	339,085.16	5,058,695.19	412.5	VESTAS V90 1800 90.0 !O! hub: 8...	Yes	VESTAS	V90-1,800	1,800	90.0	80.0	14.9

Shadow receptor-Input

UTM NAD83 Zone: 15

No.	East	North	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
A	338,939.97	5,058,963.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
B	339,093.34	5,058,999.84	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
C	339,244.51	5,058,954.82	414.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
D	339,352.98	5,058,840.37	412.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
E	339,389.82	5,058,687.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
F	339,344.80	5,058,535.83	413.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
G	339,230.35	5,058,427.36	414.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
H	339,076.98	5,058,390.52	414.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
I	338,925.81	5,058,435.54	416.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
J	338,817.34	5,058,549.99	413.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
K	338,780.50	5,058,703.36	411.8	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
L	338,825.52	5,058,854.53	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	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	92:25	90	1:13	30:18

To be continued on next page...

Project:
SF_V90_80HH

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SHADOW - Main Result

Calculation: Vestas V90, 80 HH, RD 90

...continued from previous page

No.	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]
B	22:42	38	0:45	6:14
C	89:14	88	1:13	23:05
D	79:43	93	1:07	24:17
E	84:06	99	1:07	37:22
F	10:44	28	0:29	5:40
G	0:00	0	0:00	0:00
H	0:00	0	0:00	0:00
I	0:00	0	0:00	0:00
J	13:21	31	0:32	5:35
K	83:47	98	1:07	37:11
L	79:14	92	1:07	30:36

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	VESTAS V90 1800 90.0 !O! hub: 80.0 m (1)	555:16	200:21

Project:
SF_V90_80HH

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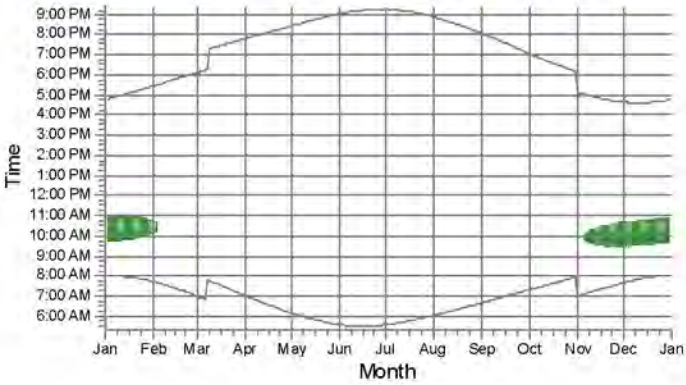
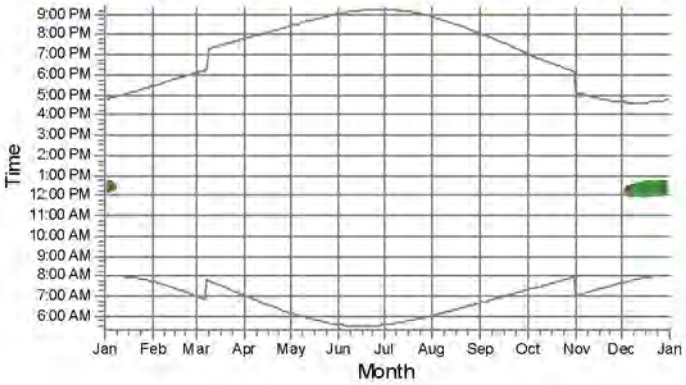
SHADOW - Calendar, graphical

Calculation: Vestas V90, 80 HH, RD 90

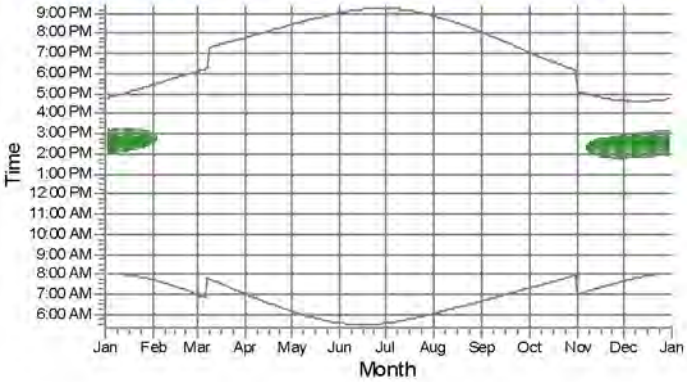
A: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (2)



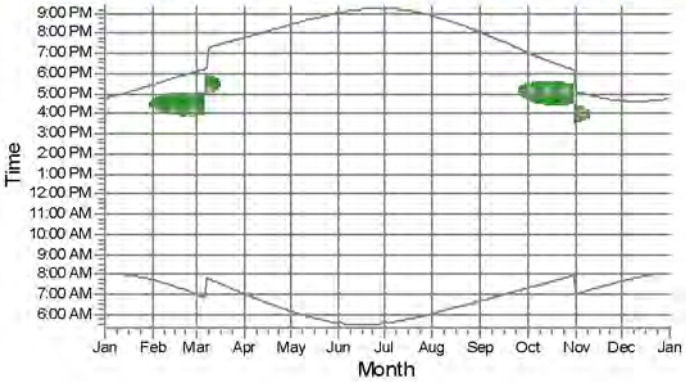
B: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (3)



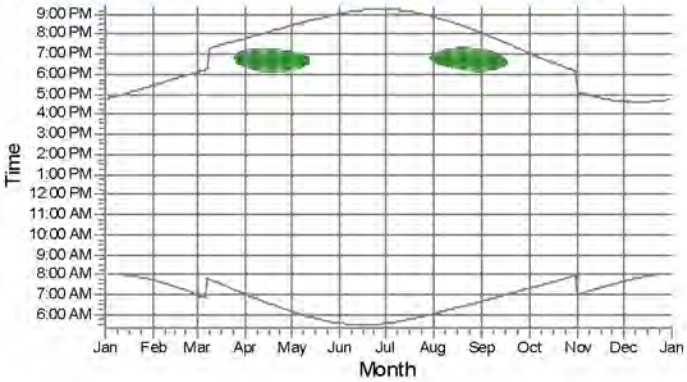
C: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (4)



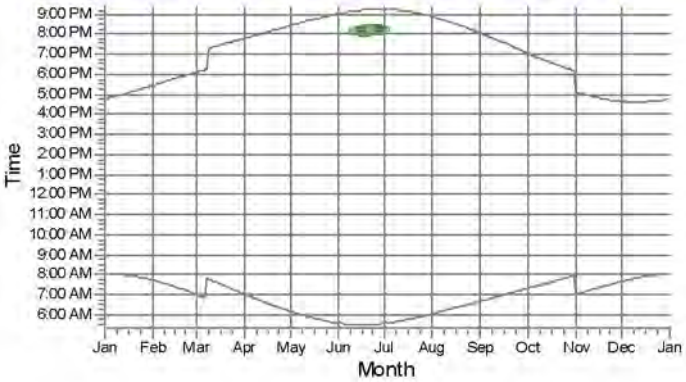
D: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (5)



E: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (6)



F: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (7)



WTGs

1: VESTAS V90 1800 90.0 !O! hub: 80.0 m (1)

Project:
SF_V90_80HH

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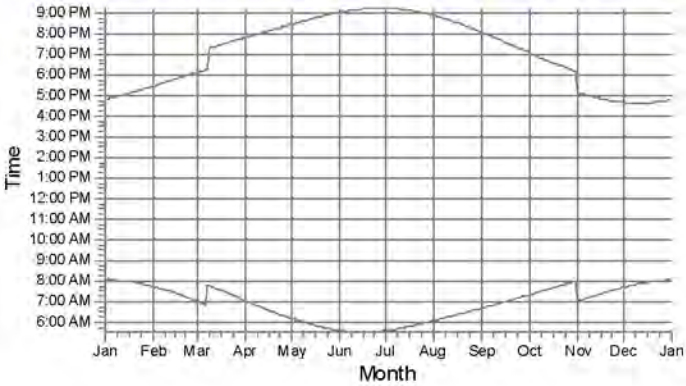
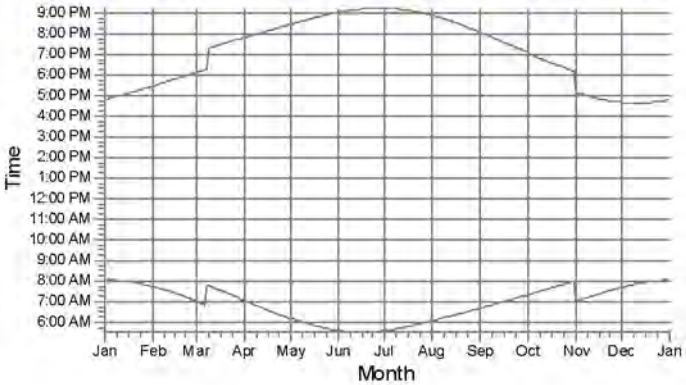
SHADOW - Calendar, graphical

Calculation: Vestas V90, 80 HH, RD 90

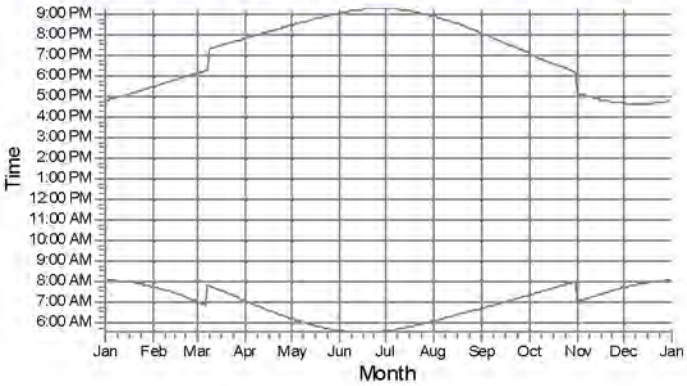
G: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (8)



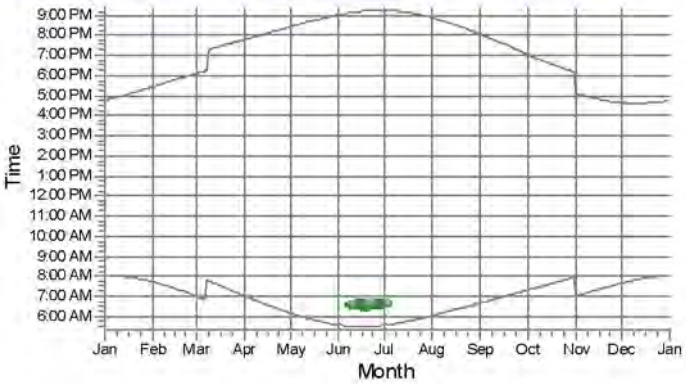
H: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (9)



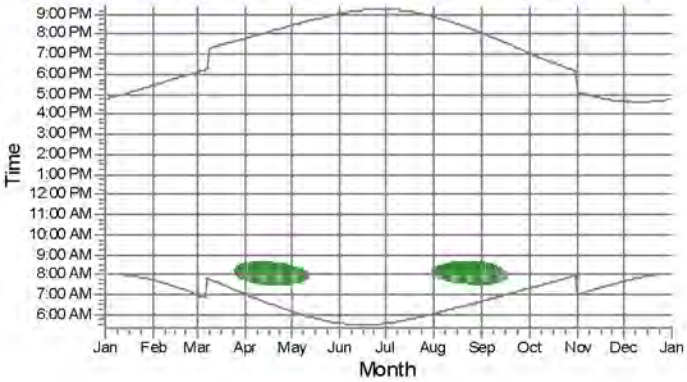
I: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (10)



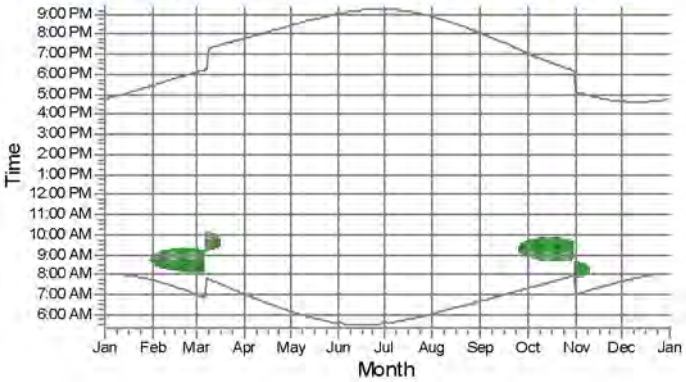
J: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (11)



K: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (12)



L: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (13)



WTGs

1: VESTAS V90 1800 90.0 !O! hub: 80.0 m (1)

Project:
SF_GE16_80HH

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12/1/2010 2:16 PM / 1

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Calculated:
12/1/2010 2:16 PM/2.7.473

SHADOW - Main Result

Calculation: GE1.6xle_HH80m

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
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) [BISMARCK]

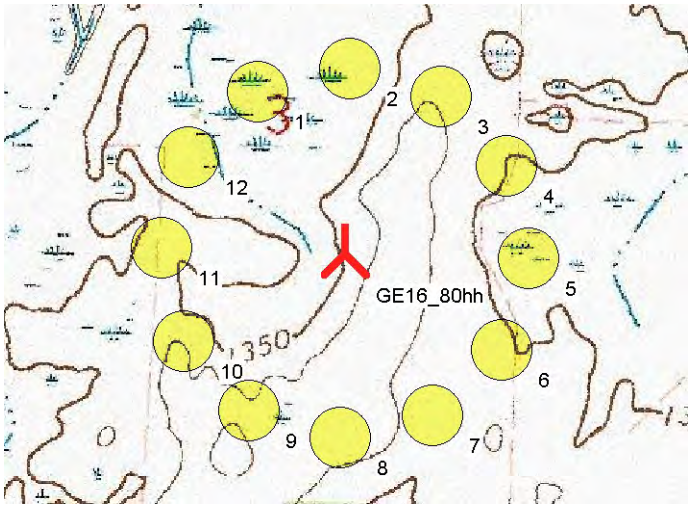
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.92	5.13	7.45	8.03	10.20	11.21	11.69	10.35	8.68	5.69	4.02	3.69

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
817	449	416	498	873	941	956	515	418	782	1,014	1,081	8,760

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: Height Contours: Contour_m.wpo (6)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:12,500
New WTG
Shadow receptor

WTGs

	UTM NAD83 Zone: 15 East	North	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	RPM
	UTM NAD83 Zone: 15		[m]					[kW]	[m]	[m]	[RPM]
GE16_80hh	339,085.16	5,058,695.19	412.5	GE WIND ENERGY G...	Yes	GE WIND ENERGY	GE 1.5 xle-1,500	1,500	82.5	80.0	18.0

Shadow receptor-Input

No.	UTM NAD83 Zone: 15 East	North	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
1	338,939.97	5,058,963.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
2	339,093.34	5,058,999.84	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
3	339,244.51	5,058,954.82	414.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
4	339,352.98	5,058,840.37	412.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
5	339,389.82	5,058,687.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
6	339,344.80	5,058,535.83	413.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
7	339,230.35	5,058,427.36	414.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
8	339,076.98	5,058,390.52	414.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
9	338,925.81	5,058,435.54	416.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
10	338,817.34	5,058,549.99	413.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
11	338,780.50	5,058,703.36	411.8	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
12	338,825.52	5,058,854.53	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	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]
1	80:51	86	1:07	26:30
2	12:29	28	0:33	3:20

To be continued on next page...

Project:
SF_GE16_80HH

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Calculated:
12/1/2010 2:16 PM/2.7.473

SHADOW - Main Result

Calculation: GE1.6xle_HH80m

...continued from previous page

No.	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]
3	77:28	84	1:07	20:01
4	66:36	83	1:02	20:16
5	70:20	90	1:02	31:10
6	0:00	0	0:00	0:00
7	0:00	0	0:00	0:00
8	0:00	0	0:00	0:00
9	0:00	0	0:00	0:00
10	2:10	13	0:13	0:53
11	70:05	88	1:01	31:01
12	66:24	84	1:02	25:36

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

No.	Name	Worst case [h/year]	Expected [h/year]
GE16_80hh	GE WIND ENERGY GE 1.5 xle 1500 82.5 !O! hub: 80.0 m (1)	446:23	158:51

Project:
SF_GE16_80HH

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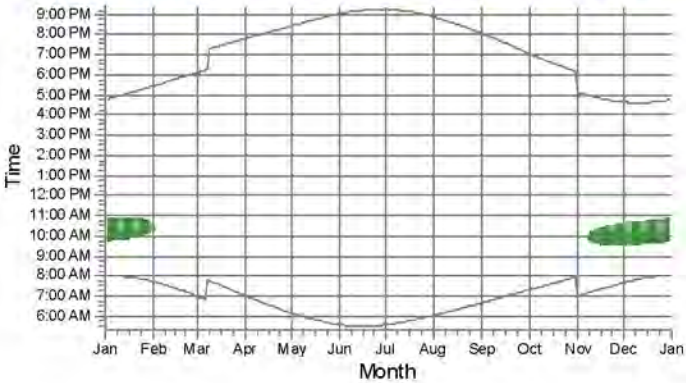
12/1/2010 2:16 PM/2.7.473

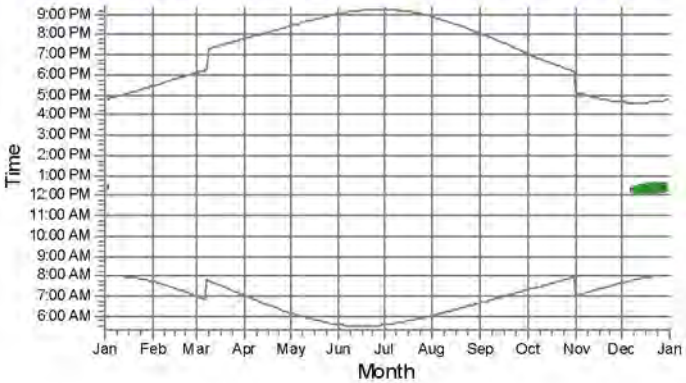
SHADOW - Calendar, graphical

Calculation: GE1.6xle_HH80m

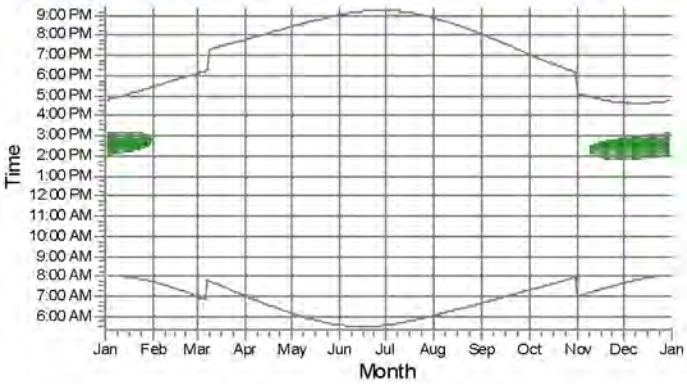
1: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (2)



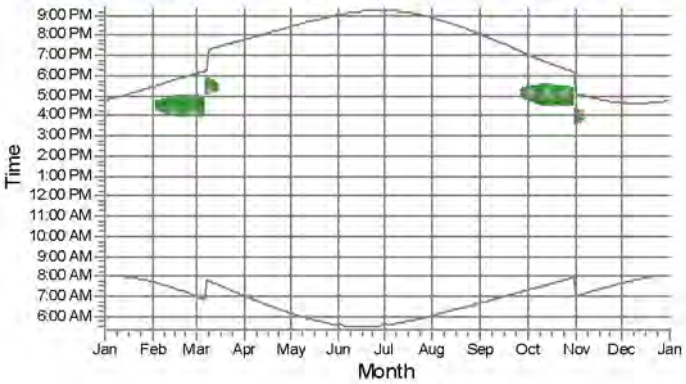
2: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (3)



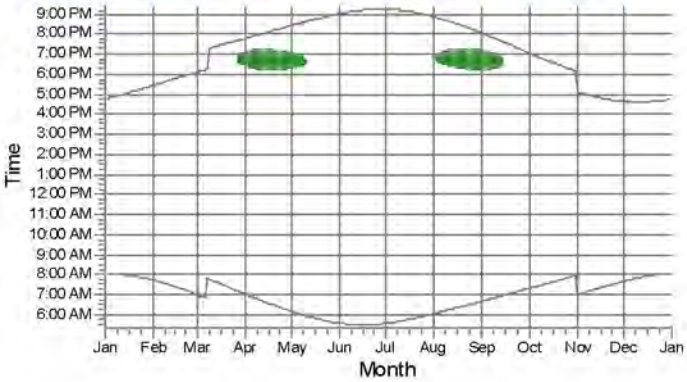
3: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (4)



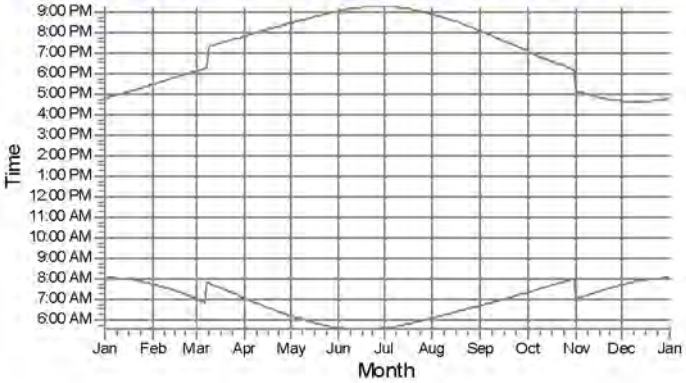
4: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (5)



5: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (6)



6: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (7)



WTGs

GE16_80hh: GE WIND ENERGY GE 1.5 xle 1500 82.5 !O! hub: 80.0 m (1)

Project:
SF_GE16_80HH

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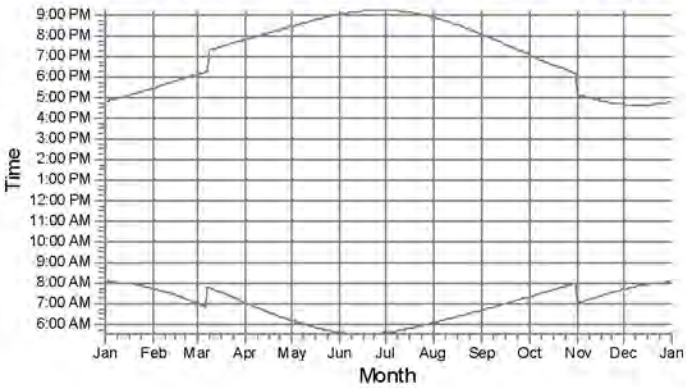
Calculated:
12/1/2010 2:16 PM/2.7.473

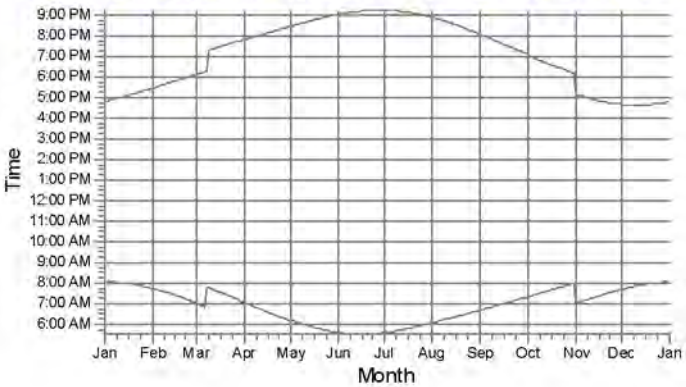
SHADOW - Calendar, graphical

Calculation: GE1.6xle_HH80m

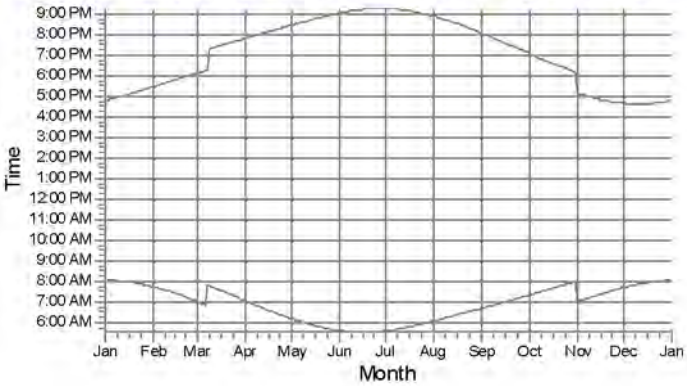
7: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (8)



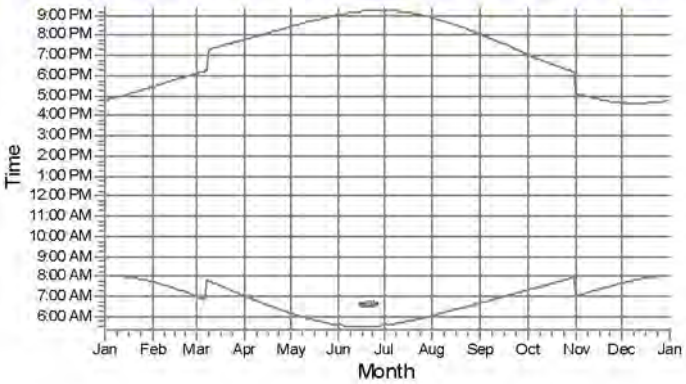
8: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (9)



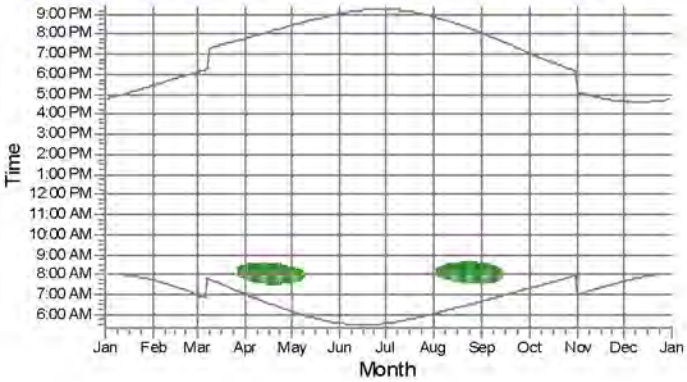
9: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (10)



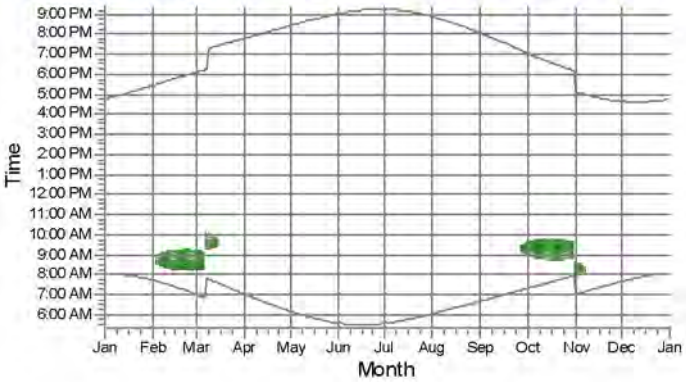
10: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (11)



11: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (12)



12: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (13)



WTGs

GE16_80hh: GE WIND ENERGY GE 1.5 xle 1500 82.5 !O! hub: 80.0 m (1)

Project:
SF_GE16_100HH

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Calculated:
12/1/2010 12:38 PM/2.7.473

SHADOW - Main Result

Calculation: GE1.6xle_HH100m

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
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) [BISMARCK]

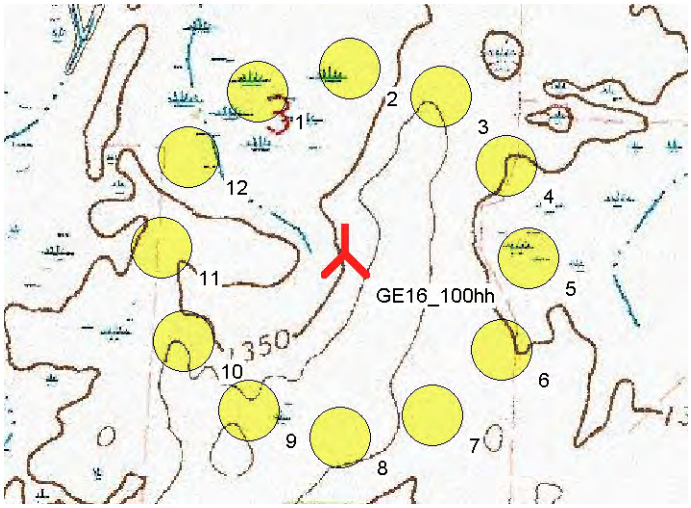
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.92	5.13	7.45	8.03	10.20	11.21	11.69	10.35	8.68	5.69	4.02	3.69

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
817	449	416	498	873	941	956	515	418	782	1,014	1,081	8,760

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: Height Contours: Contour_m.wpo (6)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:12,500
New WTG
Shadow receptor

WTGs

	UTM NAD83 Zone: 15 East	North	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	RPM
	UTM NAD83 Zone: 15		[m]					[kW]	[m]	[m]	[RPM]
GE16_100hh	339,085.16	5,058,695.19	412.5	GE WIND ENERGY G...	Yes	GE WIND ENERGY	GE 1.5 xle-1,500	1,500	82.5	100.0	18.0

Shadow receptor-Input

UTM NAD83 Zone: 15

No.	East	North	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
1	338,939.97	5,058,963.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
2	339,093.34	5,058,999.84	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
3	339,244.51	5,058,954.82	414.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
4	339,352.98	5,058,840.37	412.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
5	339,389.82	5,058,687.00	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
6	339,344.80	5,058,535.83	413.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
7	339,230.35	5,058,427.36	414.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
8	339,076.98	5,058,390.52	414.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
9	338,925.81	5,058,435.54	416.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
10	338,817.34	5,058,549.99	413.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
11	338,780.50	5,058,703.36	411.8	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
12	338,825.52	5,058,854.53	411.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	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]
1	98:42	105	1:04	32:27
2	54:19	64	1:01	15:26

To be continued on next page...

Project:
SF_GE16_100HH

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Calculated:
12/1/2010 12:38 PM/2.7.473

SHADOW - Main Result

Calculation: GE1.6xle_HH100m

...continued from previous page

No.	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]
3	97:36	102	1:05	25:19
4	60:16	79	1:00	19:34
5	72:57	95	1:00	33:00
6	0:00	0	0:00	0:00
7	0:00	0	0:00	0:00
8	0:00	0	0:00	0:00
9	0:00	0	0:00	0:00
10	0:00	0	0:00	0:00
11	72:33	95	1:00	32:47
12	59:56	79	1:00	24:40

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

No.	Name	Worst case [h/year]	Expected [h/year]
GE16_100hh	GE WIND ENERGY GE 1.5 xle 1500 82.5 !O! hub: 100.0 m (1)	516:18	183:16

Project:
SF_GE16_100HH

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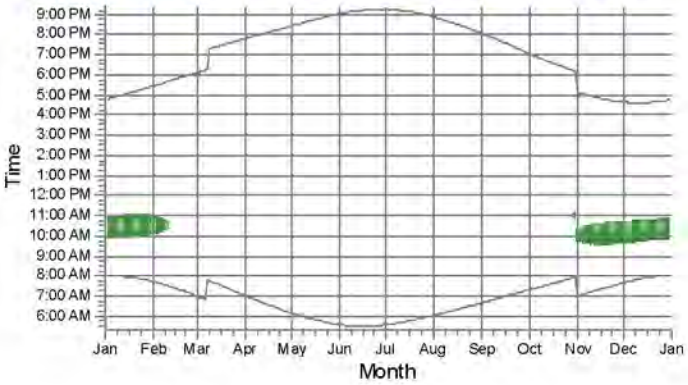
Calculated:
12/1/2010 12:38 PM/2.7.473

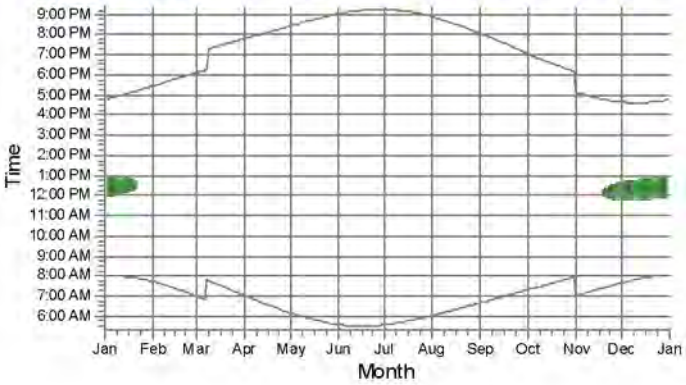
SHADOW - Calendar, graphical

Calculation: GE1.6xle_HH100m

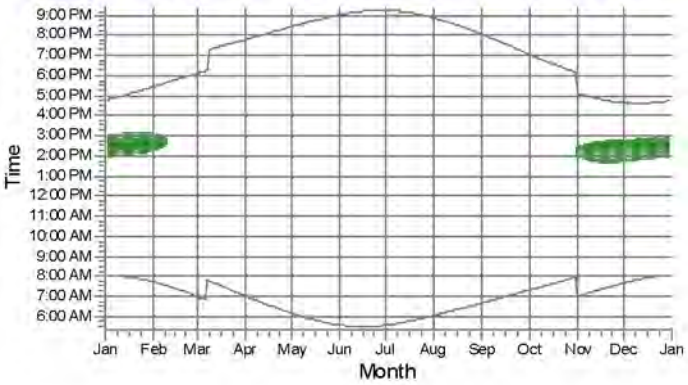
1: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (2)



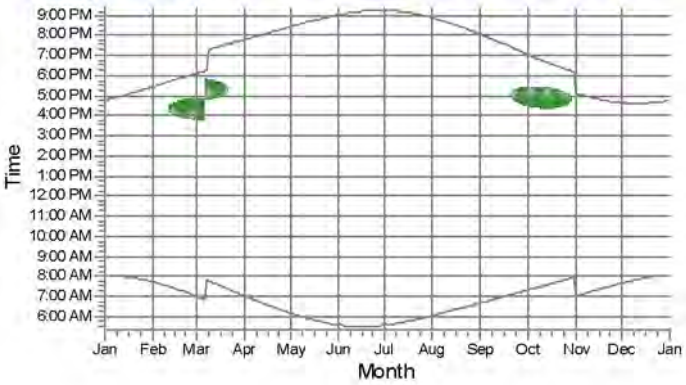
2: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (3)



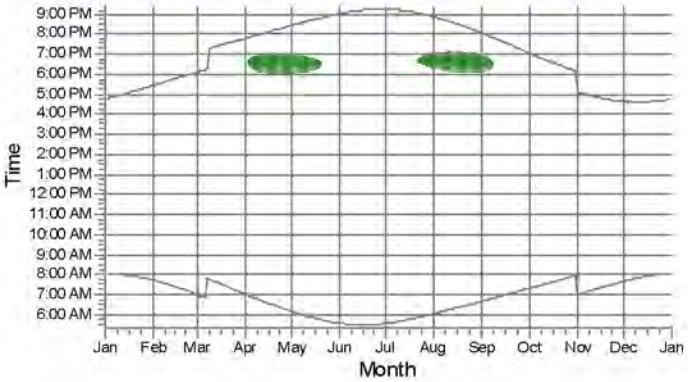
3: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (4)



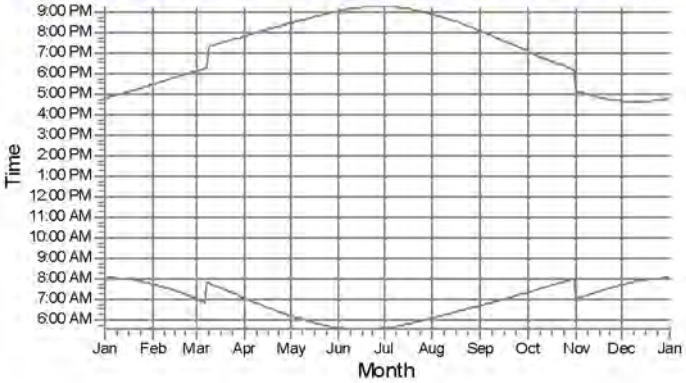
4: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (5)



5: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (6)



6: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (7)



WTGs

GE16_100hh: GE WIND ENERGY GE 1.5 xle 1500 82.5 !O! hub: 100.0 m (1)

Project:
SF_GE16_100HH

Printed/Page
12/1/2010 12:41 PM / 2

Licensed user:
HDR
701 Xenia Av. So. Suite 600
US-MINNEAPOLI MN 55416

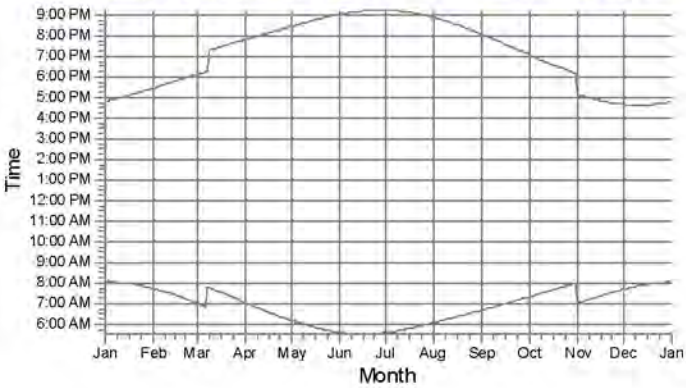
Anjali Malhotra / Anjali.Malhotra@hdrinc.com

Calculated:
12/1/2010 12:38 PM/2.7.473

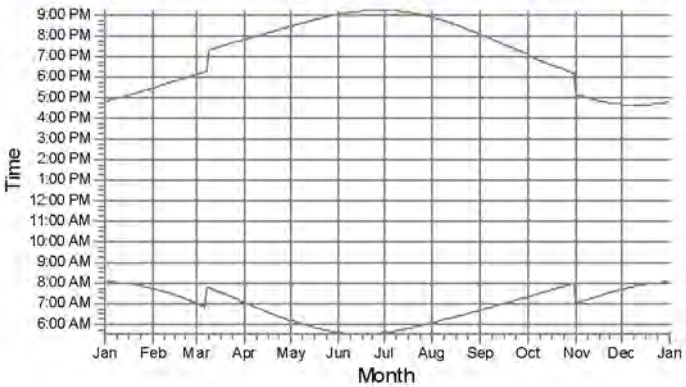
SHADOW - Calendar, graphical

Calculation: GE1.6xle_HH100m

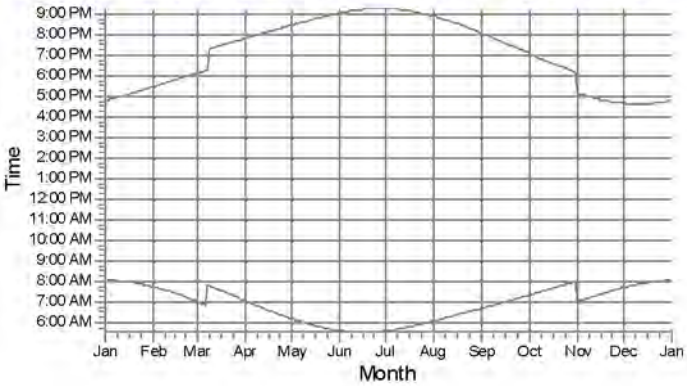
7: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (8)



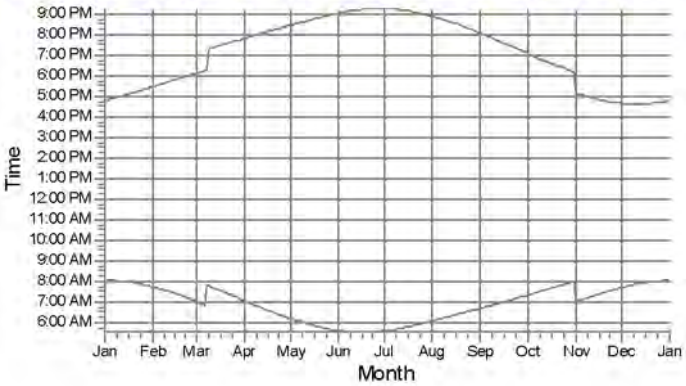
8: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (9)



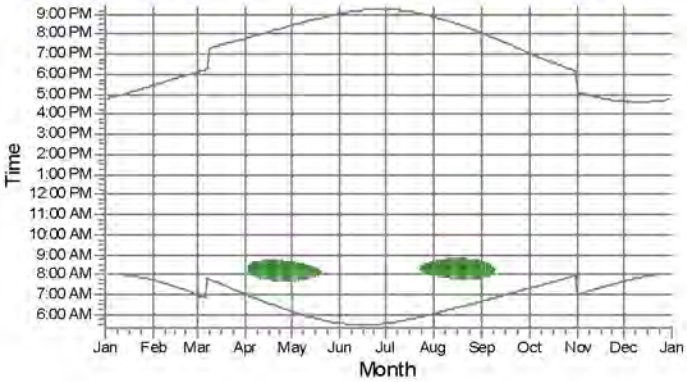
9: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (10)



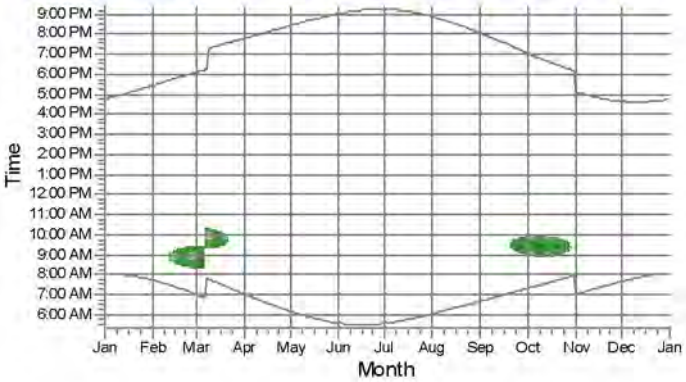
10: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (11)



11: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (12)



12: Shadow Receptor: 1.0 × 1.0 Azimuth: -180.0° Slope: 90.0° (13)



WTGs

GE16_100hh: GE WIND ENERGY GE 1.5 xle 1500 82.5 !O! hub: 100.0 m (1)