

North Wind Measurement - Technical Note

Shadow Flicker Impact for Small Wind Systems

A guide for wind turbine ordinances in Michigan

Many municipalities are currently writing or revising ordinances for small wind systems. Ordinances often require that the applicant provide a shadow flicker analysis as part of the permitting process. A commercial study can cost as much as \$1000 which, when added to the other requirement, represents a significant and often unnecessary burden on the homeowner.

This paper provides guidelines that can greatly simplify the shadow flicker evaluation process and avoid both cost for the homeowner and unnecessary administrative issues for the municipality.

Shadow flicker is seldom an issue for small wind systems for two reasons:

1. The shadow cannot be cast beyond 12 rotor diameters, which is often within the setback requirements for the turbine.
2. The sun cannot cast a shadow on the receptor if the turbine is to the north or south, so about ½ of possible turbine-to-receptor orientations cannot create shadow flicker.

Definitions

Shadow Flicker - Shadow flicker is the phenomenon where the blades of a rotating wind turbine cast a moving shadow on an observation point (receptor). The moving shadow causes the interior of a room to have recurring light and dark periods which can make it difficult to perform tasks that require a constant light source. This is most commonly observed in the hour just after sunrise or just before sunset when the sun is low in the sky. Shadow flicker is not the sun seen through a rotating blade nor what an observer might view moving through the shadows of a wind turbine system.

Small Wind System – A turbine with a rating 20 kw or less, sized for onsite energy use for a home or farm, and connected under Michigan's netmetering provisions.

Receptor – typically the occupied residence of an adjacent homeowner.

HAWT – Horizontal Axis Wind Turbine. The most common small wind turbine systems.

VAWT – Vertical Axis Wind Turbine. Systems whose rotational axis is vertical. Typically small, low-output systems usually used for demonstration projects. They have no potential for shadow flicker because the blades are small and the hub height is low.

Rotor Diameter – the diameter of the blades of a HAWT.

Hub Height – the height of the center of the turbine

Azimuth – the direction in degrees (true) from the receptor to the turbine. (north = 0 deg, east = 90 deg, south = 180 deg, west = 270 deg).

The following two guidelines will determine if shadow flicker is a potential problem and if a study should be performed. If both conditions are met, a study should be performed.

1. Is the receptor within 12 rotor diameters of the turbine? If the receptor is beyond 12 rotor diameters, no shadow flicker study is required. The shadow will dissipate before it reaches the receptor.
2. Is the azimuth (from receptor to turbine) within the possible shadow flicker range?
 - 65 to 160 degrees for sunrise exposure, or
 - 200 to 295 degrees for sunset exposure

If it is not in this range, shadow flicker cannot occur on the receptor.

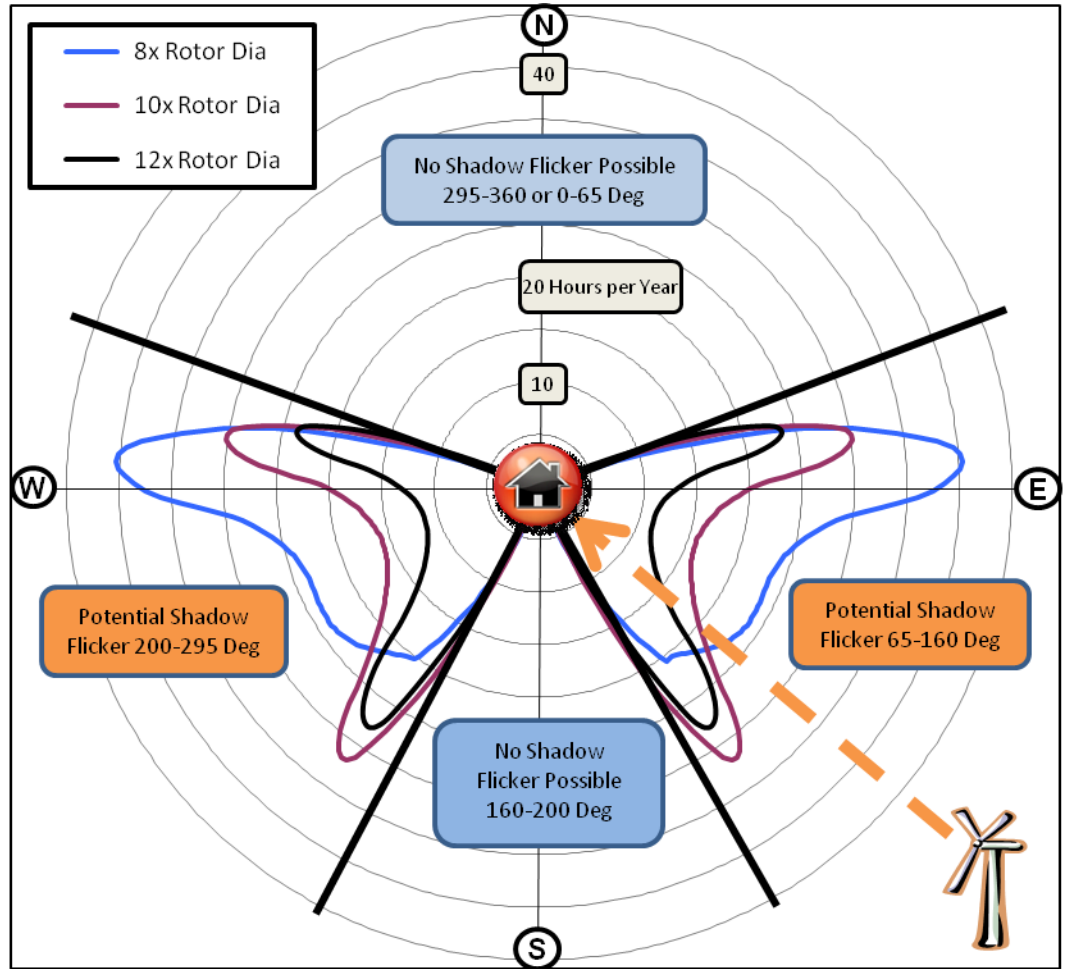
The “butterfly” plot shown is typical of shadow flicker impact possible in Michigan. Azimuths within the butterfly plot are of concern and should be analyzed.

Reading the Plot

- The turbine can only impact the receptor if it is installed in one of the “Potential Shadow Flicker” directions.
- The three “butterflies” represent distances from the receptor to the turbine. The closer (8x) will produce shadow flicker for more hours per year than the farther 12x distance.
- The concentric rings represent the number of hours per year that the shadow will be cast on the receptor

Assumptions for the plot

- Receptor is a 2000 square foot, two story home (35 x 35 ft x 20 ft high)
- Turbine is a 10 kw, 24 ft rotor diameter on a 100 ft tower
- Exposure hours are adjusted for sunshine probability and turbine operation probability.
- Plot is valid for latitudes from 42 to 47 degrees.



Shadow Flicker Characteristics for Common Small Wind Turbines

Model	Rotor Diameter (ft)	Maximum Shadow Distance (ft)	Rating (kw)	Flicker Frequency (Hz)
Skystream 3.7 or Proven WT2500	12	144	2.4	0 - 15
Bergey Excel or ARE 442	23	276	10	0 – 8.0
Jacobs 31-20	31	372	20	0 – 5.0

Flicker Frequency and Potential Health Issues

Small wind turbines will produce a flicker frequency from 0 to 15 Hz, depending on rotor size. There is evidence that about 1 person in 5000 in the United States is sensitive to frequencies between 3 and 25Hz and could suffer photosensitive epileptic seizure if exposed for a period of time. There has never been a case of a seizure occurring from wind turbine flicker, but it is a known phenomenon that has occurred from exposure to video games and cartoons.

The US Epilepsy Foundation has several papers on the subject:

<http://www.epilepsyfoundation.org/about/photosensitivity/>