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Wind Turbine

wind turbine mitigation analysis

Town of

Falmouth

MASSACHUSETTS

Wind Energy Facility Mitigation Alternatives Analysis

December 2011

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

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EXECUTIVE SUMMARY

At the request of the Town of Falmouth, Weston & Sampson has evaluated the cost of several options associated with operation of the Town-owned wind turbines. The options included dismantling one or both wind turbines, relocation of one or both wind turbines and the cost and revenue impact of curtailing operations to minimize sound, shadow flicker and ice throw. Dismantling both of the wind turbines would cost the Town on the order of $14.69 million dollars. This is based on the $9,857,000 in principal debt incurred to build the projects; $2,983,000 in interest; $838,000 in construction cost to dismantle the turbines, and repayment of approximately $1,010,000 to repay an advance REC payment made to the Town by the MassCEC. These costs assume no revenue generated from operation of the wind turbines.

Relocating each wind turbine to an alternate location would cost approximately $2.0 million per turbine or $4.0 million dollars. This is based on the cost for dismantling, installation of new foundations, and reassembly and commissioning at the alternate location. Major components which could be reused are the wind turbine generators themselves, and potentially electrical components such as switches, transformers, metering and similar hardware. The cost for installation in alternate locations assumes that they are Town-owned land, without any additional cost for use of the land, and with interconnection and permitting certainty.

The resale value of the turbines to a third party, without a manufacturer warranty, is estimated to be on the order of $300,000 each for a total of $600,000, excluding dismantling and shipping costs. The salvage value for the steel and copper is estimated at $102,000 and the miscellaneous components, if there were a buyer for use as spare parts, is valued at $80,000, for a total estimated salvage value of $182,000, also excluding dismantling, material preparation and transportation costs. When considering dismantling, material preparation and transportation costs, the salvage value is near zero.

Operating the wind turbines generates revenue for the Town from energy production (net metering credit) and renewable energy certificates (RECs). The annual revenue from the operation of both wind turbines is expected to be $975,000. Any time the wind turbines are not operating, whether through voluntary curtailment or down time due to circumstances beyond the Owner's control, revenue is lost. In general, there are seasonal variations in average wind speed which affects generating capacity of the wind turbines. The higher average wind speeds, the higher the resulting revenue. Expected revenues are highest in the winter months ($265,557), followed by spring ($254,203) and fall ($239,900), with less wind and revenue expected during the summer ($216,161). Shutting down of both wind turbines concurrently for a six months period, would cost the Town on the order of $453,000 to $523,000, depending upon which months the turbines were shut down.

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Any curtailment of the wind turbine operation will have an impact on revenue. Statistically, the operation of both wind turbines generates $111.30 per hour ($975,000/8,760 hours per year). The current curtailment, which has Wind I turbine operation suspended when the average wind speeds are at or above 10 meters per second (in place since March 1, 2011) has resulted in "lost" revenue of approximately $325,000 through November 31, 2011 (nine months). Curtailment under this scenario would result in full year revenue losses of approximately $500,000 per turbine. The actual dollar amount will vary, based on actual versus predicted wind conditions.

Based on the prior sound studies and modeling, sound impacts above 10 dBA were predicted to occur only during light winds and quietest background sound levels, which occur between 12:00 midnight and approximately 3:00 am. A curtailment plan for the wind turbines, consisting of increased cut in speeds from 3.5 meters per second to 8.0 meters per second during night time hours of 12:00 midnight to 3:00 am, would result in operational curtailment of approximately 694 hours and annual revenue losses of approximately $38,500 per year. An expanded curtailment plan for the wind turbines, consisting of increased cut in speeds from 3.5 meters per second to 8.0 meters per second for one turbine during night time hours of 11:00 pm to 5:00 am, would result in operational curtailment of 1,388 hours per year and annual revenue losses of approximately $77,000 per year.

HMMH began the sound insulation feasibility evaluation by conducting an on-site survey of existing home constructions. Nine homes were inspected in total. The study suggests sound insulation would provide modest improvement (4 to 8 decibels) in the homes with windows closed. Six of the 9 homes we surveyed would likely require air conditioning to be added, so the windows could be closed during noisy periods in the summer and the sound insulation treatment would work. The cost is estimated to be about $30,000 per home with central A/C and $45,000 per home that does not currently have central air conditioning.

Physical noise barriers (i.e. sound walls) were determined to be prohibitively expensive an impractical based on a cost benefit analysis. The barriers likely could not be placed close enough to the homes to have a significant effect. It is estimated that the walls would need to be 40-45 feet high to benefit the first floor of homes closest to Blacksmith Shop Road, with 7 to 9 decibels of noise reduction, assuming it is located 25 feet north of the road. A 50 foot high wall would be needed to improve second floors. The cost of the sound wall is estimated to be $250,000 to $500,000 per home benefited.

Design and implementation of control technology to minimize shadow flicker would have an initial cost of $15,000. A curtailment plan for the wind turbines, consisting of shutting down the turbines to mitigate the occurrence of flicker at a specific receptor which experiences 25 hours of flicker annually, might result in annual revenue losses of approximately $2,780 per year per receptor.

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Design and implementation of automated control technology to minimize the potential for ice throw would have an initial cost of $25,000. Use of lower technology, operational awareness and usury (human) intervention would have an initial cost of approximately $5,000. Curtailment due to automated ice detection is estimated to results in projected annual down time as much as 40 hours per year, or revenue losses of approximately $4,450 per year. Ice detection equipment for use in curtailment is only in experimental stages of development, and is not considered fool proof. The risk for significant ice throw is considered relatively low.

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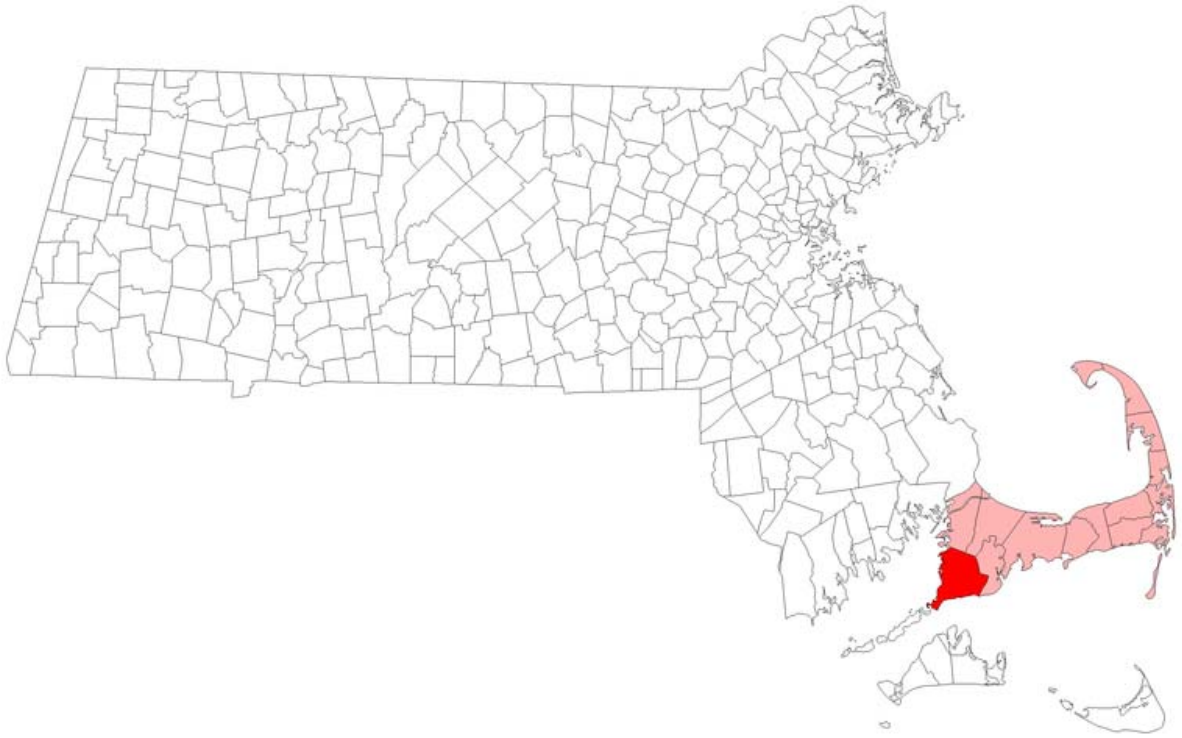
1.0 COST AND BENEFIT OF TURBINE OPERATION

1.1 Cost Benefit Analysis

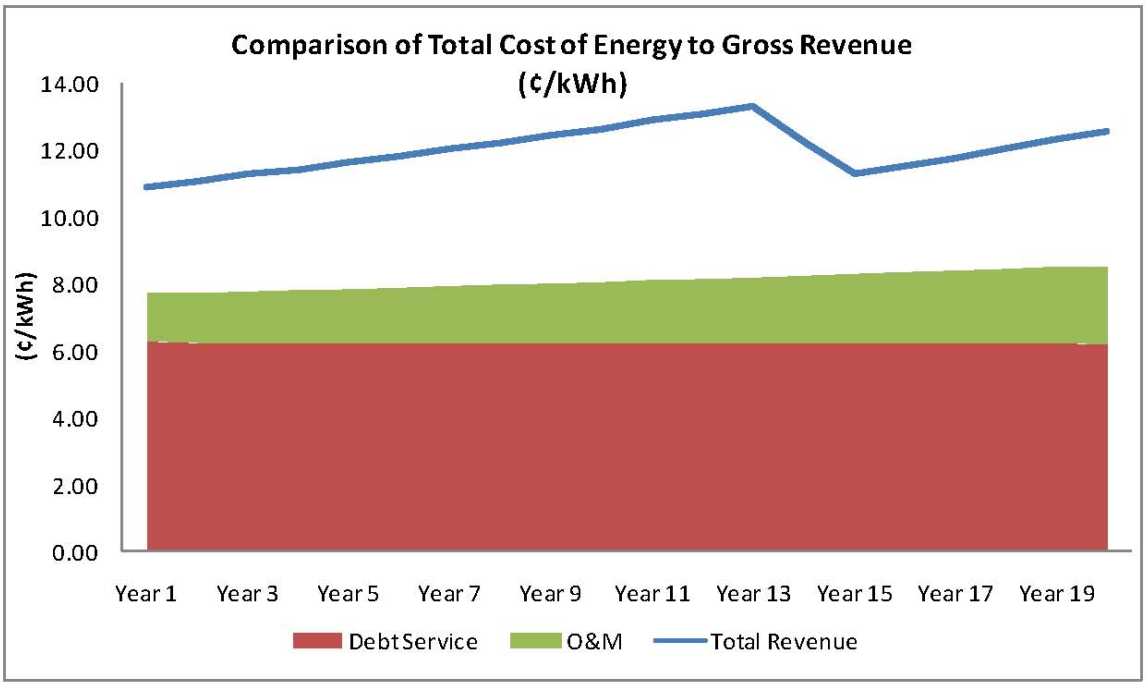
A cost benefit analysis was conducted as part of a feasibility study which examined the financial and technical viability of developing a wind project in the Town of Falmouth in southeast Massachusetts. The location of the Town is illustrated in Figure 1-1. A Feasibility Study Report, dated November 2005, prepared by KEMA, Inc., suggested the project was technically and economically feasible, based largely on the favorable wind conditions at the site. The economic viability of the project increased dramatically with passage of the Green Communities Act in July 2008, when the generator size eligible for net metering increased from 60 kW to 2 MW.

Figure 1-1
Project Location Map



The energy production from operating the wind turbines is calculated based on wind probability statistics and the manufacturer's published power curve. A cost benefit analysis was prepared by Sustainable Energy Advantage (SEA) and presented to the Town of Falmouth Financial Committee in October 2007. The cash flow model presented suggested that the project was economically viable.

Figure 1-2
Cost Benefit Analysis of Wind I



(SEA, 2007)

The cash flow model prepared by SEA indicated that the project had a net present value of $1,905,000, 20-years cash flow of $3,338,000 and positive cash flows starting in Year 1 of $134,000 and growing to as much as $217,000 a year. Year over year cash flow will rise and fall based on the value of net metering credits (i.e. retail cost of electricity) and the value of RECs.

Figure 1-3
Cash Flow Model for Wind I

Results of Economic Analysis[i]

Summary Statement of Cash Flows					
	Total Revenue	Total O&M	Debt Service	Annual Cash Flow	Cumulative Cash Flow
Year 1	$462,000	($62,000)	($266,000)	$134,000	$134,000
Year 2	$470,000	($63,000)	($264,000)	$143,000	$277,000
Year 3	$479,000	($65,000)	($264,000)	$150,000	$427,000
Year 4	$485,000	($67,000)	($264,000)	$154,000	$581,000
Year 5	$493,000	($68,000)	($264,000)	$161,000	$742,000
Year 6	$501,000	($70,000)	($264,000)	$167,000	$909,000
Year 7	$511,000	($72,000)	($264,000)	$175,000	$1,084,000
Year 8	$518,000	($74,000)	($264,000)	$180,000	$1,264,000
Year 9	$527,000	($75,000)	($264,000)	$188,000	$1,452,000
Year 10	$536,000	($77,000)	($264,000)	$195,000	$1,647,000
Year 11	$546,000	($80,000)	($264,000)	$202,000	$1,849,000
Year 12	$554,000	($81,000)	($264,000)	$209,000	$2,058,000
Year 13	$564,000	($83,000)	($264,000)	$217,000	$2,275,000
Year 14	$521,000	($85,000)	($264,000)	$172,000	$2,447,000
Year 15	$479,000	($88,000)	($264,000)	$127,000	$2,574,000
Year 16	$489,000	($90,000)	($264,000)	$135,000	$2,709,000
Year 17	$499,000	($92,000)	($264,000)	$143,000	$2,852,000
Year 18	$510,000	($94,000)	($264,000)	$152,000	$3,004,000
Year 19	$523,000	($97,000)	($264,000)	$162,000	$3,166,000
Year 20	$533,000	($99,000)	($262,000)	$172,000	$3,338,000
				Cumulative Net Cash Flow to Town:	**$3,338,000**
				Net Present Value of Cumulative Net Cash Flow @ 5.5%:	**$1,905,000**

(SEA, 2007)

The actual year over year cash flow is affected by several factors, including actual energy production, which can vary from month to month and year to year, also due to numerous other factors. The variables include actual wind speeds, losses due to grid and equipment downtime, maintenance and repair activities and voluntary curtailment.

1.2 Wind Turbine Benefits

The Town of Falmouth derives financial benefit from three sources: 1 - retail offset for wastewater treatment facility (WWTF) at 154 Blacksmith shop Road; 2 - from net metering credit for excess energy sent to the grid; and 3 - from sale of renewable energy certificates (REC) for each megawatt hour (MWh) of electricity produced from the wind turbines. One MWh is equal to one REC and 1,000 kilowatt hours (kWh). The value of the energy produced is subject to changes in the market rates for the net metered energy produced and contracted rate for the RECs.

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Weston & Sampson prepared an updated cash flow model for both Wind I and Wind II, presented in Table 1-1 below. The model assumptions include a 2% annual increase in electricity costs (i.e. net metering credit value) and a REC value of $45 for Wind I in years 1 to 5, and $0 for Years 6 through 20 (since they have been pre-paid by MassCEC). A conservative REC value of $20.50 has been used in Years 1 through 20 for Wind II.

Table 1-1
Summary Statement of Cash Flows
Combined Wind I and Wind II

Year	Total Revenue	Total O&M	Debt Service	Annual Cash Flow	Cumulative Cash Flow
1	$531,300	($90,000)	$0	$441,300	$441,300
2	$974,874	($90,000)	($354,551)	$530,323	$971,623
3	$989,783	($90,000)	($387,705)	$512,078	$1,483,701
4	$1,004,989	($160,000)	($425,916)	$419,073	$1,902,774
5	$1,020,500	($160,000)	($421,638)	$438,862	$2,341,636
6	$876,931	($168,000)	($417,169)	$291,762	$2,633,397
7	$893,068	($176,400)	($407,706)	$308,962	$2,942,359
8	$909,528	($185,220)	($398,306)	$326,002	$3,268,361
9	$926,317	($194,481)	($386,306)	$345,530	$3,613,891
10	$943,442	($204,205)	($378,981)	$360,256	$3,974,146
11	$960,909	($219,520)	($368,931)	$372,458	$4,346,604
12	$978,726	($235,984)	($358,881)	$383,861	$4,730,465
13	$996,899	($253,683)	($351,356)	$391,860	$5,122,325
14	$1,015,436	($272,710)	($338,456)	$404,270	$5,526,595
15	$1,034,343	($293,163)	($334,334)	$406,846	$5,933,442
16	$1,053,629	($315,150)	($325,275)	$413,204	$6,346,645
17	$1,073,300	($338,786)	($320,650)	$413,864	$6,760,509
18	$1,093,365	($364,195)	($310,500)	$418,669	$7,179,178
19	$1,113,830	($391,510)	($304,988)	$417,333	$7,596,511
20	$1,134,706	($420,873)	($294,375)	$419,458	$8,015,969
Cumulative Net Cash Flow to Town					$8,015,969
Net Present Value of Cumulative Net Cash Flow @ 5.5%					$4,839,254

The wastewater treatment facility (WWTF) uses an average of 1,200 MWh of electricity annually. The facility was converted to a primary metering facility, prior to the interconnection of Wind I in 2010, where the rate for energy is on the order of $105 MWh or $0.105 per kWh. The energy produced by the wind turbine is metered through the WWTF account, where the facility's electrical energy demands are met first, with credit accrued for the excess energy. The credits are monetized (paid) by NSTAR to the Town on a monthly basis in the form a check. The amount of each credit is dependent upon the amount of excess energy produced. If no energy

is produced, the facility would receive a bill, as usual. The average monthly electric usage costs are on the order of $10,000 to $12,000 per month, for a total annual cost of $120,000 per year.

The Town is contracted with the Cape & Vineyard Electric Cooperative (CVEC), a load serving entity obligated to meet Renewable Portfolio Standards under Massachusetts laws, for years one through five at a rate of $45 per MWh or per REC. The RECs are tracked by the ISO-NE, minted (certified) and paid to the Town by CVEC on a quarterly basis.

The Town was a participant of the State's Community Wind Program administered by the Massachusetts Clean Energy Center (MassCEC and formerly the Massachusetts Technology Collaborative or MTC) and received the State's standard financial offer (SFO). The SFO allowed the MassCEC to hire consultants to perform wind measurement program, prepare the feasibility study, Phase I Avian Study and other related services with no out-of-pocket expense to the Town. The SFO contained provisions to pre-purchase RECs for years six through 20 of the project, thus increasing the certainty of the project's financial success. The contracted rate for these RECs is valued at $42/MWh.

In order to help the Town pay initial design, procurement and construction costs, the MassCEC agreed to pre-pay the present value of the RECs in one lump sum payment to the Town. Based on the expected energy production and net present value, the REC payment received by the Town was $1,010,623.

These pre-paid REC funds allowed the Town to proceed to construction and later define its borrowing amounts, funded through two general obligation bonds (GOB), which total $4,992,000. An updated revenue model, with revenue estimates and cash flow for both Wind I and Wind II is provided in Table 1-1 above.

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

Table 1-2
Falmouth Energy Production and Revenue Forecast
Operate As Designed

Month	A Wind I Forecast MWh/ Month	B Wind II Forecast MWh/ Month	C Estimated Net Metering Credit, MWh (WI & II)	D Wind I* REC Revenue, MWh	E Wind II** REC Revenue, MWh	F Total Forecasted Revenue, Month
January	327	327	$105.00	$45.00	$20.50	$90,092
February	308	308	$105.00	$45.00	$20.50	$84,931
March	311	311	$105.00	$45.00	$20.50	$85,816
April	314	314	$105.00	$45.00	$20.50	$86,405
May	298	298	$105.00	$45.00	$20.50	$81,982
June	268	268	$105.00	$45.00	$20.50	$73,725
July	247	247	$105.00	$45.00	$20.50	$68,122
August	270	270	$105.00	$45.00	$20.50	$74,315
September	268	268	$105.00	$45.00	$20.50	$73,872
October	295	295	$105.00	$45.00	$20.50	$81,245
November	308	308	$105.00	$45.00	$20.50	$84,783
December	329	329	$105.00	$45.00	$20.50	$90,534
Total	3,542	3,542			Total	$975,821

Forecasted revenue = A * (C + D) + B * (C + E)
* Contract rate with CLC for years 1-5 (2010-2015) for Wind I
** Estimated value of Class I REC rate 2011-2012; Wind II is not yet under contract for RECs

1.3 Wind Turbine Costs

The Town of Falmouth has costs associated with the operation and maintenance of the wind turbines. The costs are primarily the principal and interest on the two bond obligations and operation and maintenance, which includes electronic metering, monitoring and administrative expenses. The total cost for development of both wind turbines is approximately $9,857,000.

The bond debt for Wind I is based on two general obligation bond issues with a combined principal of $4,992,000 over 20 years and the annual payment amount is not fixed from year to year. The principal and interest costs in the Town's fiscal year 2011 are $379,318 and the O&M

expenses are $98,104, for a total cost of $477,422.

The Wind II project was funded through an ARRA grant with 100% forgiveness of the principal and interest, which is, therefore, a grant from the federal government for a fixed maximum cost. The O&M expenses will increase after Year 3, when the service contract (paid as part of construction) expires and becomes the responsibility of the Town for the rest of the useful life of the turbines. Like any man made machines, wind turbines require increased care and thus, become more expensive to maintain in later years. It is also wise to establish a budget for unscheduled maintenance and repairs for unforeseen equipment replacement after warranties have expired.

There are some simple financial figures of merit which are often useful in the evaluation of the financial viability of renewable energy projects, such as net present value, cost to benefit ratio, annual cash flow and simple payback. There is common misapplication of the term payback, when cash is not used to finance a project and borrowing or debt is involved. The Falmouth wind turbine projects were designed and developed based on the strong likelihood of positive cash flow and significantly positive net present value over the life of project. The positive cash flow and significant NPV however, was based on operating the wind turbine as designed and specified. Curtailing operations has had a significant impact on cash flow and will continue to negatively erode the projected financial performance where the benefits will be less than the cost and thus a financial burden, rather than an asset, to the Town.

1.4 Financial Impacts of Curtailment

A curtailment plan for the wind turbines, consisting of increased cut in speeds from 3.5 meters per second to 8.0 meters per second for one of the turbines is the current design recommendation, in which modeling results suggest no violations of DEP sound policies will occur during the quietest night time hours of approximately 12:00 midnight to 3:00 am. This curtailment, once Wind II is commissioned, is expected to result in slightly less production from the curtailed turbine. The modeling suggests the operation of either Wind I or Wind II could be curtailed in order to satisfy the DEP sound policy compliance requirements. This action is expected to result in annual average revenue losses of approximately $15,563 per year.

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

Table 1-3
Falmouth Energy Production and Revenue Forecast
Modified Operation of Wind I or II
Increase Cut-In Speed to 8ms from 12 midnight to 3:00 a.m.

Month	A Wind I Forecast MWh/Month	B Wind II Forecast MWh/ Month	C Estimated Net Metering Credit, MWh (WI & II)	D Wind I* REC Revenue, MWh	E Wind II** EC Revenue, MWh	F Total Forecasted Revenue, Month
January	327	316	$105.00	$45.00	$20.50	$88,655
February	308	297	$105.00	$45.00	$20.50	$83,576
March	311	301	$105.00	$45.00	$20.50	$84,447
April	314	303	$105.00	$45.00	$20.50	$85,027
May	298	287	$105.00	$45.00	$20.50	$80,674
June	268	258	$105.00	$45.00	$20.50	$72,549
July	247	239	$105.00	$45.00	$20.50	$67,035
August	270	260	$105.00	$45.00	$20.50	$73,129
September	268	259	$105.00	$45.00	$20.50	$72,694
October	295	285	$105.00	$45.00	$20.50	$79,949
November	308	297	$105.00	$45.00	$20.50	$83,431
December	329	317	$105.00	$45.00	$20.50	$89,090
Total	3,542	3,418				$960,258

Forecasted revenue = A * (C + D) + B * (C + E)
* Contract rate with Cape Light Compact for years 1-5 (2010-2015) for Wind I

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

2.0 COST TO REMOVE WIND I AND WIND II

2.1 Decommission and Removal Procedure and Costs

Analysis of this option is first based on cost for the Town to hire a Contractor to dismantle the wind turbines. The turbines would then presumably be stored on site, transported and re-installed on another site, sold or scrapped for the salvage value of the turbines. Essentially, dismantling of the turbines is the reverse order of erection. There is a variety of equipment and specialized labor required to dismantle a wind turbine; including a large (300 ton, 300 foot tall) crane, smaller 75-ton "tailing" or "helper" crane needed to assist the large crane, as well as rigging, slings, tag lines and tools to accomplish the job. There are a limited number of cranes of this size that are available and therefore, long lead time and premium fees are typical. The large crane needed for the task is shipped to the site in multiple pieces and assembled on site.

The crane assembly alone generally requires one week for transporting and assembling. The cranes pad site requires ground improvements and wooden cribbing to minimize the potential for sudden differential settlement. The number of personnel needed for the erection or dismantling of a wind turbine is 11 to 12 individuals, including operators for each crane, two man rigging crew for the crane, two up-tower, two down-tower, plus labors and line tenders. The cost for the cranes, rigging, tools and labor is on the order of $350,000 per turbine, plus project management and coordination. The cost for removal of the second wind turbine would be perhaps $50,000 less, as the large crane would still need to be dismantled and re-built for the second location. Additional cost for preparation of the crane pad and storage area would result in a total cost of approximately $838,000.

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

Table 2-1
Estimated Cost to Dismantle Both Wind Turbines

Task	Cost/Value	Quantity	Total
Dismantle WTG, Crane and Rigging, per turbine	$350,000	2	$700,000
Preparation of On Site Storage Area, each	$30,000	1	$30,000
Short/Long Term Care, month	$4,500	24	$108,000
Sale (No Warranty)	$300,000	2	$600,000
Or Salvage Value	$51,000	2	$102,000

The storage area sub-grades must be stabilized and level and specialized racking must be provided to maneuver and store each tower section, hub, blades and nacelle. Other sensitive electronic components, located within the nacelle and first two stories of the turbine, should be removed and stored in a climate-controlled environment. This can be accomplished on site, or off site. On site storage would require the construction of appropriate storage shed or other suitable covered storage to protect sensitive equipment or arrange for off-site storage.

Wind turbines are design for operation and not long term storage. Equipment must be rotated manually and lubricated regularly to prevent the development of flat spots in major bearings, which would result in premature failure if and when the unit is placed back into service.

2.2 Costs to Remove Turbines and Abandon Facility

The cost for the preparation of a staging area, equipment and short term care would be on the order of $75,000, plus $35,000 per year of short or long term preventive maintenance and care. There is a small market for used wind turbines and sale of the turbines “as is” may be possible, if there were any interested buyers. The value of turbines would be higher if the manufacturer’s warranty were still in place and available to a new owner. Weston & Sampson contacted Blue Sky Wind, LLC of White Plains, NY, and inquired about the potential value of the turbines. Blue Sky suggested that if a warranty continued with the turbines, they would have a value in the range of $400,000 to $600,000 each. Without a warranty, the value would be $300,000 to $400,000 each and taking them down and shipping would run $200,000 to $300,000 each,

depending on how far they needed to be transported. Based on the warranty and service agreement with Vestas, no warranty would likely be available to a new Owner. Therefore, a value for each turbine of $300,000 should be used for planning level budgeting purposes.

2.3 Salvage Value

If a buyer could not be found, there is the possibility of scrap salvage value for the wind turbine components. Raw materials which have salvage values are generally steel (tower) and copper (generator windings and wiring). The wind turbine consists of four steel tower sections, totaling 119,500 kilograms (approximately 131.7 tons) of steel. There are an estimated five tons of copper in the wiring and windings of the generator and transformer for each wind turbine. According to Gateway Metal Recycling of Salem, NH, the salvage value for No.1 unprepared steel, at the time of this assessment, was $270 per ton and value of electric motor and generator copper (unprepared) was on the order of $600 per ton. When contacted, representatives from Gateway Metals warned of high volatility and downward pricing on the scrap steel market, suggesting prices could go down by $100 per ton over a short period of time.

Based on this data, the scrap value of steel and copper is estimated to be $51,000 per turbine, or $102,000 total, less the cost of some minor materials preparation and transportation. No scrap value is assigned for the blades, which are composed of wood and fiberglass. The cost of preparation and transportation could be on the order of $30,000, resulting in a net scrap value of $72,000. The various components may also have some residual value as spare parts for use by other wind turbine owners with the same make and model wind turbine. For the purpose of this estimate, a value of $40,000 for each turbine has been assigned as a value for spare parts, provided you could find a willing buyer.

The cost estimate for dismantling and salvage value of the wind turbines should be considered a planning level evaluation and implementation cost from the information available at the time the estimate was prepared. The final cost or value of the project will depend upon the actual labor, materials and market conditions at the time the project is undertaken and advertised for competitive; therefore, actual amounts may vary from the values provided herein. Below is an estimated cost for turbine removal, and resale or salvage:

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Table 2-2
Estimated Salvage Value

Item Description	Salvage Weight	Unit	Rate (11/1/11)	Total
Tower (Four Sections)	131.7	Ton	$270.00	$35,559.00
Nacelle (Gearbox, Frame, etc.)	28.0	Ton	$270.00	$7,549.20
Copper (Generator)	16,020	Pound	$0.30	$4,806.00
Copper (Transformer)	8,100	Pound	$0.30	$2,430.00
Copper Cabling	2,500	Pound	$0.35	$875.00
Total, each turbine				$51,219.20
Total Salvage				$102,438.40

2.4 Debt Obligations

The cost associated with dismantling the turbines must be added to debt encumbered by the Town to procure and install each of the wind turbines. The Town is obligated to deliver RECs to the Massachusetts Clean Energy Center as part of the Standard Financial Offer under the Community Wind Program, in which the Town is a participant. The Town would likely be required to repay the $1,010,623 it received from the Renewable Energy Trust as prepayment for the RECs scheduled to be generated in years 2015-2029. The contract stipulates that the turbine output not fall below 30% of the forecasted production.

The Town used this advance payment to assist in the short term project construction costs. The DEP has indicated that the Wind II project funding, which was administered by the DEP under the State Revolving Funds (SRF) program with 100% forgiveness of both principal and interest (i.e. ARRA Grant), would revert to the standard 2% loan, if the wind turbine was not used for generating electricity as the Town intended and represented in the application for funding. The principal and interest debt repayment schedule for Wind I is provided in Table 2-3.

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Table 2-3
Wind I Debt Repayment Schedule

Year	Principal	Interest	Total
2011	$215,000	$139,551	$354,551
2012	$215,000	$172,705	$387,705
2013	$252,000	$173,916	$425,916
2014	$255,000	$166,638	$421,638
2015	$260,000	$157,169	$417,169
2016	$260,000	$147,706	$407,706
2017	$260,000	$138,306	$398,306
2018	$260,000	$126,306	$386,306
2019	$265,000	$113,981	$378,981
2020	$265,000	$103,931	$368,931
2021	$265,000	$93,881	$358,881
2022	$270,000	$81,356	$351,356
2023	$270,000	$68,456	$338,456
2024	$275,000	$59,334	$334,334
2025	$275,000	$50,275	$325,275
2026	$280,000	$40,650	$320,650
2027	$280,000	$30,500	$310,500
2028	$285,000	$19,988	$304,988
2029	$285,000	$9,375	$294,375
Total	$4,992,000	$1,894,025	$6,886,025

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3.0 COST TO RELOCATE WIND I AND WIND II

3.1 Relocating Wind I and Wind II

The Town requested that Weston & Sampson provide an estimate of the cost to relocate the wind turbines, presumably to another Town-owned property. This could also include relocation of one or both of the wind turbines within the footprint of the WWTF property.

The major construction tasks include delivery of equipment to the construction sites. This task requires a 300 ton to erect and dismantle the turbines and a 75 ton crane and specialized trailers designed to accommodate moving the components based on the size and dimensions of the tower, nacelle and blades, with care to prevent damage to the components, especially the blades.

3.2 Estimated Costs to Relocate Wind Turbines

The costs to relocate the wind turbines would be comparable to the original cost for design, permitting and installation of each of the first two wind turbines. There are certain tasks, such as wind measurements studies and Phase I Avian Studies, which would not necessarily need to be repeated, whiles some studies, such as geotechnical exploration, air space obstruction analysis and electrical interconnection studies and processes, would be considered essential. The costs associated with engineering design and permitting would generally tend to follow industry standard fees that could be estimated as a percentage of construction cost. The items that would be included are geotechnical studies, civil, structural and electrical design plans and specifications. Items which are unique to wind turbines, include additional studies, such as wind measurement programs, avian studies, shadow flicker, sound impact studies, etc. which, if necessary, increase project costs.

Based on the Town's recent experience with bidding of the first two projects, and the number of other similar projects in the Commonwealth, the Town could reasonably rely on cost data for most of the elements of turbine relocation. Also, the wind turbines themselves as a capital expenditure represent approximately 60% of the

total value of each project, which the Town would already own, serves to increase the cost estimate certainty. Other tasks cannot however, be estimated or the outcome predicted, until actual locations are selected.

The turbine foundation represents a significant percentage of the contract value. The foundation systems for the two existing wind turbines consist of a 32-foot deep by 14-foot diameter outer corrugated metal pipe (CMP) set around a 10-foot diameter inner CMP, with anchor bolts running the full depth. The annular space and cap is then filled with reinforcement steel and concrete. The complete foundation system is on the order of $500,000 for each turbine.

The wind turbine is connected to the electrical distribution grid through an electrical duct bank with 25 kilovolt (kV) cabling and includes current transforms, protective relays, switches, meters, various manholes, and related appurtenances. The average cost for electrical infrastructure improvements is on the order of $400,000, including a nominal length of concrete encased underground duct bank of 1,000 feet.

Increased distances can be covered using traditional overhead lines, where permitted; however, the cost could also be higher for greater distances if placed underground. The installed cost of utility grade switches and 600 volt to 23,000 volt transformers are $50,000 and $75,000, respectively. Balance of plant construction items, such as communication cabling, pad and tower grounding, road cuts and asphalt patching, fencing, loam and seeding, and testing and commissioning, are estimated to cost on the order of $310,000.

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Table 3-1
Estimated Cost to Relocate Wind Turbines

Task	Cost, per turbine	Quantity	Total
Planning, Design, Permitting	$200,000	2	$400,000
De-Commission Wind Turbine	$210,000	2	$420,000
General Conditions, Bond, Insurance, Mob.	$225,000	2	$450,000
Site Work and Preparation	$100,000	2	$200,000
WTG Transport	$125,000	2	$250,000
Wind Turbine Foundation	$400,000	2	$800,000
WTG Installation, Crane and Rigging	$350,000	2	$700,000
Primary Electrical Duct, Conduit and Cabling	$125,000	2	$250,000
Transformers and Switches	$200,000	2	$400,000
Manhole Frames and Covers	$50,000	2	$100,000
Communication Cabling	$15,000	2	$30,000
Pad and Tower Grounding	$25,000	2	$50,000
Road Cuts and Asphalt Patching	$25,000	2	$50,000
Fencing	$25,000	2	$50,000
Loam and Seeding	$15,000	2	$30,000
Testing and Re-Commissioning	$150,000	2	$300,000
Total Cost			$4,480,000

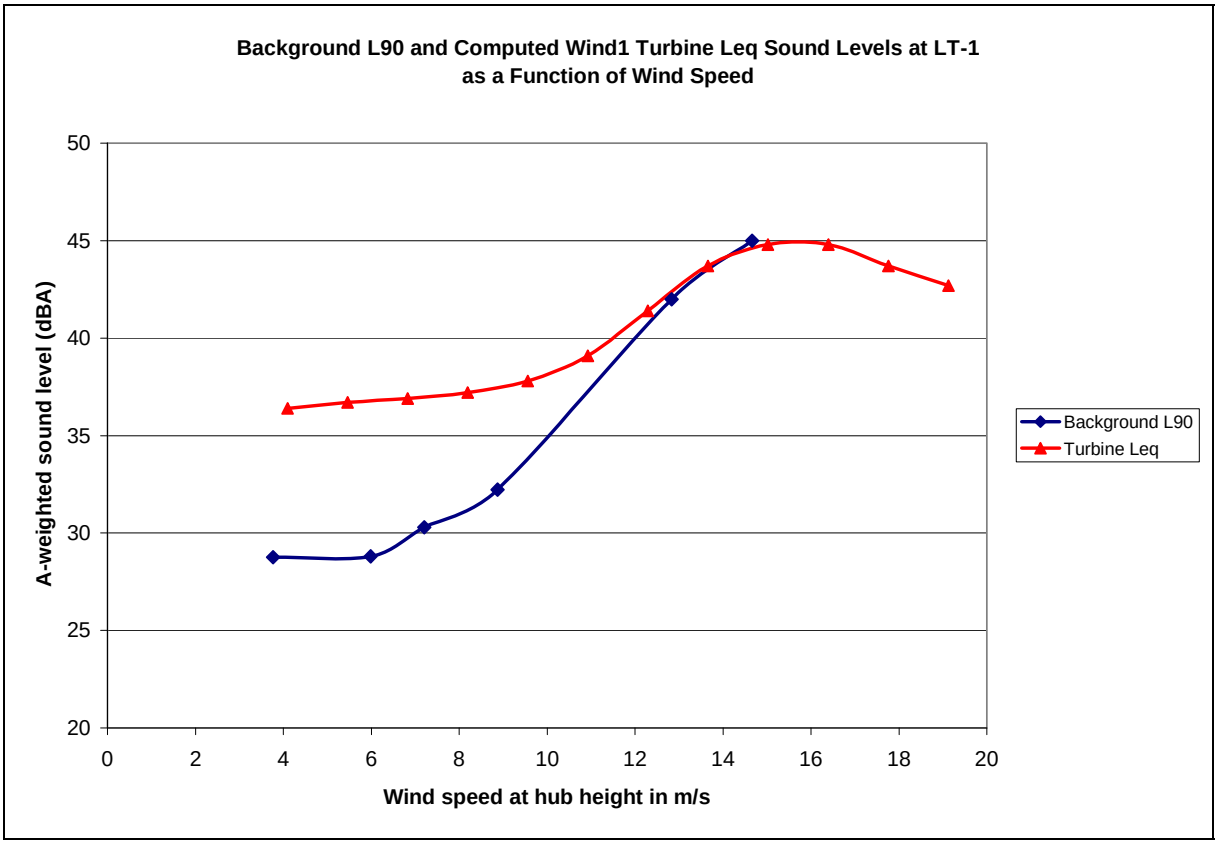
FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

4.0 SOUND MITIGATION OPTIONS

4.1 Summary of Sound Effects at Nearby Properties

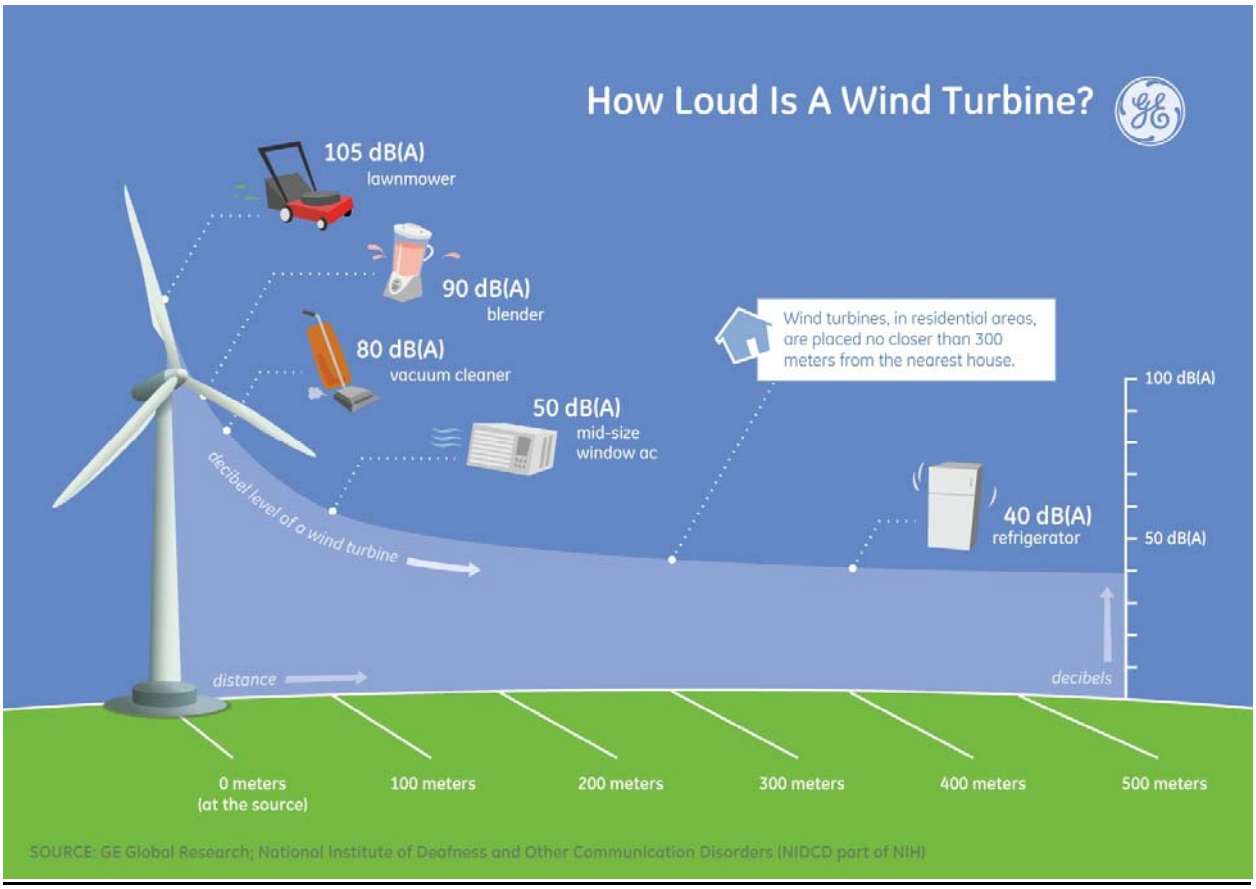
Wind turbine and background sound levels have been widely studied. The wind turbine sound power levels, which are a part of the IEC certification process, are published by the manufacture for the turbines used for this project. Sound naturally attenuates with distance from the source and are characterized in general by:

Figure 4-1
Background L90 vs. Computed Wind Turbine Sound Levels



Sound impacts of turbine sound on the surrounding area were documented by HMMH in their 2010 *Falmouth Wind Turbine Noise Study* report. Background sound levels increase naturally with wind and are influence significantly by human activities, traffic, mechanical equipment, air conditioners, bird, insects and other natural and man-made sources. The background and turbine sound impacts at the Falmouth site can be characterized in the following graphic:

Figure 4-2
How Loud Is a Wind Turbine?



4.2 Sound Mitigation Strategies

Sound Insulation

HMMH began the sound insulation feasibility evaluation by conducting an on-site survey of existing homes construction. Nine homes were inspected in total. Four of the five residences along Blacksmith Shop Road that are the closest to Wind 1 were inspected, including 191, 201, 211 and 221 Blacksmith Shop Road. Also, the five residences to the west of Route 28 that are the closest to Wind 2 were inspected, including 118, 123, 124 and 126 Ambleside Drive, and 84 West Falmouth Highway. One additional residence on Blacksmith Shop Road initially identified for this survey was unavailable for evaluation. HMMH inspected all nine homes during the daytime on Tuesday, Nov 22, 2011 to examine the construction of walls, windows, and doors on facades that face the wind turbines. We used a special laser rangefinder to determine glass and air space thicknesses for windows and sliders. We also documented our observations in the form of notes, sketches, and photographs. We were able to conduct a sufficient analysis

without any access to the interior of the homes. A quick survey of other homes in the area indicated the types of construction evaluated are reasonably representative of all of the potential candidate homes in the area.

HMMH reviewed the information collected during our survey of existing home construction to determine average conditions for modeling. All homes inspected have cedar shingle, clapboard, or batten board exterior wall materials. Using INSUL, a specialized software library of sound transmission-loss (TL) data, we estimated the sound transmission class (STC) of a typical exterior wall to be about STC 40. Figure 4-3 indicates the wall cross-section modeled, and Figure 4-4 shows the resulting TL data for two possible constructions. STC ratings and representative TL data were also determined for windows, sliders, and entry doors, as shown in Figures 4-5 and 4-6. All homes have approximately STC 25 rated double-glazed windows and sliders, with a typical design consisting of 1/16" glass panes and a 1/4" airspace. Most homes also have a hollow-aluminum entry door rated about STC 35, and many of those do not have an additional storm door.

Figure 4-3
Wall Cross Section

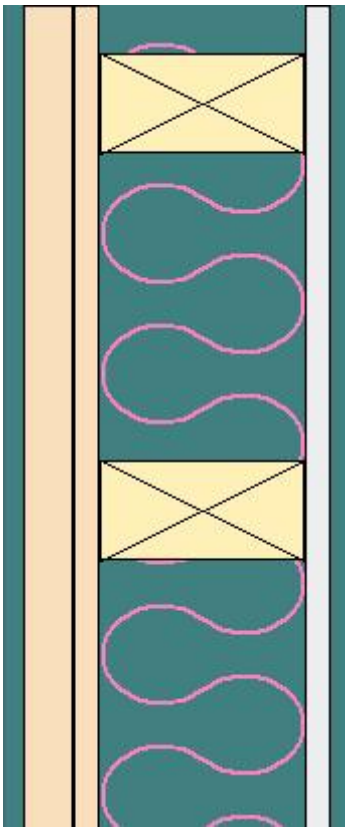


Figure 4-4
Transmission Loss Data

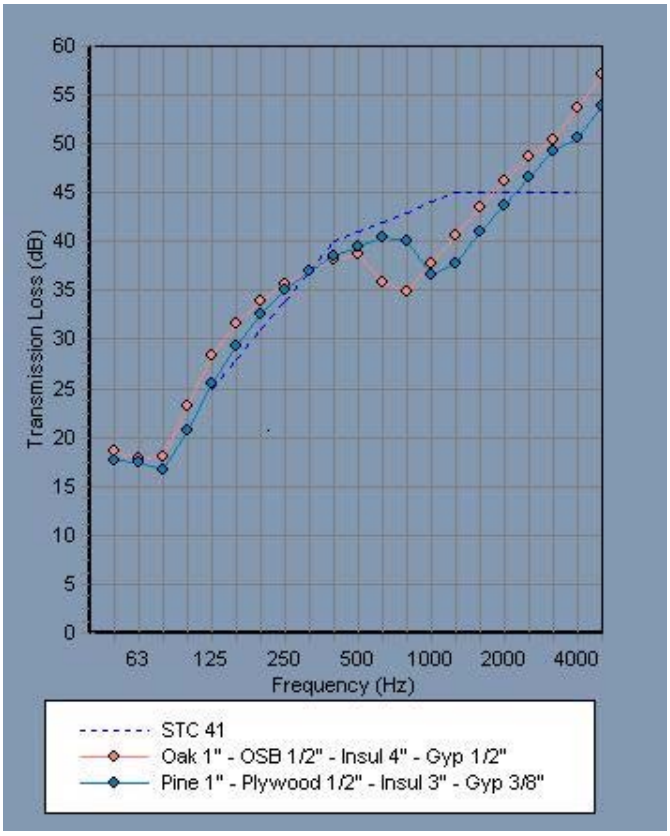


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Figure 4-5
Transmission Loss Data (Doors)

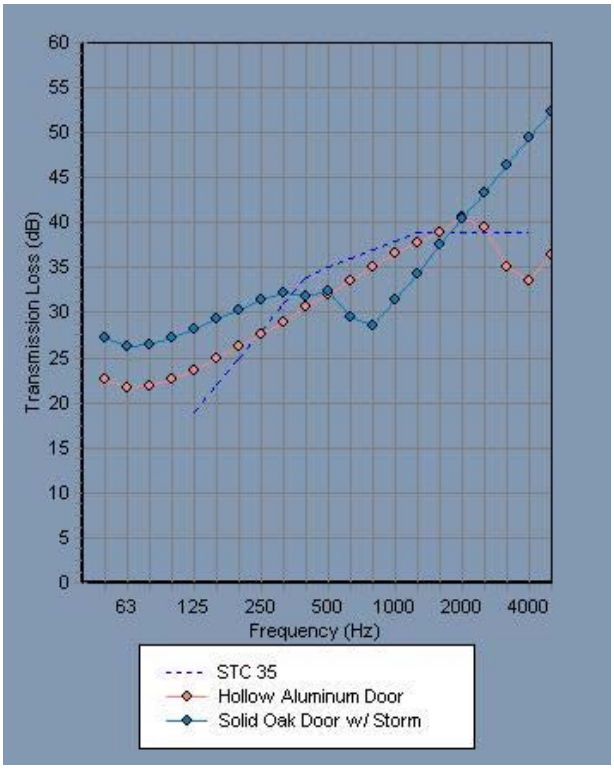
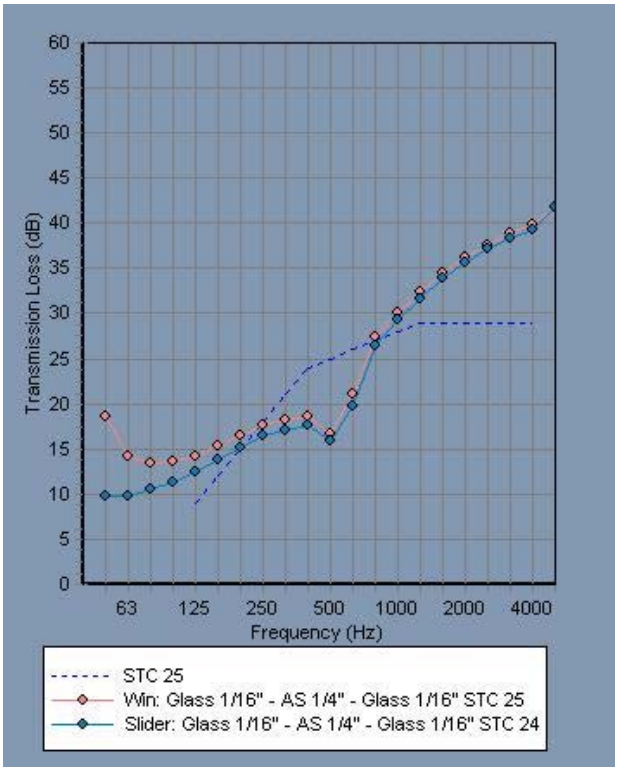


Figure 4-6
Transmission Loss Data (Windows)



Based on these results, HMMH then reviewed floor plans from the Town of Falmouth Assessor to determine reasonable interior conditions and reference rooms for modeling. We determined that the following rooms would be representative of the homes evaluated:

Small Room
10' x 10' x 8'
One 30" x 50" double-glazed
Carpet flooring

Medium Room
20' x 20' x 10'
Two 30" x 50" double-glazed
One 70" x 80" double-glazed slider
Tile/marble flooring

Large Room
30' x 30' x 20'
Two 30" x 50" double-glazed
Two 60" x 50" double-glazed
One 35" x 80" hollow-aluminum entry door
Hardwood flooring

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HMMH modeled the outdoor-to-indoor noise level reduction capability of these rooms for both existing and acoustically-treated constructions. Three conditions were considered: all windows fully open (but all doors/sliders closed), all windows fully closed (as well as doors/sliders), and all windows/doors/sliders upgraded to STC 40 rated products. We then projected interior sound levels based on the exterior wind turbine sound spectrum with Wind 1 and 2 both operating and the modeled outdoor-to-indoor noise level reductions for each room. Spectral results of this analysis are shown in Figures 5 through 7, and results for the overall A-weighted sound level are presented in Tables 4-1 through 4-3. In the figures and tables, overall sound levels are normalized to an exterior Leq of 40 dBA, which is typical of the projected turbine noise level in both communities with a hub-height wind speed of 11 m/s. Turbine sound levels vary over approximately a 10-decibel range depending on wind speed, so the Leq sound levels shown in these tables would vary by plus/minus approximately 5 decibels, depending on wind speed.

First, the modeling results show that the outdoor-to-indoor noise reduction is improved very substantially, by between 16 and 18 decibels, simply by closing all windows. Therefore, providing air conditioning for homes without it would enable residents to close windows whenever noise is a concern, substantially reducing the turbine sound levels inside the home.
Second, the results indicate a potential improvement of 3 to 8 dB in interior A-weighted sound levels due to acoustical treatments, and about 5 dB on average. These improvements are observed only relative to the condition with windows closed, of course. The spectral data indicate the improvement is greatest in the 250 and 500 Hz octave bands and is not as significant in the low-frequency 125 Hz band. No improvement is projected in the low-frequency 63 Hz band.

Figure 4-7
Outdoor vs. Indoor Noise Level (Small Room)

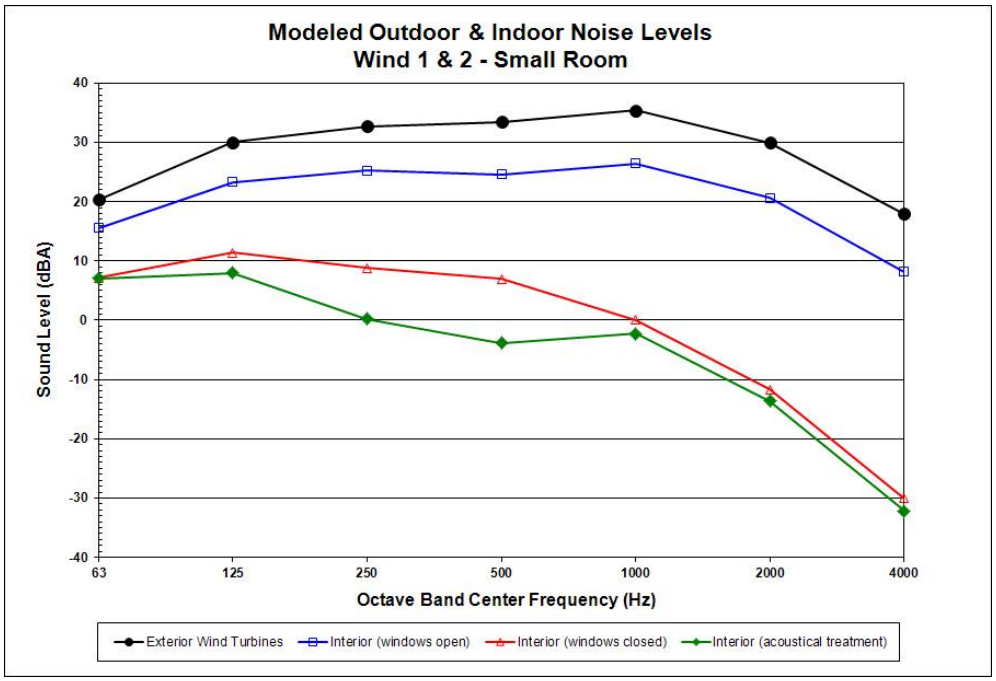


Figure 4-8
Outdoor vs. Indoor Noise Level (Medium Room)

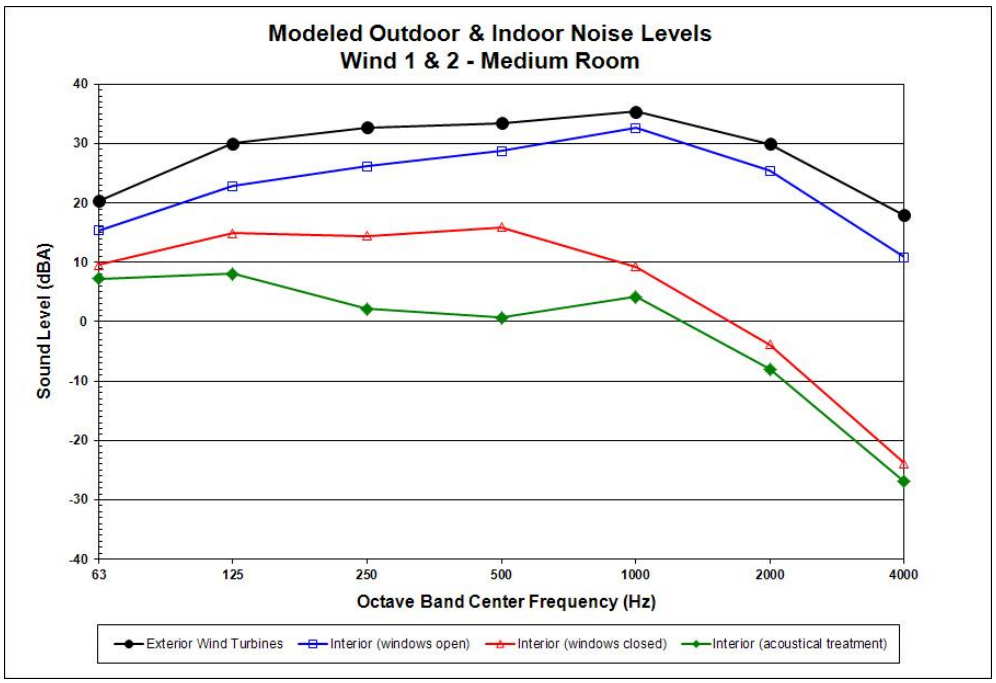
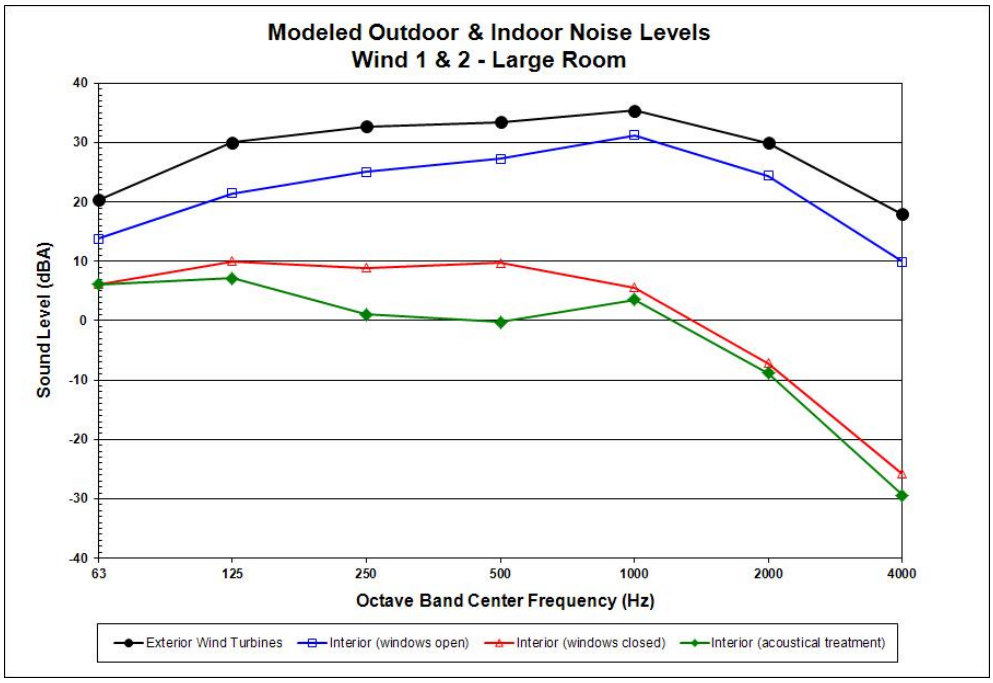


Figure 4-9
Outdoor vs. Indoor Noise Level (Large Room)



Higher acoustically-rated products, such as STC 45 to 50, would not significantly alter the anticipated level of sound reduction. To achieve an improvement on the order of 10 dB would require the construction on an additional interior wall section on the noise-exposed facades of each residence. This degree of mitigation is likely very cost-prohibitive as well as intrusive and possibly unacceptable to affected residents (we have found residents are resistant to having room size reduced), and so that approach has not been evaluated for this report.

To estimate potential costs associated with sound insulation of the nine homes evaluated, HMMH consulted with industry partners regarding treatment of an average home, with and without addition of central air-conditioning. Based on our survey, we assumed a 2000 square feet building footprint and that three facades are noise-exposed for two stories. We estimated that approximately 25 windows, two doors, and one slider would need to be replaced with STC 40 rated products. In addition, five vents would require acoustic baffles, a chimney would need acoustic treatment, and one skylight would need to be upgraded to STC 40. We did not consider any improvements to the walls or roof.

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Table 4-1 A-weighted Noise Reduction and Leq – Small Room			
Room Status	Noise Level Reduction	Wind I and Wind II Combined Sound Level	
		Exterior	Interior
Windows Open	8	40	32
Windows Closed	25		15
Acoustical Treatments	28		12

Table 4-2 A-weighted Noise Reduction and Leq – Medium Room			
Room Status	Noise Level Reduction	Wind I and Wind II Combined Sound Level	
		Exterior	Interior
Windows Open	4	40	36
Windows Closed	19		21
Acoustical Treatments	27		13

Table 4-3 A-weighted Noise Reduction and Leq – Large Room			
Room Status	Noise Level Reduction	Wind I and Wind II Combined Sound Level	
		Exterior	Interior
Windows Open	6	40	34
Windows Closed	24		16
Acoustical Treatments	28		12

Based on the information outlined above (including cost of acoustical measurement, design, and validation services), the likely cost to sound insulate a single average residence is $30,000. The total cost increases to $45,000 with the addition of a central air-conditioning system, which allows residents to keep their windows closed whenever the noise is a concern. Given that our survey indicates that only 3 of the 9 homes evaluated currently have central air, the total cost to sound insulate all nine residences is projected to be approximately $360,000. At this average cost per home of $40,000, if the town wished to expand the treatment area to, say the 25 closest homes, the cost would be in the neighborhood of $1 million.

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Criteria, Summary and Recommendations

The U.S. EPA, Department of Housing and Urban Development and the Federal Aviation Administration have all recommended that interference with human activity becomes significant where interior average Day-Night sound levels exceed 45 decibels. The nighttime sound level is roughly five decibels lower than the Day-Night sound level, so this recommendation would translate roughly to nighttime interior average sound levels of 40 decibels. At levels that exceed this value, the agencies recommend mitigation measures. The World Health Organization (WHO), in its 1999 guidelines document, recommended the lower nighttime criterion of 30 decibels (average) in bedrooms for protection against any sleep disturbance effects.

Data from Table 4-1 above suggests that interior turbine sound levels in bedrooms even with windows open are 32 dBA, well below the U.S. agency criteria of approximately 40 dBA. The table also shows turbine sound levels at 15 dBA in bedrooms with windows closed. This is well below the WHO 30-decibel criterion. Levels would drop to 12 dBA with the acoustical treatment.

Should the Town of Falmouth choose to reduce nighttime turbine sound levels in residents' bedrooms to below the WHO criteria, we believe that by far the most cost-effective solution is to provide air conditioning to those residents who do not have it. This will give those the residents the option of substantially reducing turbine sound levels in their homes if and when the sound levels are of concern.

Noise Barrier

Noise barriers reduce noise by forcing sound to bend ("diffract") over the tops of them on their path from the noise source to the receiver. Through the process of bending, sound loses energy. Noise barriers are used commonly adjacent to highways and other ground-based noise sources to provide a measure of noise relief in residential areas where noise levels are so high that outdoor communication between people outdoors is reduced to a few feet.

Noise barriers are not commonly recommended as a means of mitigating wind turbine noise because they must block the direct sound paths between the source and receiver to provide noticeable benefit, and wind turbines are generally located so high above the ground that blocking the sound paths is not practical. HMMH investigated the feasibility of noise barriers for the homes closest to Wind 1 along Blacksmith Shop Road, since town land is located just north of Blacksmith Shop Road, and the distances between the homes and a potential noise barrier are not so great as to make noise barriers completely out of the question as a possible mitigation measure.

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To evaluate the barrier feasibility, we used the SoundPLAN model that had been developed for the 2010 Falmouth Wind noise study, which includes a three-dimensional model with all of the terrain in the areas surrounding Wind 1 and Wind 2. Also, the model incorporates the sound source information for the Wind turbines and it has the capability of accurately computing the noise reduction provided by potential noise barriers, using well-established and validated mathematical modeling. We chose to examine the potential noise reduction of two homes: the home closest to Wind 1 at 191 Blacksmith Shop Road, and the home at 211 Blacksmith Shop Road, at which we have conducted extensive noise measurements and previous noise modeling, as site "LT-1." 191 Blacksmith Shop Road is set back approximately 100 feet from the road, which is typical of most of the homes in the area. However, 211 Blacksmith Shop Road is set back 200 feet, which puts it in a much less advantageous position to receive benefit from even a tall height noise barrier.

Turbine noise levels and noise reduction from barriers of various heights were computed at two receiver locations at each home, at the east and west ends on the front side of the home, toward the turbine. Figure 4-10 illustrate the receiver locations and also where the noise barrier was modeled, 25 feet north of the edge of Blacksmith Shop Road. We evaluated different receiver heights at each location: five feet above the ground exterior, first floor interior, and second floor interior.

Data in Table 4-4 provides the results of the sound modeling. The computed reduction on A-weighted Wind 1 turbine noise levels is shown for the different receiver locations and the different barrier heights. The results for 191 Blacksmith Shop Road would be similar for the other neighboring homes at 183, 201 and 221 Blacksmith Shop Road. The results for 211 Blacksmith Shop Road are poorer due to the home's increased distance from the barrier – approximately 250 feet, vs. about 150 feet for the other homes.

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Table 4-4
Reduction of A-weighted Noise Provided by a Barrier of Different Heights
Noise Reduction of Barrier – Wind I (decibels; A-weighted)

	Barrier Height (ft)					
	31	36	41	44	49	54
191 Blacksmith Shop Rd.						
1st floor and Exterior East End	1	1	7	9	11	12
2nd floor	0	0	1	1	8	10
Exterior West End	1	6	9	10	12	13
211 Blacksmith Shop Rd.						
1st floor and Exterior East End	0	0	0	0	1	6
2nd floor	0	0	0	0	0	1
Exterior West End	0	0	1	4	7	9

These results suggest that to attain a meaningful and noticeable reduction of noise levels at the first floor of the closest homes, in the range of 7 to 9 decibels, a barrier higher than 40 feet would be needed in this area. To benefit the second floors of any homes, a 50-ft barrier in this location would be needed. The barrier could possibly be located slightly closer to Blacksmith Shop Road, but that would only reduce the height requirements slightly.

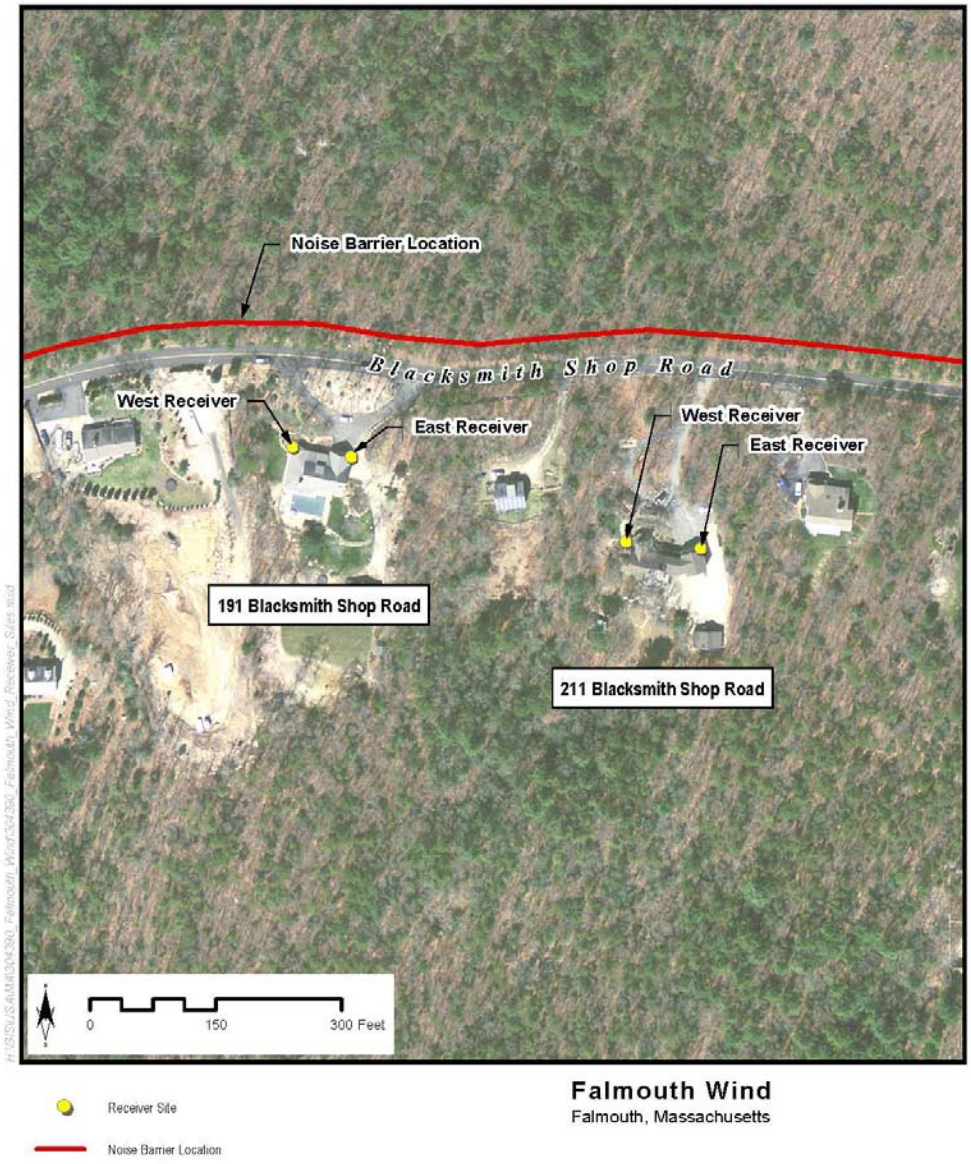
We should point out that noise barriers at these heights are rare, and they are very expensive, unless they can be constructed as earth berms with effectively “free” fill that is made available. Unfortunately along Blacksmith Shop Road, all of the trees would have to be removed to install such a large earth berm. Also, a 50-ft high berm would have to be approximately 200 feet wide at the base, which would move the top of the berm about 75 feet farther away from the road toward the turbine, further reducing its noise-reduction effectiveness.

In the lower-frequency octave bands centered at 63 Hz and 125 Hz, which represent the “thump” sound character that is occasionally heard by residents, the model projects that the barrier will also provide benefit. For the 41-ft high barrier, the reduction in these low-frequencies would be approximately 5 to 6 decibels at the homes that are set back up to approximately 100 feet from Blacksmith Shop Road.

Constructed as a wall, such a noise barrier would likely cost in the range of $30 to $60 per square foot installed. Also, the significant wind loads that must be designed for such tall barriers can increase the cost notably. To benefit the four homes closest to Wind 1, all of which

are within about 100 feet of Blacksmith Shop road in this area, approximately 900 ft of barrier length would be needed. At a height of 41 feet, the cost of this barrier would be in the range of $1 million to $2 million, or about $250,000 to $500,000 per home. Such a high cost per home benefited is approximately ten times what U.S. state departments of transportation are typically willing to pay (using public funds) for highway noise barriers that benefit impacted homes.

Figure 4-10
Sound Barrier Wall Location



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Currently, Vestas has not developed a sound mitigation product that is commercially available. However, we are aware that other manufacturers are developing a type of blade that can reduce the potential for noise. This includes a serrated blade design which is estimated to reduce sound by approximately 3dB. Replacing the current blades with a serrated blade design (if/when this option becomes available) would cost approximately $1,558,000. This includes the cost for transport of the new blades ($100,000); installation/labor ($100,000); crane rental ($350,000); and the purchase price of the blades which is estimated at $336,000 per blade ($1,008,000).

Vestas has a product called Vestas Online Business (VOB) which is software designed to allow more localized control the operation of individual wind turbines. Typically, this option is for large wind farms who want full control over the turbines to maximize power generation. With this tool, the Town would have the ability to de-rate the turbines dynamically; however, it is unknown if this feature would have any sound implications, though it will certainly give Falmouth the ability to de-rate, turn-off/turn-on the turbines at their convenience. The Vestas Online Business software with power regulation monitor would cost approximately $275,000.

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

5.0 ASSESSMENT OF SHADOW FLICKER AND ICE THROW CONCERNS

5.1 Summary of Potential Shadow Flicker from Wind I and Wind II

The wind turbines have the potential to create a phenomenon known as shadow flicker. An example of the flicker was presented by a Falmouth resident at 124 Ambleside Drive during the June 6, 2011 Board of Selectmen meeting. While we do not believe that shadow flicker is a hazard to human health, or creates a distraction to passing motorists traveling on any roads, we do recognize that some people may find shadow flicker objectionable or annoying.

The two wind turbines have the potential to create shadow flicker at the wastewater treatment facility property and in other areas at certain distances and directions beyond the property boundaries. Shadow flicker will occur under certain conditions of sunlight intensity, time of day, and wind speed and direction, all of which are predictable in occurrence and duration. The potential occurrence for shadow flicker was modeled using a variety of assumptions and simulated conditions. The receptor location selected for the modeling was also 124 Ambleside Drive in Falmouth, MA.

<u>Shadow Flicker Study</u>
Shadow flicker probabilities were modeled using commercially available software WindPRO Version 2.6 SHADOW module, published by EMD International A/S. The software is capable of calculating how often and in which intervals a specific location will be affected by shadows generated by one or more wind turbines. The calculations are worst case scenarios using astronomical maximum shadow calculations based on the position of the sun, the location of the turbine and the assumption that each day is clear and sunny, the rotor is always perpendicular to the viewer position and the rotor is always turning.

According to the software documentation, updated January 2008, only the country of Germany has established guidelines on limits and conditions for calculating shadow impact. According to the German guidelines, the limit of the shadow is set by two factors:

- The angle of the sun over the horizon must be at least 3 degrees
- The blade of the wind WTG must cover at least 20 % of the sun.

The maximum shadow impact for a neighbor to a wind farm according to the German guidelines is:

- Maximum 30 hours per year of astronomical maximum shadow (worst case)
- Maximum 30 minutes worst day of astronomical maximum shadow (worst case)
- If automatic regulation is used, the real shadow impact must be limited to 8 hrs/year

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

In Sweden and Denmark there are no official guidelines as yet on shadow flickering, but for practical purposes, 10 hours (Denmark) and 8 hours (Sweden) real case (weather dependent) shadow impact is used as the limit.

The time of the day for which shadow impact is critical and the definition of a shadow receptor for which shadow impact is calculated are less rigidly defined by the guides and is often something which should be evaluated in each individual case.

As an example, a factory or office building would not be affected if all the shadow impact occurred outside of normal business hours, whereas it would be more acceptable for private homes to experience shadow impact during working hours, when the family members are typically at work or school. Also, it is sometimes questionable whether the shadow impact should be calculated for a window, the facade of a house or the full outdoor area of the property. Should a shadow impact in one area be added to a shadow impact in another area of the same grounds?

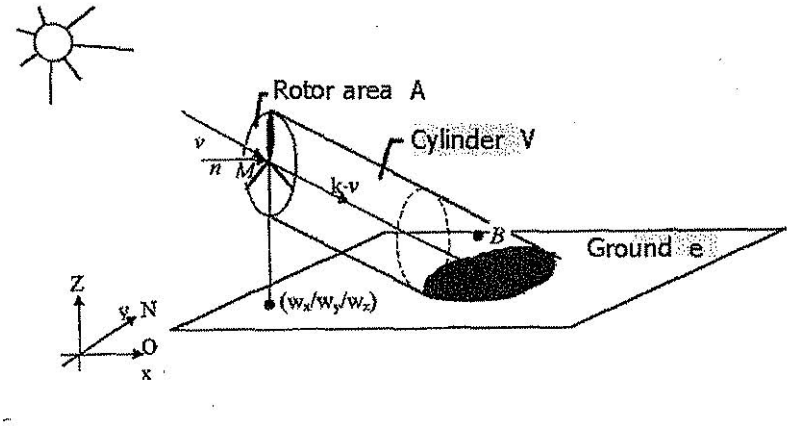
Finally, the actual amount of shadow impact as a fraction of the calculated potential risk will depend heavily on the geographic location in question. In areas with high rates of overcast weather the problem would obviously decrease, and during potential hours of shadow impact in the summer the WTG may often be stopped due to lack of wind. Statistics regarding the wind conditions and number of hours with clear sky can also be taken into account.

The calculation of the potential shadow impact at a given shadow receptor was carried out simulating the situation at 124 Ambleside Drive in Falmouth. The position of the sun relative to the WTG rotor disk and the resulting shadow is calculated in one minute steps throughout a complete year. If the shadow of the rotor disk, which in the calculation is assumed at any time casts a shadow reflection on the window which has been defined as a shadow receptor, then this step will be registered as 1-minute of potential shadow impact. The following information was input:

- The position of the wind turbine (x, y, z coordinates)
- The hub height and rotor diameter of the wind turbine
- The position of the shadow receptor object (x, y, z coordinates)
- The size of the window and its orientation, both directional (relative to south) and tilt angle of window plane to the horizontal
- The geographic position (latitude and longitude) together with time zone and daylight saving time

A simulation model, which holds information about the earth's orbit and rotation relative to the sun as follows:

Figure 5-1
Shadow Flicker Diagram



Where:

The diameter of the sun, D	= 1,390,000 km
The distance to the sun, d	= 150,000,000 km
The Angle of attack	= 0.531 degrees

Theoretically, this would lead to shadow impacts in an area up to 4.8 km behind a 45 meter diameter rotor. In reality, however, the shadows never reach the theoretical maximum due to the optic conditions of the atmosphere. When the sun gets too low on the horizon and the distance becomes too long the shadow dissipates before it reaches the ground (or the receptor). How far away from the WTG the shadow will be visible is not well documented and so far only the German guidelines set up limits for the analysis. The default distance of WindPRO is 2 km and the default minimum angle is 3 degrees above the horizon. If the German guidelines are used, the maximum distance from each WTG can be calculated using the formula:

Maximum distance = (5*w*d) 11,097,780

The shadow receptors are objects (areas) for which the potential shadow area is calculated. For this analysis, the objects at receptor A represented the windows at 124 Ambleside Drive and the outside yard. The windows were estimated to measure approximately 1.0 meter wide by 1.0 meter high and are located at an elevation of 1.0 meter above ground level. The object for the yard area was estimated to measure 10.0 meters wide by 4.0 meters high and impacts were calculated at a height of 1.0 meter above the ground level. On the output map, the receptor appears as a bowl with a stick. The shadow is thrown into the “bowl” and the stick gives the direction of the window. The shadow receptors are described by the following information:

- The position of the "window" above ground level and its size (height and width)
- The tilt of the "window" relative to horizontal

- The directional orientation of the window relative to south (in degrees, positive, westwards)

The default parameters are good as a standard description of typical windows. Alternatively "Green house" mode can be selected, where the receptor faces all directions. This is useful if the actual properties of the receptor are unknown or if there are wind turbines on more sides of the house that will contribute to the flickering impact and for outdoor areas, such as a garden or yard. The area receptors studied for this project included one location at 124 Ambleside Drive. This receptor is located 1,950 feet from Wind I and 1,265 feet from Wind II.

Modeling Results

The first model scenario was based on worst case "base model" conditions of astronomical maximum shadow calculations based on the position of the sun, the location of the turbine and the assumption that each day is clear and sunny, the rotor is always perpendicular to the viewer position and the rotor is always turning. This first scenario was performed in omnidirectional or "greenhouse" mode which assumes that the shadows produced as a result of sunlight passing through the moving blade at the receptor location would be visible in all directions (i.e. there are no walls or ceiling that would obscure the view of the shadows. This scenario was also performed in a fixed unidirectional mode which assumes that the shadows produced would be visible in only one direction such as where the windows on a building are located.

The second modeling scenario was based on "real case" average daily sunshine hours per day per month, derived from a nearby weather station data. This scenario was also performed both in omnidirectional "greenhouse" mode and fixed unidirectional mode. The results of the modeling indicate the expected number of shadow flicker hours per year, which are summarized below.

Table 5-1
Shadow Flicker Results Per Turbine, hours per year

	Worst Case Greenhouse Mode	Worst Case Unidirectional Mode	Real Case Greenhouse Mode	Real Case Unidirectional Mode
Wind I	41:06	37:04	11:42	10:33
Wind II	53:44	46:43	18:07	15:43
Total Hours Per Year	94:50	83:47	29:49	26:16

As the attached analysis indicates, under "real case" conditions (i.e. taking into account historic local weather patterns), flicker at 124 Ambleside Drive is just 26:16 hours per year. This includes 10:33 hours per year from Wind I and 15:43 hours per year from Wind II. The WindPRO modeling output reports for each scenario are attached for reference.

5.2 Strategies Available to Mitigate Potential Shadow Flicker

The design of the wind turbines for this project are such that they are capable of being programmed to operate (or cease operation) based on user inputs that include time of day, wind speed, and/or rotor direction. It may also be possible, with the manufacturers engineering support, to integrate the output signal of a simple pyronometer (a device used to measure sunlight intensity), to also control the turbine operation to minimize flicker impacts, while maximizing the output of the turbine. Modifying the Vestas turbines with this equipment is expected to cost approximately $15,000 per wind turbine.

Other mitigation methods, such as window blinds, shades, landscaping can also be used to minimize shadow flicker impacts, if amenable to the impacted party. The Town of Falmouth should be aware that any curtailment of the turbine and other mitigation methods will have a cost and impact on the project economics, and there are no regulatory requirements that would compel mitigation for shadow flicker.

5.3 Evaluation of Ice Throw Potential

According to the U.S. Department of Energy, under certain conditions in climates such as those found in New England, ice can accumulate on wind turbine blades. The release of that ice from moving turbine blades is possible. The potential for ice throw is highest at mountain-top sites, remote from most observers in the harshest of weather. Under icing conditions, all exposed parts of the wind turbine are liable to ice build-up. However, it has been observed that a moving turbine rotor is liable to accrete significantly heavier quantities of ice than stationary components. Furthermore, the rotor blade ice has the potential to be cast some distance from the turbine if the ice breaks off of a rotating blade.

No studies have been conducted in the United States concerning ice shedding from wind turbine blades. The 1998 European study, "Assessment of Safety Risks Arising from Wind Turbine Icing" by European Commission, DGXII, and the UK Department of Trade and Industry examines the issue as well as the study "*Risk Analysis of Ice Throw from Wind Turbines*" presented in April 2003 at BOREAS conference in Finland. The lack of previous work by others on the subject may reflect the fact that there has been no reported injury from ice thrown from wind turbines, despite the installation of more than 6,000 MW of wind energy world-wide.

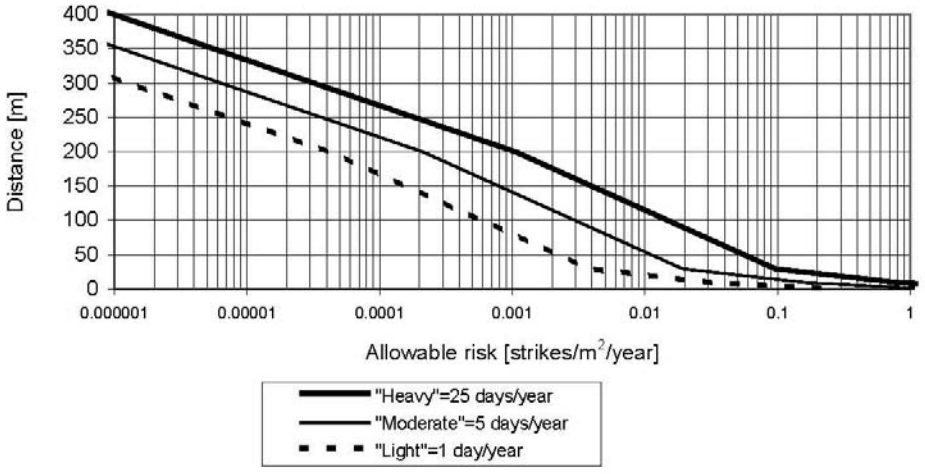
There are several mechanisms of ice accretion on structures. The most important of these, for wind turbines, is rime icing which occurs when the structure is at a sub-zero temperature and is subject to incident flow with significant velocity and liquid water content. The precise deposition mechanism is the subject of ongoing experimental and theoretical research. Field observations indicate that most ice shedding occurs as temperatures rise and the ice thaws from the rotor. A typical scenario is that ice builds up on the rotor and on the wind speed and

direction sensors which are mounted on the nacelle. Sensor malfunction causes automatic turbine shutdown. In this situation, most turbines will restart only when the ice has thawed and fallen from the stationary turbine which the operator then resets. However it is common practice for the operator to accelerate the process by thawing the sensors and restarting the turbine with ice still on the rotor. This circumstance has been observed to lead to heavy shedding of ice.

As regards the size of ice fragments shed from rotor blades, their mass and the distance which they are cast, there is very limited objective and subjective information. The only objective source of information is that collected in the recently completed EU Joule project "Icing of wind turbines", also funded by DGXII. As part of this work, carried out by DEWI and FMI, a questionnaire was circulated to a large number of turbine operators. The questionnaire asked for information on the occurrence of icing including mass and location of any observed ice debris flung off the rotor.

The data presented in Figure 5-2 show that most fragments which were found on the ground were estimated to be in the range 0.1 to 1 kg mass and were found 15 to 100 m from the turbines. Of course these figures must be taken as very approximate, and it is not possible to know how well the ground was searched especially at larger distances from the turbines.

Figure 5-2
Ice Throw Risk Potential vs. Distance



(Garrad Hassan, 1998)

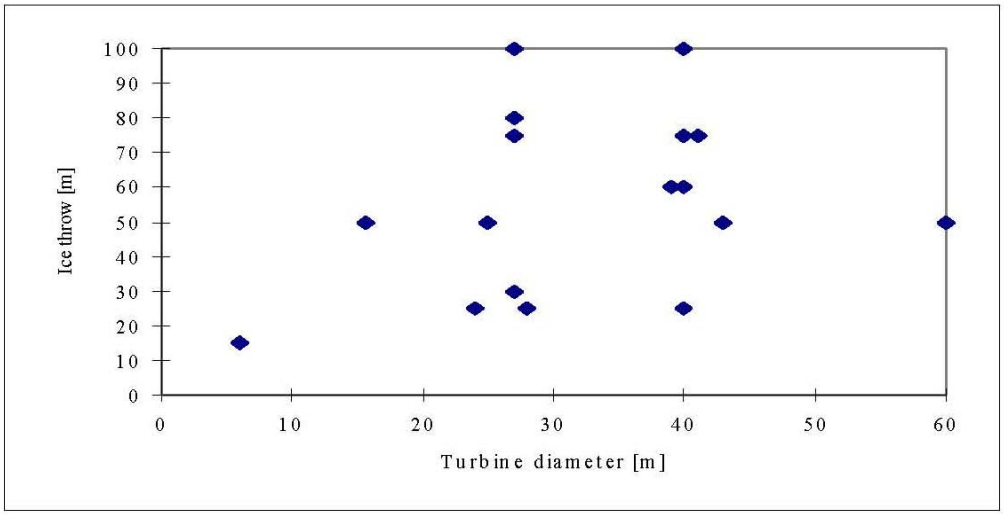
In addition to this objective information, anecdotal evidence suggests that the tendency is for ice fragments to be dropped off, rather than thrown off, the rotor. Also, it tends to be shed off

the tips in preference to other parts of the blade and large pieces of debris tend to fragment in flight. There is significant evidence that rime ice continues to form when the turbine is operating and is not shaken off by blade flexing, even though this may be the case for other types of ice formation. Also, rime ice formation appears to occur with remarkable symmetry on all turbine blades with the result that no imbalance occurs and the turbine continues to operate.

An estimate should be made of the time (number of days per year) during which icing conditions occur at the turbine site:

- "Heavy icing" - more than 5 days, less than 25 days icing per year.
- "Moderate icing" - more than 1 day, less than 5 days icing per year.
- "Light icing" - less than 1 day icing per year.
- "No icing" - no appropriate icing conditions occur.

Figure 5-3
Ice Throw Distance vs. Rotor Diameter



(Garrad Hassan, 1998)

Figure 5-3 is based on a rate of ice accretion averaging 75 kg/day during icing conditions, a figure which has been estimated for a 3-bladed turbine of 50m diameter. The allowable risk should be scaled pro rata under different assumptions.

The level of risk which is acceptable should be determined. This is subject to case specific factors such as ease of access; however a suitable level may be 10^{-6} strikes/m2/year which is the typical probability of lightning strike in the UK.

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5.4 Modifications and Controls Available to Mitigate Ice Throw

Turbines can be programmed to automatically shut down when severe ice buildup is present. Modern turbines can also be equipped with cold weather packages, which make them adaptable to temperatures as low as -40 Celsius, reducing the risk of ice accumulation. These packages include special coatings on the blades to eliminate the adherence of ice, thermostat-controlled resistive element forced air heaters strategically placed to heat instruments and operating components during cold weather conditions to prevent the formation and adherence of ice, and low-temperature lubricants. Operational staff should be aware of the conditions likely to lead to ice accretion on the turbine, of the risk of ice falling from the rotor and of the areas of risk. Vestas Ice Detection equipment is expected to costs approximately $25,000 per wind turbine.

The use of warning signs alerting anyone in the area of risk can also be utilized. The IceAlert™ system consists of 6-inch diameter indicators which change color from white to blue as temperatures approach freezing. The indicators are mounted on large signs which explain that "BLUE REFLECTORS INDICATE FREEZING TEMPERATURES". These can be placed at strategic locations to ensure that operational staff and members of the public are aware that icing potential exists. Each individual IceAlert™ unit is mounted on a 7" x 10" backing sign which graphically indicates that "a blue symbol means freezing temperatures".

Units are popular with maintenance personnel because they install quickly and easily and require essentially no maintenance. The units are rugged and self-contained, with no wires, batteries or electronic components. Each application is unique and the cost depends upon the number of reflectors and signs required. Generally speaking, a 100-car parking lot and sidewalk system can be protected for about $500.

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

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[6] J.F.MacQueen et al, "Risks associated with wind-turbine blade failures", IEE Proceedings Vol. 130 Pt. A No. 9, December 1983.

[7] Colin Morgan, Ervin Bossanyi, Henry Seifert, * Garrad Hassan and Partners Ltd, Assessment Of Safety Risks Arising From Wind Turbine Icing, The Coach House, Folleigh Lane, Long Ashton, Bristol BS18 9JB, BOREAS IV, 31 March - 2 April 1998, Hetta, Finland

FALMOUTH RENEWABLE ENERGY FACILITIES MITIGATION STRATEGIES

APPENDIX A

Shadow Flickr Model Report

Project:
Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:22 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:22 AM/2.7.486

SHADOW - Main Result

Calculation: Unidirectional - window - worst case

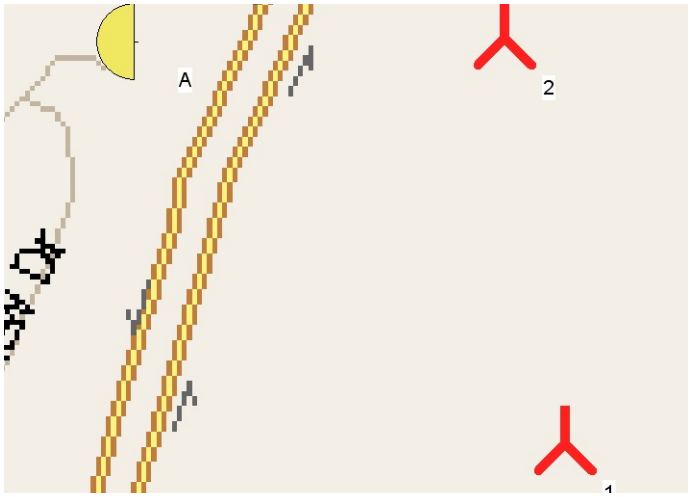
Assumptions for shadow calculations

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

The calculated times are "worst case" given by the following assumptions:
- The sun is shining all the day, from sunrise to sunset
- The rotor plane is always perpendicular to the line from the WTG to the sun
- The WTG is always operating

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Height Contours: Contours_3m_Optimized.wpo (2)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:7,500
New WTG Shadow receptor

WTGs

	UTM NAD83 Zone: 19				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: 19		[m]					[kW]	[m]	[m]	[m]	[RPM]
1	364,948.00	4,607,295.98	45.0	Wind I	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4
2	364,896.00	4,607,696.98	39.0	Wind II	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4

Shadow receptor-Input

			UTM NAD83 Zone: 19							
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	124 Ambleside - unidirectional	364,528.00	4,607,699.98	19.7	1.0	1.0	1.0	-90.0	90.0	Fixed direction

Calculation Results

Shadow receptor

		Shadow, worst case		
No.	Name	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]
A	124 Ambleside - unidirectional	83:47	144	0:50

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	Wind I	37:04	
2	Wind II	46:43	

Project:

Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:23 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:22 AM/2.7.486

SHADOW - Calendar

Calculation: Unidirectional - window - worst case **Shadow receptor:** A - 124 Ambleside - unidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

The sun is shining all the day, from sunrise to sunset

The rotor plane is always perpendicular to the line from the WTG to the sun

The WTG is always operating

	January		February	March		April		May		June
1	07:10	08:02 (1)	06:56	06:19		06:27	07:20 (2)	05:41	07:06 (2)	05:12
	16:23	35 08:37 (1)	16:58	17:33		19:08	20 07:40 (2)	19:40	31 07:37 (2)	20:10
2	07:10	08:02 (1)	06:55	06:17		06:26	07:17 (2)	05:40	07:07 (2)	05:11
	16:24	35 08:37 (1)	16:59	17:34		19:09	26 07:43 (2)	19:41	27 07:34 (2)	20:10
3	07:10	08:03 (1)	06:54	06:16		06:24	07:14 (2)	05:38	07:09 (2)	05:11
	16:25	35 08:38 (1)	17:00	17:35		19:10	31 07:45 (2)	19:42	23 07:32 (2)	20:11
4	07:10	08:03 (1)	06:53	06:14		06:22	07:12 (2)	05:37	07:11 (2)	05:10
	16:26	35 08:38 (1)	17:02	17:36		19:11	34 07:46 (2)	19:43	19 07:30 (2)	20:12
5	07:10	08:04 (1)	06:52	06:13		06:21	07:11 (2)	05:36	07:15 (2)	05:10
	16:27	35 08:39 (1)	17:03	17:37		19:12	37 07:48 (2)	19:45	12 07:27 (2)	20:13
6	07:10	08:03 (1)	06:51	06:11		06:19	07:09 (2)	05:34		05:10
	16:28	35 08:38 (1)	17:04	17:39		19:13	39 07:48 (2)	19:46		20:13
7	07:10	08:04 (1)	06:49	06:09		06:17	07:07 (2)	05:33		05:09
	16:29	35 08:39 (1)	17:06	17:40		19:14	42 07:49 (2)	19:47		20:14
8	07:10	08:05 (1)	06:48	07:08		06:16	07:06 (2)	05:32		05:09
	16:30	34 08:39 (1)	17:07	18:41		19:15	44 07:50 (2)	19:48		20:15
9	07:10	08:05 (1)	06:47	07:06		06:14	07:05 (2)	05:31		05:09
	16:31	35 08:40 (1)	17:08	18:42		19:16	45 07:50 (2)	19:49		20:15
10	07:09	08:06 (1)	06:46	07:05		06:12	07:03 (2)	05:30		05:09
	16:32	34 08:40 (1)	17:09	18:43		19:17	47 07:50 (2)	19:50		20:16
11	07:09	08:06 (1)	06:45	07:03		06:11	07:03 (2)	05:29		05:08
	16:33	34 08:40 (1)	17:11	18:44		19:19	48 07:51 (2)	19:51		20:16
12	07:09	08:07 (1)	06:43	07:01		06:09	07:02 (2)	05:28		05:08
	16:34	34 08:41 (1)	17:12	18:45		19:20	48 07:50 (2)	19:52		20:17
13	07:09	08:07 (1)	06:42	07:00		06:08	07:02 (2)	05:26		05:08
	16:35	33 08:40 (1)	17:13	18:47		19:21	49 07:51 (2)	19:53		20:17
14	07:08	08:08 (1)	06:41	06:58		06:06	07:01 (2)	05:25		05:08
	16:36	33 08:41 (1)	17:14	18:48		19:22	49 07:50 (2)	19:54		20:18
15	07:08	08:09 (1)	06:39	06:56		06:04	07:01 (2)	05:24		05:08
	16:37	32 08:41 (1)	17:16	18:49		19:23	50 07:51 (2)	19:55		20:18
16	07:07	08:09 (1)	06:38	06:55		06:03	07:00 (2)	05:23		05:08
	16:38	32 08:41 (1)	17:17	18:50		19:24	50 07:50 (2)	19:56		20:19
17	07:07	08:10 (1)	06:37	06:53		06:01	06:59 (2)	05:22		05:08
	16:39	30 08:40 (1)	17:18	18:51		19:25	50 07:49 (2)	19:57		20:19
18	07:06	08:11 (1)	06:35	06:51		06:00	07:00 (2)	05:21		05:08
	16:41	29 08:40 (1)	17:19	18:52		19:26	49 07:49 (2)	19:58		20:19
19	07:06	08:12 (1)	06:34	06:49		05:58	06:59 (2)	05:21		05:08
	16:42	28 08:40 (1)	17:21	18:53		19:27	49 07:48 (2)	19:59		20:20
20	07:05	08:13 (1)	06:32	06:48		05:57	07:00 (2)	05:20		05:09
	16:43	27 08:40 (1)	17:22	18:54		19:28	48 07:48 (2)	20:00		20:20
21	07:05	08:14 (1)	06:31	06:46		05:55	06:59 (2)	05:19		05:09
	16:44	25 08:39 (1)	17:23	18:56		19:29	48 07:47 (2)	20:00		20:20
22	07:04	08:15 (1)	06:30	06:44		05:54	07:00 (2)	05:18		05:09
	16:45	23 08:38 (1)	17:24	18:57		19:30	47 07:47 (2)	20:01		20:21
23	07:03	08:16 (1)	06:28	06:43		05:52	07:00 (2)	05:17		05:09
	16:47	21 08:37 (1)	17:26	18:58		19:32	47 07:47 (2)	20:02		20:21
24	07:03	08:19 (1)	06:27	06:41		05:51	07:00 (2)	05:16		05:09
	16:48	18 08:37 (1)	17:27	18:59		19:33	45 07:45 (2)	20:03		20:21
25	07:02	08:20 (1)	06:25	06:39		05:49	07:01 (2)	05:16		05:10
	16:49	15 08:35 (1)	17:28	19:00		19:34	44 07:45 (2)	20:04		20:21
26	07:01	08:24 (1)	06:24	06:38		05:48	07:01 (2)	05:15		05:10
	16:50	8 08:32 (1)	17:29	19:01		19:35	42 07:43 (2)	20:04		20:21
27	07:00		06:22	06:36		05:46	07:02 (2)	05:14		05:10
	16:52		17:30	19:02		19:36	40 07:42 (2)	20:05		20:21
28	06:59		06:21	06:34		05:45	07:03 (2)	05:14		05:11
	16:53		17:32	19:03		19:37	38 07:41 (2)	20:06		20:21
29	06:59			06:32		05:44	07:03 (2)	05:13		05:11
	16:54			19:04		19:38	36 07:39 (2)	20:07		20:21
30	06:58			06:31		05:42	07:05 (2)	05:13		05:12
	16:55			19:05		19:39	33 07:38 (2)	20:08		20:21
31	06:57			06:29	07:25 (2)			05:12		
	16:57			19:07	10 07:35 (2)			20:09		
Potential sun hours	296		297	370		400		450		454
Total, worst case		770			10		1275		112	

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:23 AM / 2
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:22 AM/2.7.486

SHADOW - Calendar

Calculation: Unidirectional - window - worst case **Shadow receptor:** A - 124 Ambleside - unidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

The sun is shining all the day, from sunrise to sunset

The rotor plane is always perpendicular to the line from the WTG to the sun

The WTG is always operating

	July		August			September			October			November			December		
1	05:12		05:37			06:08		07:02 (2)	06:39			06:14			06:50		07:48 (1)
	20:21		20:03			19:17	48	07:50 (2)	18:26			16:39			16:14	34	08:22 (1)
2	05:13		05:38			06:09		07:02 (2)	06:40			06:15			06:51		07:48 (1)
	20:21		20:01			19:16	47	07:49 (2)	18:24			16:37			16:14	34	08:22 (1)
3	05:13		05:39			06:10		07:03 (2)	06:41			06:17			06:52		07:49 (1)
	20:21		20:00			19:14	45	07:48 (2)	18:23			16:36			16:13	34	08:23 (1)
4	05:14		05:40			06:11		07:03 (2)	06:42			06:18			06:53		07:49 (1)
	20:21		19:58			19:12	44	07:47 (2)	18:21			16:35			16:13	34	08:23 (1)
5	05:14		05:41			06:12		07:04 (2)	06:43			06:19			06:54		07:49 (1)
	20:21		19:57			19:11	42	07:46 (2)	18:19			16:34			16:13	35	08:24 (1)
6	05:15		05:42			06:13		07:05 (2)	06:44			06:20			06:55		07:50 (1)
	20:20		19:56			19:09	39	07:44 (2)	18:18			16:33			16:13	34	08:24 (1)
7	05:16		05:43			06:14		07:06 (2)	06:45			06:21			06:56		07:50 (1)
	20:20		19:54			19:07	37	07:43 (2)	18:16			16:32			16:13	35	08:25 (1)
8	05:16		05:44		07:22 (2)	06:15		07:07 (2)	06:47			06:23			06:56		07:50 (1)
	20:20		19:53	15	07:37 (2)	19:06	34	07:41 (2)	18:14			16:30			16:13	35	08:25 (1)
9	05:17		05:45		07:19 (2)	06:16		07:08 (2)	06:48			06:24			06:57		07:51 (1)
	20:20		19:52	20	07:39 (2)	19:04	31	07:39 (2)	18:13			16:29			16:13	35	08:26 (1)
10	05:18		05:46		07:17 (2)	06:17		07:10 (2)	06:49			06:25			06:58		07:52 (1)
	20:19		19:51	25	07:42 (2)	19:02	26	07:36 (2)	18:11			16:28			16:13	34	08:26 (1)
11	05:18		05:47		07:15 (2)	06:18		07:13 (2)	06:50			06:26			06:59		07:52 (1)
	20:19		19:49	28	07:43 (2)	19:01	20	07:33 (2)	18:09			16:27			16:13	35	08:27 (1)
12	05:19		05:48		07:14 (2)	06:19		07:17 (2)	06:51			06:27			07:00		07:53 (1)
	20:18		19:48	31	07:45 (2)	18:59	11	07:28 (2)	18:08			16:26			16:13	34	08:27 (1)
13	05:20		05:49		07:12 (2)	06:20			06:52			06:29			07:01		07:53 (1)
	20:18		19:47	34	07:46 (2)	18:57			18:06			16:25			16:13	35	08:28 (1)
14	05:20		05:50		07:11 (2)	06:21			06:53			06:30			07:02		07:53 (1)
	20:17		19:45	36	07:47 (2)	18:55			18:05			16:24			16:13	35	08:28 (1)
15	05:21		05:51		07:10 (2)	06:22			06:54			06:31			07:02		07:54 (1)
	20:17		19:44	38	07:48 (2)	18:54			18:03			16:24			16:13	34	08:28 (1)
16	05:22		05:52		07:09 (2)	06:23			06:55			06:32		07:56 (1)	07:03		07:55 (1)
	20:16		19:42	40	07:49 (2)	18:52			18:01			16:23	9	08:05 (1)	16:14	34	08:29 (1)
17	05:23		05:53		07:08 (2)	06:24			06:56			06:34		07:53 (1)	07:04		07:55 (1)
	20:16		19:41	42	07:50 (2)	18:50			18:00			16:22	15	08:08 (1)	16:14	34	08:29 (1)
18	05:24		05:54		07:07 (2)	06:26			06:58			06:35		07:52 (1)	07:04		07:55 (1)
	20:15		19:39	43	07:50 (2)	18:49			17:58			16:21	19	08:11 (1)	16:14	35	08:30 (1)
19	05:25		05:55		07:06 (2)	06:27			06:59			06:36		07:51 (1)	07:05		07:56 (1)
	20:14		19:38	45	07:51 (2)	18:47			17:57			16:20	21	08:12 (1)	16:15	34	08:30 (1)
20	05:25		05:56		07:05 (2)	06:28			07:00			06:37		07:50 (1)	07:06		07:56 (1)
	20:13		19:36	46	07:51 (2)	18:45			17:55			16:20	23	08:13 (1)	16:15	34	08:30 (1)
21	05:26		05:57		07:04 (2)	06:29			07:01			06:38		07:49 (1)	07:06		07:57 (1)
	20:13		19:35	48	07:52 (2)	18:43			17:54			16:19	25	08:14 (1)	16:16	34	08:31 (1)
22	05:27		05:58		07:04 (2)	06:30			07:02			06:39		07:49 (1)	07:07		07:57 (1)
	20:12		19:33	48	07:52 (2)	18:42			17:52			16:18	27	08:16 (1)	16:16	34	08:31 (1)
23	05:28		05:59		07:03 (2)	06:31			07:03			06:41		07:49 (1)	07:07		07:58 (1)
	20:11		19:32	49	07:52 (2)	18:40			17:51			16:18	28	08:17 (1)	16:17	34	08:32 (1)
24	05:29		06:00		07:03 (2)	06:32			07:05			06:42		07:48 (1)	07:08		07:58 (1)
	20:10		19:30	49	07:52 (2)	18:38			17:49			16:17	29	08:17 (1)	16:17	34	08:32 (1)
25	05:30		06:01		07:03 (2)	06:33			07:06			06:43		07:48 (1)	07:08		07:58 (1)
	20:09		19:29	49	07:52 (2)	18:36			17:48			16:16	30	08:18 (1)	16:18	35	08:33 (1)
26	05:31		06:02		07:02 (2)	06:34			07:07			06:44		07:48 (1)	07:08		08:00 (1)
	20:09		19:27	50	07:52 (2)	18:35			17:47			16:16	32	08:20 (1)	16:18	34	08:34 (1)
27	05:32		06:03		07:02 (2)	06:35			07:08			06:45		07:48 (1)	07:09		08:00 (1)
	20:08		19:26	50	07:52 (2)	18:33			17:45			16:15	32	08:20 (1)	16:19	34	08:34 (1)
28	05:33		06:04		07:02 (2)	06:36			07:09			06:46		07:48 (1)	07:09		08:00 (1)
	20:07		19:24	50	07:52 (2)	18:31			17:44			16:15	33	08:21 (1)	16:20	34	08:34 (1)
29	05:34		06:05		07:02 (2)	06:37			07:10			06:47		07:48 (1)	07:09		08:00 (1)
	20:06		19:22	49	07:51 (2)	18:30			17:43			16:15	33	08:21 (1)	16:20	34	08:34 (1)
30	05:35		06:06		07:02 (2)	06:38			07:12			06:48		07:48 (1)	07:10		08:00 (1)
	20:05		19:21	49	07:51 (2)	18:28			17:41			16:14	34	08:22 (1)	16:21	35	08:35 (1)
31	05:36		06:07		07:02 (2)				07:13						07:10		08:02 (1)
	20:04		19:19	48	07:50 (2)				17:40						16:22	34	08:36 (1)
Potential sun hours	461		429			375			344			296			286		
Total, worst case				982			424				390					1064	

Table layout: For each day in each month the following matrix apply

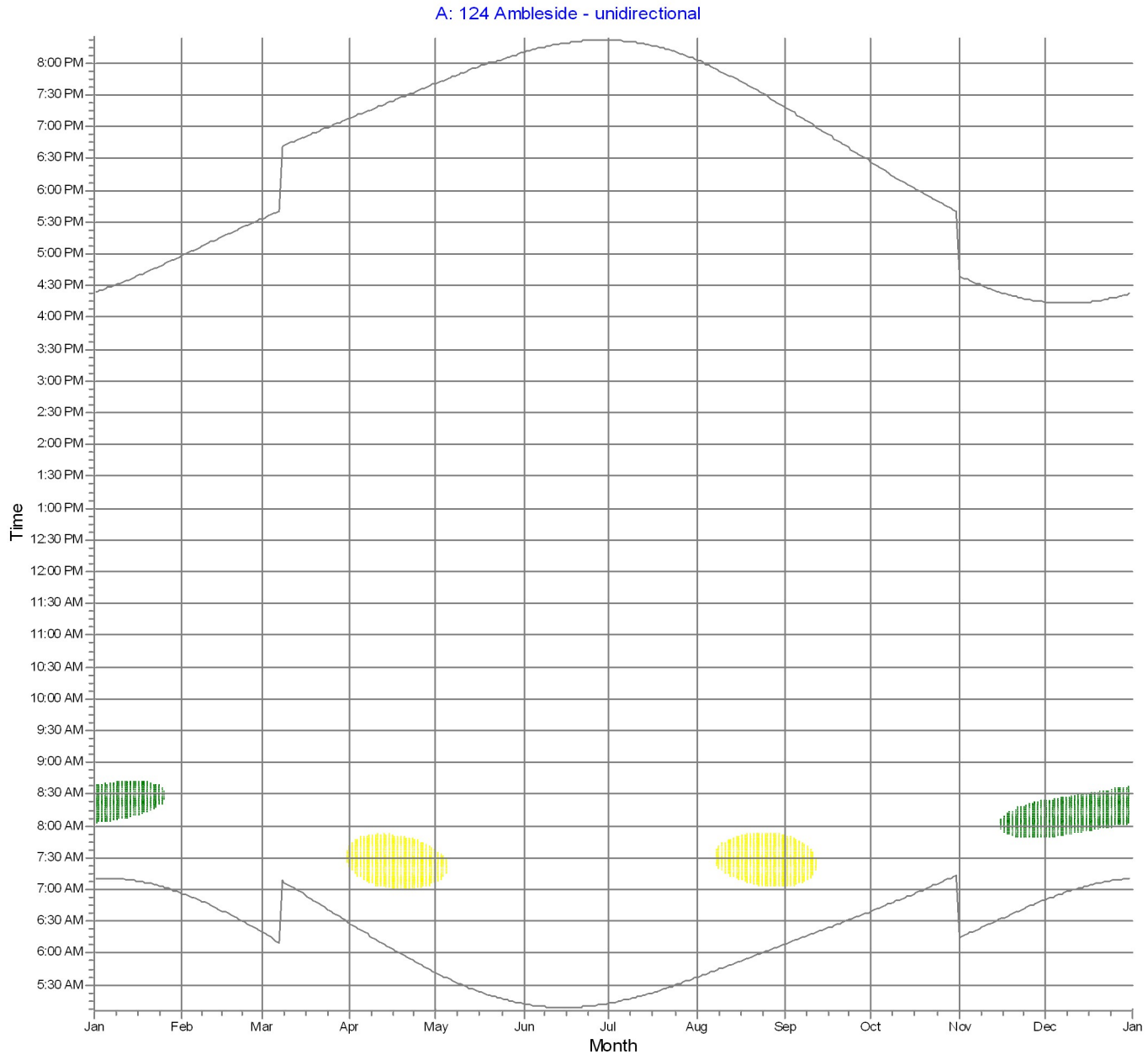
Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:
Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:24 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:22 AM/2.7.486

SHADOW - Calendar, graphical

Calculation: Unidirectional - window - worst case **Shadow receptor:** A - 124 Ambleside - unidirectional



WTGs

1: Wind I

2: Wind II

Project:

Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:24 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:22 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Unidirectional - window - worst case **WTG:** 1 - Wind I

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

The sun is shining all the day, from sunrise to sunset

The rotor plane is always perpendicular to the line from the WTG to the sun

The WTG is always operating

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10 08:02-08:37/35 16:23	06:56 16:58	06:19 17:33	06:27 19:08	05:41 19:40	05:12 20:10	05:12 20:21	05:37 20:03	06:08 19:17	06:39 18:26	06:14 16:39	06:50 07:48-08:22/34 16:14
2	07:10 08:02-08:37/35 16:24	06:55 16:59	06:17 17:34	06:26 19:09	05:40 19:41	05:11 20:10	05:13 20:21	05:38 20:01	06:09 19:16	06:40 18:24	06:15 16:37	06:51 07:48-08:22/34 16:14
3	07:10 08:03-08:38/35 16:25	06:54 17:00	06:16 17:35	06:24 19:10	05:38 19:42	05:11 20:11	05:13 20:21	05:39 20:00	06:10 19:14	06:41 18:23	06:16 16:36	06:52 07:49-08:23/34 16:13
4	07:10 08:03-08:38/35 16:26	06:53 17:02	06:14 17:36	06:22 19:11	05:37 19:43	05:10 20:12	05:14 20:21	05:40 19:58	06:11 19:12	06:42 18:21	06:18 16:35	06:53 07:49-08:23/34 16:13
5	07:10 08:04-08:39/35 16:27	06:52 17:03	06:13 17:37	06:21 19:12	05:36 19:45	05:10 20:12	05:14 20:21	05:41 19:57	06:12 19:11	06:43 18:19	06:19 16:34	06:54 07:49-08:24/35 16:13
6	07:10 08:03-08:38/35 16:28	06:50 17:04	06:11 17:39	06:19 19:13	05:34 19:46	05:10 20:13	05:15 20:20	05:42 19:56	06:13 19:09	06:44 18:18	06:20 16:33	06:55 07:50-08:24/34 16:13
7	07:10 08:04-08:39/35 16:29	06:49 17:06	06:09 17:40	06:17 19:14	05:33 19:47	05:09 20:14	05:16 20:20	05:43 19:54	06:14 19:07	06:45 18:16	06:21 16:32	06:56 07:50-08:25/35 16:13
8	07:10 08:05-08:39/34 16:30	06:48 17:07	07:08 18:41	06:16 19:15	05:32 19:48	05:09 20:14	05:16 20:20	05:44 19:53	06:15 19:06	06:46 18:14	06:23 16:30	06:56 07:50-08:25/35 16:13
9	07:10 08:05-08:40/35 16:31	06:47 17:08	07:06 18:42	06:14 19:16	05:31 19:49	05:09 20:15	05:17 20:19	05:45 19:52	06:16 19:04	06:48 18:13	06:24 16:29	06:57 07:51-08:26/35 16:13
10	07:09 08:06-08:40/34 16:32	06:46 17:09	07:04 18:43	06:12 19:17	05:30 19:50	05:09 20:16	05:18 20:19	05:46 19:51	06:17 19:02	06:49 18:11	06:25 16:28	06:58 07:52-08:26/34 16:13
11	07:09 08:06-08:40/34 16:33	06:45 17:11	07:03 18:44	06:11 19:18	05:29 19:51	05:08 20:16	05:18 20:19	05:47 19:49	06:18 19:01	06:50 18:09	06:26 16:27	06:59 07:52-08:27/35 16:13
12	07:09 08:07-08:41/34 16:34	06:43 17:12	07:01 18:45	06:09 19:20	05:27 19:52	05:08 20:17	05:19 20:18	05:48 19:48	06:19 18:59	06:51 18:08	06:27 16:26	07:00 07:53-08:27/34 16:13
13	07:09 08:07-08:40/33 16:35	06:42 17:13	07:00 18:47	06:08 19:21	05:26 19:53	05:08 20:17	05:20 20:18	05:49 19:46	06:20 18:57	06:52 18:06	06:29 16:25	07:01 07:53-08:28/35 16:13
14	07:08 08:08-08:41/33 16:36	06:41 17:14	06:58 18:48	06:06 19:22	05:25 19:54	05:08 20:18	05:20 20:17	05:50 19:45	06:21 18:55	06:53 18:05	06:30 16:24	07:01 07:53-08:28/35 16:13
15	07:08 08:09-08:41/32 16:37	06:39 17:16	06:56 18:49	06:04 19:23	05:24 19:55	05:08 20:18	05:21 20:17	05:51 19:44	06:22 18:54	06:54 18:03	06:31 16:24	07:02 07:54-08:28/34 16:13
16	07:07 08:09-08:41/32 16:38	06:38 17:17	06:54 18:50	06:03 19:24	05:23 19:56	05:08 20:19	05:22 20:16	05:52 19:42	06:23 18:52	06:55 18:01	06:32 07:56-08:05/9 16:23	07:03 07:55-08:29/34 16:14
17	07:07 08:10-08:40/30 16:39	06:37 17:18	06:53 18:51	06:01 19:25	05:22 19:57	05:08 20:19	05:23 20:15	05:53 19:41	06:24 18:50	06:56 18:00	06:33 07:53-08:08/15 16:22	07:04 07:55-08:29/34 16:14
18	07:06 08:11-08:40/29 16:41	06:35 17:19	06:51 18:52	06:00 19:26	05:21 19:58	05:08 20:19	05:24 20:15	05:54 19:39	06:25 18:48	06:58 17:58	06:35 07:52-08:11/19 16:21	07:04 07:55-08:30/35 16:14
19	07:06 08:12-08:40/28 16:42	06:34 17:21	06:49 18:53	05:58 19:27	05:21 19:59	05:08 20:20	05:25 20:14	05:55 19:38	06:27 18:47	06:59 17:57	06:36 07:51-08:12/21 16:20	07:05 07:56-08:30/34 16:15
20	07:05 08:13-08:40/27 16:43	06:32 17:22	06:48 18:54	05:57 19:28	05:20 20:00	05:09 20:20	05:25 20:13	05:56 19:36	06:28 18:45	07:00 17:55	06:37 07:50-08:13/23 16:20	07:05 07:56-08:30/34 16:15
21	07:05 08:14-08:39/25 16:44	06:31 17:23	06:46 18:56	05:55 19:29	05:19 20:00	05:09 20:20	05:26 20:13	05:57 19:35	06:29 18:43	07:01 17:54	06:38 07:49-08:14/25 16:19	07:06 07:57-08:31/34 16:16
22	07:04 08:15-08:38/23 16:45	06:30 17:24	06:44 18:57	05:54 19:30	05:18 20:01	05:09 20:21	05:27 20:12	05:58 19:33	06:30 18:42	07:02 17:52	06:39 07:49-08:16/27 16:18	07:07 07:57-08:31/34 16:16
23	07:03 08:16-08:37/21 16:47	06:28 17:26	06:43 18:58	05:52 19:32	05:17 20:02	05:09 20:21	05:28 20:11	05:59 19:32	06:31 18:40	07:03 17:51	06:41 07:49-08:17/28 16:18	07:07 07:58-08:32/34 16:17
24	07:03 08:19-08:37/18 16:48	06:27 17:27	06:41 18:59	05:51 19:33	05:16 20:03	05:09 20:21	05:29 20:10	06:00 19:30	06:32 18:38	07:05 17:49	06:42 07:48-08:17/29 16:17	07:08 07:58-08:32/34 16:17
25	07:02 08:20-08:35/15 16:49	06:25 17:28	06:39 19:00	05:49 19:34	05:16 20:04	05:10 20:21	05:30 20:09	06:01 19:29	06:33 18:36	07:06 17:48	06:43 07:48-08:18/30 16:16	07:08 07:58-08:33/35 16:18
26	07:01 08:24-08:32/8 16:50	06:24 17:29	06:38 19:01	05:48 19:35	05:15 20:04	05:10 20:21	05:31 20:09	06:02 19:27	06:34 18:35	07:07 17:47	06:44 07:48-08:20/32 16:16	07:08 08:00-08:34/34 16:18
27	07:00 16:52	06:22 17:30	06:36 19:02	05:46 19:36	05:14 20:05	05:10 20:21	05:32 20:08	06:03 19:26	06:35 18:33	07:08 17:45	06:45 07:48-08:20/32 16:15	07:09 08:00-08:34/34 16:19
28	06:59 16:53	06:21 17:32	06:34 19:03	05:45 19:37	05:14 20:06	05:11 20:21	05:33 20:07	06:04 19:24	06:36 18:31	07:09 17:44	06:46 07:48-08:21/33 16:15	07:09 08:00-08:34/34 16:20
29	06:59 16:54		06:32 19:04	05:44 19:38	05:13 20:07	05:11 20:21	05:34 20:06	06:05 19:22	06:37 18:29	07:10 17:43	06:47 07:48-08:21/33 16:15	07:09 08:00-08:34/34 16:20
30	06:58 16:55		06:31 19:05	05:42 19:39	05:13 20:08	05:12 20:21	05:35 20:05	06:06 19:21	06:38 18:28	07:12 17:41	06:48 07:48-08:22/34 16:14	07:09 08:00-08:35/35 16:21
31	06:57 16:57		06:29 19:06		05:12 20:09		05:36 20:04	06:07 19:19		07:13 17:40		07:10 08:02-08:36/34 16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	770	0	0	0	0	0	0	0	0	0	390	1064

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:

Town of Falmouth Wind Turbine Project

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6/14/2011 11:24 AM / 2

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Calculated:
6/14/2011 11:22 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Unidirectional - window - worst case **WTG:** 2 - Wind II

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

- The sun is shining all the day, from sunrise to sunset
- The rotor plane is always perpendicular to the line from the WTG to the sun
- The WTG is always operating

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10	06:56	06:19	06:27 07:20-07:40/20	05:41 07:06-07:37/31	05:12	05:12	05:37	06:08 07:02-07:50/48	06:39	06:14	06:50
	16:23	16:58	17:33	19:08	19:40	20:10	20:21	20:03	19:17	18:26	16:39	16:14
2	07:10	06:55	06:17	06:26 07:17-07:43/26	05:40 07:07-07:34/27	05:11	05:13	05:38	06:09 07:02-07:49/47	06:40	06:15	06:51
	16:24	16:59	17:34	19:09	19:41	20:10	20:21	20:01	19:16	18:24	16:37	16:14
3	07:10	06:54	06:16	06:24 07:14-07:45/31	05:38 07:09-07:32/23	05:11	05:13	05:39	06:10 07:03-07:48/45	06:41	06:16	06:52
	16:25	17:00	17:35	19:10	19:42	20:11	20:21	20:00	19:14	18:23	16:36	16:13
4	07:10	06:53	06:14	06:22 07:12-07:46/34	05:37 07:11-07:30/19	05:10	05:14	05:40	06:11 07:03-07:47/44	06:42	06:18	06:53
	16:26	17:02	17:36	19:11	19:43	20:12	20:21	19:58	19:12	18:21	16:35	16:13
5	07:10	06:52	06:13	06:21 07:11-07:48/37	05:36 07:15-07:27/12	05:10	05:14	05:41	06:12 07:04-07:46/42	06:43	06:19	06:54
	16:27	17:03	17:37	19:12	19:45	20:12	20:21	19:57	19:11	18:19	16:34	16:13
6	07:10	06:50	06:11	06:19 07:09-07:48/39	05:34	05:10	05:15	05:42	06:13 07:05-07:44/39	06:44	06:20	06:55
	16:28	17:04	17:39	19:13	19:46	20:13	20:20	19:56	19:09	18:18	16:33	16:13
7	07:10	06:49	06:09	06:17 07:07-07:49/42	05:33	05:09	05:15	05:43	06:14 07:06-07:43/37	06:45	06:21	06:56
	16:29	17:06	17:40	19:14	19:47	20:14	20:20	19:54	19:07	18:16	16:32	16:13
8	07:10	06:48	07:08	06:16 07:06-07:50/44	05:32	05:09	05:16	05:44 07:22-07:37/15	06:15 07:07-07:41/34	06:46	06:23	06:56
	16:30	17:07	18:41	19:15	19:48	20:14	20:20	19:53	19:06	18:14	16:30	16:13
9	07:10	06:47	07:06	06:14 07:05-07:50/45	05:31	05:09	05:17	05:45 07:19-07:39/20	06:16 07:08-07:39/31	06:48	06:24	06:57
	16:31	17:08	18:42	19:16	19:49	20:15	20:19	19:52	19:04	18:13	16:29	16:13
10	07:09	06:46	07:05	06:12 07:03-07:50/47	05:30	05:09	05:18	05:46 07:17-07:42/25	06:17 07:10-07:36/26	06:49	06:25	06:58
	16:32	17:09	18:43	19:17	19:50	20:16	20:19	19:51	19:02	18:11	16:28	16:13
11	07:09	06:45	07:03	06:11 07:03-07:51/48	05:29	05:08	05:18	05:47 07:15-07:43/28	06:18 07:13-07:33/20	06:50	06:26	06:59
	16:33	17:11	18:44	19:18	19:51	20:16	20:19	19:49	19:01	18:09	16:27	16:13
12	07:09	06:43	07:01	06:09 07:02-07:50/48	05:27	05:08	05:19	05:48 07:14-07:45/31	06:19 07:17-07:28/11	06:51	06:27	07:00
	16:34	17:12	18:45	19:20	19:52	20:17	20:18	19:48	18:59	18:08	16:26	16:13
13	07:09	06:42	07:00	06:08 07:02-07:51/49	05:26	05:08	05:20	05:49 07:12-07:46/34	06:20	06:52	06:29	07:01
	16:35	17:13	18:47	19:21	19:53	20:17	20:18	19:46	18:57	18:06	16:25	16:13
14	07:08	06:41	06:58	06:06 07:01-07:50/49	05:25	05:08	05:20	05:50 07:11-07:47/36	06:21	06:53	06:30	07:02
	16:36	17:14	18:48	19:22	19:54	20:18	20:17	19:45	18:55	18:05	16:24	16:13
15	07:08	06:39	06:56	06:04 07:01-07:51/50	05:24	05:08	05:21	05:51 07:10-07:48/38	06:22	06:54	06:31	07:02
	16:37	17:16	18:49	19:23	19:55	20:18	20:17	19:44	18:54	18:03	16:24	16:13
16	07:07	06:38	06:54	06:03 07:00-07:50/50	05:23	05:08	05:22	05:52 07:09-07:49/40	06:23	06:55	06:32	07:03
	16:38	17:17	18:50	19:24	19:56	20:19	20:16	19:42	18:52	18:01	16:23	16:14
17	07:07	06:37	06:53	06:01 06:59-07:49/50	05:22	05:08	05:23	05:53 07:08-07:50/42	06:24	06:56	06:33	07:04
	16:39	17:18	18:51	19:25	19:57	20:19	20:15	19:41	18:50	18:00	16:22	16:14
18	07:06	06:35	06:51	06:00 07:00-07:49/49	05:21	05:08	05:24	05:54 07:07-07:50/43	06:25	06:58	06:35	07:04
	16:41	17:19	18:52	19:26	19:58	20:19	20:15	19:39	18:48	17:58	16:21	16:14
19	07:06	06:34	06:49	05:58 06:59-07:48/49	05:21	05:08	05:25	05:55 07:06-07:51/45	06:27	06:59	06:36	07:05
	16:42	17:21	18:53	19:27	19:59	20:20	20:14	19:38	18:47	17:57	16:20	16:15
20	07:05	06:32	06:48	05:57 07:00-07:48/48	05:20	05:09	05:25	05:56 07:05-07:51/46	06:28	07:00	06:37	07:06
	16:43	17:22	18:54	19:28	20:00	20:20	20:13	19:36	18:45	17:55	16:20	16:15
21	07:05	06:31	06:46	05:55 06:59-07:47/48	05:19	05:09	05:26	05:57 07:04-07:52/48	06:29	07:01	06:38	07:06
	16:44	17:23	18:56	19:29	20:00	20:20	20:13	19:35	18:43	17:54	16:19	16:16
22	07:04	06:30	06:44	05:54 07:00-07:47/47	05:18	05:09	05:27	05:58 07:04-07:52/48	06:30	07:02	06:39	07:07
	16:45	17:24	18:57	19:30	20:01	20:21	20:12	19:33	18:42	17:52	16:18	16:16
23	07:03	06:28	06:43	05:52 07:00-07:47/47	05:17	05:09	05:28	05:59 07:03-07:52/49	06:31	07:03	06:41	07:07
	16:47	17:26	18:58	19:32	20:02	20:21	20:11	19:32	18:40	17:51	16:18	16:17
24	07:03	06:27	06:41	05:51 07:00-07:45/45	05:16	05:09	05:29	06:00 07:03-07:52/49	06:32	07:05	06:42	07:08
	16:48	17:27	18:59	19:33	20:03	20:21	20:10	19:30	18:38	17:49	16:17	16:17
25	07:02	06:25	06:39	05:49 07:01-07:45/44	05:16	05:10	05:30	06:01 07:03-07:52/49	06:33	07:06	06:43	07:08
	16:49	17:28	19:00	19:34	20:04	20:21	20:09	19:29	18:36	17:48	16:16	16:18
26	07:01	06:24	06:38	05:48 07:01-07:43/42	05:15	05:10	05:31	06:02 07:02-07:52/50	06:34	07:07	06:44	07:08
	16:50	17:29	19:01	19:35	20:04	20:21	20:09	19:27	18:35	17:47	16:16	16:18
27	07:00	06:22	06:36	05:46 07:02-07:42/40	05:14	05:10	05:32	06:03 07:02-07:52/50	06:35	07:08	06:45	07:09
	16:52	17:30	19:02	19:36	20:05	20:21	20:08	19:26	18:33	17:45	16:15	16:19
28	06:59	06:21	06:34	05:45 07:03-07:41/38	05:14	05:11	05:33	06:04 07:02-07:52/50	06:36	07:09	06:46	07:09
	16:53	17:32	19:03	19:37	20:06	20:21	20:07	19:24	18:31	17:44	16:15	16:20
29	06:59		06:32	05:44 07:03-07:39/36	05:13	05:11	05:34	06:05 07:02-07:51/49	06:37	07:10	06:47	07:09
	16:54		19:04	19:38	20:07	20:21	20:06	19:22	18:29	17:43	16:15	16:20
30	06:58		06:31	05:42 07:05-07:38/33	05:13	05:12	05:35	06:06 07:02-07:51/49	06:38	07:12	06:48	07:09
	16:55		19:05	19:39	20:08	20:21	20:05	19:21	18:28	17:41	16:14	16:21
31	06:57		06:29 07:25-07:35/10		05:12		05:36	06:07 07:02-07:50/48		07:13		07:10
	16:57		19:06		20:09		20:04	19:19		17:40		16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	0	0	10	1275	112	0	0	982	424	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
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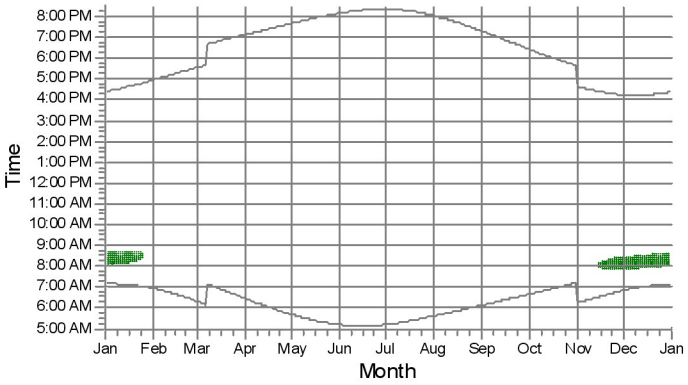
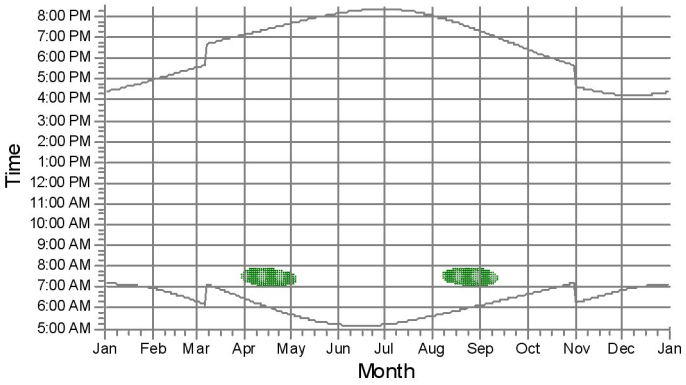
SHADOW - Calendar per WTG, graphical

Calculation: Unidirectional - window - worst case

1: Wind I



2: Wind II



Shadow receptor

A: 124 Ambleside - unidirectional

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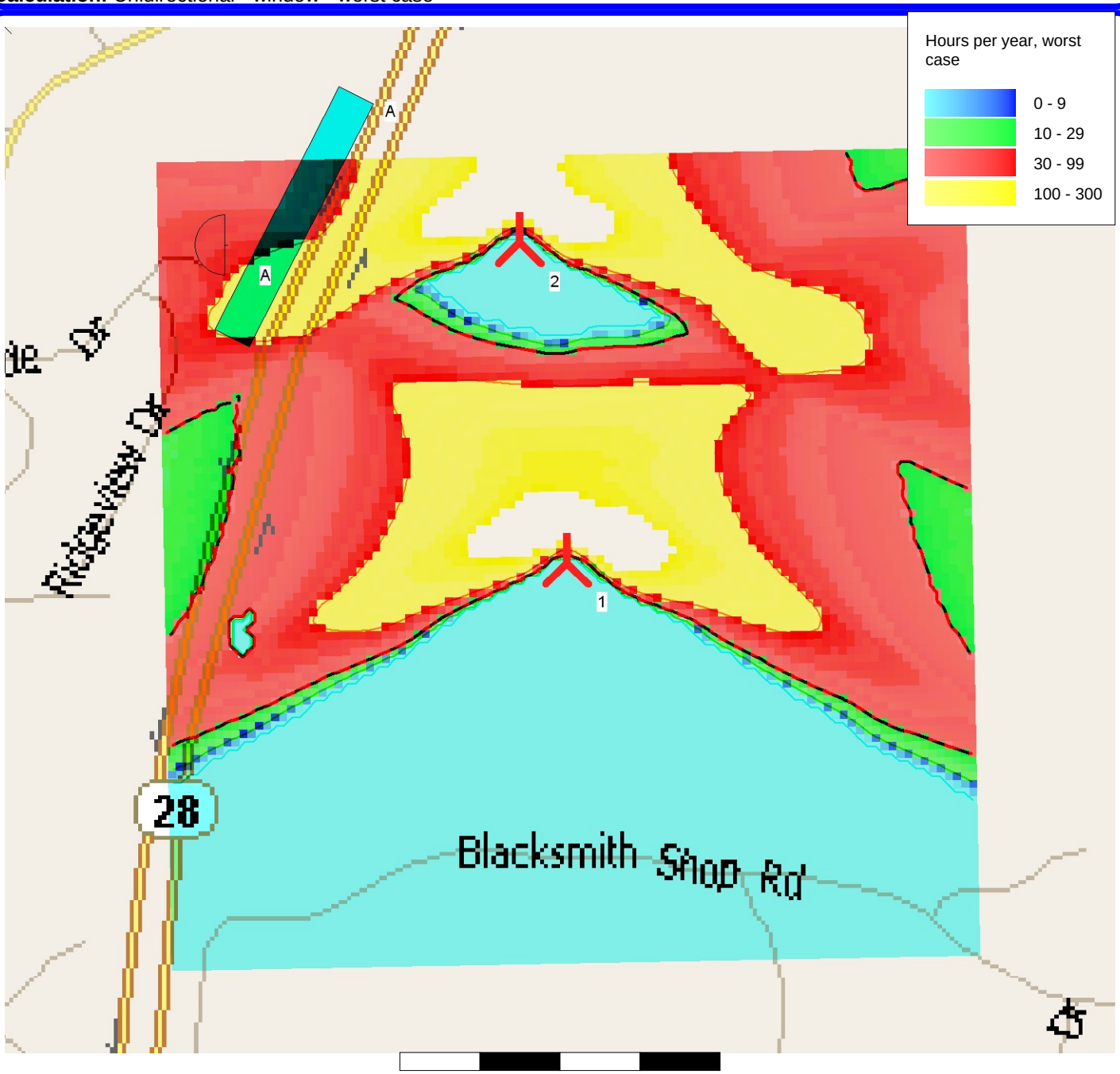
SHADOW - Map

Calculation: Unidirectional - window - worst case



Map: WindPRO map , Print scale 1:7,500, Map center UTM NAD 83 Zone: 19 East: 364,950.00 North: 4,607,336.10

New WTG Obstacle Shadow receptor

Isolines showing shadow in Hours per year, worst case

0 10 30 100

Project:
Town of Falmouth Wind Turbine Project

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Calculated:
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SHADOW - Main Result

Calculation: Unidirectional - window - real case

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

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

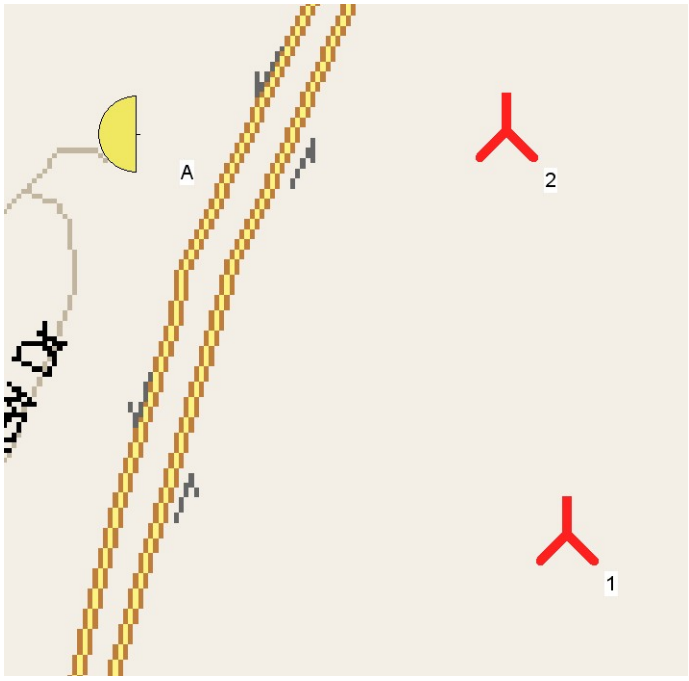
Operational hours are calculated from WTGs in calculation and wind distribution:
RERL Met Tower

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Height Contours: Contours_3m_Optimized.wpo (2)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:7,500
New WTG Shadow receptor

WTGs

	UTM NAD83 Zone: 19				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: 19		[m]					[kW]	[m]	[m]	[m]	[RPM]
1	364,948.00	4,607,295.98	45.0	Wind I	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4
2	364,896.00	4,607,696.98	39.0	Wind II	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4

Shadow receptor-Input

		UTM NAD83 Zone: 19								
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	124 Ambleside - unidirectional	364,528.00	4,607,699.98	19.7	1.0	1.0	1.0	-90.0	90.0	Fixed direction

Calculation Results

Shadow receptor

		Shadow, expected values
No.	Name	Shadow hours per year [h/year]
A	124 Ambleside - unidirectional	26:16

Project:
Town of Falmouth Wind Turbine Project

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6/14/2011 11:38 AM/2.7.486

SHADOW - Main Result

Calculation: Unidirectional - window - real case

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	Wind I	37:04	10:33
2	Wind II	46:43	15:43

Project:

Town of Falmouth Wind Turbine Project

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Calculated:
6/14/2011 11:38 AM/2.7.486

SHADOW - Calendar

Calculation: Unidirectional - window - real case **Shadow receptor:** A - 124 Ambleside - unidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	January		February	March		April		May		June
1	07:10	08:02 (1)	06:56	06:19		06:27	07:20 (2)	05:41	07:06 (2)	05:12
	16:23	35 08:37 (1)	16:58	17:33		19:08	20 07:40 (2)	19:40	31 07:37 (2)	20:10
2	07:10	08:02 (1)	06:55	06:17		06:26	07:17 (2)	05:40	07:07 (2)	05:11
	16:24	35 08:37 (1)	16:59	17:34		19:09	26 07:43 (2)	19:41	27 07:34 (2)	20:10
3	07:10	08:03 (1)	06:54	06:16		06:24	07:14 (2)	05:38	07:09 (2)	05:11
	16:25	35 08:38 (1)	17:00	17:35		19:10	31 07:45 (2)	19:42	23 07:32 (2)	20:11
4	07:10	08:03 (1)	06:53	06:14		06:22	07:12 (2)	05:37	07:11 (2)	05:10
	16:26	35 08:38 (1)	17:02	17:36		19:11	34 07:46 (2)	19:43	19 07:30 (2)	20:12
5	07:10	08:04 (1)	06:52	06:13		06:21	07:11 (2)	05:36	07:15 (2)	05:10
	16:27	35 08:39 (1)	17:03	17:37		19:12	37 07:48 (2)	19:45	12 07:27 (2)	20:13
6	07:10	08:03 (1)	06:51	06:11		06:19	07:09 (2)	05:34		05:10
	16:28	35 08:38 (1)	17:04	17:39		19:13	39 07:48 (2)	19:46		20:13
7	07:10	08:04 (1)	06:49	06:09		06:17	07:07 (2)	05:33		05:09
	16:29	35 08:39 (1)	17:06	17:40		19:14	42 07:49 (2)	19:47		20:14
8	07:10	08:05 (1)	06:48	07:08		06:16	07:06 (2)	05:32		05:09
	16:30	34 08:39 (1)	17:07	18:41		19:15	44 07:50 (2)	19:48		20:15
9	07:10	08:05 (1)	06:47	07:06		06:14	07:05 (2)	05:31		05:09
	16:31	35 08:40 (1)	17:08	18:42		19:16	45 07:50 (2)	19:49		20:15
10	07:09	08:06 (1)	06:46	07:05		06:12	07:03 (2)	05:30		05:09
	16:32	34 08:40 (1)	17:09	18:43		19:17	47 07:50 (2)	19:50		20:16
11	07:09	08:06 (1)	06:45	07:03		06:11	07:03 (2)	05:29		05:08
	16:33	34 08:40 (1)	17:11	18:44		19:19	48 07:51 (2)	19:51		20:16
12	07:09	08:07 (1)	06:43	07:01		06:09	07:02 (2)	05:28		05:08
	16:34	34 08:41 (1)	17:12	18:45		19:20	48 07:50 (2)	19:52		20:17
13	07:09	08:07 (1)	06:42	07:00		06:08	07:02 (2)	05:26		05:08
	16:35	33 08:40 (1)	17:13	18:47		19:21	49 07:51 (2)	19:53		20:17
14	07:08	08:08 (1)	06:41	06:58		06:06	07:01 (2)	05:25		05:08
	16:36	33 08:41 (1)	17:14	18:48		19:22	49 07:50 (2)	19:54		20:18
15	07:08	08:09 (1)	06:39	06:56		06:04	07:01 (2)	05:24		05:08
	16:37	32 08:41 (1)	17:16	18:49		19:23	50 07:51 (2)	19:55		20:18
16	07:07	08:09 (1)	06:38	06:55		06:03	07:00 (2)	05:23		05:08
	16:38	32 08:41 (1)	17:17	18:50		19:24	50 07:50 (2)	19:56		20:19
17	07:07	08:10 (1)	06:37	06:53		06:01	06:59 (2)	05:22		05:08
	16:39	30 08:40 (1)	17:18	18:51		19:25	50 07:49 (2)	19:57		20:19
18	07:06	08:11 (1)	06:35	06:51		06:00	07:00 (2)	05:21		05:08
	16:41	29 08:40 (1)	17:19	18:52		19:26	49 07:49 (2)	19:58		20:19
19	07:06	08:12 (1)	06:34	06:49		05:58	06:59 (2)	05:21		05:08
	16:42	28 08:40 (1)	17:21	18:53		19:27	49 07:48 (2)	19:59		20:20
20	07:05	08:13 (1)	06:32	06:48		05:57	07:00 (2)	05:20		05:09
	16:43	27 08:40 (1)	17:22	18:54		19:28	48 07:48 (2)	20:00		20:20
21	07:05	08:14 (1)	06:31	06:46		05:55	06:59 (2)	05:19		05:09
	16:44	25 08:39 (1)	17:23	18:56		19:29	48 07:47 (2)	20:00		20:20
22	07:04	08:15 (1)	06:30	06:44		05:54	07:00 (2)	05:18		05:09
	16:45	23 08:38 (1)	17:24	18:57		19:30	47 07:47 (2)	20:01		20:21
23	07:03	08:16 (1)	06:28	06:43		05:52	07:00 (2)	05:17		05:09
	16:47	21 08:37 (1)	17:26	18:58		19:32	47 07:47 (2)	20:02		20:21
24	07:03	08:19 (1)	06:27	06:41		05:51	07:00 (2)	05:16		05:09
	16:48	18 08:37 (1)	17:27	18:59		19:33	45 07:45 (2)	20:03		20:21
25	07:02	08:20 (1)	06:25	06:39		05:49	07:01 (2)	05:16		05:10
	16:49	15 08:35 (1)	17:28	19:00		19:34	44 07:45 (2)	20:04		20:21
26	07:01	08:24 (1)	06:24	06:38		05:48	07:01 (2)	05:15		05:10
	16:50	8 08:32 (1)	17:29	19:01		19:35	42 07:43 (2)	20:04		20:21
27	07:00		06:22	06:36		05:46	07:02 (2)	05:14		05:10
	16:52		17:30	19:02		19:36	40 07:42 (2)	20:05		20:21
28	06:59		06:21	06:34		05:45	07:03 (2)	05:14		05:11
	16:53		17:32	19:03		19:37	38 07:41 (2)	20:06		20:21
29	06:59			06:32		05:44	07:03 (2)	05:13		05:11
	16:54			19:04		19:38	36 07:39 (2)	20:07		20:21
30	06:58			06:31		05:42	07:05 (2)	05:13		05:12
	16:55			19:05		19:39	33 07:38 (2)	20:08		20:21
31	06:57			06:29	07:25 (2)			05:12		
	16:57			19:07	10 07:35 (2)			20:09		
Potential sun hours	296		297	370		400		450		454
Total, worst case		770			10		1275		112	
Sun reduction		0.57			0.60		0.57		0.61	
Oper. time red.		0.94			0.94		0.94		0.94	
Wind dir. red.		0.58			0.58		0.58		0.58	
Total reduction		0.31			0.33		0.31		0.34	
Total, real		237			3		396		38	

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:39 AM / 2

Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:38 AM/2.7.486

SHADOW - Calendar

Calculation: Unidirectional - window - real case **Shadow receptor:** A - 124 Ambleside - unidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	July		August		September		October		November		December	
1	05:12		05:37		06:08		06:39		06:14		06:50	
	20:21		20:03		19:17	48	07:50 (2)	18:26	16:39		16:14	34
2	05:13		05:38		06:09		07:02 (2)	06:40	06:15		06:51	
	20:21		20:01		19:16	47	07:49 (2)	18:24	16:37		16:14	34
3	05:13		05:39		06:10		07:03 (2)	06:41	06:17		06:52	
	20:21		20:00		19:14	45	07:48 (2)	18:23	16:36		16:13	34
4	05:14		05:40		06:11		07:03 (2)	06:42	06:18		06:53	
	20:21		19:58		19:12	44	07:47 (2)	18:21	16:35		16:13	34
5	05:14		05:41		06:12		07:04 (2)	06:43	06:19		06:54	
	20:21		19:57		19:11	42	07:46 (2)	18:19	16:34		16:13	35
6	05:15		05:42		06:13		07:05 (2)	06:44	06:20		06:55	
	20:20		19:56		19:09	39	07:44 (2)	18:18	16:33		16:13	34
7	05:16		05:43		06:14		07:06 (2)	06:45	06:21		06:56	
	20:20		19:54		19:07	37	07:43 (2)	18:16	16:32		16:13	35
8	05:16		05:44		07:22 (2)		06:15		07:07 (2)	06:47	06:23		06:56	
	20:20		19:53	15	07:37 (2)		19:06	34	07:41 (2)	18:14	16:30		16:13	35
9	05:17		05:45		07:19 (2)		06:16		07:08 (2)	06:48	06:24		06:57	
	20:20		19:52	20	07:39 (2)		19:04	31	07:39 (2)	18:13	16:29		16:13	35
10	05:18		05:46		07:17 (2)		06:17		07:10 (2)	06:49	06:25		06:58	
	20:19		19:51	25	07:42 (2)		19:02	26	07:36 (2)	18:11	16:28		16:13	34
11	05:18		05:47		07:15 (2)		06:18		07:13 (2)	06:50	06:26		06:59	
	20:19		19:49	28	07:43 (2)		19:01	20	07:33 (2)	18:09	16:27		16:13	35
12	05:19		05:48		07:14 (2)		06:19		07:17 (2)	06:51	06:27		07:00	
	20:18		19:48	31	07:45 (2)		18:59	11	07:28 (2)	18:08	16:26		16:13	34
13	05:20		05:49		07:12 (2)		06:20			06:52	06:29		07:01	
	20:18		19:47	34	07:46 (2)		18:57			18:06	16:25		16:13	35
14	05:20		05:50		07:11 (2)		06:21			06:53	06:30		07:02	
	20:17		19:45	36	07:47 (2)		18:55			18:05	16:24		16:13	35
15	05:21		05:51		07:10 (2)		06:22			06:54	06:31		07:02	
	20:17		19:44	38	07:48 (2)		18:54			18:03	16:24		16:13	34
16	05:22		05:52		07:09 (2)		06:23			06:55	06:32		07:56 (1)	07:03		07:55 (1)
	20:16		19:42	40	07:49 (2)		18:52			18:01	16:23	9	08:05 (1)	16:14	34	08:29 (1)
17	05:23		05:53		07:08 (2)		06:24			06:56	06:34		07:53 (1)	07:04		07:55 (1)
	20:16		19:41	42	07:50 (2)		18:50			18:00	16:22	15	08:08 (1)	16:14	34	08:29 (1)
18	05:24		05:54		07:07 (2)		06:26			06:58	06:35		07:52 (1)	07:04		07:55 (1)
	20:15		19:39	43	07:50 (2)		18:49			17:58	16:21	19	08:11 (1)	16:14	35	08:30 (1)
19	05:25		05:55		07:06 (2)		06:27			06:59	06:36		07:51 (1)	07:05		07:56 (1)
	20:14		19:38	45	07:51 (2)		18:47			17:57	16:20	21	08:12 (1)	16:15	34	08:30 (1)
20	05:25		05:56		07:05 (2)		06:28			07:00	06:37		07:50 (1)	07:06		07:56 (1)
	20:13		19:36	46	07:51 (2)		18:45			17:55	16:20	23	08:13 (1)	16:15	34	08:30 (1)
21	05:26		05:57		07:04 (2)		06:29			07:01	06:38		07:49 (1)	07:06		07:57 (1)
	20:13		19:35	48	07:52 (2)		18:43			17:54	16:19	25	08:14 (1)	16:16	34	08:31 (1)
22	05:27		05:58		07:04 (2)		06:30			07:02	06:39		07:49 (1)	07:07		07:57 (1)
	20:12		19:33	48	07:52 (2)		18:42			17:52	16:18	27	08:16 (1)	16:16	34	08:31 (1)
23	05:28		05:59		07:03 (2)		06:31			07:03	06:41		07:49 (1)	07:07		07:58 (1)
	20:11		19:32	49	07:52 (2)		18:40			17:51	16:18	28	08:17 (1)	16:17	34	08:32 (1)
24	05:29		06:00		07:03 (2)		06:32			07:05	06:42		07:48 (1)	07:08		07:58 (1)
	20:10		19:30	49	07:52 (2)		18:38			17:49	16:17	29	08:17 (1)	16:17	34	08:32 (1)
25	05:30		06:01		07:03 (2)		06:33			07:06	06:43		07:48 (1)	07:08		07:58 (1)
	20:09		19:29	49	07:52 (2)		18:36			17:48	16:16	30	08:18 (1)	16:18	35	08:33 (1)
26	05:31		06:02		07:02 (2)		06:34			07:07	06:44		07:48 (1)	07:08		08:00 (1)
	20:09		19:27	50	07:52 (2)		18:35			17:47	16:16	32	08:20 (1)	16:18	34	08:34 (1)
27	05:32		06:03		07:02 (2)		06:35			07:08	06:45		07:48 (1)	07:09		08:00 (1)
	20:08		19:26	50	07:52 (2)		18:33			17:45	16:15	32	08:20 (1)	16:19	34	08:34 (1)
28	05:33		06:04		07:02 (2)		06:36			07:09	06:46		07:48 (1)	07:09		08:00 (1)
	20:07		19:24	50	07:52 (2)		18:31			17:44	16:15	33	08:21 (1)	16:20	34	08:34 (1)
29	05:34		06:05		07:02 (2)		06:37			07:10	06:47		07:48 (1)	07:09		08:00 (1)
	20:06		19:22	49	07:51 (2)		18:30			17:43	16:15	33	08:21 (1)	16:20	34	08:34 (1)
30	05:35		06:06		07:02 (2)		06:38			07:12	06:48		07:48 (1)	07:10		08:00 (1)
	20:05		19:21	49	07:51 (2)		18:28			17:41	16:14	34	08:22 (1)	16:21	35	08:35 (1)
31	05:36		06:07		07:02 (2)					07:13				07:10		08:02 (1)
	20:04		19:19	48	07:50 (2)					17:40				16:22	34	08:36 (1)
Potential sun hours	461		429		375				344		296			286		
Total, worst case				982			424					390			1064	
Sun reduction				0.67			0.63					0.48			0.51	
Oper. time red.				0.94			0.94					0.94			0.94	
Wind dir. red.				0.58			0.58					0.58			0.58	
Total reduction				0.37			0.35					0.26			0.28	
Total, real				359			147					102			295	

Table layout: For each day in each month the following matrix apply

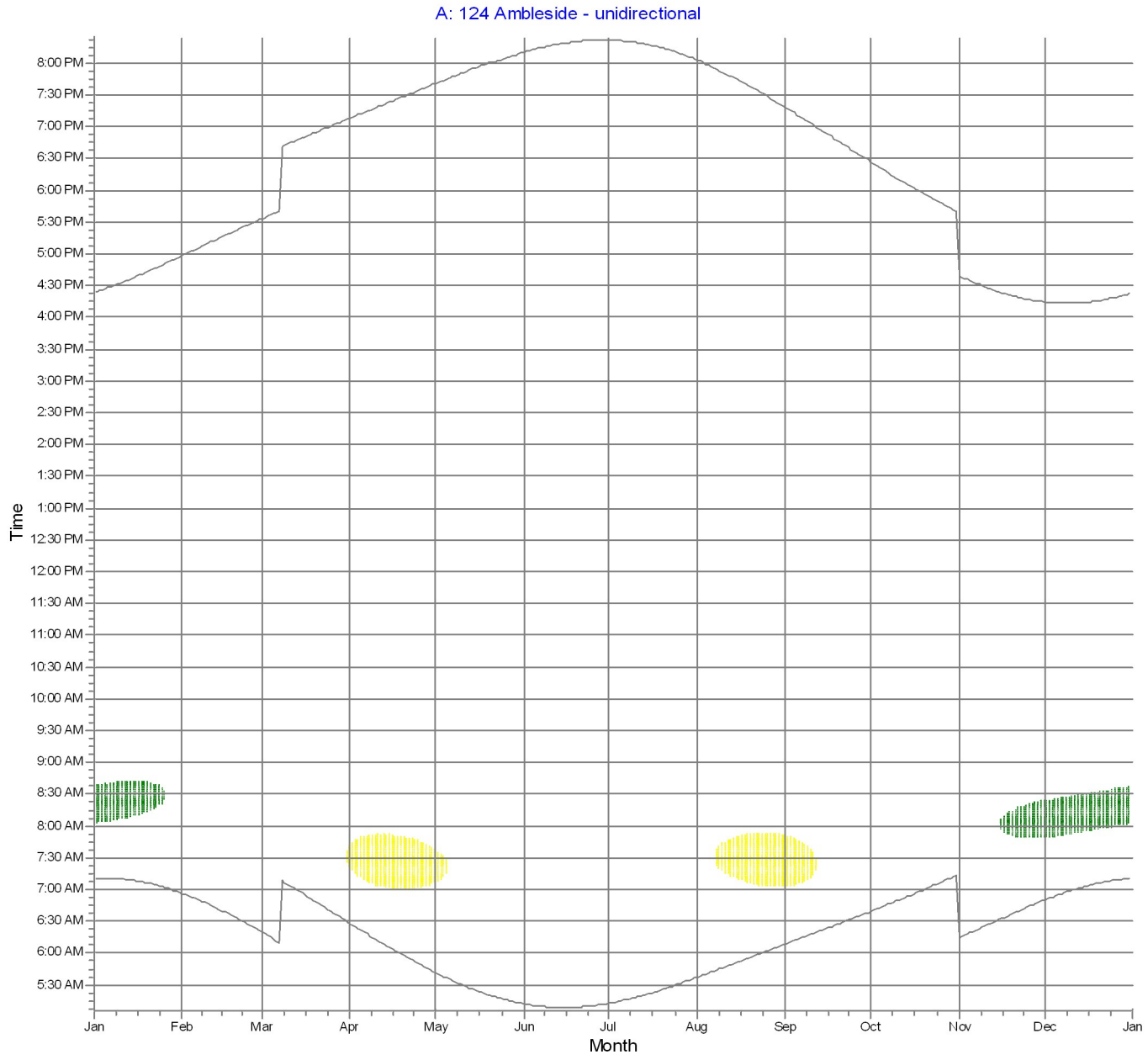
Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:
Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:39 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:38 AM/2.7.486

SHADOW - Calendar, graphical

Calculation: Unidirectional - window - real case**Shadow receptor:** A - 124 Ambleside - unidirectional



WTGs

1: Wind I

2: Wind II

Project:

Town of Falmouth Wind Turbine Project

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6/14/2011 11:39 AM / 1

Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:38 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Unidirectional - window - real case **WTG:** 1 - Wind I

Assumptions for shadow calculations

Maximum distance for influence	2,000 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10 08:02-08:37/35 16:23	06:56 16:58	06:19 17:33	06:27 19:08	05:41 19:40	05:12 20:10	05:12 20:21	05:37 20:03	06:08 19:17	06:39 18:26	06:14 16:39	06:50 07:48-08:22/34 16:14
2	07:10 08:02-08:37/35 16:24	06:55 16:59	06:17 17:34	06:26 19:09	05:40 19:41	05:11 20:10	05:13 20:21	05:38 20:01	06:09 19:16	06:40 18:24	06:15 16:37	06:51 07:48-08:22/34 16:14
3	07:10 08:03-08:38/35 16:25	06:54 17:00	06:16 17:35	06:24 19:10	05:38 19:42	05:11 20:11	05:13 20:21	05:39 20:00	06:10 19:14	06:41 18:23	06:16 16:36	06:52 07:49-08:23/34 16:13
4	07:10 08:03-08:38/35 16:26	06:53 17:02	06:14 17:36	06:22 19:11	05:37 19:43	05:10 20:12	05:14 20:21	05:40 19:58	06:11 19:12	06:42 18:21	06:18 16:35	06:53 07:49-08:23/34 16:13
5	07:10 08:04-08:39/35 16:27	06:52 17:03	06:13 17:37	06:21 19:12	05:36 19:45	05:10 20:12	05:14 20:21	05:41 19:57	06:12 19:11	06:43 18:19	06:19 16:34	06:54 07:49-08:24/35 16:13
6	07:10 08:03-08:38/35 16:28	06:50 17:04	06:11 17:39	06:19 19:13	05:34 19:46	05:10 20:13	05:15 20:20	05:42 19:56	06:13 19:09	06:44 18:18	06:20 16:33	06:55 07:50-08:24/34 16:13
7	07:10 08:04-08:39/35 16:29	06:49 17:06	06:09 17:40	06:17 19:14	05:33 19:47	05:09 20:14	05:16 20:20	05:43 19:54	06:14 19:07	06:45 18:16	06:21 16:32	06:56 07:50-08:25/35 16:13
8	07:10 08:05-08:39/34 16:30	06:48 17:07	07:08 18:41	06:16 19:15	05:32 19:48	05:09 20:14	05:16 20:20	05:44 19:53	06:15 19:06	06:46 18:14	06:23 16:30	06:56 07:50-08:25/35 16:13
9	07:10 08:05-08:40/35 16:31	06:47 17:08	07:06 18:42	06:14 19:16	05:31 19:49	05:09 20:15	05:17 20:19	05:45 19:52	06:16 19:04	06:48 18:13	06:24 16:29	06:57 07:51-08:26/35 16:13
10	07:09 08:06-08:40/34 16:32	06:46 17:09	07:04 18:43	06:12 19:17	05:30 19:50	05:09 20:16	05:18 20:19	05:46 19:51	06:17 19:02	06:49 18:11	06:25 16:28	06:58 07:52-08:26/34 16:13
11	07:09 08:06-08:40/34 16:33	06:45 17:11	07:03 18:44	06:11 19:18	05:29 19:51	05:08 20:16	05:18 20:19	05:47 19:49	06:18 19:01	06:50 18:09	06:26 16:27	06:59 07:52-08:27/35 16:13
12	07:09 08:07-08:41/34 16:34	06:43 17:12	07:01 18:45	06:09 19:20	05:27 19:52	05:08 20:17	05:19 20:18	05:48 19:48	06:19 18:59	06:51 18:08	06:27 16:26	07:00 07:53-08:27/34 16:13
13	07:09 08:07-08:40/33 16:35	06:42 17:13	07:00 18:47	06:08 19:21	05:26 19:53	05:08 20:17	05:20 20:18	05:49 19:46	06:20 18:57	06:52 18:06	06:29 16:25	07:01 07:53-08:28/35 16:13
14	07:08 08:08-08:41/33 16:36	06:41 17:14	06:58 18:48	06:06 19:22	05:25 19:54	05:08 20:18	05:20 20:17	05:50 19:45	06:21 18:55	06:53 18:05	06:30 16:24	07:01 07:53-08:28/35 16:13
15	07:08 08:09-08:41/32 16:37	06:39 17:16	06:56 18:49	06:04 19:23	05:24 19:55	05:08 20:18	05:21 20:17	05:51 19:44	06:22 18:54	06:54 18:03	06:31 16:24	07:02 07:54-08:28/34 16:13
16	07:07 08:09-08:41/32 16:38	06:38 17:17	06:54 18:50	06:03 19:24	05:23 19:56	05:08 20:19	05:22 20:16	05:52 19:42	06:23 18:52	06:55 18:01	06:32 07:56-08:05/9 16:23	07:03 07:55-08:29/34 16:14
17	07:07 08:10-08:40/30 16:39	06:37 17:18	06:53 18:51	06:01 19:25	05:22 19:57	05:08 20:19	05:23 20:15	05:53 19:41	06:24 18:50	06:56 18:00	06:33 07:53-08:08/15 16:22	07:04 07:55-08:29/34 16:14
18	07:06 08:11-08:40/29 16:41	06:35 17:19	06:51 18:52	06:00 19:26	05:21 19:58	05:08 20:19	05:24 20:15	05:54 19:39	06:25 18:48	06:58 17:58	06:35 07:52-08:11/19 16:21	07:04 07:55-08:30/35 16:14
19	07:06 08:12-08:40/28 16:42	06:34 17:21	06:49 18:53	05:58 19:27	05:21 19:59	05:08 20:20	05:25 20:14	05:55 19:38	06:27 18:47	06:59 17:57	06:36 07:51-08:12/21 16:20	07:05 07:56-08:30/34 16:15
20	07:05 08:13-08:40/27 16:43	06:32 17:22	06:48 18:54	05:57 19:28	05:20 20:00	05:09 20:20	05:25 20:13	05:56 19:36	06:28 18:45	07:00 17:55	06:37 07:50-08:13/23 16:20	07:05 07:56-08:30/34 16:15
21	07:05 08:14-08:39/25 16:44	06:31 17:23	06:46 18:56	05:55 19:29	05:19 20:00	05:09 20:20	05:26 20:13	05:57 19:35	06:29 18:43	07:01 17:54	06:38 07:49-08:14/25 16:19	07:06 07:57-08:31/34 16:16
22	07:04 08:15-08:38/23 16:45	06:30 17:24	06:44 18:57	05:54 19:30	05:18 20:01	05:09 20:21	05:27 20:12	05:58 19:33	06:30 18:42	07:02 17:52	06:39 07:49-08:16/27 16:18	07:07 07:57-08:31/34 16:16
23	07:03 08:16-08:37/21 16:47	06:28 17:26	06:43 18:58	05:52 19:32	05:17 20:02	05:09 20:21	05:28 20:11	05:59 19:32	06:31 18:40	07:03 17:51	06:41 07:49-08:17/28 16:18	07:07 07:58-08:32/34 16:17
24	07:03 08:19-08:37/18 16:48	06:27 17:27	06:41 18:59	05:51 19:33	05:16 20:03	05:09 20:21	05:29 20:10	06:00 19:30	06:32 18:38	07:05 17:49	06:42 07:48-08:17/29 16:17	07:08 07:58-08:32/34 16:17
25	07:02 08:20-08:35/15 16:49	06:25 17:28	06:39 19:00	05:49 19:34	05:16 20:04	05:10 20:21	05:30 20:09	06:01 19:29	06:33 18:36	07:06 17:48	06:43 07:48-08:18/30 16:16	07:08 07:58-08:33/35 16:18
26	07:01 08:24-08:32/8 16:50	06:24 17:29	06:38 19:01	05:48 19:35	05:15 20:04	05:10 20:21	05:31 20:09	06:02 19:27	06:34 18:35	07:07 17:47	06:44 07:48-08:20/32 16:16	07:08 08:00-08:34/34 16:18
27	07:00 16:52	06:22 17:30	06:36 19:02	05:46 19:36	05:14 20:05	05:10 20:21	05:32 20:08	06:03 19:26	06:35 18:33	07:08 17:45	06:45 07:48-08:20/32 16:15	07:09 08:00-08:34/34 16:19
28	06:59 16:53	06:21 17:32	06:34 19:03	05:45 19:37	05:14 20:06	05:11 20:21	05:33 20:07	06:04 19:24	06:36 18:31	07:09 17:44	06:46 07:48-08:21/33 16:15	07:09 08:00-08:34/34 16:20
29	06:59 16:54		06:32 19:04	05:44 19:38	05:13 20:07	05:11 20:21	05:34 20:06	06:05 19:22	06:37 18:29	07:10 17:43	06:47 07:48-08:21/33 16:15	07:09 08:00-08:34/34 16:20
30	06:58 16:55		06:31 19:05	05:42 19:39	05:13 20:08	05:12 20:21	05:35 20:05	06:06 19:21	06:38 18:28	07:12 17:41	06:48 07:48-08:22/34 16:14	07:09 08:00-08:35/35 16:21
31	06:57 16:57		06:29 19:06		05:12 20:09		05:36 20:04	06:07 19:19		07:13 17:40		07:10 08:02-08:36/34 16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	770	0	0	0	0	0	0	0	0	0	390	1064

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:

Town of Falmouth Wind Turbine Project

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6/14/2011 11:39 AM / 2

Licensed user:
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+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:38 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Unidirectional - window - real case **WTG:** 2 - Wind II

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10	06:56	06:19	06:27 07:20-07:40/20	05:41 07:06-07:37/31	05:12	05:12	05:37	06:08 07:02-07:50/48	06:39	06:14	06:50
	16:23	16:58	17:33	19:08	19:40	20:10	20:21	20:03	19:17	18:26	16:39	16:14
2	07:10	06:55	06:17	06:26 07:17-07:43/26	05:40 07:07-07:34/27	05:11	05:13	05:38	06:09 07:02-07:49/47	06:40	06:15	06:51
	16:24	16:59	17:34	19:09	19:41	20:10	20:21	20:01	19:16	18:24	16:37	16:14
3	07:10	06:54	06:16	06:24 07:14-07:45/31	05:38 07:09-07:32/23	05:11	05:13	05:39	06:10 07:03-07:48/45	06:41	06:16	06:52
	16:25	17:00	17:35	19:10	19:42	20:11	20:21	20:00	19:14	18:23	16:36	16:13
4	07:10	06:53	06:14	06:22 07:12-07:46/34	05:37 07:11-07:30/19	05:10	05:14	05:40	06:11 07:03-07:47/44	06:42	06:18	06:53
	16:26	17:02	17:36	19:11	19:43	20:12	20:21	19:58	19:12	18:21	16:35	16:13
5	07:10	06:52	06:13	06:21 07:11-07:48/37	05:36 07:15-07:27/12	05:10	05:14	05:41	06:12 07:04-07:46/42	06:43	06:19	06:54
	16:27	17:03	17:37	19:12	19:45	20:12	20:21	19:57	19:11	18:19	16:34	16:13
6	07:10	06:50	06:11	06:19 07:09-07:48/39	05:34	05:10	05:15	05:42	06:13 07:05-07:44/39	06:44	06:20	06:55
	16:28	17:04	17:39	19:13	19:46	20:13	20:20	19:56	19:09	18:18	16:33	16:13
7	07:10	06:49	06:09	06:17 07:07-07:49/42	05:33	05:09	05:15	05:43	06:14 07:06-07:43/37	06:45	06:21	06:56
	16:29	17:06	17:40	19:14	19:47	20:14	20:20	19:54	19:07	18:16	16:32	16:13
8	07:10	06:48	07:08	06:16 07:06-07:50/44	05:32	05:09	05:16	05:44 07:22-07:37/15	06:15 07:07-07:41/34	06:46	06:23	06:56
	16:30	17:07	18:41	19:15	19:48	20:14	20:20	19:53	19:06	18:14	16:30	16:13
9	07:10	06:47	07:06	06:14 07:05-07:50/45	05:31	05:09	05:17	05:45 07:19-07:39/20	06:16 07:08-07:39/31	06:48	06:24	06:57
	16:31	17:08	18:42	19:16	19:49	20:15	20:19	19:52	19:04	18:13	16:29	16:13
10	07:09	06:46	07:05	06:12 07:03-07:50/47	05:30	05:09	05:18	05:46 07:17-07:42/25	06:17 07:10-07:36/26	06:49	06:25	06:58
	16:32	17:09	18:43	19:17	19:50	20:16	20:19	19:51	19:02	18:11	16:28	16:13
11	07:09	06:45	07:03	06:11 07:03-07:51/48	05:29	05:08	05:18	05:47 07:15-07:43/28	06:18 07:13-07:33/20	06:50	06:26	06:59
	16:33	17:11	18:44	19:18	19:51	20:16	20:19	19:49	19:01	18:09	16:27	16:13
12	07:09	06:43	07:01	06:09 07:02-07:50/48	05:27	05:08	05:19	05:48 07:14-07:45/31	06:19 07:17-07:28/11	06:51	06:27	07:00
	16:34	17:12	18:45	19:20	19:52	20:17	20:18	19:48	18:59	18:08	16:26	16:13
13	07:09	06:42	07:00	06:08 07:02-07:51/49	05:26	05:08	05:20	05:49 07:12-07:46/34	06:20	06:52	06:29	07:01
	16:35	17:13	18:47	19:21	19:53	20:17	20:18	19:46	18:57	18:06	16:25	16:13
14	07:08	06:41	06:58	06:06 07:01-07:50/49	05:25	05:08	05:20	05:50 07:11-07:47/36	06:21	06:53	06:30	07:02
	16:36	17:14	18:48	19:22	19:54	20:18	20:17	19:45	18:55	18:05	16:24	16:13
15	07:08	06:39	06:56	06:04 07:01-07:51/50	05:24	05:08	05:21	05:51 07:10-07:48/38	06:22	06:54	06:31	07:02
	16:37	17:16	18:49	19:23	19:55	20:18	20:17	19:44	18:54	18:03	16:24	16:13
16	07:07	06:38	06:54	06:03 07:00-07:50/50	05:23	05:08	05:22	05:52 07:09-07:49/40	06:23	06:55	06:32	07:03
	16:38	17:17	18:50	19:24	19:56	20:19	20:16	19:42	18:52	18:01	16:23	16:14
17	07:07	06:37	06:53	06:01 06:59-07:49/50	05:22	05:08	05:23	05:53 07:08-07:50/42	06:24	06:56	06:33	07:04
	16:39	17:18	18:51	19:25	19:57	20:19	20:15	19:41	18:50	18:00	16:22	16:14
18	07:06	06:35	06:51	06:00 07:00-07:49/49	05:21	05:08	05:24	05:54 07:07-07:50/43	06:25	06:58	06:35	07:04
	16:41	17:19	18:52	19:26	19:58	20:19	20:15	19:39	18:48	17:58	16:21	16:14
19	07:06	06:34	06:49	05:58 06:59-07:48/49	05:21	05:08	05:25	05:55 07:06-07:51/45	06:27	06:59	06:36	07:05
	16:42	17:21	18:53	19:27	19:59	20:20	20:14	19:38	18:47	17:57	16:20	16:15
20	07:05	06:32	06:48	05:57 07:00-07:48/48	05:20	05:09	05:25	05:56 07:05-07:51/46	06:28	07:00	06:37	07:06
	16:43	17:22	18:54	19:28	20:00	20:20	20:13	19:36	18:45	17:55	16:20	16:15
21	07:05	06:31	06:46	05:55 06:59-07:47/48	05:19	05:09	05:26	05:57 07:04-07:52/48	06:29	07:01	06:38	07:06
	16:44	17:23	18:56	19:29	20:00	20:20	20:13	19:35	18:43	17:54	16:19	16:16
22	07:04	06:30	06:44	05:54 07:00-07:47/47	05:18	05:09	05:27	05:58 07:04-07:52/48	06:30	07:02	06:39	07:07
	16:45	17:24	18:57	19:30	20:01	20:21	20:12	19:33	18:42	17:52	16:18	16:16
23	07:03	06:28	06:43	05:52 07:00-07:47/47	05:17	05:09	05:28	05:59 07:03-07:52/49	06:31	07:03	06:41	07:07
	16:47	17:26	18:58	19:32	20:02	20:21	20:11	19:32	18:40	17:51	16:18	16:17
24	07:03	06:27	06:41	05:51 07:00-07:45/45	05:16	05:09	05:29	06:00 07:03-07:52/49	06:32	07:05	06:42	07:08
	16:48	17:27	18:59	19:33	20:03	20:21	20:10	19:30	18:38	17:49	16:17	16:17
25	07:02	06:25	06:39	05:49 07:01-07:45/44	05:16	05:10	05:30	06:01 07:03-07:52/49	06:33	07:06	06:43	07:08
	16:49	17:28	19:00	19:34	20:04	20:21	20:09	19:29	18:36	17:48	16:16	16:18
26	07:01	06:24	06:38	05:48 07:01-07:43/42	05:15	05:10	05:31	06:02 07:02-07:52/50	06:34	07:07	06:44	07:08
	16:50	17:29	19:01	19:35	20:04	20:21	20:09	19:27	18:35	17:47	16:16	16:18
27	07:00	06:22	06:36	05:46 07:02-07:42/40	05:14	05:10	05:32	06:03 07:02-07:52/50	06:35	07:08	06:45	07:09
	16:52	17:30	19:02	19:36	20:05	20:21	20:08	19:26	18:33	17:45	16:15	16:19
28	06:59	06:21	06:34	05:45 07:03-07:41/38	05:14	05:11	05:33	06:04 07:02-07:52/50	06:36	07:09	06:46	07:09
	16:53	17:32	19:03	19:37	20:06	20:21	20:07	19:24	18:31	17:44	16:15	16:20
29	06:59		06:32	05:44 07:03-07:39/36	05:13	05:11	05:34	06:05 07:02-07:51/49	06:37	07:10	06:47	07:09
	16:54		19:04	19:38	20:07	20:21	20:06	19:22	18:29	17:43	16:15	16:20
30	06:58		06:31	05:42 07:05-07:38/33	05:13	05:12	05:35	06:06 07:02-07:51/49	06:38	07:12	06:48	07:09
	16:55		19:05	19:39	20:08	20:21	20:05	19:21	18:28	17:41	16:14	16:21
31	06:57		06:29 07:25-07:35/10		05:12		05:36	06:07 07:02-07:50/48		07:13		07:10
	16:57		19:06		20:09		20:04	19:19		17:40		16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	0	0	10	1275	112	0	0	982	424	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Town of Falmouth Wind Turbine Project

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6/14/2011 11:39 AM / 1

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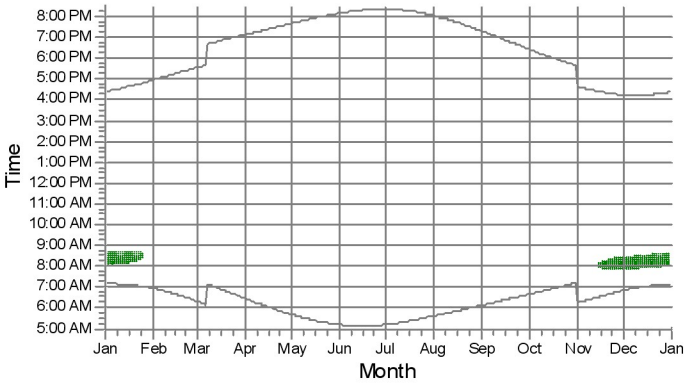
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:38 AM/2.7.486

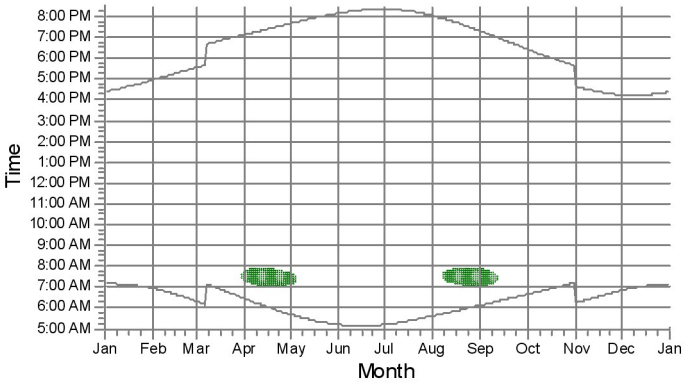
SHADOW - Calendar per WTG, graphical

Calculation: Unidirectional - window - real case

1: Wind I



2: Wind II



Shadow receptor

A: 124 Ambleside - unidirectional

Project:
Town of Falmouth Wind Turbine Project

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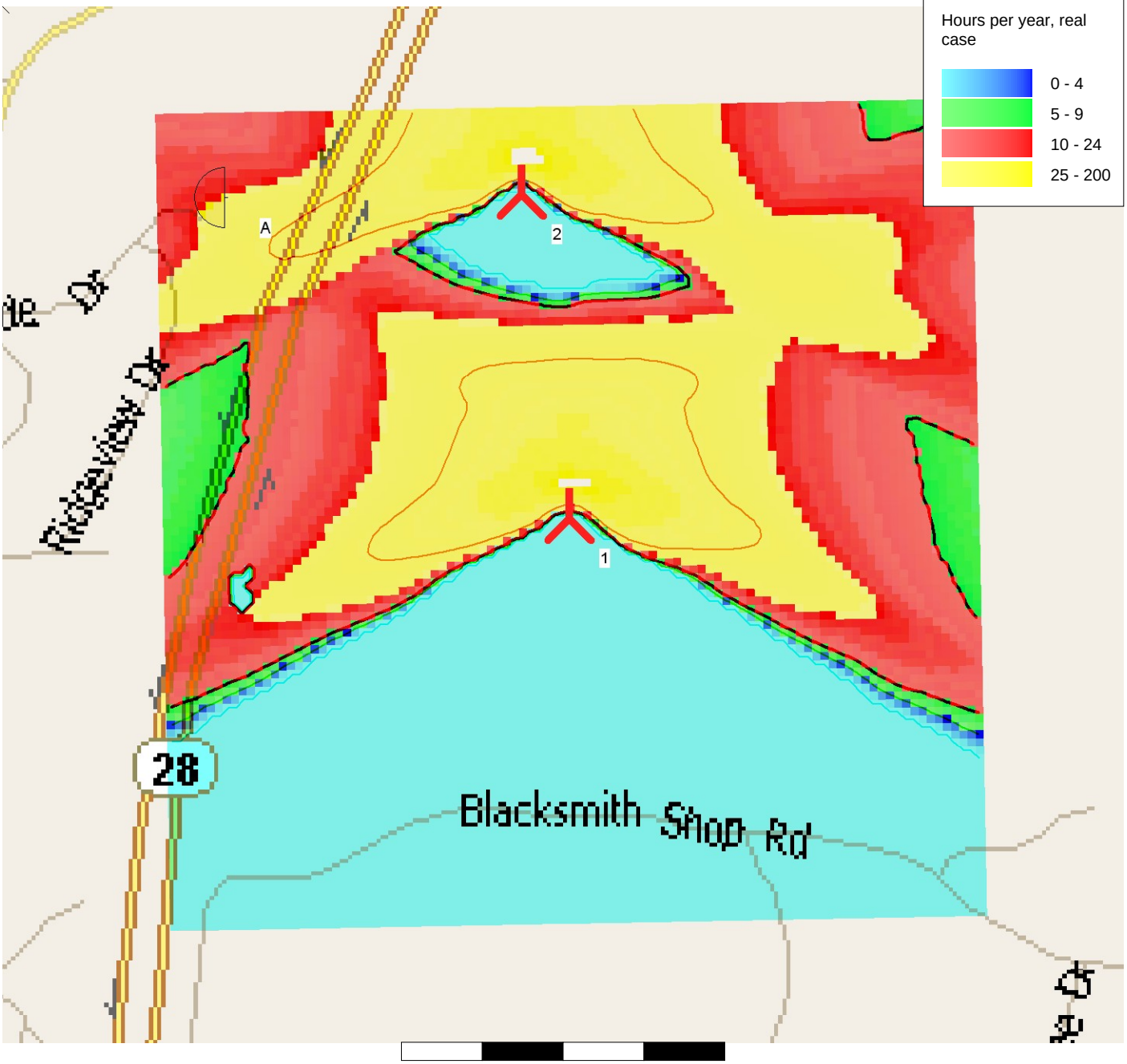
SHADOW - Map

Calculation: Unidirectional - window - real case



Map: WindPRO map , Print scale 1:7,500, Map center UTM NAD 83 Zone: 19 East: 364,950.00 North: 4,607,300.00

New WTG
Shadow receptor

Isolines showing shadow in Hours per year, real case

0 5 10 50

Project:
Town of Falmouth Wind Turbine Project

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US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:14 AM/2.7.486

SHADOW - Main Result

Calculation: Omnidirectional - lawn - worst case

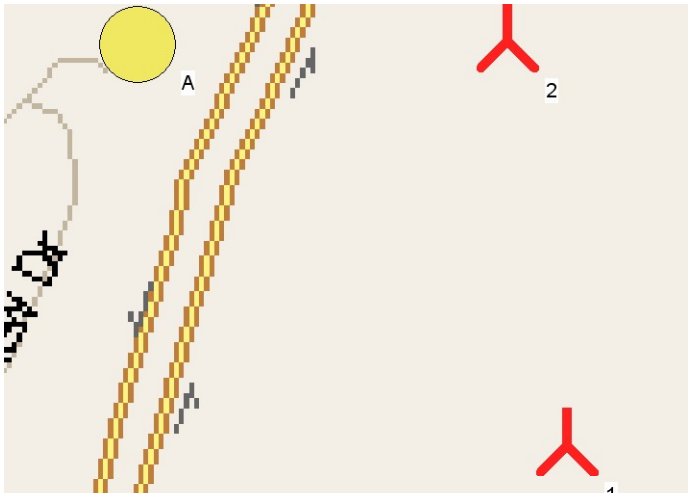
Assumptions for shadow calculations

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

The calculated times are "worst case" given by the following assumptions:
- The sun is shining all the day, from sunrise to sunset
- The rotor plane is always perpendicular to the line from the WTG to the sun
- The WTG is always operating

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Height Contours: Contours_3m_Optimized.wpo (2)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:7,500
New WTG Shadow receptor

WTGs

	UTM NAD83 Zone: 19 East	North	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Shadow data Calculation distance	RPM
	UTM NAD83 Zone: 19		[m]					[kW]	[m]	[m]	[m]	[RPM]
1	364,948.00	4,607,295.98	45.0	Wind I	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4
2	364,896.00	4,607,696.98	39.0	Wind II	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4

Shadow receptor-Input

No.	Name	UTM NAD83 Zone: 19 East	North	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
A	124 Ambleside - omnidirectional	364,528.00	4,607,699.98	19.7	10.0	4.0	1.0	-180.0	0.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]
A	124 Ambleside - omnidirectional	94:50	153	0:53

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	Wind I	41:06	
2	Wind II	53:44	

Project:

Town of Falmouth Wind Turbine Project

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US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:14 AM/2.7.486

SHADOW - Calendar

Calculation: Omnidirectional - lawn - worst case**Shadow receptor:** A - 124 Ambleside - omnidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

The sun is shining all the day, from sunrise to sunset

The rotor plane is always perpendicular to the line from the WTG to the sun

The WTG is always operating

	January		February	March		April		May		June
1	07:10		08:01 (1)	06:56	06:19		06:27		07:18 (2)	05:41		07:02 (2)	05:12
	16:23	37	08:38 (1)	16:58	17:33		19:08	27	07:45 (2)	19:40	36	07:38 (2)	20:10
2	07:10		08:01 (1)	06:55	06:17		06:26		07:17 (2)	05:40		07:02 (2)	05:11
	16:24	38	08:39 (1)	16:59	17:34		19:09	31	07:48 (2)	19:41	34	07:36 (2)	20:10
3	07:10		08:02 (1)	06:54	06:16		06:24		07:14 (2)	05:38		07:04 (2)	05:11
	16:25	37	08:39 (1)	17:00	17:35		19:10	35	07:49 (2)	19:42	31	07:35 (2)	20:11
4	07:10		08:02 (1)	06:53	06:14		06:22		07:12 (2)	05:37		07:06 (2)	05:10
	16:26	38	08:40 (1)	17:02	17:36		19:11	38	07:50 (2)	19:43	27	07:33 (2)	20:12
5	07:10		08:03 (1)	06:52	06:13		06:21		07:11 (2)	05:36		07:07 (2)	05:10
	16:27	37	08:40 (1)	17:03	17:37		19:12	40	07:51 (2)	19:45	24	07:31 (2)	20:13
6	07:10		08:02 (1)	06:51	06:11		06:19		07:09 (2)	05:34		07:10 (2)	05:10
	16:28	38	08:40 (1)	17:04	17:39		19:13	43	07:52 (2)	19:46	19	07:29 (2)	20:13
7	07:10		08:03 (1)	06:49	06:09		06:17		07:07 (2)	05:33		07:12 (2)	05:09
	16:29	37	08:40 (1)	17:06	17:40		19:14	45	07:52 (2)	19:47	13	07:25 (2)	20:14
8	07:10		08:03 (1)	06:48	07:08		06:16		07:06 (2)	05:32			05:09
	16:30	38	08:41 (1)	17:07	18:41		19:15	47	07:53 (2)	19:48			20:15
9	07:10		08:04 (1)	06:47	07:06		06:14		07:04 (2)	05:31			05:09
	16:31	37	08:41 (1)	17:08	18:42		19:16	49	07:53 (2)	19:49			20:15
10	07:09		08:05 (1)	06:46	07:05		06:12		07:03 (2)	05:30			05:09
	16:32	37	08:42 (1)	17:09	18:43		19:17	50	07:53 (2)	19:50			20:16
11	07:09		08:05 (1)	06:45	07:03		06:11		07:02 (2)	05:29			05:08
	16:33	36	08:41 (1)	17:11	18:44		19:19	51	07:53 (2)	19:51			20:16
12	07:09		08:05 (1)	06:43	07:01		06:09		07:01 (2)	05:28			05:08
	16:34	37	08:42 (1)	17:12	18:45		19:20	52	07:53 (2)	19:52			20:17
13	07:09		08:05 (1)	06:42	07:00		06:08		07:01 (2)	05:26			05:08
	16:35	36	08:41 (1)	17:13	18:47		19:21	52	07:53 (2)	19:53			20:17
14	07:08		08:06 (1)	06:41	06:58		06:06		07:00 (2)	05:25			05:08
	16:36	36	08:42 (1)	17:14	18:48		19:22	53	07:53 (2)	19:54			20:18
15	07:08		08:07 (1)	06:39	06:56		06:04		07:00 (2)	05:24			05:08
	16:37	35	08:42 (1)	17:16	18:49		19:23	53	07:53 (2)	19:55			20:18
16	07:07		08:07 (1)	06:38	06:55		06:03		06:59 (2)	05:23			05:08
	16:38	35	08:42 (1)	17:17	18:50		19:24	53	07:52 (2)	19:56			20:19
17	07:07		08:08 (1)	06:37	06:53		06:01		06:58 (2)	05:22			05:08
	16:39	33	08:41 (1)	17:18	18:51		19:25	53	07:51 (2)	19:57			20:19
18	07:06		08:09 (1)	06:35	06:51		06:00		06:58 (2)	05:21			05:08
	16:41	32	08:41 (1)	17:19	18:52		19:26	53	07:51 (2)	19:58			20:19
19	07:06		08:09 (1)	06:34	06:49		05:58		06:57 (2)	05:21			05:08
	16:42	32	08:41 (1)	17:21	18:53		19:27	53	07:50 (2)	19:59			20:20
20	07:05		08:11 (1)	06:32	06:48		05:57		06:58 (2)	05:20			05:09
	16:43	30	08:41 (1)	17:22	18:54		19:28	52	07:50 (2)	20:00			20:20
21	07:05		08:11 (1)	06:31	06:46		05:55		06:57 (2)	05:19			05:09
	16:44	29	08:40 (1)	17:23	18:56		19:29	52	07:49 (2)	20:00			20:20
22	07:04		08:12 (1)	06:30	06:44		05:54		06:58 (2)	05:18			05:09
	16:45	27	08:39 (1)	17:24	18:57		19:30	50	07:48 (2)	20:01			20:21
23	07:03		08:13 (1)	06:28	06:43		05:52		06:58 (2)	05:17			05:09
	16:47	24	08:37 (1)	17:26	18:58		19:32	50	07:48 (2)	20:02			20:21
24	07:03		08:15 (1)	06:27	06:41		05:51		06:58 (2)	05:16			05:09
	16:48	22	08:37 (1)	17:27	18:59		19:33	48	07:46 (2)	20:03			20:21
25	07:02		08:17 (1)	06:25	06:39		05:49		06:59 (2)	05:16			05:10
	16:49	19	08:36 (1)	17:28	19:00		19:34	46	07:45 (2)	20:04			20:21
26	07:01		08:19 (1)	06:24	06:38		05:48		06:58 (2)	05:15			05:10
	16:50	15	08:34 (1)	17:29	19:01		19:35	46	07:44 (2)	20:04			20:21
27	07:00		08:21 (1)	06:22	06:36		05:46		06:59 (2)	05:14			05:10
	16:52	10	08:31 (1)	17:30	19:02		19:36	44	07:43 (2)	20:05			20:21
28	06:59			06:21	06:34		05:45		07:00 (2)	05:14			05:11
	16:53			17:32	19:03		19:37	42	07:42 (2)	20:06			20:21
29	06:59				06:32		05:44		07:00 (2)	05:13			05:11
	16:54				19:04		19:38	40	07:40 (2)	20:07			20:21
30	06:58				06:31	07:27 (2)	05:42		07:01 (2)	05:13			05:12
	16:55				19:05	12 07:39 (2)	19:39	38	07:39 (2)	20:08			20:21
31	06:57				06:29	07:22 (2)				05:12			
	16:57				19:07	21 07:43 (2)				20:09			
Potential sun hours	296			297	370		400			450			454
Total, worst case		862				33		1386			184		

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:17 AM / 2
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:14 AM/2.7.486

SHADOW - Calendar

Calculation: Omnidirectional - lawn - worst case**Shadow receptor:** A - 124 Ambleside - omnidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

The sun is shining all the day, from sunrise to sunset

The rotor plane is always perpendicular to the line from the WTG to the sun

The WTG is always operating

	July		August			September			October		November			December		
1	05:12		05:37			06:08		07:01 (2)	06:39		06:14			06:50		07:47 (1)
	20:21		20:03			19:17	51	07:52 (2)	18:26		16:39			16:14	36	08:23 (1)
2	05:13		05:38			06:09		07:02 (2)	06:40		06:15			06:51		07:47 (1)
	20:21		20:01			19:16	50	07:52 (2)	18:24		16:37			16:14	37	08:24 (1)
3	05:13		05:39			06:10		07:02 (2)	06:41		06:17			06:52		07:47 (1)
	20:21		20:00			19:14	49	07:51 (2)	18:23		16:36			16:13	37	08:24 (1)
4	05:14		05:40			06:11		07:03 (2)	06:42		06:18			06:53		07:47 (1)
	20:21		19:58			19:12	47	07:50 (2)	18:21		16:35			16:13	38	08:25 (1)
5	05:14		05:41		07:26 (2)	06:12		07:04 (2)	06:43		06:19			06:54		07:48 (1)
	20:21		19:57	6	07:32 (2)	19:11	45	07:49 (2)	18:19		16:34			16:13	37	08:25 (1)
6	05:15		05:42		07:21 (2)	06:13		07:05 (2)	06:44		06:20			06:55		07:48 (1)
	20:20		19:56	16	07:37 (2)	19:09	43	07:48 (2)	18:18		16:33			16:13	38	08:26 (1)
7	05:16		05:43		07:19 (2)	06:14		07:06 (2)	06:45		06:21			06:56		07:49 (1)
	20:20		19:54	20	07:39 (2)	19:07	40	07:46 (2)	18:16		16:32			16:13	37	08:26 (1)
8	05:16		05:44		07:15 (2)	06:15		07:07 (2)	06:47		06:23			06:56		07:49 (1)
	20:20		19:53	25	07:40 (2)	19:06	38	07:45 (2)	18:14		16:30			16:13	38	08:27 (1)
9	05:17		05:45		07:14 (2)	06:16		07:08 (2)	06:48		06:24			06:57		07:50 (1)
	20:20		19:52	28	07:42 (2)	19:04	35	07:43 (2)	18:13		16:29			16:13	37	08:27 (1)
10	05:18		05:46		07:12 (2)	06:17		07:10 (2)	06:49		06:25			06:58		07:50 (1)
	20:19		19:51	32	07:44 (2)	19:02	31	07:41 (2)	18:11		16:28			16:13	38	08:28 (1)
11	05:18		05:47		07:11 (2)	06:18		07:11 (2)	06:50		06:26			06:59		07:51 (1)
	20:19		19:49	34	07:45 (2)	19:01	28	07:39 (2)	18:09		16:27			16:13	38	08:29 (1)
12	05:19		05:48		07:10 (2)	06:19		07:14 (2)	06:51		06:27			07:00		07:52 (1)
	20:18		19:48	36	07:46 (2)	18:59	21	07:35 (2)	18:08		16:26			16:13	37	08:29 (1)
13	05:20		05:49		07:08 (2)	06:20		07:18 (2)	06:52		06:29			07:01		07:52 (1)
	20:18		19:47	39	07:47 (2)	18:57	13	07:31 (2)	18:06		16:25			16:13	38	08:30 (1)
14	05:20		05:50		07:07 (2)	06:21			06:53		06:30			07:02		07:52 (1)
	20:17		19:45	41	07:48 (2)	18:55			18:05		16:24			16:13	37	08:29 (1)
15	05:21		05:51		07:07 (2)	06:22			06:54		06:31		07:54 (1)	07:02		07:53 (1)
	20:17		19:44	42	07:49 (2)	18:54			18:03		16:24	10	08:04 (1)	16:13	37	08:30 (1)
16	05:22		05:52		07:06 (2)	06:23			06:55		06:32		07:52 (1)	07:03		07:54 (1)
	20:16		19:42	44	07:50 (2)	18:52			18:01		16:23	15	08:07 (1)	16:14	37	08:31 (1)
17	05:23		05:53		07:05 (2)	06:24			06:56		06:34		07:50 (1)	07:04		07:54 (1)
	20:16		19:41	46	07:51 (2)	18:50			18:00		16:22	19	08:09 (1)	16:14	37	08:31 (1)
18	05:24		05:54		07:04 (2)	06:26			06:58		06:35		07:49 (1)	07:04		07:54 (1)
	20:15		19:39	47	07:51 (2)	18:49			17:58		16:21	22	08:11 (1)	16:14	37	08:31 (1)
19	05:25		05:55		07:04 (2)	06:27			06:59		06:36		07:48 (1)	07:05		07:55 (1)
	20:14		19:38	48	07:52 (2)	18:47			17:57		16:20	24	08:12 (1)	16:15	37	08:32 (1)
20	05:25		05:56		07:03 (2)	06:28			07:00		06:37		07:47 (1)	07:06		07:55 (1)
	20:13		19:36	50	07:53 (2)	18:45			17:55		16:20	27	08:14 (1)	16:15	37	08:32 (1)
21	05:26		05:57		07:02 (2)	06:29			07:01		06:38		07:46 (1)	07:06		07:56 (1)
	20:13		19:35	51	07:53 (2)	18:43			17:54		16:19	29	08:15 (1)	16:16	37	08:33 (1)
22	05:27		05:58		07:02 (2)	06:30			07:02		06:39		07:47 (1)	07:07		07:56 (1)
	20:12		19:33	51	07:53 (2)	18:42			17:52		16:18	30	08:17 (1)	16:16	37	08:33 (1)
23	05:28		05:59		07:02 (2)	06:31			07:03		06:41		07:46 (1)	07:07		07:57 (1)
	20:11		19:32	52	07:54 (2)	18:40			17:51		16:18	32	08:18 (1)	16:17	37	08:34 (1)
24	05:29		06:00		07:01 (2)	06:32			07:05		06:42		07:46 (1)	07:08		07:57 (1)
	20:10		19:30	53	07:54 (2)	18:38			17:49		16:17	32	08:18 (1)	16:17	37	08:34 (1)
25	05:30		06:01		07:01 (2)	06:33			07:06		06:43		07:46 (1)	07:08		07:57 (1)
	20:09		19:29	53	07:54 (2)	18:36			17:48		16:16	33	08:19 (1)	16:18	37	08:34 (1)
26	05:31		06:02		07:01 (2)	06:34			07:07		06:44		07:47 (1)	07:08		07:59 (1)
	20:09		19:27	53	07:54 (2)	18:35			17:47		16:16	34	08:21 (1)	16:18	37	08:36 (1)
27	05:32		06:03		07:01 (2)	06:35			07:08		06:45		07:46 (1)	07:09		07:59 (1)
	20:08		19:26	53	07:54 (2)	18:33			17:45		16:15	35	08:21 (1)	16:19	37	08:36 (1)
28	05:33		06:04		07:01 (2)	06:36			07:09		06:46		07:46 (1)	07:09		07:59 (1)
	20:07		19:24	53	07:54 (2)	18:31			17:44		16:15	36	08:22 (1)	16:20	37	08:36 (1)
29	05:34		06:05		07:01 (2)	06:37			07:10		06:47		07:46 (1)	07:09		07:59 (1)
	20:06		19:22	53	07:54 (2)	18:30			17:43		16:15	36	08:22 (1)	16:20	37	08:36 (1)
30	05:35		06:06		07:01 (2)	06:38			07:12		06:48		07:46 (1)	07:10		07:59 (1)
	20:05		19:21	52	07:53 (2)	18:28			17:41		16:14	37	08:23 (1)	16:21	38	08:37 (1)
31	05:36		06:07		07:01 (2)				07:13					07:10		08:01 (1)
	20:04		19:19	52	07:53 (2)				17:40					16:22	37	08:38 (1)
Potential sun hours	461		429			375			344		296			286		
Total, worst case				1130			491					451			1153	

Table layout: For each day in each month the following matrix apply

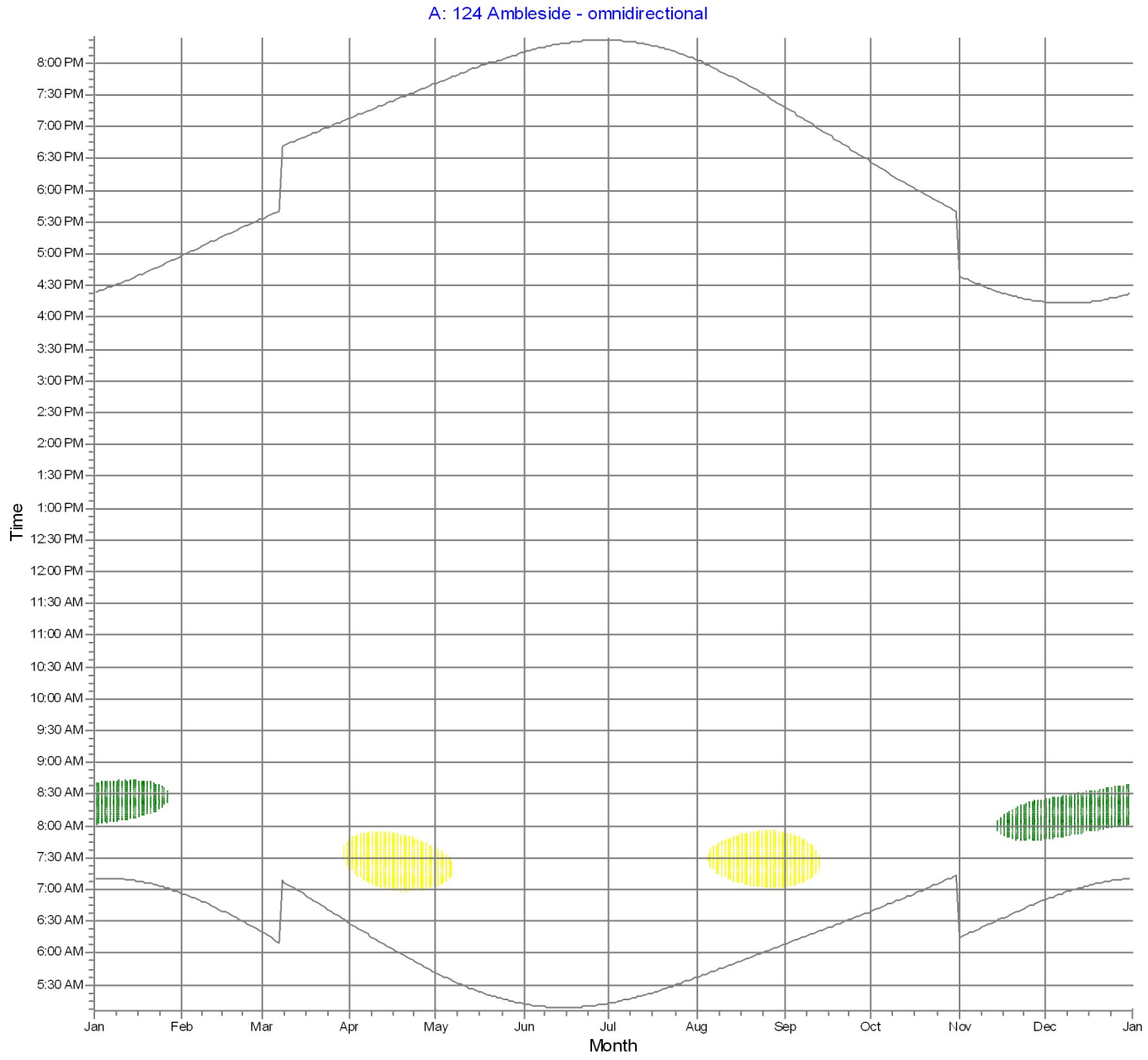
Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:
Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:17 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:14 AM/2.7.486

SHADOW - Calendar, graphical

Calculation: Omnidirectional - lawn - worst case**Shadow receptor:** A - 124 Ambleside - omnidirectional



WTGs

1: Wind I

2: Wind II

Project:

Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:18 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:14 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Omnidirectional - lawn - worst case **WTG:** 1 - Wind I

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

The sun is shining all the day, from sunrise to sunset

The rotor plane is always perpendicular to the line from the WTG to the sun

The WTG is always operating

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10 08:01-08:38/37	06:56	06:19	06:27	05:41	05:12	05:12	05:37	06:08	06:39	06:14	06:50 07:47-08:23/36
	16:23	16:58	17:33	19:08	19:40	20:10	20:21	20:03	19:17	18:26	16:39	16:14
2	07:10 08:01-08:39/38	06:55	06:17	06:26	05:40	05:11	05:13	05:38	06:09	06:40	06:15	06:51 07:47-08:24/37
	16:24	16:59	17:34	19:09	19:41	20:10	20:21	20:01	19:16	18:24	16:37	16:14
3	07:10 08:02-08:39/37	06:54	06:16	06:24	05:38	05:11	05:13	05:39	06:10	06:41	06:16	06:52 07:47-08:24/37
	16:25	17:00	17:35	19:10	19:42	20:11	20:21	20:00	19:14	18:23	16:36	16:13
4	07:10 08:02-08:40/38	06:53	06:14	06:22	05:37	05:10	05:14	05:40	06:11	06:42	06:18	06:53 07:47-08:25/38
	16:26	17:02	17:36	19:11	19:43	20:12	20:21	19:58	19:12	18:21	16:35	16:13
5	07:10 08:03-08:40/37	06:52	06:13	06:21	05:36	05:10	05:14	05:41	06:12	06:43	06:19	06:54 07:48-08:25/37
	16:27	17:03	17:37	19:12	19:45	20:12	20:21	19:57	19:11	18:19	16:34	16:13
6	07:10 08:02-08:40/38	06:50	06:11	06:19	05:34	05:10	05:15	05:42	06:13	06:44	06:20	06:55 07:48-08:26/38
	16:28	17:04	17:39	19:13	19:46	20:13	20:20	19:56	19:09	18:18	16:33	16:13
7	07:10 08:03-08:40/37	06:49	06:09	06:17	05:33	05:09	05:16	05:43	06:14	06:45	06:21	06:56 07:49-08:26/37
	16:29	17:06	17:40	19:14	19:47	20:14	20:20	19:54	19:07	18:16	16:32	16:13
8	07:10 08:03-08:41/38	06:48	07:08	06:16	05:32	05:09	05:16	05:44	06:15	06:46	06:23	06:56 07:49-08:27/38
	16:30	17:07	18:41	19:15	19:48	20:14	20:20	19:53	19:06	18:14	16:30	16:13
9	07:10 08:04-08:41/37	06:47	07:06	06:14	05:31	05:09	05:17	05:45	06:16	06:48	06:24	06:57 07:50-08:27/37
	16:31	17:08	18:42	19:16	19:49	20:15	20:19	19:52	19:04	18:13	16:29	16:13
10	07:09 08:05-08:42/37	06:46	07:04	06:12	05:30	05:09	05:18	05:46	06:17	06:49	06:25	06:58 07:50-08:28/38
	16:32	17:09	18:43	19:17	19:50	20:16	20:19	19:51	19:02	18:11	16:28	16:13
11	07:09 08:05-08:41/36	06:45	07:03	06:11	05:29	05:08	05:18	05:47	06:18	06:50	06:26	06:59 07:51-08:29/38
	16:33	17:11	18:44	19:18	19:51	20:16	20:19	19:49	19:01	18:09	16:27	16:13
12	07:09 08:05-08:42/37	06:43	07:01	06:09	05:27	05:08	05:19	05:48	06:19	06:51	06:27	07:00 07:52-08:29/37
	16:34	17:12	18:45	19:20	19:52	20:17	20:18	19:48	18:59	18:08	16:26	16:13
13	07:09 08:05-08:41/36	06:42	07:00	06:08	05:26	05:08	05:20	05:49	06:20	06:52	06:29	07:01 07:52-08:30/38
	16:35	17:13	18:47	19:21	19:53	20:17	20:18	19:46	18:57	18:06	16:25	16:13
14	07:08 08:06-08:42/36	06:41	06:58	06:06	05:25	05:08	05:20	05:50	06:21	06:53	06:30	07:01 07:52-08:29/37
	16:36	17:14	18:48	19:22	19:54	20:18	20:17	19:45	18:55	18:05	16:24	16:13
15	07:08 08:07-08:42/35	06:39	06:56	06:04	05:24	05:08	05:21	05:51	06:22	06:54	06:31 07:54-08:04/10	07:02 07:53-08:30/37
	16:37	17:16	18:49	19:23	19:55	20:18	20:17	19:44	18:54	18:03	16:24	16:13
16	07:07 08:07-08:42/35	06:38	06:54	06:03	05:23	05:08	05:22	05:52	06:23	06:55	06:32 07:52-08:07/15	07:03 07:54-08:31/37
	16:38	17:17	18:50	19:24	19:56	20:19	20:16	19:42	18:52	18:01	16:23	16:14
17	07:07 08:08-08:41/33	06:37	06:53	06:01	05:22	05:08	05:23	05:53	06:24	06:56	06:33 07:50-08:09/19	07:04 07:54-08:31/37
	16:39	17:18	18:51	19:25	19:57	20:19	20:15	19:41	18:50	18:00	16:22	16:14
18	07:06 08:09-08:41/32	06:35	06:51	06:00	05:21	05:08	05:24	05:54	06:25	06:58	06:35 07:49-08:11/22	07:04 07:54-08:31/37
	16:41	17:19	18:52	19:26	19:58	20:19	20:15	19:39	18:48	17:58	16:21	16:14
19	07:06 08:09-08:41/32	06:34	06:49	05:58	05:21	05:08	05:25	05:55	06:27	06:59	06:36 07:48-08:12/24	07:05 07:55-08:32/37
	16:42	17:21	18:53	19:27	19:59	20:20	20:14	19:38	18:47	17:57	16:20	16:15
20	07:05 08:11-08:41/30	06:32	06:48	05:57	05:20	05:09	05:25	05:56	06:28	07:00	06:37 07:47-08:14/27	07:05 07:55-08:32/37
	16:43	17:22	18:54	19:28	20:00	20:20	20:13	19:36	18:45	17:55	16:20	16:15
21	07:05 08:11-08:40/29	06:31	06:46	05:55	05:19	05:09	05:26	05:57	06:29	07:01	06:38 07:46-08:15/29	07:06 07:56-08:33/37
	16:44	17:23	18:56	19:29	20:00	20:20	20:13	19:35	18:43	17:54	16:19	16:16
22	07:04 08:12-08:39/27	06:30	06:44	05:54	05:18	05:09	05:27	05:58	06:30	07:02	06:39 07:47-08:17/30	07:07 07:56-08:33/37
	16:45	17:24	18:57	19:30	20:01	20:21	20:12	19:33	18:42	17:52	16:18	16:16
23	07:03 08:13-08:37/24	06:28	06:43	05:52	05:17	05:09	05:28	05:59	06:31	07:03	06:41 07:46-08:18/32	07:07 07:57-08:34/37
	16:47	17:26	18:58	19:32	20:02	20:21	20:11	19:32	18:40	17:51	16:18	16:17
24	07:03 08:15-08:37/22	06:27	06:41	05:51	05:16	05:09	05:29	06:00	06:32	07:05	06:42 07:46-08:18/32	07:08 07:57-08:34/37
	16:48	17:27	18:59	19:33	20:03	20:21	20:10	19:30	18:38	17:49	16:17	16:17
25	07:02 08:17-08:36/19	06:25	06:39	05:49	05:16	05:10	05:30	06:01	06:33	07:06	06:43 07:46-08:19/33	07:08 07:57-08:34/37
	16:49	17:28	19:00	19:34	20:04	20:21	20:09	19:29	18:36	17:48	16:16	16:18
26	07:01 08:19-08:34/15	06:24	06:38	05:48	05:15	05:10	05:31	06:02	06:34	07:07	06:44 07:47-08:21/34	07:08 07:59-08:36/37
	16:50	17:29	19:01	19:35	20:04	20:21	20:09	19:27	18:35	17:47	16:16	16:18
27	07:00 08:21-08:31/10	06:22	06:36	05:46	05:14	05:10	05:32	06:03	06:35	07:08	06:45 07:46-08:21/35	07:09 07:59-08:36/37
	16:52	17:30	19:02	19:36	20:05	20:21	20:08	19:26	18:33	17:45	16:15	16:19
28	06:59	06:21	06:34	05:45	05:14	05:11	05:33	06:04	06:36	07:09	06:46 07:46-08:22/36	07:09 07:59-08:36/37
	16:53	17:32	19:03	19:37	20:06	20:21	20:07	19:24	18:31	17:44	16:15	16:20
29	06:59		06:32	05:44	05:13	05:11	05:34	06:05	06:37	07:10	06:47 07:46-08:22/36	07:09 07:59-08:36/37
	16:54		19:04	19:38	20:07	20:21	20:06	19:22	18:29	17:43	16:15	16:20
30	06:58		06:31	05:42	05:13	05:12	05:35	06:06	06:38	07:12	06:48 07:46-08:23/37	07:09 07:59-08:37/38
	16:55		19:05	19:39	20:08	20:21	20:05	19:21	18:28	17:41	16:14	16:21
31	06:57		06:29		05:12		05:36	06:07		07:13		07:10 08:01-08:38/37
	16:57		19:06		20:09		20:04	19:19		17:40		16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	862	0	0	0	0	0	0	0	0	0	451	1153

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:

Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:18 AM / 2

Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:14 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Omnidirectional - lawn - worst case**WTG:** 2 - Wind II

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

The calculated times are "worst case" given by the following assumptions:

The sun is shining all the day, from sunrise to sunset
The rotor plane is always perpendicular to the line from the WTG to the sun
The WTG is always operating

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10	06:56	06:19	06:27 07:18-07:45/27	05:41 07:02-07:38/36	05:12	05:12	05:37	06:08 07:01-07:52/51	06:39	06:14	06:50
	16:23	16:58	17:33	19:08	19:40	20:10	20:21	20:03	19:17	18:26	16:39	16:14
2	07:10	06:55	06:17	06:26 07:17-07:48/31	05:40 07:02-07:36/34	05:11	05:13	05:38	06:09 07:02-07:52/50	06:40	06:15	06:51
	16:24	16:59	17:34	19:09	19:41	20:10	20:21	20:01	19:16	18:24	16:37	16:14
3	07:10	06:54	06:16	06:24 07:14-07:49/35	05:38 07:04-07:35/31	05:11	05:13	05:39	06:10 07:02-07:51/49	06:41	06:16	06:52
	16:25	17:00	17:35	19:10	19:42	20:11	20:21	20:00	19:14	18:23	16:36	16:13
4	07:10	06:53	06:14	06:22 07:12-07:50/38	05:37 07:06-07:33/27	05:10	05:14	05:40	06:11 07:03-07:50/47	06:42	06:18	06:53
	16:26	17:02	17:36	19:11	19:43	20:12	20:21	19:58	19:12	18:21	16:35	16:13
5	07:10	06:52	06:13	06:21 07:11-07:51/40	05:36 07:07-07:31/24	05:10	05:14	05:41 07:26-07:32/6	06:12 07:04-07:49/45	06:43	06:19	06:54
	16:27	17:03	17:37	19:12	19:45	20:12	20:21	19:57	19:11	18:19	16:34	16:13
6	07:10	06:50	06:11	06:19 07:09-07:52/43	05:34 07:10-07:29/19	05:10	05:15	05:42 07:21-07:37/16	06:13 07:05-07:48/43	06:44	06:20	06:55
	16:28	17:04	17:39	19:13	19:46	20:13	20:20	19:56	19:09	18:18	16:33	16:13
7	07:10	06:49	06:09	06:17 07:07-07:52/45	05:33 07:12-07:25/13	05:09	05:15	05:43 07:19-07:39/20	06:14 07:06-07:46/40	06:45	06:21	06:56
	16:29	17:06	17:40	19:14	19:47	20:14	20:20	19:54	19:07	18:16	16:32	16:13
8	07:10	06:48	07:08	06:16 07:06-07:53/47	05:32	05:09	05:16	05:44 07:15-07:40/25	06:15 07:07-07:45/38	06:46	06:23	06:56
	16:30	17:07	18:41	19:15	19:48	20:14	20:20	19:53	19:06	18:14	16:30	16:13
9	07:10	06:47	07:06	06:14 07:04-07:53/49	05:31	05:09	05:17	05:45 07:14-07:42/28	06:16 07:08-07:43/35	06:48	06:24	06:57
	16:31	17:08	18:42	19:16	19:49	20:15	20:19	19:52	19:04	18:13	16:29	16:13
10	07:09	06:46	07:05	06:12 07:03-07:53/50	05:30	05:09	05:18	05:46 07:12-07:44/32	06:17 07:10-07:41/31	06:49	06:25	06:58
	16:32	17:09	18:43	19:17	19:50	20:16	20:19	19:51	19:02	18:11	16:28	16:13
11	07:09	06:45	07:03	06:11 07:02-07:53/51	05:29	05:08	05:18	05:47 07:11-07:45/34	06:18 07:11-07:39/28	06:50	06:26	06:59
	16:33	17:11	18:44	19:18	19:51	20:16	20:19	19:49	19:01	18:09	16:27	16:13
12	07:09	06:43	07:01	06:09 07:01-07:53/52	05:27	05:08	05:19	05:48 07:10-07:46/36	06:19 07:14-07:35/21	06:51	06:27	07:00
	16:34	17:12	18:45	19:20	19:52	20:17	20:18	19:48	18:59	18:08	16:26	16:13
13	07:09	06:42	07:00	06:08 07:01-07:53/52	05:26	05:08	05:20	05:49 07:08-07:47/39	06:20 07:18-07:31/13	06:52	06:29	07:01
	16:35	17:13	18:47	19:21	19:53	20:17	20:18	19:46	18:57	18:06	16:25	16:13
14	07:08	06:41	06:58	06:06 07:00-07:53/53	05:25	05:08	05:20	05:50 07:07-07:48/41	06:21	06:53	06:30	07:02
	16:36	17:14	18:48	19:22	19:54	20:18	20:17	19:45	18:55	18:05	16:24	16:13
15	07:08	06:39	06:56	06:04 07:00-07:53/53	05:24	05:08	05:21	05:51 07:07-07:49/42	06:22	06:54	06:31	07:02
	16:37	17:16	18:49	19:23	19:55	20:18	20:17	19:44	18:54	18:03	16:24	16:13
16	07:07	06:38	06:54	06:03 06:59-07:52/53	05:23	05:08	05:22	05:52 07:06-07:50/44	06:23	06:55	06:32	07:03
	16:38	17:17	18:50	19:24	19:56	20:19	20:16	19:42	18:52	18:01	16:23	16:14
17	07:07	06:37	06:53	06:01 06:58-07:51/53	05:22	05:08	05:23	05:53 07:05-07:51/46	06:24	06:56	06:33	07:04
	16:39	17:18	18:51	19:25	19:57	20:19	20:15	19:41	18:50	18:00	16:22	16:14
18	07:06	06:35	06:51	06:00 06:58-07:51/53	05:21	05:08	05:24	05:54 07:04-07:51/47	06:25	06:58	06:35	07:04
	16:41	17:19	18:52	19:26	19:58	20:19	20:15	19:39	18:48	17:58	16:21	16:14
19	07:06	06:34	06:49	05:58 06:57-07:50/53	05:21	05:08	05:25	05:55 07:04-07:52/48	06:27	06:59	06:36	07:05
	16:42	17:21	18:53	19:27	19:59	20:20	20:14	19:38	18:47	17:57	16:20	16:15
20	07:05	06:32	06:48	05:57 06:58-07:50/52	05:20	05:09	05:25	05:56 07:03-07:53/50	06:28	07:00	06:37	07:06
	16:43	17:22	18:54	19:28	20:00	20:20	20:13	19:36	18:45	17:55	16:20	16:15
21	07:05	06:31	06:46	05:55 06:57-07:49/52	05:19	05:09	05:26	05:57 07:02-07:53/51	06:29	07:01	06:38	07:06
	16:44	17:23	18:56	19:29	20:00	20:20	20:13	19:35	18:43	17:54	16:19	16:16
22	07:04	06:30	06:44	05:54 06:58-07:48/50	05:18	05:09	05:27	05:58 07:02-07:53/51	06:30	07:02	06:39	07:07
	16:45	17:24	18:57	19:30	20:01	20:21	20:12	19:33	18:42	17:52	16:18	16:16
23	07:03	06:28	06:43	05:52 06:58-07:48/50	05:17	05:09	05:28	05:59 07:02-07:54/52	06:31	07:03	06:41	07:07
	16:47	17:26	18:58	19:32	20:02	20:21	20:11	19:32	18:40	17:51	16:18	16:17
24	07:03	06:27	06:41	05:51 06:58-07:46/48	05:16	05:09	05:29	06:00 07:01-07:54/53	06:32	07:05	06:42	07:08
	16:48	17:27	18:59	19:33	20:03	20:21	20:10	19:30	18:38	17:49	16:17	16:17
25	07:02	06:25	06:39	05:49 06:59-07:45/46	05:16	05:10	05:30	06:01 07:01-07:54/53	06:33	07:06	06:43	07:08
	16:49	17:28	19:00	19:34	20:04	20:21	20:09	19:29	18:36	17:48	16:16	16:18
26	07:01	06:24	06:38	05:48 06:58-07:44/46	05:15	05:10	05:31	06:02 07:01-07:54/53	06:34	07:07	06:44	07:08
	16:50	17:29	19:01	19:35	20:04	20:21	20:09	19:27	18:35	17:47	16:16	16:18
27	07:00	06:22	06:36	05:46 06:59-07:43/44	05:14	05:10	05:32	06:03 07:01-07:54/53	06:35	07:08	06:45	07:09
	16:52	17:30	19:02	19:36	20:05	20:21	20:08	19:26	18:33	17:45	16:15	16:19
28	06:59	06:21	06:34	05:45 07:00-07:42/42	05:14	05:11	05:33	06:04 07:01-07:54/53	06:36	07:09	06:46	07:09
	16:53	17:32	19:03	19:37	20:06	20:21	20:07	19:24	18:31	17:44	16:15	16:20
29	06:59		06:32	05:44 07:00-07:40/40	05:13	05:11	05:34	06:05 07:01-07:54/53	06:37	07:10	06:47	07:09
	16:54		19:04	19:38	20:07	20:21	20:06	19:22	18:29	17:43	16:15	16:20
30	06:58		06:31 07:27-07:39/12	05:42 07:01-07:39/38	05:13	05:12	05:35	06:06 07:01-07:53/52	06:38	07:12	06:48	07:09
	16:55		19:05	19:39	20:08	20:21	20:05	19:21	18:28	17:41	16:14	16:21
31	06:57		06:29 07:22-07:43/21		05:12		05:36	06:07 07:01-07:53/52		07:13		07:10
	16:57		19:06		20:09		20:04	19:19		17:40		16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	0	0	33	1386	184	0	0	1130	491	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:18 AM / 1

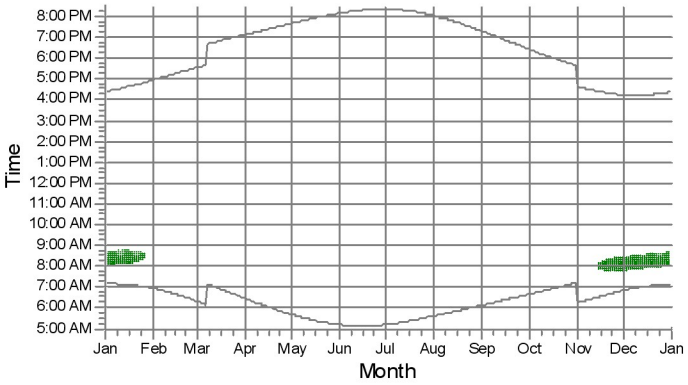
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:14 AM/2.7.486

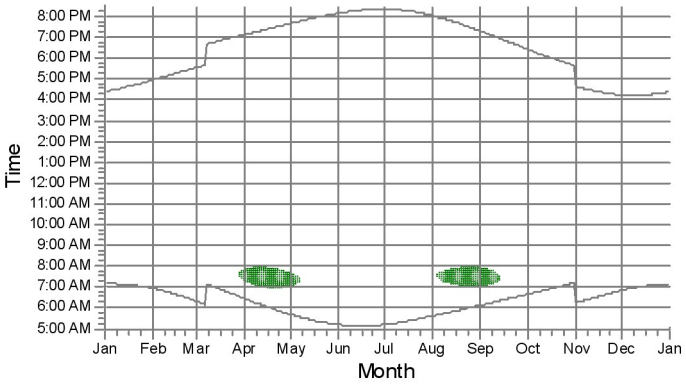
SHADOW - Calendar per WTG, graphical

Calculation: Omnidirectional - lawn - worst case

1: Wind I



2: Wind II



Shadow receptor

A: 124 Ambleside - omnidirectional

Project:
Town of Falmouth Wind Turbine Project

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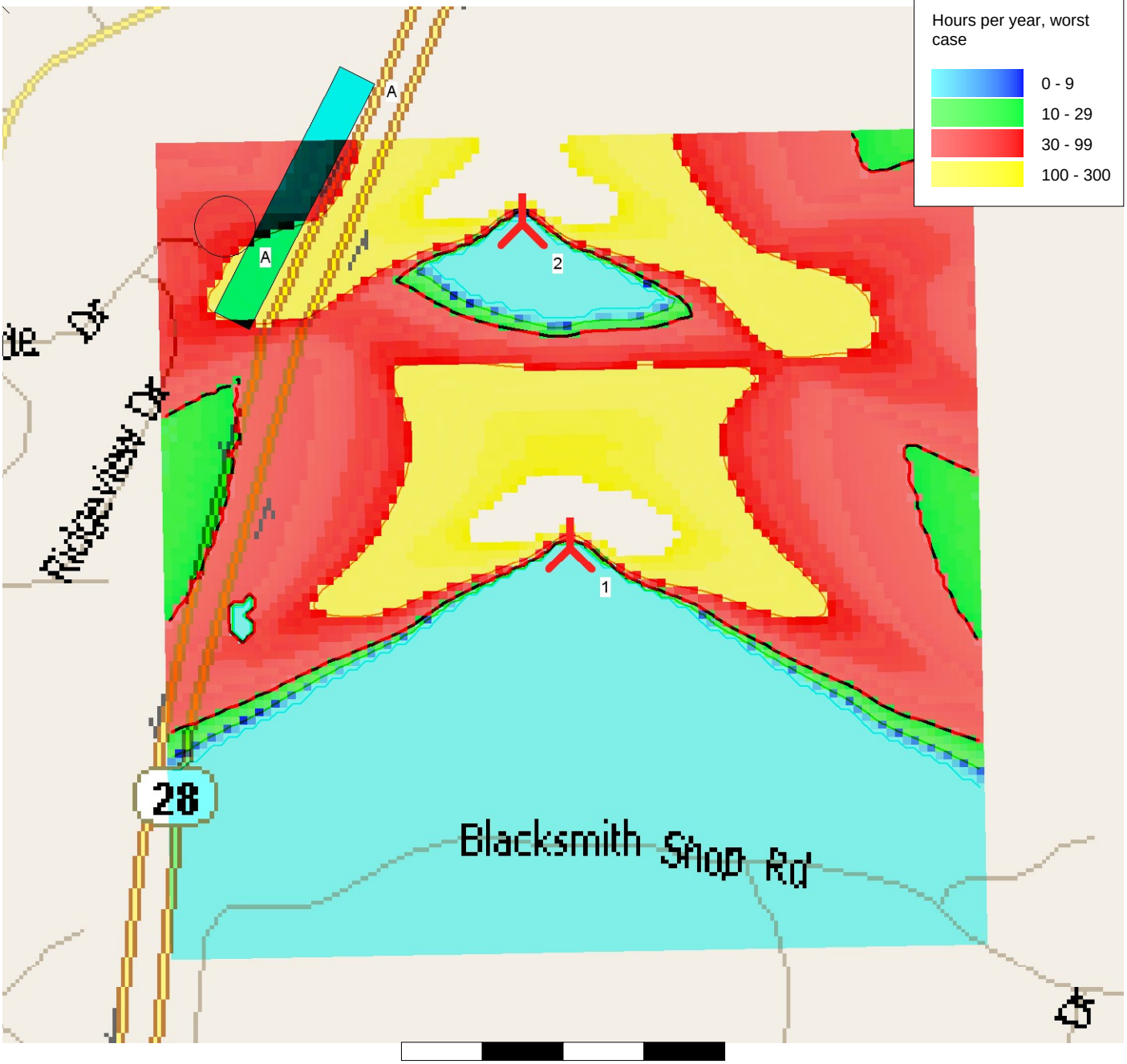
6/14/2011 11:18 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:14 AM/2.7.486

SHADOW - Map

Calculation: Omnidirectional - lawn - worst case



Map: WindPRO map , Print scale 1:7,500, Map center UTM NAD 83 Zone: 19 East: 364,950.00 North: 4,607,336.10

New WTG Obstacle Shadow receptor

Isolines showing shadow in Hours per year, worst case

0 10 30 100

Project:
Town of Falmouth Wind Turbine Project

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Licensed user:
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Calculated:
6/14/2011 11:33 AM/2.7.486

SHADOW - Main Result

Calculation: Omnidirectional - lawn -real case

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

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

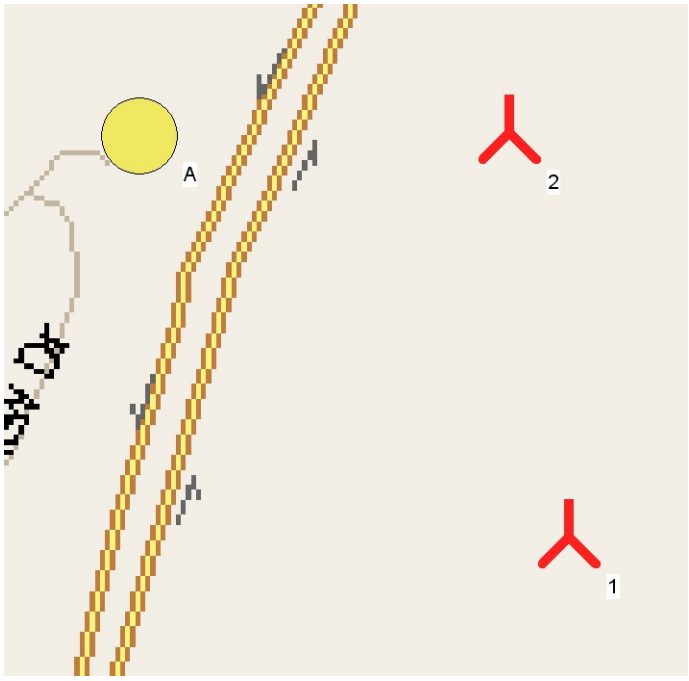
Operational hours are calculated from WTGs in calculation and wind distribution:
RERL Met Tower

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Height Contours: Contours_3m_Optimized.wpo (2)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:7,500
New WTG
Shadow receptor

WTGs

	UTM NAD83 Zone: 19				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: 19		[m]					[kW]	[m]	[m]	[m]	[RPM]
1	364,948.00	4,607,295.98	45.0	Wind I	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4
2	364,896.00	4,607,696.98	39.0	Wind II	No	VESTAS	V82-1650/900-1,650/900	1,650	82.0	80.0	1,046	14.4

Shadow receptor-Input

			UTM NAD83 Zone: 19								
No.	Name		East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
					[m]	[m]	[m]	[m]	[°]	[°]	
A	124 Ambleside - omnidirectional		364,528.00	4,607,699.98	19.7	10.0	4.0	1.0	-180.0	0.0	"Green house mode"

Calculation Results

Shadow receptor

		Shadow, expected values
No.	Name	Shadow hours per year [h/year]
A	124 Ambleside - omnidirectional	29:48

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Calculated:
6/14/2011 11:33 AM/2.7.486

SHADOW - Main Result

Calculation: Omnidirectional - lawn -real case

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	Wind I	41:06	11:42
2	Wind II	53:44	18:07

Project:

Town of Falmouth Wind Turbine Project

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Calculated:
6/14/2011 11:33 AM/2.7.486

SHADOW - Calendar

Calculation: Omnidirectional - lawn -real case **Shadow receptor:** A - 124 Ambleside - omnidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	January		February		March		April		May		June	
1	07:10		08:01 (1)	06:56		06:19		06:27		07:18 (2)	05:41	07:02 (2)	05:12
	16:23	37	08:38 (1)	16:58		17:33		19:08	27	07:45 (2)	19:40	36	07:38 (2)	20:10
2	07:10		08:01 (1)	06:55		06:17		06:26		07:17 (2)	05:40		07:02 (2)	05:11
	16:24	38	08:39 (1)	16:59		17:34		19:09	31	07:48 (2)	19:41	34	07:36 (2)	20:10
3	07:10		08:02 (1)	06:54		06:16		06:24		07:14 (2)	05:38		07:04 (2)	05:11
	16:25	37	08:39 (1)	17:00		17:35		19:10	35	07:49 (2)	19:42	31	07:35 (2)	20:11
4	07:10		08:02 (1)	06:53		06:14		06:22		07:12 (2)	05:37		07:06 (2)	05:10
	16:26	38	08:40 (1)	17:02		17:36		19:11	38	07:50 (2)	19:43	27	07:33 (2)	20:12
5	07:10		08:03 (1)	06:52		06:13		06:21		07:11 (2)	05:36		07:07 (2)	05:10
	16:27	37	08:40 (1)	17:03		17:37		19:12	40	07:51 (2)	19:45	24	07:31 (2)	20:13
6	07:10		08:02 (1)	06:51		06:11		06:19		07:09 (2)	05:34		07:10 (2)	05:10
	16:28	38	08:40 (1)	17:04		17:39		19:13	43	07:52 (2)	19:46	19	07:29 (2)	20:13
7	07:10		08:03 (1)	06:49		06:09		06:17		07:07 (2)	05:33		07:12 (2)	05:09
	16:29	37	08:40 (1)	17:06		17:40		19:14	45	07:52 (2)	19:47	13	07:25 (2)	20:14
8	07:10		08:03 (1)	06:48		07:08		06:16		07:06 (2)	05:32			05:09
	16:30	38	08:41 (1)	17:07		18:41		19:15	47	07:53 (2)	19:48			20:15
9	07:10		08:04 (1)	06:47		07:06		06:14		07:04 (2)	05:31			05:09
	16:31	37	08:41 (1)	17:08		18:42		19:16	49	07:53 (2)	19:49			20:15
10	07:09		08:05 (1)	06:46		07:05		06:12		07:03 (2)	05:30			05:09
	16:32	37	08:42 (1)	17:09		18:43		19:17	50	07:53 (2)	19:50			20:16
11	07:09		08:05 (1)	06:45		07:03		06:11		07:02 (2)	05:29			05:08
	16:33	36	08:41 (1)	17:11		18:44		19:19	51	07:53 (2)	19:51			20:16
12	07:09		08:05 (1)	06:43		07:01		06:09		07:01 (2)	05:28			05:08
	16:34	37	08:42 (1)	17:12		18:45		19:20	52	07:53 (2)	19:52			20:17
13	07:09		08:05 (1)	06:42		07:00		06:08		07:01 (2)	05:26			05:08
	16:35	36	08:41 (1)	17:13		18:47		19:21	52	07:53 (2)	19:53			20:17
14	07:08		08:06 (1)	06:41		06:58		06:06		07:00 (2)	05:25			05:08
	16:36	36	08:42 (1)	17:14		18:48		19:22	53	07:53 (2)	19:54			20:18
15	07:08		08:07 (1)	06:39		06:56		06:04		07:00 (2)	05:24			05:08
	16:37	35	08:42 (1)	17:16		18:49		19:23	53	07:53 (2)	19:55			20:18
16	07:07		08:07 (1)	06:38		06:55		06:03		06:59 (2)	05:23			05:08
	16:38	35	08:42 (1)	17:17		18:50		19:24	53	07:52 (2)	19:56			20:19
17	07:07		08:08 (1)	06:37		06:53		06:01		06:58 (2)	05:22			05:08
	16:39	33	08:41 (1)	17:18		18:51		19:25	53	07:51 (2)	19:57			20:19
18	07:06		08:09 (1)	06:35		06:51		06:00		06:58 (2)	05:21			05:08
	16:41	32	08:41 (1)	17:19		18:52		19:26	53	07:51 (2)	19:58			20:19
19	07:06		08:09 (1)	06:34		06:49		05:58		06:57 (2)	05:21			05:08
	16:42	32	08:41 (1)	17:21		18:53		19:27	53	07:50 (2)	19:59			20:20
20	07:05		08:11 (1)	06:32		06:48		05:57		06:58 (2)	05:20			05:09
	16:43	30	08:41 (1)	17:22		18:54		19:28	52	07:50 (2)	20:00			20:20
21	07:05		08:11 (1)	06:31		06:46		05:55		06:57 (2)	05:19			05:09
	16:44	29	08:40 (1)	17:23		18:56		19:29	52	07:49 (2)	20:00			20:20
22	07:04		08:12 (1)	06:30		06:44		05:54		06:58 (2)	05:18			05:09
	16:45	27	08:39 (1)	17:24		18:57		19:30	50	07:48 (2)	20:01			20:21
23	07:03		08:13 (1)	06:28		06:43		05:52		06:58 (2)	05:17			05:09
	16:47	24	08:37 (1)	17:26		18:58		19:32	50	07:48 (2)	20:02			20:21
24	07:03		08:15 (1)	06:27		06:41		05:51		06:58 (2)	05:16			05:09
	16:48	22	08:37 (1)	17:27		18:59		19:33	48	07:46 (2)	20:03			20:21
25	07:02		08:17 (1)	06:25		06:39		05:49		06:59 (2)	05:16			05:10
	16:49	19	08:36 (1)	17:28		19:00		19:34	46	07:45 (2)	20:04			20:21
26	07:01		08:19 (1)	06:24		06:38		05:48		06:58 (2)	05:15			05:10
	16:50	15	08:34 (1)	17:29		19:01		19:35	46	07:44 (2)	20:04			20:21
27	07:00		08:21 (1)	06:22		06:36		05:46		06:59 (2)	05:14			05:10
	16:52	10	08:31 (1)	17:30		19:02		19:36	44	07:43 (2)	20:05			20:21
28	06:59			06:21		06:34		05:45		07:00 (2)	05:14			05:11
	16:53			17:32		19:03		19:37	42	07:42 (2)	20:06			20:21
29	06:59					06:32		05:44		07:00 (2)	05:13			05:11
	16:54					19:04		19:38	40	07:40 (2)	20:07			20:21
30	06:58					06:31	07:27 (2)	05:42		07:01 (2)	05:13			05:12
	16:55					19:05	12 07:39 (2)	19:39	38	07:39 (2)	20:08			20:21
31	06:57					06:29	07:22 (2)				05:12			
	16:57					19:07	21 07:43 (2)				20:09			
Potential sun hours	296			297		370		400			450			454
Total, worst case		862					33		1386			184		
Sun reduction		0.57					0.60		0.57			0.61		
Oper. time red.		0.94					0.94		0.94			0.94		
Wind dir. red.		0.58					0.58		0.58			0.58		
Total reduction		0.31					0.33		0.31			0.34		
Total, real		265					11		431			62		

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:

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SHADOW - Calendar

Calculation: Omnidirectional - lawn -real case **Shadow receptor:** A - 124 Ambleside - omnidirectional

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	July		August		September		October		November		December	
1	05:12		05:37		06:08	07:01 (2)	06:39		06:14		06:50	07:47 (1)
	20:21		20:03		19:17	51 07:52 (2)	18:26		16:39		16:14	36 08:23 (1)
2	05:13		05:38		06:09	07:02 (2)	06:40		06:15		06:51	07:47 (1)
	20:21		20:01		19:16	50 07:52 (2)	18:24		16:37		16:14	37 08:24 (1)
3	05:13		05:39		06:10	07:02 (2)	06:41		06:17		06:52	07:47 (1)
	20:21		20:00		19:14	49 07:51 (2)	18:23		16:36		16:13	37 08:24 (1)
4	05:14		05:40		06:11	07:03 (2)	06:42		06:18		06:53	07:47 (1)
	20:21		19:58		19:12	47 07:50 (2)	18:21		16:35		16:13	38 08:25 (1)
5	05:14		05:41	07:26 (2)	06:12	07:04 (2)	06:43		06:19		06:54	07:48 (1)
	20:21		19:57	6 07:32 (2)	19:11	45 07:49 (2)	18:19		16:34		16:13	37 08:25 (1)
6	05:15		05:42	07:21 (2)	06:13	07:05 (2)	06:44		06:20		06:55	07:48 (1)
	20:20		19:56	16 07:37 (2)	19:09	43 07:48 (2)	18:18		16:33		16:13	38 08:26 (1)
7	05:16		05:43	07:19 (2)	06:14	07:06 (2)	06:45		06:21		06:56	07:49 (1)
	20:20		19:54	20 07:39 (2)	19:07	40 07:46 (2)	18:16		16:32		16:13	37 08:26 (1)
8	05:16		05:44	07:15 (2)	06:15	07:07 (2)	06:47		06:23		06:56	07:49 (1)
	20:20		19:53	25 07:40 (2)	19:06	38 07:45 (2)	18:14		16:30		16:13	38 08:27 (1)
9	05:17		05:45	07:14 (2)	06:16	07:08 (2)	06:48		06:24		06:57	07:50 (1)
	20:20		19:52	28 07:42 (2)	19:04	35 07:43 (2)	18:13		16:29		16:13	37 08:27 (1)
10	05:18		05:46	07:12 (2)	06:17	07:10 (2)	06:49		06:25		06:58	07:50 (1)
	20:19		19:51	32 07:44 (2)	19:02	31 07:41 (2)	18:11		16:28		16:13	38 08:28 (1)
11	05:18		05:47	07:11 (2)	06:18	07:11 (2)	06:50		06:26		06:59	07:51 (1)
	20:19		19:49	34 07:45 (2)	19:01	28 07:39 (2)	18:09		16:27		16:13	38 08:29 (1)
12	05:19		05:48	07:10 (2)	06:19	07:14 (2)	06:51		06:27		07:00	07:52 (1)
	20:18		19:48	36 07:46 (2)	18:59	21 07:35 (2)	18:08		16:26		16:13	37 08:29 (1)
13	05:20		05:49	07:08 (2)	06:20	07:18 (2)	06:52		06:29		07:01	07:52 (1)
	20:18		19:47	39 07:47 (2)	18:57	13 07:31 (2)	18:06		16:25		16:13	38 08:30 (1)
14	05:20		05:50	07:07 (2)	06:21		06:53		06:30		07:02	07:52 (1)
	20:17		19:45	41 07:48 (2)	18:55		18:05		16:24		16:13	37 08:29 (1)
15	05:21		05:51	07:07 (2)	06:22		06:54		06:31	07:54 (1)	07:02	07:53 (1)
	20:17		19:44	42 07:49 (2)	18:54		18:03		16:24	10 08:04 (1)	16:13	37 08:30 (1)
16	05:22		05:52	07:06 (2)	06:23		06:55		06:32	07:52 (1)	07:03	07:54 (1)
	20:16		19:42	44 07:50 (2)	18:52		18:01		16:23	15 08:07 (1)	16:14	37 08:31 (1)
17	05:23		05:53	07:05 (2)	06:24		06:56		06:34	07:50 (1)	07:04	07:54 (1)
	20:16		19:41	46 07:51 (2)	18:50		18:00		16:22	19 08:09 (1)	16:14	37 08:31 (1)
18	05:24		05:54	07:04 (2)	06:26		06:58		06:35	07:49 (1)	07:04	07:54 (1)
	20:15		19:39	47 07:51 (2)	18:49		17:58		16:21	22 08:11 (1)	16:14	37 08:31 (1)
19	05:25		05:55	07:04 (2)	06:27		06:59		06:36	07:48 (1)	07:05	07:55 (1)
	20:14		19:38	48 07:52 (2)	18:47		17:57		16:20	24 08:12 (1)	16:15	37 08:32 (1)
20	05:25		05:56	07:03 (2)	06:28		07:00		06:37	07:47 (1)	07:06	07:55 (1)
	20:13		19:36	50 07:53 (2)	18:45		17:55		16:20	27 08:14 (1)	16:15	37 08:32 (1)
21	05:26		05:57	07:02 (2)	06:29		07:01		06:38	07:46 (1)	07:06	07:56 (1)
	20:13		19:35	51 07:53 (2)	18:43		17:54		16:19	29 08:15 (1)	16:16	37 08:33 (1)
22	05:27		05:58	07:02 (2)	06:30		07:02		06:39	07:47 (1)	07:07	07:56 (1)
	20:12		19:33	51 07:53 (2)	18:42		17:52		16:18	30 08:17 (1)	16:16	37 08:33 (1)
23	05:28		05:59	07:02 (2)	06:31		07:03		06:41	07:46 (1)	07:07	07:57 (1)
	20:11		19:32	52 07:54 (2)	18:40		17:51		16:18	32 08:18 (1)	16:17	37 08:34 (1)
24	05:29		06:00	07:01 (2)	06:32		07:05		06:42	07:46 (1)	07:08	07:57 (1)
	20:10		19:30	53 07:54 (2)	18:38		17:49		16:17	32 08:18 (1)	16:17	37 08:34 (1)
25	05:30		06:01	07:01 (2)	06:33		07:06		06:43	07:46 (1)	07:08	07:57 (1)
	20:09		19:29	53 07:54 (2)	18:36		17:48		16:16	33 08:19 (1)	16:18	37 08:34 (1)
26	05:31		06:02	07:01 (2)	06:34		07:07		06:44	07:47 (1)	07:08	07:59 (1)
	20:09		19:27	53 07:54 (2)	18:35		17:47		16:16	34 08:21 (1)	16:18	37 08:36 (1)
27	05:32		06:03	07:01 (2)	06:35		07:08		06:45	07:46 (1)	07:09	07:59 (1)
	20:08		19:26	53 07:54 (2)	18:33		17:45		16:15	35 08:21 (1)	16:19	37 08:36 (1)
28	05:33		06:04	07:01 (2)	06:36		07:09		06:46	07:46 (1)	07:09	07:59 (1)
	20:07		19:24	53 07:54 (2)	18:31		17:44		16:15	36 08:22 (1)	16:20	37 08:36 (1)
29	05:34		06:05	07:01 (2)	06:37		07:10		06:47	07:46 (1)	07:09	07:59 (1)
	20:06		19:22	53 07:54 (2)	18:30		17:43		16:15	36 08:22 (1)	16:20	37 08:36 (1)
30	05:35		06:06	07:01 (2)	06:38		07:12		06:48	07:46 (1)	07:10	07:59 (1)
	20:05		19:21	52 07:53 (2)	18:28		17:41		16:14	37 08:23 (1)	16:21	38 08:37 (1)
31	05:36		06:07	07:01 (2)			07:13				07:10	08:01 (1)
	20:04		19:19	52 07:53 (2)			17:40				16:22	37 08:38 (1)
Potential sun hours	461		429		375		344		296		286	
Total, worst case				1130		491				451		1153
Sun reduction				0.67		0.63				0.48		0.51
Oper. time red.				0.94		0.94				0.94		0.94
Wind dir. red.				0.58		0.58				0.58		0.58
Total reduction				0.37		0.35				0.26		0.28
Total, real				413		170				117		320

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:
Town of Falmouth Wind Turbine Project

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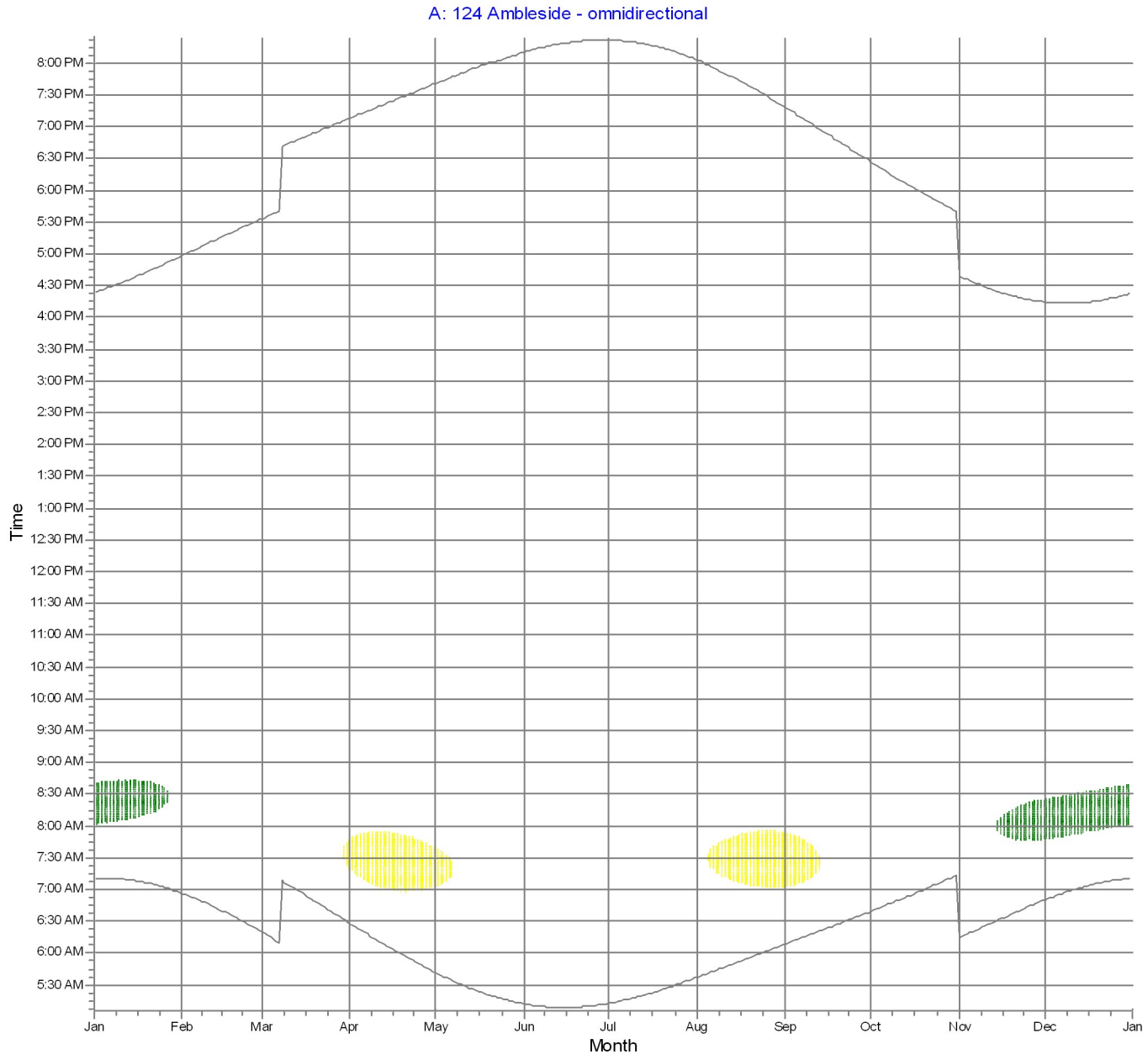
6/14/2011 11:34 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:33 AM/2.7.486

SHADOW - Calendar, graphical

Calculation: Omnidirectional - lawn -real case**Shadow receptor:** A - 124 Ambleside - omnidirectional



WTGs

1: Wind I

2: Wind II

Project:

Town of Falmouth Wind Turbine Project

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6/14/2011 11:34 AM / 1

Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:33 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Omnidirectional - lawn -real case**WTG:** 1 - Wind I

Assumptions for shadow calculations

Maximum distance for influence	2,000 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10 08:01-08:38/37 16:23	06:56 16:58	06:19 17:33	06:27 19:08	05:41 19:40	05:12 20:10	05:12 20:21	05:37 20:03	06:08 19:17	06:39 18:26	06:14 16:39	06:50 07:47-08:23/36 16:14
2	07:10 08:01-08:39/38 16:24	06:55 16:59	06:17 17:34	06:26 19:09	05:40 19:41	05:11 20:10	05:13 20:21	05:38 20:01	06:09 19:16	06:40 18:24	06:15 16:37	06:51 07:47-08:24/37 16:14
3	07:10 08:02-08:39/37 16:25	06:54 17:00	06:16 17:35	06:24 19:10	05:38 19:42	05:11 20:11	05:13 20:21	05:39 20:00	06:10 19:14	06:41 18:23	06:16 16:36	06:52 07:47-08:24/37 16:13
4	07:10 08:02-08:40/38 16:26	06:53 17:02	06:14 17:36	06:22 19:11	05:37 19:43	05:10 20:12	05:14 20:21	05:40 19:58	06:11 19:12	06:42 18:21	06:18 16:35	06:53 07:47-08:25/38 16:13
5	07:10 08:03-08:40/37 16:27	06:52 17:03	06:13 17:37	06:21 19:12	05:36 19:45	05:10 20:12	05:14 20:21	05:41 19:57	06:12 19:11	06:43 18:19	06:19 16:34	06:54 07:48-08:25/37 16:13
6	07:10 08:02-08:40/38 16:28	06:50 17:04	06:11 17:39	06:19 19:13	05:34 19:46	05:10 20:13	05:15 20:20	05:42 19:56	06:13 19:09	06:44 18:18	06:20 16:33	06:55 07:48-08:26/38 16:13
7	07:10 08:03-08:40/37 16:29	06:49 17:06	06:09 17:40	06:17 19:14	05:33 19:47	05:09 20:14	05:16 20:20	05:43 19:54	06:14 19:07	06:45 18:16	06:21 16:32	06:56 07:49-08:26/37 16:13
8	07:10 08:03-08:41/38 16:30	06:48 17:07	07:08 18:41	06:16 19:15	05:32 19:48	05:09 20:14	05:16 20:20	05:44 19:53	06:15 19:06	06:46 18:14	06:23 16:30	06:56 07:49-08:27/38 16:13
9	07:10 08:04-08:41/37 16:31	06:47 17:08	07:06 18:42	06:14 19:16	05:31 19:49	05:09 20:15	05:17 20:19	05:45 19:52	06:16 19:04	06:48 18:13	06:24 16:29	06:57 07:50-08:27/37 16:13
10	07:09 08:05-08:42/37 16:32	06:46 17:09	07:04 18:43	06:12 19:17	05:30 19:50	05:09 20:16	05:18 20:19	05:46 19:51	06:17 19:02	06:49 18:11	06:25 16:28	06:58 07:50-08:28/38 16:13
11	07:09 08:05-08:41/36 16:33	06:45 17:11	07:03 18:44	06:11 19:18	05:29 19:51	05:08 20:16	05:18 20:19	05:47 19:49	06:18 19:01	06:50 18:09	06:26 16:27	06:59 07:51-08:29/38 16:13
12	07:09 08:05-08:42/37 16:34	06:43 17:12	07:01 18:45	06:09 19:20	05:27 19:52	05:08 20:17	05:19 20:18	05:48 19:48	06:19 18:59	06:51 18:08	06:27 16:26	07:00 07:52-08:29/37 16:13
13	07:09 08:05-08:41/36 16:35	06:42 17:13	07:00 18:47	06:08 19:21	05:26 19:53	05:08 20:17	05:20 20:18	05:49 19:46	06:20 18:57	06:52 18:06	06:29 16:25	07:01 07:52-08:30/38 16:13
14	07:08 08:06-08:42/36 16:36	06:41 17:14	06:58 18:48	06:06 19:22	05:25 19:54	05:08 20:18	05:20 20:17	05:50 19:45	06:21 18:55	06:53 18:05	06:30 16:24	07:01 07:52-08:29/37 16:13
15	07:08 08:07-08:42/35 16:37	06:39 17:16	06:56 18:49	06:04 19:23	05:24 19:55	05:08 20:18	05:21 20:17	05:51 19:44	06:22 18:54	06:54 18:03	06:31 07:54-08:04/10 16:24	07:02 07:53-08:30/37 16:13
16	07:07 08:07-08:42/35 16:38	06:38 17:17	06:54 18:50	06:03 19:24	05:23 19:56	05:08 20:19	05:22 20:16	05:52 19:42	06:23 18:52	06:55 18:01	06:32 07:52-08:07/15 16:23	07:03 07:54-08:31/37 16:14
17	07:07 08:08-08:41/33 16:39	06:37 17:18	06:53 18:51	06:01 19:25	05:22 19:57	05:08 20:19	05:23 20:15	05:53 19:41	06:24 18:50	06:56 18:00	06:33 07:50-08:09/19 16:22	07:04 07:54-08:31/37 16:14
18	07:06 08:09-08:41/32 16:41	06:35 17:19	06:51 18:52	06:00 19:26	05:21 19:58	05:08 20:19	05:24 20:15	05:54 19:39	06:25 18:48	06:58 17:58	06:35 07:49-08:11/22 16:21	07:04 07:54-08:31/37 16:14
19	07:06 08:09-08:41/32 16:42	06:34 17:21	06:49 18:53	05:58 19:27	05:21 19:59	05:08 20:20	05:25 20:14	05:55 19:38	06:27 18:47	06:59 17:57	06:36 07:48-08:12/24 16:20	07:05 07:55-08:32/37 16:15
20	07:05 08:11-08:41/30 16:43	06:32 17:22	06:48 18:54	05:57 19:28	05:20 20:00	05:09 20:20	05:25 20:13	05:56 19:36	06:28 18:45	07:00 17:55	06:37 07:47-08:14/27 16:20	07:05 07:55-08:32/37 16:15
21	07:05 08:11-08:40/29 16:44	06:31 17:23	06:46 18:56	05:55 19:29	05:19 20:00	05:09 20:20	05:26 20:13	05:57 19:35	06:29 18:43	07:01 17:54	06:38 07:46-08:15/29 16:19	07:06 07:56-08:33/37 16:16
22	07:04 08:12-08:39/27 16:45	06:30 17:24	06:44 18:57	05:54 19:30	05:18 20:01	05:09 20:21	05:27 20:12	05:58 19:33	06:30 18:42	07:02 17:52	06:39 07:47-08:17/30 16:18	07:07 07:56-08:33/37 16:16
23	07:03 08:13-08:37/24 16:47	06:28 17:26	06:43 18:58	05:52 19:32	05:17 20:02	05:09 20:21	05:28 20:11	05:59 19:32	06:31 18:40	07:03 17:51	06:41 07:46-08:18/32 16:18	07:07 07:57-08:34/37 16:17
24	07:03 08:15-08:37/22 16:48	06:27 17:27	06:41 18:59	05:51 19:33	05:16 20:03	05:09 20:21	05:29 20:10	06:00 19:30	06:32 18:38	07:05 17:49	06:42 07:46-08:18/32 16:17	07:08 07:57-08:34/37 16:17
25	07:02 08:17-08:36/19 16:49	06:25 17:28	06:39 19:00	05:49 19:34	05:16 20:04	05:10 20:21	05:30 20:09	06:01 19:29	06:33 18:36	07:06 17:48	06:43 07:46-08:19/33 16:16	07:08 07:57-08:34/37 16:18
26	07:01 08:19-08:34/15 16:50	06:24 17:29	06:38 19:01	05:48 19:35	05:15 20:04	05:10 20:21	05:31 20:09	06:02 19:27	06:34 18:35	07:07 17:47	06:44 07:47-08:21/34 16:16	07:08 07:59-08:36/37 16:18
27	07:00 08:21-08:31/10 16:52	06:22 17:30	06:36 19:02	05:46 19:36	05:14 20:05	05:10 20:21	05:32 20:08	06:03 19:26	06:35 18:33	07:08 17:45	06:45 07:46-08:21/35 16:15	07:09 07:59-08:36/37 16:19
28	06:59 16:53	06:21 17:32	06:34 19:03	05:45 19:37	05:14 20:06	05:11 20:21	05:33 20:07	06:04 19:24	06:36 18:31	07:09 17:44	06:46 07:46-08:22/36 16:15	07:09 07:59-08:36/37 16:20
29	06:59 16:54		06:32 19:04	05:44 19:38	05:13 20:07	05:11 20:21	05:34 20:06	06:05 19:22	06:37 18:29	07:10 17:43	06:47 07:46-08:22/36 16:15	07:09 07:59-08:36/37 16:20
30	06:58 16:55		06:31 19:05	05:42 19:39	05:13 20:08	05:12 20:21	05:35 20:05	06:06 19:21	06:38 18:28	07:12 17:41	06:48 07:46-08:23/37 16:14	07:09 07:59-08:37/38 16:21
31	06:57 16:57		06:29 19:06		05:12 20:09		05:36 20:04	06:07 19:19		07:13 17:40		07:10 08:01-08:38/37 16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	862	0	0	0	0	0	0	0	0	0	451	1153

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:

Town of Falmouth Wind Turbine Project

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6/14/2011 11:34 AM / 2

Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:33 AM/2.7.486

SHADOW - Calendar per WTG

Calculation: Omnidirectional - lawn -real case**WTG:** 2 - Wind II

Assumptions for shadow calculations

Maximum distance for influence	2,000	m
Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

Sunshine probability S (Average daily sunshine hours) []

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.43	6.00	7.13	7.56	8.90	9.56	10.03	9.23	7.90	6.86	4.76	4.73

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
976	817	535	329	374	558	436	1,147	1,186	619	627	622	8,227

Idle start wind speed: Cut in wind speed from power curve

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:10	06:56	06:19	06:27 07:18-07:45/27	05:41 07:02-07:38/36	05:12	05:12	05:37	06:08 07:01-07:52/51	06:39	06:14	06:50
	16:23	16:58	17:33	19:08	19:40	20:10	20:21	20:03	19:17	18:26	16:39	16:14
2	07:10	06:55	06:17	06:26 07:17-07:48/31	05:40 07:02-07:36/34	05:11	05:13	05:38	06:09 07:02-07:52/50	06:40	06:15	06:51
	16:24	16:59	17:34	19:09	19:41	20:10	20:21	20:01	19:16	18:24	16:37	16:14
3	07:10	06:54	06:16	06:24 07:14-07:49/35	05:38 07:04-07:35/31	05:11	05:13	05:39	06:10 07:02-07:51/49	06:41	06:16	06:52
	16:25	17:00	17:35	19:10	19:42	20:11	20:21	20:00	19:14	18:23	16:36	16:13
4	07:10	06:53	06:14	06:22 07:12-07:50/38	05:37 07:06-07:33/27	05:10	05:14	05:40	06:11 07:03-07:50/47	06:42	06:18	06:53
	16:26	17:02	17:36	19:11	19:43	20:12	20:21	19:58	19:12	18:21	16:35	16:13
5	07:10	06:52	06:13	06:21 07:11-07:51/40	05:36 07:07-07:31/24	05:10	05:14	05:41 07:26-07:32/6	06:12 07:04-07:49/45	06:43	06:19	06:54
	16:27	17:03	17:37	19:12	19:45	20:12	20:21	19:57	19:11	18:19	16:34	16:13
6	07:10	06:50	06:11	06:19 07:09-07:52/43	05:34 07:10-07:29/19	05:10	05:15	05:42 07:21-07:37/16	06:13 07:05-07:48/43	06:44	06:20	06:55
	16:28	17:04	17:39	19:13	19:46	20:13	20:20	19:56	19:09	18:18	16:33	16:13
7	07:10	06:49	06:09	06:17 07:07-07:52/45	05:33 07:12-07:25/13	05:09	05:15	05:43 07:19-07:39/20	06:14 07:06-07:46/40	06:45	06:21	06:56
	16:29	17:06	17:40	19:14	19:47	20:14	20:20	19:54	19:07	18:16	16:32	16:13
8	07:10	06:48	07:08	06:16 07:06-07:53/47	05:32	05:09	05:16	05:44 07:15-07:40/25	06:15 07:07-07:45/38	06:46	06:23	06:56
	16:30	17:07	18:41	19:15	19:48	20:14	20:20	19:53	19:06	18:14	16:30	16:13
9	07:10	06:47	07:06	06:14 07:04-07:53/49	05:31	05:09	05:17	05:45 07:14-07:42/28	06:16 07:08-07:43/35	06:48	06:24	06:57
	16:31	17:08	18:42	19:16	19:49	20:15	20:19	19:52	19:04	18:13	16:29	16:13
10	07:09	06:46	07:05	06:12 07:03-07:53/50	05:30	05:09	05:18	05:46 07:12-07:44/32	06:17 07:10-07:41/31	06:49	06:25	06:58
	16:32	17:09	18:43	19:17	19:50	20:16	20:19	19:51	19:02	18:11	16:28	16:13
11	07:09	06:45	07:03	06:11 07:02-07:53/51	05:29	05:08	05:18	05:47 07:11-07:45/34	06:18 07:11-07:39/28	06:50	06:26	06:59
	16:33	17:11	18:44	19:18	19:51	20:16	20:19	19:49	19:01	18:09	16:27	16:13
12	07:09	06:43	07:01	06:09 07:01-07:53/52	05:27	05:08	05:19	05:48 07:10-07:46/36	06:19 07:14-07:35/21	06:51	06:27	07:00
	16:34	17:12	18:45	19:20	19:52	20:17	20:18	19:48	18:59	18:08	16:26	16:13
13	07:09	06:42	07:00	06:08 07:01-07:53/52	05:26	05:08	05:20	05:49 07:08-07:47/39	06:20 07:18-07:31/13	06:52	06:29	07:01
	16:35	17:13	18:47	19:21	19:53	20:17	20:18	19:46	18:57	18:06	16:25	16:13
14	07:08	06:41	06:58	06:06 07:00-07:53/53	05:25	05:08	05:20	05:50 07:07-07:48/41	06:21	06:53	06:30	07:02
	16:36	17:14	18:48	19:22	19:54	20:18	20:17	19:45	18:55	18:05	16:24	16:13
15	07:08	06:39	06:56	06:04 07:00-07:53/53	05:24	05:08	05:21	05:51 07:07-07:49/42	06:22	06:54	06:31	07:02
	16:37	17:16	18:49	19:23	19:55	20:18	20:17	19:44	18:54	18:03	16:24	16:13
16	07:07	06:38	06:54	06:03 06:59-07:52/53	05:23	05:08	05:22	05:52 07:06-07:50/44	06:23	06:55	06:32	07:03
	16:38	17:17	18:50	19:24	19:56	20:19	20:16	19:42	18:52	18:01	16:23	16:14
17	07:07	06:37	06:53	06:01 06:58-07:51/53	05:22	05:08	05:23	05:53 07:05-07:51/46	06:24	06:56	06:33	07:04
	16:39	17:18	18:51	19:25	19:57	20:19	20:15	19:41	18:50	18:00	16:22	16:14
18	07:06	06:35	06:51	06:00 06:58-07:51/53	05:21	05:08	05:24	05:54 07:04-07:51/47	06:25	06:58	06:35	07:04
	16:41	17:19	18:52	19:26	19:58	20:19	20:15	19:39	18:48	17:58	16:21	16:14
19	07:06	06:34	06:49	05:58 06:57-07:50/53	05:21	05:08	05:25	05:55 07:04-07:52/48	06:27	06:59	06:36	07:05
	16:42	17:21	18:53	19:27	19:59	20:20	20:14	19:38	18:47	17:57	16:20	16:15
20	07:05	06:32	06:48	05:57 06:58-07:50/52	05:20	05:09	05:25	05:56 07:03-07:53/50	06:28	07:00	06:37	07:06
	16:43	17:22	18:54	19:28	20:00	20:20	20:13	19:36	18:45	17:55	16:20	16:15
21	07:05	06:31	06:46	05:55 06:57-07:49/52	05:19	05:09	05:26	05:57 07:02-07:53/51	06:29	07:01	06:38	07:06
	16:44	17:23	18:56	19:29	20:00	20:20	20:13	19:35	18:43	17:54	16:19	16:16
22	07:04	06:30	06:44	05:54 06:58-07:48/50	05:18	05:09	05:27	05:58 07:02-07:53/51	06:30	07:02	06:39	07:07
	16:45	17:24	18:57	19:30	20:01	20:21	20:12	19:33	18:42	17:52	16:18	16:16
23	07:03	06:28	06:43	05:52 06:58-07:48/50	05:17	05:09	05:28	05:59 07:02-07:54/52	06:31	07:03	06:41	07:07
	16:47	17:26	18:58	19:32	20:02	20:21	20:11	19:32	18:40	17:51	16:18	16:17
24	07:03	06:27	06:41	05:51 06:58-07:46/48	05:16	05:09	05:29	06:00 07:01-07:54/53	06:32	07:05	06:42	07:08
	16:48	17:27	18:59	19:33	20:03	20:21	20:10	19:30	18:38	17:49	16:17	16:17
25	07:02	06:25	06:39	05:49 06:59-07:45/46	05:16	05:10	05:30	06:01 07:01-07:54/53	06:33	07:06	06:43	07:08
	16:49	17:28	19:00	19:34	20:04	20:21	20:09	19:29	18:36	17:48	16:16	16:18
26	07:01	06:24	06:38	05:48 06:58-07:44/46	05:15	05:10	05:31	06:02 07:01-07:54/53	06:34	07:07	06:44	07:08
	16:50	17:29	19:01	19:35	20:04	20:21	20:09	19:27	18:35	17:47	16:16	16:18
27	07:00	06:22	06:36	05:46 06:59-07:43/44	05:14	05:10	05:32	06:03 07:01-07:54/53	06:35	07:08	06:45	07:09
	16:52	17:30	19:02	19:36	20:05	20:21	20:08	19:26	18:33	17:45	16:15	16:19
28	06:59	06:21	06:34	05:45 07:00-07:42/42	05:14	05:11	05:33	06:04 07:01-07:54/53	06:36	07:09	06:46	07:09
	16:53	17:32	19:03	19:37	20:06	20:21	20:07	19:24	18:31	17:44	16:15	16:20
29	06:59		06:32	05:44 07:00-07:40/40	05:13	05:11	05:34	06:05 07:01-07:54/53	06:37	07:10	06:47	07:09
	16:54		19:04	19:38	20:07	20:21	20:06	19:22	18:29	17:43	16:15	16:20
30	06:58		06:31 07:27-07:39/12	05:42 07:01-07:39/38	05:13	05:12	05:35	06:06 07:01-07:53/52	06:38	07:12	06:48	07:09
	16:55		19:05	19:39	20:08	20:21	20:05	19:21	18:28	17:41	16:14	16:21
31	06:57		06:29 07:22-07:43/21		05:12		05:36	06:07 07:01-07:53/52		07:13		07:10
	16:57		19:06		20:09		20:04	19:19		17:40		16:22
Potential sun hours	296	297	370	400	450	454	461	429	375	344	296	286
Sum of minutes with flicker	0	0	33	1386	184	0	0	1130	491	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

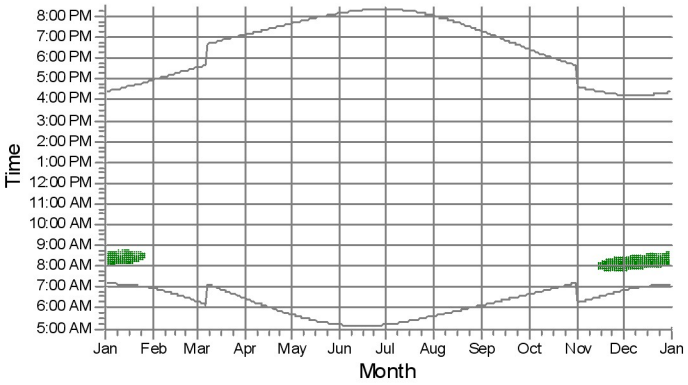
Project:
Town of Falmouth Wind Turbine Project

Printed/Page
6/14/2011 11:34 AM / 1
Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com
Calculated:
6/14/2011 11:33 AM/2.7.486

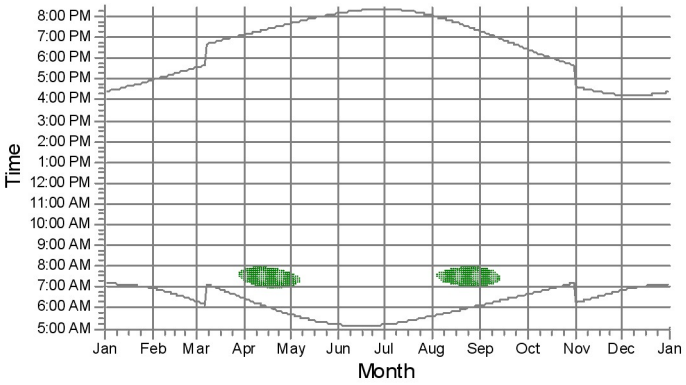
SHADOW - Calendar per WTG, graphical

Calculation: Omnidirectional - lawn -real case

1: Wind I



2: Wind II



Shadow receptor

A: 124 Ambleside - omnidirectional

Project:
Town of Falmouth Wind Turbine Project

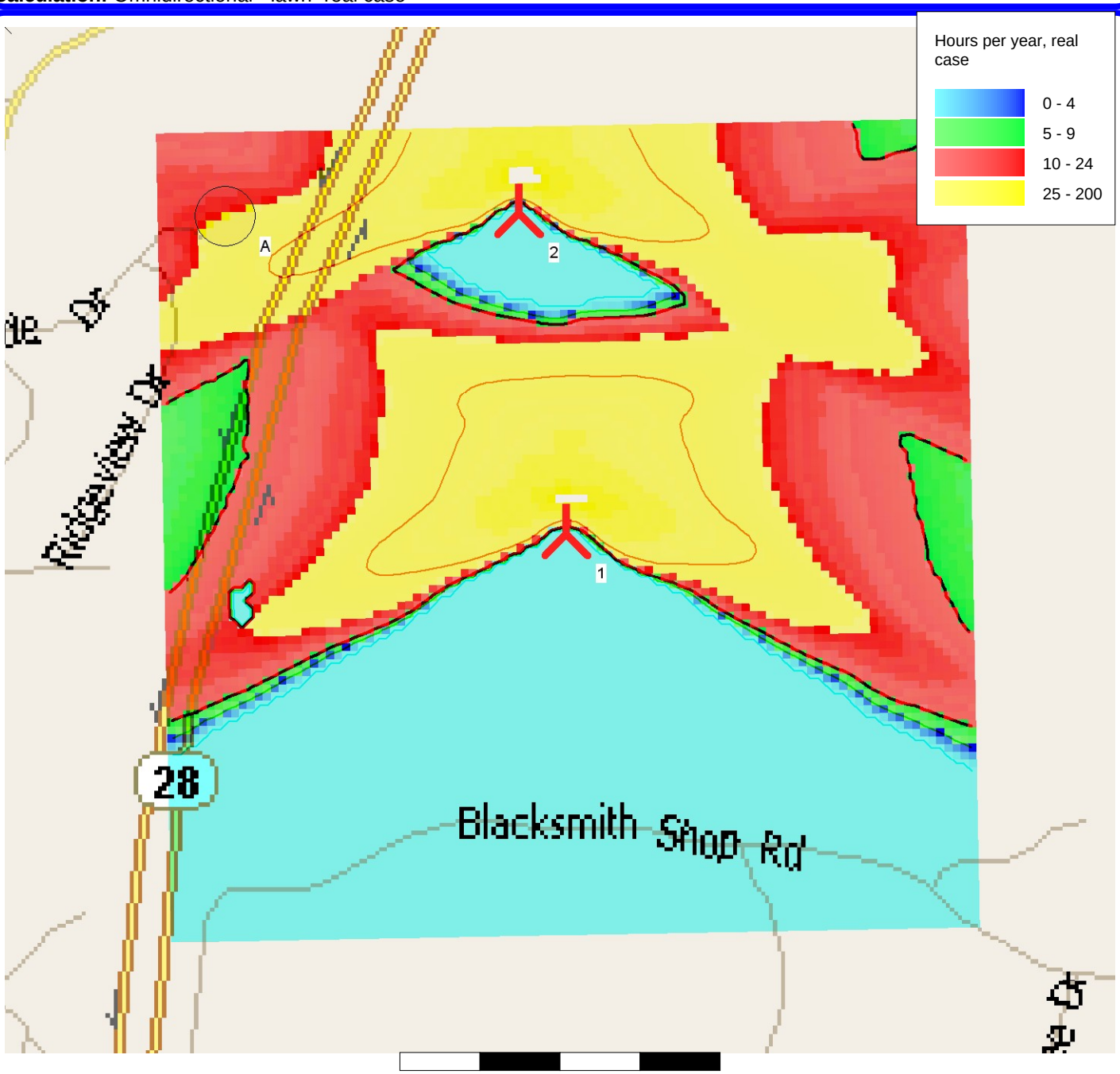
Printed/Page
6/14/2011 11:34 AM / 1

Licensed user:
Weston & Sampson Engineers Inc.
Five Centennial Drive
US-PEABODY, MA 01960
+1 978 532 1900
WindPro / tomlinsons@wseinc.com

Calculated:
6/14/2011 11:33 AM/2.7.486

SHADOW - Map

Calculation: Omnidirectional - lawn -real case



Map: WindPRO map , Print scale 1:7,500, Map center UTM NAD 83 Zone: 19 East: 364,950.00 North: 4,607,300.00

New WTG
Shadow receptor

Isolines showing shadow in Hours per year, real case

0 5 10 50