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Appendix 20 - Blade Throw Assessment

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Bullawah Wind Farm Project

Blade Throw Assessment

Client: **Umwelt (Australia) Pty Ltd**
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Project: Bullawah Wind Farm – Blade Throw Assessment
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FINAL

Revision control

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Executive Summary

Middleton Group Engineering (MGE) has been engaged by Umwelt (Australia) Pty Ltd to undertake a Blade Throw Assessment for the Bullawah Wind Farm Project (the Project), located approximately 36 km south east of Hay, within the South West Renewable Energy Zone. The Project Area is located within the Hay Shire, Murrumbidgee and Edward River Local Government Areas (LGAs).

The Project will include the installation, operation, maintenance and decommissioning of up to 143 wind turbine generators (WTGs), battery storage, ancillary infrastructure and temporary facilities associated with construction of the Project. The Project design incorporates up to 143 wind turbine generators (WTGs), with a maximum blade-tip height of 300 m above ground level, and an installed capacity of up to 815.1 megawatts (MW).

Methodology

This study has been undertaken to address the blade throw risk element of the NSW Planning Secretary's Environmental Assessment Requirements (SEARs) for the Project, specifically, the following requirement: "*Blade Throw – assess blade throw risks.*"

Assessment Overview

The boundary between "broadly acceptable" and "tolerable" blade throw risk is generally taken as a one (1) in 1 million years fatality. The boundary between "tolerable" and "unacceptable" is generally taken for the public at large as a one (1) in 10,000 years fatality [1].

The likelihood of a fatal blade throw event, the instance when a WTG loses all or part of its blade, at the Project is estimated to be once in 15.5 million years, which is comfortably within the bounds of what is considered to be broadly acceptable.

One (1) host residence (R1) lies within 800 m of two (2) WTGs. The likelihood that it is struck in a blade throw event is estimated to be once in 3.4 trillion years, which is also comfortably within the bounds of what is considered to be broadly acceptable.

This estimate is based on the characterisation of the following:

- The likelihood of a blade failure, based on existing Australian wind turbines and reported blade failure events in Australia.
- The impact area of such a blade failure.
- The likelihood that the impact extent of such a blade failure would be occupied.
- The likelihood that a person or residence is within the landing zone.

The low likelihood of adverse outcome is due to low incidence of failure and low rates of occupation in the vicinity of the WTGs.

Recommendations

The Project design has avoided, minimised and mitigated risks and impacts associated with blade throw. Accordingly, there are no project-specific recommendations required or provided by MGE, as relevant to the Project assessed in this study.

To safeguard against potential equipment selection, installation and maintenance issues, the following conceptual management measure options should be considered:

- Ensure all WTG are manufactured and certified to achieve relevant Australian and international safety standards (IEC 61400-23).
- Ensure all WTG are equipped with suitable measurement instrumentation that can detect and then respond to any rotor blade imbalances and shut down WTG if required.
- Ensure all WTGs will be suitably managed and maintained according to industry best-practice standards and are subject to a regular and comprehensive maintenance and servicing regime.

To safeguard against potential future impacts, identified as a result of any design changes, the following conceptual avoidance, minimisation and/or mitigation options may be considered:

- Modify the design to either relocate and/or remove wind turbines to avoid, minimise and/or mitigate any blade throw issues, risks and impacts.
- Confirm during detailed design that any change in probability of fatality, and blade fragmentation and blade drop risk at R1, as a result of any relevant design modification (i.e. relocation of WTG near R1) results in a risk and associated impact being maintained within suitable thresholds of acceptability.

Where these options require future investigation, any interaction and/or cumulative impact as a result of the developments listed in section 3.8 (or any additional developments that have entered the public domain since) should be considered.

No further recommendations and/or safeguards are provided in this report.

Contents

Tables

Figures

Abbreviations/Definitions

Table 1: Abbreviations and Definitions

Abbreviation / definition	Explanation
BESS	Battery Energy Storage System
BWF	Bullawah Wind Farm
DPHI	Department of Planning, Housing and Infrastructure
HIPAP4	Hazardous Industry Planning Advisory Paper No 4
km	Kilometre
km/h	Kilometres per hour
m	Metre
m/s	Metres per second
MGE	Middleton Group Engineering
MW	Mega-Watt
MWh	Mega-Watt-hour
NSW	New South Wales
P(...)	Probability
QLD	Queensland
the Project	Bullawah Wind Farm Project
SEARs	Secretary's Environmental Assessment Requirements
VIC	Victoria
WTG	Wind Turbine Generator

1 Introduction

Bullawah Wind Farm Pty Ltd (BWF) proposes to develop the Bullawah Wind Farm (the Project), located approximately 36 km southeast of Hay, within the South West Renewable Energy Zone. The Project Area is located within the Hay Shire, Murrumbidgee and Edward River Local Government Areas (LGAs). The Project will include the installation, operation, maintenance and decommissioning of up to 143 wind turbine generators (WTGs), battery storage, ancillary infrastructure and temporary facilities associated with construction of the Project. The Project design incorporates up to 143 wind turbines, with a maximum blade-tip height of 300 m above ground level, and an installed capacity of up to 815.1 megawatts (MW).

Middleton Group Engineering (MGE) has been engaged by Umwelt (Australia) Pty Ltd (Umwelt) to prepare this Blade Throw Assessment for inclusion within the Environmental Impact Statement (EIS) for the Project.

2 Scope

2.1 SEARS Requirements

This study has been undertaken to address the blade throw risk element of the NSW Planning Secretary's Environmental Assessment Requirements (SEARs) for the Project (SSD-50505215), specifically, the following requirement: "*Blade Throw – assess blade throw risks.*"

This is done by estimating the risk of a blade striking a residence and the risk to human life associated with a blade failure event, based on likelihood of a human occupying space within the potential impact zone and the likelihood of blade failure.

This study supports the overall Environmental Impact Statement (EIS) for the Project that has been prepared to address all matters discussed in the SEARS for the Project.

2.2 Other Requirements

The NSW Government – Department of Planning and Environment (DPE, former) – Wind Energy Guideline for State significant wind energy development (the Wind Energy Guideline), dated December 2016, provides the community, industry, and regulators with guidance on the planning framework for the assessment of large-scale wind energy development proposals that are State Significant Development (SSD).

Section 3 of the Wind Energy Guideline provides a summary of assessment matters for wind energy developments. Page 7, point 7 lists "*blade throw: consider blade throw risks*" as a matter requiring assessment amongst other hazards and risks, and environmental matters more broadly. The Wind Energy Guideline does not provide guidance on an applicable methodology for blade throw assessment, and/or suitable thresholds of acceptability.

Whilst various international standards and guidelines exist, MGE is not aware of any other assessment requirements, to those documented in this report, that are applicable to the assessment of an NSW wind farm.

2.3 Inputs

This assessment is based on the details of Project and stakeholder infrastructure specified in Table 2 and Table 3.

Table 2 Study Inputs – Project Infrastructure

Project Detail	Value
Wind turbine coordinates	Wind turbine layout received from Umwelt.
Wind turbine dimensions	Tip Height: Up to 300 m Hub Height: Up to 200 m Turbine Blade Diameter: Up to 200 m

Table 3 Study Inputs – Stakeholder Infrastructure

Input	Source	Date Provided/Accessed
Dwellings coordinates	The Proponent	05.09.23

2.4 Assumptions

This study has been developed on the following basis:

- The study is desktop only. No site visit or on-site ground-truthing has been conducted.
- Blade throw return period:
  - The study assumes that the hours of operation to date of WTGs in Australia and the number of blade throw events reported are representative of the Project and that a return period can be extrapolated from these data.
  - It is assumed that blade throw events that have been reported are representative of all such events.
- Statistical independence:
  - It is assumed that the Project Area usage can be approximated as a simple occupancy likelihood while the likelihood of blade failure can also be described through a failure return period, and that the two (2) events are statistically independent.
  - Blade failure is likely to occur during severe weather events, while occupancy within the vicinity of the WTG is likely to be reduced during severe weather.
  - The assumption of statistical independence is a source of conservatism in the model.
- Australian data: analysis is confined to Australian data and Australian events.
- Representative WTG: analysis is based on a conservative representation of a WTG at the Project (refer to Section 6.3) , with representative road distances, dwellings and buildings located within the impact zones. This analysis assumes that the number of people and the rate of their occupancy in the vicinity of the representative WTG established for the Project (the BWF Representative WTG) has been over-estimated.

- Traffic volumes and site occupation: traffic volumes and site occupation specifications have been assumed based on consultation with the Proponent.

3 Background

3.1 Project Overview

Key features of the Project layout, nearby residences and public roads are shown in Figure 1.

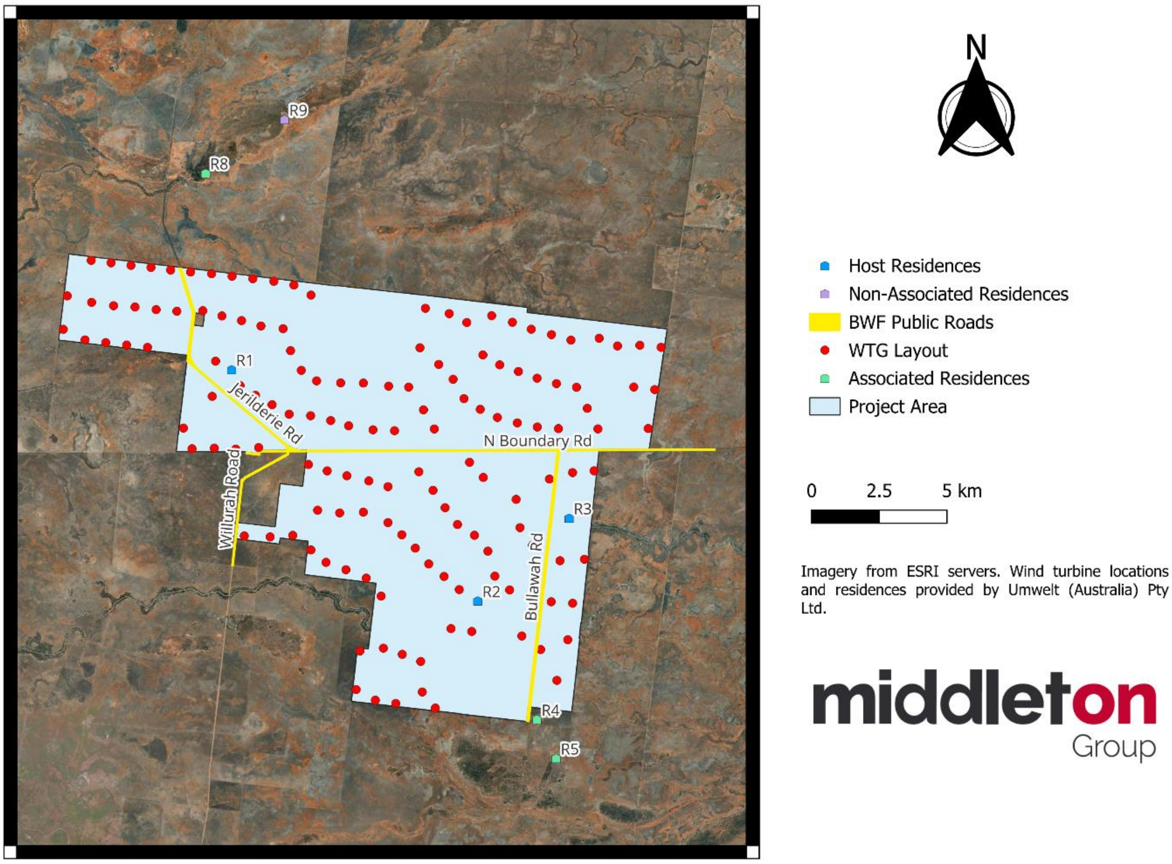

Figure 1: WTG layout overlaid with the Project Area, public roads and residences

The Project Area is predominantly grazing land with areas of native vegetation and creeks. The Project Area is zoned as RU1 Primary Production within the Hay Local Environment Plan (LEP) 2011, the Murrumbidgee LEP 2013 and Conargo LEP 2013. Accordingly, farmland (cropping and grazing) is considered in this assessment.

3.2 Defining Blade Throw

Blade throw is the instance where a WTG loses all or part of its blade. WTGs often suffer damage; however, this damage does not always result in blade throw. In their analysis, Branner and Ghadirian [2] identify four levels of blade damage:

0. Observation, no harm.
1. Damage to be repaired at an opportunity.
2. Damage must be repaired as soon as possible.
3. Serious damage, the turbine is stopped.

It is noted that blade defects, examples of which are described by Branner & Ghadirian [2] – whether by manufacturing defect or by wear and tear, are not included in this assessment. This assessment focusses on catastrophic failure of a blade – that is, where they fall under the level 3 subset of damage.

Blade defect and/or degradation events are relatively commonplace in wind farms around the world, with Branner and Ghadirian [2] identifying a mean outage per WTG due to blade or rotor issues between 9 and 62 hours per year, and a mean outage time per failure of between 0.9 hours and 17.2 days. Most of these events are dealt with in the course of the WTG's maintenance programme and pose no risk to human life. Even where serious damage occurs, WTG control systems will typically detect the failure and shutdown the WTG preventing a catastrophic failure, i.e., a blade throw event [3].

For the purposes of this study, blade throw is defined as a catastrophic blade failure, which is divided into two (2) types of events: blade drop and fragmentation.

- **Blade drop** – Blade drop is defined as where the whole blade or the majority of the blade detaches from the WTG's hub.
- **Blade fragmentation** – Fragmentation is defined as an event where a smaller blade fragment such as a blade tip or part of the shell detaches from the blade.

The distinction between these two (2) instances impacts the likelihood of blade throw as it is a determining factor of the distance thrown and the threat to human life.

Within Australia there have been five (5) instances of blade throw as seen in Table 4. The implications of these incidents on this study are further investigated in section 5.1.

Table 4: Blade throw instances within Australia.

Wind Farm	Date	Classification
Windy Hill Wind Farm (QLD)	July 2005	General Failure: Unsure – Assume fragmentation.
Wonthaggi Wind Farm (VIC)	March 2012	General Failure: Fragmentation.
Lal Lal Wind Farm (VIC)	September 2019	Lightning Failure: Blade drop.

Wind Farm	Date	Classification
Bald Hills Wind Farm (VIC)	June 2020	General Failure: Assume fragmentation.
Dundonnell Wind Farm (VIC)	October 2020	General Failure: Blade drop.

3.3 Causes of Blade Throw

Blade throw can occur for a vast variety of reasons. The age of the WTG is a contributing factor, as age leads to wear and increases the likelihood of damage. Additionally, extreme weather conditions such as lighting events, exceptionally high wind speeds and natural disasters can cause damage which results in blade throw. Other causes include:

- Fatigue failure – cracking of the turbine rotor or structure due to high levels of cyclical stress.
- Wind turbine overspeed – a mechanical failure resulting in the turbine rotor spinning out of control and breaking.
- Installation issues – turbine installation defects causing blade throw.
- Manufacturing issues – turbine manufacturing defects causing blade throw.

Not all these factors will result in a blade throw event. It is more likely that they will fall under levels 0 to 2 [1] of blade damage. The likelihood of these contributing factors occurring and leading to a blade throw event are considered within this Blade Throw Assessment.

4 Methodology

To assess the risk associated with blade throw, this methodology considers both the risk of fatality by blade throw to people occupying the surrounding land, and the risk to nearby dwellings. The following high-level methodology is applied:

1. Assess the likelihood of blade failure based on Australian WTG operational statistics.
2. Identify the radii of impact, and the likelihood of impact within those respective radii.
3. Determine the likelihood of occupation by examining the average land usages surrounding each turbine for the BWF Representative WTG.
4. Determine the probability of the residence(s) within the radius of a WTG being struck by a blade thrown from that WTG.
5. Obtain the probability of fatality due to blade failure for the BWF Representative WTG. This considers project layout specifics such as number and location of residences and public roads.
6. Find the overall probability of fatality due to blade failure by multiplication of the probability for the BWF Representative WTG by the total number of WTGs proposed for the Project.
7. Assess probability of fatality and probability of impact to the residences(s) against broadly accepted risk criteria.

General methodologies for the Blade Throw Assessment are provided in section 4.1 to 4.3 below, and additional information relating to blade throw parameters and probability inputs are provided in section 5 and section 6 respectively.

4.1 Probability Equation

The probability of a fatality P(fatality) is described in the following equation:

$$
\begin{aligned}
P(fatality) = {} & P(Blade\ Drop) \times P(Blade\ Drop\ on\ Particular\ Location) \\
& \times P(Blade\ Drop\ Area\ Inhabited) \\
& + P(Fragmentation) \times P(Fragmentation\ reaching\ Particular\ Location) \\
& \times P(Fragmentation\ Area\ Inhabited)
\end{aligned}
$$

This equation is a mathematical representation of MGE's methodology established by MGE to assess the likelihood of blade throw. The parameters and probability values are established in section 5 and section 6 respectively using relevant texts and sources.

The probability of residence impact uses the same equation but negates the likelihood that the area is inhabited. This equation also assumes that all impact to an individual will result in a fatality. Based on the above, it is possible to assess whether both the likelihood of fatality and risk to residents falls within accepted community standards. Section 6 expands on the calculation methodology for each of the inputs of the equations.

4.2 Determining Probability Values

Various approaches have been employed to assess the risk associated with WTG blade throw around the world, based on a mix of empirical and kinematic models (e.g. [4, 5, 6, 7]). The methodology used here has been developed using data from these various models.

The methodology to identify the inputs to the *P(fatality)* equation for the BWF representative WTG considers the following four (4) factors:

- Likelihood of blade failure.
- Area of impact in the case of blade failure.
- Likelihood of the impact area being occupied.
- Likelihood of person within the impact area to be hit by blade fragment.

Likelihood of Blade Failure is developed by the following steps:

- Identify the number of operating years of WTGs in Australia.
- Identify and classify the number of blade failures in Australia.
    - Classification is based on whether blade drop is observed or whether there is fragmentation.

Impact Area is found by identifying the radii of impact for blade fragmentation and blade drop based on the kinematic and empirical models.

Likelihood that the Impact Area is Occupied is developed through conservative estimates of farming practices, traffic data, dwelling, and shed occupancy rates, and wind farm maintenance practice.

Likelihood that a person within the Impact Area is hit is found by combination of:

- For an area within 150 m to 300 m of the WTG (based on Rogers et al.'s kinematic model [6]), this is taken as the likelihood of blade drop plus the likelihood of blade fragmentation.
- For an area within 400 m to 800 m of the WTG (based on Rogers et al.'s kinematic model [6]), this is taken as the likelihood of blade fragmentation.

4.3 Risk Assessment Criterion

Risk is assessed as a combination of likelihood and consequence. Where a hazard has fatal consequences, such as WTG blade throw, the likelihood must be extremely low for the residual risk to be considered acceptable.

The British Health & Safety Executive identify that the boundary between "broadly acceptable" and "tolerable" risks is generally taken as a one (1) in 1 million years fatality. The boundary between "tolerable" and "unacceptable" is generally taken for the public at large as a one (1) in 10,000 years fatality [1], on the proviso that there is a broader benefit to society in accepting this higher risk.

Similarly, the NSW Department of Planning, Housing and Infrastructure (DPHI), in their Hazardous Industry Planning Advisory Paper No 4 (HIPAP4 [8]), set similar return periods for fatalities: a 2-million-year return period for hospitals, schools, child-care facilities, old age housing; residential premises and places of continuous occupancy should have return periods greater than 1 million years. For industrial facilities, the return period should be greater than 20,000 years. These values assist in providing appropriate benchmarking, summarised in Table 5.

Due to the remote nature of the Project's location, the only relevant risk criterion for the Project is the 1-million-year return period for residential areas. This risk criterion has been applied to the assessment at scattered rural dwellings within the Project Area and it surrounds.

Table 5: NSW risk fatality risk criterion [8]

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

5 Blade Throw Parameters

The probability of a fatality due to blade throw is modelled by assessing the likelihood that part of the blade will be thrown and the likelihood that a person will be within the impact area. The following sections provide a basis for the blade throw frequency and impact radii modelled by MGE.

5.1 Domestic Blade Throw Frequency

To gain perspective of the severity of the risk it is important to quantify the frequency of blade throw within Australia. Blade failure is inclusive of all blade damage resulting in failure with the most catastrophic of these being blade throw. Blade failures are generally not publicised by wind farm owners and WTG manufacturers; however, catastrophic failures such as blade throw events are mostly reported in the media, as WTGs tend to be prominently placed in the landscape.

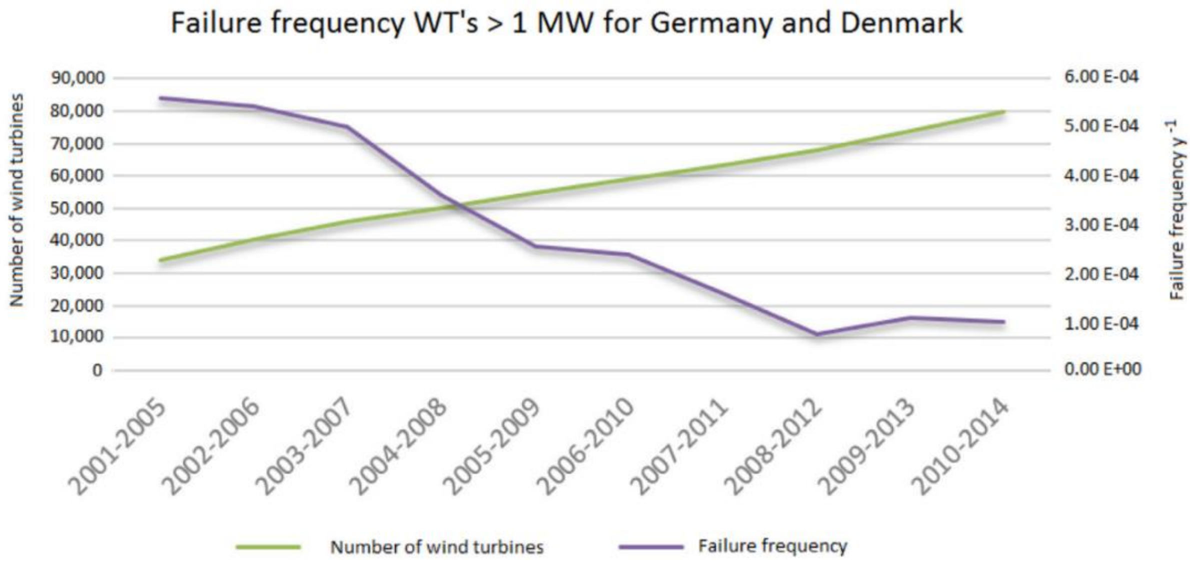

Figure 2: Estimated failure frequencies of wind turbines of 1MW and above based on Germany and Denmark statistics. [10]

Research by Brouwer et al. [9] demonstrates that blade failure events have tended to reduce over time despite the rapid increase in the number of WTGs, as shown in Figure 2. This is owing to “improvements in wind turbine safety over time” [9]. This report explicitly references Australian statistics to ensure that the findings are not influenced by early European data. As Australia was slow to adopt wind farms compared to many European countries, using Australian statistics will prevent MGE’s analysis from being skewed by early European installations.

Five (5) catastrophic blade failures have been identified in Australia and are assumed to represent blade throw events. These are described and classified in

Table 6. It is noted that there is very little detail on the incidents in the public domain. Thus, details such as root cause analyses, projectile/debris scatter zones, and failure modes are not available. However, there are some broad data to suggest that manufacturing defects and lightning are two (2) key causes of failure. There have been no injuries or fatalities associated with these events.

Of the failure events identified in Table 6, two (2) failures are described as "blade drop", while the remaining three (3) events are classified as "fragmentation".

MGE are aware that there have been several other catastrophic WTG failures not listed in Table 6, for example the Alinta Wind Farm turbine collapse in 2022. However, these failures did not constitute blade throw, and are not considered within the scope of the current study.

For the purposes of this study, it is assumed that each of the events had the potential to be a life-threatening event. It is noted that in the case of the Wonthaggi Wind Farm blade failure event, reports describe debris, in the form of foam packing, being strewn across fields in the vicinity of the affected WTG. While details are scant, at face value the impact potential (that is, the potential to cause death or serious injury) from foam packing appears to be less than for fragments of a blade shell. The implications of this data on the inputs to the study are further discussed in section 6.1.

Table 6: Blade Failures in Australia

Event	Date	Description	Classification	Source
Windy Hill Wind Farm (QLD)	July 2005	Blade "sheared off" from wind turbine.	General Failure: Unsure – Assume fragmentation.	Herald Sun, 29 July 2005.
Wonthaggi Wind Farm (VIC)	March 2012	Blade cracked. Fibreglass delaminated. Blade fill strewn around vicinity of WTG.	General Failure: Fragmentation.	Wonthaggi Wind Farm – Wikipedia Various media reports.
Lal Lal Wind Farm (VIC)	September 2019	Blade broke and fell to the ground. Prior to incident, there was severe weather including lightning.	Lightning Failure: Blade drop.	Lal Lal Wind Farms Press Release: 23 September 2019
Bald Hills Wind Farm (VIC)	June 2020	No reliable details on cause.	General Failure: Assume fragmentation.	Turbine Trouble For Bald Hills Wind Farm – South Gippsland Sentinel-Times
Dundonnell Wind Farm (VIC)	October 2020	A single blade separated from the hub of a turbine and fell to the ground soon after mechanical completion.	General Failure: Blade drop.	Tilt Press Release: 6 October 2020 Dundonnell Wind Farm stops production after blade falls off turbine (wpengine.com)

5.2 Blade Throw Impact Radius

Two (2) maximum impact radii are considered – a 300 m radius to account for blade drop events and an 800 m radius to account for fragmentation. The basis of these values is found in sections 5.2.1 and 5.2.2.

5.2.1 Calculation of Impact Radii – Blade Drop

The values used for MGE's study are based on the Rogers et al [6] simplified point-mass blade fragment model for maximum throwing distance that assumes a flat surface. The maximum blade throwing distance *D* is a function of tip velocity v_T, the sine and cosine of the launch angle θ_T, denoted as $s_{\theta T}$ and $c_{\theta T}$, gravitational acceleration, *g*, the hub height, *h*, and the rotor radius, *R*.

Thus, the maximum blade throwing distance is given as:

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

The frame of reference is provided in Figure 3 and results are plotted in Figure 4.

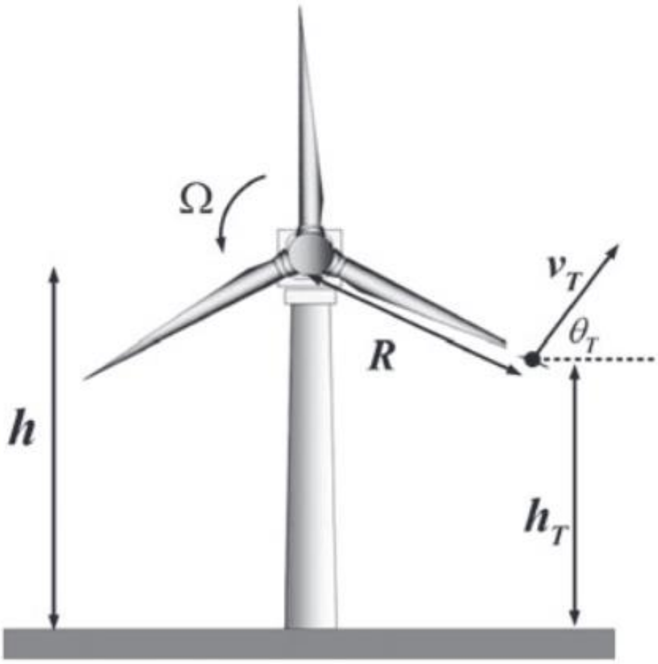

Figure 3: Frame of reference. Diagram from Rogers et al. [6].

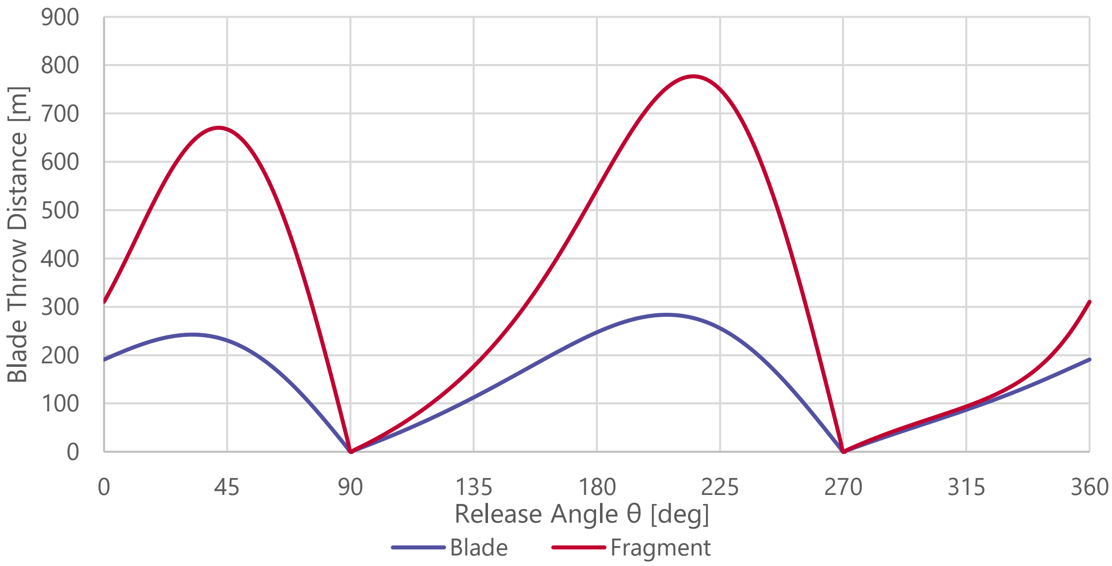

Figure 4: Maximum blade throw distance based on Rogers et al.'s kinematic model assuming a 75 m/s release velocity for the fragment, a 170 m hub height and a 172 m rotor. The blade scenario is based on a 37.5 m/s release velocity and the effective radius being halfway along the blade.

Various sources provide a wide range of impact radii. For example, Braam & Rademakers [10] provide a commentary on the Dutch "Handbook Risk Assessment of Wind Turbines", which assessed 200 severe incidents that occurred over 43,000 WTG years in Germany, Denmark and Holland until 2002 with WTGs having nameplate capacities ranging between 500 kW and 2 MW. Of those 200 incidents, 62 were relevant to the assessment of safety for nearby objects. Based on this data, the handbook identified "*maximum throwing distances of a blade during overspeed*" varying between 300 m and 400 m. Interestingly, the kinematic model developed by Rogers et al. [6] highlights that "*maximum throwing distance*" is most dependent on the tip speed, rather than on the size of the WTG, suggesting that older studies such as Braam & Rademakers' [10] empirical assessment may have some level of applicability for much larger WTGs.

Alternatively, Persimia conducted Monte Carlo simulations using a WTG with rotor diameter of 158 m. The maximum simulated blade fragment throw distance was less than 475 m [7].

While the empirical data is useful for validating the empirical models, there is simply insufficient empirical blade throw data on which to base a blade throw assessment. As such it would seem prudent to base modelling on Monte Carlo simulations.

Further, there is some conjecture regarding whether it is more or less conservative to model a larger area. In assuming a larger potential area of impact, the likelihood of impacting a person within that area of impact is reduced, assuming a homogenous distribution. However, by assuming a larger potentially impacted area, a greater number of people may be impacted. As such the conservatism is entirely dependent on the specific scenario modelled.

For the blade drop analysis, the impact area around a WTG is divided into two regions – a 50 m radius, and an outer area with radius of 300 m. It is assumed that while the level of human activity within these two areas differs, the likelihood of a blade dropping in a particular location within that 300 m radius is homogenous across the area. However, it is noted that in reality the dominant wind direction and the prevalence of extreme wind gusts would likely invalidate the homogeneity assumption.

Table 7 summarises the characterisation of the blade drop impact area, including radius limits, the probability of blade drop within that radius and area size in m^2.

Table 7: Characterisation of blade drop impact area.

Area	Radius Limits [m]	Distance weighting: Probability of Blade Drop within Area	Area in square metres [m2]
1	0 – 50	2.8%	7,854
2	50 – 300	97.2%	274,890

5.2.2 Calculation of Impact Radii – Blade Fragmentation

The characterisation of the likelihood of a blade fragment landing in a particular location is assessed based on a Monte Carlo simulation. Persimia [7], in their blade throw assessment for the Grove Park Wind Farm, used a Monte Carlo simulation to derive a probability density function, with the likelihood of a blade landing in a specific location generally decreasing as that location is farther from the WTG [7]. GE's Cypress platform with a 158 m rotor diameter was used as the candidate WTG; the result is shown in Figure 5. This study provides a helpful reference point as it is a recent-model utility-scale WTG.

Figure 5, using 12.5 m distance bins, shows that within 50 m of a WTG, the likelihood of impact is approximately 75% higher for the 50 m to 200 m range. Beyond 200 m there is a steady decline in likelihood of impact.

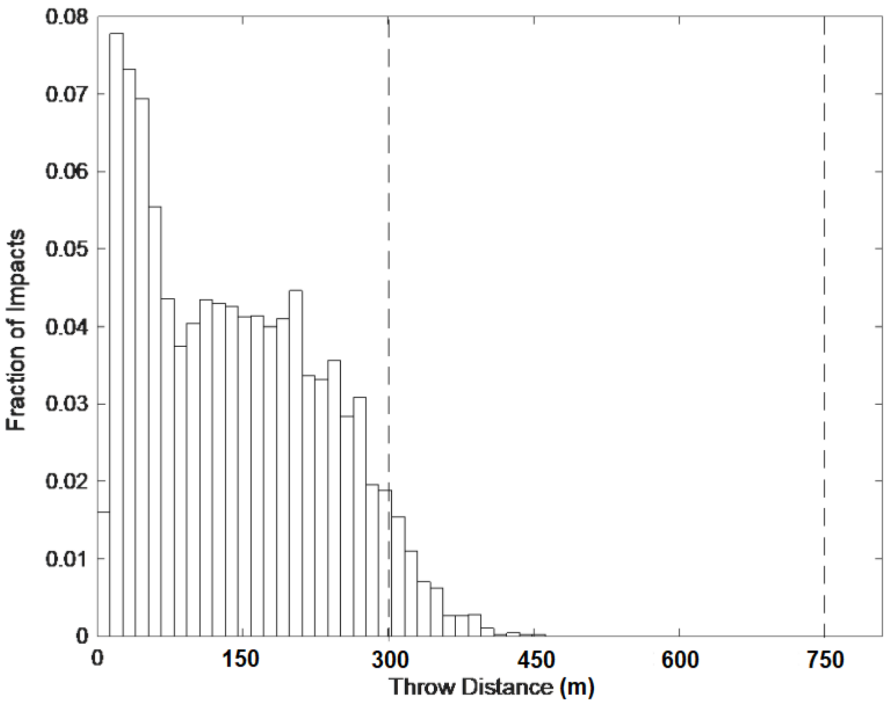

Figure 5: Histogram of blade fragment throw distance based on Monte Carlo simulations [4]. Throw distances converted from feet to metres.

Based on Figure 5, the impact area is broken up into four (4) concentric circles and the respective likelihood of occurrence, as described in Table 8 for the blade fragment analysis, and Table 7 for the blade drop analysis, to give distance weightings. Examples of the concentric circles are shown in Figure 6. Table 8 is derived from the work of Persimia [7], with some minor deviation to reflect the up to 800 m extent of the impact zone.

Table 8: Characterisation of blade fragmentation impact area.

Area	Radius Limits [m]	Distance weighting: Probability of Fragment within Area	Area [m2]
1	0 – 50	25%	7,854
2	50 – 275	65%	229,729
3	275 – 400	9.9%	265,072
4	400 – 800	0.1%	1,507,964

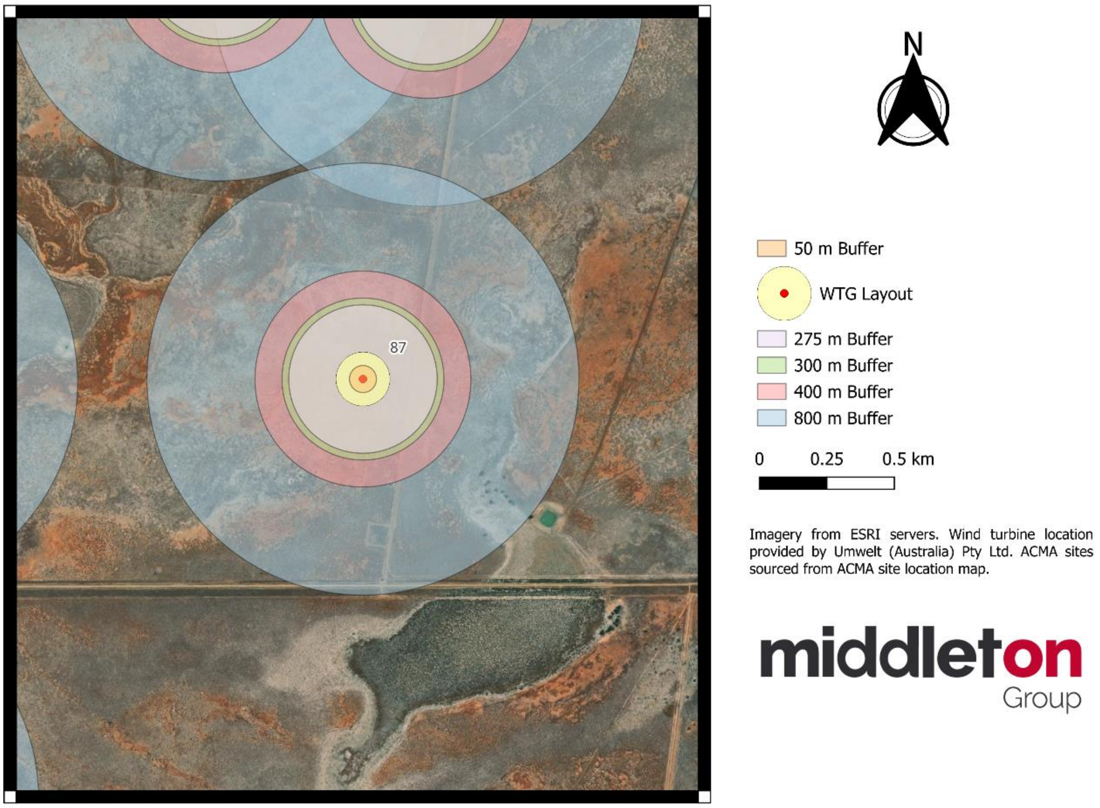

Figure 6: Concentric circles around turbines.

6 Probability Inputs

6.1 Likelihood of Blade Throw

As tabulated in Appendix A, the 4,183 WTGs in Australia have accumulated more than 40,126 years of operation since 1987 to 2024. Each year these number increase with a 4,000 additional years of WTG operation in Australia as well as any newly installed wind farms.

Based on the two (2) blade drop events across approximately 40,126 years of WTG operation, the return period for a catastrophic failure event resulting in fragmentation is 20,000 years of operation, or 0.000,050 year^{-1}. For application in the probability of fatality equation in section 4.1, the probability of blade drop or **P(Blade Drop) is 1 in 20,063 years.**

Similarly, based on the three (3) fragmentation events, the return period for a catastrophic failure event resulting in blade drop is 13,000 years of operation, or 0.000,075 year^{-1}. For application in the probability of fatality equation in section 4.1, the probability of fragmentation or **P(Fragmentation) is 1 in 13,375 years.**

6.2 Land Uses and Occupancy Rates

The likelihood of a person being within the impact radius of a wind turbine blade drop or blade fragmentation is estimated by assessing the usage of land in the Project Area.

The area around WTGs is divided between various categories of how the land is used. A significant portion of the land is used for farming, while smaller portions are occupied by buildings, roads and vegetation.

The land use categories within the Project Area are tabulated in Table 9. This table also shows the assumed occupancy rate used for the P(fatality) calculation, in section 0, for any given location within that land area category. When calculating the risk to residences specifically, in section 7.1, MGE ignores occupancy, assessing the risk to the structure not the residents.

It is noted that this assessment focusses on host residences (i.e. R1 to R3, which are located within the Project Area) as the nearest residence outside the Project Area (R4) is located approximately 1.5 km from the nearest WTG and is therefore outside the impact radii for both blade drop and blade fragmentation.

Table 9: Land use categories and occupancy rate assumptions

Category	Occupancy Rate Assumption
Farmland – cropping and grazing	Ploughing/seeding/spraying/harvesting: assume coverage of area six times per year, at a rate of 20 km/h, at a width of five (5) m. By default, all land is assumed to be farmland unless otherwise assigned.
Road – public	100 cars per day driving at 100 km/h.
Road – internal	Four (4) cars per day driving at 40 km/h.

Category	Occupancy Rate Assumption
Native Vegetation, creeks, rivers and dams.	Minimal human interaction
Wind farm maintenance	Eight (8) hours per day for two (2) working weeks (ten (10) days) for four (4) people.
Host residences	Three (3) people per residence for 16 hours per day each.

6.3 Representative Wind Turbine Values

The Project Area is predominantly grazing land with some areas of native vegetation and creeks. Additionally, there are several roads running through the Project Area. By utilising GIS modelling, MGE found the area occupied by each land use within the impact radii of each turbine. Using these values, MGE established a representative WTG for the Project to analyse. The following sections present the input values calculated for the representative WTG established for the Project (BWF Representative WTG). The land use at the BWF Representative WTG established for the Project is tabulated in Table 12. The total area of each sector is derived from Table 8.

It is not practical, for the purpose of this study, to exactly measure the area of land use for each category for each WTG. Conservative assumptions for land use are applied for the BWF Representative WTG, and then scaled to the entire wind farm, as presented in Section 7.

6.3.1 Roads

Internal road describes access roads within the Project Area which connect WTGs and may be used by farm personnel to traverse their land, or operational personnel to access the wind farm. Each WTG has an internal road. Reference to internal road also refers to unnamed roads within 1 km of WTGs. Internal roads are assumed to be of 5 m width. Internal road length within each impact area sector is shown in Table 10.

Table 10: Length of internal road in Impact Areas for BWF Representative WTG

Impact area sector	Internal road length [m]	Calculation Method
800 m	1,500	800 m of access road plus 700 m of internal farm roads
400 m	270	250 m of access road plus 20 m of internal farm roads
300 m	510	480 m of access road plus 30 m of internal farm roads
275 m	470	450 m of access road plus 20 m of internal farm roads
50 m	100	100 m of access road

Four (4) public roads are in the vicinity of the Project:

- North Boundary Road: 11 WTGs (120, 110, 99, 89, 88, 87, 84, 75, 49, 48, 47) within 800 m.
- Bullewah Road:
  - Six (6) WTGs (132, 119, 116, 115, 107) within 800 m.
  - Four (4) WTGs (133, 118, 108) within 400 m.
- Jerilderie Road – within 800 m of WTGs 50, 25, 18 and 5:
  - Six (6) WTGs (55, 42, 41, 40, 39, 11) within 800 m.
  - Four (4) WTGs (50, 25, 18, 5) within 400 m.
- Willurah Road:
  - One (1) WTG (55) within 800 m.
  - One (1) WTG (122) within 400 m.

Public roads are assumed to be of 20 m width. While the actual carriageway width is between 5.5 and 6 m this is a conservative value which accounts for the areas on the sides of the roads. The input summary is provided in Table 11 and a Project overview of blade throw radii and public roads is provided in Figure 7.

Table 11: Length of public road in Impact Areas for BWF Representative WTG

Impact area	Public road length [m]	Calculation Method
800 m	179	32 of 143 WTGs have 1 public road with the maximum length 1790 m
400 m	70	9 of 143 WTGs have 1 public road with the maximum length 701.393 m
300 m	40	2 of 143 WTGs have 1 public road with the maximum length 400 m.
275 m	38	2 of 143 WTGs have 1 public road with the maximum length 375 m.
50 m	0	No public roads within 50 m of any WTGs

Figure 7: Public Roads within impact radius.

6.3.2 Farming and Natural Environments

Native vegetation, creeks, dams take up maximum approximately 6% of the 400 m and 800 m impact area sectors.

Farming is the land use allocated to the remaining land not used by roads or vegetation.

Table 12: Representative WTG surrounding land use area.

Impact area sector	Area of sector [m2]	Internal road [m]	Public road [m]	Native vegetation, creeks, dams [m2]	Farmland [m2]
800 m	1,507,964	1,500	179	90,480	1,415,805
400 m	265,072	2,702	70	15,900	246,400
300 m	274889	510	40	0	271,539
275 m	229,729	470	38	0	229,221
50 m	7,854	100	0	0	7,354

6.3.3 Residences

One host residence (R1) is located within 800 m of both WTG 37 and WTG 38, as seen in Figure 8. This will be modelled as approximately 1/70th of a residence within 800m of a WTG. No residences are located within the blade drop radius of the WTGs. The specific risk of strike to this residence will be assessed separately in accordance with the NSW risk fatality risk criterion in section 7.1.

Table 13: Residences in vicinity of WTGs.

Impact area sector	WTGs with host residences in sector
800 m	0.014
400 m	0
300 m	0
275 m	0
50 m	0

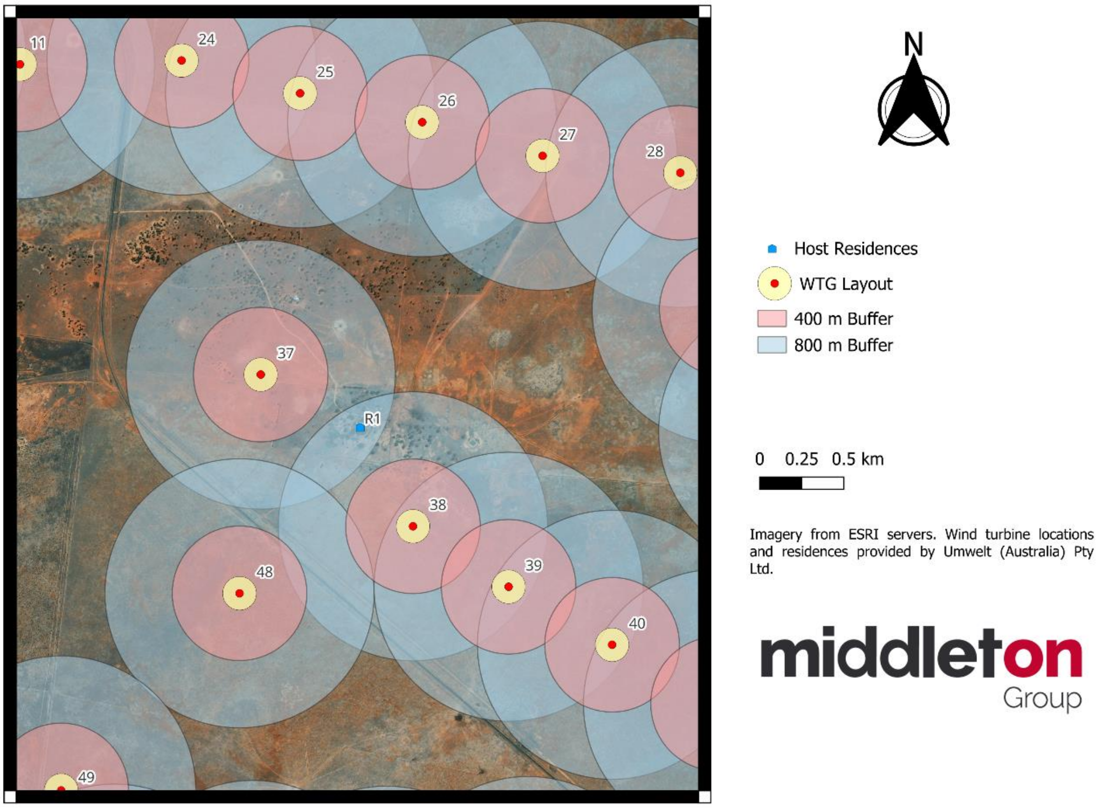

Figure 8: Host Residence R1 within turbine radius

6.3.4 Summary of Land Use Occupation Hours for Representative WTG

The assumed occupancy around the BWF Representative WTG is tabulated in Table 14 for the blade fragmentation case, with the equivalent analysis for the blade drop case shown in Table 15.

Table 14: Land use categories and assumed occupation rates for the BWF Representative WTG – for analysis of blade fragmentation.

Category	Occupancy details	Hours of occupation per year			
		800 m	400 m	275 m	50 m
Farmland – cropping and grazing	Ploughing/seeding/spraying/harvesting: assume coverage of area six times per year, at a rate of 20 km/h, at a width of 5 m.	84.4	14.8	13.6	0.4
Road – public	100 cars per day driving at 100 km/h.	108.9	42.6	23.1	0
Road – internal	Four (4) cars per day driving at 40 km/h.	54.8	9.9	17.2	3.7
Native Vegetation, creeks, rivers and dams	Minimal human interaction,	0	0	0	0
Wind farm maintenance	Eight (8) hours per day for two (2) working weeks (ten (10) days) for four (4) people.	0	0	0	320
Host residences	16 hours per day for three (3) people.	243.3	0	0	0
TOTAL		491.4 h	67.3 h	53.9 h	324.1 h

Table 15: Land use categories and assumed occupation rates for the BWF Representative WTG – for analysis of blade drop.

Category	Occupancy details	Hours of occupation per year	
		300 m	50 m
Farmland – cropping and grazing	Ploughing/seeding/spraying/harvesting: assume coverage of area six times per year, at a rate of 20 km/h, at a width of 5 m. By default, all land is assumed to be farmland unless otherwise assigned.	16.3	0.4
Road – public	100 cars per day driving at 100 km/h.	25.2	0
Road – internal	Four (4) cars per day driving at 40 km/h.	18.7	3.7
Native Vegetation, creeks, rivers, and dams.	Minimal human interaction.	0	0

Category	Occupancy details	Hours of occupation per year	
		300 m	50 m
Wind farm maintenance	Eight (8) hours per day for two (2) working weeks (ten (10) days) for four (4) people.	0	320
Host residences	16 hours per day for three (3) people.	0	0
TOTAL		60.2 h	324.1 h

6.4 Assumed Area Occupied

The area footprint of a person within the impact radius is assumed to be reflective of both the size of the person, and the potential landing area of debris should it pass through a person.

This area varies as a function of both the size and location of the person, the size of the blade or blade fragment, and the trajectory of the projectile. As a conservative measure, it is assumed that a person inhabiting the impact radius is 1 m wide, and that, due to the projectile's trajectory, a potential landing area of 3 m in length would impact on the occupant, as illustrated in Figure 9. Thus, an impact area of 3 m^2 is assumed.

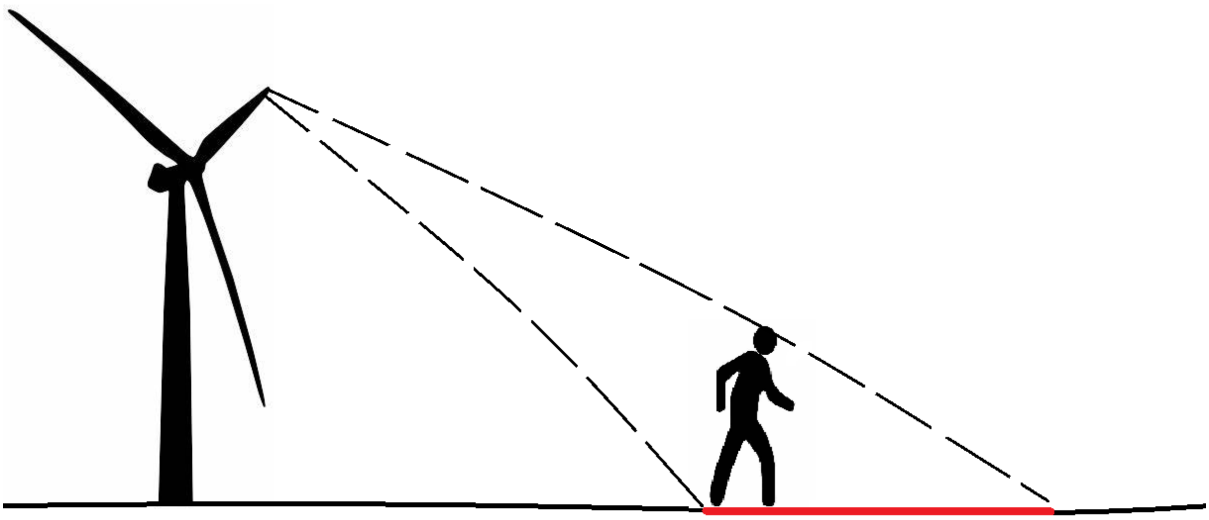

Figure 9: Illustration of potential landing area. The landing area is assumed to be longer than the occupant is tall.

Additionally, for the purposes of the host residence risk assessment, the assumed area occupied by R1 is 1000m^2. This is a conservative approximation based on measurements of the host residences occupied structure (a dwelling) size taken using satellite imagery.

7 Results

The probability of blade failure, P(drop) and P(fragment) is presented in Table 16. The probability is represented in the form of a decimal ranging from 0 to 1, where 0 is impossible (i.e. no probability of ever occurring) and 1 is certain (i.e. will occur). The return period represents the estimated period of time between blade failure events in years.

Land use in the vicinity of the BWF Representative WTG is presented in Table 12, which is based on aerial imagery of the site, and conservative estimates of traffic volumes and speed. The number of WTGs with associated residences located within impact areas is shown in Table 13.

The numbers found in sections 7.1 and 0 will be assessed in accordance with the NSW risk fatality risk criterion as outlined in Table 5 in section 4.3.

Table 16: Blade Failure Probability

	Fragmentation	Blade Drop
Probability [years-1]	0.0000748	0.0000498
Return Period [years]	13,380	20,060

7.1 Risk to Residences

Six (6) residences are situated within 5 km of the proposed WTGs, including three (3) host residences (R1, R2 and R3) and three (3) associated residences (R4, R5 and R8). Based on the analysis conducted in section 6.3.3 it is reasonable to assume that all residences outside of the 5 km radius will be safe from any potential blade throw instances. In Table 17 the distance between these residences (R1 to R5, and R8) and the nearest WTGs are recorded to assess the risk of possible blade throw.

Table 17: Risk to Residences

Residence ID	Closest Turbine ID	Distance From Nearest Turbine	Is the residence within impact radius
R1	38	587 m	Blade Drop: No Blade Fragmentation: Yes
R2	96	802 m	Blade Drop: No Blade Fragmentation: No
R3	115	1590 m	Blade Drop: No Blade Fragmentation: No
R4	134	1619 m	Blade Drop: No Blade Fragmentation: No
R5	134	2881 m	Blade Drop: No Blade Fragmentation: No
R8	17	3692 m	Blade Drop: No Blade Fragmentation: No

As it can be seen in Table 17 that one (1) host residence (R1) is situated within the blade fragmentation impact zone of two (2) WTGs. Looking at the risk specifically to R1, Table 18 summarises the probability of impact by blade fragmentation to this residence.

Table 18: Residence Impact Probability (R1)

	Probability [years-1]	Return Period (years)
Single WTG	0.000000000000149	6,723,000,000,000
Both WTGs	0.000000000000298	3,362,000,000,000

Based on the available data, it is estimated that there is a worst-case (both WTG) 3.4-trillion-year return period for a blade failure impacting R1. The likelihood of such an event occurring is extremely low and the level of risk is well within the bounds of being considered broadly acceptable. Thus, the proposed WTGs are appropriately located to comply with NSW risk fatality criterion for residential uses.

7.2 Risk of fatality

Table 19 summarises the probability of fatality found by MGE. The data is aggregated in Table 20 to represent blade fragmentation scenarios and in Table 21 to represent blade drop scenarios. The probability of these two scenarios is then summed to provide a final estimate of the probability of a fatal blade throw incident, and the corresponding return period.

Table 19: Blade Failure Probability

	Fragmentation	Blade Drop	Combined
P(fatality, single WTG) **[$years^{-1}$]**	2.687E-10	1.797E-10	4.484E-10
P(fatality, Project) **[$years^{-1}$]**	3.869E-08	2.588E-08	6.457E-08
Return Period Project [years]	38,640,000	25,850,000	15,490,000

Table 20: Occupancy by sector and calculation of return period for fragmentation events.

Impact Area Sector	Hours of occupancy	% Time occupied	Occupier footprint/ Sector Area	Distance weighting	P(Location)	P(fatality) = % Time occupied × P(Location) × P(Blade Fragmentation)
800 m	491.33	5.61%	1.99E-06	0.10%	1.99E-09	8.34E-15
400 m	67.22	0.77%	1.13E-05	9.90%	1.12E-06	6.43E-13
275 m	53.87	0.61%	1.31E-05	65%	8.49E-06	3.90E-12
50 m	324.09	3.70%	3.82E-04	25%	9.55E-05	2.64E-10
			P(fatality, fragmentation, single WTG) [years^{-1}]			2.69E-10
			P(fatality, fragmentation, Project) [years^{-1}]			3.87E-08
			Return Period Project [years]			25,850,000

Table 21: Occupancy by sector and calculation of return period for blade drop events.

Impact Area Sector	Hours of occupancy	% Time occupied	Occupier footprint/ Sector Area	Distance weighting	P(Location)	P(fatality) = % Time occupied × P(Location) × P(Blade Fragmentation)
300 m	60.13	0.69%	1.09E-05	97%	1.06E-05	3.63E-12
50 m	324.09	3.70%	3.82E-04	3%	9.55E-05	1.76E-10
			P(fatality, blade drop, single WTG) [years^{-1}]			1.80E-10
			P(fatality, blade drop, Project) [years^{-1}]			2.59E-08
			Return Period Project [years]			38,640,000

7.3 Cumulative Impacts

NSW Government – EnergyCo seeks to maximise opportunities created by the transformation of the NSW electricity system by coordinating investment in Renewable Energy Zones (REZs) across NSW. A REZ is the equivalent of modern-day power stations, combing new renewable energy infrastructure, including generators (such as solar and wind farms), storage (such as batteries and pumped hydro) and then high-voltage transmission infrastructure. Five (5) dedicated REZs have already been identified in NSW.

The Project is located wholly within the South West REZ.

Because of this, and the REZ benefits anticipated by NSW Government – EnergyCo, the South West REZ has the potential to see strong interest for renewable energy development.

Based on information available within the public domain, specifically the NSW Government – Major Projects website, the following wind farm developments are identified in the vicinity of the Project:

- Pottinger Wind Farm (SSD-59235464)
- Conargo Wind Farm (SSD-70611708)
- Booroorban (Saltbush) Wind Farm (SSD-70636459)
- Dinawan Wind Farm (SSD-50725708)
- Argoon Wind Farm (SSD-64935522)
- Yanco Delta Wind Farm (SSD-41743746)
- The Plains Wind Farm (SSD-50629707)
- Tchelery Wind Farm (SSD-59701722).

Based on the proximity of the above-mentioned developments to the Project, and the limited potential for interactions to occur with respect to blade throw, cumulative impacts are considered highly unlikely to occur (i.e., blade throw risks are not likely to be increased due to any other proposed wind farm project)..

It is noted that other developments are situated in the vicinity of the Project and are considered as part of the broader EIS e.g. SSD solar farm developments, but these projects to not include any potential blade throw risk and hence are excluded from the list above.

It is noted that because of the development activity in the South West REZ the above list may not address all potential sites being privately developed and not yet in the public domain. Information pertaining to any developments not yet in the public domain is therefore unavailable and excluded for this study.

8 Mitigation Measures

The Project design has avoided, minimised and mitigated risks and impacts associated with blade throw i.e. an instance where a WTG loses all or part of its blade. Accordingly, there are no project-specific recommendations required or provided by MGE, as relevant to the Project assessed in this study.

To safeguard against potential equipment selection, installation and maintenance issues, the following conceptual management measure options should be considered:

- Ensure all WTG are manufactured and certified to achieve relevant Australian and international safety standards (IEC 61400-23).
- Ensure all WTG are equipped with suitable measurement instrumentation that can detect and then respond to any rotor blade imbalances and shut down WTG if required.
- Ensure all WTGs will be suitably managed and maintained according to industry best-practice standards and are subject to a regular and comprehensive maintenance and servicing regime.

To safeguard against potential future impacts, identified as a result of any design changes, the following conceptual avoidance, minimisation and/or mitigation options may be considered:

- Modify the design to either relocate and/or remove wind turbines to avoid, minimise and/or mitigate any blade throw issues, risks and impacts.
- Confirm during detailed design that any change in probability of fatality, and blade fragmentation and blade drop risk at R1, as a result of any relevant design modification (i.e. relocation of WTG near R1) results in a risk and associated impact being maintained within suitable thresholds of acceptability.

Where these options require future investigation, any interaction and/or cumulative impact as a result of the developments listed in section 7.1 (or any additional developments that have entered the public domain since) should be considered.

No further recommendations and/or safeguards are provided in this report.

9 Conclusion

This study provides an estimate of the risk to human life associated with a blade failure event, based on likelihood of a human occupying space within the potential impact zone at the time of blade failure.

It is noted that the distance between the nearest non-associated residence and a proposed WTG location is well in excess of 800 m. The various models and empirical data examined demonstrate that the risk associated with blade drop for these residences is negligible as they are beyond the potential impact area. However, one (1) host residence (R1) is located within 800 m of two (2) turbines, suggesting there is a possibility of risk to this residence from blade fragmentation.

Based on the available data, it is estimated that there is a 15.5-million-year return period for a blade failure causing a fatality. Thus, the likelihood of such an event occurring is very low and the level of risk is well within the bounds of being considered broadly acceptable. NSW DPHI's HIPAP4 document [8] provides suitable thresholds of acceptability; these thresholds are shown in Table 22.

The low likelihood of adverse outcome is due to the low incidence of blade failure and low rates of occupation in the vicinity of any of the WTGs.

Table 22: HIPAP4 risk thresholds [8] alongside the calculated return period for the Project for a fatality due to blade throw.

Land Use or Activity	Acceptable Risk/Return Period
Risk to host residence (R1)	3.4-trillion-year return period
Blade failure event	15.5-million-year return period
Hospitals, schools, child-care facilities, old age housing	2 million years
Residential, hotels, motels, tourist resorts	1 million years
Probability of dying in a plane	205,552 years
Commercial developments including retail centres, offices and entertainment centres	200,000 years
Sporting complexes and active open space	100,000 years
Industrial	20,000 years
Probability of being struck by lightning	12,000 years
Probability of fatality from car crash	102 years

10 References

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Appendix A Wind Turbine Years of Operation

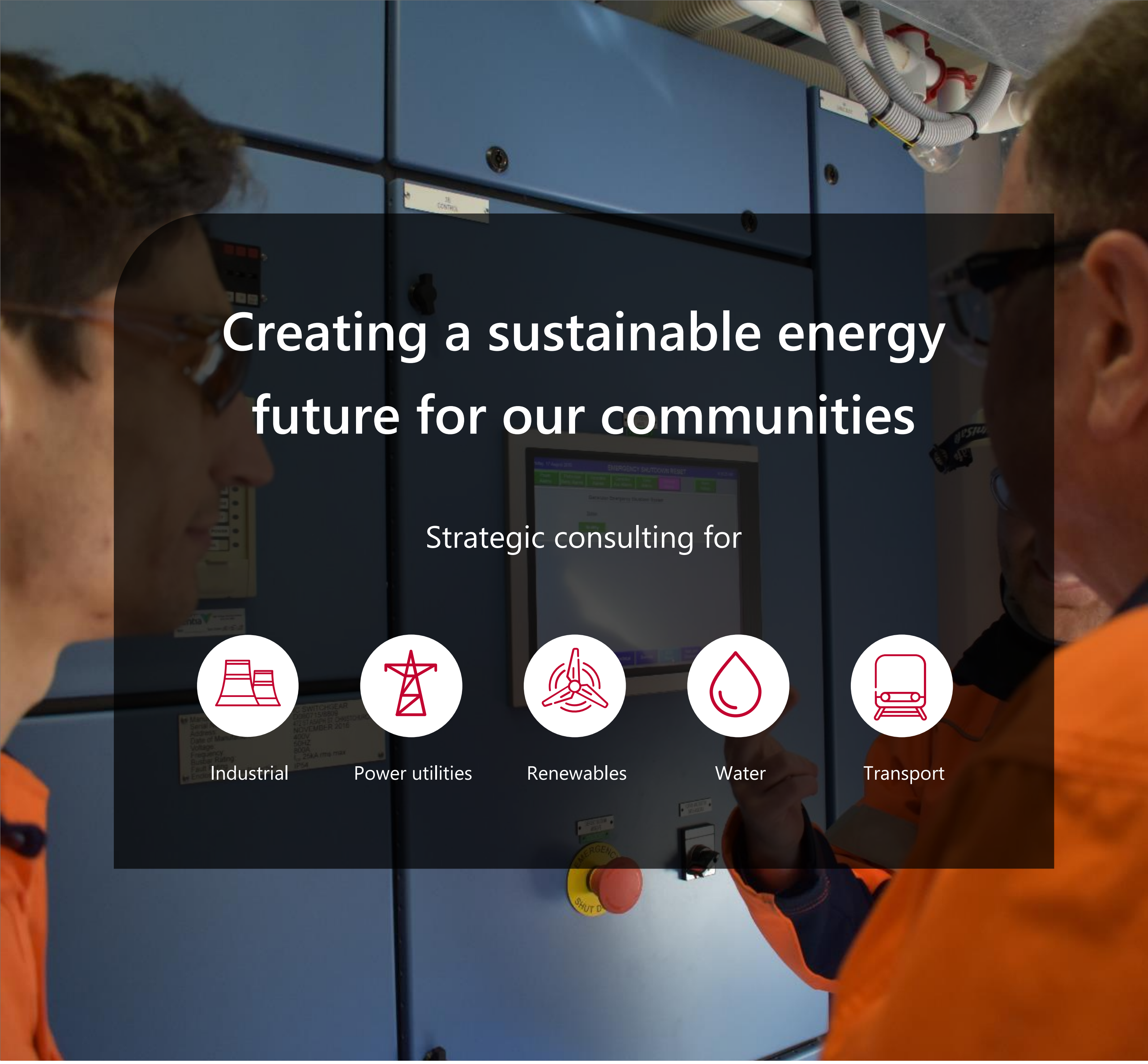
Wind Farm	No of WTGs	Year of Commencement	Years of Operation	WTG Years
Berrybank 2	26	2023	1	26
Dulacca Wind Farm	43	2023	1	43
Bango Wind Farm	46	2022	2	92
Crudine Ridge	37	2022	2	74
Esperance Power Project	2	2022	2	4
Mortlake South	35	2022	2	70
Berrybank 1	43	2021	3	129
Biala Wind Farm	31	2021	3	93
Collector Wind Farm	54	2021	3	162
Ferguson	3	2021	3	9
Kalbarri	2	2021	3	6
Murra Warra II Wind Farm	38	2021	3	114
Port Augusta	50	2021	3	150
Agnew	5	2020	4	20
Cherry Tree Wind Farm	16	2020	4	64
Coopers Gap Wind Farm	123	2020	4	492
Diapur	2	2020	4	8
Dundonnell Wind Farm	80	2020	4	320
Moorabool Wind Farm (North & South)	104	2020	4	416
Stockyard Hill Wind Farm	149	2020	4	596
Warradarge	51	2020	4	204
Yandin Wind Farm	51	2020	4	204
Badgingarra	37	2019	5	185
Beros Rd	19	2019	5	95
Bodangora Wind Farm	33	2019	5	165
Bulgana	56	2019	5	280
Cattle Hill Wind Farm	48	2019	5	240
Kennedy	12	2019	5	60
Lal Lal Wind Farm	60	2019	5	300

Wind Farm	No of WTGs	Year of Commencement	Years of Operation	WTG Years
Murra Warra Wind Farm	61	2019	5	305
Port Gregory	5	2019	5	25
Silverton Wind Farm	58	2019	5	290
Willogoleche Wind Farm	32	2019	5	160
Crookwell 2	46	2018	6	276
Crowlands Wind Farm	39	2018	6	234
Granville Harbour Wind Farm	31	2018	6	186
Hornsdale 3	35	2018	6	210
Kiata	9	2018	6	54
Lincoln Gap Wind Farm	59	2018	6	354
Maroona	2	2018	6	12
Mount Emerald Wind Farm	53	2018	6	318
Mount Gellibrand Wind Farm	44	2018	6	264
Salt Creek Wind Farm	15	2018	6	90
Sapphire Wind Farm	75	2018	6	450
Timboon West	2	2018	6	12
Yaloak South	14	2018	6	84
Yawong Wind Farm	2	2018	6	12
Ararat Wind Farm	75	2017	7	525
Coober Pedy 2	2	2017	7	14
Flinders Island	1	2017	7	7
Hornsdale 1	32	2017	7	224
Hornsdale 2	32	2017	7	224
Waterloo 2	6	2017	7	42
White Rock Wind Farm (Stage I)	70	2017	7	490
Coonooer Bridge	6	2016	8	48
Bald Hills Wind Farm	52	2015	9	468
Boco Rock Wind Farm	67	2015	9	603
Chepstowe Wind Farm	3	2015	9	27
Portland 4	23	2015	9	207
Taralga Wind Farm	51	2015	9	459
Mount Mercer Wind Farm	64	2014	10	640

Wind Farm	No of WTGs	Year of Commencement	Years of Operation	WTG Years
Snowtown 2	90	2014	10	900
Denmark community Wind Farm	2	2013	11	22
Gullen Range Wind Farm	73	2013	11	803
Karakin Wind Farm	10	2013	11	110
Macarthur Wind Farm	140	2013	11	1540
Mortons Lane Wind Farm	13	2013	11	143
Mumbida Wind Farm	22	2013	11	242
Musselroe Wind Farm	56	2013	11	616
Sumich West Hills	10	2013	11	110
Hallett 5	25	2012	12	300
Hepburn	2	2012	12	24
Oaklands Hill Wind Farm	32	2012	12	384
Woodlawn Wind Farm	23	2012	12	276
Collgar Wind Farm	111	2011	13	1443
Grasmere Wind Farm (Albany)	6	2011	13	78
Gunning Wind Farm	31	2011	13	403
Hallett 4	63	2011	13	819
Mount Barker	3	2011	13	39
Waterloo Wind Farm	37	2011	13	481
Clements Gap Wind Farm	27	2010	14	378
Hallett 2	34	2010	14	476
Lake Bonney 3	13	2010	14	182
Yambuk Wind Farm	20	2010	14	280
Capital Wind Farm	67	2009	15	1005
Cullerin Range	15	2009	15	225
Portland 3	22	2009	15	330
Snowtown 1	47	2009	15	705
Waubra Wind Farm	128	2009	15	1920
Salmon beach Wind Farm	6	1987	15	90
Hallett 1 Wind Farm	45	2008	16	720
Lake Bonney 2 Wind Farm	53	2008	16	848
Portland 2 Wind Farm	29	2008	16	464

Wind Farm	No of WTGs	Year of Commencement	Years of Operation	WTG Years
Nichols Poultry – Sassafras	1	2008	16	16
Cathedral Rocks Wind Farm	33	2007	17	561
Coral Bay Wind Farm	3	2007	17	51
Denham Wind Farm	4	2007	17	68
Hopetoun Bay Wind Farm 2	1	2007	17	17
Portland 1 Wind Farm	20	2007	17	340
Woolnorth Studland Bay Wind Farm	25	2007	17	425
Kooragang Wind Farm	1	1997	17	17
Dulacca Wind Farm	48	2006	18	864
EMU Downs Wind Farm	48	2006	18	864
Mt Millar Wind Farm	35	2006	18	630
Walkaway Wind Farm	54	2006	18	972
Canunda Wind Farm	23	2005	19	437
Lake Bonney 1 Wind Farm	46	2005	19	874
Wattle Point Wind Farm	55	2005	19	1045
Wonthaggi Wind Farm	6	2005	19	114
Bremer Bay Wind Turbine	1	2004	20	20
Hopetoun Bay Wind Farm 1	1	2004	20	20
Rottnest Wind Turbine	1	2004	20	20
Woolnorth Wind Farm	37	2004	20	740
Challicum Hills Wind Farm	35	2003	21	735
Huxley Hill 2 Wind Farm	2	2003	21	42
Nine Mile Beach Wind Farm	6	2003	21	126
Starfish Hill Wind Farm	22	2003	21	462
Toora Wind Farm	12	2002	22	264
Albany Wind Farm	12	2001	23	276
Codrington Wind Farm	14	2001	23	322
Hampton Wind Park	2	2001	23	46
Blayney Wind Farm	15	2000	24	360
Windy Hill Wind Farm	20	2000	24	480
Crookwell 1 Wind Farm	8	1998	26	208

Wind Farm	No of WTGs	Year of Commencement	Years of Operation	WTG Years
Huxley Hill 1 Wind Farm	3	1998	26	78
Coober Pedy 1 Wind Farm	1	1991	26	26
Thursday Island Wind Farm	2	1997	27	54
Ten Mile Lagoon Wind Farm	9	1993	29	261
TOTAL	4114		1454	40057



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