

Case No. PU-11-57
Minnesota Power
Late-filed Exhibit 9
Shadow Flicker Study Results

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Main Result

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)

Assumptions for shadow calculations

Maximum distance for influence 1,500 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

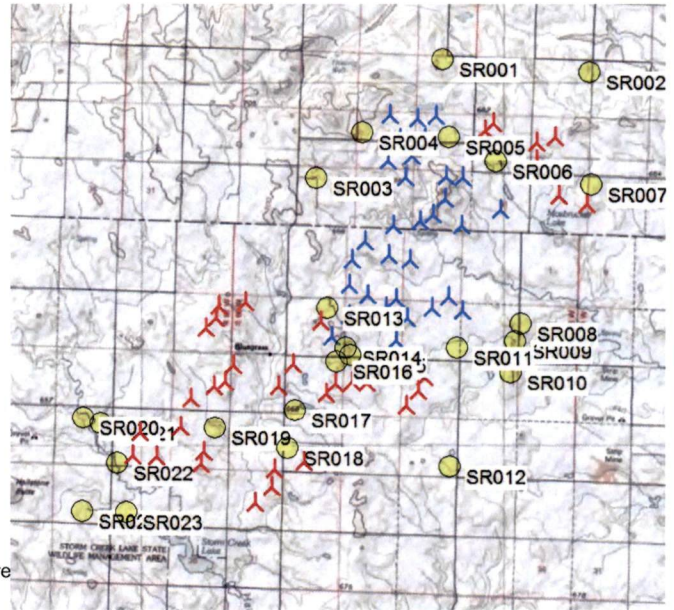
Operational hours are calculated from WTGs in calculation and wind distribution:
 SDO for PARK 8643

Operational time
 N NNE NE ENE E ESE SE SSE S SSW SW WSW
 458 248 266 220 302 504 760 767 521 378 415 371

W WNW NW NNW Sum
 576 904 1,027 793 8,509

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: 20110421_BISON_nested_HCLs_v2_re
 Obstacles not used in calculation
 Eye height: 1.5 m
 Grid resolution: 10 m



Scale 1:200,000
 ▲ New WTG ● Shadow receptor

WTGs

UTM WGS84 Zone: 14

Row	UTM WGS84 Zone: 14			Row data/Description	WTG type		Power, rated [kW]	Rotor diameter [m]	Hub height [m]	RPM [RPM]	
	East	North	Z		Valid	Manufact.					Type-generator
1	308,045	5,206,621	710.2	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
2	308,398	5,207,681	712.8	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
3	305,708	5,204,697	697.2	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
4	306,742	5,204,066	684.1	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
5	306,144	5,205,889	687.5	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
6	307,814	5,208,723	699.8	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
7	306,789	5,208,091	697.9	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
8	305,723	5,203,854	694.7	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
9	308,835	5,206,312	686.8	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
10	308,356	5,207,066	704.4	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
11	309,883	5,206,747	665.7	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
12	308,458	5,204,347	662.0	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
13	307,026	5,204,302	678.5	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
14	306,821	5,205,492	674.2	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
15	307,258	5,207,647	696.1	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
16	306,222	5,204,408	682.6	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
17	307,611	5,209,252	691.9	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
18	306,948	5,206,325	663.9	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
19	307,408	5,205,372	666.1	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
20	307,108	5,208,697	698.3	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
22	307,008	5,203,168	670.0	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
23	305,241	5,203,255	705.6	BISON 1A	Yes	Siemens	SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
25	308,117	5,209,319	675.4	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
26	306,823	5,209,364	689.1	BISON 1B	Yes	Siemens	SWT-3.0-101-3,000	3,000	101.0	80.0	16.0

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SHADOW - Main Result

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)

...continued from previous page

UTM WGS84 Zone: 14

Row data/Description	UTM WGS84 Zone: 14			WTG type		Power, rated [kW]	Rotor diameter [m]	Hub height [m]	RPM [RPM]
	East	North	Z [m]	Valid	Manufact. Type-generator				
27	307,666	5,206,450	684.1	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
28	307,454	5,208,223	699.8	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
29	308,855	5,203,961	659.6	Yes	Siemens SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
30	308,850	5,207,651	682.8	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
31	308,007	5,204,045	659.6	Yes	Siemens SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
32	305,787	5,205,371	676.0	Yes	Siemens SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
33	307,319	5,203,760	676.0	Yes	Siemens SWT-2.3-101-2,300	2,300	101.0	80.0	16.0
201	309,464	5,208,918	677.3	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
202	309,685	5,209,120	676.7	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
203	310,887	5,208,104	665.3	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
204	310,897	5,208,576	676.0	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
205	311,399	5,208,734	691.6	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
206	311,493	5,207,129	663.0	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
207	312,259	5,206,895	682.4	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
208	307,794	5,202,144	666.4	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
209	307,622	5,201,766	676.7	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
210	307,287	5,201,341	678.5	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
211	306,204	5,201,988	691.0	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
212	305,792	5,201,997	687.0	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
213	305,343	5,201,946	685.8	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
214	305,086	5,201,688	683.4	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
215	304,921	5,203,659	700.3	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
216	304,151	5,202,483	677.3	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
217	303,760	5,201,883	670.6	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
218	304,453	5,199,790	684.6	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
219	303,654	5,199,579	680.9	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
220	303,574	5,199,109	668.2	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
221	303,104	5,198,656	658.4	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
222	299,716	5,199,978	657.8	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
223	299,930	5,200,609	665.1	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
224	301,600	5,199,737	677.0	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
225	301,676	5,200,064	678.5	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
226	301,044	5,200,758	684.0	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
227	301,339	5,201,562	683.4	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
228	300,385	5,199,954	656.5	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
229	301,958	5,201,876	689.4	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
230	302,272	5,202,012	695.0	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
231	302,500	5,202,464	685.2	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
232	301,742	5,203,479	692.5	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
233	302,013	5,203,777	696.8	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
234	302,093	5,204,102	699.8	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0
235	302,838	5,204,194	681.1	Yes	Siemens SWT-3.0-101-3,000	3,000	101.0	80.0	16.0

Shadow receptor-Input

UTM WGS84 Zone: 14

No.	Name	East	North	Z	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
SR001	SR001	308,281	5,210,878	684.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR002	SR002	312,331	5,210,518	667.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR003	SR003	304,789	5,207,620	679.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR004	SR004	306,077	5,208,878	691.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR005	SR005	308,456	5,208,732	677.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

To be continued on next page...

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SHADOW - Main Result

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)

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UTM WGS84 Zone: 14

No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
		[m]	[m]	[m]	[m]	[m]	[m]	[°]	[°]	
SR006	SR006	309,777	5,208,086	658.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR007	SR007	312,386	5,207,439	674.5	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR008	SR008	310,463	5,203,623	650.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR009	SR009	310,303	5,203,128	643.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR010	SR010	310,167	5,202,263	676.7	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR011	SR011	308,704	5,202,962	655.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR012	SR012	308,504	5,199,667	674.6	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR013	SR013	305,091	5,204,059	680.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR014	SR014	305,600	5,202,951	680.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR015	SR015	305,735	5,202,742	681.1	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR016	SR016	305,362	5,202,580	681.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR017	SR017	304,204	5,201,211	671.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR018	SR018	304,015	5,200,169	672.6	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR019	SR019	302,002	5,200,728	663.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR020	SR020	298,345	5,201,007	658.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR021	SR021	298,817	5,200,870	660.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR022	SR022	299,277	5,199,763	649.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR023	SR023	299,548	5,198,404	658.4	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
SR024	SR024	298,327	5,198,450	669.3	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

Shadow, worst case

Shadow, expected values

No.	Name	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]
SR001	SR001	0:00	0	0:00	0:00
SR002	SR002	0:00	0	0:00	0:00
SR003	SR003	0:00	0	0:00	0:00
SR004	SR004	12:26	54	0:22	4:49
SR005	SR005	63:53	199	0:36	26:57
SR006	SR006	34:08	137	0:24	12:12
SR007	SR007	7:54	32	0:23	2:21
SR008	SR008	0:00	0	0:00	0:00
SR009	SR009	0:00	0	0:00	0:00
SR010	SR010	0:00	0	0:00	0:00
SR011	SR011	8:15	34	0:18	1:53
SR012	SR012	0:00	0	0:00	0:00
SR013	SR013	58:27	127	0:46	18:28
SR014	SR014	2:11	18	0:11	0:53
SR015	SR015	3:31	25	0:13	1:27
SR016	SR016	23:52	93	0:24	8:18
SR017	SR017	15:05	51	0:24	5:55
SR018	SR018	47:18	92	0:42	16:32
SR019	SR019	10:04	32	0:25	4:21
SR020	SR020	0:00	0	0:00	0:00
SR021	SR021	12:08	55	0:20	4:23
SR022	SR022	43:53	89	0:46	17:40
SR023	SR023	0:00	0	0:00	0:00
SR024	SR024	0:00	0	0:00	0:00

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SHADOW - Main Result**Calculation: BISON 2 Shadow Flicker (with existing BISON 1)**

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	BISON 1B	0:00	0:00
2	BISON 1B	4:43	1:29
3	BISON 1A	0:00	0:00
4	BISON 1A	0:00	0:00
5	BISON 1A	0:00	0:00
6	BISON 1B	22:12	9:27
7	BISON 1B	5:18	1:40
8	BISON 1A	20:41	8:33
9	BISON 1B	0:00	0:00
10	BISON 1B	0:00	0:00
11	BISON 1B	0:00	0:00
12	BISON 1A	0:00	0:00
13	BISON 1A	0:00	0:00
14	BISON 1A	0:00	0:00
15	BISON 1B	0:00	0:00
16	BISON 1A	6:50	2:49
17	BISON 1B	17:29	9:05
18	BISON 1A	0:00	0:00
19	BISON 1A	0:00	0:00
20	BISON 1B	11:13	4:53
22	BISON 1A	5:41	2:20
23	BISON 1A	0:00	0:00
25	BISON 1B	0:00	0:00
26	BISON 1B	0:00	0:00
27	BISON 1B	0:00	0:00
28	BISON 1B	8:50	2:20
29	BISON 1A	0:00	0:00
30	BISON 1B	10:25	2:53
31	BISON 1A	0:00	0:00
32	BISON 1A	0:00	0:00
33	BISON 1A	0:00	0:00
201	BISON 2	8:09	3:17
202	BISON 2	4:56	2:02
203	BISON 2	6:17	2:39
204	BISON 2	12:42	5:11
205	BISON 2	0:00	0:00
206	BISON 2	7:54	2:21
207	BISON 2	0:00	0:00
208	BISON 2	8:15	1:53
209	BISON 2	0:00	0:00
210	BISON 2	0:00	0:00
211	BISON 2	11:57	4:08
212	BISON 2	8:09	2:32
213	BISON 2	0:00	0:00
214	BISON 2	15:05	5:55
215	BISON 2	30:56	7:23
216	BISON 2	3:46	1:34
217	BISON 2	0:00	0:00
218	BISON 2	47:18	16:32
219	BISON 2	0:00	0:00
220	BISON 2	0:00	0:00
221	BISON 2	0:00	0:00
222	BISON 2	43:38	16:59
223	BISON 2	5:31	2:15
224	BISON 2	0:00	0:00
225	BISON 2	0:00	0:00

To be continued on next page...

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Duluth, MN 55802-2093

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US-GRAND FORKS, ND 58201
+1 701 775 3000
wind@eapc.net
Calculated:
6/17/2011 8:43 AM/2.7.486

SHADOW - Main Result

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)

...continued from previous page

No.	Name	Worst case [h/year]	Expected [h/year]
226	BISON 2	10:04	4:21
227	BISON 2	0:00	0:00
228	BISON 2	6:52	2:47
229	BISON 2	0:00	0:00
230	BISON 2	0:00	0:00
231	BISON 2	0:00	0:00
232	BISON 2	0:00	0:00
233	BISON 2	0:00	0:00
234	BISON 2	0:00	0:00
235	BISON 2	0:00	0:00

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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 US-GRAND FORKS, ND 58201
 +1 701 775 3000
 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR001 - SR001

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:33	08:13	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	07:28	08:11
	17:08	17:48	18:30	20:14	20:55	21:33	21:46	21:21	20:30	19:30	17:31	17:00
2	08:33	08:11	07:26	07:25	06:31	05:55	05:56	06:26	07:06	07:46	07:30	08:12
	17:09	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:28	19:28	17:30	16:59
3	08:33	08:10	07:24	07:23	06:29	05:55	05:56	06:27	07:08	07:47	07:31	08:13
	17:10	17:52	18:33	20:16	20:58	21:34	21:45	21:19	20:26	19:26	17:28	16:59
4	08:33	08:09	07:22	07:21	06:27	05:54	05:57	06:29	07:09	07:49	07:33	08:15
	17:11	17:53	18:34	20:18	20:59	21:35	21:45	21:17	20:24	19:24	17:27	16:59
5	08:32	08:07	07:20	07:19	06:26	05:54	05:58	06:30	07:10	07:50	07:34	08:16
	17:12	17:55	18:36	20:19	21:00	21:36	21:45	21:16	20:22	19:22	17:26	16:58
6	08:32	08:06	07:18	07:17	06:24	05:53	05:58	06:31	07:12	07:51	07:36	08:17
	17:13	17:56	18:37	20:21	21:02	21:37	21:44	21:14	20:20	19:20	17:24	16:58
7	08:32	08:04	07:17	07:15	06:23	05:53	05:59	06:33	07:13	07:53	07:37	08:18
	17:14	17:58	18:38	20:22	21:03	21:38	21:44	21:13	20:18	19:18	17:23	16:58
8	08:32	08:03	08:15	07:13	06:21	05:52	06:00	06:34	07:14	07:54	07:39	08:19
	17:15	17:59	18:40	20:23	21:04	21:38	21:43	21:11	20:16	19:16	17:21	16:58
9	08:31	08:02	08:13	07:11	06:20	05:52	06:01	06:35	07:15	07:55	07:40	08:20
	17:16	18:01	19:41	20:25	21:06	21:39	21:43	21:10	20:14	19:14	17:20	16:57
10	08:31	08:00	08:11	07:10	06:19	05:52	06:01	06:36	07:17	07:57	07:42	08:21
	17:17	18:01	19:43	20:26	21:07	21:40	21:42	21:08	20:12	19:12	17:19	16:57
11	08:31	07:59	08:09	07:08	06:17	05:51	06:02	06:38	07:18	07:58	07:43	08:22
	17:19	18:02	19:44	20:28	21:08	21:41	21:42	21:07	20:10	19:10	17:17	16:57
12	08:30	07:57	08:07	07:06	06:16	05:51	06:03	06:39	07:19	08:00	07:45	08:23
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14	08:29	07:54	08:03	07:02	06:13	05:51	06:05	06:42	07:22	08:02	07:48	08:24
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	17:24	18:09	19:50	20:33	21:13	21:43	21:39	21:00	20:02	19:02	17:13	16:58
16	08:28	07:51	07:59	06:58	06:11	05:51	06:07	06:44	07:25	08:05	07:51	08:26
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18	08:27	07:47	07:55	06:55	06:08	05:51	06:09	06:47	07:27	08:08	07:53	08:27
	17:28	18:13	19:54	20:37	21:17	21:44	21:37	20:55	19:56	18:55	17:09	16:58
19	08:26	07:46	07:53	06:53	06:07	05:51	06:10	06:48	07:29	08:09	07:55	08:28
	17:29	18:15	19:56	20:39	21:18	21:44	21:36	20:53	19:54	18:53	17:08	16:59
20	08:25	07:44	07:51	06:51	06:06	05:51	06:11	06:49	07:30	08:11	07:56	08:29
	17:31	18:16	19:57	20:40	21:20	21:45	21:35	20:52	19:52	18:51	17:08	16:59
21	08:24	07:42	07:49	06:49	06:05	05:51	06:12	06:51	07:31	08:12	07:58	08:29
	17:32	18:18	19:58	20:41	21:21	21:45	21:34	20:50	19:50	18:50	17:07	17:00
22	08:23	07:40	07:47	06:47	06:04	05:51	06:13	06:52	07:32	08:14	07:59	08:30
	17:33	18:19	20:00	20:43	21:22	21:45	21:33	20:48	19:48	18:48	17:06	17:00
23	08:22	07:39	07:45	06:46	06:03	05:52	06:14	06:53	07:34	08:15	08:00	08:30
	17:35	18:21	20:01	20:44	21:23	21:46	21:32	20:46	19:46	18:46	17:05	17:01
24	08:21	07:37	07:43	06:44	06:02	05:52	06:15	06:55	07:35	08:17	08:02	08:31
	17:36	18:22	20:03	20:45	21:24	21:46	21:31	20:45	19:44	18:44	17:04	17:01
25	08:20	07:35	07:41	06:42	06:01	05:52	06:17	06:56	07:36	08:18	08:03	08:31
	17:38	18:24	20:04	20:47	21:25	21:46	21:30	20:43	19:42	18:43	17:03	17:02
26	08:19	07:33	07:39	06:40	06:00	05:53	06:18	06:57	07:38	08:20	08:05	08:31
	17:39	18:25	20:05	20:48	21:26	21:46	21:29	20:41	19:40	18:41	17:03	17:03
27	08:18	07:32	07:37	06:39	05:59	05:53	06:19	06:58	07:39	08:21	08:06	08:32
	17:41	18:27	20:07	20:50	21:27	21:46	21:28	20:39	19:38	18:39	17:02	17:03
28	08:17	07:30	07:35	06:37	05:59	05:53	06:20	07:00	07:40	08:23	08:07	08:32
	17:42	18:28	20:08	20:51	21:29	21:46	21:27	20:37	19:36	18:38	17:01	17:04
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31	08:14		07:29		05:56		06:24	07:04		08:27		08:33
	17:47		20:12		21:32		21:23	20:31		18:33		17:06
Potential sun hours	279	287	368	407	466	475	480	441	378	338	282	266
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) 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)

Project: **Minnesota Power - BISON Wind Energy Center**

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

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 wind@eapc.net
 Calculated:
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SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR002 - SR002

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:32	08:12	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	07:28	08:11
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	17:18	18:02	19:44	20:27	21:08	21:40	21:42	21:07	20:10	19:10	17:17	16:57
12	08:30	07:57	08:07	07:06	06:16	05:51	06:03	06:39	07:19	07:59	07:45	08:23
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	17:33	18:19	20:00	20:42	21:22	21:45	21:33	20:48	19:47	18:48	17:06	17:00
23	08:22	07:38	07:45	06:45	06:03	05:51	06:14	06:53	07:34	08:15	08:00	08:30
	17:35	18:21	20:01	20:44	21:23	21:45	21:32	20:46	19:45	18:46	17:05	17:00
24	08:21	07:37	07:43	06:44	06:02	05:52	06:15	06:54	07:35	08:16	08:02	08:31
	17:36	18:22	20:02	20:45	21:24	21:45	21:31	20:44	19:43	18:44	17:04	17:01
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31	08:14		07:29		05:56		06:24	07:04		08:27		08:32
	17:47		20:12		21:31		21:23	20:31		18:33		17:06
Potential sun hours	279	287	368	407	466	475	480	441	378	338	282	266
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)

Project: **Minnesota Power - BISON Wind Energy Center**

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 +1 701 775 3000
 wind@eapc.net
 Calculated: 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR003 - SR003

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:33	08:13	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:45	07:29	08:11
	17:08	17:49	18:30	20:14	20:55	21:33	21:46	21:22	20:30	19:30	17:32	17:00
2	08:33	08:11	07:26	07:25	06:31	05:55	05:56	06:27	07:07	07:46	07:30	08:12
	17:09	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:28	19:28	17:30	17:00
3	08:33	08:10	07:24	07:23	06:29	05:55	05:57	06:28	07:08	07:47	07:31	08:13
	17:10	17:52	18:33	20:17	20:58	21:34	21:45	21:19	20:26	19:26	17:29	16:59
4	08:33	08:09	07:22	07:21	06:28	05:54	05:57	06:29	07:09	07:49	07:33	08:15
	17:11	17:53	18:34	20:18	20:59	21:35	21:45	21:17	20:24	19:24	17:27	16:59
5	08:32	08:07	07:20	07:19	06:26	05:54	05:58	06:30	07:10	07:50	07:34	08:16
	17:12	17:55	18:36	20:19	21:00	21:36	21:45	21:16	20:22	19:22	17:26	16:58
6	08:32	08:06	07:19	07:18	06:25	05:53	05:59	06:32	07:12	07:51	07:36	08:17
	17:13	17:56	18:37	20:21	21:02	21:37	21:44	21:15	20:20	19:20	17:24	16:58
7	08:32	08:05	07:17	07:16	06:23	05:53	05:59	06:33	07:13	07:53	07:37	08:18
	17:14	17:58	18:39	20:22	21:03	21:38	21:44	21:13	20:18	19:18	17:23	16:58
8	08:32	08:03	08:15	07:14	06:22	05:53	06:00	06:34	07:14	07:54	07:39	08:19
	17:15	18:00	18:40	20:24	21:04	21:39	21:44	21:12	20:16	19:16	17:22	16:58
9	08:31	08:02	08:13	07:12	06:20	05:52	06:01	06:35	07:16	07:56	07:40	08:20
	17:16	18:00	19:42	20:25	21:06	21:39	21:43	21:10	20:14	19:14	17:20	16:58
10	08:31	08:00	08:11	07:10	06:19	05:52	06:02	06:37	07:17	07:57	07:42	08:21
	17:18	18:01	19:43	20:26	21:07	21:40	21:43	21:09	20:12	19:12	17:19	16:58
11	08:31	07:59	08:09	07:08	06:17	05:52	06:03	06:38	07:18	07:58	07:43	08:22
	17:19	18:03	19:44	20:28	21:08	21:41	21:42	21:07	20:10	19:10	17:18	16:58
12	08:30	07:57	08:07	07:06	06:16	05:51	06:03	06:39	07:20	08:00	07:45	08:23
	17:20	18:04	19:46	20:29	21:10	21:41	21:41	21:05	20:08	19:08	17:16	16:58
13	08:30	07:56	08:05	07:04	06:15	05:51	06:04	06:40	07:21	08:01	07:46	08:24
	17:21	18:06	19:47	20:30	21:11	21:42	21:41	21:04	20:06	19:06	17:15	16:58
14	08:29	07:54	08:03	07:02	06:14	05:51	06:05	06:42	07:22	08:02	07:48	08:25
	17:23	18:07	19:49	20:32	21:12	21:42	21:40	21:02	20:04	19:04	17:14	16:58
15	08:29	07:52	08:01	07:00	06:12	05:51	06:06	06:43	07:23	08:04	07:49	08:25
	17:24	18:09	19:50	20:33	21:14	21:43	21:39	21:00	20:02	19:03	17:13	16:58
16	08:28	07:51	07:59	06:58	06:11	05:51	06:07	06:44	07:25	08:05	07:51	08:26
	17:25	18:10	19:52	20:35	21:15	21:43	21:39	20:59	20:00	19:01	17:12	16:58
17	08:27	07:49	07:57	06:57	06:10	05:51	06:08	06:46	07:26	08:07	07:52	08:27
	17:27	18:12	19:53	20:36	21:16	21:44	21:38	20:57	19:58	18:57	17:11	16:58
18	08:27	07:47	07:55	06:55	06:09	05:51	06:09	06:47	07:27	08:08	07:54	08:28
	17:28	18:13	19:54	20:37	21:17	21:44	21:37	20:55	19:56	18:55	17:10	16:59
19	08:26	07:46	07:53	06:53	06:08	05:51	06:10	06:48	07:29	08:10	07:55	08:28
	17:29	18:15	19:56	20:39	21:18	21:45	21:36	20:54	19:54	18:53	17:09	16:59
20	08:25	07:44	07:51	06:51	06:06	05:51	06:11	06:50	07:30	08:11	07:56	08:29
	17:31	18:16	19:57	20:40	21:20	21:45	21:35	20:52	19:52	18:52	17:08	16:59
21	08:24	07:42	07:49	06:49	06:05	05:52	06:12	06:51	07:31	08:12	07:58	08:29
	17:32	18:18	19:59	20:41	21:21	21:45	21:34	20:50	19:50	18:50	17:07	17:00
22	08:23	07:41	07:47	06:48	06:04	05:52	06:14	06:52	07:33	08:14	07:59	08:30
	17:34	18:19	20:00	20:43	21:22	21:45	21:33	20:48	19:48	18:48	17:06	17:00
23	08:22	07:39	07:45	06:46	06:03	05:52	06:15	06:53	07:34	08:15	08:01	08:30
	17:35	18:21	20:01	20:44	21:23	21:46	21:32	20:46	19:46	18:46	17:05	17:01
24	08:22	07:37	07:43	06:44	06:02	05:52	06:16	06:55	07:35	08:17	08:02	08:31
	17:37	18:22	20:03	20:46	21:24	21:46	21:31	20:45	19:44	18:45	17:04	17:02
25	08:21	07:35	07:41	06:42	06:01	05:53	06:17	06:56	07:37	08:18	08:03	08:31
	17:38	18:24	20:04	20:47	21:25	21:46	21:30	20:43	19:42	18:43	17:04	17:02
26	08:19	07:33	07:39	06:41	06:01	05:53	06:18	06:57	07:38	08:20	08:05	08:32
	17:40	18:25	20:06	20:48	21:26	21:46	21:29	20:41	19:40	18:41	17:03	17:03
27	08:18	07:32	07:37	06:39	06:00	05:53	06:19	06:59	07:39	08:21	08:06	08:32
	17:41	18:27	20:07	20:50	21:28	21:46	21:28	20:39	19:38	18:40	17:02	17:04
28	08:17	07:30	07:35	06:37	05:59	05:54	06:20	07:00	07:41	08:23	08:07	08:32
	17:43	18:28	20:08	20:51	21:29	21:46	21:27	20:37	19:36	18:38	17:02	17:04
29	08:16	07:33	07:36	06:36	05:58	05:54	06:22	07:01	07:42	08:24	08:09	08:32
	17:44	18:29	20:09	20:52	21:30	21:46	21:25	20:35	19:34	18:36	17:01	17:05
30	08:15	07:31	07:34	06:34	05:57	05:55	06:23	07:03	07:43	08:26	08:10	08:32
	17:46	18:31	20:11	20:54	21:31	21:46	21:24	20:33	19:32	18:35	17:01	17:06
31	08:14	07:29	07:32	06:32	05:55	05:53	06:24	07:04	07:44	08:27	08:11	08:33
	17:47	18:32	20:12	20:55	21:32	21:46	21:23	20:32	19:31	18:33	17:01	17:07
Potential sun hours	279	287	388	407	466	475	480	441	378	338	282	266
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)	Minutes with flicker	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)		Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project: **Minnesota Power - BISON Wind Energy Center**

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:
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Printed/Page
 6/21/2011 8:44 AM / 9
 Licensed user:
EAPC Wind Energy
 3100 DeMers Avenue
 US-GRAND FORKS, ND 58201
 +1 701 775 3000
 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR004 - SR004

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December		
1	08:33	09:23 (7)	08:13	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:45	08:07 (20)	07:28	08:11
2	17:08	10 09:33 (7)	17:49	18:30	20:14	20:55	21:33	21:46	21:21	20:30	19:30	15 08:22 (20)	17:32	17:00
3	08:33	09:25 (7)	08:11	07:26	07:25	06:31	05:55	05:56	06:26	07:06	07:46	08:08 (20)	07:30	08:12
4	17:09	7 09:32 (7)	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:28	19:28	13 08:21 (20)	17:30	16:59
5	08:33	08:27 (7)	08:10	07:24	07:23	06:29	05:55	05:56	06:28	07:08	07:47	08:09 (20)	07:31	08:13
6	17:10	4 09:31 (7)	17:52	18:33	20:17	20:58	21:34	21:45	21:19	20:26	19:26	10 08:19 (20)	17:29	16:59
7	08:33	08:09	07:22	07:21	06:28	05:54	05:57	06:29	07:09	07:49	07:49	08:11 (20)	07:33	08:15
8	17:11	17:53	18:34	20:18	20:59	21:35	21:45	21:17	20:24	19:24	7 08:18 (20)	17:27	16:59	16:59
9	08:32	08:07	07:20	07:19	06:26	05:54	05:58	06:30	07:10	07:50	08:12 (20)	07:34	08:16	16:59
10	17:12	17:55	18:36	20:19	21:00	21:36	21:45	21:16	20:22	19:22	2 08:14 (20)	17:26	16:58	16:58
11	08:32	08:06	07:19	07:17	06:25	05:53	05:58	06:31	07:12	07:51	07:51	07:36	08:17	16:58
12	17:13	17:56	18:37	20:21	21:02	21:37	21:44	21:15	20:20	19:20	19:20	17:24	16:58	16:58
13	08:32	08:05	07:17	07:15	06:23	05:53	05:59	06:33	07:13	07:53	07:53	07:37	08:18	16:58
14	17:14	17:58	18:39	20:22	21:03	21:38	21:44	21:13	20:18	19:18	19:18	17:23	16:58	16:58
15	08:32	08:03	08:15	07:14	06:22	05:52	06:00	06:34	07:14	07:54	07:54	07:39	08:19	16:58
16	17:15	17:59	18:40	20:24	21:04	21:38	21:44	21:12	20:16	19:16	19:16	17:21	16:58	16:58
17	08:31	08:02	08:13	07:12	06:20	05:52	06:01	06:35	07:16	07:55	07:55	07:40	08:20	09:15 (7)
18	17:16	18:01	19:42	5 08:39 (20)	20:25	21:06	21:39	21:43	21:10	20:14	19:14	17:20	16:58	4 09:19 (7)
19	08:31	08:00	08:11	08:32 (20)	07:10	06:19	05:52	06:02	06:37	07:17	07:57	07:42	08:21	09:14 (7)
20	17:18	18:01	19:43	9 08:41 (20)	20:26	21:07	21:40	21:43	21:08	20:12	19:12	17:19	16:58	7 09:21 (7)
21	08:31	07:59	08:09	08:30 (20)	07:08	06:17	05:52	06:02	06:38	07:18	07:58	07:43	08:22	09:13 (7)
22	17:19	18:03	19:44	12 08:42 (20)	20:28	21:08	21:41	21:42	21:07	20:10	19:10	17:18	16:57	10 09:23 (7)
23	08:30	07:57	08:07	08:28 (20)	07:06	06:16	05:51	06:03	06:39	07:19	08:00	07:45	08:23	09:13 (7)
24	17:20	18:04	19:46	14 08:42 (20)	20:29	21:10	21:41	21:41	21:05	20:08	19:08	17:16	16:58	11 09:24 (7)
25	08:30	07:56	08:05	08:26 (20)	07:04	06:15	05:51	06:04	06:40	07:21	08:01	07:46	08:24	09:13 (7)
26	17:21	18:06	19:47	17 08:43 (20)	20:30	21:11	21:42	21:41	21:04	20:06	19:06	17:15	16:58	12 09:25 (7)
27	08:29	07:54	08:03	08:24 (20)	07:02	06:13	05:51	06:05	06:42	07:22	08:02	07:48	08:25	09:13 (7)
28	17:23	18:07	19:49	19 08:43 (20)	20:32	21:12	21:42	21:40	21:02	20:04	19:04	17:14	16:58	13 09:26 (7)
29	08:29	07:52	08:01	08:22 (20)	07:00	06:12	05:51	06:06	06:43	07:23	08:04	07:49	08:25	09:14 (7)
30	17:24	18:09	19:50	21 08:43 (20)	20:33	21:13	21:43	21:39	21:00	20:02	19:03	17:13	16:58	13 09:27 (7)
31	08:28	07:51	07:59	08:20 (20)	06:58	06:11	05:51	06:07	06:44	07:25	08:05	07:51	08:26	09:13 (7)
32	17:25	18:10	19:52	22 08:42 (20)	20:35	21:15	21:43	21:39	20:59	20:00	19:01	17:12	16:58	14 09:27 (7)
33	08:27	07:49	07:57	08:20 (20)	06:57	06:10	05:51	06:08	06:46	07:26	08:07	07:52	08:27	09:14 (7)
34	17:27	18:12	19:53	22 08:42 (20)	20:36	21:16	21:44	21:38	20:57	19:58	18:57	17:11	16:58	14 09:28 (7)
35	08:27	07:47	07:55	08:20 (20)	06:55	06:09	05:51	06:09	06:47	07:27	08:08	07:54	08:28	09:14 (7)
36	17:28	18:13	19:54	21 08:41 (20)	20:37	21:17	21:44	21:37	20:55	19:56	18:55	17:10	16:59	15 09:29 (7)
37	08:26	07:46	07:53	08:21 (20)	06:53	06:07	05:51	06:10	06:48	07:29	08:10	07:55	08:28	09:14 (7)
38	17:29	18:15	19:56	19 08:40 (20)	20:39	21:18	21:45	21:36	20:54	19:54	18:53	17:09	16:59	15 09:29 (7)
39	08:25	07:44	07:51	08:22 (20)	06:51	06:06	05:51	06:11	06:49	07:30	08:11	07:56	08:29	09:15 (7)
40	17:31	18:16	19:57	16 08:38 (20)	20:40	21:20	21:45	21:35	20:52	19:52	18:52	17:08	16:59	15 09:30 (7)
41	08:24	07:42	07:49	08:23 (20)	06:49	06:05	05:51	06:12	06:51	07:31	08:12	07:58	08:29	09:16 (7)
42	17:32	18:16	19:59	13 08:36 (20)	20:41	21:21	21:45	21:34	20:50	19:50	18:50	17:07	17:00	15 09:31 (7)
43	08:23	07:41	07:47	08:27 (20)	06:47	06:04	05:52	06:13	06:52	07:33	08:14	07:59	08:30	09:16 (7)
44	17:34	18:19	20:00	5 08:32 (20)	20:43	21:22	21:45	21:33	20:49	19:48	18:48	17:06	17:00	15 09:31 (7)
45	08:22	07:39	07:45	08:46	06:03	05:52	06:15	06:53	07:34	08:15	09:07 (20)	08:15	08:01	08:30
46	17:35	18:21	20:01	20:44	21:23	21:46	21:32	20:46	19:46	18:46	17:46	17:05	17:01	15 09:31 (7)
47	08:21	07:37	07:43	06:44	06:02	05:52	06:16	06:55	07:35	08:15	09:05 (20)	08:17	08:02	08:31
48	17:37	18:22	20:03	20:46	21:24	21:46	21:31	20:45	19:44	18 08:23 (20)	18:45	17:04	17:01	15 09:32 (7)
49	08:20	07:35	07:41	06:42	06:01	05:52	06:17	06:56	07:37	08:18	09:04 (20)	08:18	08:03	08:31
50	17:38	18:24	20:04	20:47	21:25	21:46	21:30	20:43	19:42	20 08:24 (20)	18:43	17:04	17:02	15 09:32 (7)
51	08:19	07:33	07:39	06:41	06:00	05:53	06:18	06:57	07:38	08:19	09:03 (20)	08:20	08:05	08:32
52	17:40	18:25	20:06	20:48	21:26	21:46	21:29	20:41	19:40	21 08:24 (20)	18:41	17:03	17:03	15 09:32 (7)
53	08:18	07:32	07:37	06:39	06:00	05:53	06:19	06:59	07:39	08:20	09:02 (20)	08:21	08:06	08:32
54	17:41	18:27	20:07	20:50	21:28	21:46	21:28	20:39	19:38	22 08:24 (20)	18:40	17:02	17:03	14 09:33 (7)
55	08:17	07:30	07:35	06:37	05:59	05:54	06:20	07:00	07:41	08:03 (20)	08:23	08:07	08:32	09:19 (7)
56	17:43	18:28	20:08	20:51	21:29	21:46	21:27	20:37	19:36	21 08:24 (20)	18:38	17:02	17:04	14 09:33 (7)
57	08:16	07:33	07:33	06:36	05:58	05:54	06:22	07:01	07:42	08:04 (20)	08:24	08:08	08:32	09:20 (7)
58	17:44	18:29	20:10	20:52	21:30	21:46	21:25	20:35	19:34	20 08:24 (20)	18:36	17:01	17:05	13 09:33 (7)
59	08:15	07:31	07:31	06:34	05:57	05:55	06:23	07:03	07:43	08:05 (20)	08:26	08:10	08:32	09:21 (7)
60	17:46	18:31	20:11	20:54	21:31	21:46	21:24	20:33	19:32	18 08:23 (20)	18:35	17:00	17:06	12 09:33 (7)
61	08:14	07:29	07:29	06:31	05:57	05:57	06:24	07:04	07:44	08:06 (20)	08:27	08:07	08:33	09:22 (7)
62	17:47	18:32	20:12	21:12	21:32	21:47	21:23	20:32	19:31	18 08:23 (20)	18:33	17:01	17:07	11 09:33 (7)
Potential sun hours	279	287	368	407	466	475	480	441	378	338	282	266		
Total, worst case	21		215						166		47			297
Sun reduction	0.55		0.63						0.69		0.52			0.43

Project:
Minnesota Power - BISON Wind Energy Center
 Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:
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 wind@eapc.net
Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR005 - SR005

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June
1	08:33 17:08	08:12 17:49 11	17:11 (28) 07:28 17:22 (28) 18:30	07:27 20:14	19:00 (6) 06:32 19:36 (6) 20:55	06:54 (202) 05:56 07:03 (202) 21:32
2	08:33 17:09	08:11 17:50 14	17:09 (28) 07:26 17:23 (28) 18:31	07:25 20:15	18:59 (6) 06:31 19:35 (6) 20:56	9 06:53 (202) 05:55 07:04 (202) 21:33
3	08:33 17:10	08:10 17:51 16	17:09 (28) 07:24 17:25 (28) 18:33	07:23 20:16	18:59 (6) 06:29 19:35 (6) 20:58	11 06:51 (202) 05:55 07:03 (202) 21:34
4	08:32 17:11	08:09 17:52 18	17:09 (28) 07:22 17:26 (28) 18:34	07:21 20:18	18:59 (6) 06:27 19:34 (6) 20:59	12 06:50 (202) 05:54 07:04 (202) 21:35
5	08:32 17:12	08:07 17:53 20	17:08 (28) 07:20 17:27 (28) 18:36	07:19 20:19	18:59 (6) 06:26 19:34 (6) 21:00	14 06:48 (202) 05:54 07:03 (202) 21:36
6	08:32 17:13	08:06 17:54 21	17:08 (28) 07:18 17:28 (28) 18:37	07:17 20:21	19:00 (6) 06:24 19:33 (6) 21:02	15 06:47 (202) 05:53 07:03 (202) 21:37
7	08:32 17:14	08:04 17:55 21	17:08 (28) 07:16 17:29 (28) 18:37	07:15 20:21	19:00 (6) 06:23 19:33 (6) 21:02	16 06:46 (202) 05:53 07:02 (202) 21:38
8	08:32 17:15	08:03 17:56 22	17:08 (28) 08:15 17:29 (28) 18:38	07:13 20:22	19:01 (6) 06:21 19:32 (6) 21:03	16 06:46 (202) 05:52 07:02 (202) 21:38
9	08:31 17:16	08:02 17:57 22	17:08 (28) 08:13 17:30 (28) 18:40	07:12 20:23	19:02 (6) 06:20 19:31 (6) 21:04	15 06:46 (202) 05:52 07:01 (202) 21:38
10	08:31 17:17	08:01 17:58 20	17:09 (28) 08:11 17:29 (28) 18:41	07:10 20:25	19:03 (6) 06:19 19:30 (6) 21:06	12 06:48 (202) 05:52 07:00 (202) 21:39
11	08:31 17:19	08:01 17:59 20	17:09 (28) 08:09 17:29 (28) 18:43	07:08 20:26	19:05 (6) 06:17 19:28 (6) 21:07	10 06:52 (202) 05:51 06:52 (202) 21:40
12	08:30 17:20	08:02 18:00 19	17:28 (28) 18:44 17:10 (28) 08:07	07:06 20:28	19:06 (6) 06:16 19:26 (6) 21:08	3 06:55 (202) 21:40 05:51 23 21:12 (17)
13	08:30 17:21	08:04 18:01 17	17:27 (28) 18:46 17:11 (28) 08:05	07:04 20:29	19:23 (6) 21:10 07:25 (201) 06:15	24 21:13 (17) 05:51 24 21:13 (17)
14	08:29 17:22	08:05 18:02 16	17:27 (28) 18:47 17:13 (28) 08:03	07:02 20:30	19:20 (6) 21:11 07:23 (201) 06:13	24 21:13 (17) 05:51 24 21:13 (17)
15	08:29 17:23	08:07 18:03 12	17:25 (28) 18:49 17:16 (28) 08:01	07:00 20:32	07:29 (201) 21:12 07:21 (201) 06:12	25 21:14 (17) 05:51 25 21:14 (17)
16	08:28 17:25	08:09 18:04 7	17:23 (28) 18:50 07:51	07:00 20:33	07:30 (201) 21:13 07:20 (201) 06:11	25 21:14 (17) 05:51 25 21:14 (17)
17	08:27 17:26	08:10 18:05 17	19:51 07:57	20:34 07:57	07:32 (201) 21:15 07:18 (201) 06:10	25 21:15 (17) 05:51 25 21:15 (17)
18	08:26 17:28	08:12 18:06 18	19:53 07:55	20:36 19:28 (20) 06:55	07:32 (201) 21:16 07:16 (201) 06:08	25 21:15 (17) 05:51 25 21:15 (17)
19	08:26 17:29	08:13 18:07 19	19:54 07:53	4 19:32 (20) 20:37 19:26 (20) 06:53	16 07:32 (201) 21:17 07:14 (201) 06:07	25 21:15 (17) 05:51 25 21:15 (17)
20	08:25 17:31	08:15 18:08 20	19:56 07:51	7 19:33 (20) 20:39 19:25 (20) 06:51	18 07:32 (201) 21:18 07:12 (201) 06:06	25 21:15 (17) 05:51 25 21:15 (17)
21	08:24 17:32	08:16 18:09 21	19:57 07:49	10 19:35 (20) 20:40 19:24 (20) 06:49	20 07:32 (201) 21:19 07:11 (201) 06:05	25 21:15 (17) 05:51 25 21:15 (17)
22	08:23 17:34	08:18 18:10 22	19:58 07:47	12 19:36 (20) 20:41 19:14 (6) 06:47	21 07:32 (201) 21:21 07:09 (201) 06:04	25 21:15 (17) 05:51 25 21:15 (17)
23	08:22 17:35	08:19 18:11 23	20:00 07:45	24 19:38 (20) 20:43 19:10 (6) 06:46	22 07:31 (201) 21:22 07:09 (201) 06:03	25 21:15 (17) 05:52 25 21:15 (17)
24	08:21 17:36	08:21 18:12 24	20:01 07:43	29 19:39 (20) 20:44 19:08 (6) 06:44	21 07:30 (201) 21:23 07:10 (201) 06:02	25 21:16 (17) 05:52 25 21:16 (17)
25	08:20 17:38	08:22 18:13 25	20:03 07:41	32 19:40 (20) 20:45 19:06 (6) 06:42	20 07:30 (201) 21:24 07:10 (201) 06:01	25 21:16 (17) 05:52 25 21:16 (17)
26	08:19 17:39	08:24 18:14 26	20:04 07:39	33 19:39 (20) 20:47 19:05 (6) 06:40	19 07:29 (201) 21:25 07:10 (201) 06:00	25 21:16 (17) 05:53 25 21:17 (17)
27	08:18 17:41	08:25 18:15 27	20:05 07:37	32 19:37 (20) 20:48 19:03 (6) 06:39	17 07:27 (201) 21:26 07:12 (201) 06:00	25 21:17 (17) 05:53 25 21:17 (17)
28	08:17 17:42	08:27 18:16 28	20:07 07:35	32 19:35 (6) 20:49 19:02 (6) 06:37	14 07:26 (201) 21:27 06:59 (202) 05:59	25 21:17 (17) 05:54 25 21:17 (17)
29	08:16 17:44	08:28 18:17 29	20:08 07:33	34 19:36 (6) 20:51 19:02 (6) 06:35	13 07:24 (201) 21:28 06:57 (202) 05:58	25 21:17 (17) 05:54 25 21:17 (17)
30	08:15 17:45	17:14 (28) 17:45 4	20:10 07:31	34 19:36 (6) 20:52 19:01 (6) 06:34	5 07:02 (202) 21:29 06:56 (202) 05:57	25 21:17 (17) 05:55 25 21:17 (17)
31	08:14 17:47	17:12 (28) 17:47 8	20:11 07:29	35 19:36 (6) 20:54 19:00 (6)	7 07:03 (202) 21:30 05:56 20:49 (17)	24 21:17 (17) 21:03 (17) 21:46 15 21:04 (17)
Potential sun hours	279	287	368	407	466	475
Total, worst case	12	255	354	629	195	692
Sun reduction	0.55	0.50	0.63	0.59	0.68	0.71
Oper. time red.	0.97	0.97	0.97	0.97	0.97	0.97
Wind dir. red.	0.57	0.57	0.67	0.66	0.65	0.74
Total reduction	0.30	0.27	0.41	0.37	0.43	0.51
Total, real	4	70	144	235	83	351

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

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

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR005 - SR005

Assumptions for shadow calculations

Maximum distance for influence 1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	July	August	September	October	November	December
1	05:55 21:46	20:53 (17) 21:16 (17)	06:25 21:21	07:05 20:29	19:04 (6) 19:30	07:28 17:00
2	05:56 21:45	20:53 (17) 21:17 (17)	06:26 21:20	07:06 20:28	19:01 (6) 19:28	07:30 16:59 (28)
3	05:56 21:45	20:53 (17) 21:16 (17)	06:28 21:19	07:08 20:26	18:59 (6) 19:26	07:31 17:28
4	05:57 21:45	20:54 (17) 21:16 (17)	06:29 21:17	07:09 20:24	18:59 (6) 19:24	07:33 17:27
5	05:58 21:44	20:54 (17) 21:15 (17)	06:30 21:16	07:10 20:22	18:57 (6) 19:22	07:34 17:26
6	05:58 21:44	20:54 (17) 21:15 (17)	06:31 21:14	07:12 20:20	18:56 (6) 19:20	07:36 17:24
7	05:59 21:44	20:55 (17) 21:15 (17)	06:33 21:13	07:13 20:18	18:54 (6) 19:18	07:37 17:23
8	06:00 21:43	20:56 (17) 21:15 (17)	06:34 21:11	07:14 20:16	18:54 (6) 19:16	07:39 17:21
9	06:01 21:43	20:56 (17) 21:14 (17)	06:35 21:10	07:15 20:14	18:53 (6) 19:14	07:40 17:20
10	06:01 21:42	20:56 (17) 21:13 (17)	06:36 21:08	07:17 20:12	18:53 (6) 19:12	07:42 17:19
11	06:02 21:42	20:57 (17) 21:13 (17)	06:38 21:07	07:18 20:10	18:52 (6) 19:10	07:43 17:17
12	06:03 21:41	20:57 (17) 21:12 (17)	06:39 21:05	07:19 20:08	18:52 (6) 19:08	07:45 17:16
13	06:04 21:41	20:58 (17) 21:12 (17)	06:40 21:04	07:21 20:06	18:52 (6) 19:06	07:46 17:15
14	06:05 21:40	20:59 (17) 21:11 (17)	06:42 21:02	07:22 20:04	18:52 (6) 19:04	07:48 17:14
15	06:06 21:39	21:00 (17) 21:11 (17)	06:43 21:00	07:23 20:02	18:53 (6) 19:02	07:49 17:13
16	06:07 21:38	21:02 (17) 21:10 (17)	06:44 20:59	07:25 20:00	18:53 (6) 19:01	07:50 17:12
17	06:08 21:38	21:03 (17) 21:10 (17)	06:45 20:57	07:26 19:58	18:53 (6) 18:57	07:52 17:11
18	06:09 21:37	21:06 (17) 21:09 (17)	06:47 20:55	07:27 19:56	18:53 (6) 18:55	07:53 17:10
19	06:10 21:36	21:09 (17) 20:53	06:48 20:53	07:29 19:54	18:55 (6) 18:53	07:55 17:09
20	06:11 21:35	21:11 (17) 20:52	06:49 20:52	07:30 19:52	18:56 (6) 18:51	07:56 17:08
21	06:12 21:34	21:12 (17) 20:51	06:51 20:50	07:31 19:50	18:58 (6) 18:50	07:58 17:07
22	06:13 21:33	21:13 (17) 20:50	06:52 20:48	07:32 19:48	19:03 (6) 18:48	07:59 17:06
23	06:14 21:32	21:14 (17) 20:49	06:53 20:46	07:34 19:46	19:09 (20) 18:46	08:00 17:05
24	06:16 21:31	21:15 (17) 20:48	06:55 20:44	07:35 19:44	19:09 (20) 18:44	08:02 17:04
25	06:17 21:30	21:16 (17) 20:47	06:56 20:43	07:36 (201) 19:42	19:10 (20) 18:43	08:03 17:03
26	06:18 21:29	21:17 (17) 20:46	06:57 20:41	07:38 19:40	19:13 (20) 18:41	08:04 17:03
27	06:19 21:28	21:18 (17) 20:45	06:58 20:39	07:39 19:38	19:14 (20) 18:41	08:06 17:03
28	06:20 21:26	21:19 (17) 20:44	06:59 20:37	07:40 19:36	19:15 (20) 18:40	08:08 17:02
29	06:21 21:25	21:20 (17) 20:43	07:01 20:35	07:42 19:34	19:16 (20) 18:40	08:10 17:01
30	06:23 21:24	21:21 (17) 20:42	07:02 20:33	07:43 19:32	19:17 (20) 18:39	08:12 17:00
31	06:24 21:23	21:22 (17) 20:41	07:04 20:31	19:06 (6) 19:23 (6)	18:39 19:17	17:39 (28) 17:58 (28)
Potential sun hours	480	441	378	338	282	266
Total, worst case	295	424	714	74	189	
Sun reduction	0.75	0.73	0.69	0.52	0.43	
Oper. time red.	0.97	0.97	0.97	0.97	0.97	
Wind dir. red.	0.74	0.62	0.68	0.57	0.57	
Total reduction	0.54	0.44	0.45	0.29	0.23	
Total, real	159	186	320	21	44	

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

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

Project:
Minnesota Power - BISON Wind Energy Center
 Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR006 - SR006

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June								
1	08:32	08:12	07:28	17:42 (2)	07:27	07:48 (203)	06:32	05:56	06:31 (204)					
	17:08	17:48	18:30	16	17:58 (2)	20:14	16	08:04 (203)	20:55	21:32	15	06:46 (204)		
2	08:32	08:11	07:26	17:43 (2)	07:25	07:46 (203)	06:30	05:55	06:32 (204)					
	17:09	17:50	18:31	13	17:56 (2)	20:15	18	08:04 (203)	20:56	21:33	14	06:46 (204)		
3	08:32	08:10	07:24	17:45 (2)	07:23	07:44 (203)	06:29	05:55	06:33 (204)					
	17:10	17:52	18:33	11	17:56 (2)	20:16	20	08:04 (203)	20:58	21:34	13	06:46 (204)		
4	08:32	08:08	17:18 (30)	07:22	17:47 (2)	07:21	07:42 (203)	06:27	05:54	06:33 (204)				
	17:11	17:53	8	17:26 (30)	18:34	6	17:53 (2)	20:18	21	08:03 (203)	20:59	21:35	12	06:45 (204)
5	08:32	08:07	17:16 (30)	07:20	17:46 (2)	07:19	07:42 (203)	06:26	05:54	06:34 (204)				
	17:12	17:55	12	17:28 (30)	18:36	20	19	08:02 (203)	21:00	21:36	10	06:44 (204)		
6	08:32	08:06	17:15 (30)	07:18	17:47 (2)	07:17	07:43 (203)	06:24	05:53	06:35 (204)				
	17:13	17:56	15	17:30 (30)	18:37	18	18	08:01 (203)	21:02	21:37	8	06:43 (204)		
7	08:32	08:04	17:13 (30)	07:16	17:48 (2)	07:15	07:44 (203)	06:23	05:53	06:37 (204)				
	17:14	17:58	18	17:31 (30)	18:38	15	15	07:59 (203)	21:03	21:38	5	06:42 (204)		
8	08:32	08:03	17:13 (30)	08:14	17:49 (2)	07:13	07:45 (203)	06:21	05:52	06:42 (204)				
	17:15	17:59	20	17:33 (30)	18:40	13	13	07:58 (203)	21:04	21:38				
9	08:31	08:01	17:12 (30)	08:13	17:50 (2)	07:11	07:46 (203)	06:20	05:52	06:43 (204)				
	17:16	18:01	22	17:34 (30)	19:41	7	7	07:55 (203)	21:06	21:39				
10	08:31	08:00	17:12 (30)	08:11	17:51 (2)	07:10	07:47 (203)	06:19	05:52	06:44 (204)				
	17:17	18:01	23	17:35 (30)	19:43	20	20	08:05 (203)	21:07	21:40				
11	08:30	07:58	17:11 (30)	08:09	17:52 (2)	07:08	07:48 (203)	06:17	05:51	06:45 (204)				
	17:19	18:02	24	17:35 (30)	19:44	20	20	08:06 (203)	21:08	21:40				
12	08:30	07:57	17:11 (30)	08:07	17:53 (2)	07:06	07:49 (203)	06:16	05:51	06:46 (204)				
	17:20	18:04	23	17:34 (30)	19:46	20	20	08:07 (203)	21:09	21:41				
13	08:30	07:55	17:12 (30)	08:05	17:54 (2)	07:04	07:50 (203)	06:15	05:51	06:47 (204)				
	17:21	18:05	23	17:35 (30)	19:47	20	20	08:08 (203)	21:11	21:42				
14	08:29	07:54	17:12 (30)	08:03	17:55 (2)	07:02	07:51 (203)	06:13	05:51	06:48 (204)				
	17:22	18:07	22	17:34 (30)	19:48	20	20	08:09 (203)	21:12	21:42				
15	08:28	07:52	17:12 (30)	08:01	17:56 (2)	07:00	07:52 (203)	06:12	05:51	06:49 (204)				
	17:24	18:09	22	17:34 (30)	19:50	20	20	08:10 (203)	21:13	21:43				
16	08:28	07:51	17:13 (30)	07:59	17:57 (2)	06:58	07:53 (203)	06:11	05:51	06:50 (204)				
	17:25	18:10	21	17:34 (30)	19:51	20	20	08:11 (203)	21:15	21:43				
17	08:27	07:49	17:13 (30)	07:57	17:58 (2)	06:56	07:54 (203)	06:10	05:51	06:51 (204)				
	17:26	18:12	20	17:33 (30)	19:53	20	20	08:12 (203)	21:16	21:44				
18	08:26	07:47	17:14 (30)	07:55	17:59 (2)	06:55	07:55 (203)	06:08	05:51	06:52 (204)				
	17:28	18:13	17	17:31 (30)	19:54	20	20	08:13 (203)	21:17	21:44				
19	08:26	07:46	17:17 (30)	07:53	17:59 (2)	06:53	07:56 (203)	06:07	05:51	06:53 (204)				
	17:29	18:15	13	17:30 (30)	19:56	20	20	08:14 (203)	21:18	21:44				
20	08:25	07:44	17:19 (30)	07:51	17:59 (2)	06:51	07:57 (203)	06:06	05:51	06:54 (204)				
	17:31	18:16	8	17:27 (30)	19:57	20	20	08:15 (203)	21:19	21:45				
21	08:24	07:42	17:20 (30)	07:49	17:59 (2)	06:49	07:58 (203)	06:05	05:51	06:55 (204)				
	17:32	18:18		19:58	20:41	20	20	08:16 (203)	21:21	21:45				
22	08:23	07:40	17:48 (2)	07:47	17:59 (2)	06:47	07:59 (203)	06:04	05:51	06:56 (204)				
	17:33	18:19	6	17:54 (2)	20:00	20	20	08:17 (203)	21:22	21:45				
23	08:22	07:39	17:45 (2)	07:45	17:59 (2)	06:46	08:00 (203)	06:03	05:52	06:57 (204)				
	17:35	18:21	11	17:56 (2)	20:01	20	20	08:18 (203)	21:23	21:45				
24	08:21	07:37	17:45 (2)	07:43	17:59 (2)	06:44	08:01 (203)	06:02	05:52	06:58 (204)				
	17:36	18:22	13	17:58 (2)	20:03	20	20	08:19 (203)	21:24	21:45				
25	08:20	07:35	17:43 (2)	07:41	17:59 (2)	06:42	08:02 (203)	06:01	05:52	06:59 (204)				
	17:38	18:24	16	17:59 (2)	20:04	20	20	08:20 (203)	21:25	21:46				
26	08:19	07:33	17:43 (2)	07:39	17:59 (2)	06:40	08:03 (203)	06:00	05:53	07:00 (204)				
	17:39	18:25	16	17:59 (2)	20:05	20	20	08:21 (203)	21:26	21:46				
27	08:18	07:31	17:42 (2)	07:37	17:59 (2)	06:39	08:04 (203)	05:59	05:53	07:01 (204)				
	17:41	18:27	17	17:59 (2)	20:07	20	20	08:22 (203)	21:27	21:46				
28	08:17	07:30	17:42 (2)	07:35	17:59 (2)	06:37	08:05 (203)	05:59	05:53	07:02 (204)				
	17:42	18:28	16	17:58 (2)	20:08	5	5	08:01 (203)	20:51	21:28	18	06:47 (204)		
29	08:16	07:29	17:42 (2)	07:33	17:59 (2)	06:35	08:06 (203)	05:58	05:54	07:03 (204)				
	17:44	18:30	9	17:59 (2)	20:09	9	9	08:03 (203)	20:52	21:29	18	06:47 (204)		
30	08:15	07:28	17:42 (2)	07:31	17:59 (2)	06:34	08:07 (203)	05:57	05:54	07:04 (204)				
	17:45	18:31	11	17:59 (2)	20:11	11	11	08:03 (203)	20:53	21:30	17	06:47 (204)		
31	08:14	07:27	17:42 (2)	07:29	17:59 (2)	06:33	08:08 (203)	05:56	05:54	07:05 (204)				
	17:47	18:32	14	17:59 (2)	20:12	14	14	08:04 (203)	20:54	21:31	16	06:46 (204)		
Potential sun hours	279	287	368	407	466	475	77							
Total, worst case		406	85	148	304	77								
Sun reduction		0.50	0.63	0.59	0.68	0.71								
Oper. time red.		0.97	0.97	0.97	0.97	0.97								
Wind dir. red.		0.59	0.64	0.68	0.58	0.58								
Total reduction		0.28	0.39	0.39	0.38	0.40								
Total, real		115	33	57	117	31								

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

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

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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wind@eapc.net

Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR006 - SR006

Assumptions for shadow calculations

Maximum distance for influence 1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	July	August	September	October	November	December
1	05:55	06:25	07:05	07:44	07:28	16:41 (30) 08:11
	21:45	21:21	20:29	19:30	17:31	22 17:03 (30) 17:00
2	05:56	06:26	07:06	07:46	07:30	16:42 (30) 08:12
	21:45	21:20	20:27	19:28	17:30	21 17:03 (30) 16:59
3	05:56	06:27	07:08	07:47	07:31	16:42 (30) 08:13
	21:45	21:19	20:26	19:26	17:28	20 17:02 (30) 16:59
4	05:57	06:29	07:09	07:48	07:33	16:43 (30) 08:14
	21:45	21:17	20:24	19:24	17:27	18 17:01 (30) 16:59
5	05:58	06:44 (204)	06:30	07:10	07:41 (203)	07:50 16:45 (30) 08:15
	21:44	06:48 (204)	21:16	20:22	16 07:57 (203)	19:22 17:25 15 17:00 (30) 16:58
6	05:58	06:42 (204)	06:31	07:11	07:39 (203)	07:51 07:36 16:46 (30) 08:17
	21:44	06:49 (204)	21:14	20:20	18 07:57 (203)	19:20 17:24 12 16:58 (30) 16:58
7	05:59	06:41 (204)	06:33	07:13	07:38 (203)	07:53 07:37 16:49 (30) 08:18
	21:44	06:50 (204)	21:13	20:18	19 07:57 (203)	19:18 17:23 7 16:56 (30) 16:58
8	06:00	06:41 (204)	06:34	07:14	07:37 (203)	07:54 07:39 08:19
	21:43	06:51 (204)	21:11	20:16	21 07:58 (203)	19:16 17:21 16:58
9	06:01	06:39 (204)	06:35	07:15	07:38 (203)	07:55 07:40 08:20
	21:43	06:52 (204)	21:10	20:14	20 07:58 (203)	19:14 17:20 16:57
10	06:01	06:39 (204)	06:36	07:17	07:39 (203)	07:57 18:20 (2) 07:42 08:21
	21:42	06:53 (204)	21:08	20:12	18 07:57 (203)	19:12 9 18:29 (2) 17:19 16:57
11	06:02	06:39 (204)	06:38	07:18	07:40 (203)	07:58 18:17 (2) 07:43 08:22
	21:42	06:54 (204)	21:07	20:10	16 07:56 (203)	19:10 13 18:30 (2) 17:17 16:57
12	06:03	06:39 (204)	06:39	07:19	07:42 (203)	07:59 18:17 (2) 07:45 08:23
	21:41	06:54 (204)	21:05	20:08	14 07:56 (203)	19:08 14 18:31 (2) 17:16 16:57
13	06:04	06:38 (204)	06:40	07:21	07:43 (203)	08:01 18:15 (2) 07:46 08:23
	21:40	06:55 (204)	21:03	20:06	12 07:55 (203)	19:06 16 18:31 (2) 17:15 16:57
14	06:05	06:38 (204)	06:42	07:22	07:44 (203)	08:02 18:15 (2) 07:48 08:24
	21:40	06:56 (204)	21:02	20:04	9 07:53 (203)	19:04 17 18:32 (2) 17:14 16:58
15	06:06	06:38 (204)	06:43	07:23	07:45 (203)	08:04 18:15 (2) 07:49 08:25
	21:39	06:56 (204)	21:00	20:02	6 07:51 (203)	19:02 16 18:31 (2) 17:13 16:58
16	06:07	06:38 (204)	06:44	07:25	07:47 (203)	08:05 18:15 (2) 07:50 08:26
	21:38	06:57 (204)	20:58	20:00	2 07:49 (203)	19:00 16 18:31 (2) 17:12 16:58
17	06:08	06:38 (204)	06:45	07:26	08:06	18:15 (2) 07:52 08:27
	21:38	06:57 (204)	20:57	19:58	18:57	15 18:30 (2) 17:10 16:58
18	06:09	06:37 (204)	06:47	07:27	08:08	18:16 (2) 07:53 08:27
	21:37	06:57 (204)	20:55	19:56	18:55	13 18:29 (2) 17:09 16:58
19	06:10	06:37 (204)	06:48	07:28	08:09	18:17 (2) 07:55 08:28
	21:36	06:57 (204)	20:53	19:54	18:53	10 18:27 (2) 17:08 16:59
20	06:11	06:38 (204)	06:49	07:30	08:11	18:21 (2) 07:56 08:29
	21:35	06:58 (204)	20:52	19:52	18:51	3 18:24 (2) 17:08 16:59
21	06:12	06:38 (204)	06:51	07:31	08:12	3 18:24 (2) 17:08 08:29
	21:34	06:58 (204)	20:50	19:50	18:50	17:07 08:29
22	06:13	06:39 (204)	06:52	07:32	08:14	17:48 (30) 07:59 08:30
	21:33	06:58 (204)	20:48	19:48	18:48	11 17:59 (30) 17:06 17:00
23	06:14	06:40 (204)	06:53	07:34	08:15	17:46 (30) 08:00 08:30
	21:32	06:58 (204)	20:46	19:46	18:46	14 18:00 (30) 17:05 17:01
24	06:15	06:41 (204)	06:55	07:35	08:17	17:44 (30) 08:02 08:31
	21:31	06:58 (204)	20:44	19:44	18:44	18 18:02 (30) 17:04 17:01
25	06:17	06:42 (204)	06:56	07:36	08:18	17:43 (30) 08:03 08:31
	21:30	06:57 (204)	20:43	19:42	18:43	19 18:02 (30) 17:03 17:02
26	06:18	06:43 (204)	06:57	07:38	08:19	17:42 (30) 08:04 08:31
	21:29	06:57 (204)	20:41	19:40	18:41	22 18:04 (30) 17:03 17:03
27	06:19	06:44 (204)	06:58	07:39	08:21	17:41 (30) 08:06 08:32
	21:28	06:56 (204)	20:39	19:38	18:39	22 18:03 (30) 17:02 17:03
28	06:20	06:45 (204)	07:00	07:40	08:22	17:41 (30) 08:07 08:32
	21:26	06:56 (204)	20:37	19:36	18:38	23 18:04 (30) 17:01 17:04
29	06:21	06:46 (204)	07:01	07:42	08:24	17:41 (30) 08:08 08:32
	21:25	06:55 (204)	20:35	19:34	18:36	24 18:05 (30) 17:01 17:05
30	06:23	06:47 (204)	07:02	07:43	08:25	17:41 (30) 08:10 08:32
	21:24	06:53 (204)	20:33	19:32	18:35	23 18:04 (30) 17:00 17:06
31	06:24	06:49 (204)	07:04	07:44	08:27	17:41 (30) 08:32 08:32
	21:23	06:52 (204)	20:31	19:31	18:33	23 18:04 (30) 17:06 17:06
Potential sun hours	480	441	378	338	282	266
Total, worst case	382		190	341	115	
Sun reduction	0.76		0.69	0.52	0.43	
Oper. time red.	0.97		0.97	0.97	0.97	
Wind dir. red.	0.58		0.68	0.59	0.58	
Total reduction	0.43		0.45	0.30	0.24	
Total, real	164		86	102	28	

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)

Project:

Minnesota Power - BISON Wind Energy Center

Description:

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wind@eapc.net

Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR007 - SR007

Assumptions for shadow calculations

Maximum distance for influence 1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:32	08:12	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	07:28	08:11
	17:08	17:48	18:29	20:13	20:55	21:32	21:45	21:21	20:29	19:29	17:31	17:00
2	08:32	08:11	07:26	07:25	06:30	05:55	05:55	06:26	07:06	07:46	07:30	08:12
	17:08	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:27	19:27	17:30	16:59
3	08:32	08:10	07:24	07:23	06:29	05:54	05:56	06:27	07:07	07:47	07:31	08:13
	17:09	17:51	18:32	20:16	20:57	21:34	21:45	21:18	20:25	19:25	17:28	16:59
4	08:32	08:08	07:22	07:21	06:27	05:54	05:57	06:29	07:09	07:48	07:33	08:14
	17:10	17:53	18:34	20:18	20:59	21:35	21:45	21:17	20:23	19:23	17:27	16:58
5	08:32	08:07	07:20	07:19	06:26	05:53	05:57	06:30	07:10	07:50	07:34	08:15
	17:12	17:54	18:35	20:19	21:00	21:36	21:44	21:16	20:22	19:21	17:25	16:58
6	08:32	08:06	07:18	07:17	06:24	05:53	05:58	06:31	07:11	07:51	07:36	08:16
	17:13	17:56	18:37	20:20	21:01	21:37	21:44	21:14	20:20	19:19	17:24	16:58
7	08:32	08:04	07:16	07:15	06:23	05:53	05:59	06:32	07:13	07:52	07:37	08:18
	17:14	17:58	18:38	20:22	21:03	21:37	21:44	21:13	20:18	19:18	17:23	16:58
8	08:31	08:03	08:14	07:13	06:21	05:52	06:00	06:34	07:14	07:54	07:39	08:19
	17:15	17:59	18:40	20:23	21:04	21:38	21:43	21:11	20:16	19:16	17:21	16:57
9	08:31	08:01	08:12	07:11	06:20	05:52	06:00	06:35	07:15	07:55	07:40	08:20
	17:16	18:01	19:41	20:25	21:05	21:39	21:43	21:10	20:14	19:14	17:20	16:57
10	08:31	08:00	08:10	07:09	06:18	05:52	06:01	06:36	07:17	07:57	07:41	08:21
	17:17	18:01	19:43	20:26	21:07	21:40	21:42	21:08	20:12	19:12	17:19	16:57
11	08:30	07:58	08:09	07:07	06:17	05:51	06:02	06:38	07:18	07:58	07:43	08:22
	17:18	18:02	19:44	20:27	21:08	21:40	21:42	21:07	20:10	19:10	17:17	16:57
12	08:30	07:57	08:07	07:06	06:16	05:51	06:03	06:39	07:19	07:59	07:44	08:22
	17:20	18:04	19:45	20:29	21:09	21:41	21:41	21:05	20:08	19:08	17:16	16:57
13	08:29	07:55	17:38 (206)	08:05	07:04	06:14	05:51	06:04	06:40	07:20	08:01	08:23
	17:21	18:05	4 17:42 (206)	19:47	20:30	21:11	21:41	21:40	21:03	20:06	19:06	17:15
14	08:29	07:54	17:37 (206)	08:03	07:02	06:13	05:51	06:05	06:41	07:22	08:02	08:24
	17:22	18:07	6 17:43 (206)	19:48	20:31	21:12	21:42	21:40	21:02	20:04	19:04	18:22 (206)
15	08:28	07:52	17:35 (206)	08:01	07:00	06:12	05:51	06:06	06:43	07:23	08:03	18:11 (206)
	17:24	18:08	9 17:44 (206)	19:50	20:33	21:13	21:42	21:39	21:00	20:02	19:02	18:25 (206)
16	08:28	07:50	17:35 (206)	07:59	06:58	06:11	05:51	06:07	06:44	07:24	08:05	18:09 (206)
	17:25	18:10	12 17:47 (206)	19:51	20:34	21:14	21:43	21:38	20:58	20:00	19:00	18:27 (206)
17	08:27	07:49	17:34 (206)	07:57	06:56	06:09	05:51	06:08	06:45	07:26	08:06	18:07 (206)
	17:26	18:11	14 17:48 (206)	19:53	20:36	21:16	21:43	21:37	20:57	19:58	18:57	20 18:27 (206)
18	08:26	07:47	17:34 (206)	07:55	06:54	06:08	05:51	06:09	06:47	07:27	08:08	18:05 (206)
	17:28	18:13	15 17:49 (206)	19:54	20:37	21:17	21:44	21:37	20:55	19:56	18:55	23 18:28 (206)
19	08:25	07:45	17:33 (206)	07:53	06:53	06:07	05:51	06:10	06:48	07:28	08:09	18:05 (206)
	17:29	18:14	18 17:51 (206)	19:55	20:38	21:18	21:44	21:36	20:53	19:54	18:53	23 18:28 (206)
20	08:25	07:44	17:34 (206)	07:51	06:51	06:06	05:51	06:11	06:49	07:30	08:11	18:04 (206)
	17:31	18:16	19 17:53 (206)	19:57	20:40	21:19	21:44	21:35	20:51	19:52	18:51	22 18:26 (206)
21	08:24	07:42	17:34 (206)	07:49	06:49	06:05	05:51	06:12	06:50	07:31	08:12	18:04 (206)
	17:32	18:18	20 17:54 (206)	19:58	20:41	21:20	21:45	21:34	20:50	19:49	18:49	20 18:24 (206)
22	08:23	07:40	17:34 (206)	07:47	06:47	06:04	05:51	06:13	06:52	07:32	08:13	18:04 (206)
	17:33	18:19	22 17:56 (206)	20:00	20:42	21:22	21:45	21:33	20:48	19:47	18:48	19 18:23 (206)
23	08:22	07:38	17:34 (206)	07:45	06:45	06:03	05:52	06:14	06:53	07:34	08:15	18:04 (206)
	17:35	18:21	23 17:57 (206)	20:01	20:44	21:23	21:45	21:32	20:46	19:45	18:46	17 18:21 (206)
24	08:21	07:37	17:35 (206)	07:43	06:44	06:02	05:52	06:15	06:54	07:35	08:16	18:04 (206)
	17:36	18:22	22 17:57 (206)	20:02	20:45	21:24	21:45	21:31	20:44	19:43	18:44	15 18:19 (206)
25	08:20	07:35	17:36 (206)	07:41	06:42	06:01	05:52	06:17	06:56	07:36	08:18	18:04 (206)
	17:38	18:24	19 17:55 (206)	20:04	20:47	21:25	21:45	21:30	20:42	19:41	18:43	13 18:17 (206)
26	08:19	07:33	17:37 (206)	07:39	06:40	06:00	05:53	06:18	06:57	07:38	08:19	18:05 (206)
	17:39	18:25	17 17:54 (206)	20:05	20:48	21:26	21:46	21:29	20:41	19:39	18:41	11 18:16 (206)
27	08:18	07:31	17:39 (206)	07:37	06:39	05:59	05:53	06:19	06:58	07:39	08:21	18:05 (206)
	17:41	18:27	12 17:51 (206)	20:07	20:49	21:27	21:46	21:27	20:39	19:37	18:39	8 18:13 (206)
28	08:17	07:29	17:44 (206)	07:35	06:37	05:59	05:53	06:20	07:00	07:40	08:22	18:06 (206)
	17:42	18:28	2 17:46 (206)	20:08	20:51	21:28	21:46	21:26	20:37	19:35	18:38	6 18:12 (206)
29	08:16		07:33	06:35	05:58	05:54	06:21	07:01	07:42	08:24	18:07 (206)	
	17:44		20:09	20:52	21:29	21:45	21:25	20:35	19:33	18:36	3 18:10 (206)	
30	08:15		07:31	06:34	05:57	05:54	06:22	07:02	07:43	08:25	18:08 (206)	
	17:45		20:11	20:53	21:30	21:45	21:24	20:33	19:31	18:34	17:00	
31	08:13		07:29		05:56		06:24	07:04		08:27		
	17:47		20:12		21:31		21:22	20:31		18:33		
Potential sun hours	279	287	368	407	466	475	480	441	378	338	282	266
Total, worst case		234								240		
Sun reduction		0.50								0.52		
Oper. time red.		0.97								0.97		
Wind dir. red.		0.60								0.60		
Total reduction		0.29								0.30		
Total, real		68								73		

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

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

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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 wind@eapc.net
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SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR008 - SR008

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:32	08:12	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	07:28	08:11
	17:08	17:49	18:30	20:14	20:55	21:32	21:45	21:21	20:29	19:29	17:31	17:00
2	08:32	08:11	07:26	07:25	06:31	05:55	05:56	06:26	07:06	07:46	07:30	08:12
	17:09	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:27	19:28	17:30	16:59
3	08:32	08:10	07:24	07:23	06:29	05:55	05:56	06:28	07:08	07:47	07:31	08:13
	17:10	17:52	18:33	20:16	20:57	21:34	21:45	21:18	20:25	19:26	17:28	16:59
4	08:32	08:08	07:22	07:21	06:27	05:54	05:57	06:29	07:09	07:48	07:33	08:14
	17:11	17:53	18:34	20:18	20:59	21:35	21:45	21:17	20:24	19:24	17:27	16:59
5	08:32	08:07	07:20	07:19	06:26	05:54	05:58	06:30	07:10	07:50	07:34	08:15
	17:12	17:55	18:35	20:19	21:00	21:36	21:44	21:16	20:22	19:22	17:26	16:58
6	08:32	08:06	07:18	07:17	06:24	05:53	05:58	06:31	07:11	07:51	07:36	08:16
	17:13	17:56	18:37	20:20	21:01	21:37	21:44	21:14	20:20	19:20	17:24	16:58
7	08:32	08:04	07:16	07:15	06:23	05:53	05:59	06:33	07:13	07:52	07:37	08:17
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8	08:31	08:03	08:14	07:13	06:21	05:52	06:00	06:34	07:14	07:54	07:39	08:19
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15	08:28	07:52	08:01	07:00	06:12	05:51	06:06	06:43	07:23	08:04	07:49	08:25
	17:24	18:09	19:50	20:33	21:13	21:42	21:39	21:00	20:02	19:02	17:13	16:58
16	08:28	07:50	07:59	06:58	06:11	05:51	06:07	06:44	07:25	08:05	07:50	08:26
	17:25	18:10	19:51	20:34	21:14	21:43	21:38	20:58	20:00	19:00	17:12	16:58
17	08:27	07:49	07:57	06:56	06:10	05:51	06:08	06:45	07:26	08:06	07:52	08:26
	17:27	18:12	19:53	20:36	21:16	21:43	21:37	20:57	19:58	18:57	17:11	16:58
18	08:26	07:47	07:55	06:55	06:09	05:51	06:09	06:47	07:27	08:08	07:53	08:27
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19	08:25	07:45	07:53	06:53	06:07	05:51	06:10	06:48	07:28	08:09	07:55	08:28
	17:29	18:15	19:56	20:38	21:18	21:44	21:36	20:53	19:54	18:53	17:09	16:59
20	08:25	07:44	07:51	06:51	06:06	05:51	06:11	06:49	07:30	08:11	07:56	08:28
	17:31	18:16	19:57	20:40	21:19	21:44	21:35	20:51	19:52	18:51	17:08	16:59
21	08:24	07:42	07:49	06:49	06:05	05:51	06:12	06:51	07:31	08:12	07:57	08:29
	17:32	18:18	19:58	20:41	21:20	21:45	21:34	20:50	19:50	18:50	17:07	17:00
22	08:23	07:40	07:47	06:47	06:04	05:52	06:13	06:52	07:32	08:14	07:59	08:29
	17:34	18:19	20:00	20:42	21:22	21:45	21:33	20:48	19:48	18:48	17:06	17:00
23	08:22	07:38	07:45	06:46	06:03	05:52	06:14	06:53	07:34	08:15	08:00	08:30
	17:35	18:21	20:01	20:44	21:23	21:45	21:32	20:46	19:46	18:46	17:05	17:01
24	08:21	07:37	07:43	06:44	06:02	05:52	06:16	06:55	07:35	08:16	08:02	08:30
	17:36	18:22	20:02	20:45	21:24	21:45	21:31	20:44	19:44	18:44	17:04	17:01
25	08:20	07:35	07:41	06:42	06:01	05:52	06:17	06:56	07:36	08:18	08:03	08:31
	17:38	18:24	20:04	20:47	21:25	21:45	21:30	20:42	19:42	18:43	17:03	17:02
26	08:19	07:33	07:39	06:40	06:00	05:53	06:18	06:57	07:38	08:19	08:04	08:31
	17:39	18:25	20:05	20:48	21:26	21:45	21:28	20:41	19:40	18:41	17:03	17:03
27	08:18	07:31	07:37	06:39	06:00	05:53	06:19	06:58	07:39	08:21	08:06	08:31
	17:41	18:27	20:07	20:49	21:27	21:45	21:27	20:39	19:37	18:39	17:02	17:03
28	08:17	07:29	07:35	06:37	05:59	05:54	06:20	07:00	07:40	08:22	08:07	08:32
	17:42	18:28	20:08	20:51	21:28	21:45	21:26	20:37	19:35	18:38	17:01	17:04
29	08:16		07:33	06:35	05:58	05:54	06:21	07:01	07:42	08:24	08:08	08:32
	17:44		20:09	20:52	21:29	21:45	21:25	20:35	19:33	18:36	17:01	17:05
30	08:15		07:31	06:34	05:57	05:55	06:23	07:02	07:43	08:25	08:09	08:32
	17:45		20:11	20:53	21:30	21:45	21:24	20:33	19:31	18:35	17:00	17:06
31	08:13		07:29		05:57		06:24	07:04		08:27		08:32
	17:47		20:12		21:31		21:22	20:31		18:33		17:07
Potential sun hours	279	287	368	407	466	474	480	441	378	338	282	266
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)	Minutes with flicker	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)		Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project: **Minnesota Power - BISON Wind Energy Center**

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR009 - SR009

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:32	08:12	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	07:28	08:11
	17:08	17:49	18:30	20:14	20:55	21:32	21:45	21:21	20:29	19:30	17:31	17:00
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	17:09	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:27	19:28	17:30	16:59
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10	08:31	08:00	08:11	07:10	06:19	05:52	06:02	06:36	07:17	07:57	07:41	08:21
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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)	Minutes with flicker	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)		Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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6/21/2011 8:44 AM / 17

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wind@eapc.net

Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR010 - SR010

Assumptions for shadow calculations

Maximum distance for influence

1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:32	08:12	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	07:28	08:11
	17:08	17:49	18:30	20:14	20:55	21:32	21:45	21:21	20:29	19:30	17:31	17:00
2	08:32	08:11	07:26	07:25	06:31	05:55	05:56	06:26	07:06	07:46	07:30	08:12
	17:09	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:27	19:28	17:30	16:59
3	08:32	08:10	07:24	07:23	06:29	05:55	05:56	06:28	07:08	07:47	07:31	08:13
	17:10	17:52	18:33	20:16	20:57	21:34	21:45	21:18	20:25	19:26	17:28	16:59
4	08:32	08:08	07:22	07:21	06:27	05:54	05:57	06:29	07:09	07:48	07:33	08:14
	17:11	17:53	18:34	20:18	20:59	21:35	21:45	21:17	20:24	19:24	17:27	16:59
5	08:32	08:07	07:20	07:19	06:26	05:54	05:58	06:30	07:10	07:50	07:34	08:15
	17:12	17:55	18:36	20:19	21:00	21:36	21:44	21:16	20:22	19:22	17:26	16:58
6	08:32	08:06	07:18	07:17	06:24	05:53	05:58	06:31	07:12	07:51	07:36	08:16
	17:13	17:56	18:37	20:20	21:01	21:36	21:44	21:14	20:20	19:20	17:24	16:58
7	08:32	08:04	07:16	07:15	06:23	05:53	05:59	06:33	07:13	07:52	07:37	08:17
	17:14	17:58	18:38	20:22	21:03	21:37	21:43	21:13	20:18	19:18	17:23	16:58
8	08:31	08:03	08:14	07:13	06:22	05:52	06:00	06:34	07:14	07:54	07:39	08:18
	17:15	17:59	18:40	20:23	21:04	21:38	21:43	21:11	20:16	19:16	17:21	16:58
9	08:31	08:01	08:12	07:11	06:20	05:52	06:01	06:35	07:15	07:55	07:40	08:20
	17:16	18:01	19:41	20:25	21:05	21:39	21:43	21:10	20:14	19:14	17:20	16:58
10	08:31	08:00	08:11	07:10	06:19	05:52	06:02	06:36	07:17	07:57	07:41	08:20
	17:18	18:01	19:43	20:26	21:07	21:39	21:42	21:08	20:12	19:12	17:19	16:58
11	08:30	07:58	08:09	07:08	06:17	05:52	06:02	06:38	07:18	07:58	07:43	08:21
	17:19	18:02	19:44	20:27	21:08	21:40	21:41	21:07	20:10	19:10	17:18	16:57
12	08:30	07:57	08:07	07:06	06:16	05:51	06:03	06:39	07:19	07:59	07:44	08:22
	17:20	18:04	19:46	20:29	21:09	21:41	21:41	21:05	20:08	19:08	17:16	16:58
13	08:29	07:55	08:05	07:04	06:15	05:51	06:04	06:40	07:21	08:01	07:46	08:23
	17:21	18:06	19:47	20:30	21:11	21:41	21:40	21:03	20:06	19:06	17:15	16:58
14	08:29	07:54	08:03	07:02	06:13	05:51	06:05	06:42	07:22	08:02	07:47	08:24
	17:23	18:07	19:48	20:31	21:12	21:42	21:40	21:02	20:04	19:04	17:14	16:58
15	08:28	07:52	08:01	07:00	06:12	05:51	06:06	06:43	07:23	08:04	07:49	08:25
	17:24	18:09	19:50	20:33	21:13	21:42	21:39	21:00	20:02	19:02	17:13	16:58
16	08:28	07:50	07:59	06:58	06:11	05:51	06:07	06:44	07:25	08:05	07:50	08:26
	17:25	18:10	19:51	20:34	21:14	21:43	21:38	20:58	20:00	19:01	17:12	16:58
17	08:27	07:49	07:57	06:56	06:10	05:51	06:08	06:45	07:26	08:06	07:52	08:26
	17:27	18:12	19:53	20:36	21:16	21:43	21:37	20:57	19:58	18:57	17:11	16:58
18	08:26	07:47	07:55	06:55	06:09	05:51	06:09	06:47	07:27	08:08	07:53	08:27
	17:28	18:13	19:54	20:37	21:17	21:44	21:36	20:55	19:56	18:55	17:10	16:59
19	08:25	07:45	07:53	06:53	06:07	05:51	06:10	06:48	07:28	08:09	07:55	08:28
	17:29	18:15	19:56	20:38	21:18	21:44	21:36	20:53	19:54	18:53	17:09	16:59
20	08:25	07:44	07:51	06:51	06:06	05:51	06:11	06:49	07:30	08:11	07:56	08:28
	17:31	18:16	19:57	20:40	21:19	21:44	21:35	20:51	19:52	18:51	17:08	16:59
21	08:24	07:42	07:49	06:49	06:05	05:51	06:12	06:51	07:31	08:12	07:57	08:29
	17:32	18:18	19:58	20:41	21:20	21:45	21:34	20:50	19:50	18:50	17:07	17:00
22	08:23	07:40	07:47	06:47	06:04	05:52	06:13	06:52	07:32	08:14	07:59	08:29
	17:34	18:19	20:00	20:42	21:22	21:45	21:33	20:48	19:48	18:48	17:06	17:00
23	08:22	07:38	07:45	06:46	06:03	05:52	06:15	06:53	07:34	08:15	08:00	08:30
	17:35	18:21	20:01	20:44	21:23	21:45	21:32	20:46	19:46	18:46	17:05	17:01
24	08:21	07:37	07:43	06:44	06:02	05:52	06:16	06:55	07:35	08:16	08:01	08:30
	17:37	18:22	20:02	20:45	21:24	21:45	21:31	20:44	19:44	18:44	17:04	17:01
25	08:20	07:35	07:41	06:42	06:01	05:52	06:17	06:56	07:36	08:18	08:03	08:31
	17:38	18:24	20:04	20:47	21:25	21:45	21:30	20:42	19:42	18:43	17:03	17:02
26	08:19	07:33	07:39	06:40	06:00	05:53	06:18	06:57	07:38	08:19	08:04	08:31
	17:40	18:25	20:05	20:48	21:26	21:45	21:28	20:41	19:40	18:41	17:03	17:03
27	08:18	07:31	07:37	06:39	06:00	05:53	06:19	06:58	07:39	08:21	08:05	08:31
	17:41	18:27	20:07	20:49	21:27	21:45	21:27	20:39	19:38	18:39	17:02	17:03
28	08:17	07:29	07:35	06:37	05:59	05:54	06:20	07:00	07:40	08:22	08:07	08:32
	17:42	18:28	20:08	20:51	21:28	21:45	21:26	20:37	19:36	18:38	17:01	17:04
29	08:16	07:33	07:35	06:35	05:58	05:54	06:21	07:01	07:42	08:24	08:08	08:32
	17:44	20:09	20:52	21:29	21:45	21:45	21:25	20:35	19:34	18:36	17:01	17:05
30	08:15	07:31	07:31	06:34	05:57	05:55	06:23	07:02	07:43	08:25	08:09	08:32
	17:46	20:11	20:53	21:30	21:45	21:45	21:24	20:33	19:32	18:35	17:00	17:06
31	08:13	07:29	07:29	06:31	05:57	05:57	06:24	07:04	07:45	08:27	08:11	08:32
	17:47	20:12	20:12	21:31	21:31	21:31	21:22	20:31	19:30	18:33	17:00	17:07
Potential sun hours	279	288	368	407	466	474	480	441	378	338	282	267
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)	Minutes with flicker	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)		Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR011 - SR011

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December			
1	08:32	16:11 (208)	08:12	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	08:11			
15	17:08	16:26 (208)	17:49	18:30	20:14	20:55	21:32	21:45	21:21	20:29	19:30	17:32	17:00		
2	08:32	16:12 (208)	08:11	07:26	07:25	06:31	05:55	05:56	06:26	07:06	07:46	08:12			
14	17:09	16:26 (208)	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:27	19:28	17:30	17:00		
3	08:32	16:12 (208)	08:10	07:24	07:23	06:29	05:55	05:56	06:28	07:08	07:47	08:13			
13	17:10	16:25 (208)	17:52	18:33	20:16	20:57	21:34	21:45	21:18	20:26	19:26	17:29	16:59		
4	08:32	16:13 (208)	08:08	07:22	07:21	06:28	05:54	05:57	06:29	07:09	07:48	08:14			
12	17:11	16:25 (208)	17:53	18:34	20:18	20:59	21:35	21:45	21:17	20:24	19:24	17:27	16:59		
5	08:32	16:15 (208)	08:07	07:20	07:19	06:26	05:54	05:58	06:30	07:10	07:50	08:15	16:04 (208)		
11	17:12	16:25 (208)	17:55	18:36	20:19	21:00	21:36	21:44	21:16	20:22	19:22	17:26	16:58	5	16:09 (208)
6	08:32	16:17 (208)	08:06	07:18	07:17	06:25	05:53	05:59	06:31	07:12	07:51	08:16	16:03 (208)		
10	17:13	16:25 (208)	17:56	18:37	20:21	21:01	21:37	21:44	21:14	20:20	19:20	17:24	16:58	8	16:11 (208)
7	08:32	16:18 (208)	08:04	07:16	07:15	06:23	05:53	05:59	06:33	07:13	07:53	08:18	16:02 (208)		
17	17:14	16:23 (208)	17:58	18:39	20:22	21:03	21:37	21:44	21:13	20:18	19:18	17:23	16:58	10	16:12 (208)
8	08:31	08:03	08:15	07:13	06:22	05:53	06:00	06:34	07:14	07:54	08:39	08:19	16:02 (208)		
16	17:15	17:59	18:40	20:23	21:04	21:38	21:43	21:11	20:16	19:16	17:21	16:58	11	16:13 (208)	
9	08:31	08:01	08:13	07:12	06:20	05:52	06:01	06:35	07:15	07:55	08:40	08:20	16:01 (208)		
15	17:16	18:01	19:41	20:25	21:05	21:39	21:43	21:10	20:14	19:14	17:20	16:58	13	16:14 (208)	
10	08:31	08:00	08:11	07:10	06:19	05:52	06:02	06:37	07:17	07:57	08:42	08:21	16:01 (208)		
18	17:18	18:01	19:43	20:26	21:07	21:40	21:42	21:08	20:12	19:12	17:19	16:58	14	16:15 (208)	
11	08:30	07:58	08:09	07:08	06:17	05:52	06:03	06:38	07:18	07:58	08:43	08:22	16:01 (208)		
17	17:19	18:02	19:44	20:27	21:08	21:40	21:42	21:07	20:10	19:10	17:18	16:58	15	16:16 (208)	
12	08:30	07:57	08:07	07:06	06:16	05:51	06:03	06:39	07:19	07:59	08:44	08:22	16:01 (208)		
19	17:20	18:04	19:46	20:29	21:09	21:41	21:41	21:05	20:08	19:08	17:16	16:58	16	16:17 (208)	
13	08:29	07:55	08:05	07:04	06:15	05:51	06:04	06:40	07:21	08:01	08:46	08:23	16:02 (208)		
17	17:21	18:06	19:47	20:30	21:11	21:41	21:40	21:03	20:06	19:06	17:15	16:58	16	16:18 (208)	
14	08:29	07:54	08:03	07:02	06:13	05:51	06:05	06:42	07:22	08:02	08:47	08:24	16:01 (208)		
16	17:23	18:07	19:49	20:32	21:12	21:42	21:40	21:02	20:04	19:04	17:14	16:58	17	16:18 (208)	
15	08:28	07:52	08:01	07:00	06:12	05:51	06:06	06:43	07:23	08:04	08:49	08:25	16:02 (208)		
17	17:24	18:09	19:50	20:33	21:13	21:42	21:39	21:00	20:02	19:02	17:13	16:58	16	16:18 (208)	
16	08:28	07:50	07:59	06:58	06:11	05:51	06:07	06:44	07:25	08:05	08:50	08:26	16:02 (208)		
17	17:25	18:10	19:51	20:34	21:14	21:43	21:38	20:58	20:00	19:01	17:12	16:58	17	16:19 (208)	
17	08:27	07:49	07:57	06:56	06:10	05:51	06:08	06:46	07:26	08:06	08:52	08:26	16:03 (208)		
18	17:27	18:12	19:53	20:36	21:16	21:43	21:37	20:57	19:58	18:57	17:11	16:58	17	16:20 (208)	
18	08:26	07:47	07:55	06:55	06:09	05:51	06:09	06:47	07:27	08:08	08:53	08:27	16:02 (208)		
17	17:28	18:13	19:54	20:37	21:17	21:44	21:37	20:55	19:56	18:55	17:10	16:59	18	16:20 (208)	
19	08:26	07:45	07:53	06:53	06:07	05:51	06:10	06:48	07:29	08:09	08:55	08:28	16:03 (208)		
17	17:29	18:15	19:56	20:38	21:18	21:44	21:36	20:53	19:54	18:53	17:09	16:59	18	16:21 (208)	
20	08:25	07:44	07:51	06:51	06:06	05:51	06:11	06:49	07:30	08:11	08:56	08:28	16:04 (208)		
21	17:31	18:16	19:57	20:40	21:19	21:44	21:35	20:52	19:52	18:52	17:08	16:59	18	16:22 (208)	
21	08:24	07:42	07:49	06:49	06:05	05:51	06:12	06:51	07:31	08:12	08:57	08:29	16:04 (208)		
17	17:32	18:18	19:58	20:41	21:20	21:45	21:34	20:50	19:50	18:50	17:07	17:00	18	16:22 (208)	
22	08:23	07:40	07:47	06:47	06:04	05:52	06:13	06:52	07:32	08:14	08:59	08:30	16:05 (208)		
17	17:34	18:19	20:00	20:43	21:22	21:45	21:33	20:48	19:48	18:48	17:06	17:00	18	16:23 (208)	
23	08:22	07:39	07:45	06:46	06:03	05:52	06:15	06:53	07:34	08:15	08:00	08:30	16:05 (208)		
17	17:35	18:21	20:01	20:44	21:23	21:45	21:32	20:46	19:46	18:46	17:05	17:01	18	16:23 (208)	
24	08:21	07:37	07:43	06:44	06:02	05:52	06:16	06:55	07:35	08:16	08:02	08:30	16:05 (208)		
17	17:37	18:22	20:03	20:45	21:24	21:45	21:31	20:44	19:44	18:45	17:04	17:01	18	16:23 (208)	
25	08:20	07:35	07:41	06:42	06:01	05:53	06:17	06:56	07:36	08:18	08:03	08:31	16:06 (208)		
17	17:38	18:24	20:04	20:47	21:25	21:45	21:30	20:43	19:42	18:43	17:04	17:02	18	16:24 (208)	
26	08:19	07:33	07:39	06:41	06:01	05:53	06:18	06:57	07:38	08:19	08:04	08:31	16:07 (208)		
17	17:40	18:25	20:05	20:48	21:26	21:46	21:29	20:41	19:40	18:41	17:03	17:03	17	16:24 (208)	
27	08:18	07:31	07:37	06:39	06:00	05:53	06:19	06:59	07:39	08:21	08:06	08:31	16:07 (208)		
17	17:41	18:27	20:07	20:49	21:27	21:46	21:27	20:39	19:38	18:40	17:02	17:03	17	16:24 (208)	
28	08:17	07:30	07:35	06:37	05:59	05:54	06:20	07:00	07:40	08:22	08:07	08:32	16:07 (208)		
17	17:43	18:28	20:08	20:51	21:28	21:46	21:26	20:37	19:36	18:38	17:02	17:04	17	16:24 (208)	
29	08:16	07:33	07:38	06:35	05:58	05:54	06:22	07:01	07:42	08:24	08:08	08:32	16:09 (208)		
17	17:44	18:29	20:10	20:52	21:29	21:46	21:25	20:35	19:34	18:36	17:01	17:05	16	16:25 (208)	
30	08:15	07:31	06:34	05:57	05:55	06:23	07:02	07:43	08:25	08:09	08:32	16:10 (208)			
17	17:46	18:31	20:11	20:53	21:30	21:45	21:24	20:33	19:32	18:35	17:00	17:06	16	16:26 (208)	
31	08:14	07:29	06:32	05:57	05:57	06:24	07:04	07:45	08:27	08:11	08:32	16:10 (208)			
17	17:47	18:32	20:12	20:54	21:31	21:45	21:22	20:31	19:30	18:33	17:01	17:07	16	16:26 (208)	
Potential sun hours	279	288	368	407	466	474	480	441	378	338	282	266	418		
Total, worst case													0.43		
Sun reduction													0.97		
Oper. time red.													0.53		
Wind dir. red.													0.53		
Total reduction													0.22		
Total, real													92		

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

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

Project: **Minnesota Power - BISON Wind Energy Center**

Description: EAPC does not warrant, guarantee, or make any such representations regarding the contents of this report. EAPC cannot be held liable for erroneous results caused by errors or omissions in the delivered data, or inaccuracy, limitations, or malfunctioning of models or software used. For any claim whatsoever related to the subject matter of this report, the liability of EAPC for actual damages, regardless of the form of action, shall be limited to the total amount paid to EAPC for the services provided as part of this consultancy service.

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 Calculated: 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR012 - SR012

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:32	08:12	07:28	07:27	06:32	05:56	05:55	06:25	07:05	07:44	07:28	08:11
	17:08	17:49	18:30	20:14	20:55	21:32	21:45	21:21	20:29	19:30	17:32	17:00
2	08:32	08:11	07:26	07:25	06:31	05:56	05:56	06:27	07:06	07:46	07:30	08:12
	17:09	17:50	18:31	20:15	20:56	21:33	21:45	21:20	20:27	19:28	17:30	17:00
3	08:32	08:10	07:24	07:23	06:29	05:55	05:57	06:28	07:08	07:47	07:31	08:13
	17:10	17:52	18:33	20:16	20:57	21:34	21:45	21:18	20:26	19:26	17:29	16:59
4	08:32	08:08	07:22	07:21	06:28	05:54	05:57	06:29	07:09	07:48	07:33	08:14
	17:11	17:53	18:34	20:18	20:59	21:35	21:44	21:17	20:24	19:24	17:27	16:59
5	08:32	08:07	07:20	07:19	06:26	05:54	05:58	06:30	07:10	07:50	07:34	08:15
	17:12	17:55	18:36	20:19	21:00	21:36	21:44	21:16	20:22	19:22	17:26	16:59
6	08:32	08:06	07:18	07:17	06:25	05:53	05:59	06:32	07:12	07:51	07:36	08:16
	17:13	17:56	18:37	20:21	21:01	21:36	21:44	21:14	20:20	19:20	17:24	16:58
7	08:32	08:04	07:16	07:15	06:23	05:53	05:59	06:33	07:13	07:53	07:37	08:17
	17:14	17:58	18:39	20:22	21:03	21:37	21:43	21:13	20:18	19:18	17:23	16:58
8	08:31	08:03	08:14	07:14	06:22	05:53	06:00	06:34	07:14	07:54	07:39	08:18
	17:15	17:59	18:40	20:23	21:04	21:38	21:43	21:11	20:16	19:16	17:22	16:58
9	08:31	08:01	08:13	07:12	06:20	05:52	06:01	06:35	07:16	07:55	07:40	08:19
	17:16	18:01	19:41	20:25	21:05	21:39	21:43	21:10	20:14	19:14	17:20	16:58
10	08:31	08:00	08:11	07:10	06:19	05:52	06:02	06:37	07:17	07:57	07:41	08:20
	17:18	18:01	19:43	20:26	21:07	21:39	21:42	21:08	20:12	19:12	17:19	16:58
11	08:30	07:58	08:09	07:08	06:17	05:52	06:03	06:38	07:18	07:58	07:43	08:21
	17:19	18:03	19:44	20:27	21:08	21:40	21:41	21:07	20:10	19:10	17:18	16:58
12	08:30	07:57	08:07	07:06	06:16	05:52	06:04	06:39	07:19	07:59	07:44	08:22
	17:20	18:04	19:46	20:29	21:09	21:41	21:41	21:05	20:08	19:08	17:16	16:58
13	08:29	07:55	08:05	07:04	06:15	05:51	06:04	06:40	07:21	08:01	07:46	08:23
	17:21	18:06	19:47	20:30	21:11	21:41	21:40	21:03	20:06	19:06	17:15	16:58
14	08:29	07:54	08:03	07:02	06:14	05:51	06:05	06:42	07:22	08:02	07:47	08:24
	17:23	18:07	19:49	20:32	21:12	21:42	21:40	21:02	20:04	19:04	17:14	16:58
15	08:28	07:52	08:01	07:00	06:12	05:51	06:06	06:43	07:23	08:04	07:49	08:25
	17:24	18:09	19:50	20:33	21:13	21:42	21:39	21:00	20:02	19:02	17:13	16:58
16	08:28	07:50	07:59	06:58	06:11	05:51	06:07	06:44	07:25	08:05	07:50	08:26
	17:25	18:10	19:51	20:34	21:14	21:43	21:38	20:58	20:00	19:01	17:12	16:58
17	08:27	07:49	07:57	06:57	06:10	05:51	06:08	06:46	07:26	08:06	07:52	08:26
	17:27	18:12	19:53	20:36	21:16	21:43	21:37	20:57	19:58	18:57	17:11	16:59
18	08:26	07:47	07:55	06:55	06:09	05:51	06:09	06:47	07:27	08:08	07:53	08:27
	17:28	18:13	19:54	20:37	21:17	21:44	21:36	20:55	19:56	18:55	17:10	16:59
19	08:25	07:45	07:53	06:53	06:08	05:51	06:10	06:48	07:29	08:09	07:55	08:28
	17:30	18:15	19:56	20:38	21:18	21:44	21:36	20:53	19:54	18:53	17:09	16:59
20	08:25	07:44	07:51	06:51	06:07	05:51	06:11	06:50	07:30	08:11	07:56	08:28
	17:31	18:16	19:57	20:40	21:19	21:44	21:35	20:51	19:52	18:52	17:08	17:00
21	08:24	07:42	07:49	06:49	06:05	05:52	06:12	06:51	07:31	08:12	07:57	08:29
	17:32	18:18	19:58	20:41	21:20	21:45	21:34	20:50	19:50	18:50	17:07	17:00
22	08:23	07:40	07:47	06:48	06:04	05:52	06:14	06:52	07:32	08:14	07:59	08:29
	17:34	18:19	20:00	20:42	21:22	21:45	21:33	20:48	19:48	18:48	17:06	17:00
23	08:22	07:39	07:45	06:46	06:03	05:52	06:15	06:53	07:34	08:15	08:00	08:30
	17:35	18:21	20:01	20:44	21:23	21:45	21:32	20:46	19:46	18:46	17:05	17:01
24	08:21	07:37	07:43	06:44	06:02	05:52	06:16	06:55	07:35	08:16	08:01	08:30
	17:37	18:22	20:03	20:45	21:24	21:45	21:31	20:44	19:44	18:45	17:04	17:02
25	08:20	07:35	07:41	06:42	06:02	05:53	06:17	06:56	07:36	08:18	08:03	08:31
	17:38	18:24	20:04	20:47	21:25	21:45	21:30	20:42	19:42	18:43	17:04	17:02
26	08:19	07:33	07:39	06:41	06:01	05:53	06:18	06:57	07:38	08:19	08:04	08:31
	17:40	18:25	20:05	20:48	21:26	21:45	21:28	20:41	19:40	18:41	17:03	17:03
27	08:18	07:31	07:37	06:39	06:00	05:53	06:19	06:59	07:39	08:21	08:05	08:31
	17:41	18:27	20:07	20:49	21:27	21:45	21:27	20:39	19:38	18:40	17:02	17:04
28	08:17	07:30	07:35	06:37	06:59	05:54	06:20	07:00	07:40	08:22	08:07	08:32
	17:43	18:28	20:08	20:51	21:28	21:45	21:26	20:37	19:36	18:38	17:02	17:04
29	08:16	07:33	07:36	06:38	06:58	05:54	06:22	07:01	07:42	08:24	08:08	08:32
	17:44	18:29	20:09	20:52	21:29	21:45	21:25	20:35	19:34	18:36	17:01	17:05
30	08:15	07:31	07:34	06:39	06:57	05:55	06:23	07:03	07:43	08:25	08:09	08:32
	17:46	18:31	20:11	20:53	21:30	21:45	21:24	20:33	19:32	18:35	17:01	17:06
31	08:13	07:29	07:32	06:34	06:52	05:57	06:24	07:04	07:44	08:26	08:10	08:32
	17:47	18:32	20:12	20:54	21:31	21:45	21:22	20:31	19:30	18:33	17:01	17:07
Potential sun hours	279	288	368	407	466	474	480	441	378	338	282	267
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)	Minutes with flicker	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)		Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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wind@eapc.net
 Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR013 - SR013

Assumptions for shadow calculations

Maximum distance for influence 1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	January	February	March	April	May	June
1	08:33	14:02 (215)	08:13	07:28	07:54 (8)	07:27
	17:08	42 14:44 (215)	17:49	18:30	28 08:22 (8)	20:14
2	08:33	14:03 (215)	08:11	07:26	07:53 (8)	07:25
	17:09	42 14:45 (215)	17:50	18:31	30 08:23 (8)	20:15
3	08:33	14:04 (215)	08:10	07:24	07:52 (8)	07:23
	17:10	41 14:45 (215)	17:52	18:33	31 08:23 (8)	20:17
4	08:32	14:04 (215)	08:09	07:22	07:51 (8)	07:21
	17:11	40 14:44 (215)	17:53	18:34	33 08:24 (8)	20:18
5	08:32	14:05 (215)	08:07	07:20	07:50 (8)	07:19
	17:12	39 14:44 (215)	17:55	18:36	34 08:24 (8)	20:19
6	08:32	14:06 (215)	08:06	07:19	07:49 (8)	07:18
	17:13	38 14:44 (215)	17:56	18:37	35 08:24 (8)	20:21
7	08:32	14:08 (215)	08:04	07:17	07:49 (8)	07:16
	17:14	36 14:44 (215)	17:58	18:39	35 08:24 (8)	20:22
8	08:32	14:09 (215)	08:03	08:15	08:49 (8)	07:14
	17:15	34 14:43 (215)	18:00	18:40	35 09:24 (8)	20:23
9	08:31	14:10 (215)	08:02	08:13	08:48 (8)	07:12
	17:17	33 14:43 (215)	18:00	19:42	35 09:23 (8)	20:25
10	08:31	14:11 (215)	08:00	08:11	08:48 (8)	07:10
	17:18	31 14:42 (215)	18:01	19:43	35 09:23 (8)	20:26
11	08:31	14:14 (215)	07:59	08:09	08:48 (8)	07:08
	17:19	28 14:42 (215)	18:03	19:44	34 09:22 (8)	20:28
12	08:30	14:15 (215)	07:57	08:07	08:49 (8)	07:06
	17:20	25 14:40 (215)	18:04	19:46	32 09:21 (8)	20:29
13	08:30	14:18 (215)	07:56	08:05	08:49 (8)	07:04
	17:21	22 14:40 (215)	18:06	19:47	31 09:20 (8)	20:30
14	08:29	14:20 (215)	07:54	08:03	08:50 (8)	07:02
	17:23	18 14:38 (215)	18:07	19:49	29 09:19 (8)	20:32
15	08:29	14:24 (215)	07:52	08:01	08:51 (8)	07:00
	17:24	10 14:34 (215)	18:09	19:50	26 09:17 (8)	20:33
16	08:28		07:51	07:59	08:52 (8)	06:58
	17:25		18:10	19:52	23 09:15 (8)	20:34
17	08:27		07:49	07:57	08:54 (8)	06:57
	17:27		18:12	19:53	19 09:13 (8)	20:36
18	08:27		07:47	07:55	08:56 (8)	06:55
	17:28		18:13	19:54	14 09:10 (8)	20:37
19	08:26		07:46	07:53		06:53
	17:30		18:15	19:56		20:39
20	08:25		07:44	07:51		06:51
	17:31		18:16	19:57		20:40
21	08:24		07:42	07:49		06:49
	17:32		18:18	19:59		20:41
22	08:23		07:41	07:47		06:48
	17:34		18:19	20:00		20:43
23	08:22		07:39	07:45		06:46
	17:35		18:21	20:01		20:44
24	08:21		07:37	07:43		06:44
	17:37		18:22	20:03		20:45
25	08:20		07:35	08:03 (8)	07:41	06:42
	17:38		18:24	11 08:14 (8)	20:04	20:47
26	08:19		07:33	07:59 (8)	07:39	06:41
	17:40		18:25	18 08:17 (8)	20:06	20:48
27	08:18		07:32	07:57 (8)	07:37	06:39
	17:41		18:27	22 08:19 (8)	20:07	20:50
28	08:17		07:30	07:55 (8)	07:35	06:37
	17:43		18:28	25 08:20 (8)	20:08	20:51
29	08:16			07:33	06:36	06:58 (16)
	17:44			20:10	8 07:06 (16)	21:29
30	08:15			07:31	06:34	06:56 (16)
	17:46			20:11	10 07:06 (16)	21:30
31	08:14			07:29		05:57
	17:47			20:12		21:31
Potential sun hours	279	287	368	407	466	474
Total, worst case	479		539	27	177	
Sun reduction	0.55	0.50	0.63	0.59	0.68	
Oper. time red.	0.97	0.97	0.97	0.97	0.97	
Wind dir. red.	0.53	0.73	0.73	0.61	0.61	
Total reduction	0.28	0.35	0.44	0.34	0.39	
Total, real	134	27	236	9	70	

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

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

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR013 - SR013

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	July	August	September	October	November	December			
1	05:55 21:46	06:25 21:21	8 07:02 (16) 07:10 (16)	07:05 20:30	07:45 19:30	08:29 (8) 09:00 (8)	07:28 17:32	08:11 17:00	13:56 (215) 14:24 (215)
2	05:56 21:45	06:27 21:20	12 07:12 (16) 06:59 (16)	07:08 20:28	07:47 19:28	08:26 (8) 09:00 (8)	07:31 17:30	08:12 17:00	13:55 (215) 14:25 (215)
3	05:57 21:45	06:28 21:19	14 07:13 (16) 06:58 (16)	07:09 20:26	07:49 19:26	08:26 (8) 09:01 (8)	07:33 17:29	08:13 16:59	13:54 (215) 14:26 (215)
4	05:57 21:45	06:29 21:17	17 07:15 (16) 06:57 (16)	07:10 20:24	07:50 19:24	08:25 (8) 09:01 (8)	07:34 17:27	08:14 16:59	13:54 (215) 14:28 (215)
5	05:58 21:45	06:30 21:16	18 07:15 (16) 06:57 (16)	07:10 20:22	07:51 19:22	08:25 (8) 09:00 (8)	07:36 17:26	08:17 16:59	13:53 (215) 14:29 (215)
6	05:59 21:44	06:32 21:14	19 07:16 (16) 06:57 (16)	07:12 20:20	07:51 19:20	08:25 (8) 09:00 (8)	07:36 17:24	08:17 16:58	13:53 (215) 14:30 (215)
7	05:59 21:44	06:33 21:13	19 07:16 (16) 06:57 (16)	07:13 20:18	07:53 19:18	08:25 (8) 09:00 (8)	07:37 17:23	08:18 16:58	13:52 (215) 14:31 (215)
8	06:00 21:43	06:34 21:13	19 07:16 (16) 06:58 (16)	07:14 20:16	07:54 19:16	08:25 (8) 08:59 (8)	07:39 17:22	08:19 16:58	13:52 (215) 14:32 (215)
9	06:01 21:43	06:35 21:10	18 07:16 (16) 07:00 (16)	07:16 20:14	07:55 19:14	08:25 (8) 08:59 (8)	07:40 17:20	08:20 16:58	13:52 (215) 14:33 (215)
10	06:02 21:42	06:37 21:08	16 07:16 (16) 07:01 (16)	07:17 20:12	07:57 19:12	08:25 (8) 08:58 (8)	07:42 17:19	08:21 16:58	13:52 (215) 14:34 (215)
11	06:03 21:42	06:38 21:07	15 07:16 (16) 07:02 (16)	07:18 20:10	07:58 19:10	08:26 (8) 08:57 (8)	07:43 17:18	08:22 16:58	13:52 (215) 14:34 (215)
12	06:04 21:41	06:39 21:05	13 07:15 (16) 07:03 (16)	07:20 20:08	08:00 19:08	08:27 (8) 08:56 (8)	07:45 17:17	08:23 16:58	13:52 (215) 14:35 (215)
13	06:04 21:41	06:41 21:04	12 07:15 (16) 07:05 (16)	20:08 20:06	08:01 19:06	08:27 (8) 08:54 (8)	07:46 17:15	08:24 16:58	13:52 (215) 14:36 (215)
14	06:05 21:40	06:42 21:02	10 07:15 (16) 07:06 (16)	20:06 20:04	08:02 19:05	08:29 (8) 08:53 (8)	07:48 17:14	08:24 16:58	13:53 (215) 14:37 (215)
15	06:06 21:39	06:43 21:00	8 07:14 (16) 07:07 (16)	20:04 20:02	08:04 19:03	08:30 (8) 08:50 (8)	07:49 17:13	08:25 16:58	13:53 (215) 14:38 (215)
16	06:07 21:38	06:44 20:59	5 07:12 (16) 07:08 (16)	20:02 20:00	08:05 19:01	08:33 (8) 08:48 (8)	07:51 17:12	08:26 16:58	13:52 (215) 14:38 (215)
17	06:08 21:38	06:46 20:57	2 07:10 (16) 07:26	20:00 19:58	08:07 18:57	08:36 (8) 08:43 (8)	07:52 17:11	08:27 16:59	13:53 (215) 14:39 (215)
18	06:09 21:37	06:47 20:55	07:27 19:56	08:08 18:55	07:53 17:10	08:08 08:08	07:53 17:09	08:27 16:59	13:54 (215) 14:39 (215)
19	06:10 21:36	06:48 20:53	07:29 19:54	08:09 18:53	07:55 17:09	08:09 08:11	07:55 17:08	08:28 17:00	13:53 (215) 14:40 (215)
20	06:11 21:35	06:50 20:52	07:30 19:52	08:11 18:52	07:56 17:08	08:11 08:12	07:56 17:07	08:29 17:00	13:54 (215) 14:40 (215)
21	06:13 21:34	06:51 20:50	07:31 19:50	08:12 18:50	07:58 17:07	08:12 08:14	07:58 17:06	08:29 17:01	13:54 (215) 14:41 (215)
22	06:14 21:33	06:52 20:48	07:33 19:48	08:14 18:48	07:59 17:06	08:14 08:15	07:59 17:05	08:30 17:01	13:55 (215) 14:41 (215)
23	06:15 21:32	06:54 20:46	07:34 19:46	08:15 18:46	08:00 17:05	08:15 08:17	08:00 17:04	08:30 17:01	13:55 (215) 14:41 (215)
24	06:16 21:31	06:55 20:45	07:35 19:44	08:16 18:45	08:02 17:04	08:17 08:18	08:02 17:03	08:31 17:02	13:56 (215) 14:42 (215)
25	06:17 21:30	06:56 20:43	07:37 19:42	08:18 18:43	08:03 17:04	08:18 08:18	08:03 17:03	08:31 17:02	13:57 (215) 14:42 (215)
26	06:18 21:29	06:57 20:41	07:38 19:40	08:20 18:41	08:04 17:03	08:18 08:18	08:04 17:03	08:31 17:03	13:57 (215) 14:43 (215)
27	06:19 21:28	06:59 20:39	07:39 19:38	08:21 18:40	08:06 17:02	08:18 08:18	08:06 17:02	08:32 17:04	13:57 (215) 14:43 (215)
28	06:21 21:26	07:00 20:37	07:41 19:36	08:23 18:38	08:07 17:02	08:18 08:18	08:07 17:02	08:32 17:04	13:59 (215) 14:44 (215)
29	06:22 21:25	07:01 20:35	07:42 19:34	08:24 18:36	08:08 17:01	08:18 08:18	08:08 17:01	08:32 17:05	13:59 (215) 14:44 (215)
30	06:23 21:24	07:03 20:33	07:43 19:32	08:25 18:35	08:10 17:01	08:18 08:18	08:10 17:01	08:32 17:06	14:00 (215) 14:44 (215)
31	06:24 21:23	07:04 20:32	07:43 19:32	08:25 18:33	08:10 17:01	08:18 08:18	08:10 17:01	08:32 17:07	14:01 (215) 14:44 (215)
Potential sun hours	480	441	378	338	282	266	1304	0.43	0.97
Total, worst case		206	134	492	73			0.97	0.53
Sun reduction		0.73	0.69	0.52	0.43			0.22	0.53
Oper. time red.		0.97	0.97	0.97	0.97			0.22	0.53
Wind dir. red.		0.61	0.73	0.73	0.53			0.22	0.53
Total reduction		0.42	0.48	0.36	0.22			0.22	0.53
Total, real		87	64	179	16			286	

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

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

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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wind@eapc.net

Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR014 - SR014

Assumptions for shadow calculations

Maximum distance for influence 1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December	
1	08:33 17:08	08:12 17:49	07:28 18:30	07:27 20:14	06:32 20:55	05:56 21:32	05:55 21:45	06:25 21:21	07:05 20:30	07:28 (22) 07:30 (22)	07:45 19:30	07:28 17:32	08:11 17:00
2	08:33 17:09	08:11 17:50	07:26 18:31	07:25 20:15	06:31 20:56	05:56 21:33	05:56 21:45	06:27 21:20	07:07 20:28	07:46 19:28	07:30 17:30	08:12 17:30	08:12 17:00
3	08:32 17:10	08:10 17:52	07:24 18:33	07:23 20:17	06:29 20:58	05:55 21:34	05:57 21:45	06:28 21:19	07:08 20:26	07:47 19:26	07:31 17:29	08:13 16:59	08:13 16:59
4	08:32 17:11	08:09 17:53	07:22 18:34	07:21 20:18	06:28 20:59	05:54 21:35	05:57 21:45	06:29 21:17	07:09 20:24	07:49 19:24	07:33 17:27	08:14 16:59	08:14 16:59
5	08:32 17:12	08:07 17:55	07:20 18:36	07:19 20:19	06:28 21:00	05:54 21:36	05:58 21:44	06:30 21:16	07:10 20:22	07:50 19:22	07:34 17:26	08:16 16:59	08:16 16:59
6	08:32 17:13	08:06 17:56	07:18 18:37	07:18 20:21	06:25 21:02	05:53 21:37	05:59 21:44	06:32 21:14	07:12 20:20	07:51 19:20	07:36 17:24	08:17 16:58	08:17 16:58
7	08:32 17:14	08:04 17:58	07:17 18:39	07:16 20:22	06:23 21:03	05:53 21:38	05:59 21:44	06:33 21:13	07:13 20:18	07:53 19:18	07:37 17:23	08:18 16:58	08:18 16:58
8	08:32 17:15	08:03 18:00	07:15 18:40	07:14 20:23	06:22 21:04	05:53 21:38	06:00 21:43	06:34 21:11	07:14 20:16	07:54 19:16	07:39 17:22	08:19 16:58	08:19 16:58
9	08:31 17:17	08:02 18:00	08:13 19:42	07:12 20:25	06:20 21:06	05:52 21:39	06:01 21:43	06:35 21:10	07:16 20:14	07:55 19:14	07:40 17:20	08:20 16:58	08:20 16:58
10	08:31 17:18	08:00 18:01	08:11 19:43	07:10 20:26	06:19 21:07	05:52 21:40	06:02 21:42	06:37 21:07	07:17 20:12	07:57 19:12	07:42 17:19	08:21 16:58	08:21 16:58
11	08:31 17:19	07:59 18:03	08:09 19:44	07:08 20:28	06:18 21:08	05:52 21:40	06:03 21:42	06:38 21:07	07:18 20:10	07:58 19:10	07:43 17:18	08:22 16:58	08:22 16:58
12	08:30 17:20	07:57 18:04	08:07 19:46	07:06 20:29	06:16 21:10	05:52 21:41	06:04 21:41	06:39 21:05	07:20 20:08	08:00 19:08	07:45 17:17	08:23 16:58	08:23 16:58
13	08:30 17:22	07:55 18:06	08:05 19:47	07:04 20:30	06:15 21:11	05:51 21:42	06:04 21:41	06:41 21:04	07:21 20:06	08:01 19:06	07:46 17:15	08:23 16:58	08:23 16:58
14	08:29 17:23	07:54 18:07	08:03 19:49	07:02 20:32	06:14 21:12	05:51 21:42	06:05 21:40	06:42 21:02	07:22 20:04	08:02 19:04	07:48 17:14	08:24 16:58	08:24 16:58
15	08:28 17:24	07:52 18:09	08:01 19:50	07:00 20:33	06:12 21:13	05:51 21:43	06:06 21:39	06:43 21:00	07:23 20:02	08:04 19:03	07:49 17:13	08:25 16:58	08:25 16:58
16	08:28 17:25	07:51 18:10	07:59 19:52	06:58 20:34	06:11 21:15	05:51 21:43	06:07 21:38	06:44 20:59	07:25 20:00	08:05 19:01	07:50 17:12	08:26 16:58	08:26 16:58
17	08:27 17:27	07:49 18:12	07:57 19:53	06:57 20:36	06:10 21:16	05:51 21:44	06:08 21:38	06:46 20:57	07:26 19:58	08:07 18:57	07:52 17:11	08:27 16:59	08:27 16:59
18	08:26 17:28	07:47 18:13	07:55 19:54	06:55 20:37	06:09 21:17	05:51 21:44	06:09 21:37	06:47 20:55	07:27 19:56	08:08 18:55	07:53 17:10	08:27 16:59	08:27 16:59
19	08:26 17:30	07:46 18:15	07:53 19:56	06:53 20:39	06:08 21:18	05:51 21:44	06:10 21:36	06:48 20:53	07:29 19:54	08:09 18:53	07:55 17:09	08:28 16:59	08:28 16:59
20	08:25 17:31	07:44 18:16	07:51 19:57	06:51 20:40	06:07 21:19	05:51 21:45	06:11 21:35	06:50 20:52	07:30 19:52	08:11 18:52	07:56 17:08	08:29 17:00	08:29 17:00
21	08:24 17:32	07:42 18:18	07:49 19:59	06:49 20:41	06:05 21:21	05:52 21:45	06:13 21:34	06:51 20:50	07:31 19:50	08:12 18:50	07:58 17:07	08:30 17:00	08:30 17:00
22	08:23 17:34	07:40 18:19	07:47 20:00	06:48 20:43	06:04 21:22	05:52 21:45	06:14 21:33	06:52 20:48	07:33 19:48	08:14 18:48	07:59 17:06	08:31 17:01	08:31 17:01
23	08:22 17:35	07:39 18:21	07:45 20:01	06:46 20:44	06:03 21:23	05:52 21:45	06:15 21:32	06:54 20:46	07:34 19:46	08:15 18:46	08:00 17:05	08:32 17:01	08:32 17:01
24	08:21 17:37	07:37 18:22	07:43 20:03	06:44 20:45	06:03 21:24	05:52 21:45	06:16 21:31	06:55 20:45	07:35 19:44	08:17 18:45	08:02 17:04	08:33 17:02	08:33 17:02
25	08:20 17:38	07:35 18:24	07:41 20:04	06:42 20:47	06:02 21:25	05:53 21:46	06:17 21:30	06:56 20:43	07:37 19:42	08:18 18:43	08:03 17:04	08:34 17:02	08:34 17:02
26	08:19 17:40	07:33 18:25	07:39 20:06	06:41 20:48	06:01 21:26	05:53 21:46	06:18 21:29	06:57 20:41	07:38 19:40	08:20 18:41	08:04 17:03	08:35 17:03	08:35 17:03
27	08:18 17:41	07:32 18:27	07:37 20:07	06:39 20:50	06:00 21:27	05:53 21:46	06:19 21:28	06:59 20:39	07:39 19:38	08:21 18:40	08:06 17:02	08:36 17:04	08:36 17:04
28	08:17 17:43	07:30 18:28	07:35 20:08	06:37 20:51	05:59 21:28	05:54 21:46	06:21 21:26	07:00 20:37	07:41 19:36	08:22 18:38	08:07 17:02	08:37 17:04	08:37 17:04
29	08:16 17:44	07:29 18:28	07:33 20:10	06:36 20:52	05:58 21:29	05:54 21:46	06:22 21:25	07:01 20:35	07:42 19:34	08:24 18:36	08:08 17:01	08:38 17:05	08:38 17:05
30	08:15 17:46	07:28 18:29	07:31 20:11	06:34 20:54	05:58 21:30	05:55 21:46	06:23 21:24	07:03 20:33	07:43 19:32	08:25 18:35	08:10 17:01	08:39 17:06	08:39 17:06
31	08:14 17:47	07:27 18:30	07:29 20:12	06:33 20:54	05:57 21:31	05:56 21:47	06:24 21:23	07:04 20:31	07:44 19:31	08:27 18:33	08:09 17:02	08:40 17:07	08:40 17:07
Potential sun hours	279	287	368	407	466	474	480	441	378	338	282	266	
Total, worst case				65					64	2			
Sun reduction				0.59					0.73	0.69			
Oper. time red.				0.97					0.97	0.97			
Wind dir. red.				0.64					0.64	0.64			
Total reduction				0.37					0.45	0.43			
Total, real				24				29	1				

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

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

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR015 - SR015

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December	
1	08:32 17:08	08:12 17:49	07:28 18:30	07:27 20:14	06:32 20:55	06:55 (22) 21:32	05:56 21:45	05:55 21:21	06:25 20:37	06:57 (22) 20:30	07:05 19:30	07:45 17:32	08:11 17:00
2	08:33 17:09	08:11 17:50	07:26 18:31	07:25 20:15	06:31 20:56	06:53 (22) 21:33	05:56 21:45	05:57 21:20	06:27 20:28	06:54 (22) 20:28	07:07 19:28	07:46 17:30	08:12 17:00
3	08:32 17:10	08:10 17:52	07:24 18:33	07:23 20:17	06:29 20:58	06:51 (22) 21:34	05:55 21:45	05:57 21:19	06:28 20:26	06:53 (22) 20:26	07:08 19:26	07:47 17:30	08:13 16:59
4	08:32 17:11	08:09 17:53	07:22 18:34	07:21 20:18	06:28 20:59	06:50 (22) 21:35	05:54 21:45	05:57 21:17	06:29 20:24	06:54 (22) 20:24	07:09 19:24	07:49 17:27	08:14 16:59
5	08:32 17:12	08:07 17:55	07:20 18:36	07:19 20:19	06:26 21:00	06:49 (22) 21:36	05:54 21:44	05:58 21:16	06:30 20:22	06:55 (22) 20:22	07:10 19:22	07:50 17:26	08:15 16:59
6	08:32 17:13	08:06 17:56	07:18 18:37	07:18 20:21	06:25 21:02	06:47 (22) 21:37	05:53 21:44	05:59 21:14	06:32 20:20	06:56 (22) 20:20	07:12 19:20	07:51 17:24	08:17 16:58
7	08:32 17:14	08:04 17:58	07:17 18:39	07:16 20:22	06:23 21:03	06:46 (22) 21:38	05:53 21:44	05:59 21:13	06:33 20:18	06:57 (22) 20:18	07:13 19:18	07:53 17:23	08:18 16:58
8	08:32 17:15	08:03 18:00	08:15 18:40	07:14 20:23	06:22 21:04	06:44 (22) 21:39	05:53 21:43	06:00 21:11	06:34 20:16	06:58 (22) 20:16	07:14 19:16	07:54 17:22	08:19 16:58
9	08:31 17:17	08:02 18:00	08:13 18:40	07:12 20:25	06:20 21:06	06:43 (22) 21:40	05:52 21:43	06:01 21:10	06:35 20:14	07:00 (22) 20:14	07:16 19:14	07:55 17:20	08:20 16:58
10	08:31 17:18	08:00 18:01	08:11 18:43	07:10 20:26	06:19 21:08	06:42 (22) 21:41	05:52 21:42	06:02 21:08	06:37 20:12	07:01 (22) 20:12	07:17 19:12	07:57 17:19	08:21 16:58
11	08:31 17:19	07:59 18:03	08:09 18:44	07:08 20:28	06:18 21:09	06:45 (22) 21:42	05:52 21:42	06:03 21:07	06:38 20:09	07:02 (22) 20:09	07:18 19:08	07:58 17:17	08:22 16:58
12	08:30 17:20	07:57 18:04	08:07 18:46	07:06 20:29	06:16 21:10	06:52 (22) 21:43	05:52 21:41	06:04 21:05	06:39 20:08	07:03 (22) 20:08	07:20 19:08	07:45 17:17	08:23 16:58
13	08:30 17:22	07:55 18:06	08:05 18:47	07:04 20:30	06:15 21:11	06:51 (22) 21:44	05:51 21:40	06:04 21:04	06:41 20:06	07:06 (22) 20:06	07:21 19:06	07:46 17:15	08:24 16:58
14	08:29 17:23	07:54 18:07	08:03 18:49	07:02 20:32	06:14 21:12	06:50 (22) 21:45	05:51 21:42	06:05 21:02	06:42 20:04	07:06 (22) 20:04	07:22 19:04	07:48 17:14	08:25 16:58
15	08:29 17:24	07:52 18:09	08:01 18:50	07:00 20:33	06:12 21:13	06:49 (22) 21:46	05:51 21:43	06:06 21:00	06:43 20:02	07:05 (22) 20:02	07:23 19:03	07:49 17:13	08:26 16:58
16	08:28 17:25	07:51 18:10	07:59 18:52	06:58 20:34	06:11 21:15	06:48 (22) 21:47	05:51 21:44	06:07 20:59	06:44 20:00	07:04 (22) 20:00	07:25 19:01	07:50 17:12	08:27 16:58
17	08:27 17:27	07:49 18:12	07:57 18:53	06:57 20:36	06:10 21:16	06:47 (22) 21:48	05:51 21:44	06:08 20:57	06:46 20:00	07:03 (22) 20:00	07:26 19:01	07:52 17:11	08:28 16:59
18	08:26 17:28	07:47 18:13	07:55 18:54	06:55 20:37	06:09 21:17	06:46 (22) 21:49	05:51 21:44	06:09 20:55	06:47 20:00	07:02 (22) 20:00	07:27 19:00	07:53 17:10	08:29 16:59
19	08:26 17:30	07:46 18:15	07:53 18:56	06:53 20:39	06:08 21:18	06:45 (22) 21:50	05:51 21:44	06:08 20:53	06:48 20:00	07:01 (22) 20:00	07:29 19:00	07:55 17:09	08:30 16:59
20	08:25 17:31	07:44 18:16	07:51 18:57	06:51 20:40	06:07 21:19	06:44 (22) 21:51	05:51 21:45	06:50 20:52	06:49 20:00	07:00 (22) 20:00	07:30 19:00	07:56 17:08	08:31 17:00
21	08:24 17:32	07:42 18:18	07:49 18:59	06:49 20:41	06:05 21:21	06:43 (22) 21:52	05:52 21:45	06:51 20:50	06:48 20:00	07:01 (22) 20:00	07:31 19:00	07:57 17:07	08:32 17:00
22	08:23 17:34	07:40 18:19	07:47 19:00	06:48 20:43	06:04 21:22	06:42 (22) 21:53	05:52 21:45	06:52 20:48	06:47 20:00	07:02 (22) 20:00	07:32 19:00	07:58 17:06	08:33 17:01
23	08:22 17:35	07:39 18:21	07:45 19:01	06:46 20:44	06:03 21:23	06:41 (22) 21:54	05:52 21:45	06:54 20:46	06:46 20:00	07:03 (22) 20:00	07:33 19:00	07:59 17:05	08:34 17:01
24	08:21 17:37	07:37 18:22	07:43 19:02	06:44 20:45	06:02 21:24	06:40 (22) 21:55	05:52 21:45	06:55 20:45	06:45 20:00	07:04 (22) 20:00	07:34 19:00	08:00 17:04	08:35 17:02
25	08:20 17:38	07:35 18:24	07:41 19:03	06:42 20:47	06:01 21:25	06:39 (22) 21:56	05:53 21:46	06:56 20:44	06:44 20:00	07:05 (22) 20:00	07:35 19:00	08:01 17:04	08:36 17:03
26	08:19 17:40	07:33 18:25	07:39 19:04	06:41 20:48	06:01 21:26	06:38 (22) 21:57	05:53 21:46	06:57 20:43	06:43 20:00	07:06 (22) 20:00	07:36 19:00	08:02 17:03	08:37 17:04
27	08:18 17:41	07:32 18:27	07:37 19:05	06:39 20:49	06:00 21:27	06:37 (22) 21:58	05:53 21:46	06:59 20:42	06:42 20:00	07:07 (22) 20:00	07:37 19:00	08:03 17:02	08:38 17:04
28	08:17 17:43	07:30 18:28	07:35 19:06	06:37 20:51	05:59 21:28	06:36 (22) 21:59	05:54 21:46	06:59 20:41	06:41 20:00	07:08 (22) 20:00	07:38 19:00	08:04 17:02	08:39 17:04
29	08:16 17:44	07:29 18:29	07:33 19:07	06:36 20:52	05:58 21:29	06:35 (22) 22:00	05:54 21:46	06:59 20:40	06:40 20:00	07:09 (22) 20:00	07:39 19:00	08:05 17:01	08:40 17:05
30	08:15 17:46	07:28 18:30	07:31 19:08	06:34 20:54	05:58 21:30	06:34 (22) 22:01	05:55 21:46	06:59 20:39	06:40 20:00	07:10 (22) 20:00	07:40 19:00	08:06 17:01	08:41 17:06
31	08:14 17:47	07:27 18:31	07:29 19:09	06:33 20:55	05:57 21:31	06:33 (22) 22:02	05:57 21:46	06:59 20:38	06:40 20:00	07:11 (22) 20:00	07:41 19:00	08:07 17:01	08:42 17:07
Potential sun hours	279	287	368	407	466	474	480	441	378	338	282	266	
Total, worst case				2	102				107				
Sun reduction				0.59	0.68				0.73				
Oper. time red.				0.97	0.97				0.97				
Wind dir. red.				0.60	0.60				0.60				
Total reduction				0.35	0.40				0.43				
Total, real				1	41				46				

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

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

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR016 - SR016

Assumptions for shadow calculations

Maximum distance for influence 1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509	

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

	January	February	March	April	May	June
1	08:33	09:47 (212)	08:12	08:43 (211)	07:28	07:27
	17:08	15 10:02 (212)	17:49	22 09:05 (211)	18:30	20:14
2	08:33	09:49 (212)	08:11	08:43 (211)	07:26	07:25
	17:09	13 10:02 (212)	17:50	21 09:04 (211)	18:31	20:15
3	08:32	09:50 (212)	08:10	08:44 (211)	07:24	07:23
	17:10	11 10:01 (212)	17:52	20 09:04 (211)	18:33	20:17
4	08:32	09:52 (212)	08:09	08:46 (211)	07:22	07:21
	17:11	7 09:59 (212)	17:53	18 09:04 (211)	18:34	20:18
5	08:32	08:07	08:07	08:47 (211)	07:20	07:19
	17:12	17:55	15 09:02 (211)	18:36	20:19	21:00
6	08:32	08:06	08:06	08:49 (211)	07:19	07:18
	17:13	17:57	12 09:01 (211)	18:37	20:21	21:02
7	08:32	08:04	08:04	08:52 (211)	07:17	07:16
	17:14	17:58	5 08:57 (211)	18:39	20:22	21:03
8	08:32	08:03	08:03	08:15	08:15	07:14
	17:15	18:00	18:40	20:23	21:04	21:38
9	08:31	08:02	08:02	08:13	08:13	07:12
	17:17	18:00	19:42	20:25	21:06	21:39
10	08:31	08:00	08:00	08:11	08:11	07:10
	17:18	18:01	19:43	20:26	21:07	21:40
11	08:31	07:59	08:09	08:09	08:09	07:08
	17:19	18:03	19:44	20:28	21:08	21:40
12	08:30	07:57	08:07	19:20 (216)	07:06	06:16
	17:20	18:04	19:46	4 19:24 (216)	20:29	21:10
13	08:30	07:55	08:05	08:05	08:05	07:04
	17:22	18:06	19:47	6 19:25 (216)	20:30	21:11
14	08:29	07:54	08:03	08:03	08:03	07:02
	17:23	18:07	19:49	8 19:26 (216)	20:32	21:12
15	08:28	07:52	08:01	08:01	08:01	07:00
	17:24	18:09	19:50	11 19:28 (216)	20:33	21:13
16	08:28	07:51	07:59	07:59	07:59	06:58
	17:25	18:10	19:52	12 19:29 (216)	20:34	21:15
17	08:27	08:52 (211)	07:49	07:57	07:57	06:57
	17:27	3 08:55 (211)	18:12	19:53	14 19:31 (216)	20:36
18	08:26	08:51 (211)	07:47	07:55	07:55	06:55
	17:28	6 08:57 (211)	18:13	19:54	15 19:32 (216)	20:37
19	08:26	08:50 (211)	07:46	07:53	07:53	06:53
	17:30	8 08:58 (211)	18:15	19:56	16 19:33 (216)	20:39
20	08:25	08:49 (211)	07:44	07:51	07:51	06:51
	17:31	10 08:59 (211)	18:16	19:57	14 19:32 (216)	20:40
21	08:24	08:48 (211)	07:42	07:49	07:49	06:49
	17:32	12 09:00 (211)	18:18	19:59	10 19:30 (216)	20:41
22	08:23	08:47 (211)	07:40	07:47	07:47	06:48
	17:34	14 09:01 (211)	18:19	20:00	20:43	21:22
23	08:22	08:46 (211)	07:39	07:45	07:45	06:46
	17:35	16 09:02 (211)	18:21	20:01	20:44	21:23
24	08:21	08:45 (211)	07:37	07:43	07:43	06:44
	17:37	18 09:03 (211)	18:22	20:03	20:45	21:24
25	08:20	08:44 (211)	07:35	07:41	07:41	06:42
	17:38	20 09:04 (211)	18:24	20:04	20:47	21:25
26	08:19	08:43 (211)	07:33	07:39	07:39	06:41
	17:40	21 09:04 (211)	18:25	20:06	20:48	21:26
27	08:18	08:42 (211)	07:32	07:37	07:37	06:39
	17:41	23 09:05 (211)	18:27	20:07	20:50	21:27
28	08:17	08:42 (211)	07:30	07:35	07:35	06:37
	17:43	23 09:05 (211)	18:28	20:08	20:51	21:28
29	08:16	08:41 (211)	07:29	07:33	07:33	06:36
	17:44	24 09:05 (211)	18:29	20:10	20:52	21:29
30	08:15	08:42 (211)	07:28	07:31	07:31	06:34
	17:46	23 09:05 (211)	18:30	20:11	20:54	21:30
31	08:14	08:42 (211)	07:27	07:29	07:29	06:33
	17:47	23 09:05 (211)	18:31	20:12	20:55	21:31
Potential sun hours	279	287	368	407	466	474
Total, worst case	290	113	110			
Sun reduction	0.55	0.50	0.63			
Oper. time red.	0.97	0.97	0.97			
Wind dir. red.	0.74	0.74	0.66			
Total reduction	0.40	0.36	0.40			
Total, real	115	41	44			

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)
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Project:
Minnesota Power - BISON Wind Energy Center
 Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

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Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR016 - SR016

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	July	August	September	October	November	December	
1	05:55	06:25	07:05	07:45	18:59 (216)	07:28	08:11
	21:45	21:21	20:30	19:30	19:04 (216)	17:32	17:00
2	05:56	06:27	07:07	07:46	19:00 (216)	07:30	08:12
	21:45	21:20	20:28	19:28	19:02 (216)	17:30	17:00
3	05:57	06:28	07:08	07:47	07:31	07:31	08:13
	21:45	21:19	20:26	19:26	17:29	17:29	16:59
4	05:57	06:29	07:09	07:49	07:33	08:21 (211)	08:14
	21:45	21:17	20:24	19:24	17:27	6 08:27 (211)	16:59
5	05:58	06:30	07:10	07:50	07:34	08:19 (211)	08:16
	21:44	21:16	20:22	19:22	17:26	12 08:31 (211)	16:59
6	05:59	06:32	07:12	07:51	07:36	08:16 (211)	08:17
	21:44	21:14	20:20	19:20	17:24	16 08:32 (211)	16:58
7	05:59	06:33	07:13	07:53	07:37	08:16 (211)	08:18
	21:44	21:13	20:18	19:18	17:23	18 08:34 (211)	16:58
8	06:00	06:34	07:14	07:54	07:39	08:14 (211)	08:19
	21:43	21:11	20:16	19:16	17:22	20 08:34 (211)	16:58
9	06:01	06:35	07:16	07:55	07:40	08:14 (211)	08:20
	21:43	21:10	20:14	19:14	17:20	21 08:35 (211)	16:58
10	06:02	06:37	07:17	07:57	07:42	08:14 (211)	08:21
	21:42	21:08	20:12	19:12	17:19	22 08:36 (211)	16:58
11	06:03	06:38	07:18	07:58	07:43	08:13 (211)	08:22
	21:42	21:07	20:10	19:10	17:18	23 08:36 (211)	16:58
12	06:04	06:39	07:20	08:00	07:45	08:13 (211)	08:23
	21:41	21:05	20:08	19:08	17:17	24 08:37 (211)	16:58
13	06:05	06:41	07:21	08:01	07:46	08:13 (211)	08:23
	21:41	21:04	20:06	19:06	17:15	24 08:37 (211)	16:58
14	06:05	06:42	07:22	08:02	07:48	08:14 (211)	08:24
	21:40	21:02	20:04	19:05	17:14	23 08:37 (211)	16:58
15	06:06	06:43	07:23	08:04	07:49	08:15 (211)	08:25
	21:39	21:00	20:02	19:03	17:13	23 08:38 (211)	16:58
16	06:07	06:44	07:25	08:05	07:50	08:16 (211)	08:26
	21:38	20:59	20:00	19:01	17:12	21 08:37 (211)	16:58
17	06:08	06:46	07:26	08:07	07:52	08:18 (211)	08:27
	21:38	20:57	19:58	18:57	17:11	20 08:38 (211)	16:59
18	06:09	06:47	07:27	08:08	07:53	08:19 (211)	08:27
	21:37	20:55	19:56	18:55	17:10	18 08:37 (211)	16:59
19	06:10	06:48	07:29	08:09	07:55	08:21 (211)	08:28
	21:36	20:53	19:54	18:53	17:09	16 08:37 (211)	16:59
20	06:11	06:50	07:30	08:11	07:56	08:22 (211)	08:29
	21:35	20:52	19:52	18:52	17:08	14 08:36 (211)	17:00
21	06:13	06:51	07:31	08:12	07:57	08:24 (211)	08:29
	21:34	20:50	19:50	18:50	17:07	12 08:36 (211)	17:00
22	06:14	06:52	07:33	19:06 (216)	08:14	07:59	08:25 (211)
	21:33	20:48	19:48	9 19:15 (216)	18:48	17:06	10 08:35 (211)
23	06:15	06:54	07:34	19:03 (216)	08:15	08:00	08:27 (211)
	21:32	20:46	19:46	13 19:16 (216)	18:46	17:05	8 08:35 (211)
24	06:16	06:55	07:35	19:01 (216)	08:17	08:02	08:28 (211)
	21:31	20:45	19:44	16 19:17 (216)	18:45	17:04	6 08:34 (211)
25	06:17	06:56	07:37	19:01 (216)	08:18	08:03	08:30 (211)
	21:30	20:43	19:42	15 19:16 (216)	18:43	17:04	3 08:33 (211)
26	06:18	06:57	07:38	18:59 (216)	08:20	08:04	08:31
	21:29	20:41	19:40	15 19:14 (216)	18:41	17:03	17:03
27	06:19	06:59	07:39	18:58 (216)	08:21	08:06	08:32
	21:28	20:39	19:38	13 19:11 (216)	18:40	17:02	17:04
28	06:21	07:00	07:41	18:59 (216)	08:22	08:07	08:32
	21:26	20:37	19:36	11 19:10 (216)	18:38	17:02	17:04
29	06:22	07:01	07:42	18:58 (216)	08:24	08:08	08:32
	21:25	20:35	19:34	10 19:08 (216)	18:36	17:01	17:05
30	06:23	07:03	07:43	18:58 (216)	08:25	08:10	08:32
	21:24	20:33	19:32	7 19:05 (216)	18:35	17:01	17:06
31	06:24	07:04		08:27			08:32
	21:23	20:31		18:33			17:07
Potential sun hours	480	441	378	338	282		267
Total, worst case			109		7	360	443
Sun reduction			0.69		0.52	0.43	0.43
Oper. time red.			0.97		0.97	0.97	0.97
Wind dir. red.			0.66		0.66	0.74	0.73
Total reduction			0.44		0.34	0.31	0.31
Total, real			48		2	112	136

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

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

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 Calculated:
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SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR017 - SR017

Assumptions for shadow calculations

Maximum distance for influence 1,500 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

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N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:33 17:08	08:12 17:49	07:28 18:30	07:27 20:14	06:33 20:55	05:56 21:32	06:21 (214) 21:45	05:56 06:22 (214) 21:21	06:25 20:30	07:05 19:30	07:45 17:32	07:28 17:00
2	08:33 17:09	08:11 17:50	07:26 18:31	07:25 20:15	06:31 20:56	05:56 21:33	06:21 (214) 21:45	05:56 06:22 (214) 21:20	06:27 20:28	07:07 19:28	07:46 17:30	07:32 17:00
3	08:32 17:10	08:10 17:52	07:24 18:33	07:23 20:17	06:29 20:58	05:55 21:34	06:20 (214) 21:45	05:57 06:23 (214) 21:19	06:28 20:26	07:08 19:26	07:47 17:29	07:31 16:59
4	08:32 17:11	08:09 17:54	07:22 18:34	07:22 20:18	06:28 20:59	05:55 21:35	06:20 (214) 21:45	05:59 06:24 (214) 21:17	06:29 20:24	07:09 19:24	07:49 17:27	07:33 16:59
5	08:32 17:12	08:07 17:55	07:20 18:36	07:20 20:19	06:26 21:00	05:54 21:36	06:19 (214) 21:44	05:58 06:25 (214) 21:16	06:30 20:22	07:11 19:22	07:50 17:26	07:34 16:59
6	08:32 17:13	08:06 17:57	07:19 18:37	07:18 20:21	06:25 21:02	05:54 21:37	06:19 (214) 21:44	05:59 06:25 (214) 21:14	06:32 20:20	07:12 19:20	07:51 17:24	07:36 16:58
7	08:32 17:14	08:04 17:58	07:17 18:39	07:16 20:22	06:23 21:03	05:53 21:38	06:18 (214) 21:44	06:00 06:26 (214) 21:13	06:33 20:18	07:13 19:18	07:53 17:23	07:37 16:58
8	08:32 17:16	08:03 18:00	07:15 18:40	07:14 20:24	06:22 21:04	05:53 21:38	06:18 (214) 21:43	06:00 06:27 (214) 21:11	06:34 20:16	07:14 19:16	07:54 17:22	07:39 16:58
9	08:31 17:17	08:02 18:00	08:13 19:42	07:12 20:25	06:20 21:06	05:53 21:39	06:18 (214) 21:43	06:01 06:28 (214) 21:10	06:36 20:14	07:16 19:14	07:56 17:20	07:40 16:58
10	08:31 17:18	08:00 18:01	08:11 19:43	07:10 20:26	06:19 21:07	05:52 21:40	06:18 (214) 21:42	06:02 06:29 (214) 21:08	06:37 20:12	07:17 19:12	07:57 17:19	07:42 16:58
11	08:31 17:19	07:59 18:03	08:09 19:45	07:08 20:28	06:18 21:08	05:52 21:40	06:17 (214) 21:42	06:03 06:29 (214) 21:07	06:38 20:10	07:18 19:10	07:58 17:18	07:43 16:58
12	08:30 17:20	07:57 18:04	08:07 19:46	07:06 20:29	06:16 21:10	05:52 21:41	06:17 (214) 21:41	06:04 06:29 (214) 21:05	06:39 20:08	07:20 19:08	08:00 17:17	07:45 16:58
13	08:30 17:22	07:56 18:06	08:05 19:47	07:04 20:30	06:15 21:11	05:52 21:42	06:17 (214) 21:41	06:05 06:30 (214) 21:04	06:41 20:06	07:21 19:06	08:01 17:15	07:46 16:58
14	08:29 17:23	07:54 18:07	08:03 19:49	07:02 20:32	06:14 21:12	05:51 21:42	06:17 (214) 21:40	06:06 06:31 (214) 21:02	06:42 20:04	07:22 19:05	08:02 17:14	07:48 16:58
15	08:28 17:24	07:52 18:09	08:01 19:50	07:00 20:33	06:12 21:13	05:51 21:43	06:17 (214) 21:40	06:06 06:32 (214) 21:00	06:43 20:02	07:24 19:03	08:04 17:13	07:49 16:58
16	08:28 17:26	07:51 18:10	07:59 19:52	06:59 20:34	06:11 21:15	05:51 21:43	06:17 (214) 21:39	06:07 06:33 (214) 21:00	06:45 20:00	07:25 19:01	08:05 17:12	07:51 16:58
17	08:27 17:27	07:49 18:12	07:57 19:53	06:57 20:36	06:10 21:16	05:51 21:44	06:17 (214) 21:38	06:08 06:34 (214) 21:00	06:46 19:58	07:26 18:57	08:07 17:11	07:52 16:59
18	08:26 17:28	07:47 18:13	07:55 19:54	06:55 20:37	06:09 21:17	05:51 21:44	06:17 (214) 21:37	06:09 06:35 (214) 21:00	06:47 19:56	07:27 18:55	08:08 17:10	07:53 16:59
19	08:26 17:30	07:46 18:15	07:54 19:56	06:53 20:39	06:08 21:18	05:51 21:44	06:17 (214) 21:36	06:11 06:36 (214) 21:00	06:48 19:54	07:29 18:54	08:09 17:09	07:55 16:59
20	08:25 17:31	07:44 18:17	07:51 19:57	06:51 20:40	06:07 21:19	05:52 21:45	06:17 (214) 21:35	06:12 06:37 (214) 21:00	06:50 19:52	07:30 18:52	08:11 17:08	07:56 17:00
21	08:24 17:33	07:42 18:18	07:49 19:59	06:49 20:41	06:06 21:21	05:52 21:45	06:18 (214) 21:34	06:13 06:38 (214) 21:00	06:51 19:50	07:31 18:50	08:12 17:07	07:58 17:00
22	08:23 17:34	07:41 18:20	07:47 20:00	06:48 20:43	06:05 21:22	05:52 21:45	06:18 (214) 21:33	06:14 06:39 (214) 21:00	06:52 19:48	07:33 18:48	08:14 17:06	07:59 17:01
23	08:22 17:35	07:39 18:21	07:45 20:01	06:46 20:44	06:04 21:23	05:52 21:45	06:18 (214) 21:32	06:15 06:40 (214) 21:00	06:54 19:46	07:34 18:47	08:15 17:05	08:00 17:01
24	08:21 17:37	07:37 18:23	07:43 20:03	06:44 20:45	06:03 21:24	05:53 21:45	06:18 (214) 21:31	06:16 06:41 (214) 21:00	06:55 19:44	07:35 18:45	08:17 17:05	08:02 17:02
25	08:20 17:38	07:35 18:24	07:41 20:04	06:42 20:47	06:02 21:25	05:53 21:46	06:19 (214) 21:30	06:17 06:42 (214) 21:00	06:56 19:42	07:37 18:43	08:18 17:04	08:03 17:02
26	08:19 17:40	07:33 18:26	07:39 20:06	06:41 20:48	06:01 21:26	05:53 21:46	06:19 (214) 21:29	06:18 06:43 (214) 21:00	06:58 19:40	07:38 18:41	08:20 17:03	08:04 17:03
27	08:18 17:41	07:32 18:27	07:37 20:07	06:39 20:50	06:00 21:27	05:54 21:46	06:20 (214) 21:28	06:19 06:44 (214) 21:00	06:59 19:39	07:39 18:40	08:21 17:02	08:06 17:04
28	08:17 17:43	07:30 18:29	07:35 20:08	06:37 20:51	05:59 21:28	05:54 21:46	06:20 (214) 21:26	06:21 06:45 (214) 21:00	07:00 19:36	07:41 18:38	08:23 17:02	08:07 17:05
29	08:16 17:44	07:29 18:30	07:36 20:10	06:36 20:52	05:58 21:29	05:55 21:46	06:23 (214) 21:25	06:22 06:46 (214) 21:00	07:01 19:34	07:42 18:37	08:24 17:01	08:08 17:05
30	08:15 17:46	07:31 18:31	07:34 20:11	06:34 20:54	05:58 21:30	05:55 21:46	06:22 (214) 21:24	06:23 06:47 (214) 21:00	07:03 19:32	07:43 18:35	08:25 17:01	08:10 17:06
31	08:14 17:47	07:29 18:32	07:32 20:12	06:33 20:55	05:57 21:31	05:56 21:47	06:22 (214) 21:23	06:24 06:48 (214) 21:00	07:04 19:32	07:44 18:33	08:27 17:02	08:11 17:07
Potential sun hours	279	288	368	407	466	474	480	441	378	338	282	267
Total, worst case					38	628	239					
Sun reduction					0.68	0.71	0.76					
Oper. time red.					0.97	0.97	0.97					
Wind dir. red.					0.56	0.56	0.56					
Total reduction					0.37	0.39	0.41					
Total, real					14	243	99					

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

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

Project:
Minnesota Power - BISON Wind Energy Center

Minnesota Power
Frank Frederickson
30 West Superior Street
Duluth, MN 55802-2093

Description:
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Printed/Page:
6/21/2011 8:44 AM / 27
Licensed user:
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wind@eapc.net
Calculated:
6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) **Shadow receptor:** SR018 - SR018

Assumptions for shadow calculations

Maximum distance for influence 1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:32	09:08 (218)	08:12	09:03 (218)	07:28	07:27	06:33	05:56	05:56	06:26	07:05	07:45
11	17:08	09:15 (218)	17:49	09:44 (218)	18:30	20:14	20:55	21:32	21:45	21:21	20:30	19:30
2	08:32	09:07 (218)	08:11	09:03 (218)	07:26	07:25	06:31	05:56	05:56	06:27	07:07	07:46
12	17:09	09:21 (218)	17:50	09:43 (218)	18:31	20:15	20:56	21:33	21:45	21:20	20:28	19:28
3	08:32	09:07 (218)	08:10	09:04 (218)	07:24	07:23	06:29	05:55	05:57	06:28	07:08	07:47
13	17:10	09:23 (218)	17:52	09:43 (218)	18:33	20:17	20:58	21:34	21:45	21:19	20:26	19:26
4	08:32	09:05 (218)	08:09	09:05 (218)	07:22	07:22	06:28	05:55	05:57	06:29	07:09	07:49
14	17:11	09:23 (218)	17:54	09:43 (218)	18:34	20:16	20:59	21:35	21:45	21:17	20:24	19:24
5	08:32	09:05 (218)	08:07	09:05 (218)	07:20	07:20	06:26	05:54	05:58	06:30	07:11	07:50
15	17:12	09:25 (218)	17:55	09:42 (218)	18:36	20:19	21:00	21:36	21:44	21:16	20:22	19:22
6	08:32	09:05 (218)	08:06	09:07 (218)	07:19	07:18	06:25	05:54	05:59	06:32	07:12	07:51
16	17:13	09:26 (218)	17:57	09:42 (218)	18:37	20:21	21:02	21:37	21:44	21:14	20:20	19:20
7	08:32	09:04 (218)	08:04	09:07 (218)	07:17	07:16	06:23	05:53	06:00	06:33	07:13	07:53
17	17:14	09:27 (218)	17:58	09:41 (218)	18:39	20:22	21:03	21:37	21:44	21:13	20:18	19:18
8	08:32	09:04 (218)	08:03	09:09 (218)	08:15	07:14	06:22	05:53	06:00	06:34	07:14	07:54
18	17:16	09:29 (218)	18:00	09:40 (218)	18:40	20:24	21:04	21:38	21:43	21:11	20:16	19:16
9	08:31	09:04 (218)	08:02	09:09 (218)	08:13	07:12	06:20	05:53	06:01	06:36	07:16	07:56
19	17:17	09:30 (218)	18:00	09:38 (218)	18:42	20:25	21:06	21:39	21:43	21:10	20:14	19:14
10	08:31	09:03 (218)	08:00	09:12 (218)	08:11	07:10	06:19	05:52	06:02	06:37	07:17	07:57
20	17:18	09:31 (218)	18:01	09:37 (218)	18:43	20:26	21:07	21:40	21:42	21:08	20:12	19:12
11	08:31	09:03 (218)	07:59	09:13 (218)	08:09	07:08	06:18	05:52	06:03	06:38	07:18	07:58
21	17:19	09:32 (218)	18:03	09:35 (218)	18:45	20:28	21:08	21:40	21:42	21:07	20:10	19:10
12	08:30	09:02 (218)	07:57	09:15 (218)	08:07	07:06	06:16	05:52	06:04	06:39	07:20	08:00
22	17:20	09:33 (218)	18:04	09:32 (218)	18:46	20:29	21:10	21:41	21:41	21:05	20:08	19:08
13	08:30	09:03 (218)	07:55	09:20 (218)	08:05	07:04	06:15	05:52	06:05	06:41	07:21	08:01
23	17:22	09:35 (218)	18:06	09:28 (218)	18:06	19:47	20:30	21:11	21:42	21:04	20:06	19:06
14	08:29	09:02 (218)	07:54	08:03	07:02	06:14	05:52	06:06	06:42	07:22	08:02	07:48
24	17:23	09:35 (218)	18:07	09:34 (218)	18:07	19:49	20:32	21:12	21:42	21:02	20:04	19:05
15	08:28	09:01 (218)	07:52	08:01	07:00	06:13	05:51	06:07	06:43	07:24	08:04	07:49
25	17:24	09:36 (218)	18:09	09:33 (218)	18:09	19:50	20:33	21:13	21:43	21:00	20:02	19:03
16	08:28	09:02 (218)	07:51	07:59	06:59	06:11	05:51	06:08	06:45	07:25	08:05	07:50
26	17:26	09:37 (218)	18:10	09:37 (218)	18:10	19:52	20:34	21:15	21:43	21:38	20:59	20:00
17	08:27	09:02 (218)	07:49	07:57	06:57	06:10	05:51	06:09	06:46	07:26	08:07	07:52
27	17:27	09:38 (218)	18:12	09:33 (218)	18:12	19:53	20:36	21:16	21:44	21:38	20:57	20:00
18	08:26	09:01 (218)	07:47	07:55	06:55	06:09	05:51	06:10	06:47	07:27	08:08	07:53
28	17:28	09:39 (218)	18:14	09:34 (218)	18:14	19:54	20:37	21:17	21:44	21:37	20:55	20:00
19	08:26	09:01 (218)	07:46	07:53	06:53	06:08	05:52	06:11	06:48	07:29	08:09	07:55
29	17:30	09:39 (218)	18:15	09:34 (218)	18:15	19:56	20:39	21:18	21:44	21:36	20:53	20:00
20	08:25	09:01 (218)	07:44	07:51	06:51	06:07	05:52	06:12	06:50	07:30	08:11	07:56
30	17:31	09:40 (218)	18:17	09:35 (218)	18:17	19:57	20:40	21:19	21:45	21:35	20:52	20:00
21	08:24	09:01 (218)	07:42	07:49	06:50	06:06	05:52	06:13	06:51	07:31	08:12	07:58
31	17:33	09:41 (218)	18:18	09:36 (218)	18:18	19:59	20:41	21:21	21:45	21:34	20:50	20:00
22	08:23	09:02 (218)	07:41	07:47	06:48	06:05	05:52	06:14	06:52	07:33	08:14	07:59
23	17:34	09:41 (218)	18:20	09:37 (218)	18:20	20:00	21:22	21:45	21:33	20:48	19:48	18:48
24	08:22	09:01 (218)	07:39	07:45	06:46	06:04	05:52	06:15	06:54	07:34	08:15	08:00
25	17:35	09:42 (218)	18:21	09:38 (218)	18:21	20:01	20:44	21:23	21:45	21:32	20:46	19:46
26	08:21	09:01 (218)	07:37	07:43	06:44	06:03	05:53	06:16	06:55	07:35	08:17	08:02
27	17:37	09:42 (218)	18:23	09:39 (218)	18:23	20:03	20:45	21:24	21:45	21:31	20:45	19:44
28	08:20	09:01 (218)	07:35	07:41	06:43	06:02	05:53	06:17	06:56	07:37	08:18	08:03
29	17:38	09:43 (218)	18:24	09:40 (218)	18:24	20:04	20:47	21:25	21:46	21:30	20:43	19:42
30	08:19	09:01 (218)	07:33	07:39	06:41	06:01	05:53	06:18	06:58	07:38	08:20	08:04
31	17:40	09:43 (218)	18:26	09:40 (218)	18:26	20:06	20:48	21:26	21:46	21:29	20:41	19:40
27	08:18	09:02 (218)	07:32	07:37	06:39	06:00	05:54	06:19	06:59	07:39	08:21	08:06
28	17:41	09:44 (218)	18:27	09:41 (218)	18:27	20:07	20:50	21:27	21:46	21:28	20:39	19:38
29	08:17	09:02 (218)	07:30	07:35	06:37	05:59	05:54	06:21	07:00	07:41	08:23	08:07
30	17:43	09:44 (218)	18:29	09:41 (218)	18:29	20:08	20:51	21:28	21:46	21:26	20:37	19:36
31	08:16	09:01 (218)	07:31	07:33	06:36	05:58	05:55	06:22	07:01	07:42	08:24	08:08
32	17:44	09:43 (218)	18:25	09:40 (218)	18:25	20:10	20:52	21:29	21:46	21:25	20:35	19:34
33	08:15	09:02 (218)	07:31	07:31	06:34	05:58	05:55	06:23	07:03	07:43	08:25	08:09
34	17:46	09:44 (218)	18:27	09:41 (218)	18:27	20:11	21:30	21:46	21:24	20:33	19:32	18:35
35	08:14	09:03 (218)	07:31	07:29	06:33	05:57	05:54	06:24	07:04	07:44	08:27	08:11
36	17:47	09:44 (218)	18:28	09:41 (218)	18:28	20:12	21:31	21:47	21:23	20:32	19:31	18:33
Potential sun hours	279	288	368	407	466	474	480	441	378	338	23	282
Total, worst case	1003	396									52	263
Sun reduction	0.55	0.50								0.52	0.43	0.43
Oper. time red.	0.97	0.97								0.97	0.97	0.97
Wind dir. red.	0.75	0.75								0.75	0.75	0.75
Total reduction	0.40	0.36								0.38	0.31	0.31
Total, real	398	144								20	349	82

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)
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Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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6/21/2011 8:44 AM / 28

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Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR019 - SR019

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
 Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:33 17:08	08:13 17:49	07:28 18:30	07:28 20:14								
2	08:33 17:09	08:11 17:51	07:26 18:32	07:26 20:15	24 19:46 (226)	06:33 20:55	05:56 21:32	05:56 21:46	06:26 21:21	07:05 20:30	07:45 19:30	08:11 17:32
3	08:33 17:10	08:10 17:52	07:24 18:33	07:24 20:17	24 19:46 (226)	06:31 20:56	05:56 21:33	05:57 21:45	06:27 21:20	07:07 20:28	07:46 19:28	08:12 17:30
4	08:33 17:11	08:09 17:54	07:22 18:35	07:22 20:17	23 19:45 (226)	06:29 20:58	05:55 21:34	05:57 21:45	06:28 21:19	07:08 20:26	07:47 19:26	08:13 17:29
5	08:32 17:12	08:07 17:55	07:21 18:36	07:20 20:18	21 19:44 (226)	06:28 20:59	05:54 21:35	05:58 21:45	06:29 21:17	07:09 20:24	07:49 19:32 (226)	08:14 17:27
6	08:32 17:13	08:06 17:58	07:19 18:37	07:18 20:19	20 19:43 (226)	06:25 21:00	05:54 21:36	05:59 21:45	06:32 21:16	07:12 20:22	07:52 19:35 (226)	08:16 17:26
7	08:32 17:14	08:05 17:58	07:17 18:39	07:16 20:21	17 19:41 (226)	06:23 21:02	05:53 21:37	06:00 21:44	06:33 21:15	07:13 20:20	07:53 19:37 (226)	08:17 17:25
8	08:32 17:16	08:03 18:00	08:15 18:40	07:14 20:22	13 19:39 (226)	06:22 21:03	05:58 21:38	06:00 21:44	06:34 21:13	07:15 20:18	07:54 19:38 (226)	08:19 17:23
9	08:31 17:17	08:02 18:00	08:13 19:42	07:12 20:25	6 19:35 (226)	06:21 21:06	05:53 21:39	06:01 21:43	06:36 21:10	07:16 20:14	07:56 19:38 (226)	08:20 17:21
10	08:31 17:18	08:00 18:01	08:11 19:43	07:10 20:26		06:19 21:07	05:52 21:40	06:02 21:42	06:37 21:08	07:17 20:12	07:57 19:39 (226)	08:21 17:19
11	08:31 17:19	07:59 18:03	08:09 19:45	07:08 20:28		06:18 21:08	05:52 21:40	06:03 21:42	06:38 21:07	07:18 20:10	07:58 19:39 (226)	08:22 17:18
12	08:30 17:20	07:57 18:04	08:07 19:46	07:06 20:29		06:16 21:10	05:52 21:41	06:04 21:41	06:39 21:05	07:20 20:08	08:00 19:38 (226)	08:23 17:17
13	08:30 17:22	07:56 18:06	08:05 19:47	07:04 20:30		06:15 21:11	05:52 21:42	06:05 21:41	06:41 21:04	07:21 20:06	08:01 19:37 (226)	08:24 17:16
14	08:29 17:23	07:54 18:08	08:03 19:49	07:02 20:32		06:14 21:12	05:52 21:42	06:06 21:40	06:42 21:02	07:22 20:04	08:03 19:37 (226)	08:24 17:14
15	08:29 17:24	07:52 18:09	08:01 19:50	07:01 20:33		06:13 21:13	05:52 21:43	06:07 21:39	06:43 21:00	07:24 20:02	08:04 19:36 (226)	08:25 17:13
16	08:28 17:26	07:51 18:11	07:59 19:52	06:59 20:35		06:11 21:15	05:51 21:43	06:08 21:38	06:45 20:59	07:25 20:00	08:05 19:34 (226)	08:26 17:12
17	08:27 17:27	07:49 18:12	07:57 19:53	06:57 20:36		06:10 21:16	05:51 21:44	06:09 21:38	06:46 20:57	07:26 19:58	08:07 19:32 (226)	08:27 17:11
18	08:27 17:28	07:47 18:14	07:55 19:55	06:55 20:37		06:09 21:17	05:52 21:44	06:10 21:37	06:47 20:55	07:28 19:56	08:08 19:30 (226)	08:27 17:10
19	08:26 17:30	07:46 18:15	07:53 19:56	06:53 20:39		06:08 21:18	05:52 21:44	06:11 21:36	06:49 20:54	07:29 19:54	08:10 19:28 (226)	08:28 17:09
20	08:25 17:31	07:44 18:17	07:51 19:57	06:51 20:40		06:07 21:20	05:52 21:45	06:12 21:35	06:50 20:52	07:30 19:52	08:11 19:28 (226)	08:29 17:08
21	08:24 17:33	07:42 18:18	07:49 19:59	06:50 20:41		06:06 21:21	05:52 21:45	06:13 21:34	06:51 20:50	07:31 19:50	08:12 19:34 (226)	08:30 17:07
22	08:23 17:34	07:41 18:20	07:47 20:00	06:48 20:43		06:05 21:22	05:52 21:45	06:14 21:33	06:52 20:48	07:33 19:48	08:14 19:28 (226)	08:31 17:06
23	08:22 17:36	07:39 18:21	07:45 20:02	06:46 20:44		06:04 21:23	05:52 21:45	06:15 21:32	06:54 20:46	07:34 19:46	08:15 19:28 (226)	08:32 17:06
24	08:21 17:37	07:37 18:23	07:43 20:03	06:44 20:46	8 19:40 (226)	06:03 21:24	05:53 21:46	06:16 21:31	06:55 20:45	07:35 19:44	08:17 19:28 (226)	08:31 17:05
25	08:20 17:38	07:35 18:24	07:41 20:04	06:43 20:47	14 19:42 (226)	06:02 21:25	05:53 21:46	06:17 21:30	06:56 20:43	07:37 19:42	08:18 19:28 (226)	08:31 17:04
26	08:19 17:40	07:34 18:26	07:39 20:06	06:41 20:48	17 19:43 (226)	06:01 21:26	05:53 21:46	06:18 21:29	06:58 20:41	07:38 19:40	08:20 19:28 (226)	08:31 17:03
27	08:18 17:41	07:32 18:27	07:37 20:07	06:39 20:50	19 19:44 (226)	06:00 21:27	05:54 21:46	06:20 21:28	06:59 20:39	07:39 19:38	08:21 19:28 (226)	08:32 17:04
28	08:17 17:43	07:30 18:29	07:35 20:08	06:38 20:51	22 19:44 (226)	05:59 21:28	05:54 21:46	06:21 21:27	07:00 20:37	07:41 19:36	08:23 19:28 (226)	08:32 17:05
29	08:16 17:44	07:33 18:20	07:33 20:10	06:36 20:52	23 19:43 (226)	05:59 21:30	05:55 21:46	06:22 21:25	07:02 20:35	07:42 19:34	08:24 19:28 (226)	08:32 17:05
30	08:15 17:46	07:31 18:21	07:31 20:11	06:34 20:54	24 19:42 (226)	05:58 21:31	05:55 21:46	06:23 21:24	07:03 20:34	07:43 19:32	08:26 19:28 (226)	08:32 17:06
31	08:14 17:48	07:29 18:13	07:29 20:13	06:34 20:54	25 19:46 (226)	05:57 21:31	05:55 21:46	06:24 21:23	07:04 20:32	07:44 19:32	08:27 19:28 (226)	08:32 17:07
Potential sun hours	279	288	368	407		466	474	480	441	378	338	267
Total, worst case			152	148						304		
Sun reduction			0.63	0.59						0.69		
Oper. time red.			0.97	0.97						0.97		
Wind dir. red.			0.69	0.69						0.69		
Total reduction			0.42	0.39						0.46		
Total, real			63	58						139		

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)

Project: **Minnesota Power - BISON Wind Energy Center**

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 Calculated: 6/17/2011 8:43 AM/2.7.486

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR020 - SR020

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:33	08:13	07:28	07:28	06:33	05:57	05:56	06:26	07:06	07:45	07:29	08:11
	17:08	17:49	18:30	20:14	20:55	21:33	21:46	21:22	20:30	19:30	17:32	17:01
2	08:33	08:12	07:26	07:26	06:31	05:56	05:56	06:27	07:07	07:46	07:30	08:12
	17:09	17:51	18:32	20:16	20:57	21:34	21:46	21:20	20:28	19:28	17:31	17:00
3	08:33	08:10	07:25	07:24	06:30	05:55	05:57	06:28	07:08	07:48	07:32	08:14
	17:10	17:52	18:33	20:17	20:58	21:34	21:45	21:19	20:26	19:26	17:29	17:00
4	08:33	08:09	07:23	07:22	06:28	05:55	05:58	06:30	07:10	07:49	07:33	08:15
	17:11	17:54	18:35	20:18	20:59	21:35	21:45	21:18	20:24	19:24	17:28	16:59
5	08:33	08:08	07:21	07:20	06:27	05:54	05:58	06:31	07:11	07:50	07:35	08:16
	17:12	17:55	18:36	20:20	21:01	21:36	21:45	21:16	20:22	19:22	17:26	16:59
6	08:32	08:06	07:19	07:18	06:25	05:54	05:59	06:32	07:12	07:52	07:36	08:17
	17:14	17:57	18:38	20:21	21:02	21:37	21:44	21:15	20:20	19:20	17:25	16:59
7	08:32	08:05	07:17	07:16	06:24	05:54	06:00	06:33	07:13	07:53	07:38	08:18
	17:15	17:58	18:39	20:22	21:03	21:38	21:44	21:13	20:18	19:18	17:23	16:59
8	08:32	08:03	08:15	07:14	06:22	05:53	06:01	06:35	07:15	07:54	07:39	08:19
	17:16	18:00	18:41	20:24	21:05	21:39	21:44	21:12	20:16	19:16	17:22	16:58
9	08:32	08:02	08:13	07:12	06:21	05:53	06:01	06:36	07:16	07:56	07:41	08:20
	17:17	18:00	19:42	20:25	21:06	21:39	21:43	21:10	20:14	19:14	17:21	16:58
10	08:31	08:00	08:11	07:10	06:19	05:53	06:02	06:37	07:17	07:57	07:42	08:21
	17:18	18:02	19:43	20:27	21:07	21:40	21:43	21:09	20:12	19:12	17:19	16:58
11	08:31	07:59	08:09	07:08	06:18	05:52	06:03	06:38	07:19	07:59	07:44	08:22
	17:19	18:03	19:45	20:28	21:09	21:41	21:42	21:07	20:10	19:11	17:18	16:58
12	08:30	07:57	08:07	07:06	06:17	05:52	06:04	06:40	07:20	08:00	07:45	08:23
	17:21	18:05	19:46	20:29	21:10	21:41	21:41	21:06	20:08	19:09	17:17	16:58
13	08:30	07:56	08:05	07:04	06:15	05:52	06:05	06:41	07:21	08:01	07:46	08:24
	17:22	18:06	19:48	20:31	21:11	21:42	21:41	21:04	20:06	19:07	17:16	16:58
14	08:29	07:54	08:03	07:03	06:14	05:52	06:06	06:42	07:23	08:03	07:48	08:25
	17:23	18:08	19:49	20:32	21:12	21:42	21:40	21:02	20:04	19:05	17:15	16:58
15	08:29	07:53	08:01	07:01	06:13	05:52	06:07	06:44	07:24	08:04	07:49	08:25
	17:25	18:09	19:51	20:33	21:14	21:43	21:39	21:01	20:02	19:03	17:13	16:59
16	08:28	07:51	07:59	06:59	06:12	05:52	06:08	06:45	07:25	08:06	07:51	08:26
	17:26	18:11	19:52	20:35	21:15	21:43	21:39	20:59	20:00	19:01	17:12	16:59
17	08:27	07:49	07:57	06:57	06:10	05:52	06:09	06:46	07:26	08:07	07:52	08:27
	17:27	18:12	19:53	20:36	21:16	21:44	21:38	20:57	19:58	18:57	17:11	16:59
18	08:27	07:48	07:55	06:55	06:09	05:52	06:10	06:47	07:28	08:08	07:54	08:28
	17:29	18:14	19:55	20:38	21:17	21:44	21:37	20:56	19:56	18:56	17:10	16:59
19	08:26	07:46	07:54	06:53	06:08	05:52	06:11	06:49	07:29	08:10	07:55	08:28
	17:30	18:15	19:56	20:39	21:19	21:45	21:36	20:54	19:54	18:54	17:09	17:00
20	08:25	07:44	07:52	06:52	06:07	05:52	06:12	06:50	07:30	08:11	07:57	08:29
	17:31	18:17	19:58	20:40	21:20	21:45	21:35	20:52	19:52	18:52	17:08	17:00
21	08:24	07:43	07:50	06:50	06:06	05:52	06:13	06:51	07:32	08:13	07:58	08:29
	17:33	18:18	19:59	20:42	21:21	21:45	21:34	20:50	19:50	18:50	17:07	17:00
22	08:24	07:41	07:48	06:48	06:05	05:52	06:14	06:53	07:33	08:14	07:59	08:30
	17:34	18:20	20:00	20:43	21:22	21:45	21:33	20:48	19:48	18:49	17:07	17:01
23	08:23	07:39	07:46	06:46	06:04	05:53	06:15	06:54	07:34	08:16	08:01	08:30
	17:36	18:21	20:02	20:44	21:23	21:46	21:32	20:47	19:46	18:47	17:06	17:02
24	08:22	07:37	07:44	06:45	06:03	05:53	06:16	06:55	07:36	08:17	08:02	08:31
	17:37	18:23	20:03	20:46	21:24	21:46	21:31	20:45	19:44	18:45	17:05	17:02
25	08:21	07:36	07:42	06:43	06:02	05:53	06:17	06:57	07:37	08:18	08:03	08:31
	17:39	18:24	20:04	20:47	21:25	21:46	21:30	20:43	19:42	18:43	17:04	17:03
26	08:20	07:34	07:40	06:41	06:01	05:54	06:19	06:58	07:38	08:20	08:05	08:32
	17:40	18:26	20:06	20:48	21:27	21:46	21:29	20:41	19:40	18:42	17:03	17:03
27	08:19	07:32	07:38	06:39	06:00	05:54	06:20	06:59	07:40	08:21	08:06	08:32
	17:42	18:27	20:07	20:50	21:28	21:46	21:28	20:39	19:38	18:40	17:03	17:04
28	08:17	07:30	07:36	06:38	05:59	05:54	06:21	07:00	07:41	08:23	08:07	08:32
	17:43	18:29	20:09	20:51	21:29	21:46	21:27	20:37	19:36	18:38	17:02	17:05
29	08:16	07:34	07:34	06:36	05:59	05:55	06:22	07:02	07:42	08:24	08:09	08:32
	17:45	18:30	20:10	20:53	21:30	21:46	21:25	20:36	19:34	18:37	17:02	17:06
30	08:15	07:32	07:32	06:34	05:58	05:55	06:23	07:03	07:44	08:26	08:10	08:33
	17:46	18:31	20:11	20:54	21:31	21:46	21:24	20:34	19:32	18:35	17:01	17:06
31	08:14	07:30	07:30	06:32	05:57	05:57	06:25	07:04	07:45	08:27	08:11	08:33
	17:48	18:33	20:13	20:56	21:32	21:46	21:23	20:32	19:30	18:34	17:01	17:07
Potential sun hours	279	288	368	407	466	474	480	441	378	338	282	267
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)	Minutes with flicker	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)		Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project: **Minnesota Power - BISON Wind Energy Center**

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR021 - SR021

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December		
1	08:33	09:08 (222)	08:13	07:28	07:28	08:33	05:57	05:56	06:26	07:06	07:45	08:12 (223)	07:29	08:11
2	08:33	09:09 (222)	08:11	07:26	07:26	08:31	05:56	05:56	06:27	07:07	07:46	08:10 (223)	07:30	08:12
3	08:33	09:10 (222)	08:10	07:24	07:24	08:30	05:55	05:57	06:28	07:08	07:48	08:10 (223)	07:32	08:13
4	08:33	09:12 (222)	08:09	07:23	07:23	08:29	05:55	05:58	06:29	07:10	07:49	08:11 (223)	07:33	08:15
5	08:33	09:12 (222)	08:08	07:21	07:21	08:27	05:54	05:58	06:31	07:11	07:50	08:12 (223)	07:35	08:16
6	08:32	09:18 (222)	08:06	07:19	07:19	08:25	05:54	05:59	06:32	07:12	07:52	08:14 (223)	07:36	08:17
7	08:32	08:05	07:17	07:38 (223)	07:16	08:24	05:54	06:00	06:33	07:13	07:53	08:15 (223)	07:38	08:18
8	08:32	08:03	08:15	07:52 (223)	07:14	08:22	05:53	06:01	06:35	07:15	07:54	08:16 (223)	07:39	08:19
9	08:32	08:02	08:13	08:52 (223)	07:12	08:21	05:53	06:01	06:36	07:16	07:56	08:17 (223)	07:41	08:20
10	08:31	08:00	08:11	08:52 (223)	07:10	08:19	05:53	06:02	06:37	07:17	07:57	08:18 (223)	07:42	08:21
11	08:31	07:59	08:09	08:31 (223)	07:08	08:18	05:52	06:03	06:38	07:19	07:59	08:19 (223)	07:43	08:22
12	08:30	07:57	08:07	08:30 (223)	07:06	08:17	05:52	06:04	06:40	07:20	08:00	08:20 (223)	07:45	08:23
13	08:30	07:56	08:05	08:34 (223)	07:04	08:16	05:52	06:05	06:41	07:21	08:01	08:21 (223)	07:46	08:24
14	08:29	07:54	08:03	08:35 (223)	07:03	08:14	05:52	06:06	06:42	07:23	08:03	08:22 (223)	07:48	08:25
15	08:29	07:53	08:01	08:38 (223)	07:01	08:13	05:52	06:07	06:44	07:24	08:04	08:23 (223)	07:49	08:25
16	08:28	07:51	07:59	08:44 (223)	06:59	08:12	05:52	06:08	06:45	07:25	08:06	08:24 (223)	07:51	08:26
17	08:27	07:49	07:57	08:35 (223)	06:57	08:11	05:52	06:09	06:46	07:26	08:07	08:25 (223)	07:52	08:27
18	08:27	07:48	07:55	08:36 (223)	06:56	08:10	05:52	06:10	06:47	07:28	08:08	08:26 (223)	07:54	08:28
19	08:26	07:46	07:53	08:37 (223)	06:55	08:09	05:52	06:11	06:49	07:29	08:10	08:27 (223)	07:55	08:28
20	08:25	07:44	07:51	08:38 (223)	06:54	08:08	05:52	06:12	06:50	07:30	08:11	08:28 (223)	07:56	08:29
21	08:24	07:43	07:50	08:39 (223)	06:53	08:07	05:52	06:13	06:51	07:32	08:13	08:29 (223)	07:58	08:29
22	08:23	07:41	07:48	08:40 (223)	06:52	08:06	05:52	06:14	06:53	07:33	08:14	08:30 (223)	07:59	08:30
23	08:23	07:39	07:46	08:41 (223)	06:51	08:05	05:52	06:15	06:54	07:34	08:16	08:31 (223)	08:01	08:30
24	08:22	07:37	07:44	08:42 (223)	06:50	08:04	05:52	06:16	06:55	07:36	08:17	08:32 (223)	08:02	08:31
25	08:21	07:35	07:42	08:43 (223)	06:49	08:03	05:52	06:17	06:57	07:37	08:18	08:33 (223)	08:03	08:31
26	08:20	07:34	07:40	08:44 (223)	06:48	08:02	05:52	06:18	06:58	07:38	08:20	08:34 (223)	08:05	08:32
27	08:19	07:32	07:38	08:45 (223)	06:47	08:01	05:52	06:19	06:59	07:40	08:21	08:35 (223)	08:07	08:32
28	08:17	07:30	07:36	08:46 (223)	06:46	08:00	05:52	06:20	07:00	07:41	08:23	08:36 (223)	08:09	08:33
29	08:16	07:29	07:35	08:47 (223)	06:45	07:59	05:52	06:21	07:02	07:42	08:24	08:37 (223)	08:11	08:34
30	08:15	07:28	07:34	08:48 (223)	06:44	07:58	05:52	06:22	07:04	07:44	08:26	08:38 (223)	08:13	08:35
31	08:14	07:27	07:33	08:49 (223)	06:43	07:57	05:52	06:23	07:06	07:46	08:28	08:39 (223)	08:15	08:36
Potential sun hours	279	288	368	407	466	474	480	441	378	338	282	267	350	350
Total, worst case	47		165						25		141			350
Sun reduction	0.55		0.63						0.69		0.52			0.43
Oper. time red.	0.97		0.97						0.97		0.97			0.97
Wind dir. red.	0.75		0.72						0.72		0.72			0.75
Total reduction	0.40		0.44						0.48		0.36			0.31
Total, real	19		72						12		51			109

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)

Project:
Minnesota Power - BISON Wind Energy Center

Minnesota Power
Frank Frederickson
30 West Superior Street
Duluth, MN 55802-2093

Description:
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wind@eapc.net
Calculated:
6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR022 - SR022

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW Sum
458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509
Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December		
1	08:33	08:13	07:28	07:28	06:33	05:57	06:29 (222)	05:56	06:32 (222)	06:26	07:06	07:45	07:29	08:11
2	08:33	08:11	07:26	07:26	06:31	05:56	06:29 (222)	05:56	06:32 (222)	06:27	07:07	07:46	07:30	08:12
3	08:33	08:10	07:24	07:24	06:30	05:55	06:28 (222)	05:57	06:32 (222)	06:28	07:08	07:48	07:32	08:13
4	08:33	08:09	07:23	07:22	06:28	05:55	06:28 (222)	05:58	06:33 (222)	06:29	07:10	07:49	07:33	08:15
5	08:32	08:06	07:19	07:18	06:25	05:54	06:28 (222)	05:59	06:34 (222)	06:32	07:12	07:52	07:36	08:17
6	08:32	08:05	07:17	07:16	06:24	05:54	06:28 (222)	06:00	06:35 (222)	06:33	07:13	07:53	07:38	08:18
7	08:32	08:05	07:17	07:16	06:24	05:54	06:28 (222)	06:00	06:35 (222)	06:33	07:13	07:53	07:38	08:18
8	08:32	08:03	08:15	07:14	06:22	05:53	06:27 (222)	06:01	06:35 (222)	06:35	07:15	07:54	07:39	08:19
9	08:32	08:02	08:13	07:12	06:21	05:53	06:27 (222)	06:01	06:35 (222)	06:36	07:16	07:56	07:40	08:20
10	08:31	08:00	08:11	07:10	06:20	05:53	06:27 (222)	06:02	06:36 (222)	06:37	07:17	07:57	07:42	08:21
11	08:31	07:59	08:09	07:08	06:18	05:52	06:28 (222)	06:03	06:37 (222)	06:38	07:19	07:59	07:43	08:22
12	08:30	07:57	08:07	07:06	06:17	05:52	06:28 (222)	06:04	06:38 (222)	06:40	07:20	08:00	07:45	08:23
13	08:30	07:56	08:05	07:04	06:15	05:52	06:27 (222)	06:05	06:39 (222)	06:41	07:21	08:01	07:46	08:24
14	08:29	07:54	08:03	07:03	06:14	05:52	06:27 (222)	06:06	06:39 (222)	06:42	07:23	08:03	07:48	08:25
15	08:29	07:53	08:01	07:01	06:13	05:52	06:27 (222)	06:07	06:40 (222)	06:44	07:24	08:04	07:49	08:25
16	08:28	07:51	07:59	06:59	06:12	05:52	06:27 (222)	06:08	06:41 (222)	06:45	07:25	08:05	07:51	08:26
17	08:27	07:49	07:57	06:57	06:10	05:52	06:27 (222)	06:09	06:43 (222)	06:46	07:26	08:07	07:52	08:27
18	08:27	07:48	07:55	06:55	06:09	05:52	06:27 (222)	06:10	06:44 (222)	06:47	07:27	08:08	07:54	08:28
19	08:26	07:46	07:53	06:53	06:08	05:52	06:28 (222)	06:11	06:46 (222)	06:49	07:29	08:10	07:55	08:28
20	08:25	07:44	07:51	06:52	06:07	05:52	06:29 (222)	06:12	06:48 (222)	06:50	07:31	08:11	07:56	08:29
21	08:24	07:43	07:49	06:50	06:06	05:52	06:29 (222)	06:13	06:52 (222)	06:51	07:32	08:13	07:58	08:29
22	08:23	07:41	07:47	06:48	06:05	05:52	06:29 (222)	06:14	06:53 (222)	06:52	07:33	08:14	07:59	08:30
23	08:23	07:39	07:46	06:46	06:04	05:53	06:28 (222)	06:15	06:54 (222)	06:51	07:34	08:15	08:01	08:30
24	08:22	07:37	07:44	06:44	06:03	05:53	06:29 (222)	06:16	06:55 (222)	06:55	07:35	08:16	08:02	08:31
25	08:21	07:35	07:42	06:43	06:02	05:53	06:29 (222)	06:17	06:57 (222)	06:57	07:36	08:17	08:03	08:31
26	08:20	07:34	07:40	06:41	06:01	05:54	06:29 (222)	06:19	06:58 (222)	06:58	07:37	08:18	08:04	08:32
27	08:19	07:32	07:38	06:39	06:00	05:54	06:30 (222)	06:20	06:59 (222)	06:59	07:38	08:19	08:05	08:32
28	08:17	07:30	07:36	06:38	05:59	05:59	06:30 (222)	06:21	07:00 (222)	07:00	07:39	08:20	08:06	08:32
29	08:16	07:29	07:34	06:36	05:59	05:59	06:31 (222)	06:22	07:02 (222)	07:02	07:40	08:21	08:07	08:32
30	08:15	07:28	07:32	06:34	05:58	05:58	06:32 (222)	06:23	07:03 (222)	07:03	07:41	08:22	08:08	08:32
31	08:14	07:27	07:30	06:33	05:57	05:57	06:33 (222)	06:24	07:04 (222)	07:04	07:42	08:23	08:09	08:32
Potential sun hours	279	288	368	407	466	474	480	441	378	338	282	267		
Total, worst case				204	227	1297	697	208						
Sun reduction				0.59	0.68	0.71	0.76	0.73						
Oper. time red.				0.97	0.97	0.97	0.97	0.97						
Wind dir. red.				0.63	0.57	0.57	0.57	0.63						
Total reduction				0.36	0.38	0.40	0.42	0.45						
Total, real				74	86	513	294	93						

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)	Last time (hh:mm) with flicker	(WTG causing flicker last time)
	Minutes with flicker		

Project: **Minnesota Power - BISON Wind Energy Center**

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

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 wind@eapc.net
 Calculated:
 6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR023 - SR023

Assumptions for shadow calculations

Maximum distance for influence 1,500 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 NE ENE E ESE SE SSE S SSW SW W WNW NW NNW Sum
 458 248 266 220 302 504 760 767 521 378 415 371 576 904 1,027 793 8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:33	08:13	07:28	07:28	06:33	05:57	05:56	06:26	07:06	07:45	07:29	08:11
	17:09	17:49	18:30	20:14	20:55	21:32	21:46	21:22	20:30	19:30	17:32	17:01
2	08:33	08:11	07:26	07:26	06:31	05:56	05:57	06:27	07:07	07:46	07:30	08:12
	17:09	17:51	18:32	20:15	20:56	21:33	21:45	21:20	20:28	19:28	17:31	17:00
3	08:33	08:10	07:24	07:24	06:30	05:55	05:57	06:28	07:08	07:48	07:32	08:13
	17:10	17:52	18:33	20:17	20:58	21:34	21:45	21:19	20:26	19:26	17:29	17:00
4	08:33	08:09	07:23	07:22	06:28	05:55	05:58	06:30	07:10	07:49	07:33	08:15
	17:11	17:54	18:35	20:18	20:59	21:35	21:45	21:17	20:24	19:24	17:28	16:59
5	08:32	08:07	07:21	07:20	06:27	05:54	05:58	06:31	07:11	07:50	07:35	08:16
	17:13	17:55	18:36	20:20	21:01	21:36	21:45	21:16	20:22	19:22	17:26	16:59
6	08:32	08:06	07:19	07:18	06:25	05:54	05:59	06:32	07:12	07:52	07:36	08:17
	17:14	17:57	18:38	20:21	21:02	21:37	21:44	21:15	20:20	19:20	17:25	16:59
7	08:32	08:05	07:17	07:16	06:24	05:54	06:00	06:33	07:13	07:53	07:37	08:18
	17:15	17:58	18:39	20:22	21:03	21:38	21:44	21:13	20:18	19:18	17:23	16:59
8	08:32	08:03	08:15	07:14	06:22	05:53	06:01	06:35	07:15	07:54	07:39	08:19
	17:16	18:00	18:40	20:24	21:04	21:38	21:43	21:12	20:16	19:16	17:22	16:58
9	08:31	08:02	08:13	07:12	06:21	05:53	06:01	06:36	07:16	07:56	07:40	08:20
	17:17	18:00	19:42	20:25	21:06	21:39	21:43	21:10	20:14	19:14	17:21	16:58
10	08:31	08:00	08:11	07:10	06:19	05:53	06:02	06:37	07:17	07:57	07:42	08:21
	17:18	18:02	19:43	20:26	21:07	21:40	21:42	21:09	20:12	19:12	17:19	16:58
11	08:31	07:59	08:09	07:08	06:18	05:52	06:03	06:38	07:19	07:58	07:43	08:22
	17:19	18:03	19:45	20:28	21:08	21:40	21:42	21:07	20:10	19:11	17:18	16:58
12	08:30	07:57	08:07	07:06	06:17	05:52	06:04	06:40	07:20	08:00	07:45	08:23
	17:21	18:05	19:46	20:29	21:10	21:41	21:41	21:05	20:08	19:09	17:17	16:58
13	08:30	07:56	08:05	07:04	06:15	05:52	06:05	06:41	07:21	08:01	07:46	08:24
	17:22	18:06	19:48	20:31	21:11	21:42	21:41	21:04	20:06	19:07	17:16	16:58
14	08:29	07:54	08:03	07:03	06:14	05:52	06:06	06:42	07:22	08:03	07:48	08:24
	17:23	18:08	19:49	20:32	21:12	21:42	21:40	21:02	20:04	19:05	17:15	16:58
15	08:29	07:53	08:01	07:01	06:13	05:52	06:07	06:44	07:24	08:04	07:49	08:25
	17:25	18:09	19:50	20:33	21:13	21:43	21:39	21:00	20:02	19:03	17:13	16:59
16	08:28	07:51	07:59	06:59	06:12	05:52	06:08	06:45	07:25	08:05	07:51	08:26
	17:26	18:11	19:52	20:35	21:15	21:43	21:38	20:59	20:00	19:01	17:12	16:59
17	08:27	07:49	07:57	06:57	06:10	05:52	06:09	06:46	07:26	08:07	07:52	08:27
	17:27	18:12	19:53	20:36	21:16	21:44	21:38	20:57	19:58	18:57	17:11	16:59
18	08:27	07:48	07:55	06:55	06:09	05:52	06:10	06:47	07:28	08:08	07:54	08:27
	17:29	18:14	19:55	20:37	21:17	21:44	21:37	20:55	19:56	18:56	17:10	16:59
19	08:26	07:46	07:53	06:53	06:08	05:52	06:11	06:49	07:29	08:10	07:55	08:28
	17:30	18:15	19:56	20:39	21:18	21:44	21:36	20:54	19:54	18:54	17:09	17:00
20	08:25	07:44	07:51	06:52	06:07	05:52	06:12	06:50	07:30	08:11	07:56	08:29
	17:31	18:17	19:57	20:40	21:20	21:45	21:35	20:52	19:52	18:52	17:08	17:00
21	08:24	07:42	07:49	06:50	06:06	05:52	06:13	06:51	07:32	08:13	07:58	08:29
	17:33	18:18	19:59	20:42	21:21	21:45	21:34	20:50	19:50	18:50	17:07	17:01
22	08:23	07:41	07:47	06:48	06:05	05:52	06:14	06:53	07:33	08:14	07:59	08:30
	17:34	18:20	20:00	20:43	21:22	21:45	21:33	20:48	19:48	18:49	17:07	17:01
23	08:22	07:39	07:45	06:46	06:04	05:53	06:15	06:54	07:34	08:15	08:01	08:30
	17:36	18:21	20:02	20:44	21:23	21:45	21:32	20:47	19:46	18:47	17:06	17:02
24	08:22	07:37	07:44	06:45	06:03	05:53	06:16	06:55	07:36	08:17	08:02	08:31
	17:37	18:23	20:03	20:46	21:24	21:46	21:31	20:45	19:44	18:45	17:05	17:02
25	08:21	07:35	07:42	06:43	06:02	05:53	06:17	06:57	07:37	08:18	08:03	08:31
	17:39	18:24	20:04	20:47	21:25	21:46	21:30	20:43	19:42	18:43	17:04	17:03
26	08:19	07:34	07:40	06:41	06:01	05:54	06:19	06:58	07:38	08:20	08:05	08:31
	17:40	18:26	20:06	20:48	21:26	21:46	21:29	20:41	19:40	18:42	17:03	17:03
27	08:18	07:32	07:38	06:39	06:00	05:54	06:20	06:59	07:40	08:21	08:06	08:32
	17:42	18:27	20:07	20:50	21:27	21:46	21:28	20:39	19:38	18:40	17:03	17:04
28	08:17	07:30	07:36	06:38	06:00	05:54	06:21	07:00	07:41	08:23	08:07	08:32
	17:43	18:29	20:09	20:51	21:29	21:46	21:27	20:37	19:36	18:38	17:02	17:05
29	08:16	07:34	07:40	06:41	06:03	05:55	06:22	07:02	07:42	08:24	08:08	08:32
	17:45	18:30	20:10	20:52	21:30	21:46	21:25	20:36	19:34	18:37	17:02	17:06
30	08:15	07:32	07:38	06:39	06:01	05:55	06:23	07:03	07:44	08:26	08:10	08:32
	17:46	18:31	20:11	20:54	21:31	21:46	21:24	20:34	19:32	18:35	17:01	17:06
31	08:14	07:30	07:36	06:37	06:00	05:55	06:24	07:04	07:45	08:27	08:11	08:33
	17:48	18:33	20:13	20:56	21:32	21:46	21:23	20:32	19:30	18:34	17:01	17:07
Potential sun hours	279	288	368	407	466	474	480	441	378	339	282	267
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) Minutes with flicker First time (hh:mm) with flicker (WTG causing flicker first time)
 Sun set (hh:mm) Last time (hh:mm) with flicker (WTG causing flicker last time)

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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Calculated:

6/17/2011 8:43 AM/2.7.486

SHADOW - Calendar

Calculation: BISON 2 Shadow Flicker (with existing BISON 1) Shadow receptor: SR024 - SR024

Assumptions for shadow calculations

Maximum distance for influence

1,500 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	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Sum
458	248	266	220	302	504	760	767	521	378	415	371	576	904	1,027	793	8,509

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

	January	February	March	April	May	June	July	August	September	October	November	December
1	08:33	08:13	07:28	07:28	06:33	05:57	05:56	06:26	07:06	07:45	07:29	08:11
	17:09	17:49	18:30	20:14	20:55	21:33	21:46	21:22	20:30	19:30	17:32	17:01
2	08:33	08:11	07:26	07:26	06:31	05:56	05:57	06:27	07:07	07:46	07:30	08:12
	17:10	17:51	18:32	20:16	20:57	21:33	21:45	21:20	20:28	19:28	17:31	17:00
3	08:33	08:10	07:24	07:24	06:30	05:56	05:57	06:28	07:08	07:48	07:32	08:13
	17:11	17:52	18:33	20:17	20:58	21:34	21:45	21:19	20:26	19:26	17:29	17:00
4	08:33	08:09	07:23	07:22	06:28	05:55	05:58	06:30	07:10	07:49	07:33	08:15
	17:12	17:54	18:35	20:18	20:59	21:35	21:45	21:17	20:24	19:24	17:28	16:59
5	08:32	08:07	07:21	07:20	06:27	05:54	05:59	06:31	07:11	07:50	07:35	08:16
	17:13	17:55	18:36	20:20	21:01	21:36	21:45	21:16	20:22	19:22	17:26	16:59
6	08:32	08:06	07:19	07:18	06:25	05:54	05:59	06:32	07:12	07:52	07:36	08:17
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	17:15	17:59	18:39	20:22	21:03	21:38	21:44	21:13	20:18	19:18	17:23	16:59
8	08:32	08:03	08:15	07:14	06:22	05:53	06:01	06:35	07:15	07:54	07:39	08:19
	17:16	18:00	18:41	20:24	21:05	21:38	21:43	21:12	20:16	19:16	17:22	16:58
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	17:17	18:00	19:42	20:25	21:06	21:39	21:43	21:10	20:14	19:14	17:21	16:58
10	08:31	08:00	08:11	07:10	06:19	05:53	06:02	06:37	07:17	07:57	07:42	08:21
	17:18	18:02	19:43	20:27	21:07	21:40	21:43	21:09	20:12	19:13	17:20	16:58
11	08:31	07:59	08:09	07:08	06:18	05:52	06:03	06:38	07:19	07:59	07:43	08:22
	17:20	18:03	19:45	20:28	21:08	21:41	21:42	21:07	20:10	19:11	17:18	16:58
12	08:30	07:57	08:07	07:06	06:17	05:52	06:04	06:40	07:20	08:00	07:45	08:23
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28	08:17	07:30	07:36	06:38	06:00	05:54	06:21	07:00	07:41	08:23	08:07	08:32
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	17:48		20:13		21:32		21:23	20:32		18:34		17:07
Potential sun hours		288		407		474		480	378	339	282	267
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)	Minutes with flicker	First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)		Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

Minnesota Power - BISON Wind Energy Center

Minnesota Power
 Frank Frederickson
 30 West Superior Street
 Duluth, MN 55802-2093

Description:

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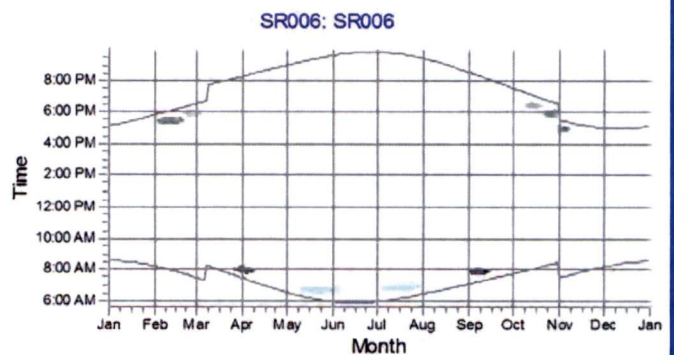
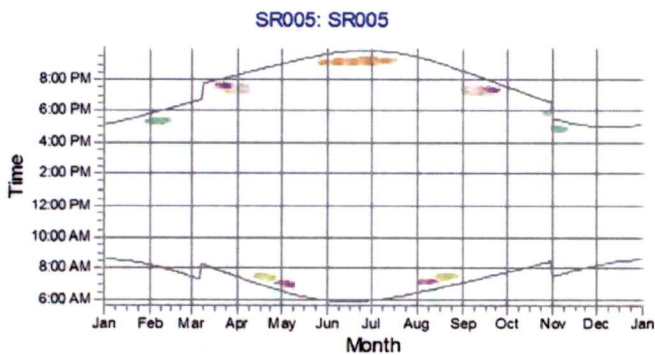
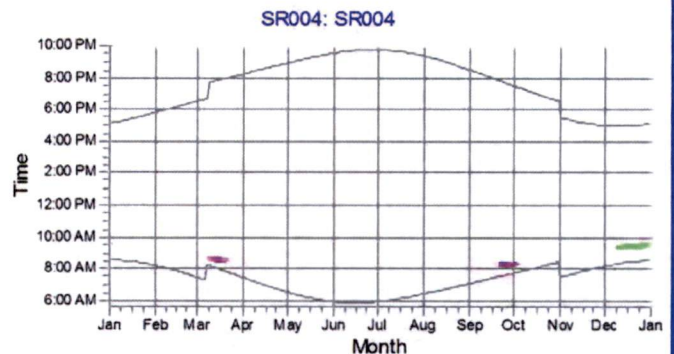
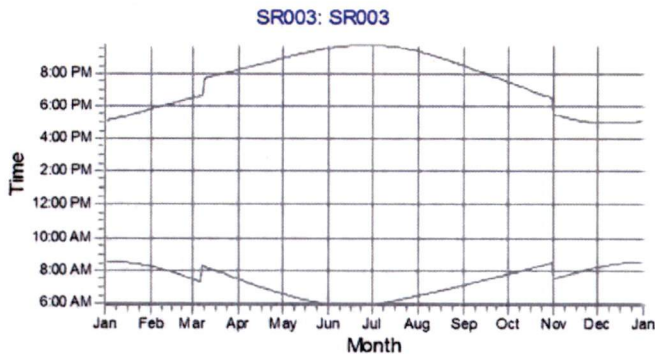
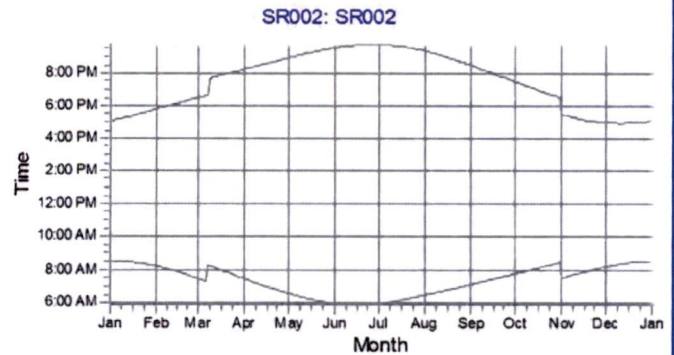
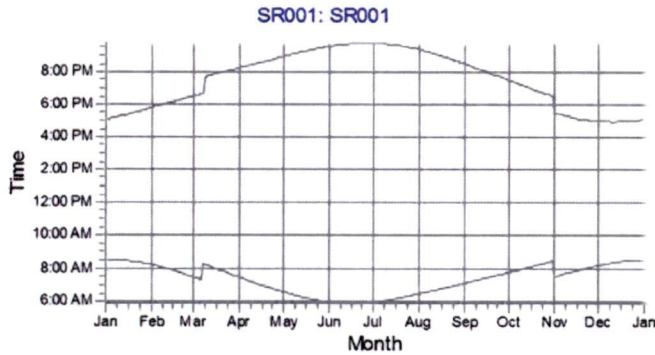
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SHADOW - Calendar, graphical

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)



WTGs

- 2: BISON 1B
- 7: BISON 1B
- 20: BISON 1B
- 30: BISON 1B
- 202: BISON 2
- 204: BISON 2
- 6: BISON 1B
- 17: BISON 1B
- 28: BISON 1B
- 201: BISON 2
- 203: BISON 2

Project:

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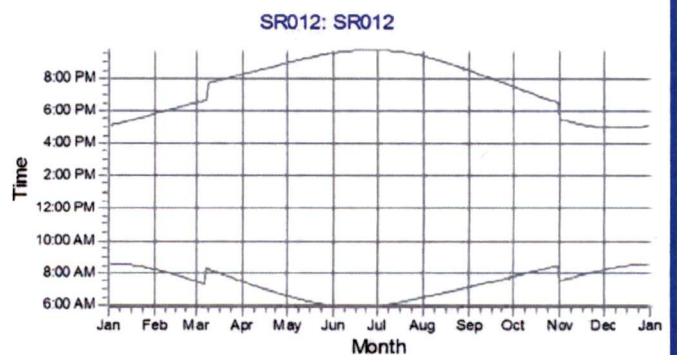
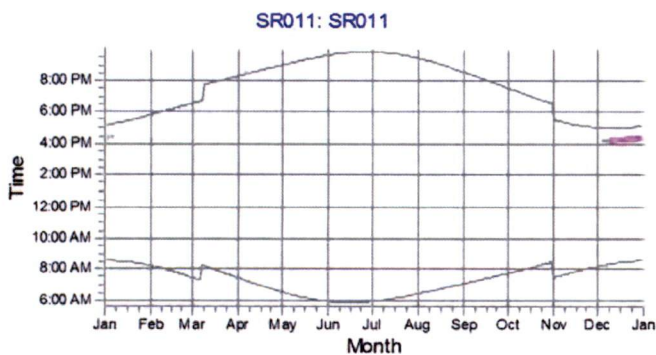
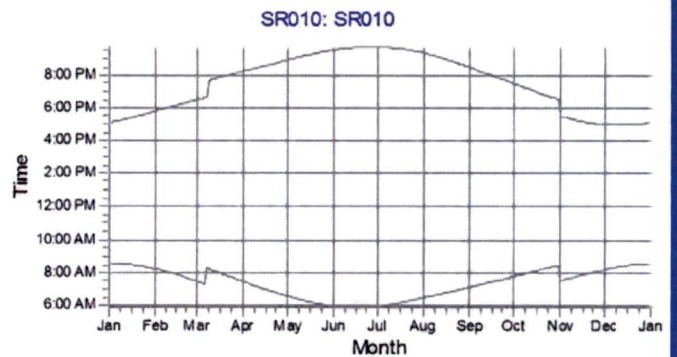
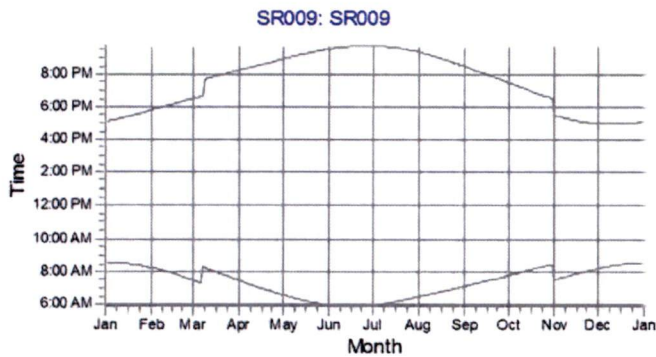
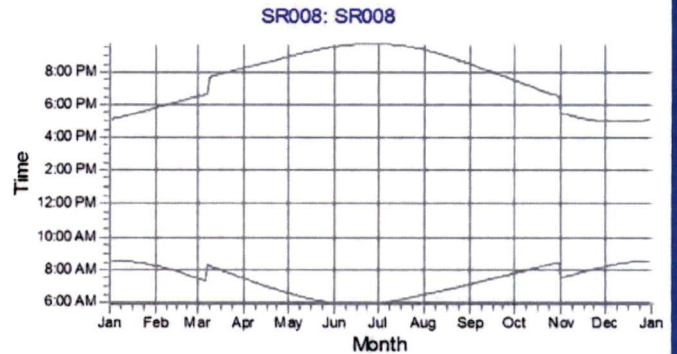
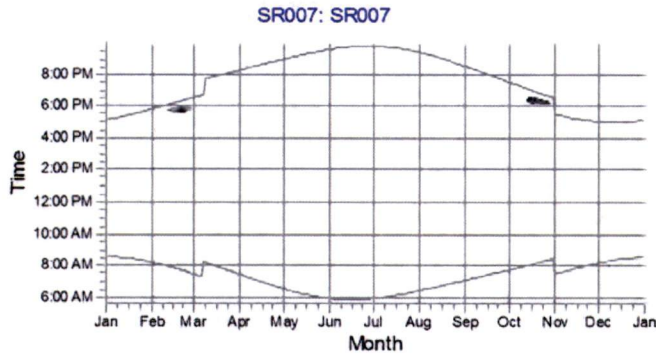
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SHADOW - Calendar, graphical

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)



WTGs

206: BISON 2 208: BISON 2

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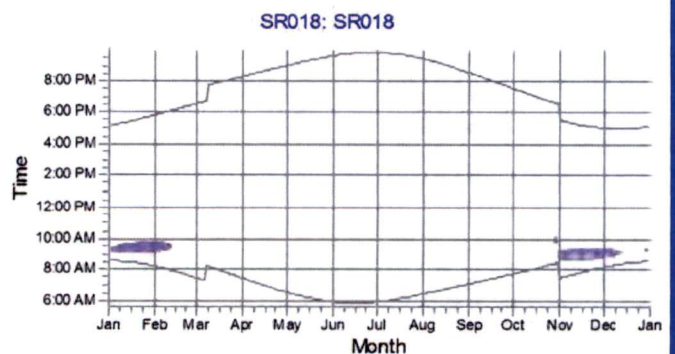
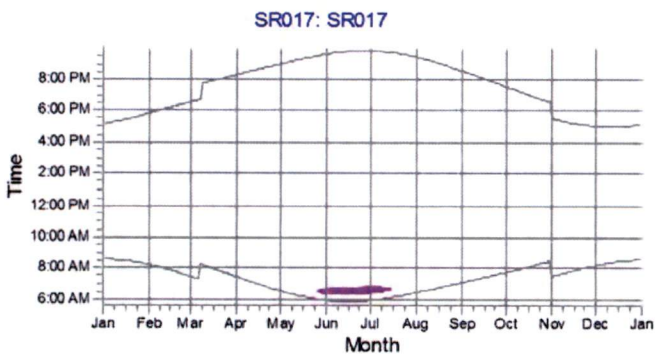
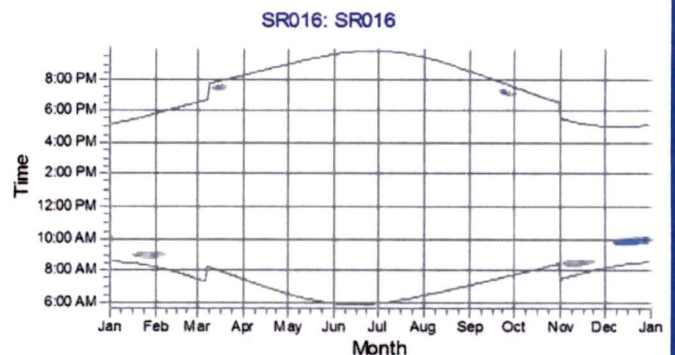
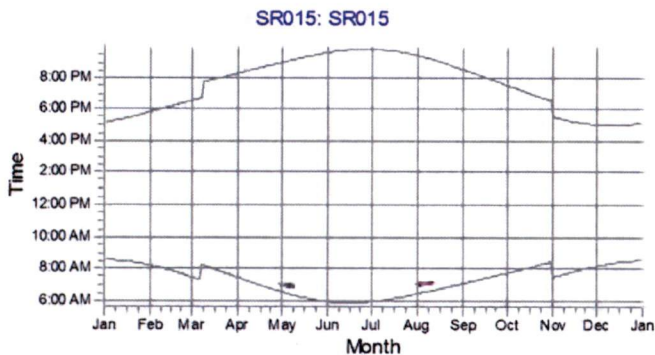
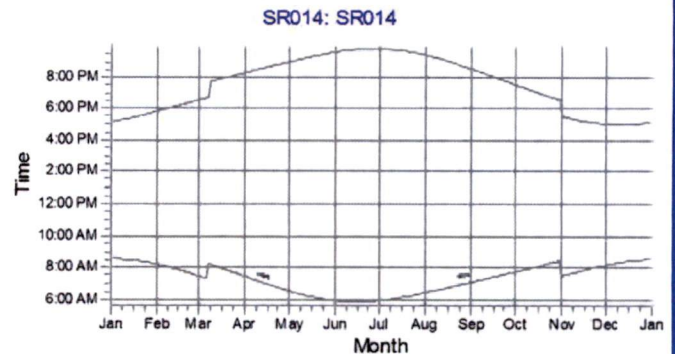
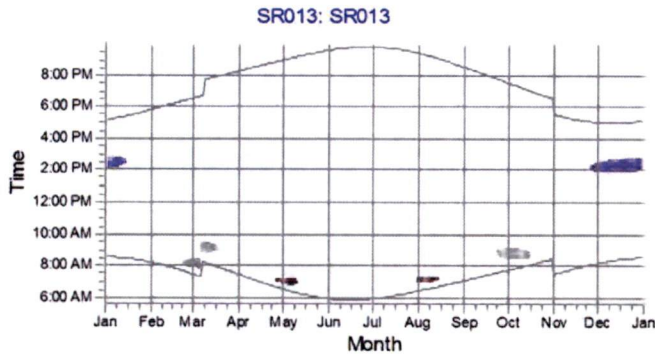
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SHADOW - Calendar, graphical

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)



WTGs

- 8: BISON 1A
- 22: BISON 1A
- 212: BISON 2
- 215: BISON 2
- 218: BISON 2
- 16: BISON 1A
- 211: BISON 2
- 214: BISON 2
- 216: BISON 2

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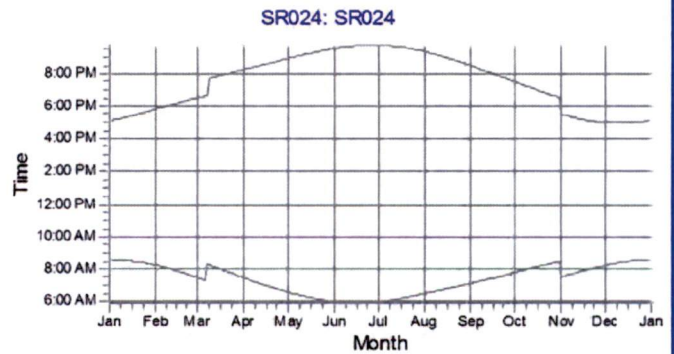
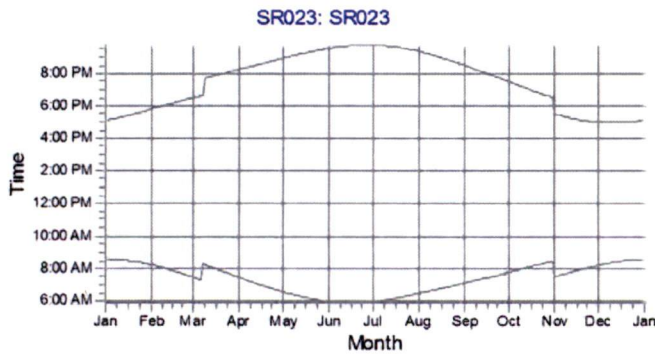
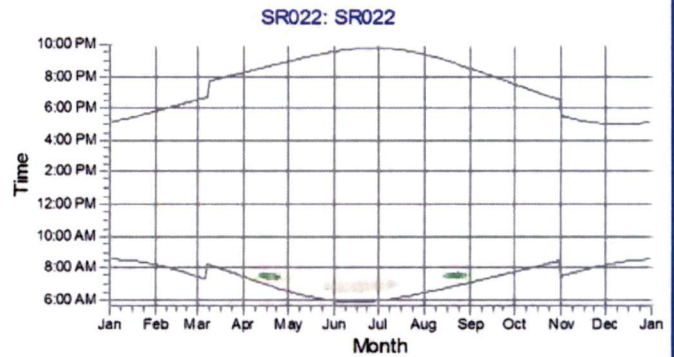
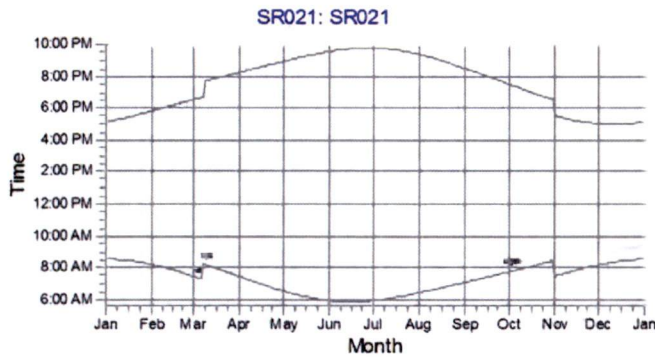
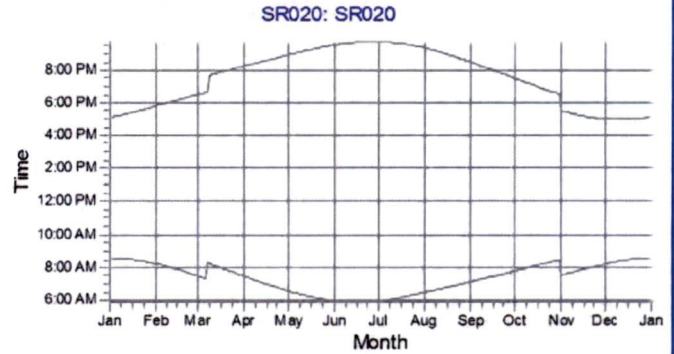
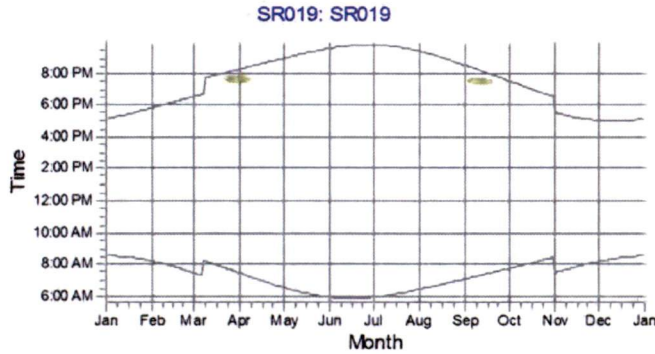
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SHADOW - Calendar, graphical

Calculation: BISON 2 Shadow Flicker (with existing BISON 1)



WTGs

- 222: BISON 2
- 223: BISON 2
- 226: BISON 2
- 228: BISON 2