



r.e. think energy

Appendix 11: Amended Blade Throw Assessment

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Dear Tom,

RE: Blade Throw Assessment updated for Amendment Report

Thank you for your email dated 3rd March 2025 with your request to provide a revised Blade Throw Assessment (BTA) for the new turbine layout using both the original Environmental Impact Statement (EIS) candidate turbine and the Amendment Report candidate turbine.

We have used the alternative assessment methodology advised to Umwelt in February 2025 to investigate the reduced wind turbine layout that was provided by Umwelt on 3 March 2025. The alternative assessment methodology is that confirmed through consultation with NSW Department of Planning, Housing and Infrastructure (DPHI) following exhibition of the Project EIS.

1. Background

A revised Blade Throw Assessment (BTA) was provided by Middleton Group (MG) in January 2025 addressing alternative assessment methodologies. Subsequently, Umwelt requested MG undertake a further assessment for a new candidate wind turbine model (N163-5.7MW) with reduced dimensions.

Turbines 37 and 38 were found to pose some risk to residence R1 with either original or amended candidate turbines. As a result, Bullawah Wind Farm Pty Ltd (BWF) made the decision to revise the project layout to mitigate this risk.

Turbine 96 was previously found to be within blade throw range of the original candidate turbines (assessed in the EIS) but not of the amended candidate turbines.

2. Risk Calculation for Bullawah Wind Farm Blade Throw

2.1 Introduction

Roads and open-land areas are not considered in this risk calculation. Experience has shown the probability values for roads and open-land areas to be several orders of magnitude lower than the results calculated at residences. Roads and open-land areas have a negligible contribution to the total blade throw risk for the Project.

The following risk calculation evaluates the annual probability of a whole blade or a blade fragment striking a dwelling, with fatality being the assumed consequence. The result will be compared with Table 2 of Hazardous Industry Planning Advisory Paper No. 4 (HIPAP 4).

2.2 Risk calculation input data

2.2.1 Original EIS Wind turbine dimensions

The basis for the Original EIS assessment is the candidate wind turbine described in Table 1a.

| WTG Model | Rotor Diameter | Blade Length | Hub Height | Tip Height |
|---------------|----------------|--------------|------------|------------|
| Not specified | 200m | 100m | 200m | 300m |

Table 1a: Dimensions of candidate wind turbine for Original EIS

2.2.2 Amendment Report Wind Turbine Dimensions

The basis for the Amendment Report assessment is a new candidate wind turbine described in Table 1b.

| WTG Model | Rotor Diameter | Blade Length | Hub Height | Tip Height |
|------------|----------------|--------------|------------|------------|
| N163-5.7MW | 163m | 79.7m | 148m | 229.5m |

Table 1b: Dimensions of candidate wind turbines for Amendment Report

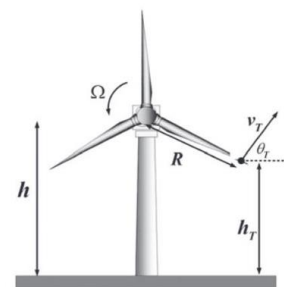
The following dimensions were used in this assessment to represent the amended candidate turbine model:

- Tip Height = 233m
- Rotor Diameter = 163m

2.2.3 Maximum impact radius

Impact radius can be calculated for all possible release angles using Rogers et al [1] simplified point-mass blade fragment model for maximum throwing distance, shown in Equation 1.

$$D = \frac{v_T^2 s_{\theta_T} c_{\theta_T} \pm v_T^2 \sqrt{s_{\theta_T}^2 c_{\theta_T}^2 + 2 \frac{g}{v_T^2} (h - R c_{\theta_T}) c_{\theta_T}^2}}{g}$$



Equation 1: Impact radius calculation

The blade throwing distance D is a function of tip velocity v_T , the sine and cosine of the release angle θ_T , denoted as s_{θ_T} and c_{θ_T} , gravitational acceleration, g , the hub height, h , and the rotor radius, R .

The maximum value of Equation 1 is used as a screening criterion to identify potentially impacted dwellings for further analysis. Applying the equation using tip velocities (adjusted for rotor diameter) of 87.2 m/s and 71 m/s respectively, produces the graphs shown in Figures 1a and 1b below.

The indicated maximum fragment ranges are as follows:

- Original EIS candidate turbine: 1018 m fragment; 388 m whole blade drop; and
- Amendment Report candidate turbine: 700 m fragment; 274 m whole blade drop.

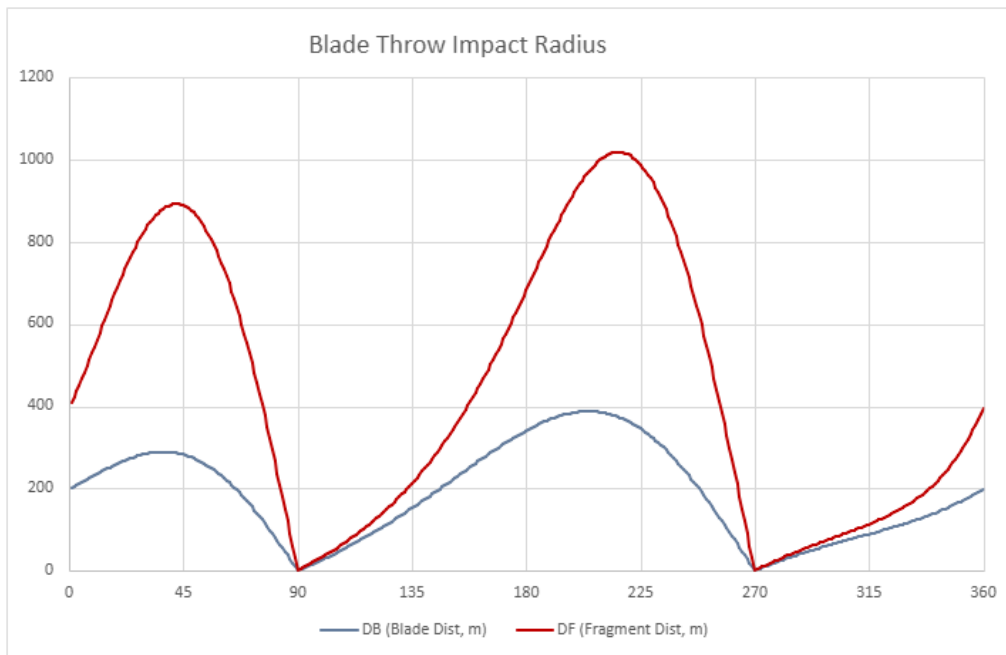


Figure 1a: Impact radius results of kinematic model for Original EIS candidate turbine

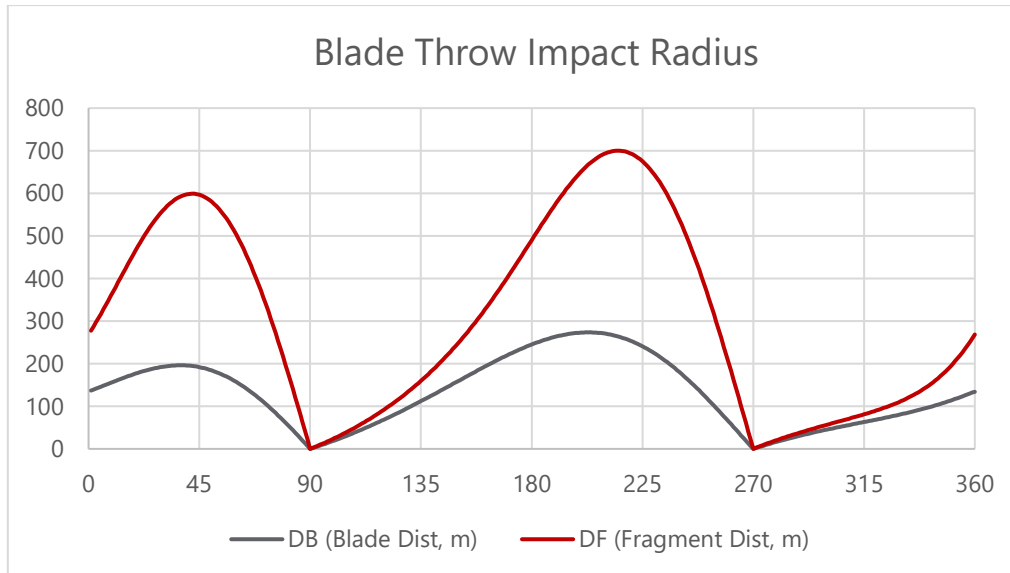


Figure 1b: Impact radius results of kinematic model for Amendment Report candidate turbine

2.2.4 Potentially impacted dwellings

Superimposing the maximum fragment impact radius of the original candidate turbine onto the wind farm layout shows that one dwelling, R2 is located 801 m within the impact radii of WTG 96. Refer to figure 2a. A risk calculation is required to determine the acceptability of this. No dwellings are within maximum whole blade drop range.



Figure 2a: Dwellings relative to fragment range (purple) of Original EIS candidate turbine

Superimposing the maximum fragment impact radius of the Amendment Report candidate turbine onto the wind farm layout shows that no dwellings are located within the impact radii of 700m. Refer to figure 2b.

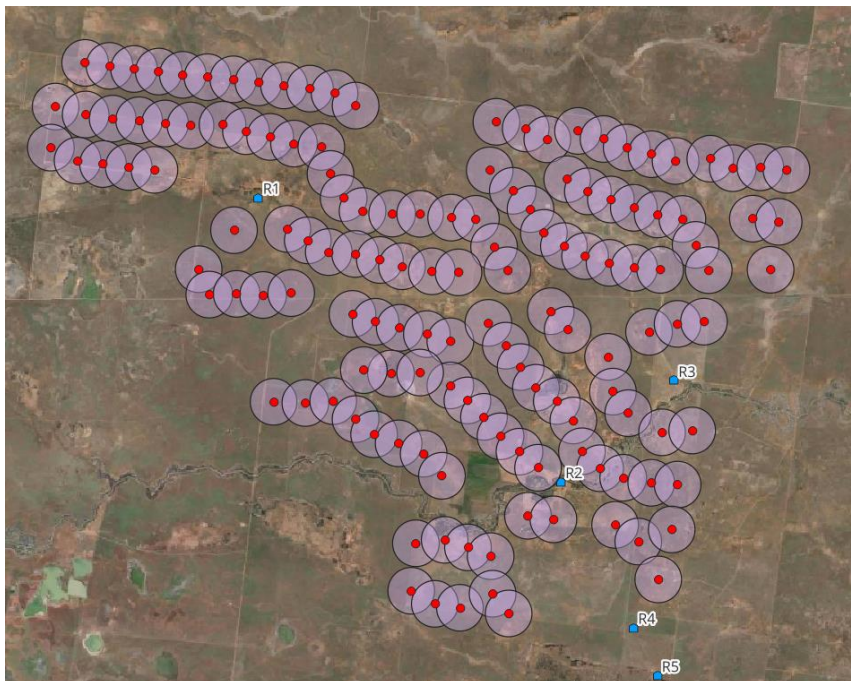


Figure 2b: Dwellings relative to fragment range (purple) of Amendment Report candidate turbine

Due to the reduced fragment range of the turbines proposed in the Amendment Report, R2 (as shown in Figure 2b) is more than 100m beyond the fragment range of turbine #96. Additionally, due to the amended turbine layout, R1 (as shown in Figure 2) is now more than 1 km beyond the fragment range of the closest turbine, #39.

Using the candidate turbines proposed in the Amendment Report, no dwellings are within maximum whole blade drop range (approx 274m) of any turbine.

2.3 Risk Calculation Methodology

2.3.1 Wind direction

Bureau of Meteorology (BoM) provides wind direction data in 45-degree sectors as shown in Figure 3.

Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 09 Jan 2015)

Custom times selected, refer to attached note for details

HAY (MILLER STREET)

Site No: 975031 • Opened Jan 1977 • Closed Jan 2015 • Latitude: -34.5194° • Longitude: 144.8545° • Elevation 93.m

An asterisk (*) indicates that calm is less than 0.5%.

Other important info about this analysis is available in the accompanying notes.

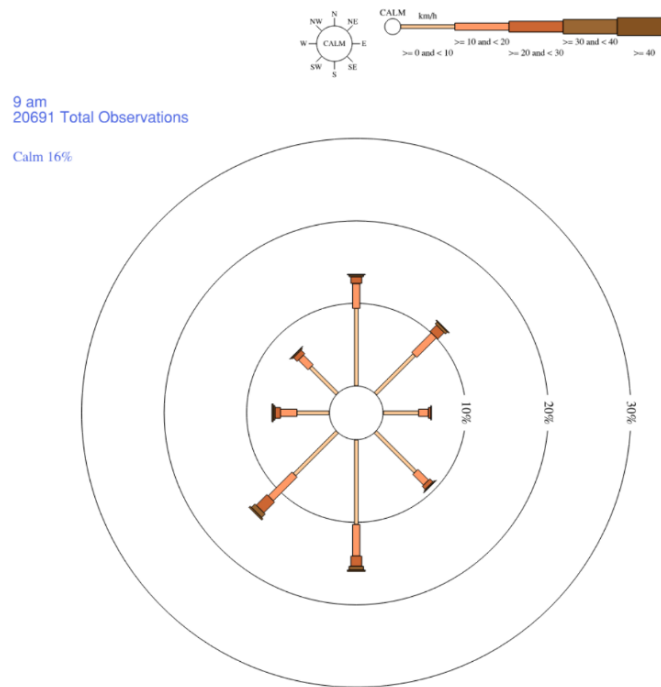


Figure 3: Wind direction data

The wind data excludes calm periods which are 16% of time at the Project location. No fragment hazard exists during calm periods as the turbines are not rotating during calm periods.

The probability of wind blowing from a particular directional sector may be read from Figure 3. The values vary between 5% and 15%.

2.3.2 Historical Australian Blade Throw Frequency

The historical annual probability of blade fragmentation in Australia, P_{frag} , is 7.48×10^{-5} per turbine (as per the EIS MG BTA report sections 5.1 and 6.1, including Table 16 and Appendix A).

2.3.3 Direction fragment throw

The direction of any projectile will align with the direction of rotor rotation. The direction of throw for a blade fragment is perpendicular to the wind direction as shown in Figure 4.

For each combination of wind turbine and house that are identified as being within the maximum impact radius, the bearing from the turbine to the house is used to determine the two wind direction sectors (each 45 degrees wide and 180 degrees opposed) which contribute to the possibility of blade throw hazard for that specific dwelling. Historical local wind data is then applied.

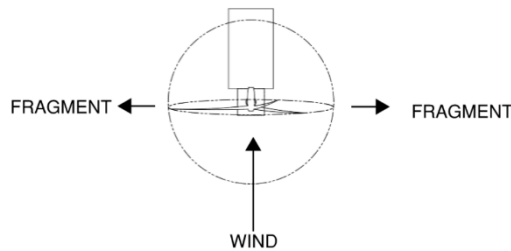


Figure 4: Fragment throw direction relative to wind direction

2.3.4 Release Angle and Range

With reference to the maximum impact radius calculation in section 2.2.3, only a select set of release angles θ_T (x-axis of figure 1a/1b), corresponding to rotation position of the fragmenting blade, will give rise to a given throw distance which also must be to the relevant side of the turbine. The percentage of release angles for which impact is possible from a distance perspective, is determined by identifying the number of release angles (to a 1-degree resolution) that result in a throw distance within ± 50 m of the house's distance from the turbine. This value is then divided by 360 degrees to obtain a likelihood that the throw range is approximately equal to the distance to the selected house.

For the original EIS turbine specifications, and dwelling R2, this likelihood is 4%.

2.3.5 Calculation of Probability

The probability of a particular dwelling being struck by a fragment from a particular turbine is as shown in Equation 2.

$$P_{\text{impact}} = P_{\text{Release Angle}} \times (P_{\text{wind sector1}} + P_{\text{wind sector2}}) \times P_{\text{frag}}$$

Equation 2: Probability of blade fragment striking a dwelling

Table 2 shows the results of this calculation.

| ID | WTG | Bearing WTG to house | Dist WTG to house | Wind Sect 1 | Wind sect 2 | Max Impact Radius | Release angle % | P_{wind} sector1 | P_{wind} sector2 | P_{frag} | P_{impact} |
|--|-----|----------------------------|----------------------------|----------------|----------------|-------------------------|--------------------|------------------------------|------------------------------|-------------------|----------------------|
| R2 | 96 | 122 | 801m | NE | SW | 1018 | 4 | 0.13 | 0.14 | 7.48E-5 | 0.8×10^{-6} |
| Total Probability with Original EIS Candidate Turbines | | | | | | | | | | | 0.8×10^{-6} |

Table 2: Calculation of Probability of Fragment Impact on potentially impacted dwellings

3. Conclusion

Using the original EIS turbine specifications, there is some risk to dwelling R2, however it is below the acceptable threshold stated in HIPAP4. The result of 0.8×10^{-6} is lower than the 1×10^{-6} chances/year location specific individual fatality risk (LSIFR) criteria stated for "Residential, hotels, motels, tourist resorts" in Table 2 of HIPAP 4 and appears to be acceptable on that basis.

Table 2: Individual Fatality Risk Criteria

| Land Use | Suggested Criteria (risk in a million per year) |
|---|--|
| Hospitals, schools, child-care facilities, old age housing | 0.5 |
| Residential, hotels, motels, tourist resorts | 1 |
| Commercial developments including retail centres, offices and entertainment centres | 5 |
| Sporting complexes and active open space | 10 |
| Industrial | 50 |

Extract from HIPAP 4

Using the Amendment EIS turbine specifications, no dwellings fall within the calculated maximum impact radius of any turbine and therefore there is no basis on which to calculate a LSIFR value. The industry-accepted approach represented by Equation 1 indicates there is no risk because no turbines are located within the blade throw range of any residences.

References

[1] J. Rogers, N. Slegers and M. Costello, "A method for defining wind turbine setback standards," Wind Energy, vol. 15, no. 2, pp. 289-303, 2012.

This assessment was prepared by: Ebony Apps and reviewed by: Craig Johnston.

Sincerely,

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