RMT | ENERGY

Shadow Flicker Monitoring and Mitigation Information

Mason County, MI
Lake Winds® Energy Park

August 2012

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Prepared For
Consumers Energy Company

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Section 1
Purpose

The purpose of this document is:

- To provide Mason County, Michigan, with detailed information regarding the planned wind turbine generator (WTG) shadow flicker monitoring and potential mitigation measures for unpooled parcels containing occupied structures, as required by the Mason County Special Land Use Permit (SLUP) Part G, Section 9.

Section 2
Background

RMT prepared a shadow flicker study (Revision 1) in June 2011 that was included in the Mason County Special Land Use Permit Application for the Lake Winds ® Energy Park (LWEP or 'Project'). The results of this study indicated that mitigation was expected to be required for 40 unpooled parcels containing occupied structures in order to comply with the Mason County Zoning Ordinance, which allows a maximum of 10 hours per year of shadow flicker on unpooled parcels containing occupied structures. At the time the application was submitted, the mechanics of how the shadow flicker mitigation would be implemented were unknown. As a result, one of the conditions of the Special Land Use Permit Part G, Section 9 states:

a) "The Applicant shall provide the County with written detailed information on the equipment and methodology to be used to monitor the duration of shadow flicker on all affected properties in any calendar year. Such information shall be submitted at least eight weeks prior to the commencement of operations of the System.

b) Such shadow flicker information shall include a description of mitigation measures for each receptor site including but not limited to siting changes, operational changes, grading or other means of mitigation.

c) The Applicant shall not require any property owner to participate or otherwise be involved in the Applicant's determination of the duration of shadow flicker on or as to any affected property."

Section 4 of this report describes the mitigation strategy that will be implemented by the Project utilizing the Vestas Shadow Detection System (VSDS) in order to meet the Ordinance requirement.

Section 3
Estimated Potential Shadow Flicker

Figure 1 shows the predicted number of occupied structures that may receive shadow flicker, the predicted average hours per year, and the locations of unpooled parcels containing occupied structures in the project area. The shadow flicker contour data can be compared with the locations of unpooled parcels containing occupied structures to assess the number of hours shadow flicker may be observed by occupants, not taking into account any shadow blocking by terrain features, trees, or other structures such as barns, silos, and garages.

Table 1 summarizes a predictive shadow flicker by occupied structure, WTG, and average hours per year. The total predicted shadow flicker hours by occupied structure is included.

Section 4
Shadow Flicker Mitigation

The Mason County Special Land Use Permit for the Project stipulates that the Project cannot cause more than 10 hours per year of shadow flicker on any unpooled parcel containing an occupied structure. In order to prevent a violation of this condition, Consumers Energy gathered data to determine when shadow flicker could occur at all unpooled parcels containing occupied structures that are predicted to receive over 8 hours of shadow flicker in an average year (refer to Table 1). The 8 hour threshold was selected to add a 20 percent buffer to the average year conditions in order to account for years or months that may have more sun or a higher coincidence of wind direction and sun position than the average considered in RMT's June 2011 shadow flicker study.

The modeling methodology used for this analysis is the same as described in the June 2011 Shadow Flicker Study (Revision 1) prepared by RMT. This study showed 40 unpooled parcels containing occupied structures could have 10 hours per year of shadow flicker. For this analysis, the WindFarmer® shadow flicker model was updated to include only the 56 turbines that are being constructed, with a model year of 2012 used for sun patterns throughout each day. Data for each of the 57 unpooled parcels containing occupied structures that are predicted to receive over 8 hours per year of shadow flicker in an average year is attached in Table 1. This data indicates all the time when shadow flicker could occur (i.e. the adjustment factors for typical year cloudiness and wind-sun angle coincidence were not applied). In Table 1, the data is summarized for each occupied structure by turbine number, as well as summed over the year. Figure 1 shows contours for the average year expected shadow flicker covering the entire Project.

Based on the results shown in Table 1, 47 wind turbine generators (WTGs) could contribute shadow flicker at unpooled parcels containing occupied structures that are predicted to receive over 8 hours of shadow flicker in an average year. These turbines, shown on Figure 2 as a turbine location with an 'X' surrounded by a box, will be equipped with a Vestas Shadow Detection System (VSDS) in order to monitor and mitigate shadow flicker at these occupied structures.

VSDS is an integrated system designed to stop the turbine in order to control a shadow flicker situation that could result in the 10-hour limit being exceeded. The VSDS system (primary mitigation method) consists of two light intensity sensors with a shadow controller (refer to Figure 3). Sensors are mounted on the east and west side of the WTG tower. A difference in light intensity readings acts as a measure of shadows. The shadow controller (configured for

each WTG) has physical site and time schedule data with which it can detect a shadow flicker condition at each receptor (occupied structure) location. When this condition occurs, the WTG will be paused as necessary to maintain compliance with the 10-hour limit.

The system operates by using calculations for a potential receptor. The shadow VSDS controller uses a shadow flicker timetable for clear weather (with the time and light intensity difference) to find the 'time window' where the controller is enabled. If the calculations indicate that the intensity of the sunlight is strong enough to cause a shadow flicker, and values exceed limits, the WTG will be paused for the remaining part of the shadow time window. The shadow controller is configured by programming a Subscriber Identity Module (SIM) card with a PC and then inserting the card into the VSDS shadow controller.

If a shadow flicker condition occurs during the time window, and the turbine is stopped, the WTG will remain paused for the time remaining in the window, even if the light intensity in this period drops below the light intensity difference threshold. At the conclusion of the time window, the turbine will be automatically re-started. As the VSDS controller takes action to start or pause the WTG, the event is logged.

Additional study may be performed at particular locations to determine the degree to which terrain features, nearby structures, and other obstacles will block turbine shadows in order to support compliance with the ordinance requirements. In addition, if new occupied structures are constructed on unpooled parcels in the future, the 10-hour per year limit and corresponding mitigation strategy will apply to those locations which may result in adding a VSDS system to the turbine(s) which are not currently equipped with VSDS. Alternate mitigation strategies in place of or in concert with WTG pause, such as strategic planting of trees, window coverings, or awnings, could be utilized to reduce shadow flicker impacts if desired by a resident, to the extent that the alternative strategy complies with the zoning ordinance requirements. Table 1 includes columns for alternate mitigation methods.

Table 1
Summary of Shadow Flicker for Occupied, Unpooled Structures for Greater Than 8 Hours / Year

Table 1
Lake Winds Energy Park
Summary of Predicted Shadow Flicker
For Occupied, Unpooled Structures Greater Than 8 Hours / Year

HOUSE ID	PIN NUMBER	WTG	PREDICTED AVERAGE SHADOW FLICKER (HOURS/YEAR)		PRIMARY MITIGATION METHOD	ALTERNATE MITIGATION METHODS			
			BY WTG	TOTAL	STOP WTG	TREES	AWNING	GRADING	COMMENTS
1	011-032-001-00	56	9.4	13.5	X				
		57A	4.1		X				
2	011-029-018-00	54	8.0	12.7	X				
		56	4.7		X				
3	011-029-020-00	51	10.4	21.6	X				
		52	2.6		X				
		53	8.6		X				
4	011-029-016-00	51	7.4	9.7	X				
		52	2.3		X				
5	011-029-007-00	46	8.3	27.8	X				
		47	10.5		X				
		49	6.5		X				
		50	2.6		X				
6	011-014-013-00	39	4.7	10.8	X				
		42	6.1		X				
7	011-029-011-00	47	8.8	8.8	X				
8	011-021-014-60	45	4.9	9.2	X				
		48	4.3		X				
9	011-020-028-20	46	6.9	9.6	X				
		47	2.7		X				
10	011-021-006-10	45	10.3	10.3	X				
11	014-019-020-60	41	3.9	8.7	X				
		43	4.7		X				
12	014-019-007-00	41	13.6	16.2	X				
		43	2.7		X				
13	011-020-014-01	41	6.7	8.9	X				
		43	2.3		X				
14	014-019-003-00	41	10.8	10.8	X				
15	014-113-026-00	33	8.9	8.9	X				

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For Occupied, Unpooled Structures Greater Than 8 Hours / Year

HOUSE ID	PIN NUMBER	WTG	PREDICTED AVERAGE SHADOW FLICKER (HOURS/YEAR)		PRIMARY MITIGATION METHOD	ALTERNATE MITIGATION METHODS			
			BY WTG	TOTAL	STOP WTG	TREES	AWNING	GRADING	COMMENTS
16	014-018-024-00	33	9.6	9.6	X				
17	014-018-024-00	33	11.8	11.8	X				
18	011-014-008-10	34	2.4	20.0	X				
		37	5.7		X				
		39	12.0		X				
19	011-015-004-10	25	4.1	14.2	X				
		28	1.4		X				
		34	1.7		X				
		37	7.1		X				
20	011-017-005-00	27	4.5	25.5	X				
		29	8.9		X				
		30	9.2		X				
		31	3.0		X				
21	011-016-002-00	25	1.9	9.4	X				
		26	7.5		X				
22	011-010-013-00	19	10.1	10.1	X				
23	011-009-016-10	20	3.6	14.2	X				
		22	10.6		X				
24	011-009-016-10	20	3.5	14.3	X				
		22	10.8		X				
25	011-009-016-10	20	3.8	15.2	X				
		22	10.1		X				
		23	1.3		X				
26	011-009-018-00	20	3.5	16.1	X				
		22	12.6		X				
27	011-008-014-00	17	1.5	11.7	X				
		21	7.2		X				
		23	2.9		X				
28	011-008-009-80	20	8.2	8.2	X				

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For Occupied, Unpooled Structures Greater Than 8 Hours / Year

HOUSE ID	PIN NUMBER	WTG	PREDICTED AVERAGE SHADOW FLICKER (HOURS/YEAR)		PRIMARY MITIGATION METHOD	ALTERNATE MITIGATION METHODS			
			BY WTG	TOTAL	STOP WTG	TREES	AWNING	GRADING	COMMENTS
29	011-008-011-50	17	1.6	10.3	X				
		21	3.9		X				
		23	4.7		X				
30	011-010-010-00	15	2.5	14.5	X				
		16	5.0		X				
		18	7.0		X				
31	014-112-004-00	11	2.4	10.2	X				
		13	7.8		X				
32	014-112-001-00	11	2.0	9.7	X				
		13	7.7		X				
33	011-004-015-00	5	0.5	14.1	X				
		8	12.6		X				
		14	1.1		X				
34	011-004-012-50	4	2.7	10.7	X				
		5	2.8		X				
		8	3.1		X				
		15	2.2		X				
35	011-002-012-80	3	3.8	10.6	X				
		9	6.8		X				
36	011-002-013-10	3	7.8	12.9	X				
		9	5.1		X				
37	011-004-012-00	5	3.6	11.2	X				
		8	7.6		X				
38	011-002-012-70	3	12.4	19.5	X				
		9	7.1		X				
39	011-002-012-70	3	10.9	15.6	X				
		9	4.7		X				
40	011-002-010-00	1	6.0	11.6	X				
		3	5.7		X				

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Summary of Predicted Shadow Flicker
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HOUSE ID	PIN NUMBER	WTG	PREDICTED AVERAGE SHADOW FLICKER (HOURS/YEAR)		PRIMARY MITIGATION METHOD	ALTERNATE MITIGATION METHODS			
			BY WTG	TOTAL	STOP WTG	TREES	AWNING	GRADING	COMMENTS
41	011-004-008-01	2	14.2	17.8	X				
		5	3.6		X				
42	011-004-005-70	4	8.3	8.3	X				
43	011-002-008-20	1	5.0	14.2	X				
		3	9.2		X				
44	011-015-011-00	35	5.6	11.2	X				
		36	5.6		X				
45	014-112-001-00	11	2.4	10.9	X				
		13	8.5		X				
46	014-112-001-00	11	1.8	10.5	X				
		13	8.7		X				
47	014-112-001-00	11	1.9	10.4	X				
		13	8.5		X				
48	014-112-001-00	11	2.0	10.1	X				
		13	8.1		X				
49	014-112-001-00	11	2.1	8.5	X				
		13	6.5		X				
50	014-112-001-00	11	2.0	8.7	X				
		13	6.7		X				
51	014-112-001-00	11	1.9	8.6	X				
		13	6.7		X				
52	014-112-001-00	11	2.1	9.6	X				
		13	7.5		X				
53	014-112-001-00	11	2.3	9.0	X				
		13	6.8		X				
54	014-112-001-00	11	2.2	8.3	X				
		13	6.1		X				
55	014-112-001-00	11	1.9	9.4	X				
		13	7.5		X				

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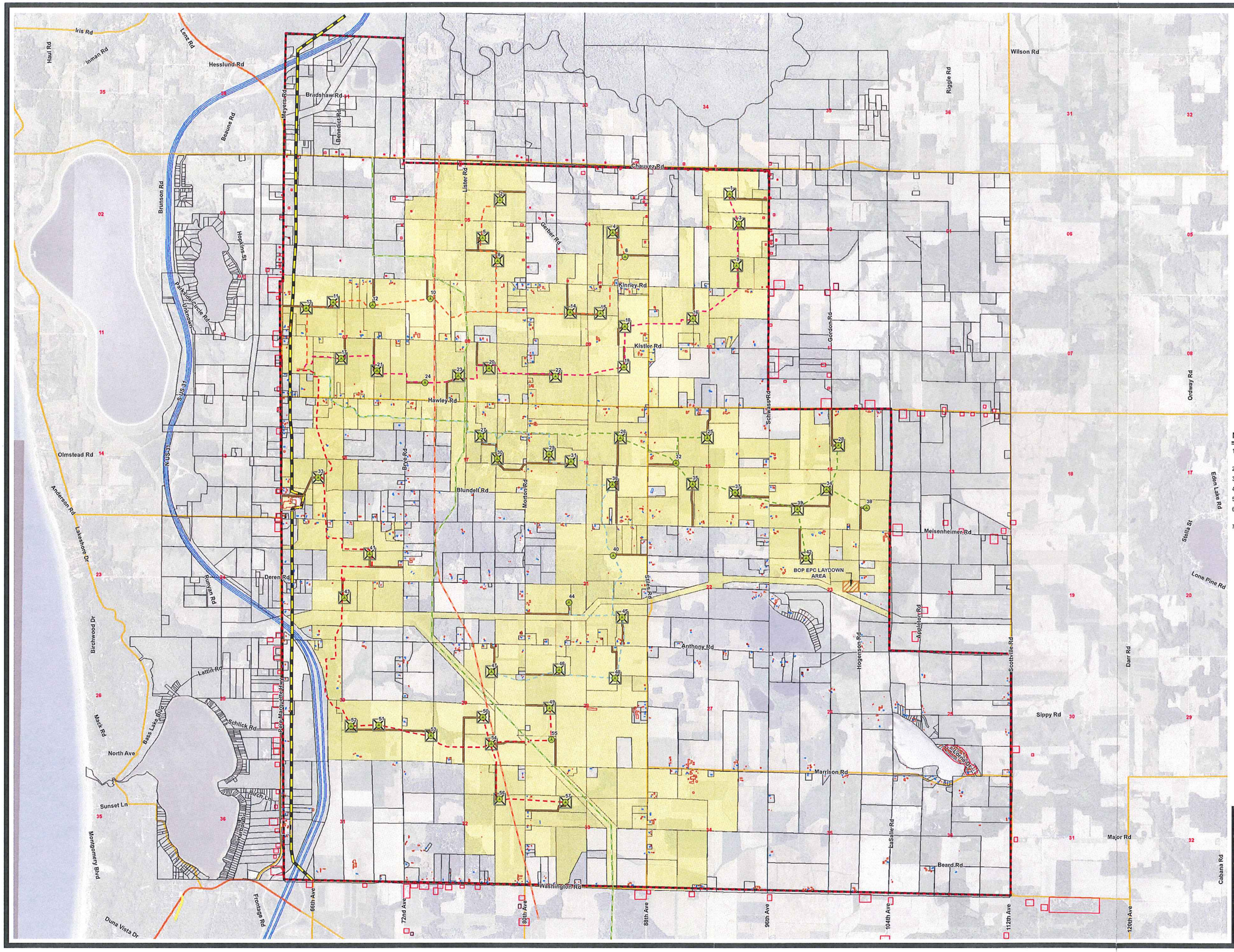
HOUSE ID	PIN NUMBER	WTG	PREDICTED AVERAGE SHADOW FLICKER (HOURS/YEAR)		PRIMARY MITIGATION METHOD	ALTERNATE MITIGATION METHODS			
			BY WTG	TOTAL	STOP WTG	TREES	AWNING	GRADING	COMMENTS
56	014-112-001-00	11	1.9	10.1	X				
		13	8.1		X				
57	014-112-001-00	11	2.2	11.6	X				
		13	9.4		X				

Figure 1
Shadow Flicker Prediction

D:\PRE_TESS_PROJECTS\08405\01\MXD\5209_ShadowFlickerPredictionMap.mxd

Figure 2
Site Plan Overview with Shadow Flicker Detection System



LEGEND

- PROPOSED WIND TURBINE LOCATION
- SHADOW FLICKER DETECTION SYSTEM
- HVD LINE LOCATION FROM LIDAR SURVEY
- PROJECT BOUNDARY
- PARCEL BOUNDARY
- POOLED PARCELS
- AREAS CONTAINING BARN OR GARAGE
- AREAS CONTAINING OCCUPIED STRUCTURES
- AREAS CONTAINING A BUSINESS
- AREAS CONTAINING A CHURCH
- HOUSE
- OTHER BUILDING
- DTE 10" NATURAL GAS PIPELINE
- OMIMEX BASIN SOUR GAS PIPELINE ROUTE
- PROPOSED ACCESS ROAD
- PROPOSED COLLECTOR CIRCUIT

1 2 3 4 5

NOTES:

1. AERIAL IMAGE FROM U.S. DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURAL IMAGERY PROGRAM 2006.
2. ROAD INFORMATION FROM ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE.
3. NOT FOR CONSTRUCTION - FOR INFORMATION ONLY.
4. EASEMENT STATUS DATE DECEMBER 14, 2010.
5. PARCEL BOUNDARIES APPROXIMATE BASED ON PLAT MAPS AND TAX PARCEL MAPS.
6. SOUR GAS PIPELINE LOCATION BASE ON COORDINATES FROM OMINEX GROUP, APRIL 6, 2011.
7. TURBINE 7 HAS BEEN REMOVED FROM THE PROPOSED SITE PLAN AND REPLACED WITH TURBINE 57A.

0 2,000 4,000 FEET

1" = 2,000'

1:24,000

NOT FOR CONSTRUCTION

PROJECT:
LAKE WINDS ENERGY PARK
MASON COUNTY, MICHIGAN

SHEET TITLE:
SITE PLAN OVERVIEW WITH SHADOW FLICKER DETECTION SYSTEM

DRAWN BY:	MCKEEFRY J	SCALE:	PROJ. NO. 00-08405.01
CHECKED BY:	PENNING K	AS NOTED	FILE NO. 8405011140.mxd
APPROVED BY:	KUCHER J	DATE PRINTED:	**FIGURE 2**
DATE:	JUNE 2012	6/25/2012	

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D:\PRE_TESS_PROJECTS\08405\01\MXD\5209_ShadowFlickerDetectionSystem.mxd

Figure 3
Shadow Flicker Control System

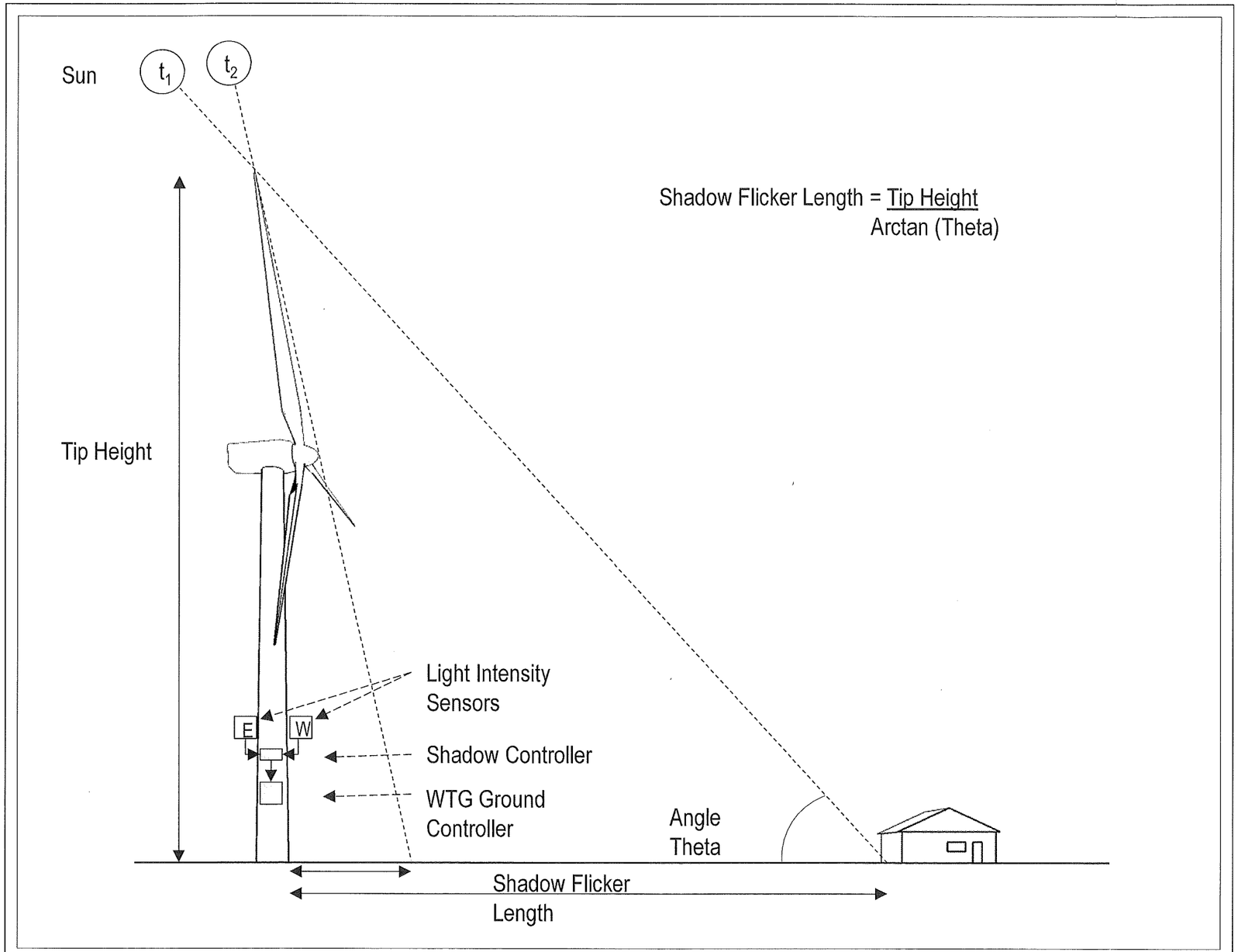

Figure 3: Shadow Flicker Control System

J:\05209\27\ShadowFlicker\Shadow_Flicker_Figure.pptx