Shadow Modeling

Subject: Shadow Modeling and Discussion of Results

Scope: Prepared for Washburn Wind Energy LLC's Application for Permit at Black Hawk County

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Summary

Shadow-flicker caused by wind turbines occurs at specific times and circumstances when rotating turbine blades creates moving shadows between the viewer and the sun. Shadows move according to the sun's path which makes it possible to calculate times with possible shadow from wind turbines with great precision and the uncertainties are therefore only related to the sun's intensity, if the turbines are operating (depends on the wind speed) thus causing the flicker effect and finally what azimuth the rotor is at (which depends on the wind direction). The Google Earth screen shot in figure 1 below illustrates how much shadow-flicker (hours per year) is expected West of a single turbine (mornings, perspective is seen from South). The shadow contours (in units of hours per year) are related to how much time the sun is expected to cast shadows from a wind turbine at any point on the ground using one minute time steps every day of a normalized year.

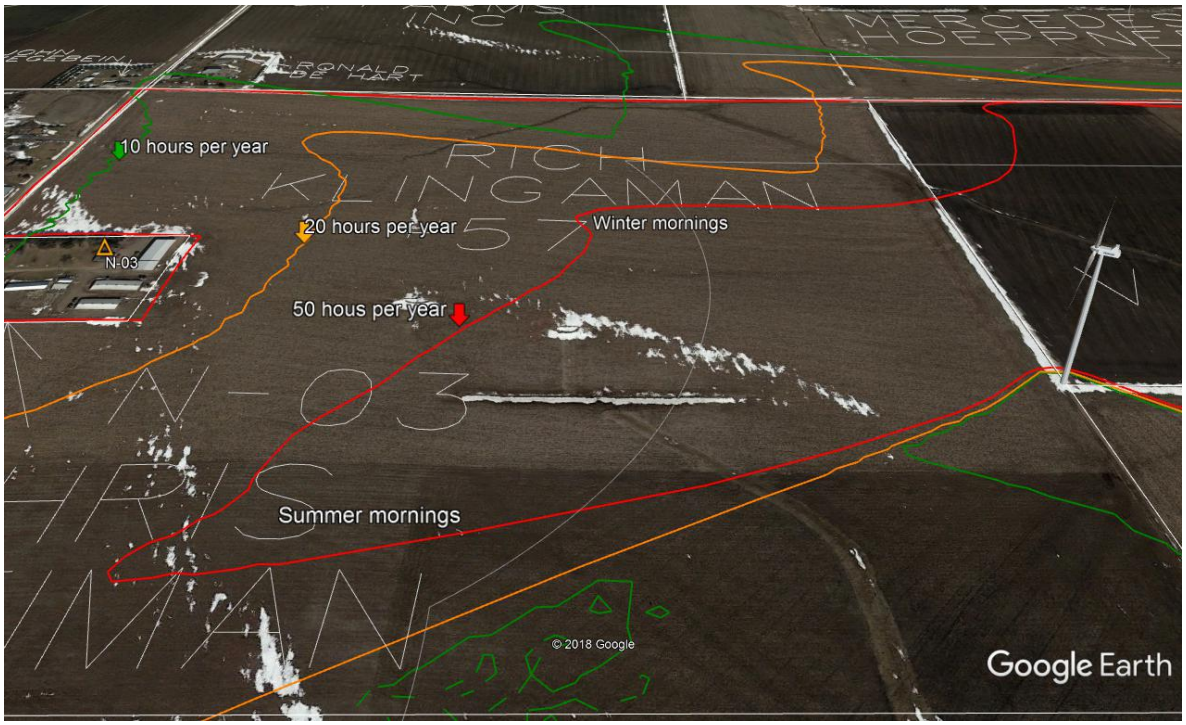


Figure 1. Shadow time West of a single turbine (mornings).

The 10, 20 and 50 h/year contours of the entire project area are shown in Attachment 1.

At this time no obstacles on the ground blocking possible shadow (trees, silos and buildings) has been included in the model because much more dimensional detail (especially heights) and type of trees (evergreens or deciduous) would have been required along with permissions to go on private property to obtain such data consequently, after reviewing this briefing and it's attachments, if a neighbor becomes concerned that shadow-flicker may become an issue then dimensions and other details of buildings, obstacles and maybe especially windows can be obtained with this neighbor's permission. Such local and off-site residence specific details can then be applied to the model and individual results produced including whether possible shadow-flicker will occur behind a residence window or not. Details of applicable methods minimizing or mitigating shadow flicker can then be prepared which ultimately (as per ordinance) must be "to the satisfaction (determination) of the Zoning Administrator".

Below under the heading "Results of the modeling environments and possible mitigations" Google Earth was used to its furthest possible extent short of actually going on an off-site resident's property. The environments including the presence of buildings, obstacles and trees and their possible effect on shadow from turbines is sought described at each individual off-site residence potentially receiving more than 10 hours of shadow per year. The order of the listing is that of the attachments. Possible off-site residence specific but generalized reductions or mitigations have been suggested. For the remaining off-site residences potentially receiving less than 10 hours of shadow per year please see Attachment 1.

Discussion

Shadow around residences is modeled with proven computer models applied with international standards and parameters of varying complexity depending on project location, the terrain elevations and weather data (wind speed, wind direction and haze/cloudiness). This modeling was done with the wind industry standard software called WINDPRO and which has been used worldwide for permitting purposes over decades.

Off-site residences within ½ mile of a turbine has been contacted by Washburn Wind Energy (WWE) and these are listed on maps and in reports with an N-number. Since possible shadow is apparent beyond such ½ mile distances a number of additional off-site residences were added to the model using the names obtained from the assessor web page which is what is used by WWE for most property research. Cross references are present in attachment 2 (main model report). Possible shadow at off-site residences further than ½ mile from a turbine is seen to occur more-so in the summer mornings and evenings (Southwest and Southeast directions respectively) and at much less time and intensity.

In general, when evaluating shadow results a lower number of possible shadow hours per year at an off-site residence also indicate lower shadow-flicker intensities because at longer distances the blade simply covers a relatively smaller part of the sun's disk thus reducing the difference between shadow and no shadow additionally, at lower sun angles the size of the sun's disk is somewhat larger thus further reducing the part covered by the blade resulting in even lower shadow-flicker intensity. For this reason, when the blade covers less than 20% of the sun's disc then possible shadow time is not counted (is a standard parameter).

When possible shadow-flicker occurs at an off-site residence then the intensity will also vary with levels of sunlight blockage (presence of clouds and/or haze). Cloud coverage is one of the parameters applied to the model listed in Attachment 2 (main model report). Other modeling parameters and all results are also listed in Attachment 2. Many conservative settings were applied such as run time (8,760 hours per year) which is a parameter that normally reduce possible shadow up to 10% howev-

er, in order to actually make such a reduction one would have to know more exact times that turbines are not running (i.e. whether low wind speeds occur more so during mornings and evenings) and such detailed data is deemed somewhat uncertain for WWE at this time. Window directions are omni-directional (perpendicular to turbine(s) which in the main report is referred to as "green house mode"). All window settings are vertical, 1m high by 1m wide and 1m above ground level (1m = 3.28ft).

The turbine layout includes all 40 turbines of which 5 will not be built. This may ultimately reduce shadow hours significantly for some off-site residences.

Again, as required by the Black Hawk ordinance "Wind energy facilities shall attempt to avoid shadow flicker in any off-site residences." This has been attempted during the Washburn project development process by carefully weighing turbine siting with other Black Hawk ordinance requirements along with participating landowner's wishes and approval (or lack thereof) of turbine locations in their fields. The turbine manufacturer's requirements as to adequate distance between turbines in order to maintain reasonable fatigue loads when turbines operate in the wake of up-wind turbines is always a major siting constraint. Also as required by the Black Hawk ordinance: "The wind energy facility owner and/or operator shall make reasonable efforts to minimize or mitigate shadow flicker to any off-site residence to the satisfaction (determination) of the Zoning Administrator". Such efforts can be fairly easy identified using the modeling results of this briefing and its attachments. Possible reductions or mitigations included in this briefing include fitting of curtains behind windows exposed to shadow and/or planting evergreen trees to block exposure.

Results of the modeling, environments and possible mitigations

All modeling results are shown in the following attachments.

Attachment 1 is the shadow contour map showing the 50, 20 and 10 hours per year shadow contours and the possible shadow values at each off-site residence in hours per year. The map format is 11x17. The turbine layout depicts 40 turbines of which 5 are alternates that will not be built. File name is:
Attachment 1, Washburn shadow contour map (11x17) w-receptor values 2018-03-22.pdf

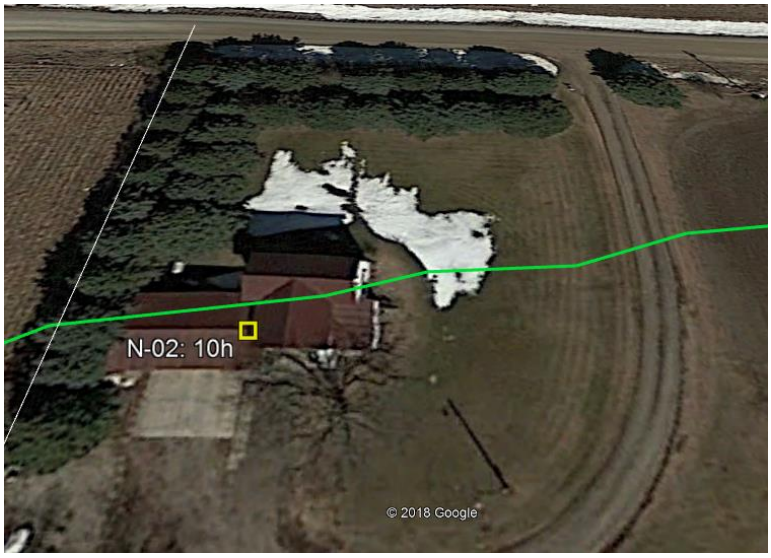
Attachment 2 is the main model report from the modeling software listing turbine and receptor locations, modeling parameters and the results. File name is:
Attachment 2, Washburn shadow, main report, all receptors 2018-03-23.pdf

Attachment 3 is a set of calendars showing what days and times each receptor may be exposed to shadow in a) the theoretical worst case scenario (always windy, wind direction in-line with receptor, sun never obscured, no obstacles etc.) and b) the real case after reductions have been made according to statistical cloudiness and wind directions although this case still includes the operational time as being 100% (8,760 hours per year). File name is:
Attachment 3, Washburn shadow calendars, receptors with shadow only 2018-03-23.pdf

Attachment 4 is the graphical presentation of calendars showing what approximate days and times each receptor may be exposed to shadow (one calendar per receptor) in the real case scenario. File name is:
Attachment 4, Washburn shadow graphical calendars, receptors with shadow only 2018-03-23.pdf

N-02 Craig A. Halupnick 2129 W. Quarry Rd. will per model receive close to 10 hours per year of shadow (before any reduction due to operational time) from turbines 7 and 39 distributed over 87 (worst case) days. Details can be seen in the main report on page 4, calendar pages 15 and 16 and graphical calendar on page 3.
This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is limited (tight) due to the manufacturer's distance requirements and from aiming to stay on property lines rather than in the middle of fields. N-02 already has many wind breaks (evergreens) to the North and West of the residence but none towards turbine 39 between the driveway and the residence as seen below. Mitigation includes planting evergreens towards the exact direction of turbine 39 and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.



N-03 Christopher L. Greiman 11219 Holmes Rd. will per model receive close to 13 hours per year of shadow (before any reduction due to operational time) from turbines 5 and 6 distributed over possible 79 (worst case). Details can be seen in the main report on page 4, calendar pages 17 and 18 and graphical calendar on page 3.

This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal for all purposes including shadow. There are barns relative close to N-03's residence that may be tall enough to shield out most shadow from turbine 6 and some from turbine 5. There are no wind breaks. Mitigation includes installing window curtains in the exposed rooms if shadow-flicker is an issue in exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

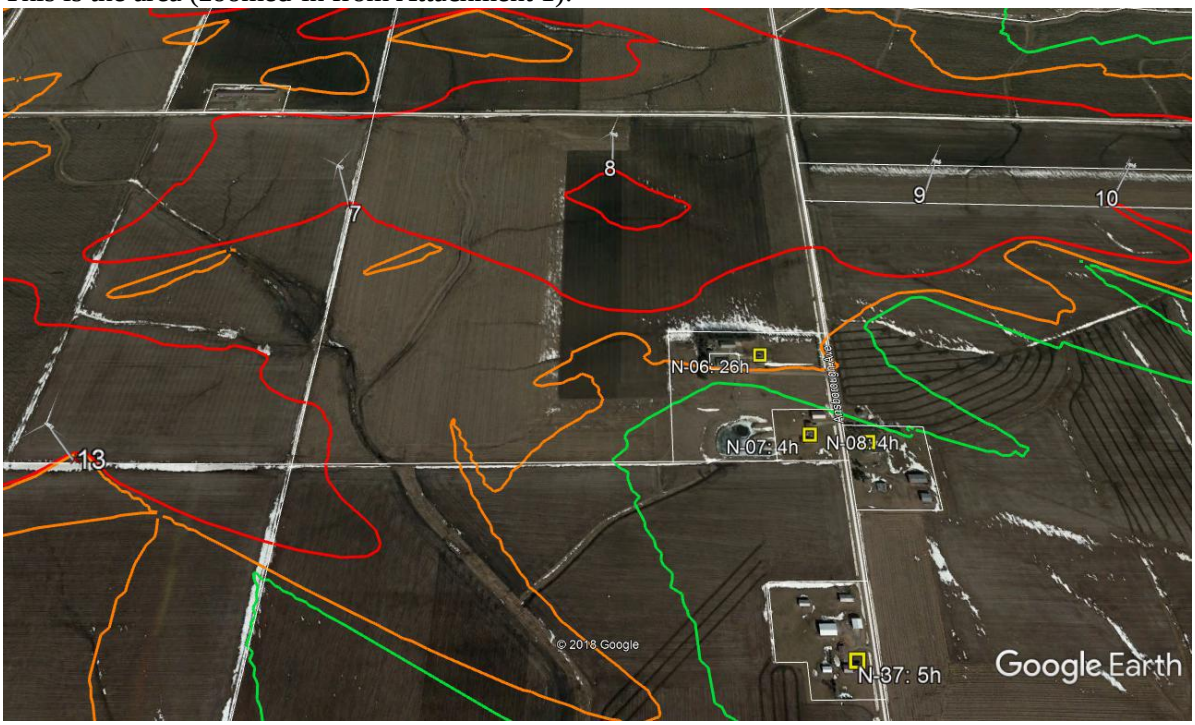
N-04 Ricky J. & Janann M. Bauler 11315 Acker Rd. will per model receive close to 12 hours per year of shadow (before any reduction due to operational time) from turbines 5 and 12 distributed over possible 75 (worst case) days. Details can be seen in the main report on page 4, calendar pages 19 and 20 and graphical calendar on page 3.
This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal for all purposes including shadow, manufacturer's distance requirements and aiming to stay on property lines. N-04 already has many evergreens and other deciduous wind breaks on the North side of the residence towards but none quite towards turbine 5 and none towards turbine 11. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

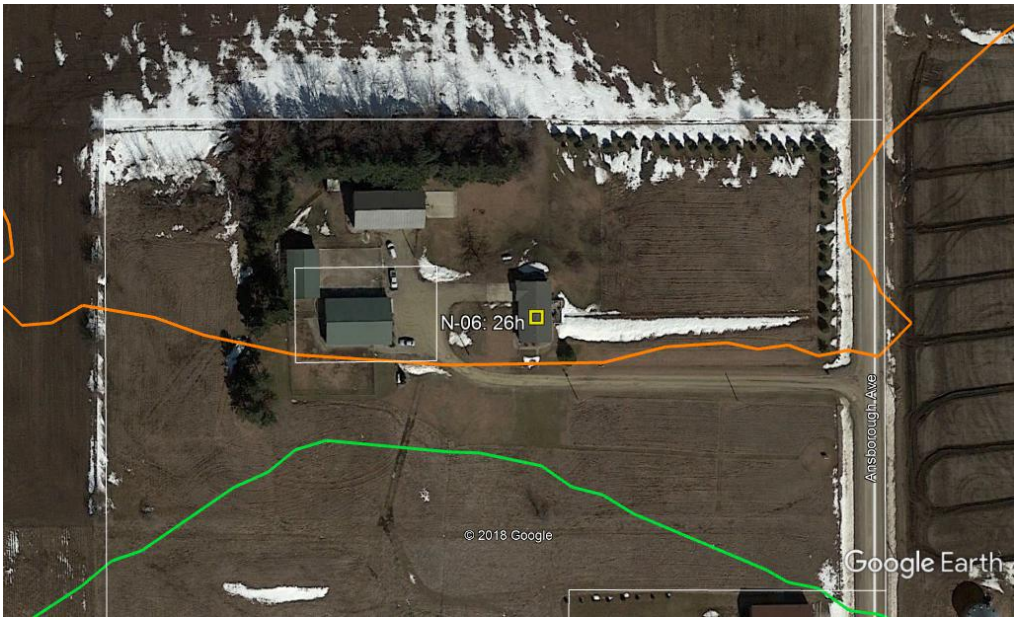
N-05 Gregory Cory 11528 Beck Rd. will per model receive 44 hours per year of shadow (before any reduction due to operational time) from turbines 12, 13 and 33 and distributed over possible 120 (worst case) days. Details can be seen in the main report on page page 4, calendar pages 21 and 22 and graphical calendar on page 3.
This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal for most purposes. N-05 has many evergreens and other deciduous wind breaks on most sides of the residence. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-06 Todd M. & Heather M. Sterrett 11336 Ansborough Ave. will per model receive 26 hours per year of shadow (before any reduction due to operational time) from turbines 7, 10 and 13 and distributed over possible 100 (worst case) days. Details can be seen in the main report on page 4, calendar pages 23 and 24 and graphical calendar on page 3.
This is the area (zoomed-in from Attachment 1):



Turbine siting configuration in this area is optimal for most purposes including shadow since turbines 8 and 9 cause no shadow. N-05 has many evergreens and other deciduous wind breaks on most sides of the residence. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.



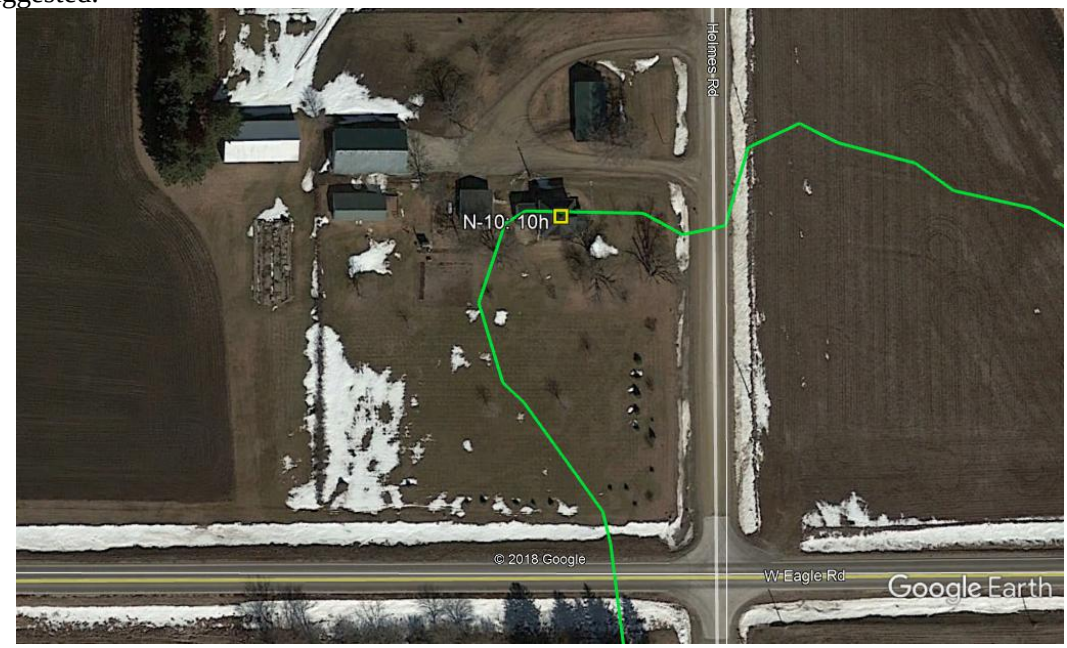
N-09 Bradley A. Halupnick 11474 Holmes Rd. will per model receive 26 hours per year of shadow (before any reduction due to operational time) from turbines 5 and 34 and distributed over possible 130 (worst case) days. Details can be seen in the main report on page 4, calendar pages 28 and 29 and graphical calendar on page 4.
This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal for most purposes except shadow from turbine 5 on summer mornings and from turbine 34 on winter evenings.
N-05 has planted many evergreens as wind breaks but these are too far away from the residence itself to avoid shadow. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-10 Brian & Diana Minard 11926 Holmes Rd. will per model receive 10 hours per year of shadow (before any reduction due to operational time) from turbine 35 only, distributed over possible 70 (worst case) days. Details can be seen in the main report on page 4, calendar page 30 and graphical calendar on page 4.

This is the area (zoomed-in from Attachment 1):

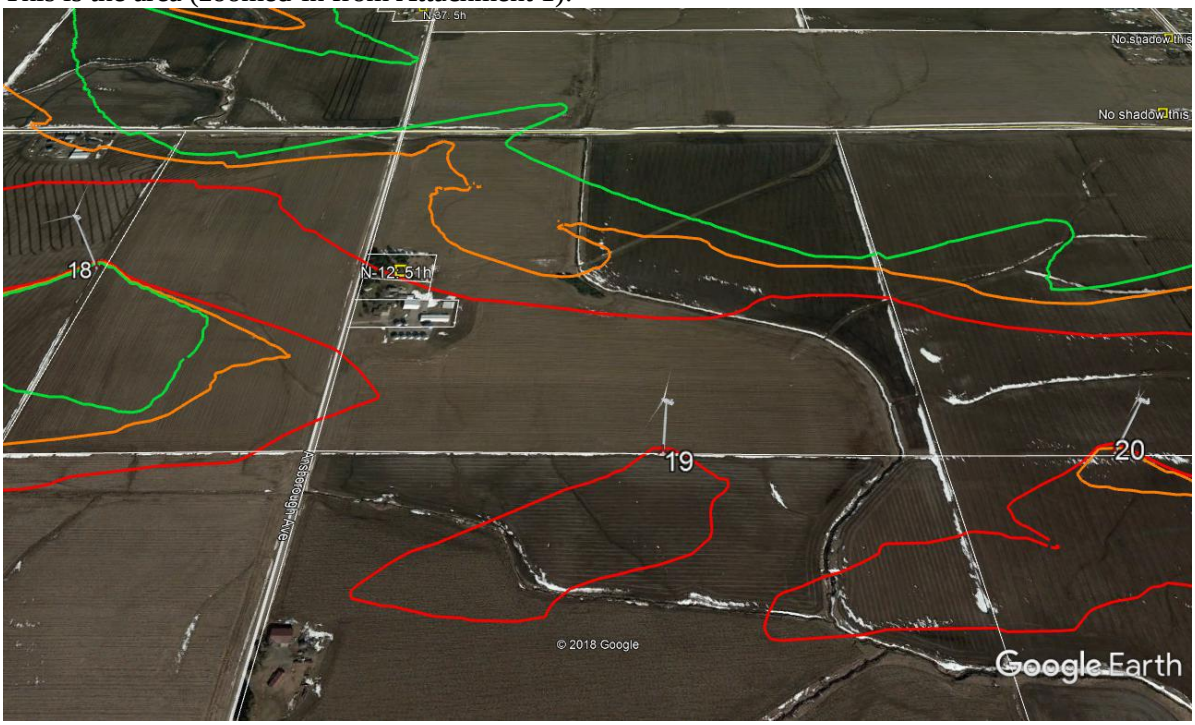
Turbine siting configuration in this area is optimal for most purposes. There are no wind breaks in the direction of turbine 35 which will cause shadow for N-10 during some winter mornings only. Mitigation includes planting evergreens towards turbine 35 and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.



N-11 Wayne R. & Rebecca L. McGarvey 2814 W. Eagle Rd. will per model receive 45 hours per year of shadow (before any reduction due to operational time) from turbines 11, 15 and 16, distributed over possible 192 (worst case) days. Details can be seen in the main report on page 4, calendar pages 31 and 32 and graphical calendar on page 4.
This is the area (zoomed-in from Attachment 1):

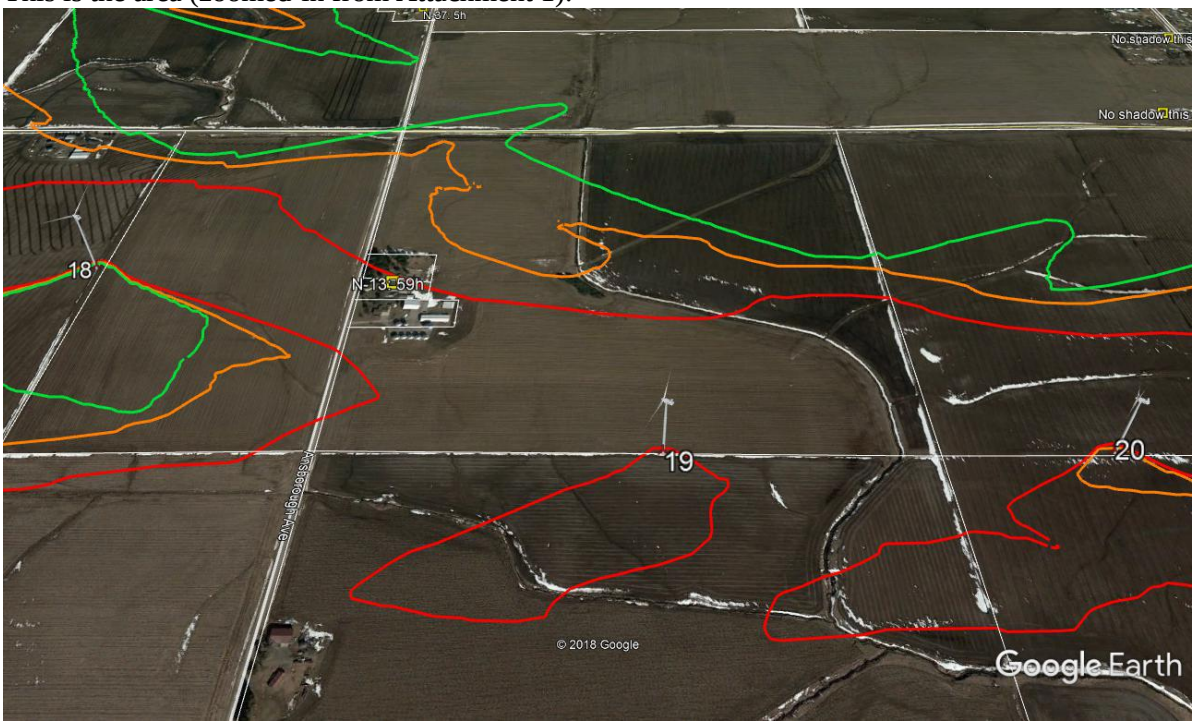
Turbine siting configuration in this area is optimal for most purposes. N-05 has no wind breaks except for a few evergreens and deciduous trees close to the residence. Mitigation includes planting more evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-12 James H. & Lynne M. Wikle 12229 Ansborough Ave. will per model receive 51 hours per year of shadow (before any reduction due to operational time) from turbines 18, 19 and 20, distributed over possible 198 (worst case) days. Details can be seen in the main report on page 4, calendar pages 33 and 34 and graphical calendar on page 4.
This is the area (zoomed-in from Attachment 1):



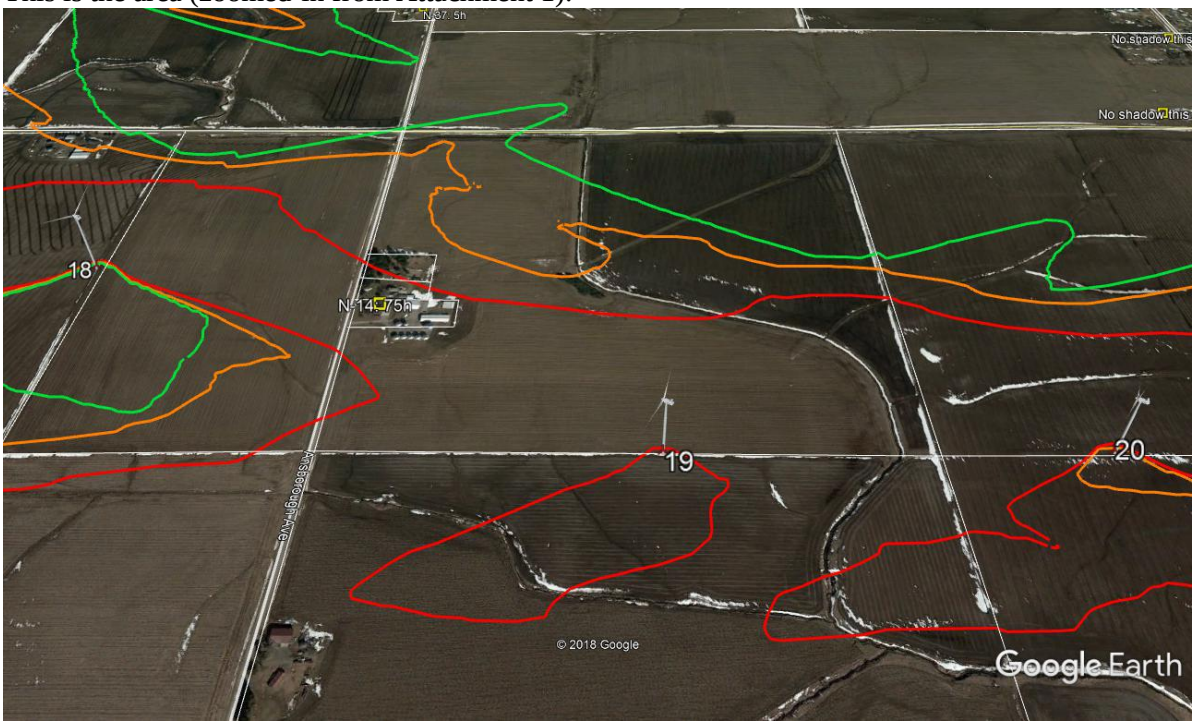
Turbine siting configuration in this area is optimal. N-12 has mature evergreens towards turbine 18 and a barn towards turbine 20 that should eliminate possible shadow from these two turbines. Mitigation includes installing window curtains in eventual exposed rooms if shadow-flicker is an issue in exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-13 Donald J. & Sandra A. Bedard 12239 Ansborough Ave. just South of N-12 (share fenceline) will per model receive 59 hours per year of shadow (before any reduction due to operational time) from turbines 18, 19 and 20, distributed over possible 218 (worst case) days. Details can be seen in the main report on page 4, calendar pages 35 and 36 and graphical calendar on page 5.
This is the area (zoomed-in from Attachment 1):



As for the previous off-site residence above, turbine siting configuration in this area is optimal. N-13 has mature evergreens towards turbine 18 and barns towards turbine 20 that should eliminate possible shadow from these two turbines. Mitigation includes planting evergreens towards the exact direction of turbine 20 and installing curtains in windows if shadow-flicker is an issue in such exposed rooms although it does not appear that there will be much exposure. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-14 Nathan R. & Jennifer M. McKenna 12249 Ansborough Ave. will per model receive 75 hours per year of shadow (before any reduction due to operational time) from turbines 18, 19 and 20, distributed over possible 218 (worst case) days. Details can be seen in the main report on page 4, calendar pages 37 and 38 and graphical calendar on page 5.
This is the area (zoomed-in from Attachment 1):



As for the two previous off-site residence above, turbine siting configuration in this area is optimal. N-14 has no wind breaks towards any of the turbines but there are several silos towards turbine 19 and a barn may cover shadows from turbine 20. Mitigation includes planting evergreens towards turbine 18 and installing curtains in eventual exposed rooms if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-17 Edwin L. & Diane K. Steffen 12838 Ansborough Ave. will per model receive 20 hours per year of shadow (before any reduction due to operational time) from turbines 23 and 40, distributed over possible 63 (worst case) days. Details can be seen in the main report on page 4, calendar page 41 and graphical calendar on page 5.
This is the area (zoomed-in from Attachment 1):

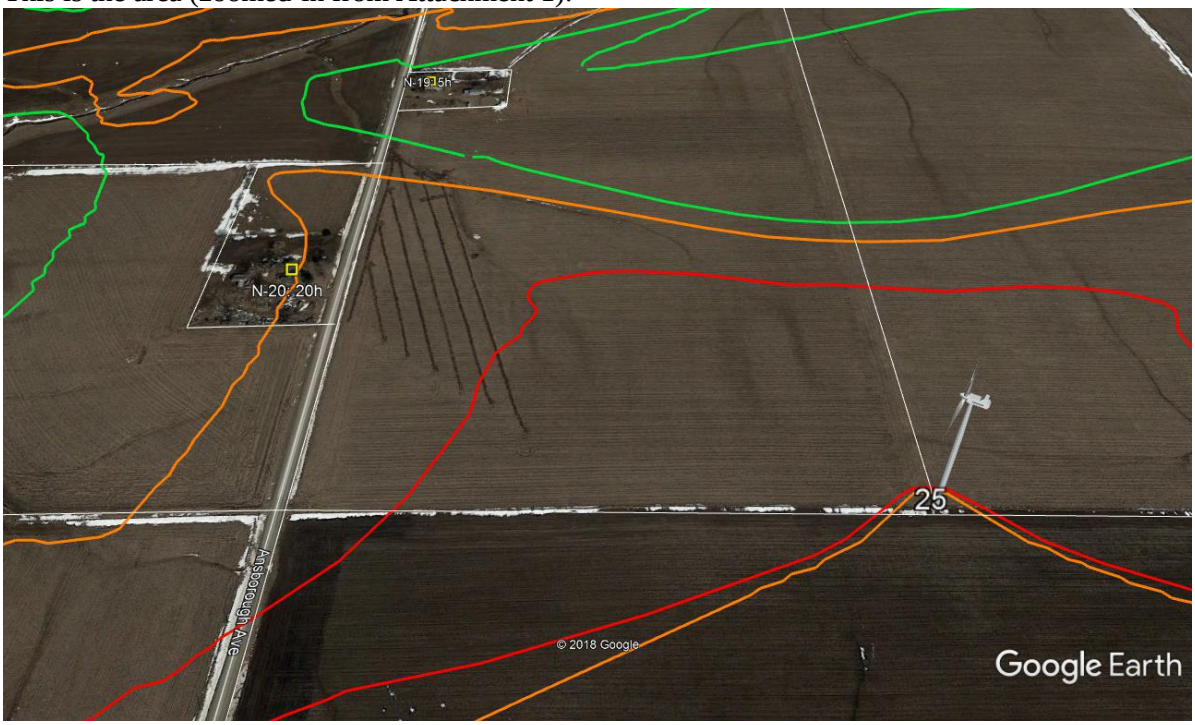
Turbine siting configuration in this area is optimal including for shadow. N-17 has a few mature evergreens towards turbine 23 and 40 which should reduce possible shadow from these two turbines. Mitigation includes planting more evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-18 James E. & Angeline M. Garthoff 12706 Kimball Ave. will per model receive 32 hours per year of shadow (before any reduction due to operational time) from turbines 19, 23, 40 and 41, distributed over possible 135 (worst case) days. Details can be seen in the main report on page 4, calendar pages 42 and 43 and graphical calendar on page 5.
This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal including for shadow especially given the limited (tight) manufacturer's distance requirements and aiming to stay on property lines. N-18 has a few evergreens towards turbine 19 although they may not be tall enough to shield for shadow. Turbine 23 is far enough away to where the silo and small garage may shield any exposure. The garage may also shield exposure from turbine 41 to some extent. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms.

N-20 Wesley Stanek 13326 Ansborough Ave. will per model receive 20 hours per year of shadow (before any reduction due to operational time) from turbine 25, distributed over possible 74 (worst case) days. Details can be seen in the main report on page 4, calendar pages 45 and 46 and graphical calendar on page 6.

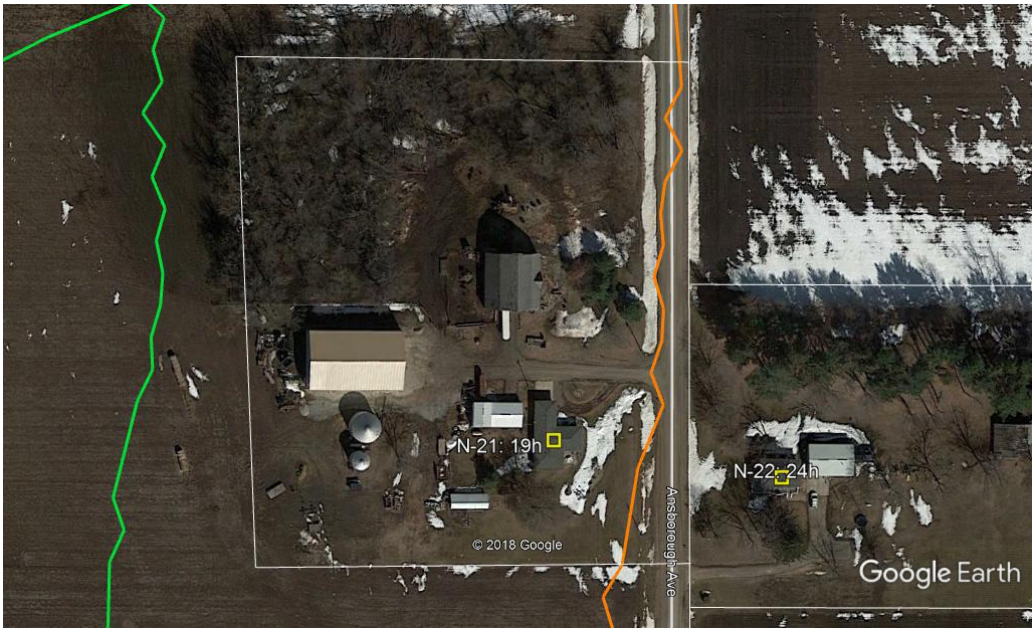
This is the area (zoomed-in from Attachment 1):



Turbine 25 is in an ideal location including for shadow. N-20 has an evergreen or two towards turbine 25 they may not be enough to shield the residence entirely for shadow (like the front porch). Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-21 Edward P. & Sara B McGarvey 13800 Ansborough Ave. will per model receive 19 hours per year of shadow (before any reduction due to operational time) from turbines 27 and 28, distributed over possible 67 (worst case) days. Details can be seen in the main report on page 4, calendar page 47 and graphical calendar on page 6.
This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal including for shadow especially given the set-backs. N-21 has no wind breaks towards these turbines. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.



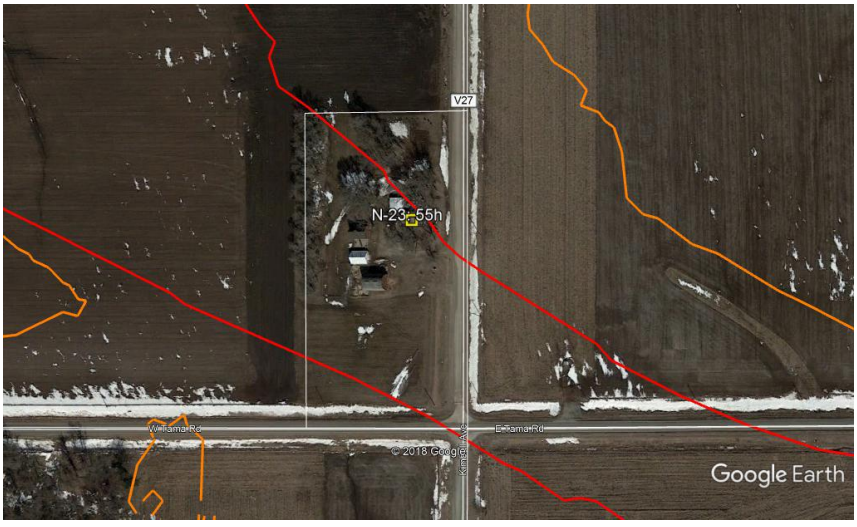
N-22 Paul M. & Marci J. Fish 13803 Ansborough Ave. is just across from N-21 and will per model receive 24 hours per year of shadow (before any reduction due to operational time) from turbines 27 and 28, distributed over possible 72 (worst case) days. Details can be seen in the main report on page 4, calendar page 48 and graphical calendar on page 6.
This is the area (zoomed-in from Attachment 1):

Like at N-21 the turbine siting configuration in this area is optimal including for shadow especially given the setbacks. N-22 has wind breaks towards both turbines (East) but these evergreens are too far from the residence to effectively shield the shadow. The garage may prevent some shadow affecting the North side of the residence but the front porch and South side of the residence may receive shadow from turbine 27. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms.

N-23 Jeremiah J. Yuska 13906 Kimball Ave. will per model receive 55 hours per year of shadow (before any reduction due to operational time) from turbines 27, 28, 29, 31 and 32 distributed over possible 211 (worst case) days. Details can be seen in the main report on page 4, calendar page 49 and 50 and graphical calendar on page 6.

This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal given the limited (tight) manufacturer's distance requirements and setbacks. N-23 has lots of deciduous trees around the residence and a wind break towards West which should eliminate shadow from turbine 27 and 28 during the summer evenings. Shadow from turbine 29 will reach the East side of the residence on winter mornings as will most shadow from turbine 32. Most of the shadow from turbine 31 may be shielded by the buildings Southwest of the residence. Mitigation includes planting evergreens towards the exact direction of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.



N-24 Aaron J. Martin 14022 Ansborough Ave. will per model receive 35 hours per year of shadow (before any reduction due to operational time) from turbines 27, 28 and 31 distributed over possible 178 (worst case) days. Details can be seen in the main report on page 4, calendar page 51 and 52 and graphical calendar on page 6.

This is the area (zoomed-in from Attachment 1):

Like at N-21 and N-22 the turbine siting configuration in this area is optimal including for shadow especially given the setbacks. N-24's neighbor across the street has evergreen wind breaks towards both turbines 27 and 28 and these trees may prevent most shadow from turbine 28 but none from turbine 27. Mitigation includes planting evergreens towards the exact direction of the turbine 27 and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-25 Stefanie R. & Adam M. Galbraith 1510 W. Eagle Rd. will per model receive 21 hours per year of shadow (before any reduction due to operational time) from turbines 18 and 33 distributed over possible 105 (worst case) days. Details can be seen in the main report on page 4, calendar page 53 and 54 and graphical calendar on page 7.
This is the area (zoomed-in from Attachment 1):

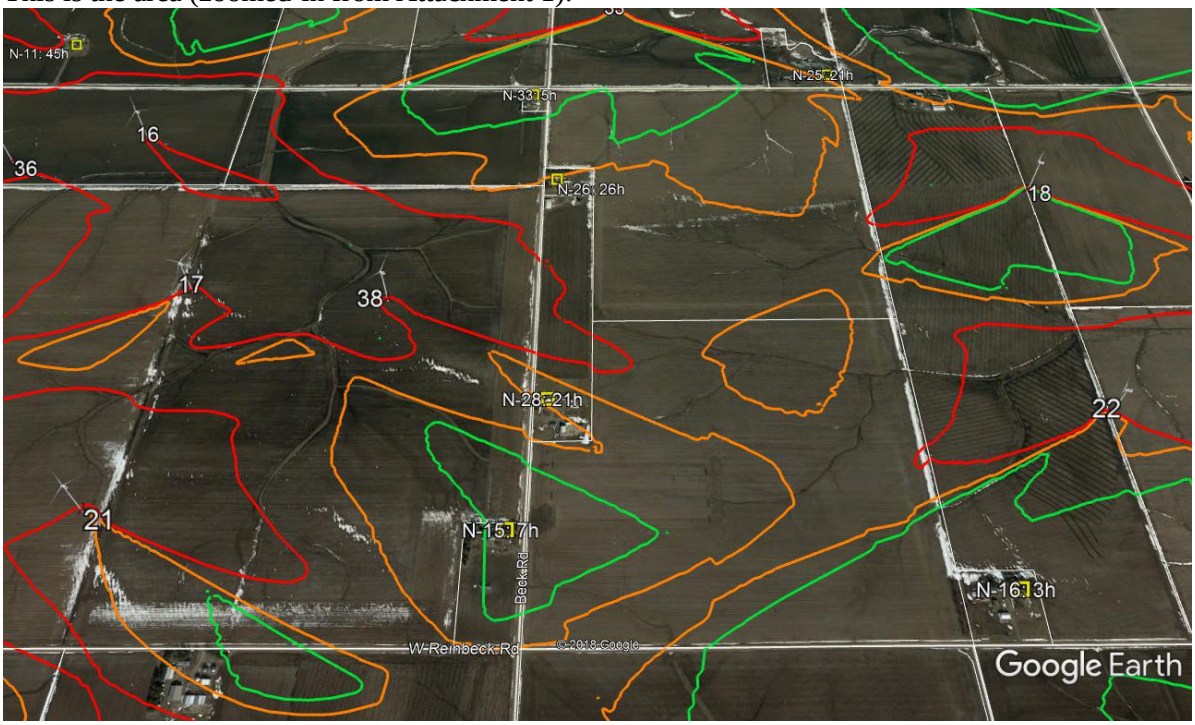
Turbine siting configuration in this area is optimal for most purposes. N-25 has lots of deciduous trees towards turbine 33 although they may not be tall enough to prevent all summer evening shadow. Shadow will also be received from turbine 18 winter mornings. Mitigation includes planting evergreens towards the exact directions of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-26 Kevin P. & Katherine L. Youngblut 12219 Beck Rd. will per model receive 26 hours per year of shadow (before any reduction due to operational time) from turbines 16, 17, 18 and 38 distributed over possible 178 (worst case) days. Details can be seen in the main report on page 4, calendar page 55 and 56 and graphical calendar on page 7.
This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal for most purposes. N-26 has a wind break of deciduous trees towards turbines 16 and 17 although exposure from turbine 17 may still be possible. Turbine 38 will cause shadow winter evenings and turbine 18 will cause shadow during spring and fall mornings. Mitigation includes planting evergreens towards the exact directions of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-28 Donald R. & Margaret E. Schrader 12635 Beck Rd. will per model receive 21 hours per year of shadow (before any reduction due to operational time) from turbines 17, 21 and 22 distributed over possible 141 (worst case) days. Details can be seen in the main report on page 58 and 59 and graphical calendar on page 7.

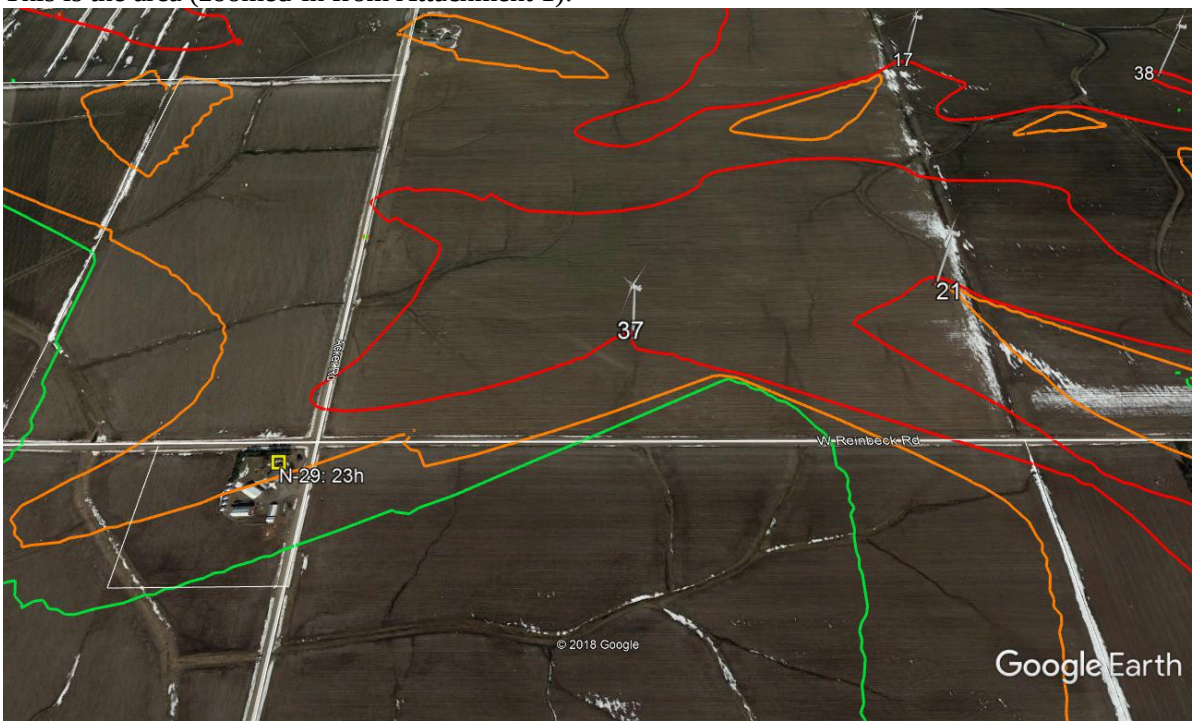
This is the area (zoomed-in from Attachment 1):



Turbine siting configuration in this area is optimal including for shadow. N-28 has a wind break of mature evergreens towards turbine 21 which may prevent most of the shadow from turbine 21 and maybe all shadow from turbine 17. Exposure from turbine 22 appears to be at the garage only. Mitigation, if needed, is planting more evergreens towards the exact directions of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

N-29 Trevor & Sue Wulf 3042 W. Reinbeck Rd. will per model receive 23 hours per year of shadow (before any reduction due to operational time) from turbines 21 and 37 distributed over possible 98 (worst case) days. Details can be seen in the main report on page 5, calendar page 60 and graphical calendar on page 7.

This is the area (zoomed-in from Attachment 1):

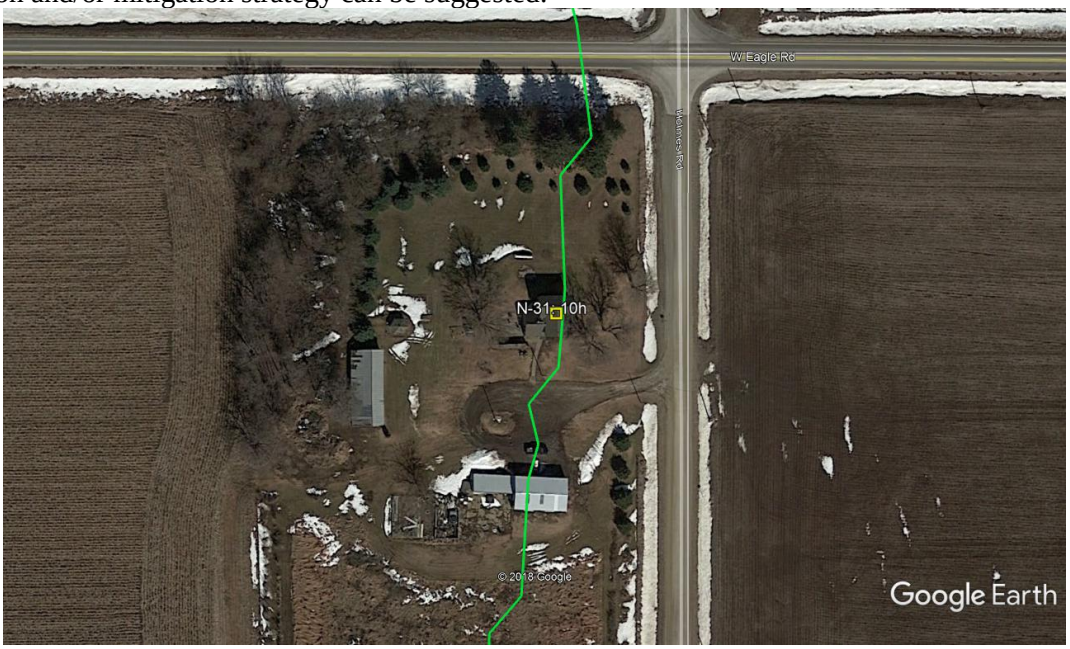


Turbine siting configuration in this area is optimal including for shadow. N-29 has wind breaks of mature evergreens but is exposed towards turbine 21 and 37. Mitigation is planting more evergreens towards the exact directions of the turbines causing shadow and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

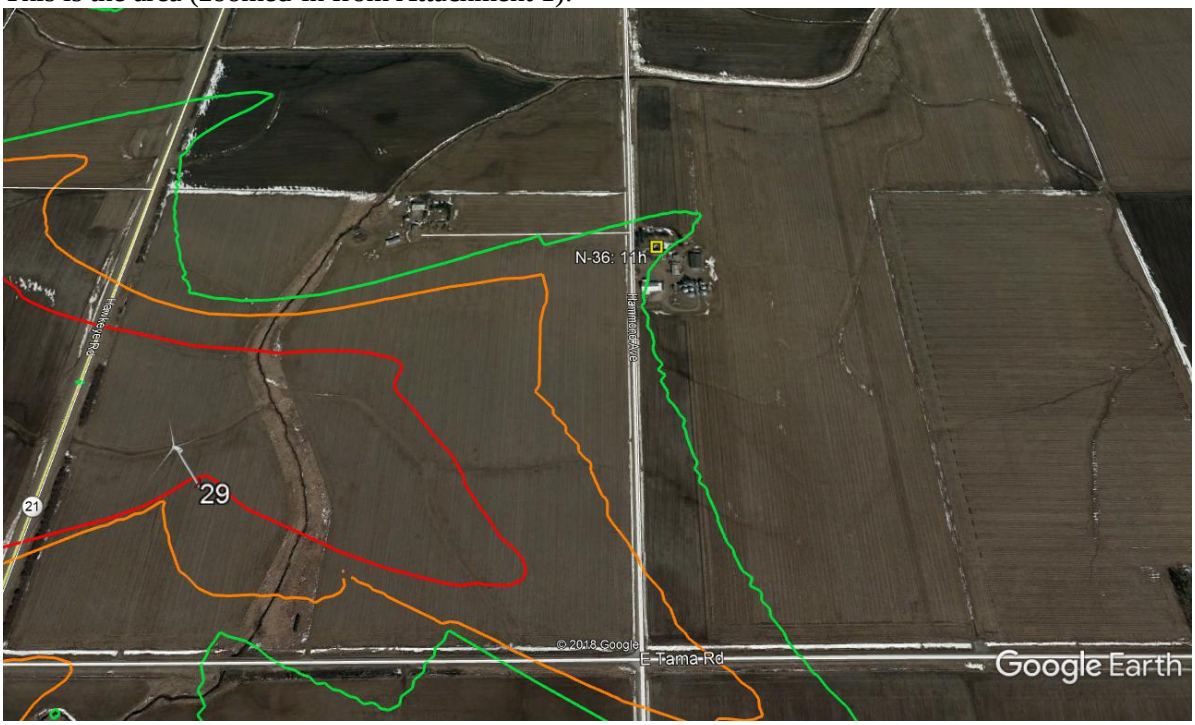
N-31 Robert D. Beard 12018 Holmes Rd. will per model receive 10 hours per year of shadow (before any reduction due to operational time) from turbines 15 and 35 distributed over possible 80 (worst case) days. Details can be seen in the main report on page 5, calendar pages 61 and 62 and graphical calendar on page 7.

This is the area (zoomed-in from Attachment 1):

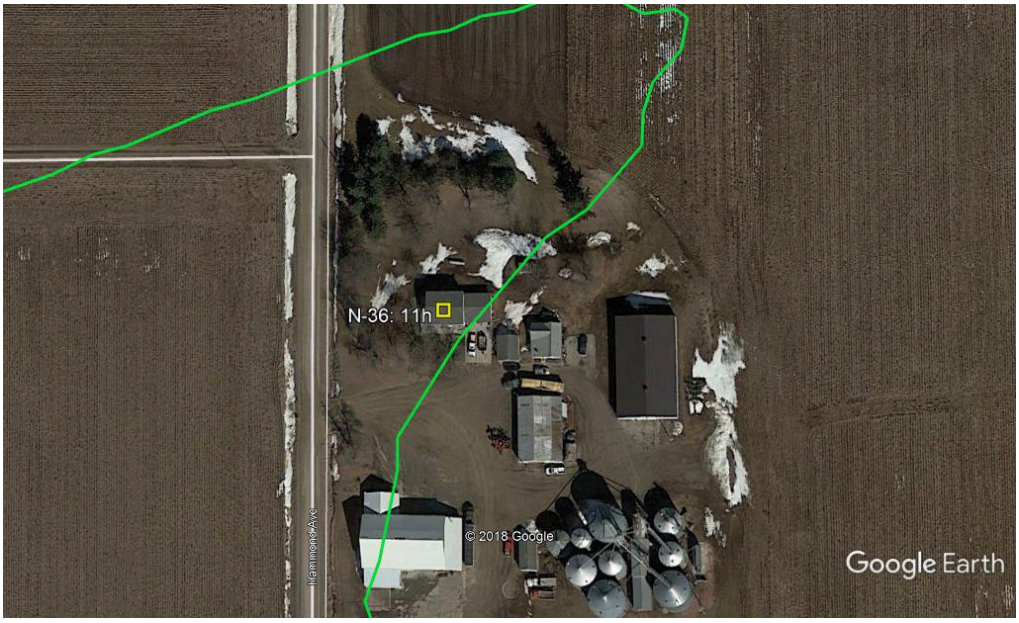
Turbine siting configuration in this area is optimal for most purposes and turbines 15 is at the edge of causing any shadow exposure at N-31 in that the turbine is relatively far away. Turbine 35 will cause shadow some winter mornings. Mitigation includes planting evergreens towards turbine 35 and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.



N-36 Benjamin & Erica Youngblut 13542 Hammond will per model receive 11 hours per year of shadow (before any reduction due to operational time) from turbine 29 distributed over possible 80 (worst case) days. Details can be seen in the main report on page 5, calendar page 65 and graphical calendar on page 8.
This is the area (zoomed-in from Attachment 1):



Turbine siting configuration in this area is optimal for most purposes. Turbine 29 will cause shadow exposure at N-36 some winter evenings since the trees in the direction of turbine 29 are deciduous. Mitigation includes planting evergreens towards turbine 35 and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

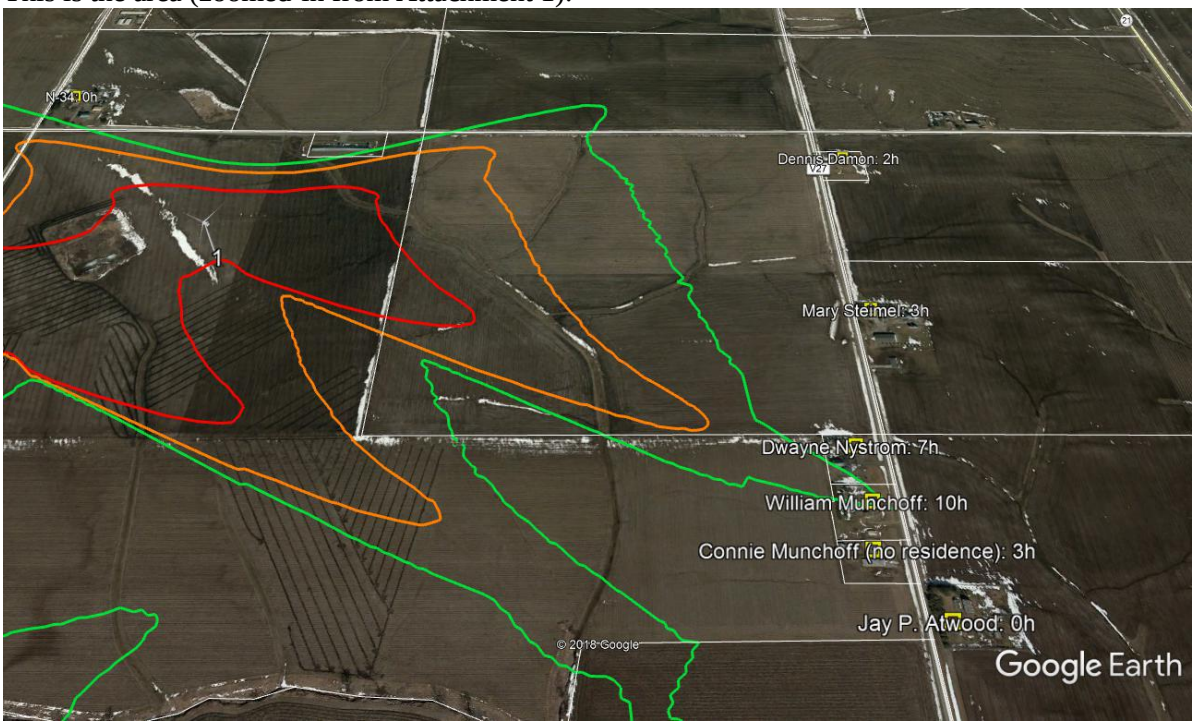


Ronald De Hart, W. Quarry Rd. will per model receive 11 hours per year of shadow (before any reduction due to operational time) from turbines 5 and 6 distributed over possible 88 (worst case) days. Details can be seen in the main report on page 5, calendar pages 67 and 68 and graphical calendar on page 8.

This is the area (zoomed-in from Attachment 1):

Turbine siting configuration in this area is optimal for most purposes including shadow. Turbines 5 and 6 will cause shadow exposure at Ronald De Hart's residence some winter mornings. The evergreen wind break in the direction of both turbines appears to be too low to shield shadow. Mitigation includes planting more evergreens towards turbines 5 and 6 and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.

William Munchoff, Kimball Ave. will per model receive 10 hours per year of shadow (before any reduction due to operational time) from turbine 29 distributed over possible 67 (worst case) days. Details can be seen in the main report on page 5, calendar page 71 and graphical calendar on page 9.
This is the area (zoomed-in from Attachment 1):



Turbine siting configuration in this area is optimal for most purposes including shadow. Turbine 1 will cause shadow exposure at William Munchoff's residence some summer evenings since the evergreen wind breaks towards turbine 1 appear to be too low to shield shadow. Mitigation includes planting more evergreens towards turbine 1 and installing window curtains in eventual exposed rooms and if shadow-flicker is an issue in such exposed rooms. If visiting the property then more details can be applied to the model and a more specific reduction and/or mitigation strategy can be suggested.