MT FYANS
WIND FARM

APPENDIX P

SHADOW FLICKER REPORT

ENTURA

AUGUST 2022

entura

Mt Fyans Wind Farm

Shadow flicker assessment

E307002
20 July 2022

Prepared by Hydro-Electric Corporation ABN48 072 377 158

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Document information

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	Shadow flicker assessment
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Revision history

Revision 4

Revision description	81 turbine layout		
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Reviewed by	Daniel Bennett		19/7/2022
Approved by	Daniel Bennett		19/7/2022
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Executive Summary

Shadow flicker modelling was carried out for the proposed Mt Fyans Wind Farm located 8 km north-east of Mortlake in Victoria, for the purpose of assessing compliance with the requirements of the Victorian Policy and Planning Guidelines for Development of Wind Energy Facilities [1], primarily:

> *"The shadow flicker experienced immediately surrounding the area of a dwelling, garden fenced area, must not exceed 30 hours per year as a result of the operation of the wind energy facility."*

The aforementioned limit does not apply to locations where the landowner has agreed to accept shadow flicker duration in excess of the limit.

It is noted the annual shadow flicker duration experienced at receptors is usually significantly less than modelled maximum due to factors including cloudy skies, rotor direction that is not perpendicular to the sun, stationary wind turbine rotors, and vegetation screening.

At the proposed Mt Fyans wind farm, for locations without landowner agreements in place, the modelled shadow flicker duration results show:

- No receptors with greater than 30 hours of modelled shadow flicker
- Four (4) receptors (which includes a 50 m buffer) experienced greater than zero (0) but less than 30 hours of modelled shadow flicker
- Thus, Mt Fyans wind farm is compliant with a 30-hour limit, considering the modelled maximum results. Actual shadow flicker experienced is likely to be significantly lower.

Blade glint is not expected to cause any issue, provided that the wind turbine to be selected ensures that blades supplied are coated with a low reflectivity treatment.

Contents

Appendices

List of figures

No table of figures entries found.

List of tables

1. Introduction

The rotating blades of wind turbines can cast intermittent shadows to a person located in the shadow of the wind turbine – termed shadow flicker. Because wind turbines are tall structures, shadow flicker can be observed at considerable distances but usually only for a brief time (a matter of a few hours a year) at any given location. Even though its duration is brief, shadow flicker can cause physiological or psychological reactions in some people and thus needs to be shown to comply with relevant standards.

Entura has undertaken an assessment of shadow flicker for the Mt Fyans Wind Farm. This report documents the findings of that assessment.

1.1 Reference guidelines

In Victoria, the Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria [1] suggests:

> *"The shadow flicker experienced immediately surrounding the area of a dwelling (garden fenced area) must not exceed 30 hours per year as a result of the operation of the wind energy facility."*

The Victorian planning guidelines do not specify a method of assessment. Entura has followed the Draft National Wind Farm Development Guidelines [2]. These guidelines are based on a worldwide review of existing shadow flicker assessment methods and are considered a 'good-practice' approach to the issue of analysing wind farm shadow flicker.

2. Method

2.1 Modelled shadow flicker

Entura has used the GL-Garrad Hassan WindFarmer 5.2.11 software package to model the maximum occurrence of shadow flicker at receptors at the Mt Fyans Wind Farm site.

In completing this analysis, Entura has used the following inputs, supplied by the proponent:

- The wind turbine layout (81 locations) listed in Appendix A.2A.1 is used in the shadow flicker assessment.
- 316 existing dwelling ('receptor') locations, listed in Appendix A.1. A 50 m buffer around each locations has been included in the assessment (i.e. the maximum shadow flicker impact within that circle is considered)
- Terrain contour file (Mt Fyans Jun2012-GDA9454.map)

The modelling parameters and settings in Table 2.1 show the recommendations of the Draft National Wind Farm Development Guidelines [2] in the centre column, and the values used in the Mt Fyans Wind Farm analysis in the right-most column.

Table 2.1: Shadow flicker modelling parameters

Model parameter	Setting required by the Draft National guideline	Value
Zone of influence of shadows	265 x Maximum blade chord	1500 m
Minimum angle to the Sun	3 degrees	3 degrees
Shape of the Sun	Disk	Disk
Time and duration of modelling	One full year representing a non-leap year 12 to 15 years after the date of DA submission	2037
Orientation of the rotor	Sphere or disk facing the Sun	Sphere[1]
Offset between rotor and tower	Not required	-
Time step	10 min or less	10 min
Effects of topography	Include	Include
Receptor height	1.5 m – 2 m and window / balcony height where dwellings have more than one storey	2 m
Receptor location	A map should be provided, and the highest level of annual shadow flicker reported.	Appendix A.1 and B. 50 m radius is included to account for 'garden fenced area'
Grid size for mapping and assessment of shadow flicker at a receptor location.	Not more than 25 m	25 m

Table 2.2 summarises the key input geometry parameters.

Table 2.2: Wind turbine properties

Model parameter	Value
Wind turbine generator type	Worst case 162 m rotor diameter, 119 m hub height
Maximum blade chord length	Conservative value of 5.66 m assumed; actual chord length expected to be in the range 4 – 5 m
Hub height	119 m
Blade diameter	162 m

[1] Sphere and disk facing the sun are generally equivalent, and neither takes into account wind direction. Wind direction analysis is a mitigating measure, and results in a lower 'actual' limit according to the guideline.

3. Results

The results of the modelling at these receptors (maximum duration within a 50 m radius) are presented in Table 3.1. The distribution of shadow flicker annual totals is shown across the sites in the map in Appendix B.

Involvement key:

I Involved Landowner (agreements in place)

U Uninvolved Landowner

Table 3.1: Receptor modelled shadow flicker

House ID	Duration (hours/year)	Wind turbines causing flicker
i1	58	C77, B71
i8	33	B44, B45
i11	30	B53
i12	12	A27
i13	48	B44
i14	18	B44
i15	22	B40
i16	15	A16
i19	20	A03
u17	29	B62
u38	20	B52
u51	13	B40
u58	14	B59

At the proposed Mt Fyans Wind Farm, for locations without landowner agreements in place, the modelled shadow flicker duration results show:

- No receptors with greater than 30 hours of modelled shadow flicker
- Four (4) receptors (which includes a 50 m buffer) experienced greater than zero (0) but less than 30 hours of modelled shadow flicker

Thus, Mt Fyans Wind Farm is compliant with a 30 hour limit, considering the modelled results. Actual shadow flicker experienced is likely to be significantly lower.

For locations with landowner agreements in place the results show nine (9) receptors (which includes a 50 m buffer) with modelled shadow flicker, of which three (3) have greater than 30 hours modelled annual duration. We note that shadow flicker is considered an amenity issue rather than a health and

safety issue, and that mitigations are available to reduce actual durations (which have not been considered in this modelling exercise). This may include existing or new plant screening.

Based on the modelling the proposed wind farm is compliant with the Victorian Planning Guidelines [1] without the need to consider the actual levels of shadow flicker or further mitigations.

4. Blade glint

Blade glint can potentially be produced when the sun's light is reflected from the surface of wind turbine blades.

As discussed in the Wind Farm Development Guidelines, all major wind turbine blade manufacturers currently finish their blades with a low reflectivity treatment. This prevents a potentially annoying reflective glint from the surface of the blades and the possibility of a strobing reflection when the turbine blades are spinning. Therefore the risk of blade glint from a new development is considered to be very low [2].

Hydro Tasmania ensures that blades supplied are coated with a low reflectivity treatment, and so no issue is foreseen.

5. References

[1] Victoria State Government, Department of Environment, Land, Water and Planning, *Development of Wind Energy Facilities in Victoria Policy and Planning Guidelines*, November 2021

[2] Environment Protection Heritage Council, *National Wind Farm Development Guidelines DRAFT - July 2010* http://www.scew.gov.au/resource/future-national-wind-farm-development-guidelines

Appendices

A Coordinates

A.1 Receptors

Table A.1: House/Residence coordinate list.

Name	X coordinate	Y coordinate	Involvement
u124	637568	5796340	U
u125	637078	5796716	U
u93	639713.3	5785296	U
u103	637150	5789776	U
u104	637082	5789903	U
u136	642087.1	5784523	U
u94	637720.7	5786452	U
u95	637875.2	5786590	U
u92	639384	5784798	U
u126	635996	5796961	U
u145	636447	5799885	U
u189	666085.2	5811193	U
u85	671502	5811127	U
u87	669729	5811625	U
u191	664986.2	5811737	U
u190	666276.8	5811802	U
u295	666011.2	5798323	U
u1	670501	5805193	U
u25	667868.1	5802257	U
u88	668334.9	5805434	U
u296	664336.7	5800236	U
u24	666344.2	5803239	U
u89	667121.7	5804584	U
u34	663373	5800537	U

u26	663809	5800561	U
u27	664011.2	5800525	U
u201	664482.3	5803492	U
u192	664579.7	5809237	U
u33	662517.3	5802258	U
u199	663045.3	5804040	U
u193	663342.9	5808102	U
u198	662601.1	5803914	U
u194	662808.1	5807091	U
u188	676692.3	5812114	U
u185	675499.5	5809226	U
u186	676371.1	5810753	U
u187	675978.7	5812259	U
u86	671709	5811127	U
u180	677879.1	5801919	U
u184	679587.5	5804540	U
u5	674261	5804722	U
u9	674262.9	5799631	U
u8	676071.2	5801671	U
i3	672363.7	5801189	I
i4	673030.3	5801785	I
i2	672103.8	5801865	I
u3	672667	5804783	U
u4	672865	5804777	U
u2	671271	5805054	U
u6	673615.3	5803201	U
u181	680747.3	5799673	U
u182	681552.1	5802022	U
u183	681626.2	5802992	U
u150	639820	5803168	U
u132	643153.8	5798406	U
u151	639304	5803207	U
u149	638526	5802064	U
u144	638203	5799760	U

u146	639120	5799174	U
u148	637118	5801358	U
u129	636970	5799158	U
u147	636673	5800961	U
u156	647706	5799453	U
u154	647924	5800525	U
u155	648059	5799679	U
u152	644634	5804485	U
u153	644869	5804612	U
u142	648261.5	5796721	U
u143	648302.8	5796232	U
u135	647470.1	5795299	U
u134	645070	5797919	U
u133	644273	5797995	U
u114	641345.7	5794760	U
u131	643136.7	5798295	U
u112	640497	5794750	U
u113	640685.8	5795028	U
u130	641688.7	5798244	U
u111	639452	5795038	U
u107	638611	5793316	U
u128	639374.9	5798879	U
u127	639094	5795765	U
u109	638968	5795213	U
u110	639020	5795336	U
u108	638579	5794137	U
u121	649339.8	5790910	U
u122	649446.7	5791092	U
u123	648928.2	5790619	U
u99	644127.3	5787639	U
u100	644022.7	5787379	U
u119	648459.5	5792895	U
u117	646741.7	5791254	U
u118	646498.9	5792861	U

u96	643082.7	5786979	U
u97	643252.9	5787016	U
u98	643372.4	5786990	U
u101	644066	5789690	U
u116	644929.8	5791873	U
u102	641796.7	5789548	U
u115	644683	5793856	U
u105	639683.7	5792324	U
u106	638513.6	5792643	U
u82	653775	5801043	U
u83	653526	5802107	U
u84	653016.9	5798226	U
u218	650831.7	5792931	U
u217	652027.5	5792668	U
u219	650260.5	5795396	U
u220	649034.5	5793228	U
u120	648271.3	5793164	U
i16	657659.2	5795094	I
i17	658010.2	5795224	I
u18	664166	5794029	U
u161	661264.2	5794527	U
u162	660777.5	5794657	U
u50	662782	5794252	U
u49	660754.3	5794401	U
u31	659259.9	5794768	U
u66	653439.5	5795130	U
u216	652872.1	5795783	U
u28	664305.5	5797104	U
u29	659146.8	5798651	U
u30	659430	5798900	U
u37	662530.7	5797677	U
u68	658341	5801811	U
u69	658779	5801961	U
u200	663710.3	5803738	U

u196	661151.6	5804491	U
u195	660963	5804193	U
u197	661635.2	5804332	U
i9	659907.3	5788137	I
i10	659645.9	5788438	I
i12	661427.3	5792502	I
u56	659314.4	5787808	U
u90	659813.3	5787900	U
u71	657397.5	5788156	U
u163	657782.9	5790185	U
u164	657720.1	5790068	U
u61	656528.2	5787050	U
u70	657944	5788331	U
i18	659127	5794699	I
u157	655081.6	5788280	U
i19	654064.8	5790672	I
u158	654198.9	5788968	U
u159	653398.7	5789715	U
u62	652144.3	5792555	U
u63	652161.8	5792645	U
u64	652425.8	5793899	U
u65	652458.4	5794210	U
u301	658710.7	5785371	U
u60	656198	5786692	U
u222	660057.9	5784375	U
u221	660056.1	5784496	U
u223	660129.5	5784269	U
u232	659756	5784315	U
u229	659865.8	5784173	U
u231	659716.2	5784304	U
u230	659649.9	5784266	U
u236	659501	5784297	U
u241	659313.6	5784252	U
u228	659153.5	5784383	U

u247	659272.5	5784170	U
u238	659145.9	5784364	U
u250	659118.3	5784258	U
u251	659108.7	5784205	U
u278	659061.4	5784252	U
u259	659104.2	5784167	U
u279	659041.5	5784175	U
u280	659032.7	5784154	U
u299	659026	5785354	U
u300	658911.9	5785399	U
u227	659129.2	5784638	U
u275	659001.9	5784412	U
u276	659019.9	5784348	U
u274	658946.5	5784362	U
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u282	658968.8	5784132	U
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u286	659023.5	5784095	U
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u306	659267.7	5784009	U
u254	659217.2	5783954	U
u256	659176.1	5783976	U
u255	659149.1	5783956	U
u260	659215.7	5784110	U
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u257	659180.5	5784130	U
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u169	659602.1	5786467	U
u171	659549	5785999	U
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u137	650540.3	5791154	U
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u298	666292.6	5786618	U
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u42	667816.9	5786972	U
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u78	674110	5785126	U
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u303	662497.9	5781385	U

u304	663911.9	5781508	U
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u204	663921.4	5782999	U
u202	662729.5	5782706	U
u176	676810.2	5796117	U
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u80	671139	5787862	U
u81	671310	5788388	U
u174	675335.3	5797038	U
u45	671101.1	5788627	U
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u14	671946.3	5794550	U
u160	670214.8	5795187	U
u15	671013.8	5794636	U
u13	672870.4	5793589	U
u10	673085.4	5798418	U
u39	670209.5	5789817	U
u38	668783	5789961	U
u58	668522.8	5791583	U
u16	670099.1	5794975	U
i1	668430.7	5795940	I
i7	667848.1	5796262	I
u22	667381.2	5796888	U
u20	667260.3	5796702	U
u36	664771.9	5796988	U
u21	665548.3	5798638	U
u23	664832.5	5799387	U
u67	663031.2	5802136	U
u170	659658.8	5786983	U

u207	660829.9	5782712	U
u235	659492.5	5784174	U
u237	659476.6	5784284	U
u239	659154	5784315	U
u240	659131.1	5784326	U
u242	659372.6	5784215	U
u243	659321.7	5784063	U
u244	659307	5784056	U
u307	659354.8	5784204	U
u245	659339.1	5784191	U
u246	659321.9	5784181	U
u249	659216.6	5783995	U
u253	659110.4	5784120	U
u261	659240.3	5784120	U
u271	659266.7	5784089	U
u272	659266.7	5784089	U
u273	659336.4	5784081	U
u292	659061.5	5784015	U
u294	658938.6	5784136	U

Coordinate reference: GDA94 / UTM zone 54

Involvement key:

I Involved Landowner

U Uninvolved Landowner

A.2 Wind turbines

Table A.2: WTG layout

Turbine number	X coordinate	Y coordinate	Turbine number	X coordinate	Y coordinate
A01	654220	5792117	**A13**	655277	5794701
A02	654553	5791325	**A14**	655964	5794091
A03	655207	5790907	**A15**	655879	5794930
A04	655430	5791555	**A16**	656397	5795472
A05	655923	5790627	**A17**	656877	5793409
A06	654999	5792071	**A18**	657025	5794171
A07	654672	5792711	**A19**	657354	5792501
A08	654722	5793338	**A20**	657799	5793896
A09	656408	5791021	**A21**	657850	5793230
A10	656721	5791922	**A22**	658458	5793144
A11	655929	5792960	**A23**	658313	5792228
A12	654975	5794218	**A24**	658830	5792616
A25	659632	5792797	**B60**	667663	5792443
A26	659595	5791846	**B61**	666686	5792435
A27	659978	5792247	**B62**	666299	5793024
B28	660477	5791459	**B63**	667150	5793248
B30	661391	5791230	**B64**	667763	5793196
B31	661826	5790575	**B65**	665830	5793760
B32	662242	5790139	**B66**	666569	5793792
B33	661877	5789367	**B67**	666642	5794385
B34	662582	5789614	**B68**	665929	5794501
B35	661713	5788497	**B69**	666098	5795080
B36	662357	5788194	**B70**	666336	5795566
B37	662896	5788444	**B71**	667192	5795441
B38	662679	5787695	**B72**	667282	5794782
B39	663397	5787946	**B73**	667977	5793926
B40	663166	5787306	**B74**	668304	5794530
B41	663175	5789275	**C77**	669731	5796626
B42	664701	5788792	**C78**	670284	5796768
B43	663705	5789380	**C79**	669449	5796956
B44	664980	5788114	**C80**	669578	5797459

Turbine number	X coordinate	Y coordinate	Turbine number	X coordinate	Y coordinate
B45	665362	5788397	**C81**	670041	5797581
B46	664817	5789436	**C82**	669606	5798065
B47	665389	5789213	**C83**	668786	5798385
B48	666037	5789323	**C84**	668180	5799072
B49	666743	5789328	**C85**	668677	5799296
B50	667081	5789708			
B51	667693	5789246			
B52	667649	5789905			
B53	666950	5790403			
B54	665296	5790313			
B55	665818	5790610			
B56	666288	5790894			
B58	666493	5791631			
B59	667200	5791992			

Coordinate reference: GDA94 / MGA zone 54

B Map

Mt Fyans Wind Farm Shadow Flicker Assessment

Client:	Hydro Tasmania
Map no:	E306828 - P13278 - GIS06 - 01
Date:	Monday, 18 July 2022
Drawn:	Agung Wahyudi
Reviewed:	Lachlan McKenna
Approved:	Daniel Bennett

Map Legend:

- WTG (03/06/2022)

Maximum Flicker Received (hours/year)

- 0.00
- 0.01 - 10.00
- 10.01 - 15.00
- 15.01 - 20.00
- 20.01 - 30.00
- > 30.00

Shadow Flicker (hours/year)

- 1 - 30
- >30
- Watercourse

Public Roads ManagedBy

- Public road - VicRoads
- Public road - council

N

0 0.5 1 1.5 2 km

1:60,000 @ A3 paper size
Coordinate System: GDA 1994 MGA Zone 54

Locality:

entura

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