# Border Winds Wind Energy Project

# Shadow Flicker Assessment

Prepared By:
Dan Cox
Manager, Project Development Services and Technology
Sequoia Energy US Inc.

March 4, 2010

69 PU-08-797 Filed 01/27/2011 Pages: 33
Exhibit 9
Sequoia Energy US Inc.

## Executive Summary

The Border Winds project is a 150MW wind energy project proposed by Sequoia Energy US Inc., consisting of 66 wind turbines and located north and east of Rolla, North Dakota. On November 3rd, 2009 the North Dakota Public Service Commission held a public hearing to discuss the human and environmental impacts of the proposed wind energy project. During this hearing the Commission requested that Sequoia submit a shadow flicker assessment for the project as a late-filed exhibit.

There are many conditions that have to be met in a particular combination in order for shadow flicker to occur, including time of day, time of year, turbine operation and sky conditions. Also there are a number of factors which determine the intensity of any shadow flicker on a receptor, such as distance from the turbine, turbine rotor speed, and obstacles surrounding the shadow receptor.

This assessment was based on two scenarios: (1) worst case (sun always shining in daytime, turbine always rotating and wind direction "worst case"), and (2) real-case (includes monthly sunshine probabilities and on site meteorological data). Neither scenario takes into account the obstacles (trees, buildings, etc.) that surround most shadow receptors. Obstacles such as trees and buildings cast shadows and help mitigate predicted effect of shadow flicker.

The results show the following receptors experiencing the most shadow flicker:

- The worst case maximum shadow flicker (minutes per day) is 47 minutes at shadow receptor M.
- The real-case maximum shadow flicker (hours per year) is 16:44 at shadow receptor M.
- The worst case maximum shadow flicker (hours per year) is 47:24 at shadow receptor M.

In the event that shadow flicker is a concern, placing shutters on windows, planting trees in strategic locations and turbine curtailment for specific wind directions and time of day are all effective mitigation techniques. To date, there are no proven health impacts caused by shadow flicker.

## Contents

## 1.0 Introduction

The Border Winds project is a 150MW wind energy project proposed by Sequoia Energy US Inc. (Sequoia), consisting of 66 wind turbines and located north and east of Rolla, North Dakota (see Appendix A). On November 3rd, 2009 the North Dakota Public Service Commission held a public hearing to discuss the human and environmental impacts of the proposed wind energy project.

During the hearing proceedings the Commission requested that Sequoia prepare a late-filed exhibit regarding the potential impacts of wind turbine shadow flicker to residences within the project area. To address this request, a detailed analysis has been performed to quantify the amount of shadow flicker from the proposed turbines on the surrounding residences. Shadow flicker is generally quantified in modeled shadow hours per year and shadow minutes per day.

This report will give a brief overview of shadow flicker, the methods that were used to assess this project, and the corresponding results.

## 2.0 Shadow Flicker Overview

Wind turbine shadow flicker is defined as alternating changes in light intensity caused by shadows cast from moving turbine blades. For this study, shadow receptors where defined as residences within the project area.

In order for shadow flicker to occur a certain set of conditions must occur in a specific combination, such as:

- Location
- Time of day (generally at sun rise and sun set)
- Time of year (elevation of the sun changes throughout the year)
- Turbine operation
- Sky conditions (must be clear)

There are also a number of factors that determine the intensity and duration of shadow flicker at a shadow receptor, such as:

- Distance from the turbine to the shadow receptor (greater than 10 rotor diameters, or approximately 1000m, the changing light intensity is low enough that a person does not perceive the turbine rotor as "chopping" through the sun, but rather as an object with the sun behind it)
- The rotor speed and number of blades on the turbine
- Obstacles in and around the shadow receptor
- Light intensity level of perception of the human eye
- Plane angle of the turbine rotor
- Ambient lighting conditions
- Aerosols in the atmosphere

Most North American jurisdictions do not have established shadow flicker regulations. However, some European countries such as Denmark and Germany have developed recommendations and guidelines suggesting acceptable hours of shadow per year at residences. Some guidelines suggest that less than 30 hours per year of modeled shadow flicker is generally not considered to be a serious concern.

In the event that shadow flicker is a concern, placing shutters on windows, planting trees in specific locations and turbine curtailment for specific wind directions and time of day are all effective mitigation techniques. To date, there are no proven health impacts caused by shadow flicker.

## 3.0 Border Winds Shadow Flicker Assessment

The shadow flicker assessment for the Border Winds project was completed using the EMD WindPRO software. WindPRO is the world's most comprehensive software package for design and planning of wind farm projects.

The SHADOW module of WindPRO calculates shadow flicker in terms of hours per year during which a shadow receptor would be exposed to flickering from nearby turbine rotors. Also, maximum minutes per day are calculated. For this project the SHADOW module calculated both worst case results (sun always shining in daytime, turbine always rotating and wind direction "worst case"), and expected values based on sunshine probabilities and turbine operation estimates.

This assessment identified 54 shadow receptors within the project area (see Appendix A), and assigned the following characteristics to each receptor:

- Window type = Green House (since the direction of the residence windows was not known the shadow receptor was considered to be perpendicular to all turbines)
- Bottom line height above ground = 1meter
- Slope of window = 90 degrees vertical

The following inputs were used in the calculation:

- Turbine Locations (66 - Siemens 2.3MW)
- Turbine geometry (80m hub height, 101m rotor diameter, 3.5m blade width and 16 rpm)
- Digital Elevation model
- Calculate flicker only when 20% of sun is covered by the blade. According to German guidelines flickering is only an issue when at least 20% of the sun disk is covered by the turbine blade.
- Angle above horizon with no shadow influence = 3.0 degrees
- Resolution for Zones of Visual Influence (ZVI) grid in shadow receptor calculation = 10 meters
- Eye height = 1.5 meters
- Turbine operational hours calculated from on site met tower data
- The sunshine probabilities shown in Table 1 (part of time from sun rise to sun set with sun shine), from www.city-data.com

**Table 1: Sunshine Probabilities for Rolla, ND**

| Month | Probability |
|---|---|
| January | 0.51 |
| February | 0.55 |
| March | 0.57 |
| April | 0.59 |
| May | 0.61 |
| June | 0.65 |
| July | 0.71 |
| August | 0.71 |
| September | 0.65 |
| October | 0.56 |
| November | 0.45 |
| December | 0.46 |

- The yaw system of the wind turbine changes the orientation of the rotor according to the wind direction, thus the shadow produced by a turbine will change according to the wind direction. Figure 1 is the wind rose representing the wind direction distribution at the Border Winds project.

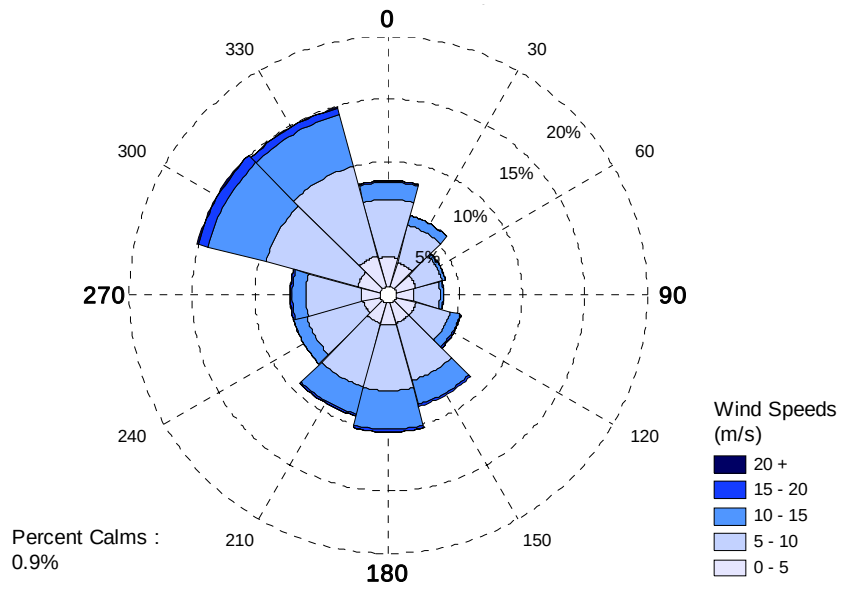



**Figure 1: Wind**

**Direction Distribution at Border Winds, Rolette County, ND**

## 4.0 Assessment Results

The Border Winds project consists of 66 Siemens 2.3MW wind turbines. Worst case and real case shadow flicker results for each receptor are presented in Table 2. Receptors experiencing the most shadow flicker are mentioned below:

- The worst case maximum shadow flicker (minutes per day) is 47 minutes at shadow receptor M.
- The real-case maximum shadow flicker (hours per year) is 16:44 at shadow receptor M.
- The worst case maximum shadow flicker (hours per year) is 47:24 at shadow receptor M.

**Table 2: Worst-case and Real-case Shadow Flicker for Each Receptor**

| Receptor No. | Shadow days per year (Worst Case) | Max Shadow hours per day (Worst Case) | Shadow hours per year (Worst Case) | Shadow hours per year (Real-Case) |
|---|---|---|---|---|
| A | 46 | 0:16 | 6:46 | 2:08 |
| B | 0 | 0:00 | 0:00 | 0:00 |
| C | 0 | 0:00 | 0:00 | 0:00 |
| D | 18 | 0:13 | 2:34 | 0:52 |
| E | 112 | 0:30 | 38:53 | 12:35 |
| F | 108 | 0:34 | 41:55 | 10:26 |
| G | 68 | 0:34 | 21:19 | 6:11 |
| H | 84 | 0:32 | 26:31 | 8:55 |
| I | 0 | 0:00 | 0:00 | 0:00 |
| J | 0 | 0:00 | 0:00 | 0:00 |
| K | 53 | 0:24 | 12:07 | 4:13 |
| L | 0 | 0:00 | 0:00 | 0:00 |
| M | 102 | 0:47 | 47:24 | 16:44 |
| N | 98 | 0:36 | 36:02 | 12:42 |
| O | 45 | 0:15 | 7:07 | 2:18 |
| P | 118 | 0:43 | 46:10 | 16:28 |
| Q | 73 | 0:15 | 9:59 | 3:27 |
| R | 0 | 0:00 | 0:00 | 0:00 |
| S | 82 | 0:28 | 21:25 | 5:14 |
| T | 0 | 0:00 | 0:00 | 0:00 |
| U | 79 | 0:20 | 14:31 | 4:43 |
| V | 0 | 0:00 | 0:00 | 0:00 |
| W | 26 | 0:17 | 4:38 | 1:53 |
| X | 0 | 0:00 | 0:00 | 0:00 |

| Receptor No. | Shadow days per year (Worst Case) | Max Shadow hours per day (Worst Case) | Shadow hours per year (Worst Case) | Shadow hours per year (Real-Case) |
|---|---|---|---|---|
| Y | 0 | 0:00 | 0:00 | 0:00 |
| Z | 0 | 0:00 | 0:00 | 0:00 |
| AA | 34 | 0:15 | 5:34 | 1:54 |
| AB | 0 | 0:00 | 0:00 | 0:00 |
| AC | 0 | 0:00 | 0:00 | 0:00 |
| AD | 0 | 0:00 | 0:00 | 0:00 |
| AE | 21 | 0:15 | 3:24 | 1:10 |
| AF | 51 | 0:24 | 11:17 | 3:59 |
| AG | 20 | 0:15 | 3:25 | 0:59 |
| AH | 90 | 0:32 | 33:03 | 13:52 |
| AI | 0 | 0:00 | 0:00 | 0:00 |
| AJ | 0 | 0:00 | 0:00 | 0:00 |
| AK | 0 | 0:00 | 0:00 | 0:00 |
| AL | 0 | 0:00 | 0:00 | 0:00 |
| AM | 0 | 0:00 | 0:00 | 0:00 |
| AN | 0 | 0:00 | 0:00 | 0:00 |
| AO | 0 | 0:00 | 0:00 | 0:00 |
| AP | 0 | 0:00 | 0:00 | 0:00 |
| AQ | 0 | 0:00 | 0:00 | 0:00 |
| AR | 0 | 0:00 | 0:00 | 0:00 |
| AS | 0 | 0:00 | 0:00 | 0:00 |
| AT | 0 | 0:00 | 0:00 | 0:00 |
| AU | 0 | 0:00 | 0:00 | 0:00 |
| AV | 0 | 0:00 | 0:00 | 0:00 |
| AW | 0 | 0:00 | 0:00 | 0:00 |
| AX | 0 | 0:00 | 0:00 | 0:00 |
| AY | 0 | 0:00 | 0:00 | 0:00 |
| AZ | 0 | 0:00 | 0:00 | 0:00 |
| BA | 0 | 0:00 | 0:00 | 0:00 |
| BB | 0 | 0:00 | 0:00 | 0:00 |

All of the numeric and graphic results of the shadow flicker calculation are in Appendices B and C.

## 5.0 References

*EMD WindPRO User Guide,* EMD International A/S, Denmark, January 2006

*Higgins Mountain II Wind Plant: Analysis of Shadow Flicker on Ski Wentworth,* Frontier Power Systems Inc, Alberton, PE, December 2007

*http://www.city-data.com/city/Rolla-North-Dakota.html*

*Bornish Wind Power Project Shadow Flicker Assessment* GENIVAR, Calgary, AB, October 2009

# Appendix A – Project Layout with Shadow Receptors

# Border Winds Wind Energy Project

**Appendix A:**
Project Layout with Shadow Receptors

PROPOSED TURBINES

SHADOW RECEPTORS

03 / 2010 1:60,000

Source(s):

SEQUOIA ENERGY™

0 0.5 1 1.5 2
Miles

# Appendix B – WindPRO Analysis Numeric Results

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:40 AM / 1

Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

# SHADOW - Main Result

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

## Assumptions for shadow calculations

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

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

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.51 | 0.55 | 0.57 | 0.59 | 0.61 | 0.65 | 0.71 | 0.71 | 0.65 | 0.56 | 0.45 | 0.46 |

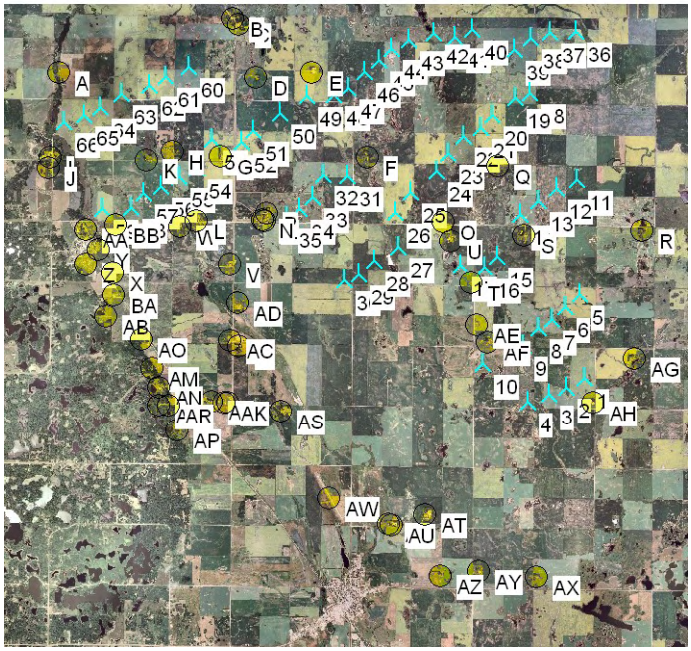
Operational hours are calculated from WTGs in calculation and wind distribution:
Validation Tower 1509

Operational time

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 349 | 310 | 244 | 176 | 167 | 161 | 158 | 144 | 196 | 316 | 344 | 430 |

| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 | 406 | 384 | 333 | 291 | 256 | 305 | 349 | 616 | 856 | 612 | 399 | 8,201 |

To avoid flicker from WTGs not visible a ZVI calculation is performed before the flicker calculation. The ZVI calculation is based on the following assumptions
Height contours used: Height Contours: Border Winds 5m Contours.WPO (1)
Obstacles not used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:200,000
New WTG  Shadow receptor

## WTGs

| | UTM NAD83 Zone: 14 | | | | WTG type | | | | | | Shadow data | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | North | Z | Row data/Description | Valid | Manufact. | Type-generator | Power, rated | Rotor diameter | Hub height | Calculation distance | RPM |
| | UTM NAD83 Zone: 14 | | [m] | | | | | [kW] | [m] | [m] | [m] | [RPM] |
| 1 | 461,209 | 5,418,024 | 543.1 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 2 | 460,745 | 5,417,760 | 545.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 3 | 460,286 | 5,417,572 | 545.5 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 4 | 459,719 | 5,417,370 | 545.4 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 5 | 461,082 | 5,420,240 | 542.1 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 6 | 460,712 | 5,419,898 | 544.9 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 7 | 460,355 | 5,419,584 | 545.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 8 | 459,992 | 5,419,352 | 547.9 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 9 | 459,597 | 5,418,893 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 10 | 458,516 | 5,418,412 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 11 | 461,006 | 5,423,257 | 540.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 12 | 460,469 | 5,423,047 | 541.7 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 13 | 460,000 | 5,422,713 | 546.2 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 14 | 459,500 | 5,422,348 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 15 | 458,909 | 5,421,220 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 16 | 458,574 | 5,420,951 | 551.9 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 17 | 457,921 | 5,420,990 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 18 | 459,764 | 5,425,573 | 541.4 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 19 | 459,389 | 5,425,435 | 544.9 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 20 | 458,769 | 5,424,966 | 548.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 21 | 458,453 | 5,424,641 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 22 | 458,017 | 5,424,421 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 23 | 457,607 | 5,423,946 | 551.9 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |

*Continued on next page...*

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:40 AM / 2
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

## SHADOW - Main Result

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

*...continued from previous page*

| | UTM NAD83 Zone: 14 | | | | WTG type | | | | | | Shadow data | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | North | Z | Row data/Description | Valid | Manufact. | Type-generator | Power, rated | Rotor diameter | Hub height | Calculation distance | RPM |
| | UTM NAD83 Zone: 14 | | [m] | | | | | [kW] | [m] | [m] | [m] | [RPM] |
| 24 | 457,302 | 5,423,497 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 25 | 456,609 | 5,422,926 | 557.5 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 26 | 456,186 | 5,422,414 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 27 | 456,269 | 5,421,489 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 28 | 455,628 | 5,421,122 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 29 | 455,215 | 5,420,778 | 556.4 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 30 | 454,847 | 5,420,625 | 560.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 31 | 454,912 | 5,423,378 | 556.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 32 | 454,289 | 5,423,386 | 560.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 33 | 454,000 | 5,422,810 | 560.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 34 | 453,647 | 5,422,510 | 560.5 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 35 | 453,321 | 5,422,282 | 563.2 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 36 | 460,991 | 5,427,202 | 527.3 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 37 | 460,293 | 5,427,179 | 535.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 38 | 459,780 | 5,427,018 | 536.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 39 | 459,349 | 5,426,709 | 540.3 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 40 | 458,225 | 5,427,257 | 544.8 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 41 | 457,776 | 5,427,048 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 42 | 457,215 | 5,427,150 | 550.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 43 | 456,562 | 5,426,965 | 552.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 44 | 456,090 | 5,426,732 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 45 | 455,750 | 5,426,442 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 46 | 455,392 | 5,426,122 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 47 | 454,946 | 5,425,687 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 48 | 454,564 | 5,425,501 | 555.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 49 | 453,860 | 5,425,494 | 560.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 50 | 453,148 | 5,425,042 | 560.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 51 | 452,431 | 5,424,572 | 560.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 52 | 452,105 | 5,424,264 | 561.7 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 53 | 451,326 | 5,424,342 | 564.9 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 54 | 450,909 | 5,423,587 | 567.9 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 55 | 450,457 | 5,423,345 | 570.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 56 | 449,978 | 5,423,089 | 570.6 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 57 | 449,512 | 5,422,906 | 575.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 58 | 449,177 | 5,422,518 | 578.1 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 59 | 448,430 | 5,422,504 | 583.5 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 60 | 450,705 | 5,426,250 | 560.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 61 | 450,094 | 5,425,995 | 564.1 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 62 | 449,681 | 5,425,759 | 570.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 63 | 448,942 | 5,425,527 | 570.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 64 | 448,372 | 5,425,189 | 574.1 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 65 | 447,926 | 5,424,971 | 575.0 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |
| 66 | 447,407 | 5,424,809 | 578.1 | Siemens SWT-2.3-10... | Yes | Siemens | SWT-2.3-101 1.19-2,300 | 2,300 | 100.6 | 80.0 | 1,463 | 16.0 |

### Shadow receptor-Input

| No. | UTM NAD83 Zone: 14 East | North | Z | Width | Height | Height a.g.l. | Degrees from south cw | Slope of window | Direction mode |
|---|---|---|---|---|---|---|---|---|---|
| | | | [m] | [m] | [m] | [m] | [°] | [°] | |
| A | 447,274 | 5,426,112 | 570.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| B | 451,890 | 5,427,531 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| C | 452,035 | 5,427,369 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| D | 452,504 | 5,425,972 | 560.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| E | 453,966 | 5,426,091 | 555.5 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |

*Continued on next page...*

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:40 AM / 3

Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

## SHADOW - Main Result

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

*...continued from previous page*

**UTM NAD83 Zone: 14**

| No. | East | North | Z | Width | Height | Height a.g.l. | Degrees from south cw | Slope of window | Direction mode |
|---|---|---|---|---|---|---|---|---|---|
| | | | [m] | [m] | [m] | [m] | [°] | [°] | |
| F | 455,465 | 5,423,866 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| G | 451,557 | 5,423,882 | 565.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| H | 450,273 | 5,424,003 | 570.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| I | 447,039 | 5,423,860 | 583.1 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| J | 446,984 | 5,423,569 | 586.3 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| K | 449,582 | 5,423,777 | 570.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| L | 450,912 | 5,422,185 | 568.6 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| M | 452,734 | 5,422,168 | 565.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| N | 452,675 | 5,422,194 | 565.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| O | 457,474 | 5,422,142 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| P | 452,788 | 5,422,379 | 564.2 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| Q | 458,919 | 5,423,625 | 550.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| R | 462,746 | 5,421,912 | 532.3 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| S | 459,607 | 5,421,788 | 550.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| T | 458,208 | 5,420,544 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| U | 457,670 | 5,421,638 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| V | 451,809 | 5,421,016 | 565.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| W | 450,477 | 5,422,030 | 566.6 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| X | 448,691 | 5,420,787 | 588.1 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| Y | 448,322 | 5,421,404 | 589.6 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| Z | 447,997 | 5,421,038 | 594.6 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AA | 447,979 | 5,421,937 | 585.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AB | 448,534 | 5,419,657 | 606.1 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AC | 451,816 | 5,419,024 | 565.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AD | 452,012 | 5,419,994 | 562.9 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AE | 458,355 | 5,419,429 | 550.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AF | 458,640 | 5,418,974 | 550.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AG | 462,531 | 5,418,515 | 530.9 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AH | 461,437 | 5,417,362 | 535.7 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AI | 452,043 | 5,418,848 | 565.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AJ | 451,772 | 5,417,345 | 570.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AK | 451,662 | 5,417,353 | 571.6 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AL | 451,329 | 5,417,370 | 575.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AM | 449,740 | 5,418,284 | 598.9 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AN | 449,933 | 5,417,764 | 602.4 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AO | 449,472 | 5,419,039 | 590.8 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AP | 450,412 | 5,416,626 | 598.8 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AQ | 449,918 | 5,417,273 | 605.9 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AR | 450,169 | 5,417,273 | 594.2 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AS | 453,163 | 5,417,128 | 560.4 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AT | 456,998 | 5,414,378 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AU | 456,102 | 5,414,086 | 553.3 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AV | 456,014 | 5,414,106 | 552.7 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AW | 454,441 | 5,414,794 | 555.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AX | 459,950 | 5,412,708 | 540.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AY | 458,412 | 5,412,856 | 550.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| AZ | 457,391 | 5,412,736 | 552.6 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| BA | 448,736 | 5,420,201 | 590.8 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |
| BB | 448,770 | 5,422,074 | 580.0 | 1.0 | 1.0 | 1.0 | 0.0 | 90.0 | "Green house mode" |

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:40 AM / 4
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

## SHADOW - Main Result

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

### Calculation Results

Shadow receptor

| | **Shadow, worst case** | | | **Shadow, expected values** |
|---|---|---|---|---|
| No. | Shadow hours per year [h/year] | Shadow days per year [days/year] | Max shadow hours per day [h/day] | Shadow hours per year [h/year] |
| A | 6:46 | 46 | 0:16 | 2:08 |
| B | 0:00 | 0 | 0:00 | 0:00 |
| C | 0:00 | 0 | 0:00 | 0:00 |
| D | 2:34 | 18 | 0:13 | 0:52 |
| E | 38:53 | 112 | 0:30 | 12:35 |
| F | 41:55 | 108 | 0:34 | 10:26 |
| G | 21:19 | 68 | 0:34 | 6:11 |
| H | 26:31 | 84 | 0:32 | 8:55 |
| I | 0:00 | 0 | 0:00 | 0:00 |
| J | 0:00 | 0 | 0:00 | 0:00 |
| K | 12:07 | 53 | 0:24 | 4:13 |
| L | 0:00 | 0 | 0:00 | 0:00 |
| M | 47:24 | 102 | 0:47 | 16:44 |
| N | 36:02 | 98 | 0:36 | 12:42 |
| O | 7:07 | 45 | 0:15 | 2:18 |
| P | 46:10 | 118 | 0:43 | 16:28 |
| Q | 9:59 | 73 | 0:15 | 3:27 |
| R | 0:00 | 0 | 0:00 | 0:00 |
| S | 21:25 | 82 | 0:28 | 5:14 |
| T | 0:00 | 0 | 0:00 | 0:00 |
| U | 14:31 | 79 | 0:20 | 4:43 |
| V | 0:00 | 0 | 0:00 | 0:00 |
| W | 4:38 | 26 | 0:17 | 1:53 |
| X | 0:00 | 0 | 0:00 | 0:00 |
| Y | 0:00 | 0 | 0:00 | 0:00 |
| Z | 0:00 | 0 | 0:00 | 0:00 |
| AA | 5:34 | 34 | 0:15 | 1:54 |
| AB | 0:00 | 0 | 0:00 | 0:00 |
| AC | 0:00 | 0 | 0:00 | 0:00 |
| AD | 0:00 | 0 | 0:00 | 0:00 |
| AE | 3:24 | 21 | 0:15 | 1:10 |
| AF | 11:17 | 51 | 0:24 | 3:59 |
| AG | 3:25 | 20 | 0:15 | 0:59 |
| AH | 33:03 | 90 | 0:32 | 13:52 |
| AI | 0:00 | 0 | 0:00 | 0:00 |
| AJ | 0:00 | 0 | 0:00 | 0:00 |
| AK | 0:00 | 0 | 0:00 | 0:00 |
| AL | 0:00 | 0 | 0:00 | 0:00 |
| AM | 0:00 | 0 | 0:00 | 0:00 |
| AN | 0:00 | 0 | 0:00 | 0:00 |
| AO | 0:00 | 0 | 0:00 | 0:00 |
| AP | 0:00 | 0 | 0:00 | 0:00 |
| AQ | 0:00 | 0 | 0:00 | 0:00 |
| AR | 0:00 | 0 | 0:00 | 0:00 |
| AS | 0:00 | 0 | 0:00 | 0:00 |
| AT | 0:00 | 0 | 0:00 | 0:00 |
| AU | 0:00 | 0 | 0:00 | 0:00 |
| AV | 0:00 | 0 | 0:00 | 0:00 |
| AW | 0:00 | 0 | 0:00 | 0:00 |
| AX | 0:00 | 0 | 0:00 | 0:00 |
| AY | 0:00 | 0 | 0:00 | 0:00 |
| AZ | 0:00 | 0 | 0:00 | 0:00 |
| BA | 0:00 | 0 | 0:00 | 0:00 |

*Continued on next page...*

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:40 AM / 5

Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

## SHADOW - Main Result

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

*...continued from previous page*

| No. | Shadow, worst case Shadow hours per year [h/year] | Shadow days per year [days/year] | Max shadow hours per day [h/day] | Shadow, expected values Shadow hours per year [h/year] |
|---|---|---|---|---|
| BB | 0:00 | 0 | 0:00 | 0:00 |

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

| No. | Name | Worst case [h/year] |
|---|---|---|
| 1 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1134) | 3:25 |
| 2 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1135) | 26:59 |
| 3 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1136) | 6:04 |
| 4 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1137) | 0:00 |
| 5 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1138) | 0:00 |
| 6 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1139) | 0:00 |
| 7 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1140) | 0:00 |
| 8 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1141) | 3:08 |
| 9 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1142) | 11:33 |
| 10 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1143) | 0:00 |
| 11 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1144) | 0:00 |
| 12 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1145) | 0:00 |
| 13 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1146) | 6:30 |
| 14 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1147) | 0:00 |
| 15 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1148) | 24:34 |
| 16 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1149) | 16:41 |
| 17 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1150) | 0:00 |
| 18 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1151) | 0:00 |
| 19 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1152) | 0:00 |
| 20 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1153) | 0:00 |
| 21 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1154) | 0:00 |
| 22 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1155) | 0:00 |
| 23 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1156) | 3:29 |
| 24 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1157) | 0:00 |
| 25 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1158) | 0:00 |
| 26 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1159) | 3:36 |
| 27 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1160) | 5:56 |
| 28 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1161) | 0:00 |
| 29 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1162) | 0:00 |
| 30 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1163) | 0:00 |
| 31 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1164) | 37:31 |
| 32 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1165) | 4:24 |
| 33 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1166) | 11:39 |
| 34 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1167) | 27:09 |
| 35 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1168) | 69:07 |
| 36 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1169) | 0:00 |
| 37 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1170) | 0:00 |
| 38 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1171) | 0:00 |
| 39 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1172) | 0:00 |
| 40 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1173) | 0:00 |
| 41 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1174) | 0:00 |
| 42 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1175) | 0:00 |
| 43 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1176) | 0:00 |
| 44 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1177) | 0:00 |
| 45 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1178) | 0:00 |
| 46 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1179) | 2:30 |
| 47 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1180) | 6:49 |
| 48 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1181) | 29:34 |

*Continued on next page...*

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:40 AM / 6

Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

## SHADOW - Main Result

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

*...continued from previous page*

| No. | Name | Worst case [h/year] |
|---|---|---|
| 49 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1182) | 2:34 |
| 50 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1183) | 0:00 |
| 51 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1184) | 0:00 |
| 52 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1185) | 1:34 |
| 53 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1186) | 7:02 |
| 54 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1187) | 41:36 |
| 55 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1188) | 14:26 |
| 56 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1189) | 0:00 |
| 57 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1190) | 0:00 |
| 58 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1191) | 10:12 |
| 59 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1192) | 0:00 |
| 60 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1193) | 0:00 |
| 61 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1194) | 0:00 |
| 62 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1195) | 0:00 |
| 63 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1196) | 0:00 |
| 64 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1197) | 6:46 |
| 65 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1198) | 0:00 |
| 66 | Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1199) | 0:00 |

# Appendix C – WindPRO Analysis Graphic Results

# Border Winds Wind Energy Project

**Appendix C:**
Graphic Results

PROPOSED TURBINES

SHADOW RECEPTORS

**Shadow Hours Per Year (Real Case)**

- 0.015
- 0.016 - 10.000
- 10.001 - 25.000
- 25.001 - 50.000
- 50.001 - 100.000
- 100.001 - 200.000

03 / 2010

1:60,000

Source(s):

SEQUOIA ENERGY™

0 0.5 1 1.5 2
Miles

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:44 AM / 1

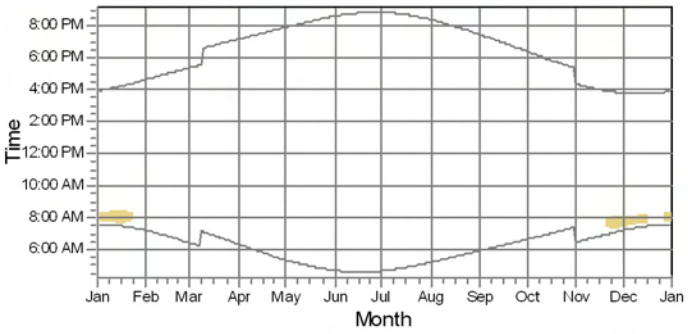
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

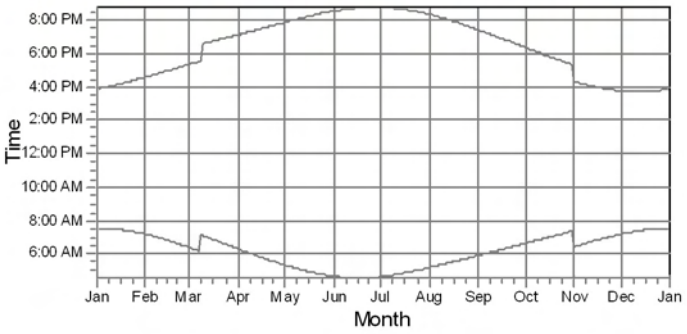
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

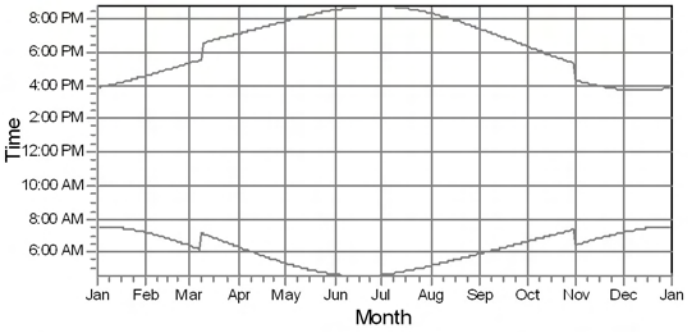
A: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (1)



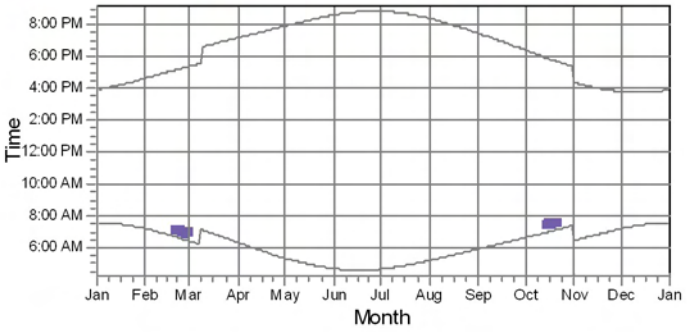

B: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (2)



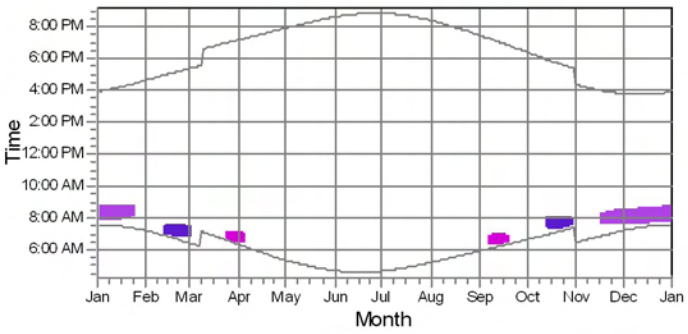

C: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (3)



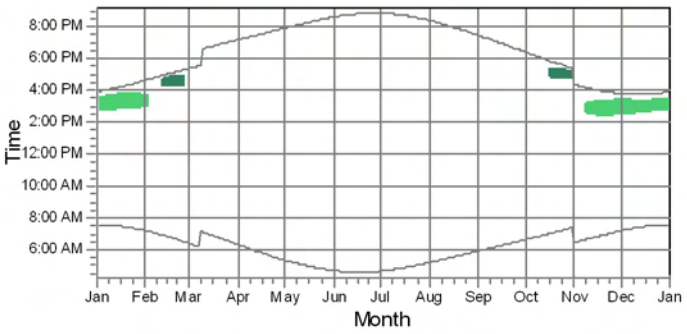

D: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (4)




E: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (5)




F: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (6)




WTGs

- 31: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1164)
- 32: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1165)
- 46: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1179)
- 47: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1180)
- 48: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1181)
- 49: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1182)
- 64: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1197)

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

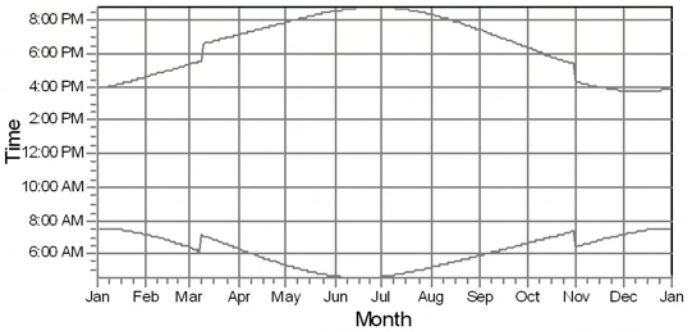
Printed/Page
3/4/2010 9:44 AM / 9
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

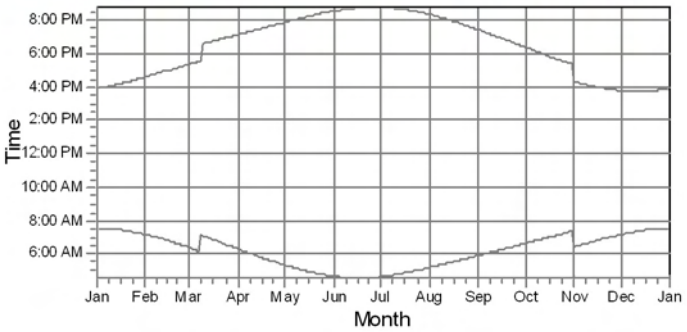
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

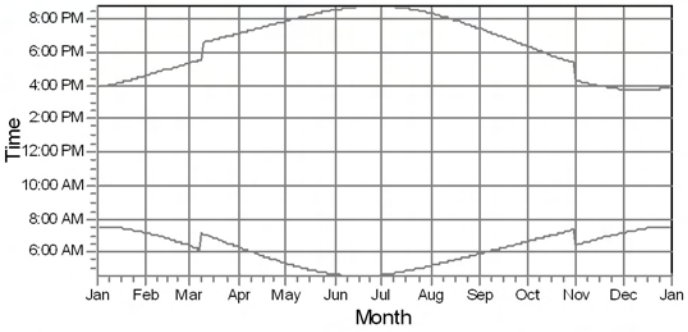
AW: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (49)



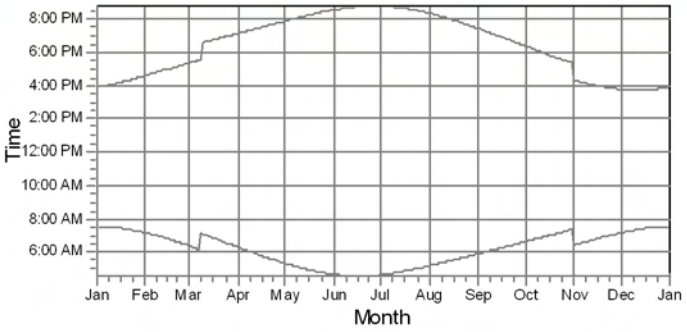

AX: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (50)



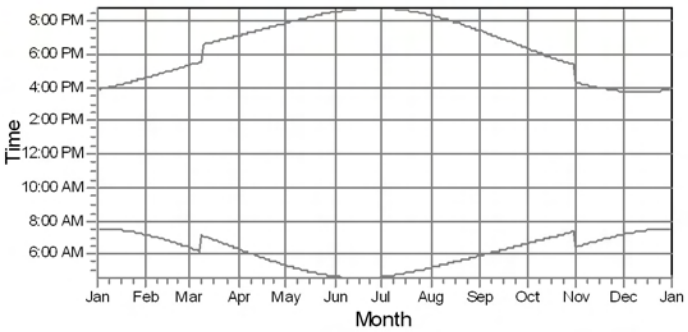

AY: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (51)



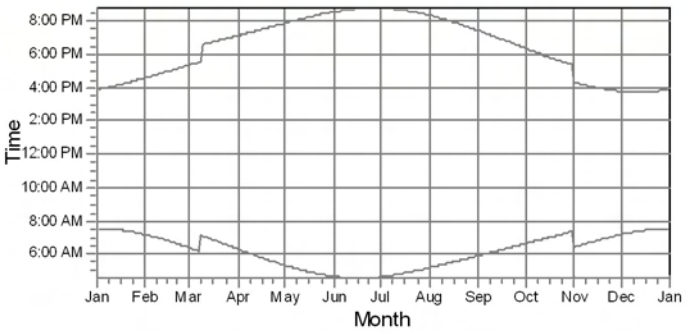

AZ: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (52)




BA: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (53)




BB: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (54)




WTGs

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

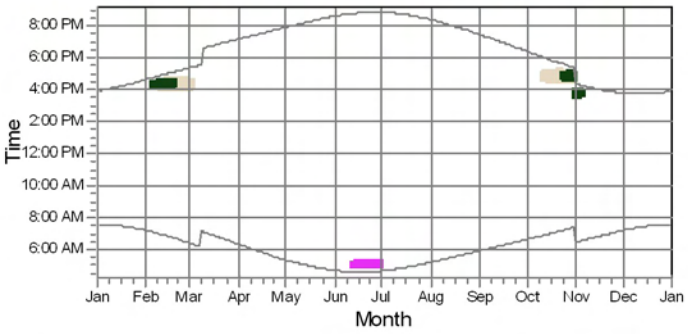
Printed/Page
3/4/2010 9:44 AM / 2
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

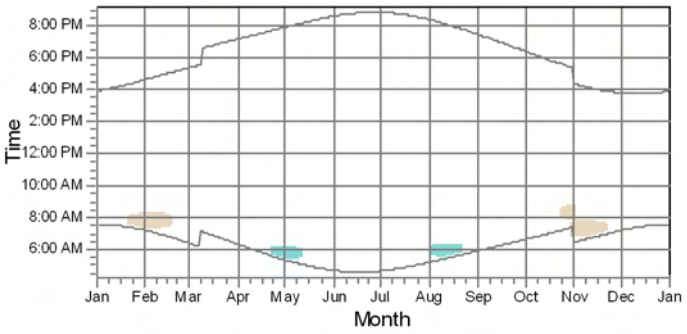
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

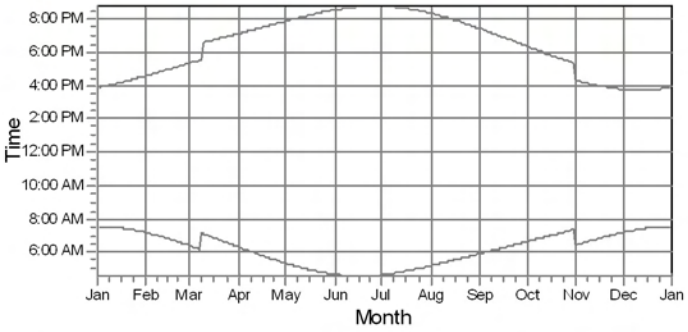
G: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (7)



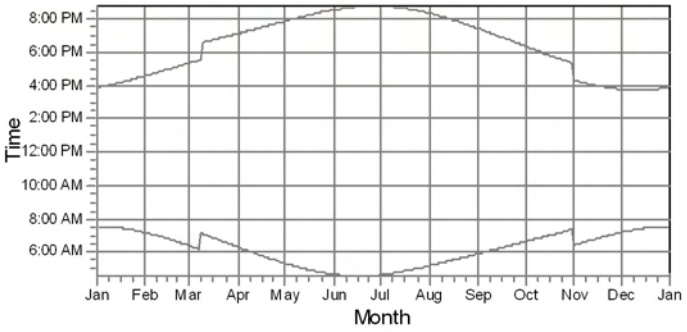

H: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (8)



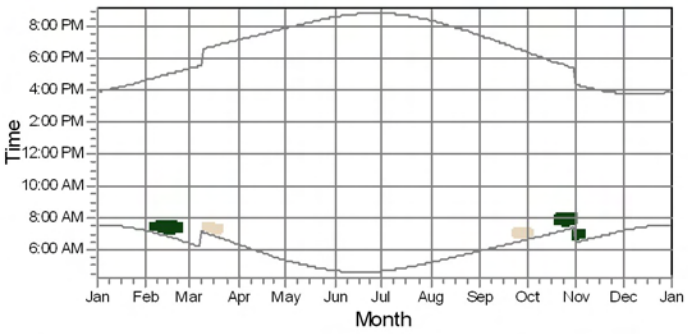

I: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (9)



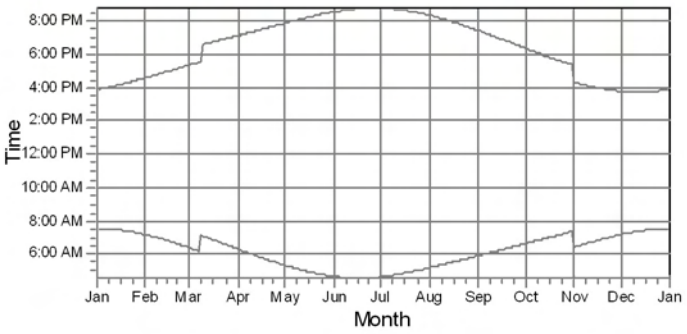

J: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (10)




K: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (11)




L: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (12)




WTGs

- 52: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1185)
- 53: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1186)
- 54: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1187)
- 55: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1188)

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

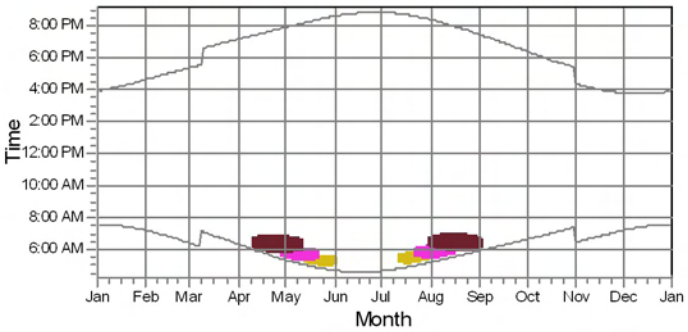
Printed/Page
3/4/2010 9:44 AM / 3
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

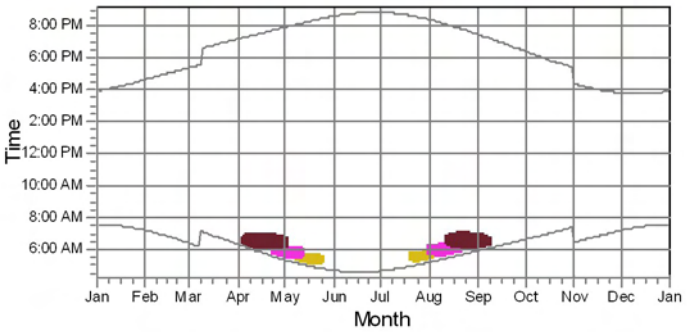
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

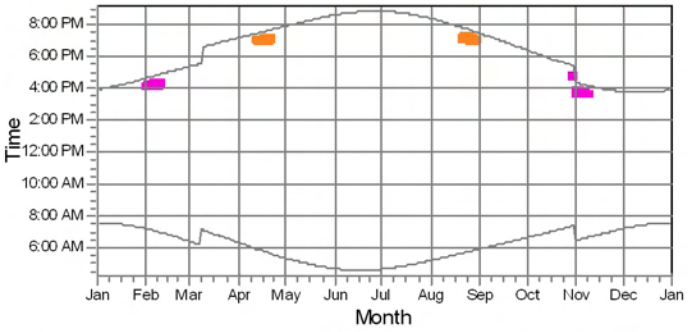
M: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (13)



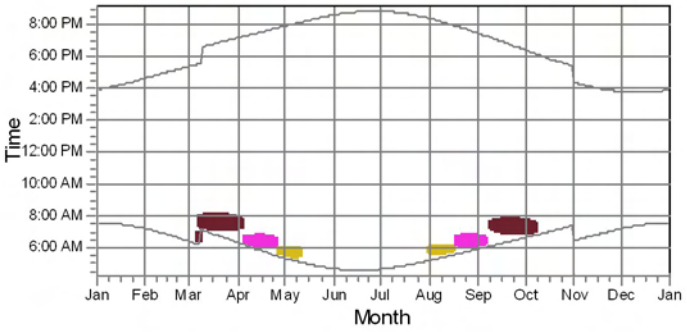

N: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (14)



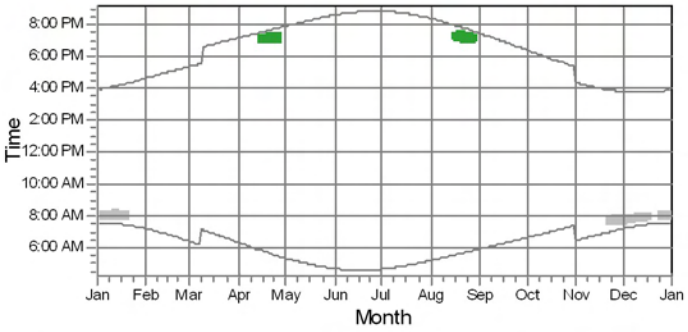

O: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (15)



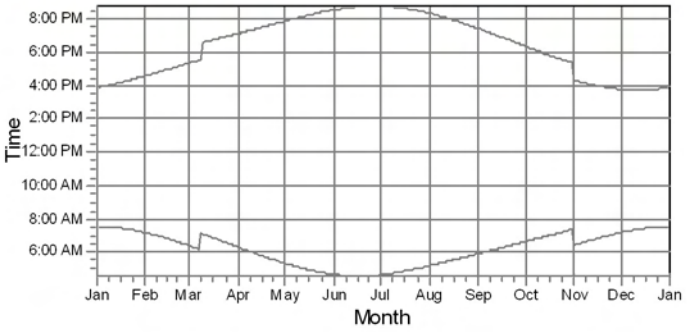

P: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (16)




Q: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (17)




R: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (18)




WTGs

- 13: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1146)
- 23: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1156)
- 26: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1159)
- 27: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1160)
- 33: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1166)
- 34: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1167)
- 35: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1168)

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

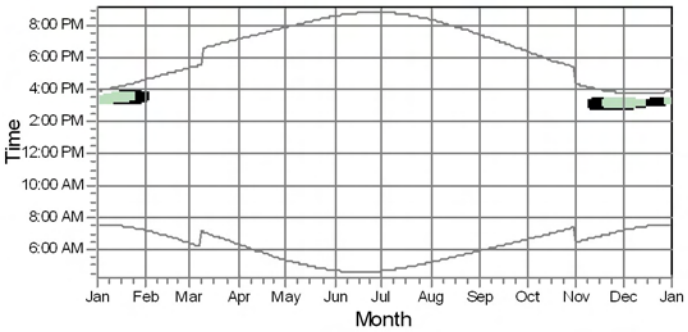
Printed/Page
3/4/2010 9:44 AM / 4
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

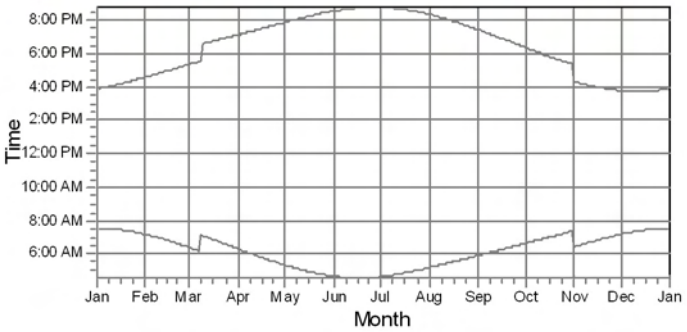
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

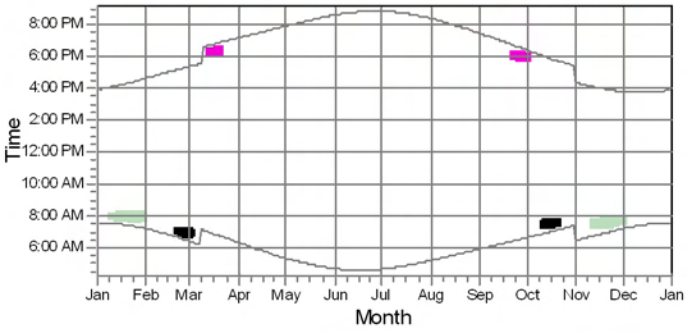
S: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (19)



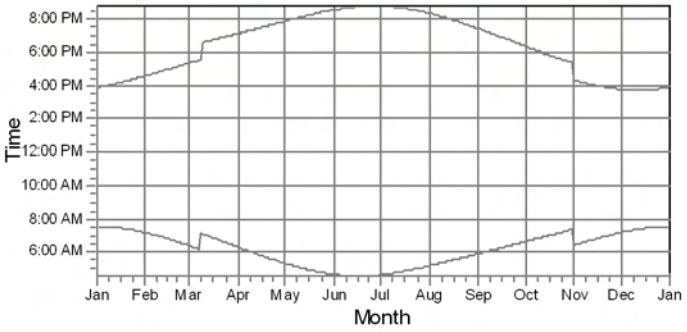

T: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (20)



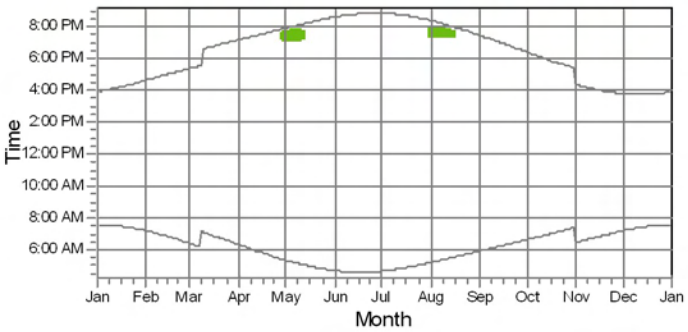

U: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (21)



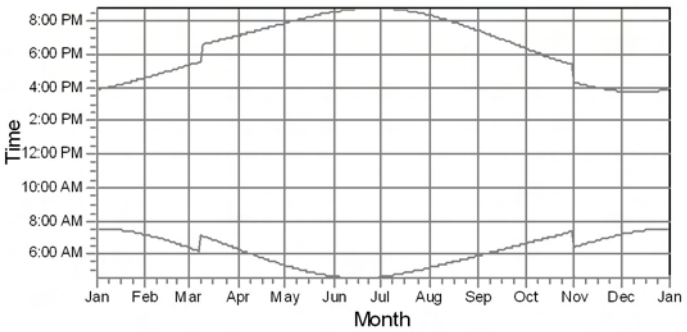

V: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (22)




W: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (23)




X: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (24)




WTGs

- 15: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1148)
- 16: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1149)
- 27: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1160)
- 58: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1191)

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

Printed/Page
3/4/2010 9:44 AM / 5

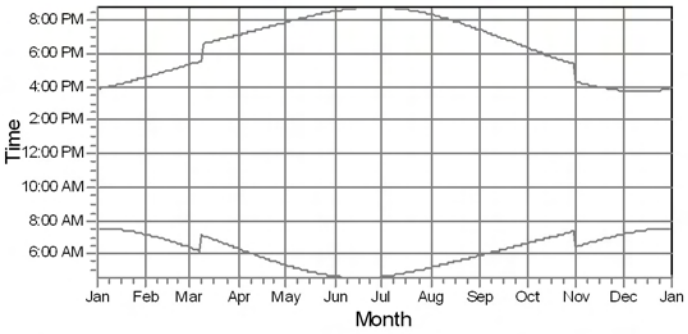
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

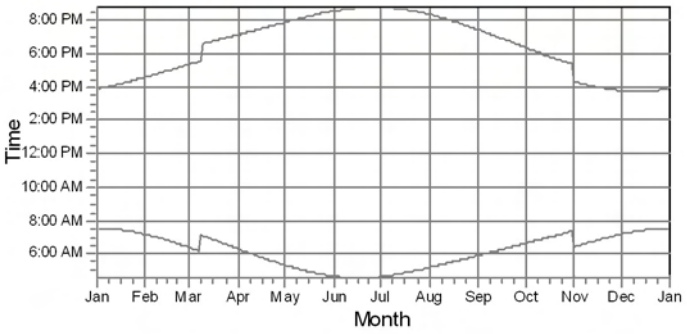
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

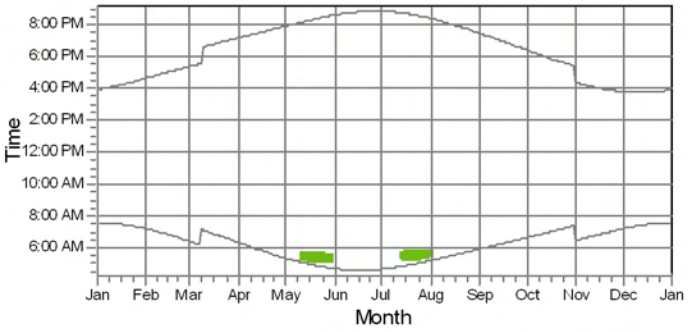
Y: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (25)



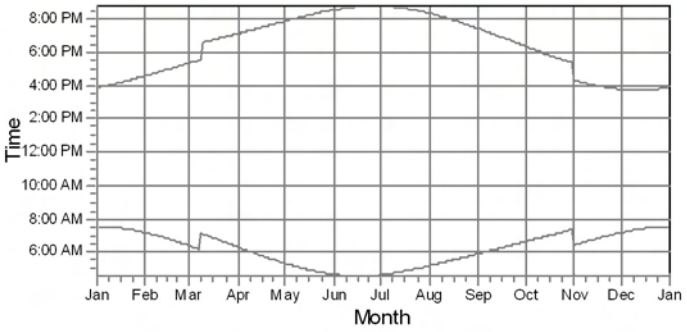

Z: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (26)



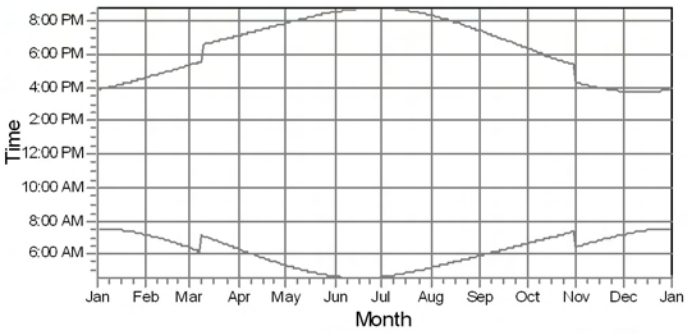

AA: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (27)



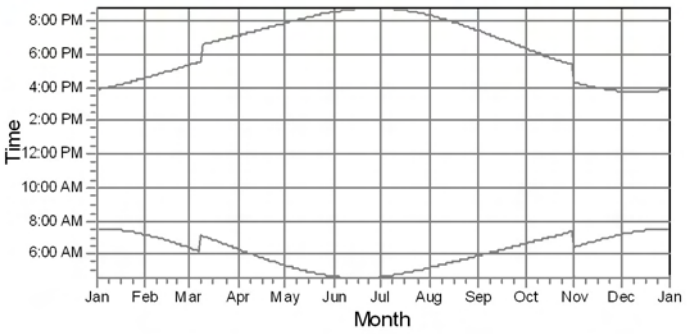

AB: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (28)




AC: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (29)




AD: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (30)




WTGs

58: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1191)

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

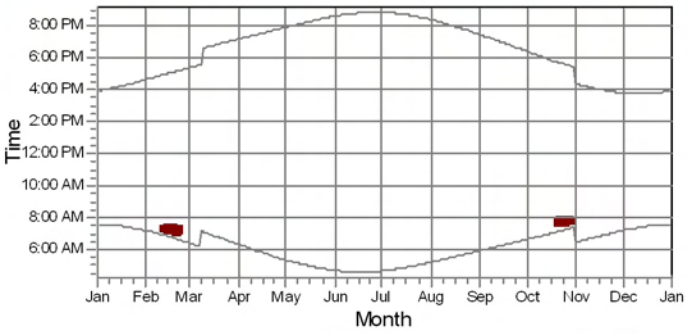
Printed/Page
3/4/2010 9:44 AM / 6
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

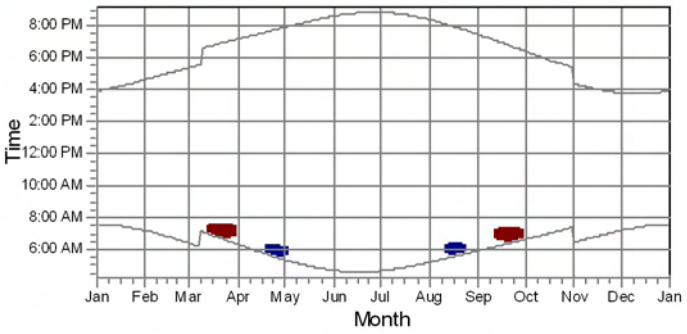
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

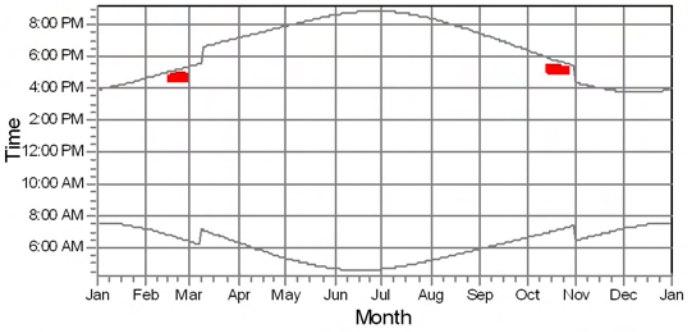
AE: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (31)



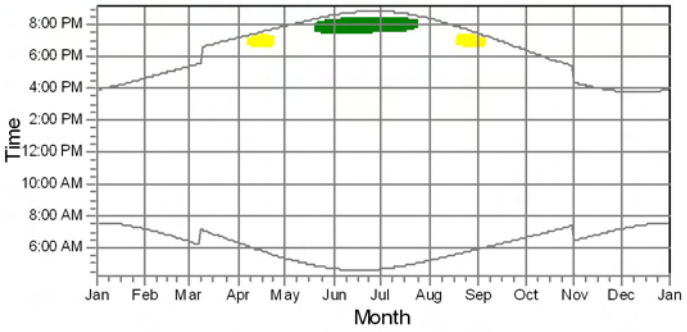

AF: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (32)



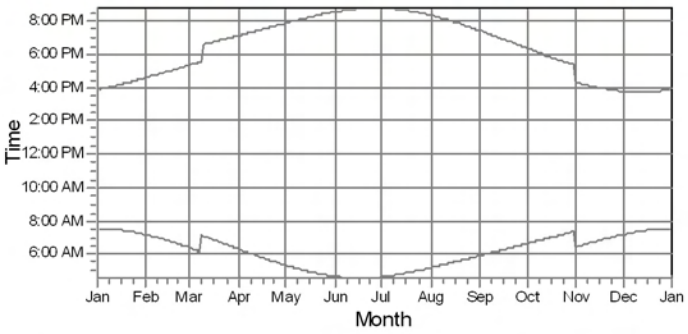

AG: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (33)



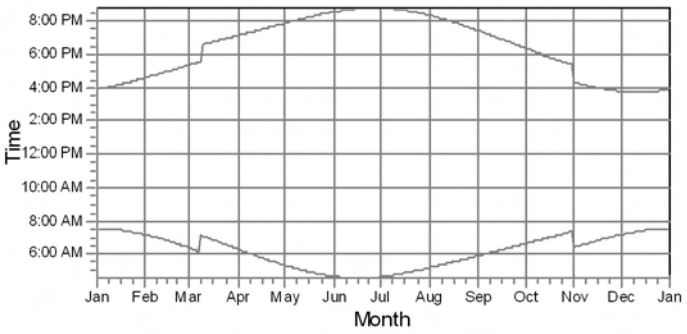

AH: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (34)




AI: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (35)




AJ: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (36)




WTGs

1: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1134)
2: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1135)
3: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1136)
8: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1141)
9: Siemens SWT-2.3-101 1.19 2300 100.6 !O! hub: 80.0 m (1142)

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

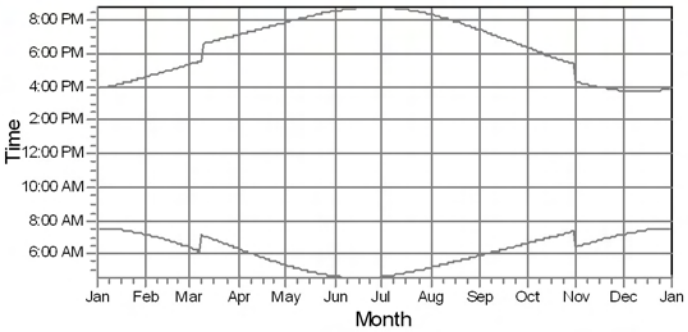
Printed/Page
3/4/2010 9:44 AM / 7
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

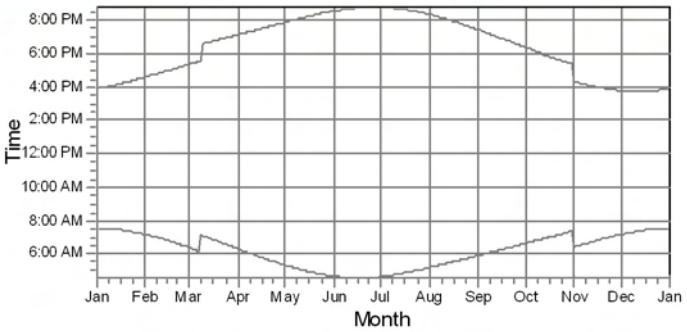
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

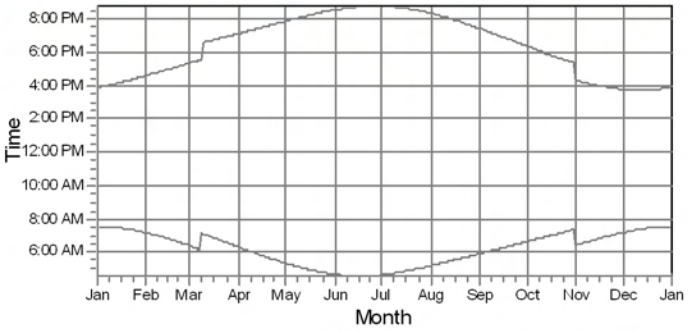
AK: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (37)



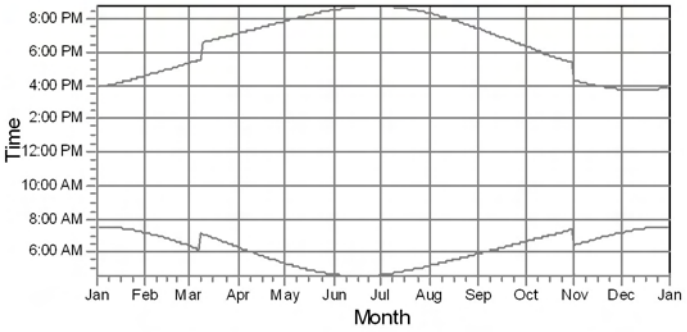

AL: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (38)



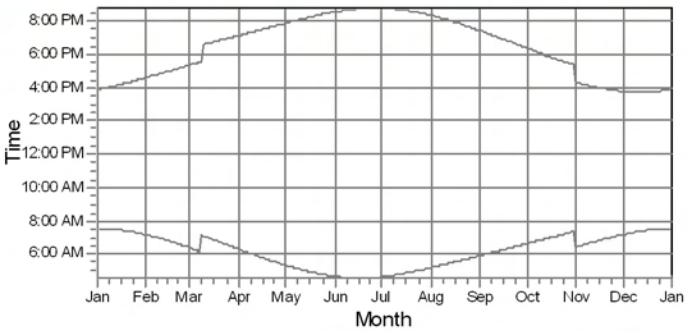

AM: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (39)



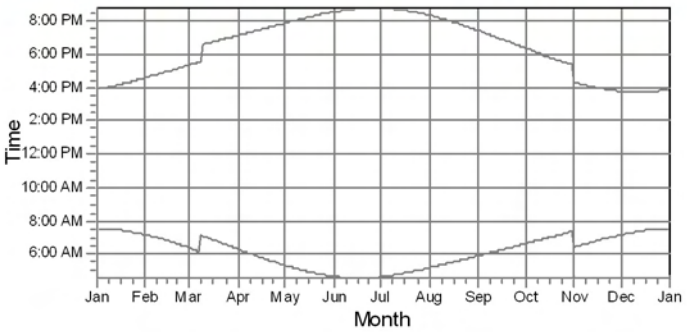

AN: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (40)




AO: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (41)




AP: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (42)




WTGs

Project:
**Border Winds Feb 09 10 Layout Options**

Description:
Shadow Flicker calculation for 54 receptors without Obstacles - Feb 09 10 150MW Layout - Using Sunshine statistics for Rolla ND and operational data from tower 1509

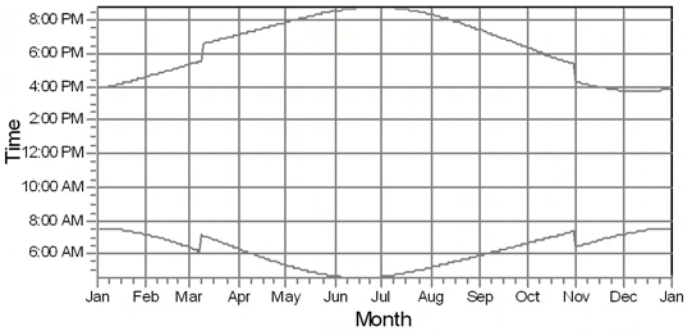
Printed/Page
3/4/2010 9:44 AM / 8
Licensed user:
**Sequoia Energy Inc.**
210 - 259 Portage Ave.
CA-WINNIPEG, MB R3B 2A9
(204)927 0290

Calculated:
3/3/2010 11:35 PM/2.6.1.252

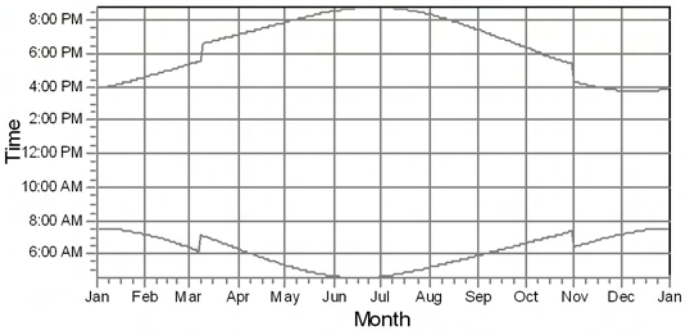
## SHADOW - Calendar, graphical

**Calculation:** Shadow Flicker - 54 receptors w/o Obstacles - Feb 09 10 150MW Layout - Using Solar and Turbine Operation D

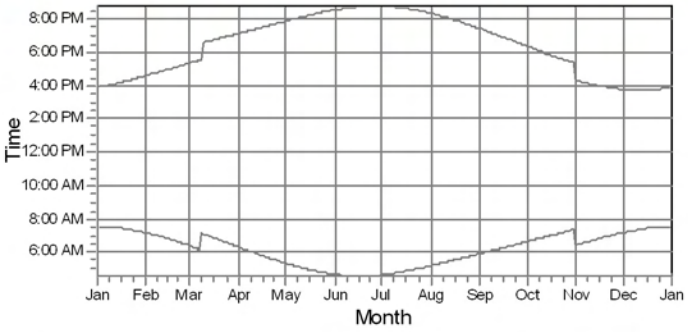
AQ: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (43)



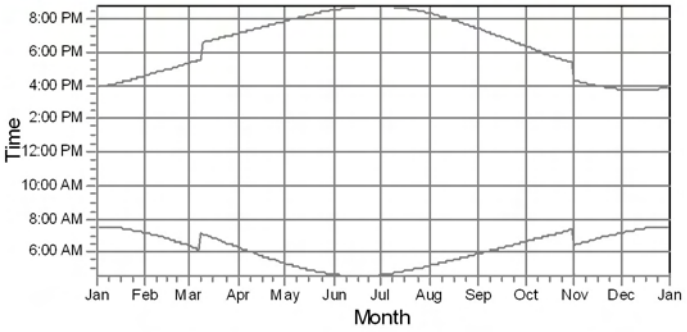

AR: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (44)



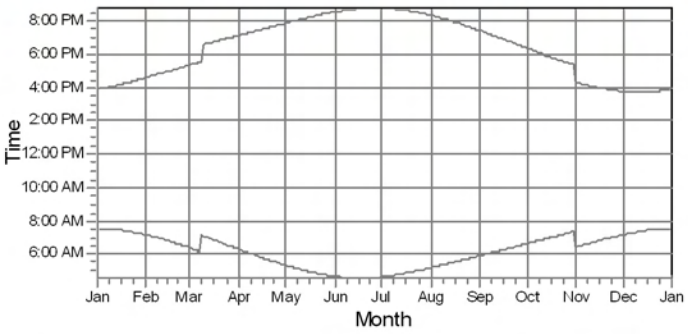

AS: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (45)



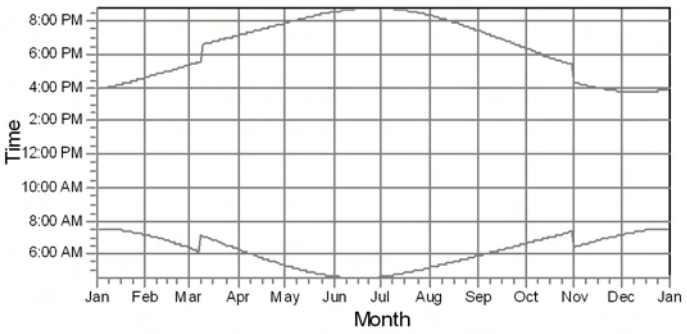

AT: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (46)




AU: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (47)




AV: Shadow Receptor: 1.0 × 1.0 Azimuth: 0.0° Slope: 90.0° (48)




WTGs