

IN THE MATTER of the Resource Management Act
1991

AND

IN THE MATTER of applications by Meridian Energy Limited to Manawatū-Whanganui Regional Council, Greater Wellington Regional Council, Tararua District Council and Masterton District Council for resource consents to enable the construction, operation, and maintenance of a new wind farm on Mount Munro, located approximately 5km south of Eketāhuna

SECTION 87F REPORT OF CLAIRE WEST – SHADOW FLICKER

**MANAWATŪ-WHANGANUI REGIONAL COUNCIL, GREATER WELLINGTON
REGIONAL COUNCIL, TARARUA DISTRICT COUNCIL AND MASTERTON DISTRICT
COUNCIL**

15 March 2024

TABLE OF CONTENTS

A.	OUTLINE OF REPORT	3
B.	QUALIFICATIONS / EXPERIENCE	3
C.	CODE OF CONDUCT	4
D.	EXECUTIVE SUMMARY	4
E.	SCOPE OF REPORT	5
F.	BACKGROUND	6
G.	ASSESSMENT OF APPLICATION	6
	Shadow Flicker Assessment	7
	Proposed Mitigation	8
H.	SUBMISSIONS	9
I.	CONDITIONS	12

A. OUTLINE OF REPORT

- 1 This report, required by section 87F of the Resource Management Act 1991 (**RMA**), addresses the issues set out in sections 104 to 112 of the RMA, to the extent that they are relevant to the applications lodged with the Manawatū-Whanganui Regional Council (**Horizons**), Greater Wellington Regional Council (**GWRC**), Tararua District Council (**TDC**) and Masterton District Council (**MDC**).
- 2 The resource consents applied for, by Meridian Energy Limited (**Meridian or the Applicant**), are required to authorise the construction, operation and maintenance and improvement of a new wind farm on Mount Munro, located approximately 5km south of Eketāhuna. The project is known as the Mt Munro windfarm project (the **Mt Munro Project**).
- 3 In this report I address shadow flicker effects in relation to the resource consent applications lodged with Horizons and GWRC (the **Regional Councils**) and TDC and MDC (the **District Councils**). Specifically, this report covers matters arising in respect of the District Councils.
- 4 While this report is pursuant to section 87F of the RMA, I have in accordance with section 42A(1A) and (1B) attempted to minimise the repetition of information included in the application and where I have considered it appropriate, adopt that information.

B. QUALIFICATIONS / EXPERIENCE

- 5 My name is Claire West. I am a Renewables Engineer at Aurecon New Zealand Limited, a multi-disciplinary consultancy firm which provides engineering, management and specialist technical services for public and private sector clients. I have held this position since October 2020.
- 6 I hold a Bachelor of Engineering (Chemical and Materials) with First Degree Honours (University of Auckland, 2019).
- 7 I have experience in a variety of wind farm development activities as noted below. I have completed shadow flicker assessments supporting resource consents for several wind farms in Australia and New Zealand.

8 My role involves shadow flicker, telecommunications interference, wind resource and energy assessments for wind farm developments, as well as layout design and other supporting activities. I also perform similar and equivalent activities for solar developments, including glare assessments.

9 I have conducted a desktop review of the site rather than visiting in person.

C. CODE OF CONDUCT

10 I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. This technical report has been prepared in accordance with that Code. In particular, unless I state otherwise, the opinions I express are within my area of expertise, and I have not omitted to consider material facts that might alter or detract from the opinions that I express.

11 I have addressed shadow flicker issues in this report.

12 I have all the information necessary to assess the application within the scope of my expertise and am not aware of any gaps in the information or my knowledge.

D. EXECUTIVE SUMMARY

13 I have reviewed the relevant application documents for the Mt Munro Project in relation to shadow flicker, and it is my opinion that shadow flicker effects can be effectively managed through conditions that require compliance with the EPHC Guidelines.

14 I am comfortable with the assessment presented in the Applicant's Shadow Flicker Assessment, although I note it is important to measure shadow flicker both in terms of hours per year and per day. An acceptable level of shadow flicker consists of a maximum of 30 modelled hours per year and 30 modelled minutes per day.

15 Given the locations of the turbines are not fixed, I consider it necessary for conditions to require a Pre-Instalment Report that assesses shadow flicker effects from the final design on surrounding dwellings in accordance with the

EPHC Guidelines. This assessment must show each assessed dwelling will be affected by no more than 30 modelled hours per year and 30 modelled minutes per day of shadow flicker.

16 I consider it acceptable for the Applicant to meet the 30 hours per year and 30 minutes per day limit through a curtailment strategy.

E. SCOPE OF REPORT

17 My report focuses only on issues related to shadow flicker.

18 I have reviewed the following information:

(a) Assessment of Environmental Effects, Section 1-2, prepared by Incite for Meridian, dated May 2023.¹

(b) Mount Munro Wind Farm, Landscape Effects Assessment, from Boffa Miskell, dated 12 May 2023 (noting this considers shadow flicker effects within Section 6.6, Appendix 3 and the Graphic Supplement) (the **Shadow Flicker Assessment**).

(c) Response to 20 December 2023 Section 92 Additional Information Request, from Incite, dated 31 January 2024 (**RFI#2 Response 1**).

(d) The proffered District Resource Consent Conditions (the **Draft Conditions**) included in the Assessment of Environmental Effects prepared by Incite, dated May 2023.²

19 In preparing this report, I have relied on the expert advice from the following technical advisors:

(a) Section 87F report of John McKensey – Lighting

¹ Pages 1-31.

² Pages 126-136.

F. BACKGROUND

20 My involvement in this project began in July 2023. A former colleague did an initial review, which I read and supported. Since his departure, I have provided the primary technical advice on shadow flicker matters.

21 In Australia and New Zealand, shadow flicker is generally assessed in accordance with the Australian Environment Protection and Heritage Council (EPHC) “National Wind Farm Development Guidelines – Draft” July 2010 (the **EPHC Guidelines**). While these are nominally “draft” guidelines, they were not updated because Australian state governments were developing their own guidelines, so the EPHC ceased the development of a national document.

22 The EPHC Guidelines are one of the few that clearly and correctly deal with the different limits for modelled (theoretical) and realistic/actual shadow flicker duration and which provide appropriate details on the methods to calculate the shadow flicker durations. The calculation methodology for the modelled (theoretical) hours per year duration specified in the EPHC Guidelines is highly conservative and the realistic (actual) shadow flicker duration will be significantly lower due to factors including turbine rotor orientation (reducing the area covered by the blade shadow), cloud cover (meaning shadows cannot be cast from the turbines), or turbine operational time (i.e. not operating due to maintenance or to wind speed being too high/low). The EPHC Guidelines specify an allowable limit of 30 hours per year (modelled), 10 hours per year (realistic) and 30 minutes per day shadow flicker duration to be an acceptable level for non-participating landowners.

23 New Zealand does not currently have shadow flicker guidelines, so the EPHC Guidelines are commonly used for assessments of New Zealand wind farms.

G. ASSESSMENT OF APPLICATION

24 The Shadow Flicker Assessment provides an overview of shadow flicker effects, assesses likely shadow flicker impacts from the Mt Munro Project, and sets out potential mitigation strategies.

25 I identify below where I agree with the approach taken in this assessment and where my opinion differs.

Shadow Flicker Assessment

26 The Shadow Flicker Assessment describes shadow flicker and the factors that influence its effects. I consider the description to be reasonable.

27 The Shadow Flicker Assessment references the EPHC Guidelines, which I consider appropriate.

28 The Shadow Flicker Assessment notes that an acceptable level of exposure of shadow flicker is deemed to be either 30 hours per year (modelled) or 10 hours per year (actual, i.e., measured), which is in accordance with the EPHC Guidelines. However, I note that the EPHC Guidelines also specify a limit of 30 minutes per day modelled shadow flicker to be an acceptable level for non-participating landowners and consider that this limit should also be considered in a shadow flicker assessment. The Shadow Flicker Assessment did not use this measure, as it only provided the mean (not the maximum) number of minutes each day nearby dwellings would be affected.

29 The Shadow Flicker Assessment does not explicitly state that their assessment has been completed in accordance with the calculation methodology outlined in the EPHC Guidelines. However, the results appear to be a reasonable estimate of shadow flicker calculated in accordance with the EPHC Guidelines, and there is nothing to suggest that any significantly erroneous parameters have been used. Given the Draft Conditions require a Pre-Instalment Shadow Flicker Assessment to be completed “by an appropriately qualified specialist” in accordance with the EPHC Guidelines prior to the commencement of construction, I consider this approach to be acceptable.

30 I note the Shadow Flicker Assessment uses a larger distance threshold for shadow flicker effects than required by the EPHC Guidelines. The Shadow Flicker Assessment uses a 10x rotor diameter (a distance of 1,360m) instead of the 265x blade chord (widest point along the blade) required by the EPHC Guidelines, which would be approximately 1,060 to 1,113m for a typical

turbine of the proposed size for the Mt Munro Project (rotor diameter up to 136m). This means the duration of shadow flicker has been calculated for some residences which the EPHC would deem too far away to be affected by significant shadow flicker. I note that this should only affect residences which are below the modelled limit of 30 hours per year and 30 minutes per day i.e., does not affect whether any residences are above or within the limit. This is a conservative approach to assessment of shadow flicker in this case, which I consider to be appropriate.

- 31 The Shadow Flicker Assessment determined that multiple residences are predicted to experience some shadow flicker effects, with the amount of shadow flicker varying between residences. Eight residences were determined to have predicted shadow flicker above the allowable 30 hours per year limit.

Proposed Mitigation

- 32 The Shadow Flicker Assessment notes the two main mitigation strategies for managing shadow flicker are curtailment (shutting down turbines at some times when they are predicted to cause shadow flicker) or creating barriers (such as sheds or windbreaks). The EPHC Guidelines notes that revising wind farm layout can also help manage shadow flicker.³
- 33 The mitigation strategies are reflected in the Draft Conditions. Specifically, they require:
- (a) The consent holder to ensure that shadow flicker effects meet the modelled limit of 30 hours per year as defined in the EPHC Guidelines, modelled to 10 times the turbine diameter. I consider it acceptable for the Applicant to meet this limit through a curtailment strategy;⁴ and
 - (b) A Pre-Instalment shadow flicker assessment to be completed prior to construction, and that the assessment shall *“demonstrate that the proposed number, layout, type and operation of wind turbines*

³ EPHC Guidelines, page 161.

⁴ Draft Condition 14.

(including the curtailment strategy for turbines if necessary)” will comply with the limit of 30 hours per year as defined in the EPHC Guidelines.⁵

34 I consider that adherence with the EPHC Guidelines will ensure that the shadow flicker assessment is reasonable and that effects are at an acceptable level for nearby and adjacent landowners. However, as noted above, the 30 minutes per day limit advised by the EPHC Guidelines should also be met by the consent holder. This limit is presently not reflected in the Draft Conditions, and in my view, it should also be explicitly required to be met.

35 The RFI#2 Response 1 specified that for residences where the EPHC Guidelines limit on theoretical shadow flicker is exceeded, curtailment will be used to achieve compliance. The Applicant has advised that this will be achieved via automation in the wind farm SCADA (operation and control) system, which will *“shut down the relevant turbines at enough of the relevant times to meet the shadow flicker limit.”*⁶

36 I consider this proposed mitigation strategy to be suitable (if the 30 minutes per day limit is also included). I note that this is standard practise in the industry to address shadow flicker requirements.

H. SUBMISSIONS

37 I have read the summary of submissions and individual submissions⁷ that raise specific shadow flicker issues.

38 I note that there are common themes raised by submitters. I have therefore grouped submitters to address submissions by topic rather than as individual submissions in paragraphs 40-50 below. Submissions fall into three general topics:

- (a) General or unspecified opposition to shadow flicker;

⁵ Draft Condition 16.

⁶ RFI#2 Response 1 at page 10.

⁷ Submissions 11, 16, 30, 34, 38, 41, 44, 45, 47, 48, 49, 67, 68.

(b) Timing and location of shadow flicker; and

(c) Adverse health effects.

39 I have not addressed submissions that relate to effects from artificial lighting as I understand these have been considered in Mr McKensey's s 87F Report.

General or unspecified opposition to shadow flicker

40 Submitters have indicated general concern or opposition to shadow flicker effects.

41 I recognise that shadow flicker can be an annoyance for residences in the vicinity of wind farms. This is also recognised by the EPHC Guidelines, which state that the key risk associated with shadow flicker is annoyance of residents.⁸

42 However, the EPHC Guidelines are the industry-standard for limiting annoyance effects to an "acceptable level" for nearby and adjacent landowners. As such, I consider it is reasonable to rely on the EPHC Guidelines to manage effects, particularly given its inherently conservative approach (outlined in paragraph 22).

Timing and location of shadow flicker

43 Some submissions indicated opposition to the timing of shadow flicker (i.e., afternoon, evening, sunsets, during nights, under the full moon) and location of effects associated with shadow flicker (i.e., outside, and on windows within houses).

44 Shadow flicker occurs when the sun is low in the sky (i.e., just after sunrise or before sunset), when the turbine shadow can be cast over a long distance. Shadow flicker is predicted to occur at certain times in the morning and evening when the sun is low. However, I am comfortable that, with my proposed recommendation (to include a limitation to 30 minutes per day in accordance with the EPHC Guidelines) at paragraph 34, shadow flicker

⁸ EPHC Guidelines, page 157.

associated with the activity will be limited to 30 minutes per day and 10 hours per year (realistic/actual duration).

45 Shadow flicker occurring at night is less noticeable because even when the moon is full and directly behind one or more turbines (from the perspective of a viewer), the much lower brightness of the moon compared to the sun will reduce the intensity of shadow flicker to near-zero impact. In addition, the much rarer occurrence of a near-full moon compared to the consistent daily sun will mean that the duration of night-time shadow flicker is only a very small amount of time per year. For these reasons, I consider that shadow flicker occurring at night is not a significant concern.

46 In addition, shadow flicker is less noticeable when outside because ambient lighting outdoors is much less directional than indoors due to (a) diffuse light scattering and (b) reflections off the ground, trees, buildings, and other surroundings. This means that the reduction in overall illumination for a viewer is much less dramatic when outdoors. In comparison, for an indoors viewer the only illumination may come from a window, so when the window is blocked by a turbine blade shadow the change in illumination for the entire room can be significant. For these reasons, I consider that shadow flicker occurring outside is not a significant concern.

47 I consider it is reasonable to rely on the EPHC Guidelines to manage effects, which can be achieved through a robust Pre-Instalment Assessment that assesses the final design and sets out how the Applicant will meet applicable limits

Adverse Health Effects

48 Some submissions addressed potential health effects linked to shadow flicker, including headaches/migraines, increased stress, and sleep disturbance.

49 The EPHC Guidelines note that the Australian National Health and Medical Research Council (NHMRC) has conducted peer reviewed research indicating that *“there is currently no published scientific evidence to positively link wind turbines with adverse health effects”*, nor are there any known direct health

impacts from shadow flicker or electromagnetic interference from correctly designed and sited wind farms.⁹ The guidelines also found that the risk of epilepsy is negligible. Since the EPHC Guidelines were published in 2010, the NHMRC completed an updated study in 2015 which also found no conclusive link between wind turbines and ill health effects.¹⁰

50 I note that I am not an expert on human health, but I am not aware of any negative health effects for residences near other wind farms around New Zealand.

I. CONDITIONS

51 The Draft Conditions have limits calculated in accordance with the EPHC Guidelines, which, for reasons I have explained above, is appropriate.

52 The Pre-Instalment Report provides a key piece of mitigation as it ensures the EPHC Guidelines will be met. This report therefore needs to be:

(a) carried out by an independent, qualified specialist and peer reviewed by a shadow flicker expert to ensure it meets EPHC Guidelines; and

(b) Provide clear evidence of how the curtailment strategy will be met (either through automation or ongoing monitoring).

53 The Draft Conditions reference the 30 hours per year theoretical limit, but not the 30 minute per day limit from the EPHC Guidelines. As I have noted, I recommend that the wording in the conditions be updated to explicitly reference the 30 minute per day limit as well.

Claire West

15 March 2024

⁹ EPHC Guidelines, page 3.

¹⁰ Merlin, T, Newton, S, Ellery, B, Milverton, J & Farah, C 2015, *Systematic review of the human health effects of wind farms*, National Health and Medical Research Council, Canberra.