# Appendix F

# Shadow Flicker Modeling for the Nobles Repower Project

Northern States Power Company
Nobles Wind Farm Repower Project
Docket No. IP-6646/WS-09-584
February 2021

ReGenerate
RENEWABLE ENERGY CONSULTING

# Shadow Flicker Assessment

PROJECT: NOBLES REPOWER (MN)

DATE: FEBRUARY 25, 2021

**REGENERATE CONSULTING**
3413 NEST AVE.
SHELDON, IA 51201
TEL: (712) 577-1825
E-MAIL: CHRIS@REGENERATECONSULTING.COM
WEB: WWW.REGENERATECONSULTING.COM

# Contents



# Revision History

| Issue | Date | Revision Purpose |
|---|---|---|
| 1 | 16-Feb-21 | Original |
| 2 | 17-Feb-21 | Minor Report Edits |
| 3 | 23-Feb-21 | Receptor Status Changes/Minor Report Edits |
| 4 | 25-Feb-21 | Include Repower of Community Wind South |

# 1. Introduction

The existing Nobles Wind Farm is being repowered, as the Nobles Repower Wind Project (Repower Project) by Xcel Energy (Xcel) in southwestern Minnesota. Merjent (on behalf of Xcel) has retained ReGenerate Consulting (ReGenerate) to carry out an independent analysis of the shadow flicker effects caused by the proposed Repower Project.

The objective of this assessment is to predict the total amount of shadow flicker generated by the project at all receptors within or near the project area and in accordance with any applicable regulations as described in further detail later in the report. This report describes the Repower Project site, modeling methodology and results of the analysis.

Appendix I shows the spatial mapping for shadow flicker results. Appendix II shows turbine coordinates provided for Nobles. Appendix III shows the results at each receptor analyzed for this study.

ReGenerate Consulting is an independent engineering consulting agency. The principal investigator for this report, Chris Nuckols, has 20-years' engineering and management experience and 15-years' of wind and solar resource assessment experience working for renewable energy developers, owners, and OEMs, He has provided engineering support to more than 100 renewable energy projects large and small, on five continents.

# 2. Background

The cumulative effects of turbine generated shadow flicker throughout the Repower Project area were studied to determine the impact on sensitive receptors. This effect occurs when wind turbine blades cast a moving shadow across the ground and nearby structures; this is perceived as a flickering effect due to the constant rotation of the blades. Flicker occurs when the following conditions are met: turbine is operating, sun is shining with insignificant cloud cover, turbine blades are positioned directly between the sun and receptor, and the receptor is close enough to distinguish the shadow created.

Calculation of potential shadow impact is carried out by simulating the position of the sun relative to the turbine rotor swept area with the resulting shadow calculated in steps of 1 minute throughout a complete year. If the shadow at any time casts a shadow reflection on the window defined for the receptor, this step will be registered as 1 minute of potential shadow impact. Information required in this calculation includes position of wind turbines, turbine hub height and rotor diameter, position of receptor, terrain elevation, window information (height, size, azimuth, and tilt), time zone and daylight-saving time information and simulation model which holds information about the earth's orbit and rotation relative to the sun. A diagram of this simulation is presented in Figure 1 below.

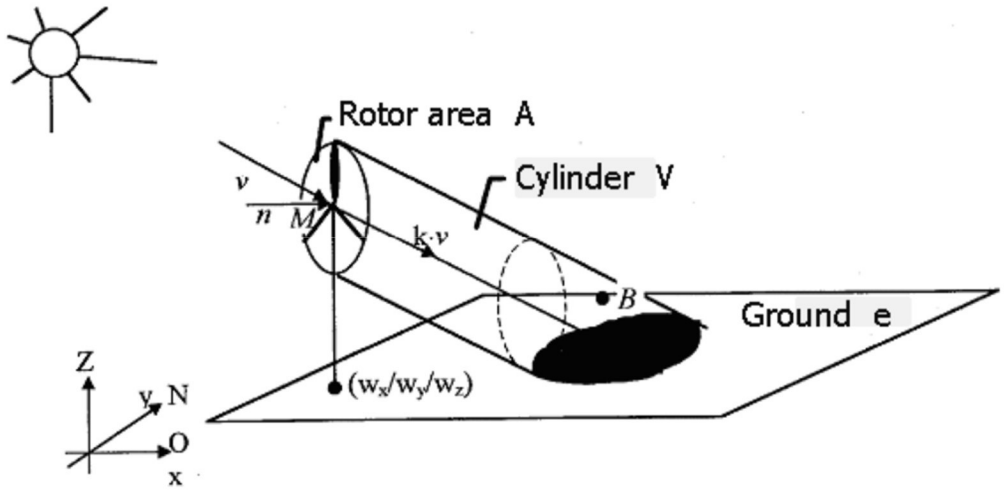


**Figure 1: Diagram of Shadow Flicker Model Simulation [1]**

Available scientific evidence suggests that shadow flicker impact from wind turbines is unlikely to affect human health. [2] It can however be considered an annoyance for homeowners near wind turbines.

## 3. Project Regulations

There are no applicable state or local regulations establishing a shadow flicker limit. [3] The Nobles Wind Farm has been operational since 2010. In its over 10-year operational history, Xcel Energy has not received any complaints about shadow flicker from the existing wind farm.

## 4. Project Details

The Repower Project is located near Reading, Minnesota in agricultural land consisting mostly of rolling hills. There are scattered dwellings, farm buildings and trees throughout the project area.

The Client provided ReGenerate with the coordinates of turbines and receptors for the Repower Project. The layout is a repowering of the currently operational Nobles project and features 111 GE 1.6-97 turbines at 80 m hub-height, 22 GE 1.6-91 turbines at 80 m hub height and 1 V136-3.6MW turbine at 82 m hub-height. Turbine coordinates provided for the Repower Project are shown in Appendix II. Coordinates for individual receptors can be found in Appendix III.

Neighboring projects that are currently operational were reviewed as part of this analysis based upon the U.S. Wind Turbine Database by USGS. [4] The effects projects within approximately 1 mile of the Repower Project were included in the calculation as well. Impact of potential repower of the Community Wind

South project was taken into account, assuming that the current MM92-2.05MW h100 turbines are replaced with V110-2.1 h100. The table below shows these projects and their turbine configuration.

| Community Wind South | Don Sneve Wind Farms | Arnold Wind Farm | Wilmont Hills |
|---|---|---|---|
| 15x V110-2.1MW h100 | 1x NM54-0.95MW h70 | 1x V82-1.65MW h70 | 1x NM72-1.5MW h70 |

**Table 1: Neighboring Wind Farms Considered in Study**

## 5. Modeling Procedures

ReGenerate used the WindPRO software [1] to model shadow flicker for this project. Modeling assumptions for the shadow flicker analysis include:

- Turbine is operating 100% of the time.
- Flicker is modeled out to ten times the rotor diameter from each respective turbine.
- Neighboring projects within ten times the rotor diameter of a receptor were included in modeling.
- Flicker is ignored if sun is less than 3° above horizon.
- Default observer eye level is 1.5 m.
- Receptors are perpendicular to all turbines, also known as greenhouse mode.
- Monthly sunshine probability has been modeled from nearest meteorological station.
- Data source for monthly sunshine hours was from Minneapolis, MN location with data from 1981 – 2010 annual climate normal.
- Turbine orientation is considered.
- Obstacles (like trees or buildings) are not considered.

Based on the assumptions above, this model is likely to produce estimates higher than those which will be experienced.

ReGenerate studied nearby meteorological reference stations available from usclimatedata.com (USCD) historical norms and from the Global Historical Climatology Network (GHCN) for this analysis; see the table below. [5,6]

| Station | State | Data Source | Average Sunshine [hr/day] | Distance from Project [km] |
|---|---|---|---|---|
| MINNEAPOLIS-ST. PAUL | MN | USCD | 7.1 | 249 |
| SIOUX FALLS | SD | GHCN | 7.0 | 77 |
| DES MOINES | IA | USCD | 7.3 | 291 |

**Table 2: Meteorological Reference Stations**

The Sioux Falls station was closest to the project area, but exhibited numerous days of erroneous data and was therefore excluded from the analysis. Based on the similar proximity and mid-range of the two data sources in terms of solar resource, the average of the Minneapolis-St. Paul and Des Moines

meteorological stations was chosen as most representative. Monthly average sunshine hours per month used in modeling are shown in the table below.

| Average Sunshine [hr/month] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 149 | 165 | 202 | 227 | 274 | 307 | 340 | 297 | 239 | 202 | 127 | 121 |

**Table 3: Average Sunshine Hours per Month**

The wind direction frequency was considered to account for turbine orientation of the rotor area relative to the sun. This data was taken from local meteorological data adjusted to project hub height. The wind frequency rose is shown in the figure below.

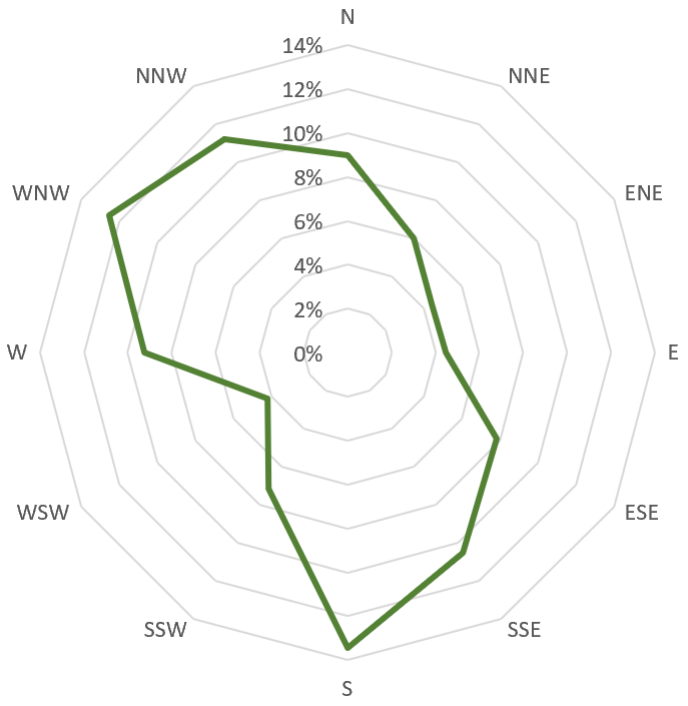


**Figure 2: Wind Frequency Rose for Project**

This model is still likely to produce estimates higher than those which will be experienced. Factors that will lower the impact, but not modeled include:

- Availability of the turbines.
- Turbines not operating below cut-in and above cut-out wind speeds.
- The impact of obstacles (like trees or buildings).
- Dust or aerosols in the air which reduce the impact of shadow flicker.

## 6. Modeling Results

The effect on receptors has been quantified using the methodology described above and the maximum value of shadow flicker at any receptor location was found to be 75.3 hr/yr. A summary of the results can be seen below in the table below; detailed results can be found in Appendix III.

| Shadow Flicker [hr/yr] | Participating | | Non-Participating | | Total | |
|---|---|---|---|---|---|---|
| | № Receptors | % of Receptors | № Receptors | % of Receptors | № Receptors | % of Receptors |
| 0 | 3 | 5.77% | 133 | 78.24% | 136 | 61.26% |
| 0.1 to 20 | 21 | 40.38% | 25 | 14.71% | 46 | 20.72% |
| 20.1 to 30 | 16 | 30.77% | 8 | 4.71% | 24 | 10.81% |
| 30.1 to 40 | 4 | 7.69% | 2 | 1.18% | 6 | 2.70% |
| 40.1 to 50 | 4 | 7.69% | 1 | 0.59% | 5 | 2.25% |
| 50.1 to 60 | 3 | 5.77% | 0 | 0.00% | 3 | 1.35% |
| 60.1 or more | 1 | 1.92% | 1 | 0.59% | 2 | 0.90% |

**Table 4: Shadow Flicker Results Summary**

## 7. Conclusions

Shadow flicker has been studied for receptors in the vicinity of the Repower Project. The maximum value of shadow flicker was found to be 75.3 hr/yr for non-participating receptors while the maximum value for participating receptors was found to be 60.3 hr/yr.

## 8. References


[1] EMD International A/S. (Apr 2019). WindPRO 3.3 User Manual – 6 Environment. Retrieved from http://help.emd.dk/WindPRO/content/windPRO3.3/c6-UK_WindPRO3.3-Environment.pdf.

[2] Knopper, Loren D et al. "Wind turbines and human health." Frontiers in public health vol. 2 63. 19 Jun. 2014, doi:10.3389/fpubh.2014.00063.

[3] Email from Brie Anderson to Chris Nuckols and Ryan McDevitt. 16-Feb-2021.

[4] United States Geological Survey. "The U.S. Wind Turbine Database." Retrieved from https://eerscmap.usgs.gov/uswtdb/.

[5] U.S. climate data. (January 2021). Climate data for Minneapolis, MN - 1981-2010 normals – weather. Retrieved from https://www.usclimatedata.com/climate/minneapolis/minnesota/united-states/usmn0503

[6] National Oceanic and Atmospheric Administration. (March 2019). Global Historical Climatology Network (GHCN). Retrieved from https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-climatology-network-ghcn.

## Appendix I – Maps

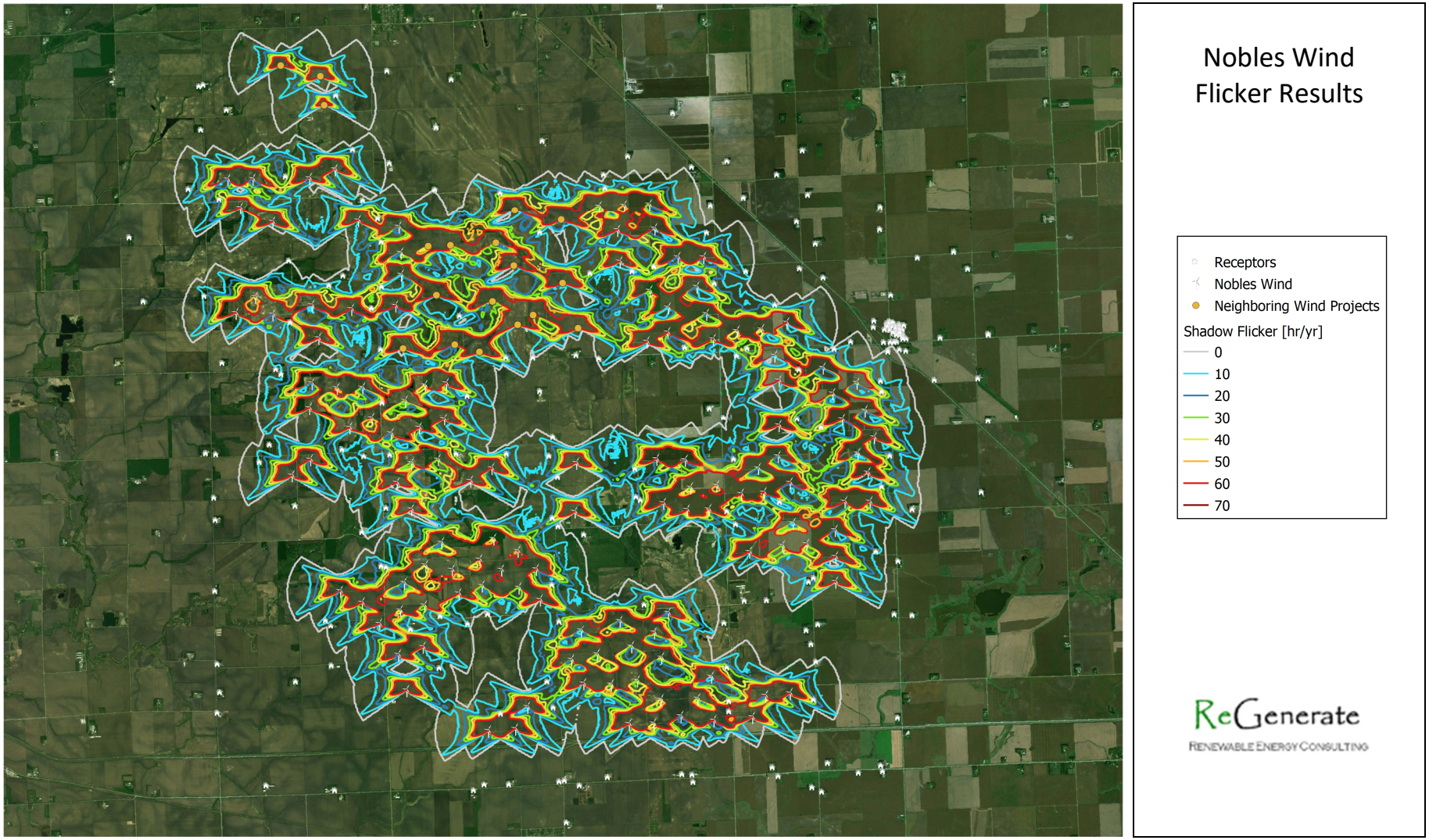


**Figure 3: Shadow Flicker Map of Nobles Wind Project**

# Appendix II – Project Turbine Coordinates (UTM WGS84 Zone 15)

| Turbine ID | X [m] | Y [m] | Turbine Type |
|---|---|---|---|
| T-1 | 269096 | 4846508 | GE 1.6-97 h80 |
| T-2 | 269575 | 4846480 | GE 1.6-97 h80 |
| T-3 | 269297 | 4845948 | GE 1.6-97 h80 |
| T-4 | 269893 | 4845630 | GE 1.6-97 h80 |
| T-5 | 270645 | 4846424 | GE 1.6-97 h80 |
| T-6 | 271139 | 4846552 | GE 1.6-97 h80 |
| T-7 | 271511 | 4845545 | GE 1.6-97 h80 |
| T-8 | 272264 | 4845367 | GE 1.6-97 h80 |
| T-9 | 272260 | 4844875 | GE 1.6-97 h80 |
| T-10 | 272242 | 4844457 | GE 1.6-97 h80 |
| T-11 | 269069 | 4843971 | GE 1.6-97 h80 |
| T-12 | 269454 | 4844237 | GE 1.6-97 h80 |
| T-13 | 269767 | 4843891 | GE 1.6-97 h80 |
| T-14 | 270513 | 4844008 | GE 1.6-97 h80 |
| T-15 | 270593 | 4843375 | GE 1.6-97 h80 |
| T-16 | 271255 | 4843883 | GE 1.6-97 h80 |
| T-17 | 272097 | 4843887 | GE 1.6-97 h80 |
| T-18 | 270329 | 4842075 | GE 1.6-97 h80 |
| T-19 | 270407 | 4842544 | GE 1.6-97 h80 |
| T-20 | 270871 | 4842417 | GE 1.6-97 h80 |
| T-21 | 271356 | 4842386 | GE 1.6-91 h80 |
| T-22 | 271054 | 4841641 | GE 1.6-97 h80 |
| T-23 | 271490 | 4841801 | GE 1.6-91 h80 |
| T-24 | 272146 | 4842080 | GE 1.6-91 h80 |
| T-25 | 272542 | 4842353 | GE 1.6-97 h80 |
| T-26 | 272945 | 4842353 | GE 1.6-97 h80 |
| T-27 | 271832 | 4841472 | GE 1.6-91 h80 |
| T-28 | 272371 | 4841545 | GE 1.6-97 h80 |
| T-29 | 272862 | 4841685 | GE 1.6-97 h80 |
| T-30 | 269906 | 4840813 | GE 1.6-97 h80 |
| T-31 | 270271 | 4841090 | GE 1.6-97 h80 |
| T-32 | 272176 | 4840889 | GE 1.6-91 h80 |
| T-33 | 272687 | 4840913 | GE 1.6-97 h80 |
| T-34 | 271876 | 4840539 | GE 1.6-97 h80 |
| T-35 | 272115 | 4840011 | GE 1.6-97 h80 |
| T-36 | 273263 | 4840470 | GE 1.6-97 h80 |
| T-37 | 273681 | 4840676 | GE 1.6-97 h80 |
| T-38 | 270661 | 4838567 | GE 1.6-97 h80 |
| T-39 | 271056 | 4838324 | GE 1.6-97 h80 |
| T-40 | 271874 | 4838637 | GE 1.6-97 h80 |
| T-41 | 272298 | 4838933 | GE 1.6-97 h80 |
| T-42 | 272633 | 4839341 | GE 1.6-97 h80 |
| T-43 | 272798 | 4838814 | GE 1.6-97 h80 |

| Turbine ID | X [m] | Y [m] | Turbine Type |
|---|---|---|---|
| T-44 | 271766 | 4838126 | GE 1.6-91 h80 |
| T-45 | 272230 | 4838183 | GE 1.6-91 h80 |
| T-46 | 272895 | 4838357 | GE 1.6-97 h80 |
| T-47 | 273333 | 4838975 | V136-4.0 h82 |
| T-48 | 273621 | 4839347 | GE 1.6-97 h80 |
| T-49 | 273727 | 4838746 | GE 1.6-97 h80 |
| T-50 | 274060 | 4839087 | GE 1.6-97 h80 |
| T-51 | 274389 | 4838711 | GE 1.6-91 h80 |
| T-52 | 273345 | 4838475 | GE 1.6-97 h80 |
| T-53 | 274035 | 4838392 | GE 1.6-97 h80 |
| T-54 | 274418 | 4838127 | GE 1.6-91 h80 |
| T-55 | 271353 | 4837892 | GE 1.6-91 h80 |
| T-56 | 271669 | 4837280 | GE 1.6-97 h80 |
| T-57 | 272146 | 4837387 | GE 1.6-91 h80 |
| T-58 | 273263 | 4835726 | GE 1.6-97 h80 |
| T-59 | 273779 | 4835729 | GE 1.6-97 h80 |
| T-60 | 274031 | 4836122 | GE 1.6-97 h80 |
| T-61 | 275152 | 4837487 | GE 1.6-97 h80 |
| T-62 | 275893 | 4837622 | GE 1.6-97 h80 |
| T-63 | 274926 | 4836946 | GE 1.6-97 h80 |
| T-64 | 275418 | 4837009 | GE 1.6-97 h80 |
| T-65 | 276074 | 4837117 | GE 1.6-97 h80 |
| T-66 | 275125 | 4836487 | GE 1.6-97 h80 |
| T-67 | 275639 | 4836433 | GE 1.6-97 h80 |
| T-68 | 276136 | 4836469 | GE 1.6-97 h80 |
| T-69 | 276814 | 4837713 | GE 1.6-97 h80 |
| T-70 | 276521 | 4837343 | GE 1.6-97 h80 |
| T-71 | 276623 | 4836866 | GE 1.6-97 h80 |
| T-72 | 277543 | 4836438 | GE 1.6-97 h80 |
| T-73 | 276562 | 4836080 | GE 1.6-97 h80 |
| T-74 | 277257 | 4836044 | GE 1.6-97 h80 |
| T-75 | 275922 | 4835665 | GE 1.6-97 h80 |
| T-76 | 276395 | 4835645 | GE 1.6-97 h80 |
| T-77 | 276910 | 4835739 | GE 1.6-97 h80 |
| T-78 | 277524 | 4835616 | GE 1.6-91 h80 |
| T-79 | 278264 | 4835627 | GE 1.6-97 h80 |
| T-80 | 278533 | 4836007 | GE 1.6-97 h80 |
| T-81 | 279007 | 4836022 | GE 1.6-97 h80 |
| T-82 | 276074 | 4845488 | GE 1.6-97 h80 |
| T-83 | 276540 | 4845469 | GE 1.6-97 h80 |
| T-84 | 276387 | 4845006 | GE 1.6-97 h80 |
| T-85 | 276385 | 4844406 | GE 1.6-91 h80 |
| T-86 | 277019 | 4845456 | GE 1.6-97 h80 |
| T-87 | 277090 | 4844983 | GE 1.6-97 h80 |
| T-88 | 277483 | 4844413 | GE 1.6-97 h80 |
| T-89 | 277967 | 4844376 | GE 1.6-97 h80 |
| T-90 | 276908 | 4843818 | GE 1.6-97 h80 |

| Turbine ID | X [m] | Y [m] | Turbine Type |
|---|---|---|---|
| T-91 | 277236 | 4843473 | GE 1.6-97 h80 |
| T-92 | 277798 | 4843830 | GE 1.6-97 h80 |
| T-93 | 276786 | 4842866 | GE 1.6-97 h80 |
| T-94 | 277192 | 4843007 | GE 1.6-97 h80 |
| T-95 | 277948 | 4843304 | GE 1.6-97 h80 |
| T-96 | 278036 | 4842819 | GE 1.6-97 h80 |
| T-97 | 278496 | 4842948 | GE 1.6-91 h80 |
| T-98 | 278964 | 4842939 | GE 1.6-91 h80 |
| T-99 | 279445 | 4843027 | GE 1.6-97 h80 |
| T-100 | 279179 | 4842424 | GE 1.6-97 h80 |
| T-101 | 279227 | 4841952 | GE 1.6-97 h80 |
| T-102 | 280070 | 4842136 | GE 1.6-91 h80 |
| T-103 | 280217 | 4841634 | GE 1.6-97 h80 |
| T-104 | 280692 | 4841803 | GE 1.6-97 h80 |
| T-105 | 279161 | 4841102 | GE 1.6-97 h80 |
| T-106 | 280366 | 4841135 | GE 1.6-97 h80 |
| T-107 | 280809 | 4841271 | GE 1.6-97 h80 |
| T-108 | 275291 | 4840666 | GE 1.6-97 h80 |
| T-109 | 271775 | 4836601 | GE 1.6-97 h80 |
| T-110 | 275196 | 4839742 | GE 1.6-97 h80 |
| T-111 | 276810 | 4840628 | GE 1.6-97 h80 |
| T-112 | 277346 | 4840574 | GE 1.6-97 h80 |
| T-113 | 276871 | 4839792 | GE 1.6-97 h80 |
| T-114 | 277408 | 4840039 | GE 1.6-97 h80 |
| T-115 | 277904 | 4840040 | GE 1.6-97 h80 |
| T-116 | 277317 | 4839627 | GE 1.6-97 h80 |
| T-117 | 277725 | 4839611 | GE 1.6-91 h80 |
| T-118 | 278713 | 4840314 | GE 1.6-91 h80 |
| T-119 | 279104 | 4840512 | GE 1.6-97 h80 |
| T-120 | 278355 | 4839855 | GE 1.6-91 h80 |
| T-121 | 278787 | 4839848 | GE 1.6-91 h80 |
| T-122 | 279292 | 4839996 | GE 1.6-91 h80 |
| T-123 | 280609 | 4840458 | GE 1.6-97 h80 |
| T-124 | 280945 | 4840742 | GE 1.6-97 h80 |
| T-125 | 280778 | 4840079 | GE 1.6-97 h80 |
| T-126 | 280298 | 4839570 | GE 1.6-97 h80 |
| T-127 | 280776 | 4839533 | GE 1.6-97 h80 |
| T-128 | 278428 | 4838749 | GE 1.6-97 h80 |
| T-129 | 279290 | 4839231 | GE 1.6-91 h80 |
| T-130 | 279058 | 4838821 | GE 1.6-97 h80 |
| T-131 | 279523 | 4838814 | GE 1.6-97 h80 |
| T-132 | 280077 | 4839040 | GE 1.6-97 h80 |
| T-133 | 280049 | 4838539 | GE 1.6-97 h80 |
| T-134 | 280014 | 4838069 | GE 1.6-97 h80 |

## Appendix III – Individual Receptor Results (UTM WGS84 Zone 15)

| Receptor ID | X [m] | Y [m] | Status | Shadow Flicker [hr/yr] |
|---|---|---|---|---|
| R-1 | 272292 | 4848350 | Non-Participating | 0 |
| R-2 | 268810 | 4848330 | Non-Participating | 0 |
| R-3 | 268726 | 4848315 | Non-Participating | 0 |
| R-4 | 273501 | 4848094 | Non-Participating | 0 |
| R-5 | 271297 | 4847948 | Non-Participating | 10.7 |
| R-6 | 269212 | 4847823 | Non-Participating | 0 |
| R-7 | 268703 | 4847486 | Non-Participating | 0 |
| R-8 | 277630 | 4847161 | Non-Participating | 0 |
| R-9 | 273149 | 4847213 | Non-Participating | 0 |
| R-10 | 275126 | 4846811 | Non-Participating | 0 |
| R-11 | 271541 | 4846905 | Participating | 12.9 |
| R-12 | 272220 | 4846599 | Non-Participating | 0 |
| R-13 | 276718 | 4846398 | Non-Participating | 0 |
| R-14 | 280021 | 4846273 | Non-Participating | 0 |
| R-15 | 270239 | 4846487 | Non-Participating | 29.3 |
| R-16 | 278586 | 4846171 | Non-Participating | 0 |
| R-17 | 277912 | 4846109 | Non-Participating | 0 |
| R-18 | 268389 | 4846386 | Non-Participating | 6.9 |
| R-19 | 276240 | 4846083 | Non-Participating | 0 |
| R-20 | 279508 | 4845850 | Non-Participating | 0 |
| R-21 | 273039 | 4846035 | Non-Participating | 0 |
| R-22 | 268953 | 4846144 | Participating | 27.9 |
| R-23 | 276253 | 4845827 | Participating | 19.9 |
| R-24 | 274265 | 4845878 | Non-Participating | 27.6 |
| R-25 | 271658 | 4845930 | Participating | 7.6 |
| R-26 | 280063 | 4845422 | Non-Participating | 0 |
| R-27 | 278848 | 4845457 | Non-Participating | 0 |
| R-28 | 278219 | 4845355 | Non-Participating | 0 |
| R-29 | 271917 | 4845561 | Participating | 42.3 |
| R-30 | 281418 | 4845100 | Non-Participating | 0 |
| R-31 | 267203 | 4845542 | Non-Participating | 0 |
| R-32 | 279820 | 4844927 | Non-Participating | 0 |
| R-33 | 274955 | 4845076 | Non-Participating | 12.1 |
| R-34 | 271950 | 4845118 | Participating | 38 |
| R-35 | 278102 | 4844847 | Non-Participating | 8.7 |
| R-36 | 281370 | 4844669 | Non-Participating | 0 |
| R-37 | 270182 | 4844883 | Participating | 0 |
| R-38 | 280140 | 4844486 | Non-Participating | 0 |
| R-39 | 282742 | 4844143 | Non-Participating | 0 |
| R-40 | 271183 | 4844527 | Non-Participating | 6.9 |
| R-41 | 277066 | 4844273 | Participating | 47 |
| R-42 | 282051 | 4844078 | Non-Participating | 0 |
| R-43 | 276650 | 4844213 | Participating | 8.1 |
| R-44 | 275854 | 4844232 | Non-Participating | 31.5 |
| R-45 | 270906 | 4844368 | Participating | 14.5 |
| R-46 | 279808 | 4844044 | Non-Participating | 0 |

| Receptor ID | X [m] | Y [m] | Status | Shadow Flicker [hr/yr] |
|---|---|---|---|---|
| R-47 | 278790 | 4844060 | Non-Participating | 6.6 |
| R-48 | 271897 | 4844265 | Participating | 11.3 |
| R-49 | 268540 | 4844334 | Non-Participating | 14.3 |
| R-50 | 282977 | 4843802 | Non-Participating | 0 |
| R-51 | 267380 | 4844319 | Non-Participating | 0 |
| R-52 | 280241 | 4843839 | Non-Participating | 0 |
| R-53 | 278178 | 4843878 | Participating | 19.7 |
| R-54 | 271682 | 4843879 | Participating | 38.5 |
| R-55 | 281491 | 4843411 | Non-Participating | 0 |
| R-56 | 270131 | 4843721 | Participating | 52.3 |
| R-57 | 273326 | 4843611 | Non-Participating | 18.7 |
| R-58 | 279288 | 4843390 | Participating | 3.3 |
| R-59 | 281141 | 4842956 | Non-Participating | 0 |
| R-60 | 281429 | 4842924 | Non-Participating | 0 |
| R-61 | 281428 | 4842908 | Non-Participating | 0 |
| R-62 | 281493 | 4842897 | Non-Participating | 0 |
| R-63 | 281379 | 4842891 | Non-Participating | 0 |
| R-64 | 281422 | 4842881 | Non-Participating | 0 |
| R-65 | 281498 | 4842874 | Non-Participating | 0 |
| R-66 | 281610 | 4842857 | Non-Participating | 0 |
| R-67 | 281432 | 4842862 | Non-Participating | 0 |
| R-68 | 281374 | 4842863 | Non-Participating | 0 |
| R-69 | 281701 | 4842828 | Non-Participating | 0 |
| R-70 | 281544 | 4842823 | Non-Participating | 0 |
| R-71 | 281610 | 4842820 | Non-Participating | 0 |
| R-72 | 281119 | 4842836 | Participating | 0 |
| R-73 | 281488 | 4842820 | Non-Participating | 0 |
| R-74 | 281435 | 4842822 | Non-Participating | 0 |
| R-75 | 281383 | 4842822 | Non-Participating | 0 |
| R-76 | 281614 | 4842791 | Non-Participating | 0 |
| R-77 | 281544 | 4842780 | Non-Participating | 0 |
| R-78 | 281331 | 4842776 | Non-Participating | 0 |
| R-79 | 271792 | 4843089 | Participating | 27.1 |
| R-80 | 281665 | 4842751 | Non-Participating | 0 |
| R-81 | 281432 | 4842758 | Non-Participating | 0 |
| R-82 | 281541 | 4842754 | Non-Participating | 0 |
| R-83 | 281608 | 4842752 | Non-Participating | 0 |
| R-84 | 281548 | 4842709 | Non-Participating | 0 |
| R-85 | 281488 | 4842709 | Non-Participating | 0 |
| R-86 | 281607 | 4842703 | Non-Participating | 0 |
| R-87 | 281540 | 4842682 | Non-Participating | 0 |
| R-88 | 281607 | 4842673 | Non-Participating | 0 |
| R-89 | 281658 | 4842662 | Non-Participating | 0 |
| R-90 | 281550 | 4842659 | Non-Participating | 0 |
| R-91 | 281605 | 4842641 | Non-Participating | 0 |
| R-92 | 281674 | 4842623 | Non-Participating | 0 |
| R-93 | 268785 | 4843053 | Non-Participating | 0 |
| R-94 | 281654 | 4842615 | Non-Participating | 0 |
| R-95 | 283278 | 4842553 | Non-Participating | 0 |
| R-96 | 283285 | 4842535 | Non-Participating | 0 |

| Receptor ID | X [m] | Y [m] | Status | Shadow Flicker [hr/yr] |
|---|---|---|---|---|
| R-97 | 281663 | 4842579 | Non-Participating | 0 |
| R-98 | 282368 | 4842548 | Non-Participating | 0 |
| R-99 | 277539 | 4842707 | Participating | 24.3 |
| R-100 | 281722 | 4842568 | Non-Participating | 0 |
| R-101 | 280669 | 4842594 | Non-Participating | 7.6 |
| R-102 | 281535 | 4842534 | Non-Participating | 0 |
| R-103 | 281294 | 4842541 | Non-Participating | 0 |
| R-104 | 281424 | 4842531 | Non-Participating | 0 |
| R-105 | 281490 | 4842528 | Non-Participating | 0 |
| R-106 | 274150 | 4842763 | Non-Participating | 27.9 |
| R-107 | 278716 | 4842610 | Participating | 24.8 |
| R-108 | 275478 | 4842715 | Non-Participating | 0 |
| R-109 | 274662 | 4842730 | Non-Participating | 0 |
| R-110 | 269789 | 4842864 | Non-Participating | 7.9 |
| R-111 | 280353 | 4842480 | Participating | 7.7 |
| R-112 | 275896 | 4842621 | Non-Participating | 4.4 |
| R-113 | 278501 | 4842488 | Non-Participating | 13.4 |
| R-114 | 281581 | 4842378 | Non-Participating | 0 |
| R-115 | 281364 | 4842381 | Non-Participating | 2.6 |
| R-116 | 269885 | 4842764 | Non-Participating | 10.9 |
| R-117 | 281703 | 4842347 | Non-Participating | 0 |
| R-118 | 281364 | 4842354 | Non-Participating | 4.4 |
| R-119 | 279656 | 4842137 | Participating | 53.8 |
| R-120 | 274738 | 4842088 | Non-Participating | 0 |
| R-121 | 273363 | 4842099 | Non-Participating | 25.2 |
| R-122 | 281183 | 4841811 | Participating | 13.1 |
| R-123 | 282195 | 4841760 | Non-Participating | 0 |
| R-124 | 283026 | 4841722 | Non-Participating | 0 |
| R-125 | 271749 | 4842086 | Participating | 60.3 |
| R-126 | 281190 | 4841615 | Participating | 44.6 |
| R-127 | 277917 | 4841529 | Participating | 0 |
| R-128 | 278170 | 4841335 | Non-Participating | 0 |
| R-129 | 279559 | 4841207 | Participating | 20.3 |
| R-130 | 269566 | 4841436 | Non-Participating | 5.5 |
| R-131 | 274922 | 4841199 | Non-Participating | 0 |
| R-132 | 280003 | 4841009 | Participating | 47.3 |
| R-133 | 283157 | 4840905 | Non-Participating | 0 |
| R-134 | 268352 | 4841363 | Non-Participating | 0 |
| R-135 | 270933 | 4841249 | Participating | 10 |
| R-136 | 268542 | 4841327 | Non-Participating | 0 |
| R-137 | 271822 | 4841082 | Participating | 23.3 |
| R-138 | 271329 | 4841086 | Non-Participating | 8.4 |
| R-139 | 273075 | 4841006 | Participating | 27.5 |
| R-140 | 269348 | 4841119 | Non-Participating | 12.6 |
| R-141 | 274028 | 4840940 | Participating | 24.5 |
| R-142 | 274822 | 4840844 | Participating | 13.5 |
| R-143 | 278307 | 4840528 | Participating | 23.4 |
| R-144 | 281254 | 4840378 | Participating | 20 |
| R-145 | 276429 | 4840478 | Participating | 28 |
| R-146 | 274962 | 4840426 | Non-Participating | 0 |

| Receptor ID | X [m] | Y [m] | Status | Shadow Flicker [hr/yr] |
|---|---|---|---|---|
| R-147 | 268446 | 4840511 | Non-Participating | 0 |
| R-148 | 269967 | 4840243 | Non-Participating | 0 |
| R-149 | 281059 | 4839802 | Non-Participating | 25.4 |
| R-150 | 276410 | 4839952 | Participating | 14.5 |
| R-151 | 271676 | 4840080 | Non-Participating | 16.3 |
| R-152 | 276492 | 4839875 | Non-Participating | 26.9 |
| R-153 | 268444 | 4840091 | Non-Participating | 0 |
| R-154 | 282927 | 4839571 | Non-Participating | 0 |
| R-155 | 279114 | 4839655 | Participating | 20.3 |
| R-156 | 274800 | 4839663 | Non-Participating | 39.9 |
| R-157 | 278102 | 4839549 | Participating | 39.7 |
| R-158 | 281603 | 4839336 | Non-Participating | 5.1 |
| R-159 | 271192 | 4839657 | Non-Participating | 0 |
| R-160 | 274898 | 4839499 | Participating | 3.1 |
| R-161 | 278247 | 4839294 | Non-Participating | 13 |
| R-162 | 275370 | 4839314 | Non-Participating | 0 |
| R-163 | 271508 | 4838995 | Participating | 28.3 |
| R-164 | 271599 | 4838955 | Participating | 31 |
| R-165 | 280864 | 4838594 | Non-Participating | 13.8 |
| R-166 | 281271 | 4838376 | Non-Participating | 0 |
| R-167 | 268338 | 4838747 | Non-Participating | 0 |
| R-168 | 274707 | 4838404 | Non-Participating | 26.1 |
| R-169 | 279645 | 4838174 | Participating | 21.4 |
| R-170 | 279554 | 4838109 | Non-Participating | 15.3 |
| R-171 | 278312 | 4837841 | Non-Participating | 0 |
| R-172 | 276417 | 4837903 | Non-Participating | 27.3 |
| R-173 | 278729 | 4837816 | Non-Participating | 0 |
| R-174 | 272556 | 4837967 | Participating | 7.4 |
| R-175 | 270381 | 4838040 | Participating | 14.5 |
| R-176 | 273450 | 4837932 | Non-Participating | 0 |
| R-177 | 270478 | 4837923 | Non-Participating | 3.5 |
| R-178 | 273066 | 4837782 | Participating | 7.1 |
| R-179 | 274788 | 4837704 | Participating | 21.4 |
| R-180 | 271973 | 4837744 | Participating | 8.9 |
| R-181 | 281120 | 4837381 | Non-Participating | 0 |
| R-182 | 281460 | 4837336 | Non-Participating | 0 |
| R-183 | 277902 | 4837448 | Non-Participating | 0 |
| R-184 | 279662 | 4837297 | Non-Participating | 0 |
| R-185 | 279434 | 4837177 | Non-Participating | 0 |
| R-186 | 268283 | 4837356 | Non-Participating | 0 |
| R-187 | 279506 | 4836919 | Non-Participating | 0 |
| R-188 | 270429 | 4837173 | Non-Participating | 0 |
| R-189 | 272460 | 4836980 | Non-Participating | 12.1 |
| R-190 | 269739 | 4836921 | Non-Participating | 0 |
| R-191 | 279579 | 4836587 | Non-Participating | 0 |
| R-192 | 277891 | 4836601 | Participating | 28.4 |
| R-193 | 268284 | 4836822 | Non-Participating | 0 |
| R-194 | 274482 | 4836578 | Participating | 11.1 |
| R-195 | 268219 | 4836440 | Non-Participating | 0 |
| R-196 | 274565 | 4836090 | Participating | 15.6 |

| Receptor ID | X [m] | Y [m] | Status | Shadow Flicker [hr/yr] |
|---|---|---|---|---|
| R-197 | 277878 | 4835962 | Non-Participating | 48.7 |
| R-198 | 279482 | 4835874 | Participating | 26.6 |
| R-199 | 273555 | 4836044 | Participating | 52.4 |
| R-200 | 277867 | 4835775 | Non-Participating | 75.3 |
| R-201 | 281044 | 4835427 | Non-Participating | 0 |
| R-202 | 279662 | 4834675 | Non-Participating | 0 |
| R-203 | 269036 | 4835015 | Non-Participating | 0 |
| R-204 | 278614 | 4834667 | Non-Participating | 0 |
| R-205 | 280657 | 4834550 | Non-Participating | 0 |
| R-206 | 275493 | 4834711 | Non-Participating | 0 |
| R-207 | 276901 | 4834656 | Non-Participating | 0 |
| R-208 | 277086 | 4834640 | Non-Participating | 0 |
| R-209 | 274677 | 4834702 | Non-Participating | 0 |
| R-210 | 273152 | 4834741 | Non-Participating | 0 |
| R-211 | 274568 | 4834690 | Non-Participating | 0 |
| R-212 | 270322 | 4834834 | Non-Participating | 0 |
| R-213 | 273620 | 4834706 | Non-Participating | 0 |
| R-214 | 280691 | 4834439 | Non-Participating | 0 |
| R-215 | 280226 | 4834447 | Non-Participating | 0 |
| R-216 | 278707 | 4834492 | Non-Participating | 0 |
| R-217 | 274952 | 4834591 | Non-Participating | 0 |
| R-218 | 272941 | 4834640 | Non-Participating | 0 |
| R-219 | 277093 | 4834499 | Non-Participating | 0 |
| R-220 | 279332 | 4834236 | Non-Participating | 0 |
| R-221 | 279506 | 4834137 | Non-Participating | 0 |
| R-222 | 274657 | 4833918 | Non-Participating | 0 |