



414 Nicollet Mall
Minneapolis, MN 55401

July 14, 2020

—Via Electronic Filing—

Will Seuffert
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101

RE: COMPLIANCE FILING
FREEBORN WIND SITE PERMIT
DOCKET NO. IP-6946/WS-17-410

Dear Mr. Seuffert:

Northern States Power Company, doing business as Xcel Energy, submits to the Minnesota Public Utilities Commission this compliance filing for the Freeborn Wind Energy project, in compliance with the Large Wind Energy Conversion System (LWECS) Site Permit Section 7.2, Shadow Flicker.

Section 7.2 Shadow Flicker

Section 7.2 of the Site Permit states:

At least 14 days prior to the pre-construction meeting, the Permittee shall provide data on shadow flicker for each residence of non-participating landowners and participating landowners within and outside of the project boundary potentially subject to turbine shadow flicker exposure. Information shall include the results of modeling used, assumptions made, and the anticipated levels of exposure from turbine shadow flicker for each residence. The Permittee shall provide documentation on its efforts to avoid, minimize, and mitigate shadow flicker exposure. A Shadow Flicker Management Plan will be prepared by the Permittee, which will include the results of any shadow flicker modeling, assumptions made, levels of exposure prior to implementation of planned minimization and mitigation efforts, planned minimization and mitigation efforts, and planned communication and follow up with residence. The Shadow Flicker Management Plan shall be filed with the Commission at least 14 days prior to the preconstruction meeting to confirm compliance with conditions of this permit.

Should shadow flicker modeling identify any residence that will experience in 30 hours, or more, of shadow flicker per year, the Permittee must specifically identify these residences in the Shadow Flicker Management Plan. If through minimization and mitigation efforts identified in the Shadow Flicker Management Plan the Permittee is not able to reduce a residence's anticipated shadow flicker exposure to less than 30 hours per year a shadow flicker detection systems will be utilized during project operations to monitor shadow flicker exposure at the residence. The Shadow Flicker Management Plan will detail the placement and use of any shadow flicker detection systems, how the monitoring data will be used to inform turbine operations, and a detailed plan of when and how turbine operations will be adjusted to mitigate shadow flicker exposure exceeding 30 hours per year at any one receptor. The results of any shadow flicker monitoring and mitigation implementation will be reported by the Permittee in the Annual Project Energy Production Report identified in Section 10.8 of this Permit.

Commission staff and EERA staff will be responsible for the review and approval of the Shadow Flicker Management Plan. The Commission may require the Permittee to conduct shadow flicker monitoring at any time during the life of this Permit.

Attachment A to this filing is the Shadow Flicker Management Plan. We appreciate the Association of Freeborn County Landowners raising this in their June 4, 2020 Reply Comments in this Docket. We also note that, although this plan lays out the Company's specific plans to manage shadow flicker at particular residences modeled to experience 30 hours or more of shadow flicker, the Company's overall plans to mitigate shadow flicker have long been a part of the record in this Docket.

We have electronically filed this document and copies have been served on the parties on the attached service list. Please contact me at (612) 330-6064 or bria.e.shea@xcelenergy.com if you have any questions regarding this filing.

Sincerely,

/s/

BRIA E. SHEA
DIRECTOR, REGULATORY AND STRATEGIC ANALYSIS

Enclosure
c: Service List

July 2020

Shadow Flicker Management Plan July 2020

Freeborn Wind Farm & Transmission Line Project Freeborn County, Minnesota

Prepared for:
Xcel Energy

414 Nicollet Mall
Minneapolis, MN 55401



Prepared by:

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Table of Contents

1.0 INTRODUCTION	1-1
2.0 SHADOW FLICKER ANALYSIS.....	2-3
3.0 AVOIDANCE, MITIGATION AND ADAPTIVE MANAGEMENT	3-1
3.1 AVOIDANCE.....	3-1
3.2 MITIGATION	3-1
3.3 ADAPTIVE MANAGEMENT	3-2

TABLES

Table 1: Residential Structures Realistic Shadow Flicker Distribution.....	2-3
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ATTACHMENTS

Attachment A: SHADOW Calendar for Residences 131, 220, and 386	
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1.0 Introduction

On behalf of Xcel Energy (Xcel Energy or Company), Wenck Associates, Inc. (Wenck) and EAPC Architects Engineers (EAPC) have prepared this Shadow Flicker Management Plan (Plan) for the proposed Freeborn Wind Farm and Transmission Line Project (Project) located in Freeborn County, Minnesota and Worth County, Iowa. Shadow flicker is defined as the effect of the sun shining through the blades of a spinning wind turbine generator (WTG), casting a moving shadow, hence the term "flicker". Shadow flicker is most noticeable within ~1,000 meters of a WTG where the distance between the blade and the observer (i.e., residence) is too short to have been adequately diffused by the atmosphere.

This Plan is being prepared in accordance with the Project's Minnesota Public Utilities Commission (MPUC) Site Permit Application (SPA; Docket Number Docket No. IP-6946/WS-17-410), specifically for Condition 7.2, which states:

"At least 14 days prior to the pre-construction meeting, the Permittee shall provide data on shadow flicker for each residence of non-participating landowners and participating landowners within and outside of the project boundary potentially subject to turbine shadow flicker exposure. Information shall include the results of modeling used, assumptions made, and the anticipated levels of exposure from turbine shadow flicker for each residence. The Permittee shall provide documentation on its efforts to avoid, minimize, and mitigate shadow flicker exposure. A Shadow Flicker Management Plan will be prepared by the Permittee, which will include the results of any shadow flicker modeling, assumptions made, levels of exposure prior to implementation of planned minimization and mitigation efforts, planned minimization and mitigation efforts, and planned communication and follow up with residence. The Shadow Flicker Management Plan shall be filed with the Commission at least 14 days prior to the preconstruction meeting to confirm compliance with conditions of this permit.

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Commission staff and EERA staff will be responsible for the review and approval of the Shadow Flicker Management Plan. The Commission may require the Permittee to conduct shadow flicker monitoring at any time during the life of this Permit."

Initial shadow flicker studies were conducted for the Project by Jay Haley of EAPC and are presented in the Shadow Flicker Study for Freeborn County, Minnesota, dated August 19, 2019¹ (which was submitted as part of the Project's SPA). Those studies are incorporated herein by reference, and the remainder of this Plan summarizes the shadow flicker studies, and addresses the avoidance and mitigation measures Xcel Energy has taken and plans to implement for the Project, including with respect to those residences modeled to potentially experience more than 30 hours per year of shadow flicker.

¹ Haley, J. (EAPC). 2019. Final Report - Freeborn Wind Farm Shadow Flicker Study - Freeborn County, MN. Available at:
<https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={80F0B06C-0000-C472-A157-4FE5C548819A}&documentTitle=20198-155331-04>.
Accessed July 2020.

2.0 Shadow Flicker Analysis

As described in EAPC's Shadow Flicker Study for Freeborn County, Minnesota, studies were conducted for 263 dwellings in Freeborn County, Minnesota, which could potentially experience shadow flicker. EAPC used WindPRO, a sophisticated wind modeling software program tailored to flicker analysis, using the following inputs: WTG coordinates, WTG specifications (a mix of Vestas V120-2.0 and V110-2.0), shadow receptor coordinates, monthly sunshine probabilities, joint wind speed and direction frequency distribution, U.S. Geologic Survey (USGS) Digital Elevation Model (DEM; height contour data), and existing WTGs.

A total of 263 residential structures within the Project vicinity were analyzed and were then modeled as greenhouse-mode receptors and the estimated shadow flicker was calculated for the array using a 2,000-meter distance limit. Shadow flicker data was then evaluated, and standard resolution realistic shadow flicker maps were generated in each WTG array (shown in EAPC's Shadow Flicker Study for Freeborn County, Minnesota). It is important to note that this analysis did not incorporate shading effects due to existing structures or trees, and the analysis were completed using an omni-directional approach rather than modeling specific facades of residences/buildings in the Project vicinity.

EAPC summarized realistic shadow flicker in terms of hours per year, and whether the residence was a project participant or non-participant. Of the 263 receptors, there were 151 receptors that registered zero flicker hours per year (29 participating), and six total (three participating) residences that modeled over 30 hours per year. **Table 1** outlines the results of EAPC's WindPRO modeling for the Project.

Table 1: Residential Structures Realistic Shadow Flicker Distribution

Realistic Shadow Flicker (hrs/year)	Vestas V120 2.0-80 & V110 2.0-80	
	Total # structures	# non- participating
0	151	122
0 to 5	60	43
5 to 10	15	9
10 to 15	9	5
15 to 20	14	5
20 to 25	5	4
25 to 30	3	2
30+	6	3

Source: Haley, J. (EAPC). 2019. Final Report - Freeborn Wind Farm Shadow Flicker Study - Freeborn County, MN. Available at:

<https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={80F0B06C-0000-C472-A157-4FE5C548819A}&documentTitle=20198-155331-04>. Accessed July 2020.

3.0 Avoidance, Mitigation and Adaptive Management

Avoidance and mitigation measures have, and will, be implemented by Xcel for the Project. Avoidance measures have included siting considerations (e.g. WTG relocation) and mitigation measures such as landowner communication, Turbine Control Software (TCS), installation of indoor or outdoor screening, and installation of flicker sensors. If necessary, further adaptive management options will be considered.

3.1 AVOIDANCE

Avoidance measures were implemented by Xcel Energy for the Project and include siting factors. As described in Section 2 of this Plan, a total of six residences (three participating and three non-participating) were determined to be affected by shadow flicker (i.e., over 30 hours per year) as modeled by EAPC's WindPRO model. Xcel Energy re-located 17 WTGs to Worth County, Iowa, including the WTGs that would have affected the three non-participating residences, thereby eliminating any shadow flicker concerns for those landowners. For the remaining three affected residences that may incur over 30 hours per year, Xcel Energy will implement mitigation strategies, and if needed, adaptive management.

3.2 MITIGATION

As discussed, three residences (131, 220, and 386) were modeled to be affected by shadow flicker due to operation of the Project. Residence 131 may be affected by WTGs T-6, T-7, and T-14; Residence 220 may be affected by WTGs T-25, T-26, and T-27; and Residence 382 may be affected by WTGs T-18 and T-19.

Xcel Energy will implement TCS—specifically, the Vestas Shadow Flicker Control system—on all turbines in the project. This software will be used to control the shadow flicker exposure of the three residences to no more than 30 hours per year in accordance with the SPA requirements. The TCS is programmed with the output from the flicker model which provides a conservative (overestimate) basis to control the shadow flicker at the three residences by curtailing operation of the WTGs during hours with a high likelihood of shadow flicker.

The TCS can control the WTGs either based on schedules and rule sets (e.g. a SHADOW Calendar; **Attachment A**), using light intensity sensors, or both. The TCS pauses WTG operation based on analytics logic that calculates the possibility of shadow flicker on a particular receptor and, when a positive result is calculated, it will request the turbine to pitch the blades out of operation and pause the WTG.

Included with this Shadow Flicker Management Plan as **Attachment A** are detailed hourly charts that lay out all potential hours of shadow flicker in a year for Residences 131, 220, and 386, and the WTGs primarily responsible for causing the flicker on any given day. The TCS will control the WTGs for a sufficient amount of time during these hours to ensure that actual shadow flicker experienced at these three residences is below 30 hours per year.

Because we believe the TCS will be able to reduce all affected residences' anticipated shadow flicker exposure to less than 30 hours per year, a shadow flicker detection system is not necessary to monitor shadow flicker exposure at any of these residences.

3.3 ADAPTIVE MANAGEMENT

If the mitigative efforts described in section 3.2 above fails to address the three residents' concerns, Xcel Energy will communicate and work with the three home owners to identify additional, appropriate, site-specific shadow flicker mitigation measures such as the installation of interior screening mechanisms (curtains or blinds) and exterior screening devices such as awnings or vegetative buffers. Selection of the most appropriate option(s) will be collaboratively determined by working with the property owner at the time of the complaint. Xcel Energy may also consider additional shadow flicker monitoring technology that would monitor for shadow flicker in real-time and curtail the appropriate turbine(s) to address the shadow flicker concern.

Additionally, should other residents, who believe they are experiencing excessive flicker compared to the modeling, bring shadow flicker issues to the attention of Xcel Energy, the Company will monitor and mitigate shadow flicker, as appropriate. However, use of additional monitoring and control technology will be at the sole discretion of Xcel Energy based on customary engineering and operational considerations such as effectiveness, reliability, availability, cost, and maintainability.

Attachment A: SHADOW Calendar for Residences 131, 220, and 386

Project: Freeborn
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.

Licensed user: EAPC Wind Energy
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Calculated: 8/19/2019 3:07 PM/3.1.633

SHADOW - Calendar

Calculation: L079 Clipped w/263 HousesShadow receptor: 131 - Participant

Assumptions for shadow calculations

Sunshine probability S/S0 (Sun hours/Possible sun hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.53	0.59	0.57	0.56	0.62	0.67	0.74	0.69	0.62	0.51	0.37	0.38

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
607	364	349	399	598	1,082	1,220	632	491	661	1,202	943	8,548

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

	January	February	March	April	May	June
1	07:47	07:31	06:51	06:56	07:16 (T-7)	06:07
	16:47	17:24	18:00	19:38	28 07:44 (T-7)	20:14
2	07:47	07:30	06:49	06:54	07:14 (T-7)	06:05
	16:48	17:25	18:01	19:39	31 07:45 (T-7)	20:15
3	07:47	07:28	06:48	06:53	07:12 (T-7)	06:04
	16:49	17:26	18:02	19:40	34 07:46 (T-7)	20:16
4	07:47	07:27	06:46	06:51	07:11 (T-7)	06:03
	16:49	17:28	18:04	19:42	37 07:48 (T-7)	20:17
5	07:47	07:26	06:44	06:49	07:09 (T-7)	06:01
	16:50	17:29	18:05	19:43	40 07:49 (T-7)	20:18
6	07:47	07:25	06:43	06:47	07:07 (T-7)	06:00
	16:51	17:31	18:06	19:44	42 07:49 (T-7)	20:20
7	07:47	07:24	06:41	06:46	07:05 (T-7)	05:59
	16:52	17:32	18:08	19:45	44 07:49 (T-7)	20:21
8	07:46	07:22	07:39	06:44	07:04 (T-7)	05:57
	16:54	17:33	18:09	19:46	47 07:51 (T-7)	20:22
9	07:46	07:21	07:37	06:42	07:02 (T-7)	05:56
	16:55	17:35	19:10	19:48	49 07:51 (T-7)	20:23
10	07:46	08:09 (T-14)	07:20	06:40	07:00 (T-7)	05:55
	16:56	1 08:10 (T-14)	17:36	19:49	50 07:50 (T-7)	20:24
11	07:46	08:09 (T-14)	07:18	06:39	06:58 (T-7)	05:54
	16:57	3 08:12 (T-14)	17:37	19:50	52 07:50 (T-7)	20:25
12	07:45	08:08 (T-14)	07:17	06:37	06:58 (T-7)	05:52
	16:58	4 08:12 (T-14)	17:39	19:51	53 07:51 (T-7)	20:26
13	07:45	08:08 (T-14)	07:16	06:35	06:57 (T-7)	05:51
	16:59	5 08:13 (T-14)	17:40	19:52	54 07:51 (T-7)	20:28
14	07:45	08:07 (T-14)	07:14	06:34	06:56 (T-7)	05:50
	17:00	7 08:14 (T-14)	17:41	19:54	54 07:50 (T-7)	20:29
15	07:44	08:07 (T-14)	07:13	06:32	06:56 (T-7)	05:49
	17:02	8 08:15 (T-14)	17:43	19:55	54 07:50 (T-7)	20:30
16	07:44	08:06 (T-14)	07:11	06:30	06:56 (T-7)	05:48
	17:03	9 08:15 (T-14)	17:44	19:56	54 07:50 (T-7)	20:31
17	07:43	08:06 (T-14)	07:10	06:28	06:55 (T-7)	05:47
	17:04	10 08:16 (T-14)	17:45	19:57	65 19:35 (T-6)	20:32
18	07:42	08:05 (T-14)	07:08	06:27	06:56 (T-7)	05:46
	17:05	11 08:16 (T-14)	17:47	19:58	68 19:36 (T-6)	20:33
19	07:42	08:04 (T-14)	07:07	06:25	06:55 (T-7)	05:45
	17:06	12 08:16 (T-14)	17:48	20:00	72 19:37 (T-6)	20:34
20	07:41	08:03 (T-14)	07:05	06:24	06:56 (T-7)	05:44
	17:08	13 08:16 (T-14)	17:49	20:01	75 19:39 (T-6)	20:35
21	07:41	08:03 (T-14)	07:04	06:22	06:56 (T-7)	05:43
	17:09	14 08:17 (T-14)	17:51	20:02	76 19:39 (T-6)	20:36
22	07:40	08:02 (T-14)	07:02	06:20	06:57 (T-7)	05:42
	17:10	15 08:17 (T-14)	17:52	20:03	78 19:41 (T-6)	20:37
23	07:39	08:01 (T-14)	07:01	06:19	06:56 (T-7)	05:41
	17:12	16 08:17 (T-14)	17:53	20:04	81 19:42 (T-6)	20:38
24	07:38	08:00 (T-14)	06:59	06:17	06:56 (T-7)	05:40
	17:13	17 08:17 (T-14)	17:55	20:05	80 19:42 (T-6)	20:39
25	07:37	07:59 (T-14)	06:58	06:16	06:57 (T-7)	05:40
	17:14	17 08:16 (T-14)	17:56	20:07	82 19:44 (T-6)	20:40
26	07:37	07:59 (T-14)	06:56	06:14	06:58 (T-7)	05:39
	17:16	17 08:16 (T-14)	17:57	20:08	81 19:45 (T-6)	20:41
27	07:36	08:01 (T-14)	06:54	06:13	06:59 (T-7)	05:38
	17:17	14 08:15 (T-14)	17:59	20:09	80 19:46 (T-6)	20:42
28	07:35	08:02 (T-14)	06:53	06:11	07:00 (T-7)	05:38
	17:18	12 08:14 (T-14)	18:00	20:10	80 19:48 (T-6)	20:43
29	07:34	08:04 (T-14)		07:02	07:00 (T-7)	05:37
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30	07:33			07:00	07:20 (T-7)	06:08
	17:21			19:36	20 07:40 (T-7)	20:13
31	07:32			06:58	07:18 (T-7)	
	17:22			19:37	24 07:42 (T-7)	
Potential sun hours	290	294	369	402	455	461
Total, worst case	213		58	1801	1115	
Sun reduction	0.53		0.57	0.56	0.62	
Oper. time red.	0.98		0.98	0.98	0.98	
Wind dir. red.	0.73		0.62	0.64	0.67	
Total reduction	0.38		0.35	0.35	0.41	
Total, real	80		20	627	455	

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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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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Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.53	0.59	0.57	0.56	0.62	0.67	0.74	0.69	0.62	0.51	0.37	0.38

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N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
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Idle start wind speed: Cut in wind speed from power curve

	July	August	September	October	November	December	
1	05:35	06:02	19:18 (T-6)	06:36	06:58 (T-7)	07:10	06:48
	20:59	20:38	43 20:01 (T-6)	19:52	52 07:50 (T-7)	18:56	17:05
2	05:36	06:03	19:17 (T-6)	06:37	06:59 (T-7)	07:11	06:49
	20:59	20:37	44 20:01 (T-6)	19:50	50 07:49 (T-7)	18:54	17:04
3	05:36	06:04	19:17 (T-6)	06:38	07:00 (T-7)	07:12	06:51
	20:58	20:36	44 20:01 (T-6)	19:48	49 07:49 (T-7)	18:52	17:02
4	05:37	06:05	19:16 (T-6)	06:39	07:01 (T-7)	07:13	06:52
	20:58	20:35	46 20:02 (T-6)	19:46	47 07:48 (T-7)	18:50	17:01
5	05:38	06:06	19:16 (T-6)	06:41	07:02 (T-7)	07:15	06:53
	20:58	20:33	46 20:02 (T-6)	19:45	44 07:46 (T-7)	18:48	17:00
6	05:38	06:07	19:15 (T-6)	06:42	07:03 (T-7)	07:16	06:55
	20:58	20:32	47 20:02 (T-6)	19:43	42 07:45 (T-7)	18:47	16:59
7	05:39	06:08	07:27 (T-7)	06:43	07:04 (T-7)	07:17	06:56
	20:57	20:31	50 20:02 (T-6)	19:41	40 07:44 (T-7)	18:45	16:57
8	05:40	06:09	07:21 (T-7)	06:44	07:05 (T-7)	07:18	06:57
	20:57	20:29	62 20:02 (T-6)	19:39	37 07:42 (T-7)	18:43	16:56
9	05:40	06:10	07:17 (T-7)	06:45	07:06 (T-7)	07:19	06:59
	20:57	20:28	69 20:02 (T-6)	19:38	35 07:41 (T-7)	18:41	16:55
10	05:41	06:11	07:15 (T-7)	06:46	07:07 (T-7)	07:21	07:00
	20:56	20:27	73 20:01 (T-6)	19:36	32 07:39 (T-7)	18:40	16:54
11	05:42	06:13	07:13 (T-7)	06:47	07:08 (T-7)	07:22	07:01
	20:56	20:25	76 20:00 (T-6)	19:34	28 07:36 (T-7)	18:38	16:53
12	05:43	06:14	07:11 (T-7)	06:48	07:09 (T-7)	07:23	07:03
	20:55	20:24	78 19:59 (T-6)	19:32	25 07:34 (T-7)	18:36	16:52
13	05:43	06:15	07:09 (T-7)	06:50	07:10 (T-7)	07:24	07:04
	20:55	20:22	79 19:57 (T-6)	19:30	21 07:31 (T-7)	18:34	16:51
14	05:44	06:16	07:08 (T-7)	06:51	07:12 (T-7)	07:25	07:05
	20:54	20:21	81 19:56 (T-6)	19:28	16 07:28 (T-7)	18:33	16:50
15	05:45	06:17	07:06 (T-7)	06:52	07:27	07:06	07:33 (T-14)
	20:54	20:19	81 19:54 (T-6)	19:27	18:31	16:49	15 07:48 (T-14)
16	05:46	19:34 (T-6)	06:18	07:05 (T-7)	06:53	07:28	07:08
	20:53	8 19:42 (T-6)	20:18	81 19:53 (T-6)	19:25	18:29	16:48
17	05:47	19:31 (T-6)	06:19	07:04 (T-7)	06:54	07:29	07:09
	20:52	14 19:45 (T-6)	20:16	81 19:51 (T-6)	19:23	18:28	16:47
18	05:48	19:30 (T-6)	06:20	07:04 (T-7)	06:55	07:30	07:10
	20:51	17 19:47 (T-6)	20:15	82 19:51 (T-6)	19:21	18:26	16:46
19	05:49	19:28 (T-6)	06:22	07:03 (T-7)	06:56	07:32	07:12
	20:51	21 19:49 (T-6)	20:13	80 19:49 (T-6)	19:19	18:25	16:45
20	05:49	19:27 (T-6)	06:23	07:02 (T-7)	06:57	07:33	07:13
	20:50	24 19:51 (T-6)	20:12	79 19:47 (T-6)	19:17	18:23	16:44
21	05:50	19:26 (T-6)	06:24	07:01 (T-7)	06:59	07:34	07:14
	20:49	26 19:52 (T-6)	20:10	79 19:46 (T-6)	19:16	18:21	16:44
22	05:51	19:25 (T-6)	06:25	07:01 (T-7)	07:00	07:35	07:15
	20:48	28 19:53 (T-6)	20:09	76 19:44 (T-6)	19:14	18:20	16:43
23	05:52	19:24 (T-6)	06:26	07:00 (T-7)	07:01	07:37	07:17
	20:47	31 19:55 (T-6)	20:07	74 19:42 (T-6)	19:12	18:18	16:42
24	05:53	19:23 (T-6)	06:27	06:59 (T-7)	07:02	07:38	07:18
	20:47	33 19:56 (T-6)	20:05	72 19:41 (T-6)	19:10	18:17	16:41
25	05:54	19:22 (T-6)	06:28	06:59 (T-7)	07:03	07:39	07:19
	20:46	34 19:56 (T-6)	20:04	68 19:39 (T-6)	19:08	18:15	16:41
26	05:55	19:22 (T-6)	06:29	06:58 (T-7)	07:04	07:40	07:20
	20:45	35 19:57 (T-6)	20:02	64 19:37 (T-6)	19:06	18:14	16:40
27	05:56	19:21 (T-6)	06:31	06:58 (T-7)	07:05	07:42	07:21
	20:44	37 19:58 (T-6)	20:00	54 07:52 (T-7)	19:05	18:12	16:40
28	05:57	19:20 (T-6)	06:32	06:57 (T-7)	07:06	07:43	07:23
	20:43	39 19:59 (T-6)	19:59	54 07:51 (T-7)	19:03	18:11	16:39
29	05:58	19:19 (T-6)	06:33	06:57 (T-7)	07:08	07:44	07:24
	20:41	40 19:59 (T-6)	19:57	54 07:51 (T-7)	19:01	18:09	16:39
30	05:59	19:19 (T-6)	06:34	06:57 (T-7)	07:09	07:46	07:25
	20:40	41 20:00 (T-6)	19:55	53 07:50 (T-7)	18:57	18:08	16:38
31	06:01	19:18 (T-6)	06:35	06:58 (T-7)	18:57	07:47	07:26
	20:39	42 20:00 (T-6)	19:53	53 07:51 (T-7)	18:06	18:06	16:46
Potential sun hours	468	433		377	342	291	279
Total, worst case	470	2023		518		210	4
Sun reduction	0.74	0.69		0.62		0.37	0.38
Oper. time red.	0.98	0.98		0.98		0.98	0.98
Wind dir. red.	0.68	0.65		0.62		0.73	0.73
Total reduction	0.49	0.44		0.38		0.26	0.27
Total, real	231	886		196		55	1

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: Freeborn
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Calculated: 8/19/2019 3:07 PM/3.1.633

SHADOW - Calendar

Calculation: L079 Clipped w/263 HousesShadow receptor: 220 - Participant

Assumptions for shadow calculations

Sunshine probability S/S0 (Sun hours/Possible sun hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.53	0.59	0.57	0.56	0.62	0.67	0.74	0.69	0.62	0.51	0.37	0.38

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
607	364	349	399	598	1,082	1,220	632	491	661	1,202	943	8,548

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

	January		February		March		April		May		June	
1	07:47	08:17 (T-26)	07:31	08:38 (T-26)	06:51	07:22 (T-27)	06:56	19:07 (T-25)	06:07	19:07 (T-25)	05:36	05:36
	16:47	58 09:15 (T-26)	17:24	34 09:12 (T-26)	18:00	14 07:36 (T-27)	19:38	10 19:17 (T-25)	20:14	20:14	20:46	20:46
2	07:47	08:17 (T-26)	07:29	08:40 (T-26)	06:49	07:25 (T-27)	06:55	19:06 (T-25)	06:06	19:06 (T-25)	05:35	05:35
	16:48	58 09:15 (T-26)	17:25	31 09:11 (T-26)	18:01	8 07:33 (T-27)	19:39	12 19:18 (T-25)	20:15	20:15	20:47	20:47
3	07:47	08:17 (T-26)	07:28	08:42 (T-26)	06:48		06:53	19:05 (T-25)	06:04	19:05 (T-25)	05:35	05:35
	16:49	58 09:15 (T-26)	17:27	27 09:09 (T-26)	18:03		19:41	15 19:20 (T-25)	20:16	19:20 (T-25)	20:48	20:48
4	07:47	08:17 (T-26)	07:27	08:44 (T-26)	06:46		06:51	19:04 (T-25)	06:03	19:04 (T-25)	05:34	05:34
	16:50	58 09:15 (T-26)	17:28	21 09:05 (T-26)	18:04		19:42	17 19:21 (T-25)	20:17	19:21 (T-25)	20:49	20:49
5	07:47	08:18 (T-26)	07:26	08:48 (T-26)	06:44		06:49	19:04 (T-25)	06:02	19:04 (T-25)	05:34	05:34
	16:51	58 09:16 (T-26)	17:29	14 09:02 (T-26)	18:05		19:43	17 19:21 (T-25)	20:18	19:21 (T-25)	20:50	20:50
6	07:47	08:18 (T-26)	07:25		06:43		06:48	19:03 (T-25)	06:00	19:03 (T-25)	05:33	05:33
	16:52	59 09:17 (T-26)	17:31		18:07		19:44	19 19:22 (T-25)	20:20	19:22 (T-25)	20:50	20:50
7	07:47	08:19 (T-26)	07:24		06:41		06:46	19:03 (T-25)	05:59	19:03 (T-25)	05:33	05:33
	16:53	58 09:17 (T-26)	17:32		18:08		19:45	21 19:24 (T-25)	20:21	19:24 (T-25)	20:51	20:51
8	07:46	08:20 (T-26)	07:22		07:39		06:44	19:03 (T-25)	05:58	19:03 (T-25)	05:33	05:33
	16:54	58 09:18 (T-26)	17:34		18:09		19:46	22 19:25 (T-25)	20:22	19:25 (T-25)	20:52	20:52
9	07:46	08:20 (T-26)	07:21		07:37		06:42	19:03 (T-25)	05:56	19:03 (T-25)	05:32	05:32
	16:55	58 09:18 (T-26)	17:35		19:10		19:48	23 19:26 (T-25)	20:23	19:26 (T-25)	20:52	20:52
10	07:46	08:20 (T-26)	07:20		07:36		06:41	19:03 (T-25)	05:55	19:03 (T-25)	05:32	05:32
	16:56	58 09:18 (T-26)	17:36		19:12		19:49	24 19:27 (T-25)	20:24	19:27 (T-25)	20:53	20:53
11	07:46	08:21 (T-26)	07:18		07:34		06:39	19:04 (T-25)	05:54	19:04 (T-25)	05:32	05:32
	16:57	58 09:19 (T-26)	17:38		19:13		19:50	23 19:27 (T-25)	20:25	19:27 (T-25)	20:54	20:54
12	07:45	08:21 (T-26)	07:17		07:32		06:37	19:05 (T-25)	05:53	19:05 (T-25)	05:32	05:32
	16:58	58 09:19 (T-26)	17:39		19:14		19:51	20 19:25 (T-25)	20:26	19:25 (T-25)	20:54	20:54
13	07:45	08:22 (T-26)	07:16		07:30		06:35	19:06 (T-25)	05:52	19:06 (T-25)	05:32	05:32
	17:00	57 09:19 (T-26)	17:40		19:15		19:52	17 19:23 (T-25)	20:27	19:23 (T-25)	20:55	20:55
14	07:44	08:22 (T-26)	07:14	07:35 (T-27)	07:29		06:34	19:08 (T-25)	05:51	19:08 (T-25)	05:32	05:32
	17:01	57 09:19 (T-26)	17:42	3 07:38 (T-27)	19:17		19:54	14 19:22 (T-25)	20:29	19:22 (T-25)	20:55	20:55
15	07:44	08:23 (T-26)	07:13	07:34 (T-27)	07:27		06:32	19:12 (T-25)	05:49	19:12 (T-25)	05:32	05:32
	17:02	57 09:20 (T-26)	17:43	6 07:40 (T-27)	19:18		19:55	5 19:17 (T-25)	20:30	19:17 (T-25)	20:56	20:56
16	07:43	08:23 (T-26)	07:11	07:32 (T-27)	07:25		06:30		05:48		05:32	05:32
	17:03	56 09:19 (T-26)	17:44	9 07:41 (T-27)	19:19		19:56		20:31		20:56	20:56
17	07:43	08:23 (T-26)	07:10	07:31 (T-27)	07:23		06:29		05:47		05:32	05:32
	17:04	56 09:19 (T-26)	17:46	11 07:42 (T-27)	19:20		19:57		20:32		20:56	20:56
18	07:42	08:25 (T-26)	07:09	07:29 (T-27)	07:22		06:27		05:46		05:32	05:32
	17:06	55 09:20 (T-26)	17:47	13 07:42 (T-27)	19:21		19:58		20:33		20:57	20:57
19	07:42	08:25 (T-26)	07:07	07:28 (T-27)	07:20		06:25		05:45		05:32	05:32
	17:07	55 09:20 (T-26)	17:48	15 07:43 (T-27)	19:23		20:00		20:34		20:57	20:57
20	07:41	08:25 (T-26)	07:05	07:26 (T-27)	07:18		06:24		05:44		05:32	05:32
	17:08	54 09:19 (T-26)	17:50	17 07:43 (T-27)	19:24		20:01		20:35		20:57	20:57
21	07:40	08:27 (T-26)	07:04	07:24 (T-27)	07:16		06:22		05:43		05:32	05:32
	17:09	53 09:20 (T-26)	17:51	19 07:43 (T-27)	19:25		20:02		20:36		20:58	20:58
22	07:40	08:27 (T-26)	07:02	07:23 (T-27)	07:14		06:21		05:43		05:32	05:32
	17:11	53 09:20 (T-26)	17:52	20 07:43 (T-27)	19:26		20:03		20:37		20:58	20:58
23	07:39	08:28 (T-26)	07:01	07:21 (T-27)	07:13		06:19		05:42		05:33	05:33
	17:12	51 09:19 (T-26)	17:54	22 07:43 (T-27)	19:27		20:04		20:38		20:58	20:58
24	07:38	08:29 (T-26)	06:59	07:20 (T-27)	07:11		06:18		05:41		05:33	05:33
	17:13	50 09:19 (T-26)	17:55	23 07:43 (T-27)	19:29		20:05		20:39		20:58	20:58
25	07:37	08:29 (T-26)	06:58	07:18 (T-27)	07:09		06:16		05:40		05:33	05:33
	17:15	49 09:18 (T-26)	17:56	24 07:42 (T-27)	19:30		20:07		20:40		20:58	20:58
26	07:36	08:30 (T-26)	06:56	07:18 (T-27)	07:07		06:14		05:39		05:34	05:34
	17:16	48 09:18 (T-26)	17:58	23 07:41 (T-27)	19:31		20:08		20:41		20:59	20:59
27	07:36	08:31 (T-26)	06:54	07:19 (T-27)	07:05		06:13		05:39		05:34	05:34
	17:17	46 09:17 (T-26)	17:59	21 07:40 (T-27)	19:32		20:09		20:42		20:59	20:59
28	07:35	08:32 (T-26)	06:53	07:20 (T-27)	07:04		06:11		05:38		05:34	05:34
	17:19	44 09:16 (T-26)	18:00	18 07:38 (T-27)	19:33		20:10		20:43		20:59	20:59
29	07:34	08:33 (T-26)			07:02		06:10		05:37		05:35	05:35
	17:20	42 09:15 (T-26)			19:35		20:11		20:44		20:59	20:59
30	07:33	08:35 (T-26)			07:00	19:11 (T-25)	06:09		05:37		05:35	05:35
	17:21	39 09:14 (T-26)			19:36	19:15 (T-25)	20:13		20:45		20:59	20:59
31	07:32	08:36 (T-26)			06:58	19:09 (T-25)			05:36			
	17:23	37 09:13 (T-26)			19:37	19:16 (T-25)			20:46			
Potential sun hours	290		294		369		402		455		461	
Total, worst case	1656		371		33		259					
Sun reduction	0.53		0.59		0.57		0.56					
Oper. time red.	0.98		0.98		0.98		0.98					
Wind dir. red.	0.73		0.71		0.68		0.66					
Total reduction	0.38		0.41		0.38		0.36					
Total, real	626		151		13		94					

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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+1 701 775 3000

Calculated: 8/19/2019 3:07 PM/3.1.633

SHADOW - Calendar

Calculation: L079 Clipped w/263 HousesShadow receptor: 220 - Participant

Assumptions for shadow calculations

Sunshine probability S/S0 (Sun hours/Possible sun hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.53	0.59	0.57	0.56	0.62	0.67	0.74	0.69	0.62	0.51	0.37	0.38

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
607	364	349	399	598	1,082	1,220	632	491	661	1,202	943	8,548

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

	July	August	September	October	November	December
1	05:36 20:59	06:02 20:38	06:36 19:52	19:03 (T-25) 18:56	07:10 17:05	06:48 16:38
2	05:36 20:58	06:03 20:37	06:38 19:50	19:02 (T-25) 18:54	07:11 17:04	06:49 16:38
3	05:37 20:58	06:04 20:36	06:39 19:48	19:01 (T-25) 18:52	07:12 17:03	06:51 16:38
4	05:37 20:58	06:05 20:34	06:40 19:47	19:00 (T-25) 18:50	07:14 17:02	06:52 16:38
5	05:38 20:58	06:06 20:33	06:41 19:45	19:00 (T-25) 18:49	07:15 17:00	06:53 16:37
6	05:39 20:58	06:07 20:32	06:42 19:43	18:59 (T-25) 18:47	07:16 16:59	06:55 16:37
7	05:39 20:57	06:09 20:31	06:43 19:41	18:59 (T-25) 18:45	07:17 16:58	06:56 16:37
8	05:40 20:57	06:10 20:29	06:44 19:39	18:58 (T-25) 18:43	07:18 16:57	06:57 16:37
9	05:41 20:56	06:11 20:28	06:45 19:38	18:58 (T-25) 18:42	07:19 16:55	06:59 16:37
10	05:41 20:56	06:12 20:27	06:46 19:36	18:59 (T-25) 18:40	07:20 16:54	06:59 16:37
11	05:42 20:56	06:13 20:25	06:48 19:34	19:00 (T-25) 18:38	07:21 16:53	07:00 16:37
12	05:43 20:55	06:14 20:24	06:49 19:32	19:01 (T-25) 18:36	07:22 16:52	07:01 16:37
13	05:44 20:55	06:15 20:22	06:50 19:30	19:02 (T-25) 18:35	07:23 16:51	07:02 16:37
14	05:45 20:54	06:16 20:21	06:51 19:29	19:06 (T-25) 18:33	07:24 16:50	07:03 16:37
15	05:45 20:53	06:17 20:19	06:52 19:27	19:06 (T-25) 18:31	07:25 16:49	07:04 16:37
16	05:46 20:53	06:19 20:18	06:53 19:25	19:06 (T-25) 18:29	07:26 16:48	07:05 16:37
17	05:47 20:52	06:20 20:16	06:54 19:23	19:06 (T-25) 18:27	07:27 16:47	07:06 16:37
18	05:48 20:51	06:21 20:15	06:55 19:21	19:06 (T-25) 18:26	07:28 16:46	07:07 16:37
19	05:49 20:51	06:22 20:13	06:56 19:19	19:06 (T-25) 18:25	07:29 16:45	07:08 16:37
20	05:50 20:50	06:23 20:12	06:58 19:18	19:06 (T-25) 18:23	07:30 16:44	07:09 16:37
21	05:51 20:49	06:24 20:10	06:59 19:16	19:06 (T-25) 18:22	07:31 16:43	07:10 16:37
22	05:52 20:48	06:25 20:08	07:00 19:14	19:06 (T-25) 18:20	07:32 16:42	07:11 16:37
23	05:53 20:47	06:26 20:07	07:01 19:12	19:06 (T-25) 18:19	07:33 16:41	07:12 16:37
24	05:54 20:46	06:27 20:05	07:02 19:10	19:06 (T-25) 18:17	07:34 16:40	07:13 16:37
25	05:55 20:45	06:29 20:04	07:03 19:08	19:06 (T-25) 18:15	07:35 16:39	07:14 16:37
26	05:56 20:44	06:30 20:02	07:04 19:07	19:06 (T-25) 18:14	07:36 16:38	07:15 16:37
27	05:57 20:43	06:31 20:00	07:05 19:05	19:06 (T-25) 18:12	07:37 16:37	07:16 16:37
28	05:58 20:42	06:32 19:59	07:06 19:03	19:06 (T-25) 18:11	07:38 16:36	07:17 16:37
29	05:59 20:41	06:33 19:57	07:07 19:01	19:06 (T-25) 18:10	07:39 16:35	07:18 16:37
30	06:00 20:40	06:34 19:55	07:08 18:58	19:06 (T-25) 18:08	07:40 16:34	07:19 16:37
31	06:01 20:39	06:35 19:53	07:09 19:05	19:06 (T-25) 18:07	07:41 16:33	07:20 16:37
Potential sun hours	467	433	377	342	292	279
Total, worst case		57	214	267	1146	1792
Sun reduction		0.69	0.62	0.51	0.37	0.38
Oper. time red.		0.98	0.98	0.98	0.98	0.98
Wind dir. red.		0.66	0.66	0.70	0.73	0.73
Total reduction		0.45	0.40	0.35	0.26	0.27
Total, real		25	86	93	302	486

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: Freeborn
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.

Licensed user: EAPC Wind Energy
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 3000

Calculated: 8/19/2019 3:07 PM/3.1.633

SHADOW - Calendar

Calculation: L079 Clipped w/263 HousesShadow receptor: 386 - Participant

Assumptions for shadow calculations

Sunshine probability S/S0 (Sun hours/Possible sun hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.53	0.59	0.57	0.56	0.62	0.67	0.74	0.69	0.62	0.51	0.37	0.38

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
607	364	349	399	598	1,082	1,220	632	491	661	1,202	943	8,548

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

	January	February	March	April	May	June	
1	07:47	07:31	16:23 (T-19)	06:51	06:56	06:07	05:35
	16:47	17:24	35 16:58 (T-19)	18:00	19:38	20:14	20:46
2	07:47	07:29	16:23 (T-19)	06:49	06:54	06:05	05:35
	16:48	17:25	37 17:00 (T-19)	18:01	19:39	20:15	20:47
3	07:47	07:28	16:24 (T-19)	06:48	06:53	06:04	05:34
	16:49	17:26	36 17:00 (T-19)	18:02	19:40	20:16	20:48
4	07:47	07:27	16:24 (T-19)	06:46	06:51	06:03	05:34
	16:50	17:28	35 16:59 (T-19)	18:04	19:42	20:17	20:49
5	07:47	07:26	16:24 (T-19)	06:44	06:49	06:01	05:33
	16:51	17:29	35 16:59 (T-19)	18:05	19:43	20:18	20:50
6	07:47	07:25	16:25 (T-19)	06:43	06:47	06:00	05:33
	16:52	17:31	34 16:59 (T-19)	18:06	19:44	20:19	20:50
7	07:47	07:24	16:26 (T-19)	06:41	06:46	05:59	05:33
	16:53	17:32	33 16:59 (T-19)	18:08	19:45	20:21	20:51
8	07:46	07:22	16:27 (T-19)	07:39	06:44	05:57	05:32
	16:54	17:33	30 16:57 (T-19)	18:09	19:46	20:22	20:52
9	07:46	07:21	16:28 (T-19)	07:37	06:42	05:56	05:32
	16:55	17:35	29 16:57 (T-19)	19:10	19:48	20:23	20:52
10	07:46	07:20	16:30 (T-19)	07:36	06:40	05:55	05:32
	16:56	17:36	26 16:56 (T-19)	19:11	19:49	20:24	20:53
11	07:46	07:18	16:30 (T-19)	07:34	06:39	05:54	05:32
	16:57	17:37	24 16:54 (T-19)	19:13	19:50	20:25	20:54
12	07:45	07:17	16:33 (T-19)	07:32	06:37	05:52	05:31
	16:58	17:39	20 16:53 (T-19)	19:14	19:51	20:26	20:54
13	07:45	16:29 (T-19)	07:16	16:35 (T-19)	07:30	06:35	05:51
	16:59	3 16:32 (T-19)	17:40	16:49 (T-19)	19:15	19:52	20:27
14	07:44	16:28 (T-19)	07:14	16:40 (T-19)	07:29	06:34	05:50
	17:00	5 16:33 (T-19)	17:41	5 16:45 (T-19)	19:16	19:54	20:29
15	07:44	16:27 (T-19)	07:13	07:27	06:32	05:49	19:54 (T-18)
	17:02	8 16:35 (T-19)	17:43	19:18	19:55	20:30	20:03 (T-18)
16	07:44	16:26 (T-19)	07:11	07:25	06:30	05:48	20:06 (T-18)
	17:03	10 16:36 (T-19)	17:44	19:19	19:56	20:31	19:48 (T-18)
17	07:43	16:25 (T-19)	07:10	07:23	06:29	05:47	20:07 (T-18)
	17:04	12 16:37 (T-19)	17:45	19:20	19:57	20:32	20:08 (T-18)
18	07:42	16:25 (T-19)	07:08	07:21	06:27	05:46	20:09 (T-18)
	17:05	14 16:39 (T-19)	17:47	19:21	19:58	20:33	20:10 (T-18)
19	07:42	16:24 (T-19)	07:07	07:20	06:25	05:45	20:11 (T-18)
	17:07	16 16:40 (T-19)	17:48	19:22	19:59	20:34	20:12 (T-18)
20	07:41	16:23 (T-19)	07:05	07:18	06:24	05:44	20:13 (T-18)
	17:08	18 16:41 (T-19)	17:49	19:24	20:01	20:35	20:14 (T-18)
21	07:40	16:24 (T-19)	07:04	07:16	06:22	05:43	20:15 (T-18)
	17:09	19 16:43 (T-19)	17:51	19:25	20:02	20:36	20:16 (T-18)
22	07:40	16:23 (T-19)	07:02	07:14	06:20	05:42	20:17 (T-18)
	17:10	21 16:44 (T-19)	17:52	19:26	20:03	20:37	20:18 (T-18)
23	07:39	16:23 (T-19)	07:01	07:12	06:19	05:41	20:19 (T-18)
	17:12	22 16:45 (T-19)	17:53	19:27	20:04	20:38	20:20 (T-18)
24	07:38	16:23 (T-19)	06:59	07:11	06:17	05:41	20:21 (T-18)
	17:13	24 16:47 (T-19)	17:55	19:28	20:05	20:39	20:22 (T-18)
25	07:37	16:22 (T-19)	06:58	07:09	06:16	05:40	20:23 (T-18)
	17:14	26 16:48 (T-19)	17:56	19:30	20:07	20:40	20:24 (T-18)
26	07:36	16:22 (T-19)	06:56	07:07	06:14	05:39	20:25 (T-18)
	17:16	27 16:49 (T-19)	17:57	19:31	20:08	20:41	20:26 (T-18)
27	07:36	16:22 (T-19)	06:54	07:05	06:13	05:38	20:27 (T-18)
	17:17	29 16:51 (T-19)	17:59	19:32	20:09	20:42	20:28 (T-18)
28	07:35	16:22 (T-19)	06:53	07:03	06:11	05:38	20:29 (T-18)
	17:18	30 16:52 (T-19)	18:00	19:33	20:10	20:43	20:30 (T-18)
29	07:34	16:22 (T-19)		07:02	06:10	05:37	20:31 (T-18)
	17:20	32 16:54 (T-19)		19:34	20:11	20:44	20:32 (T-18)
30	07:33	16:22 (T-19)		07:00	06:08	05:36	20:33 (T-18)
	17:21	33 16:55 (T-19)		19:36	20:12	20:45	20:34 (T-18)
31	07:32	16:23 (T-19)		06:58		05:36	20:35 (T-18)
	17:22	34 16:57 (T-19)		19:37		20:46	20:36 (T-18)
Potential sun hours	290	294		369	402	455	461
Total, worst case	383	393				569	1518
Sun reduction	0.53	0.59				0.62	0.67
Oper. time red.	0.98	0.98				0.98	0.98
Wind dir. red.	0.56	0.56				0.72	0.72
Total reduction	0.29	0.32				0.43	0.46
Total, real	109	125				243	701

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: Freeborn
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Licensed user:
EAPC Wind Energy
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 3000

Calculated:
8/19/2019 3:07 PM/3.1.633

SHADOW - Calendar

Calculation: L079 Clipped w/263 HousesShadow receptor: 386 - Participant

Assumptions for shadow calculations

Sunshine probability S/S0 (Sun hours/Possible sun hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.53	0.59	0.57	0.56	0.62	0.67	0.74	0.69	0.62	0.51	0.37	0.38

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
607	364	349	399	598	1,082	1,220	632	491	661	1,202	943	8,548

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

	July			August		September		October		November		December	
1	05:35		19:40 (T-18)	06:02		06:36	07:10			06:48		15:58 (T-19)	07:26
	20:59	51	20:31 (T-18)	20:38		19:52	18:56			17:05	27	16:25 (T-19)	16:38
2	05:36		19:41 (T-18)	06:03		06:37	07:11			06:49		15:58 (T-19)	07:27
	20:58	51	20:32 (T-18)	20:37		19:50	18:54			17:04	29	16:27 (T-19)	16:38
3	05:36		19:40 (T-18)	06:04		06:38	07:12			06:51		15:56 (T-19)	07:28
	20:58	51	20:31 (T-18)	20:36		19:48	18:52			17:02	31	16:27 (T-19)	16:37
4	05:37		19:41 (T-18)	06:05		06:39	07:13			06:52		15:56 (T-19)	07:29
	20:58	50	20:31 (T-18)	20:34		19:46	18:50			17:01	32	16:28 (T-19)	16:37
5	05:38		19:41 (T-18)	06:06		06:41	07:15			06:53		15:55 (T-19)	07:30
	20:58	50	20:31 (T-18)	20:33		19:45	18:48			17:00	34	16:29 (T-19)	16:37
6	05:38		19:42 (T-18)	06:07		06:42	07:16			06:55		15:54 (T-19)	07:31
	20:58	49	20:31 (T-18)	20:32		19:43	18:47			16:59	35	16:29 (T-19)	16:37
7	05:39		19:42 (T-18)	06:08		06:43	07:17			06:56		15:54 (T-19)	07:32
	20:57	49	20:31 (T-18)	20:31		19:41	18:45			16:57	36	16:30 (T-19)	16:37
8	05:40		19:42 (T-18)	06:09		06:44	07:18			06:57		15:54 (T-19)	07:33
	20:57	48	20:30 (T-18)	20:29		19:39	18:43			16:56	36	16:30 (T-19)	16:37
9	05:40		19:43 (T-18)	06:10		06:45	07:19			06:59		15:54 (T-19)	07:34
	20:57	47	20:30 (T-18)	20:28		19:37	18:41			16:55	37	16:31 (T-19)	16:36
10	05:41		19:43 (T-18)	06:12		06:46	07:21			07:00		15:54 (T-19)	07:35
	20:56	47	20:30 (T-18)	20:27		19:36	18:40			16:54	35	16:29 (T-19)	16:36
11	05:42		19:43 (T-18)	06:13		06:47	07:22			07:01		15:53 (T-19)	07:36
	20:56	45	20:28 (T-18)	20:25		19:34	18:38			16:53	35	16:28 (T-19)	16:37
12	05:43		19:44 (T-18)	06:14		06:48	07:23			07:02		15:54 (T-19)	07:37
	20:55	44	20:28 (T-18)	20:24		19:32	18:36			16:52	33	16:27 (T-19)	16:37
13	05:43		19:44 (T-18)	06:15		06:50	07:24			07:04		15:54 (T-19)	07:38
	20:55	44	20:28 (T-18)	20:22		19:30	18:34			16:51	32	16:26 (T-19)	16:37
14	05:44		19:45 (T-18)	06:16		06:51	07:25			07:05		15:55 (T-19)	07:38
	20:54	43	20:28 (T-18)	20:21		19:28	18:33			16:50	30	16:25 (T-19)	16:37
15	05:45		19:46 (T-18)	06:17		06:52	07:27			07:06		15:55 (T-19)	07:39
	20:53	41	20:27 (T-18)	20:19		19:27	18:31			16:49	29	16:24 (T-19)	16:37
16	05:46		19:45 (T-18)	06:18		06:53	07:28			07:08		15:55 (T-19)	07:40
	20:53	41	20:26 (T-18)	20:18		19:25	18:29			16:48	27	16:22 (T-19)	16:37
17	05:47		19:46 (T-18)	06:19		06:54	07:29			07:09		15:56 (T-19)	07:41
	20:52	39	20:25 (T-18)	20:16		19:23	18:28			16:47	26	16:22 (T-19)	16:38
18	05:48		19:47 (T-18)	06:20		06:55	07:30			07:10		15:57 (T-19)	07:41
	20:51	38	20:25 (T-18)	20:15		19:21	18:26			16:46	24	16:21 (T-19)	16:38
19	05:49		19:48 (T-18)	06:22		06:56	07:31			07:11		15:57 (T-19)	07:42
	20:51	36	20:24 (T-18)	20:13		19:19	18:25			16:45	22	16:19 (T-19)	16:38
20	05:50		19:48 (T-18)	06:23		06:57	07:33			07:13		15:58 (T-19)	07:43
	20:50	36	20:24 (T-18)	20:12		19:17	18:23			16:44	21	16:19 (T-19)	16:39
21	05:50		19:49 (T-18)	06:24		06:59	07:34			07:14		15:59 (T-19)	07:43
	20:49	34	20:23 (T-18)	20:10		19:16	18:21			16:44	19	16:18 (T-19)	16:39
22	05:51		19:50 (T-18)	06:25		07:00	07:35			07:15		15:59 (T-19)	07:44
	20:48	32	20:22 (T-18)	20:08		19:14	18:20			16:43	18	16:17 (T-19)	16:40
23	05:52		19:51 (T-18)	06:26		07:01	07:37			07:17		16:01 (T-19)	07:44
	20:47	30	20:21 (T-18)	20:07		19:12	18:18			16:42	16	16:17 (T-19)	16:40
24	05:53		19:53 (T-18)	06:27		07:02	07:38			07:18		16:02 (T-19)	07:45
	20:46	28	20:21 (T-18)	20:05		19:10	18:17			16:42	14	16:16 (T-19)	16:41
25	05:54		19:54 (T-18)	06:28		07:03	07:39			07:19		16:03 (T-19)	07:45
	20:45	26	20:20 (T-18)	20:04		19:08	18:15			16:41	12	16:15 (T-19)	16:41
26	05:55		19:55 (T-18)	06:29		07:04	07:40			07:20		16:05 (T-19)	07:45
	20:44	24	20:19 (T-18)	20:02		19:06	18:14			16:40	10	16:15 (T-19)	16:42
27	05:56		19:57 (T-18)	06:31		07:05	07:42			07:21		16:06 (T-19)	07:46
	20:43	21	20:18 (T-18)	20:00		19:05	18:12			16:40	8	16:14 (T-19)	16:43
28	05:57		19:59 (T-18)	06:32		07:06	07:43		17:08 (T-19)	07:23		16:08 (T-19)	07:46
	20:42	18	20:17 (T-18)	19:59		19:03	18:11	8	17:16 (T-19)	16:39	5	16:13 (T-19)	16:43
29	05:59		20:02 (T-18)	06:33		07:08	07:44		17:04 (T-19)	07:24		16:09 (T-19)	07:46
	20:41	14	20:16 (T-18)	19:57		19:01	18:09	16	17:20 (T-19)	16:39	3	16:12 (T-19)	16:44
30	06:00			06:34		07:09	07:45		17:02 (T-19)	07:25			07:46
	20:40			19:55		18:57	18:08	21	17:23 (T-19)	16:38			16:45
31	06:01			06:35		07:47	07:47		17:00 (T-19)				07:47
	20:39			19:53		18:07	18:07	24	17:24 (T-19)				16:46
Potential sun hours	467			433		377	342			291			279
Total, worst case		1127					69			716			
Sun reduction		0.74					0.51			0.37			
Oper. time red.		0.98					0.98			0.98			
Wind dir. red.		0.72					0.56			0.56			
Total reduction		0.51					0.27			0.20			
Total, real		575					19			143			

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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Responsive partner.
Exceptional outcomes.

CERTIFICATE OF SERVICE

I, Lynnette Sweet, hereby certify that I have this day served copies or summaries of the foregoing documents on the attached list(s) of persons.

xx by depositing a true and correct copy thereof, properly enveloped
with postage paid in the United States Mail at Minneapolis, Minnesota

or

xx electronic filing

Docket No. IP-6946/WS-17-410

Dated this 14th day of July 2020

/s/

Lynnette Sweet
Regulatory Administrator

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
Lisa	Agrimonti	lagrimonti@fredlaw.com	Fredrikson & Byron, P.A.	200 South Sixth Street Suite 4000 Minneapolis, MN 55402	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Christina	Brusven	cbrusven@fredlaw.com	Fredrikson Byron	200 S 6th St Ste 4000 Minneapolis, MN 554021425	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Generic Notice	Commerce Attorneys	commerce.attorneys@ag.state.mn.us	Office of the Attorney General-DOC	445 Minnesota Street Suite 1400 St. Paul, MN 55101	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Richard	Davis	Richard.Davis@state.mn.us	Department of Commerce	85 7th Place East Suite 500 Saint Paul, MN 55101	Electronic Service	Yes	OFF_SL_17-410_Official Service list Site permit
Bret	Eknes	bret.eknes@state.mn.us	Public Utilities Commission	Suite 350 121 7th Place East St. Paul, MN 551012147	Electronic Service	Yes	OFF_SL_17-410_Official Service list Site permit
Sharon	Ferguson	sharon.ferguson@state.mn.us	Department of Commerce	85 7th Place E Ste 280 Saint Paul, MN 551012198	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Sean	Gaston	sean.p.gaston@gmail.com		11133 850th Ave Glennville, MN 56036	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Dorenne	Hansen	dhansen078@gmail.com		12174 840 Avenue Glennville, MN 56036-4481	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
David	Harbert	dharbert@kaaltv.com	KAAL-TV	1320 Salem Rd SW Rochester, MN 55902	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Matt	Harris	matt.b.harris@xcelenergy.com	XCEL ENERGY	401 Nicollet Mall FL 8 Minneapolis, MN 55401	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
Michael	Kaluzniak	mike.kaluzniak@state.mn.us	Public Utilities Commission	Suite 350 121 Seventh Place East St. Paul, MN 55101	Electronic Service	Yes	OFF_SL_17-410_Official Service list Site permit
Dan	Litchfield	DLitchfield@invenergyllc.com	Invenergy LLC	One S Wacker Dr Ste 1800 Chicago, IL 60606	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Sue L	Madson	sue_madson@hotmail.com		14806 830th Ave Glenville, MN 56036	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Gregory	Merz	gregory.merz@lathropgpm.com	Lathrop GPM LLP	80 S 8th St Ste 500 Minneapolis, MN 55402-5383	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Allie	Olson	aa_olson@hotmail.com		12225 810th Ave Glenville, MN 56036	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Carol A.	Overland	overland@legalelectric.org	Legalelectric - Overland Law Office	1110 West Avenue Red Wing, MN 55066	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Generic Notice	Residential Utilities Division	residential.utilities@ag.state.mn.us	Office of the Attorney General-RUD	1400 BRM Tower 445 Minnesota St St. Paul, MN 551012131	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Richard	Savelkoul	rsavelkoul@martinsquires.com	Martin & Squires, P.A.	332 Minnesota Street Ste W2750 St. Paul, MN 55101	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit
Will	Seuffert	Will.Seuffert@state.mn.us	Public Utilities Commission	121 7th PI E Ste 350 Saint Paul, MN 55101	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit

First Name	Last Name	Email	Company Name	Address	Delivery Method	View Trade Secret	Service List Name
Janet	Shaddix Elling	jshaddix@janetshaddix.com	Shaddix And Associates	7400 Lyndale Ave S Ste 190 Richfield, MN 55423	Electronic Service	Yes	OFF_SL_17-410_Official Service list Site permit
Lynnette	Sweet	Regulatory.records@xcelenergy.com	Xcel Energy	414 Nicollet Mall FL 7 Minneapolis, MN 554011993	Electronic Service	No	OFF_SL_17-410_Official Service list Site permit