

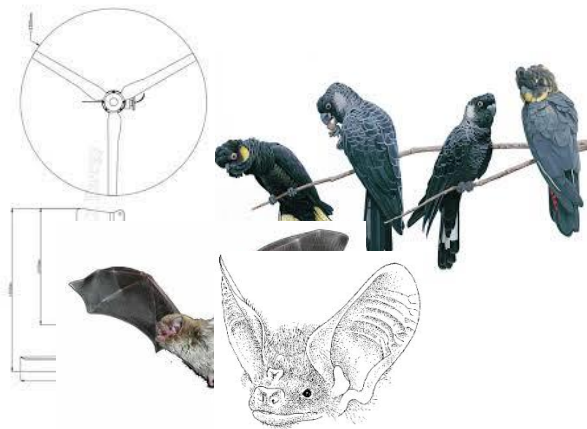


Avifauna & Bat Assessment

Turbine Strike Mitigation Methods

Arrowsmith Hydrogen Project AHP

Document No: ARW-Z01-ENV-SUR-IGE-0001



Document Control
Project Cover Sheet

Infinite Green Energy Pty Ltd
Quality Management System

Reference Number:
ARW-Z01-ENV-SUR-IGE-0001-0
Date: 28 Feb 2025
Approved by: SG

Project Acronym	AHP
Project Title	Arrowsmith Hydrogen Project
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IGE File No.	ARWD - AHP
Document Title:	Avifauna & Bat Assessment; Turbine Strike Mitigation Methods

Document Issue					
Author:			Peter Galloway		
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Authorised by:			Stephen Gauld		
Our Reference: Arrowsmith Hydrogen Project: ARW-Z01-ENV-SUR-IGE-0001-0					
Issued for: Publication			EPA: Pursuant to section 40(2)(a) of the Environmental Protection Act 1986		
Date: 28 Feb 2025					
Revision History					
Rev	Description	Date	Author	Checked	Appr
A	Changes as per EPA requirements	24/08/23	PG	MH	SG
1	Update for Re-submission to EPA	28/02/25	PG	MH	SG

IGE respectfully acknowledges traditional owners of the land and water it manages, and recognises their continuing connection to land, water and community

Table of Contents

1.	Introduction.....	1
1.1.	Renewable Energy Sources.....	1
1.2.	Domestic Utilisation.....	1
1.3.	Executive Summary.....	2
2.	Determining 'Significant' Impact.....	4
2.1.	Professional Judgment.....	4
2.2.	Available Data Sources.....	4
2.3.	Conservation Status.....	4
2.4.	Sensitivity to Wind Farm Development.....	4
2.5.	Magnitude of Impact.....	5
2.6.	Baseline Studies.....	5
2.7.	Impact Prediction.....	5
2.8.	Mitigation Measures.....	5
2.9.	Monitoring and Adaptive Management.....	5
2.10.	Conclusion.....	5
2.11.	Noise and Visual Disturbance:.....	6
2.12.	Collision with Turbine Rotor Blades:.....	6
2.13.	Loss, Degradation, or Fragmentation of Supporting Habitats:.....	6
2.14.	Behavioural Displacement:.....	6
2.15.	Mitigation Measures.....	7
2.16.	Study Focus.....	8
3.	Field Study: Bats.....	10
4.	Bat Call Analysis.....	11
5.	Bat Call.....	12
2.17.	Bat Survey Limitations.....	13
6.	Bat Identification.....	14
7.	Turbine Bat Strike.....	16
8.	Summary.....	17
9.	Introduction: Wind Turbine Bird Strike in Western Australia.....	18
10.	Threatened listed Avifauna (Birds).....	19
11.	Fauna Strike Mitigation Technology.....	23
12.	Curtailment Types.....	28
13.	Bird Strike.....	30
14.	Wind Turbine Strike Risk.....	32
15.	Examples of Commonly Used Monitoring Methods.....	38
16.	Collision Risk Modelling (Radar).....	46
17.	Advantages of installing Avifauna Detection Radar on Site.....	47
18.	Radar Technologies for Avian and Bat Detection in Wind Farms.....	48
19.	Sustainability.....	50
20.	Summary.....	52

Table References

Table 1: Fauna Sites, Habitat & Significant Fauna Locations.....	12
Table 2: Bat Identification	14
Table 3: Avifauna Conservation species.....	20
Table 4: Sensor Technologies.....	37
Table 5: Comparison of mitigation methods	39

Figure References

Figure 1: Avifauna Hazards.....	8
Figure 2: Arrowsmith Hydrogen Project (AHP)	9
Figure 3 Primary Foraging Habitat Area within the AHP Development Envelope.....	22
Figure 4 Curtailment Results (Bennett et al., 2022).	29
Figure 5 Collision Risk Models	46
Figure 6 Siemens Gamesa Renewable Energy 2023	50
Figure 7 Fauna Significant Sites	51

1. Introduction

Infinite Green Energy (IGE) is proposing to develop The Arrowsmith Hydrogen Project (AHP) Green Hydrogen Project within the Arrowsmith Development Hub (ADH), situated 30 kilometres south of Dongara in Western Australia. This facility will harness renewable energy sources, specifically a solar photovoltaic (PV) array and wind energy (Turbines), to produce green hydrogen via electrolysis on site. The produced liquid hydrogen derived from the proposed Hydrogen Production Facility (HPF) is intended for domestic use, playing a crucial role in supporting the transition to a sustainable energy future.

1.1. Renewable Energy Sources

Solar PV Arrays: Large-scale solar panels will capture solar energy to generate electricity.

Wind Turbines: Wind turbines will convert wind energy into electrical power.

Hydrogen Production:

- **Electrolysis Process:** The electricity generated from solar and wind sources will be used to power electrolysis units, which split water into hydrogen and oxygen.
- **On-site Production:** Hydrogen will be produced directly at the HPF, ensuring efficiency and reducing transportation needs.
- **Road Infrastructure and Operational hardware**
- **Energy Storage systems:** Store electricity generated from renewable sources to ensure a stable supply for hydrogen production.
- **Liquid Hydrogen Storage systems**
- **Distribution Network:** Infrastructure to facilitate the distribution of produced hydrogen for domestic use.

1.2. Domestic Utilisation

The liquid hydrogen produced will be used domestically, providing a clean energy source for various applications such as transportation, industrial processes, and project site energy needs. This aligns with broader strategies to integrate green hydrogen into the national energy mix, promoting sustainable and resilient energy systems.

Overall, IGE's proposal represents a significant step towards harnessing renewable energy for hydrogen production, contributing to both local and global sustainability goals.

The proposed facility land type is currently a combination of cleared farmland and native vegetation. It contains an area with shallow freshwater lakes, and a limestone karst area supporting at least two known caves (Arramall and River Cave systems). IGE are not proposing to disturb or construct within this environmentally sensitive area.

1.3. Executive Summary

This report provides a comprehensive assessment of the potential impacts of the AHP Wind Farm, an integral component of the proposed development, on avian and chiropteran species of conservation concern, as well as their critical habitats. The evaluation encompasses habitat disruption, collision risks, and other ecological effects, providing a detailed analysis for informed decision-making and mitigation planning.

The Proposed Development is located within the shire of Irwin, within extensively grazed farmland area, approximately 30km east south-west of Dongara in Western Australia.

Wind turbine locations are proposed within the western area of the Development Envelope (DE), situated immediately to the east of Indian Ocean Drive. This placement is strategically planned to balance efficient energy production with minimal environmental impact, ensuring that the turbines are positioned to maximise wind resource utilisation while considering the proximity to infrastructure and existing environmental values. The project aims to integrate renewable energy solutions while mitigating potential disruptions to the surrounding landscape and flora and fauna habitats.

The proposed windfarm location support a range of habitats including eight fauna habitat types that are present within the survey area (Heath, Mallee Woodland, Pastoral, Riparian, Shrubland, Waterbody (seasonal), Wetland and Woodland), of which the Waterbody and Wetland habitats are considered important for conservation-listed migratory wading birds.

The assessment follows current best practice and focuses on the potentially effects of the Proposed development on key bird receptors (i.e. bird populations of conservation concern and sensitivity to wind farm development and their supporting habitats). What is considered a 'significant' impact, in terms of the EIA Regulations, is determined by professional judgement following a standardised process, informed by available data from a range of sources including relevant published research and wind farm monitoring studies. In summary, the Proposed Development has the potential to impact birds through the following impacts:

- Noise and visual disturbance during construction, operation and site decommissioning;
- Collision with turbine rotor blade strike;
- Loss, degradation or fragmentation of supporting habitats; and
- Behavioural displacement from important habitats or flight paths due to the presence of the wind turbines.

The impact assessment process for wind turbine locations involves several key steps. Initially, there is an evaluation of the importance, or 'sensitivity,' of the proposed development area for the species under consideration. Detailed environmental surveys are then conducted to gather data on species presence and habitat quality. This is followed by an analysis of potential impacts on the identified species and habitats. Mitigation measures are developed and implemented to address these impacts. Finally, a monitoring program is established to track the effectiveness of these measures and ensure compliance with environmental regulations. This comprehensive approach aims to balance development with the conservation of local species and habitats.

The sensitivity evaluation is informed by data derived from a number of sources including the results of surveys of the proposed development area, completed between 2020 and 2022. Also considered is information from various other sources including: current national and regional population estimates (where available); data from a number of previous surveys of the area.

The Flora and vegetation surveys followed standard methods for the assessment of onshore wind farms, were agreed in consultation with DWER as part of the EPA approval process.

There is a key species that is the focus of the assessment i.e. the endangered Carnaby's Black Cockatoo and the range of potential impacts that are required to be considered to satisfy the EPA and the DCCEEW that foraging habitat disturbance within the DE is negligible and the would not impact the species in great numbers.

A core survey area was established within the Detailed Vegetation survey area (Ecoscape 2022) which included the Proposed disturbance footprint and a 50m wide buffer strip around the potential wind turbine development areas.

The assessment of the potentially impacts of the Proposed AHP Development upon key bird receptors—specifically bird populations of conservation concern (Carnaby's Black Cockatoo) and those sensitive to wind farm development—follows current best practices and focuses on the standards set forth by the Environmental Impact Assessment (EIA) Regulations.

2. Determining 'Significant' Impact

2.1. Professional Judgment

Expert Evaluation: Professional ecologists and ornithologists use their expertise to assess potential impacts. Their judgment is guided by industry standards, legal requirements, and best practices in environmental assessment.

Standardised Process: This involves a systematic approach to identify, predict, and evaluate the significance of impacts based on predefined criteria and thresholds.

2.2. Available Data Sources

Published Research: Peer-reviewed studies and scientific literature provide insights into the impacts of wind farms on bird populations, including collision risks, displacement, and behavioural changes.

Wind Farm Monitoring Studies: Data from existing wind farms, including post-construction monitoring, helps in understanding real-world impacts and effectiveness of mitigation measures.

Environmental Databases: Information on bird distributions, migration patterns, and population dynamics is crucial for accurate assessments.

2.3. Conservation Status

Protected Species: Species listed under national or international conservation regulations (e.g., MNES, national threatened and endangered species lists) are given special consideration.

Vulnerable Populations: Populations already experiencing decline or at risk from other factors (e.g., habitat loss, climate change) are considered more sensitive to additional impacts from wind farms.

2.4. Sensitivity to Wind Farm Development

Flight Behaviour: Species that fly at rotor-swept heights or have migratory patterns passing through the wind farm area are at higher risk.

Habitat Dependence: Birds that rely on habitats within or near the proposed wind farm for feeding, nesting, or breeding are more likely to be significantly affected.

2.5. Magnitude of Impact

Collision Risk: The probability and potential frequency of birds colliding with turbine blades.

Displacement Effects: The extent to which birds may be displaced from their usual habitats due to the presence of turbines.

Habitat Modification: Changes to the landscape that alter habitat quality or availability.

Assessment Process

2.6. Baseline Studies

Field Surveys: Conducting detailed surveys to gather data on bird species, their numbers, behaviours, and habitats in the project area.

Historical Data Analysis: Reviewing existing records and previous studies to establish baseline conditions.

2.7. Impact Prediction

Modelling and Simulations: Using predictive models to estimate the potential impacts based on turbine placement, bird flight paths, and other factors.

Scenario Analysis: Evaluating different scenarios, including worst-case situations, to understand the range of possible impacts.

2.8. Mitigation Measures

Design Adjustments: Modifying turbine placement, height, and operation times to reduce risks.

Technology Integration: Implementing bird detection and deterrence technologies to minimize collisions.

Habitat Management: Enhancing or creating alternative habitats to offset displacement effects.

2.9. Monitoring and Adaptive Management

Post-Construction Monitoring: Continuously monitoring bird populations and behaviour to assess actual impacts and the effectiveness of mitigation measures.

Adaptive Management: Adjusting strategies based on monitoring results and emerging research to improve outcomes.

2.10. Conclusion

In summary, the determination of 'significant' impact in the context of the EIA Regulations is a nuanced process that relies on professional judgment, standardised methodologies, and robust data. By considering conservation status, sensitivity to wind farm development, and the magnitude of potential impacts, the assessment aims to ensure that any adverse effects on key bird/bat receptors are identified, mitigated, and managed in a way that balances renewable energy development with biodiversity conservation.

2.11. Noise and Visual Disturbance:

- **Construction Phase:** The noise and activity associated with the construction of the wind farm can disturb birds, causing stress and potential displacement from the area.
- **Operational Phase:** The ongoing noise from operating turbines, as well as their visual presence, can continue to disturb bird populations, affecting their regular activities such as feeding and breeding
- **Site Decommissioning:** The process of dismantling the wind farm can once again introduce noise and disturbance, similar to the construction phase, potentially affecting birds that have become accustomed to the site's conditions during operation.

2.12. Collision with Turbine Rotor Blades:

- Birds flying at rotor-swept heights are at risk of colliding with turbine blades, which can result in injury or death. This risk is particularly significant for species that migrate through the area or have flight patterns that bring them into close proximity to the turbines.

2.13. Loss, Degradation, or Fragmentation of Supporting Habitats:

- **Habitat Loss:** The physical footprint of the wind farm and associated infrastructure can lead to the direct loss of bird habitats.
- **Habitat Degradation:** Construction and operation activities can degrade the quality of surrounding habitats, making them less suitable for birds.
- **Habitat Fragmentation:** The presence of turbines and infrastructure can fragment continuous habitats, creating barriers that affect bird movement and access to resources.

2.14. Behavioural Displacement:

- **From Important Habitats:** Birds may avoid areas around the turbines due to perceived threats, leading to displacement from crucial feeding, nesting, or breeding habitats.
- **From Flight Paths:** The presence of turbines can alter bird flight paths, potentially increasing energy expenditure and stress as birds navigate around the wind farm.

2.15. Mitigation Measures

To minimise these adverse effects, several mitigation strategies can be employed:

Careful Site Selection:

- Avoiding areas with high bird activity, especially those used by species of conservation concern or key migratory routes.
- **Timing of Construction Activities:**
Scheduling construction activities outside of critical breeding or migration periods to reduce disturbance to birds.
- **Turbine Design and Technology:**
Using advanced turbine designs that reduce collision risks, such as slower rotating blades or radar-activated shut-off systems when birds are detected nearby.
- **Habitat Management and Restoration:**
Implementing habitat enhancement or restoration projects to compensate for habitat loss and degradation.
- **Monitoring and Adaptive Management:**
Conducting ongoing monitoring of bird populations and behavior to assess the actual impacts and adjust mitigation measures as necessary.

By carefully considering these impacts and implementing appropriate mitigation strategies, the Proposed Development can balance the need for renewable energy with the protection of bird populations and their habitats.

A vegetation study compiled by Ecoscape consultants in 2023, identified 223 terrestrial vertebrate fauna species (PMST and Western Australian Databases) as potentially occurring in the proposed development envelope, including 14 mammals (eight native and six introduced), 163 birds (160 native and three introduced), 39 native reptiles and seven native amphibians. Thirty-five species are conservation listed either on NatureMap, the current DBCA database or the PMST.

2.16. Study Focus

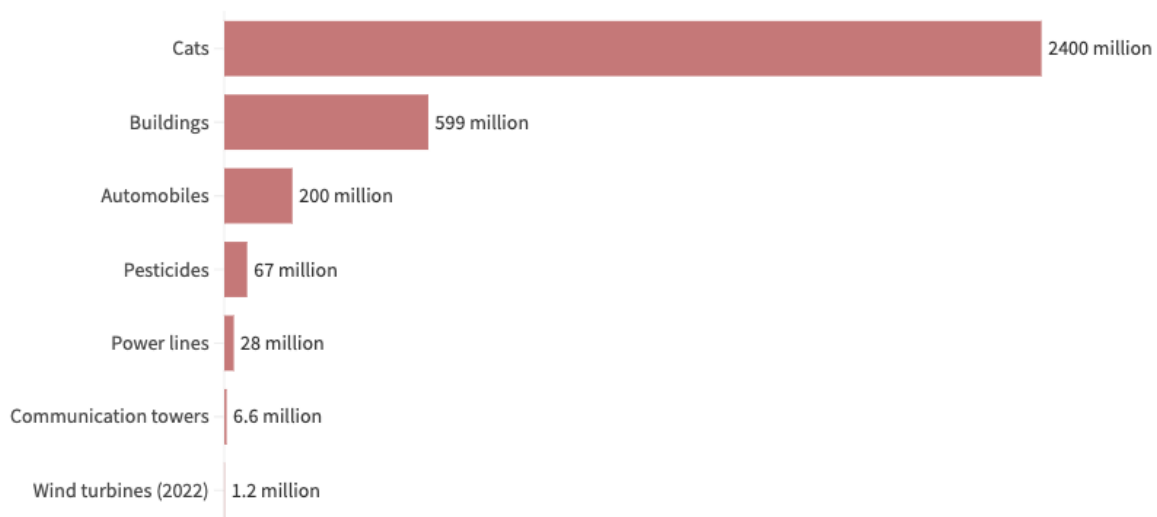
Avifauna impacts resulting from wind turbine blade strike is increasing due to the incorporation of windfarms into the global energy portfolio. It is noted that wind energy has the potential to substantially reduce anthropogenic climate change and the associated long-term negative environmental impacts of fossil fuel emissions.

Wind turbine blade strike has minimal impact upon bird and bat populations when evaluated against greater environmental threats like habitat loss from climate change, bushfire threats due to global warming, overhead powerline hazards and feral animal threats, but they do have the potential to negatively impact vulnerable or threatened species populations including the Carnaby Black Cockatoo and local bat populations.

This study focuses on birds of a particular region or habitat, and bats (mammals, order chiroptera), the only group of mammals capable of true flight. The main objective of this study is to evaluate curtailment and other tested methods of Avifauna strike mitigation at the proposed AHP facility.

Research from land-based wind farms indicates certain species of bats and birds appear to be attracted to wind turbines and that spinning blades represent a risk. The development of remote sensing technologies can be utilised to quantify collision risk and behavioural effects, of bird and bat species within a given area.

Birds killed by different hazards in the US per year



Sources: Loss et al. (2015); (2013). US Fish and Wildlife Service; Subramanian et al. (2012); American Bird Conservancy (2021).

Figure 1: Avifauna Hazards



Figure 2: Arrowsmith Hydrogen Project (AHP)

3. Field Study: Bats

Kyle Armstrong ecological consultants from specialised zoological, used Bat call analysis by deploying bat bioacoustics field monitors to evaluate species types and numbers with the Arrowsmith Hub Development area. Songmeter acoustic recorders fitted with both acoustic and ultrasonic microphones were used to understand bat activities during the survey.

The methods utilised during the field survey followed those outlined in the Fauna Technical Guidance (EPA 2020a), conducted as a Basic survey.

Survey techniques included:

Ultrasonic bat call detectors (Songmeter SM4 model operated in zero crossed mode; Wildlife Acoustics, Maynard, MA, USA) fitted with both acoustic and ultrasonic microphones to sample birds and bats types. These detectors were placed at representative locations within the project area to record bat activity (Figure. 1).

Whilst uncertainty exists regarding the use of bat call activity as a proxy for the number of individuals onsite (Barclay, 1999; Sherwin, 1998), it remains the least invasive and most reliable method for quantifying bat activity levels, especially over a longer period, as used in this study (Peterson et al., 2021).

Bat data analysis details:

- Bat call analysis was conducted by Kyle Armstrong from specialised zoological. Specialised Zoological is a scientific consultancy business that specialises in bats, bioacoustics and genetic identification;
- Types of bat detector, models included the Pettersson Elektronik D500x and the Wildlife Acoustics SM2BAT surveying the biodiversity of WA's karst environments;
- Baseline information was gathered for the project areas, as a basis for future monitoring programmes if required; and
- The non-invasive detection and identification of bat species from echolocation call recordings, targeted field surveys and monitoring of threatened bat species was conducted during the survey.

Arramall Cave within the project footprint is reported as having evidence of bats (evidence of guano piles), including *Macroderma gigas* (Ghost Bat) that is reported as extinct in the region and has now been replaced by *Chalinolobus morio* (Chocolate Wattled Bat) (Susac, 2007).

4. Bat Call Analysis

Five bat species were identified with certainty from recordings made within the survey area, none of which are conservation listed. Three of these (*Chalinolobus gouldii*, *C. morio* and *Nyctophilus geoffroyi*) are commonly known from the region, whilst two species (*Austronomus australis* and *Vespadelus baverstocki*) do not have previous DBCA records from the area and thus represent range extensions.

One additional bat species (*Ozimops kitcheneri*) was potentially recorded during the survey; however, the call could not be confidently attributed to the species with certainty and thus has been excluded from the overall species list.

By surveying and identifying bat biodiversity of the Arrowsmith Karst environment within the Arrowsmith project area, a list of bat species and sites recorded (Figure 2) during the survey are included in the table below.

5. Bat Call

Bat call analysis was completed identifying **five bat species** none of which are conservation listed.

Three of these are commonly known from the region,

- *Chalinolobus gouldii*,
- *C. Morio* and
- *Nyctophilus geoffroyi*

Two Microbat species:

- *Austronomus australis* and
- *Vespadelus baverstocki*

Microbats do not have previous DBCA records from the area and thus represent range extensions. Limestone karst and outcroppings are present throughout much of the northern extent of this habitat unit, providing breeding habitat for reptiles and microbats.

Table 1: Fauna Sites, Habitat & Significant Fauna Locations

Site Name	Site type	Easting	Northing
SM01	Fauna: Sound Recorded (Anabat / SM2)	310068.392	6736406.518
SM02	Fauna: Sound Recorded (Anabat / SM2)	310553.526	6731712.686
SM03	Fauna: Sound Recorded (Anabat / SM2)	309247.103	6733507.056
SM04	Fauna: Sound Recorded (Anabat / SM2)	307479.051	6737224.941

5.1. Bat Survey Limitations




The identifications presented in this report have been made within the following context:



- The identifications made herein were based on the ultrasonic acoustic data recorded and provided by a 'third party'.
- The scope of this report extended to providing information on the identification of bat species of conservation significance in bulk ultrasonic recordings.
- In the case of the present report, the recording equipment was not set up and supplied by specialist zoologist. The equipment was operated by the third party during the survey.
- Other than the general location of the study area, specialist zoologist was not provided with detailed information of the survey area, have not made a visit to observe the habitats available for bats, nor have they visited the specific project areas on a previous occasion.
- Specialist zoologist had no input into the overall design and timing of this bat survey, recording site placement, nor the degree of recording site replication.
- While specialist zoologist made identifications to the best of their ability given the available materials and reserves the right to re-examine the data and revise any identification following a query, it is the client's and / or proponent's responsibility to provide supporting evidence for any identification, which might require follow-up trapping efforts or non-invasive methods such as video recordings. specialist zoologist bears no liability for any follow-up work that may be required to support an identification based initially on the analysis of acoustic recordings undertaken and reported here.
- There are a variety of factors that affect the 'detectability' of each bat species, given the frequency, power and shape characteristics of their calls. Further information on the analysis and the various factors that can impinge on the reliability of identifications can be provided upon request.
- The analysis of ultrasonic recordings is one of several methods that can be used to survey for bats, and comprehensive surveys typically employ more than one method.

6. Bat Identification

The five bat species were identified from acoustic recordings within the Arrowsmith project area, within the Mid-West region of Western Australia. The identification of bat species was gathered from full spectrum WAV format recordings of their echolocation calls. This species information attributes are based on measurements of characteristic frequency, observation of pulse shape, and harmonic patterns.

Table 2: Bat Identification

Species	Common Name	Conservation Status	Bats Identified within the Project Area
Mammals			
<p><i>Austronomus australis</i> The White-striped Freetail Bat is endemic to southwest WA. The striped free-tail bat was once thought to belong to the world-wide genus Tadarida. It is now the only species of <i>Austronomus</i> and is restricted to Australia. This species is the largest and most widely distributed of Australia's free-tail bats. It can be found across southern Australia, except for Tasmania. It is also one of the few micro-bats that can produce echolocation calls audible to humans.</p>	White-striped Free-tailed Bat	White-striped Freetail Bats are vulnerable to loss of tree hollows and loss of feeding grounds by forestry activities, clearing for agriculture and housing.	
<p><i>Chalinolobus gouldii</i> <i>gouldii</i> is the largest of the genus <i>Chalinolobus</i>, a group distinguished by fleshy lobes located at the corners of its mouth. For individuals throughout their range, the average length (head and body) is 70 mm and average mass is 14 g.</p>	Gould's Wattled Bat	Gould's Wattled Bats are vulnerable to loss of roost sites in tree hollows and loss of feeding grounds by forestry activities, clearing for agriculture and housing.	
<p><i>Chalinolobus morio</i> The chocolate wattled bat is a bat in the family Vespertilionidae. It is found only in Australia, including the island Tasmania, and widespread in southern regions. It is known to reside from sea level to at least 1,570 metres in Victoria.</p>	Chocolate Wattled Bat	Chocolate Wattled Bats are vulnerable to loss of roost sites in tree hollows and loss of feeding grounds by clearing, forestry activities, clearing for agriculture and housing.	

Species	Common Name	Conservation Status	Bats Identified within the Project Area
<p><i>Nyctophilus geoffroyi</i> <i>Nyctophilus geoffroyi</i> is a vespertilionid bat, a flying nocturnal mammal found in Australia. The species is relatively common. They have been referred to as the lesser long-eared bat. The species is known to have one of the lowest flight speeds when foraging, slowing to 4 km/h when flying into the understory and through vegetation (Lumsden et al., 2021).</p>	<p>Lesser Long-eared Bat</p>	<p>Lesser Long-eared Bats are vulnerable to loss of tree hollows and loss of feeding grounds by forestry activities, clearing for agriculture and housing, and land degradation.</p>	
<p><i>Vespadelus baverstocki</i> The inland forest bat is a vesper bat that occurs in central and arid regions in Australia. They were first described in 1987, published in a review of poorly surveyed microbat population</p>	<p>Inland Forest Bat</p>	<p>Inland Forest Bats are vulnerable to the loss of roost sites in tree hollows and loss of feeding grounds by forestry activities, extensive clearing of vegetation and land degradation from agriculture.</p>	

7. Turbine Bat Strike

Despite an increasing number of studies in the Northern Hemisphere demonstrating curtailment effectiveness, no empirical studies have yet been conducted in Australia.

A study to evaluate curtailment as a method of reducing bat fatalities at the Cape Nelson North wind farm in southwest Victoria, Australia (Bennett et al., 2022). Curtailment involves operational restriction of turbines at low wind speeds (often lower than 6 ms^{-1}) between dusk and dawn during periods of high bat activity, generally from summer to autumn. In total, 46 bat carcasses were found during the study, with 30 found before curtailment and 16 found during curtailment (Figure 2). Overall fatalities from $1.03 (\pm 0.24 \text{ SE})$ to $0.50 (\pm 0.16 \text{ SE})$ per turbine following curtailment implementation (Bennett et al., 2022). White-striped free-tailed bats were the most common bat species found during mortality surveys.

In addition, increasing turbine cut-in wind speed from 3.0 to 4.5 ms^{-1} from dawn to dusk at a southern Australian wind farm significantly reduced bat fatality by 54%. Curtailment was the principle explanatory variable for reduced mortality, as bat call activity did not differ significantly between study years, but rather non-significantly increased during curtailment. These findings are consistent with the original hypothesis and a growing body of global evidence demonstrating curtailment as an effective method for reducing turbine-associated bat fatalities (Adams et al., 2021; Whitby et al., 2021).

Wind speed is a consistently reported weather variable related to bat mortality at wind farms, with lower speeds ($<6 \text{ ms}^{-1}$) frequently associated with higher bat activity and subsequent fatalities (Arnett et al., 2016; Hein & Schirmacher, 2016). A more recent meta-analysis reported a decrease in fatalities by 33% for every 1.0 ms^{-1} increase in cut-in speed, with a 5.0 ms^{-1} cut-in speed estimated to reduce bat fatalities by 62% (95% CI: (54%, 69%)) (Whitby et al., 2021).

Why bats collide with turbines is still debated (Arnett et al., 2016; Cryan et al., 2014; Thompson et al., 2017) but one hypothesis includes turbines acting as a resource attractant. For example, Foo et al., (2017) reported food resources were regularly present at turbines, with the majority of stomachs of collected carcasses being fully or partially full, indicating bats were likely killed whilst foraging. This foraging behaviour may increase their susceptibility to turbine collision in cleared environments,

Microbats are a critical component of Australia's native mammal assemblage (Lumsden & Bennett, 2010), though they are often overlooked due to their cryptic nature and small size (Milne, 2006). There is a paucity of knowledge on the populations and demographics of many of Australia's bat species; as such, the consequences of any turbine collision-driven population impacts are unknown, challenging evidence-based conservation (Rodhouse et al., 2019).

8. Summary

The bat species identified within the AHP project development envelope were distinguished using advanced acoustic recording techniques. These recordings, captured in full-spectrum WAV format, preserved the detailed echolocation calls of the bats. The identification process involved meticulous analysis of specific acoustic parameters, including characteristic frequencies, pulse shapes, and harmonic patterns of the calls.

The analysis was concentrated on five significant bat species:

- *Chalinolobus gouldii*: Commonly known as Gould's wattled bat, this species is prevalent in the region and characterized by its distinctive echolocation calls.
- *Chalinolobus morio*: Also known as the chocolate wattled bat, this species is another commonly observed bat in the area, identifiable by its unique echolocation signature.
- *Nyctophilus geoffroyi*: Known as Gould's long-eared bat, it is distinguished by its specific echolocation patterns and is commonly found in the region.

In addition to these commonly known species, the analysis also identified two species that indicate a potential range extension:

- *Austronomus australis*: Known as the white-striped freetail bat, its identification within the project area suggests an extension beyond its previously known range. This species is recognized by its high-frequency, rapid echolocation calls.
- *Vespadelus baverstocki*: Baverstock's long-eared bat, another species with a potential range extension, is identified by its distinct echolocation characteristics.

The identification of these bat species through acoustic recordings not only provides valuable information regarding their presence within the AHP project development envelope but also contributes to the understanding of their distribution and habitat use. This data is crucial for informing conservation strategies and mitigating potential impacts on these bat populations during the project's development.

9. Introduction: Wind Turbine Bird Strike in Western Australia

As the demand for renewable energy continues to grow, wind energy has emerged as a critical component in reducing greenhouse gas emissions and combating climate change. However, the installation of wind turbines has raised concerns regarding their potential impact on local wildlife, particularly birds. Wind turbine bird strikes, where birds collide with the turbine blades, have become a significant environmental consideration in the planning and development of wind energy projects worldwide, including in Western Australia.

Western Australia is home to a diverse range of bird species, including migratory birds and vulnerable populations such as the Carnaby's Black Cockatoo. The siting of wind turbines within key habitats or migration pathways can pose a threat to these species. Therefore, a comprehensive understanding of bird strike risks is essential to balance the development of renewable energy projects with the protection of biodiversity.

In response to these concerns, IGE are employing various strategies to mitigate bird strike risks. These include conducting detailed environmental impact assessments, using radar and other monitoring technologies to track bird movements, and designing turbine layouts that avoid critical bird habitats. Implementing such measures ensures that wind energy projects can proceed while minimizing their ecological footprint and safeguarding bird populations.

This introduction underscores the importance of addressing the potential impact of wind turbine bird strikes in Western Australia and highlights the role of mitigation strategies in promoting both sustainable energy development and wildlife conservation.

10. Threatened listed Avifauna (Birds)

10.1. Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

The potential for turbine strikes on Carnaby's Black Cockatoo, a threatened species, is a concern in areas where wind energy development overlaps their habitat

The project area falls within the known distribution for Carnaby's Black Cockatoo and a number of recent records exist in the local area. As the species moves between foraging resources along the broader coastline (particularly the Geraldton Sandplains and Swan Coastal Plain bioregions) during warmer months, observation of this taxon in the vicinity during survey was anticipated, and its recorded presence within the survey boundary not unexpected.

The species occurs primarily in uncleared or remnant native eucalypt woodlands, and shrubland or kwongan heathland dominated by *Hakea*, *Banksia* and *Grevillea* species. It is also known to forage on farm crops or pasture, preferring Canola and other Brassicaceae species. Areas of vegetation containing *Banksia prionotes* trees are considered to represent the most valuable foraging habitat for Carnaby's Cockatoo within the proposed project area.

10.2. Rainbow Bee-eater (*Merops ornatus*) MA Visitor

The species is classified as 'Least Concern' under IUCN listings and is not considered globally threatened. Within Australia it is listed as a Marine species under the EPBC Act, but it does not hold any State listing under the BC Act. It is abundant across the state and commonly sighted in a variety of environments, including disturbed habitats. Small numbers are likely to occur in the survey seasonally as migratory visitors and potentially during the breeding period.

10.3. Sharp-tailed Sandpiper (*Calidris acuminata*) MI Migratory



This species is a small to medium migratory wader which can be found at locations across Australia during its non-breeding season from July to April. Forage habitat for the Sharp-tailed Sandpiper includes muddy margins of shallow wetlands, preferring ephemeral terrestrial wetlands over coastal mudflats when sufficient water is present. It is anticipated that small numbers will visit and utilise the Waterbody and/or Wetland habitat of the project area on a seasonal basis only when water is present. However, no other suitable habitat occurs within the survey area and, other than when flying to and from the site, they are unlikely to be present.



10.4. Common Sandpiper

The Common Sandpiper (*Actitis hypoleucos*) is a migratory bird species that has been identified as potentially visiting Lake Arramall.

This species typically frequents freshwater and coastal wetlands, where it forages along the shores and mudflats.

Table 3: Avifauna Conservation species

		Conservation Status	
Species (*)	Common Name - Description	EPBC Act	Western Australian
Mammals			
<i>Calyptorhynchus Latiostris</i>	<p>Carnaby's Black Cockatoo (CBC)</p> <p>Carnaby's black cockatoo, also known as the short-billed black cockatoo, is a large black cockatoo endemic to southwest Australia.</p> <p>It was described in 1948 by naturalist Ivan Carnaby. Measuring 53–58 cm in length, it has a short crest on the top of its head.</p>	<p>EN Endangered</p> <p>The Carnaby's Black Cockatoo is listed as Threatened (IUCN 2022)</p>	
<i>Merops Ornatus</i>	<p>Rainbow Bee-eater</p> <p>The rainbow bee-eater is a near passerine bird in the bee-eater family Meropidae.</p> <p>A striking, colourful bird, the Rainbow Bee-eater is medium sized, with a long slim curved bill and a long tail with distinctive tail-streamers</p>	<p>MA Conservation status:</p> <p>Least Concern (Population stable)</p>	

<p><i>Calidris Acuminata</i></p>	<p>Sharp-tailed Sandpiper</p> <p>The sharp-tailed sandpiper is a small migratory wader.</p> <p>The Sharp-tailed Sandpiper is a small-medium wader. The bird has a length of 17–22 cm, a wingspan of 36–43 cm and a weight of 65 g.</p>	<p>MI Conservation status:</p> <p>Least Concern (Population stable)</p>	
<p><i>Actitis hypoleucos</i></p>	<p>Common Sandpiper</p> <p>Identification and Habitat of Common Sandpiper</p> <p>The Common Sandpiper (<i>Actitis hypoleucos</i>) is a migratory bird species that has been identified as potentially visiting Lake Arramall.</p> <p>This species typically frequents freshwater and coastal wetlands, where it forages along the shores and mudflats.</p>	<p>Scientific name: <i>Actitis hypoleucos</i></p> <p>Conservation status: Least Concern (Population decreasing)</p>	

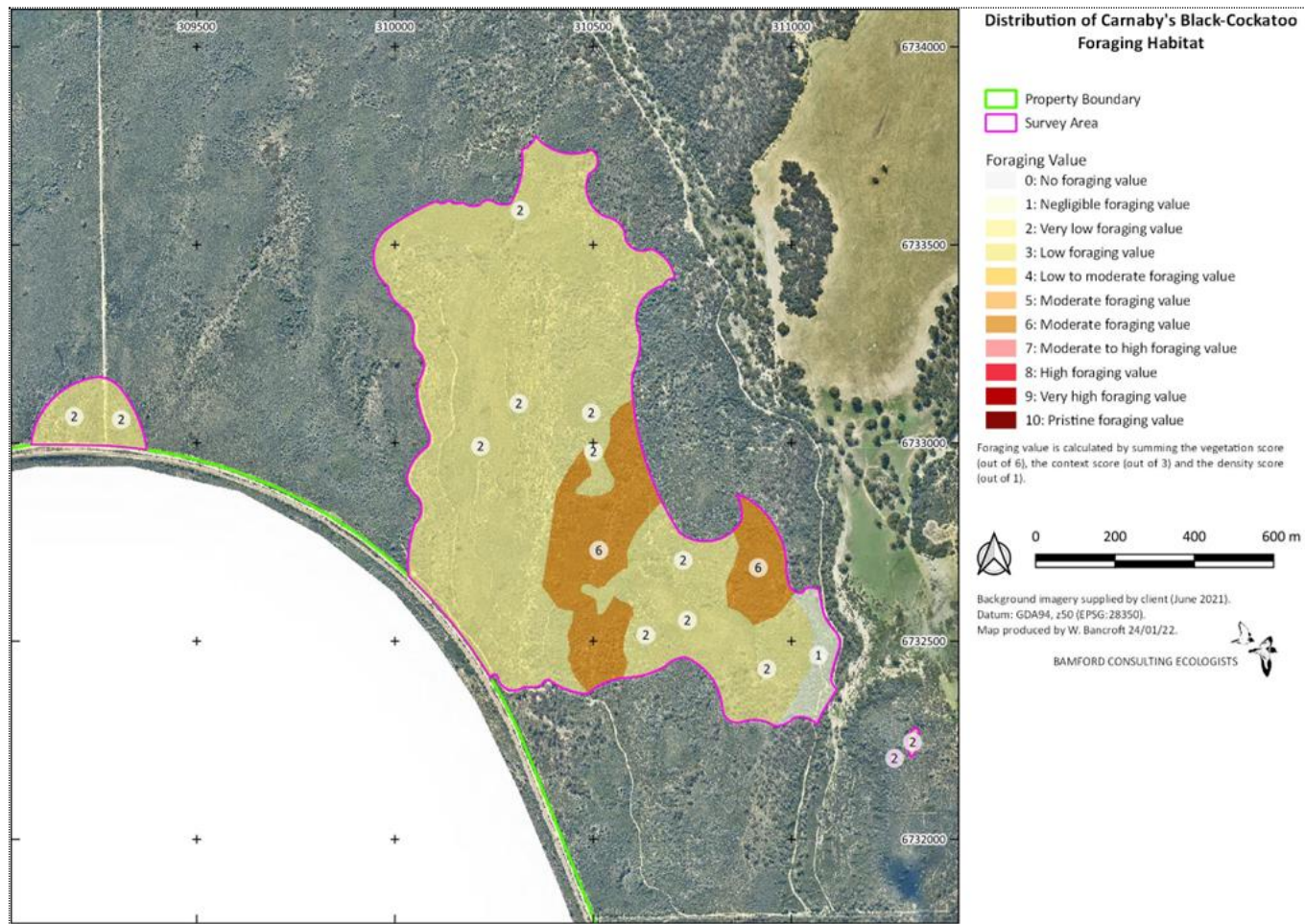


Figure 3 Primary Foraging Habitat Area within the AHP Development Envelope

11. Fauna Strike Mitigation Technology

Every wind farm site has its own unique identity, as it involves not only the physical landscape but also the three-dimensional dynamics of air and how it flows across the terrain. The complexities surrounding wind farms extend beyond just the technical aspects; they also encompass significant regulatory and environmental challenges.

One of the key challenges in wind farm development is the layout of the turbines, which must account for factors such as topography, wind flow patterns, and the spatial arrangement of the turbines themselves. These variables directly influence how the turbines interact with both the environment and wildlife. As a result, the species at risk from wind farms can vary from one site to another, depending on the local ecosystem and species that inhabit the area.

Given this variability, the approach to mitigating risks cannot be one-size-fits-all. Instead, developers must generalize from previous projects and apply broader environmental principles, adapting them to the specific characteristics and risks of each new site. This ensures a more tailored and responsible approach to balancing energy development with wildlife protection.

Dr. Emma Bennett, (*Elmoby Ecology*) who specialise in the impacts of wind farms on birds and bats, stated that in July 2021, Victoria Australia had 1,079 operational wind turbines, with an estimated 18,343 bird strikes per year, (Bennett's maximum prediction) a figure that doesn't measure up to the *377 million birds estimated to be killed each year across Australia by feral and pet cats.*

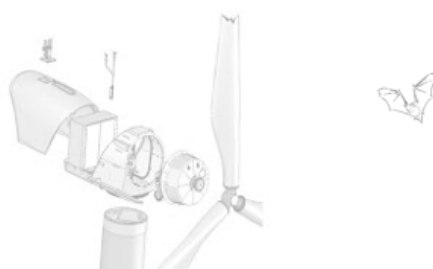
Australia's nascent wind energy industry, both built and planned, must look to innovations developed in the more mature wind industries of Europe and the U.S. to help mitigate bird strikes. Those technologies which range from radar-equipped turbines that shut down when a specified bird approaches, to simply painting a blade black, combine high or low-tech with our growing knowledge about the way birds and bats travel through the air.

11.1. Turbine Blade Collision Reduction

In a study that took place over 10 years, May's Norwegian Institute for Nature Research (NINA) team demonstrated that painting a single turbine blade black at the Smøla wind farm project reduced bird fatalities by almost 72% on average. It was particularly effective for birds of prey, although the authors cautioned the experiment needed to be repeated at other sites to find out if it could be extrapolated to other areas including birds and bats.

"To reduce collision susceptibility, provision of 'passive' visual cues may enhance the visibility of the rotor blades, enabling birds to take evasive action in due time," the team wrote in their published research.

The Musselroe wind farm based in Tasmania began using radar technology developed by Dutch company Robin Radars in 2019, which Woehler says has been extremely effective in mitigate bird strike.



11.2. Avifauna Detection Radar Installation to Detect and Mitigate Turbine Blade Strike

The installation of avifauna detection radar systems within the IGE Development envelope will be a strategic approach to minimising the impact of wind turbines upon the DE bird populations. These systems are designed to detect birds in the vicinity of wind turbines and trigger mitigation measures to prevent collisions, thereby ensuring the protection of avifauna, including species of conservation concern like the Carnaby's Black Cockatoo.

Objectives

- **Prevent Bird Collisions:** Reduce the incidence of bird strikes on turbine blades.
- **Collect Data:** Gather information on bird flight patterns and behaviours to inform future mitigation strategies.
- **Enhance Safety:** Improve the overall safety of the wind farm for avian species.

Components of the Radar System

- **Radar Units:** High-frequency radar systems capable of detecting birds of various sizes and speeds in the vicinity of wind turbines.
- **Software Integration:** Advanced software to analyse radar data and distinguish between bird species, sizes, and flight paths.
- **Control Systems:** Integration with wind turbine control systems to enable automatic response actions such as turbine shutdown or speed alteration.
- **Data Storage:** Systems to store and manage data for ongoing analysis and reporting.

11.3. Installation Process

Site Assessment and Planning:

- Conduct a thorough assessment of the wind farm site to determine the optimal locations for radar units.
- Plan the layout to ensure comprehensive coverage, taking into account the terrain, turbine placement, and prevalent bird flight paths.

Equipment Selection:

- Choose radar systems that are sensitive enough to detect small and large birds, including high-flying species.
- Ensure that the radar units can operate effectively in various weather conditions and are durable for long-term use.

Installation:

- Mount radar units on towers or existing turbine structures to achieve the best possible detection range.
- Ensure proper alignment and calibration of the radar units for accurate bird detection.

System Integration:

Integrate the radar systems with the wind turbine's operational control systems.
Set up the software to analyse radar data and automate responses to detected bird activity.

11.4. Mitigation Strategies: Curtailment

Temporary Turbine Shutdown:

When birds are detected approaching turbines, the system can automatically shut down the relevant turbines to prevent collisions

Speed Alteration:

In cases where shutdown is not feasible, the system can slow down the turbine blades, reducing the risk of fatal strikes.

Visual and Acoustic Deterrents:

Implement deterrent systems that activate when birds are detected, using lights or sounds to discourage birds from approaching the turbines.

11.5. Monitoring and Reporting

Continuous Monitoring:

- The radar systems operate continuously, providing real-time data on bird activity.
- Regularly review system performance and data accuracy to make necessary adjustments.

Data Analysis:

- Analyse collected data to identify patterns in bird activity movements, and the effectiveness of mitigation measures.
- Use insights to refine detection algorithms and response strategies.

Reporting:

- Generate regular reports detailing bird detections, turbine shutdowns, and other mitigation actions.
- Share findings with stakeholders, including environmental agencies and conservation groups, to demonstrate compliance and effectiveness.

Benefits

- **Enhanced Bird Protection:** Significant reduction in bird fatalities due to turbine collisions.
- **Informed Decision-Making:** Data-driven insights to improve future wind farm planning and operations.
- **Regulatory Compliance:** Meeting environmental protection standards and reducing the risk of regulatory breaches.
- **Community Engagement:** Providing transparency and building trust with local communities and environmental stakeholders.

Conclusion

The installation of avifauna detection radar systems at the AHP project site is a critical step towards mitigating the adverse impacts of wind turbines on bird populations. By employing advanced technology to monitor and respond to avian activity in real time, the project can ensure the protection of sensitive species and support the sustainable development of renewable energy.

11.6. Vulnerability to Wind Farm Development

Certain bird species are considered more vulnerable to the impacts of wind farm developments than others. This vulnerability is assessed based on a combination of ecological, behavioural, and physical characteristics. Below, we provide a detailed discussion on how species-specific vulnerability is considered in impact assessments, specifically focusing on Carnaby's Black Cockatoo (CBC) and other relevant species.

11.7. Criteria for Assessing Relative Vulnerability

Ecological Aspects:

- Habitat Preferences: Species that depend on specific habitats that are disrupted by wind farms are more vulnerable.
- Foraging behaviour: Species with specific foraging requirements that overlap with wind farm locations may face greater risks.

Sensitivity to Disturbance:

- Behavioural Responses: Species that are easily disturbed by human activities or structures are at higher risk.
- Displacement: Birds that avoid areas with wind turbines may experience habitat loss and increased competition for resources elsewhere.

Biometrics and Flight Behaviour:

- Flight Patterns: Species with flight behaviours that bring them into frequent contact with turbine blades are more susceptible to collision.
- Flight Altitude: Birds that fly at the height of turbine blades are at greater risk.
- Impact Assessment Process
- The impact assessment process considers the relative vulnerability of individual receptor species to wind farm development. This involves evaluating displacement, barrier effects, and collision risk based on the best available research, monitoring studies, and literature reviews.

Displacement:

- Assess the likelihood of species avoiding wind farm areas, leading to habitat loss or reduced habitat quality.
- Consider the availability of alternative habitats and the species' adaptability to change.

Barrier Effects:

- Evaluate whether wind turbines act as barriers to movement, disrupting migration routes or daily foraging activities.
- Assess the impact on population connectivity and gene flow.

Collision Risk:

- Radar Modelling of the potential for birds anticipated to collide with turbine blades based on flight patterns and turbine height.
- Consider mitigation measures such as turbine curtailment during high-risk periods.
- Species-Specific Vulnerability: Carnaby's Black Cockatoo

11.8. Ecological Aspects

Foraging Habitat: CBC relies on specific foraging habitats, particularly areas with Banksia species. The loss of these habitats could impact their food availability.

Breeding and Roosting: Although the project area has no breeding and minimal roosting habitats, these aspects are still considered in the assessment.

Sensitivity to Disturbance:

CBC's may exhibit avoidance behaviour around wind turbines, potentially leading to habitat avoidance. Disturbance during critical periods, such as foraging, will have minimal impacts.

Biometrics and Flight behaviour:

Flight Altitude: CBC generally flies at heights that would not intersect with turbine blades, decreasing collision risk.

Flight Patterns: The species' flight patterns and foraging routes are analysed to predict collision hotspots.

Mitigation Measures

Habitat Restoration and Protection:

Restore and enhance native vegetation to provide alternative foraging habitats and establish no-go zones to protect critical habitats from construction and operational disturbances.

Avifauna Detection Radar:

- Install radar systems to detect and monitor bird activity near turbines.
- Implement curtailment strategies during periods of high bird activity to reduce collision risks.
- Ongoing Monitoring and Adaptive Management:
- Conduct regular biodiversity surveys to monitor CBC populations and habitat usage.
- Adapt management strategies based on monitoring results to mitigate unforeseen impacts.

Conclusion

The Avifauna radar data processing carefully considers the relative vulnerability of species data like Carnaby's Black Cockatoo to wind farm development. By understanding species-specific ecological requirements, sensitivity to disturbance, and flight behaviours, the radar can accurately predict potential impacts and implement effective mitigation measures. This approach ensures that the development of wind farms, such as the AHP project, can proceed sustainably without significantly affecting vulnerable bird populations.

12. Curtailment Types

12.1. Blanket Curtailment

One curtailment strategy to reduce risk to birds is blanket curtailment, which refers to consistent application of curtailing turbines below a certain wind speed without consideration of other site-specific information. Typically, blanket curtailment is implemented beginning in mid-summer when bat fatalities begin to increase and continues through the end of fall migration. Some states compel blanket curtailment in the spring and early summer months as well.

Smart Curtailment

While blanket curtailment can be an effective way to reduce bat collision fatalities, it can result in unnecessary loss in electricity production and does not discriminate for species that are most at risk, or the conditions under which they are most at risk. Emerging research is helping identify conditions when bat collision risk is elevated, making it possible to optimize curtailment to be effective at reducing fatalities while minimizing power loss. For example, a smart curtailment approach that combined real-time data on wind speed and bat activity near turbines reduced estimated fatalities of all bats at a facility by nearly 85% while reducing the overall curtailment time by nearly 50% relative to controls. (American Clean Power Association 2015)

A study found that curtailment at an Australian wind farm led to a reduction in bird fatality by 54%, with marginal annual power and revenue loss. Curtailment is recognised globally as an effective means to reduce bat fatalities at wind farms (Behr et al., 2017), and the findings presented here add further support to this.

Increasing the cut-in speed at Australian wind facilities during periods of high bat activity will reduce fatalities.

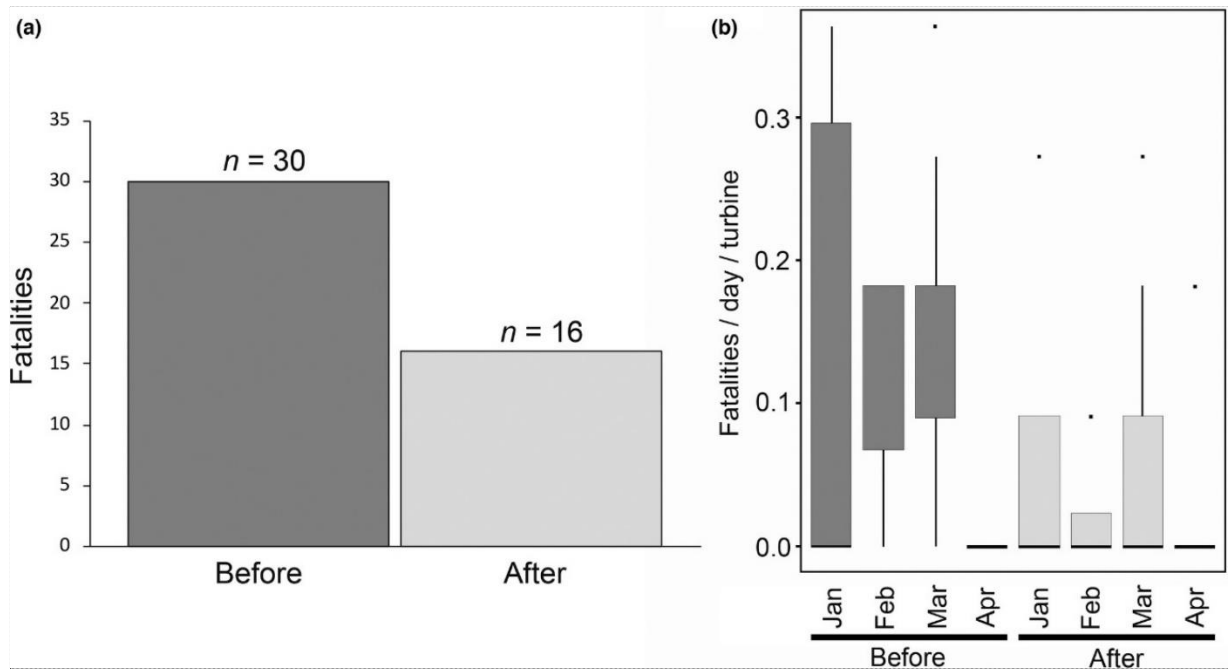


Figure 4 Curtailment Results (Bennett et al., 2022).

Above: Mortality survey findings from a curtailment-effects experiment at Cape Nelson North wind farm in Southwest Victoria, Australia, in 2018 and 2019. (a) Raw fatality counts during mortality surveys before (2018) and during (2019) curtailment. (b) Distribution of finds per turbine per survey presented as boxplot. The middle 50% of the data is contained within the box.

13. Bird Strike

Birds may adjust their behaviour in response to wind farms, which has the potential to affect their survival or reproductive success. Avoidance can occur at multiple scales, including macroavoidance (avoiding the entire wind farm), mesoavoidance (avoiding turbines or rows of turbines), and microavoidance (avoiding the rotor-swept area). Two terms associated with macroavoidance are “displacement” and “barrier effects.” Displacement occurs when birds alter their normal use of the habitat, whereas barrier effects occur when birds alter their normal flight path or altitude to move around the entire wind farm. These behaviours may limit foraging and could increase energy use during migration or commuting between breeding colonies or foraging areas. Microavoidance can be considered an escape mechanism or a last-second flight manoeuvre to avoid collision (Green et al., 2022).

13.1. Carnaby's Black-Cockatoo

Carnaby's black-cockatoo is a Commonwealth endangered species under the EPBC Act and is also 'Specially protected fauna' under the WA Wildlife Conservation Act. In Western Australia, the Carnaby's cockatoo is considered 'likely to become extinct' in the wild.

Pastoral and Wetland habitats within the DE are considered habitat for Carnaby's Cockatoo, noting that Heath and Shrubland may also represent foraging habitat, particularly areas consisting of *Banksia prionotes* and *sessilis* vegetation that are considered as a premium food source.

As a result of field survey findings (Ecoscape, 2023), IGE has revised its site layout to minimise clearing within Carnaby's Cockatoo habitat areas, including the repositioning of solar arrays and wind turbines.

There is little evidence in the scientific literature to indicate that CBC's are significantly affected by the presence of wind farms, e.g. displaced by the wind farm as a whole (macro-avoidance) or that wind farms within breeding ranges present a significant barrier to movement. However, this issue has not received much attention, in comparison to displacement effects on other species of conservation concern such as the wedge tailed eagle.

It is therefore difficult to draw firm conclusions about the potential magnitude of this effect. The Proposed Development would not have any direct displacement effect on any CBC breeding sites and is located outside of the likely core breeding range of any pairs that breed in the wider area. There is the potential for some displacement of foraging birds that occasionally use the site and nest in the wider area.

Bird fatalities due to collisions with wind turbines has been identified as one of the key adverse impacts on wildlife from wind farm development (e.g. Drewitt and Langston 2006, Marques et al. 2014103). However, most reviews of available data from studies of wind farms in the UK and the rest of Europe have found that collisions are generally rare in wind farms that have been well-sited, and do not reach a level that is likely to result in important demographic effects, other than at the scale of local populations (e.g. Crockford 1992104, Benner et al. 1993105, Winkelman 1995106, Erickson et al. 2001107 and Hötker et al. 2006108, Zwart et al. 2015109, Hötker et al. 2017110).

The risk of collision is dependent on a wide range of factors including time of year, bird age, size and flight behaviour, degree of displacement (i.e. behavioural avoidance of the wind farm area or individual turbines), nature of the surrounding topography, habitat quality, weather, wind speed and direction, wind turbine design, layout and spacing. Some of these factors may act in combination to increase collision risk (e.g. soaring species may use topographic features to help generate lift, whilst turbines placed close to these features may increase collision risk for those species) others may interact to decrease risk (e.g. birds may avoid the wind farm as a whole resulting in a reduced potential for collisions to occur).

Certain taxonomic groups are considered to be at greater risk of collision. In particular, larger, less manoeuvrable species and / or species (families, groups of species) which spend a considerable proportion of their life on the wing, for example, herons, wildfowl, waders, raptors, owls and gulls.

Potential Carnaby's Black Cockatoo impacts as a consequence of habitat loss, and possible turbine strike will be mitigated within the project area. IGE understand the flight path/ movements of Carnaby's Cockatoos are likely to be towards a water source or avifauna foraging habitat areas that are located to the east and south of the proposed wind turbines. To reduce fauna impacts we have designed the windfarm footprint to be located away from surrounding water bodies or bird foraging areas, thus lowering the risk of strike.

The size of the wind turbine also influences collision risk, with larger turbines being associated with higher collision rates, as the volume of air swept by the turbine blades generally increases with capacity of the turbine. However, the general pattern, in relation to bird mortality, is for wind farms comprising fewer and larger turbines to result in lower collision rates overall in comparison to wind farms, of a similar electricity generation capacity, with more numerous, smaller wind turbines (Thaxter et al. 2017:111).

Additionally, evidence from extensive satellite tracking of young and adult birds indicates that birds generally currently display a consistently high macro-avoidance of wind farms. Consequently, the risk of the predicted collision rate actually occurring is considered to be very low.

13.2. Waders – Cumulative Operational Collision / Displacement Effects

There is uncertainty about the extent to which collision mortality is a potentially significant issue at the regional population level for waders. This is due to limitations in standard pre-construction survey methods and collision risk modelling and the lack of systematic and effective monitoring of collision fatalities at operational wind farms. However, the available evidence indicates that collision rates, at other than local scales, are unlikely to reach a level where biological relevant demographic effects are detectable for golden plover or dunlin. Therefore, this assessment focuses on potential cumulative displacement effects only for these species.

14. Wind Turbine Strike Risk

As described above bird strike resulting in avifauna death is possible from wind turbine blade impacts. Spinning turbine blades can strike birds as they pass through the rotor-swept area; however, unlike bats, birds also collide with stationary structures. Woehler and Belbin (2019) presented a list of bird and bat species impacted by collisions with wind turbines in Tasmania, although there is no indication of the number of individuals of each species. Listed birds ranged in size from Silvereyes to larger water birds and raptors including Australian Pelicans and Tasmanian Wedge-tailed Eagles, indicating that size alone may not be significant in determining if a species is likely to occur within the rotating arc of wind turbines thus likely to collide with the turbine blades. Hull et al., (2013) identified Petrels and Shearwaters as the most likely taxonomic group to collide with wind turbines, followed by raptors, however, foraging strategies, foraging zones and key morphological features such as the ability to detect moving turbine blades, agility and behaviour of each species meant identification of risk at the taxonomic level was not reliable.

There is no publicly available data on bird strikes from wind turbines in Western Australia. Based on the avifauna recorded during this assessment, the conservation listed species considered most likely to be impacted within the range of rotating wind turbines are *Calyptorhynchus latirostris* (Carnaby's Cockatoo), listed as Endangered, one Migratory bird species: *Calidris acuminata* (Sharp-tailed Sandpiper), listed under the EPBC Act and one Marine bird species: *Merops ornatus* (Rainbow Bee-eater) listed under the EPBC Act, although not considered threatened, noting that other species may also occur) due to their hovering (stationary) behaviour when they have the potential to be 'sucked' into the rotating blades. It is not possible to estimate if, or how many, individuals of these, and other, species may be struck by wind turbine blades. Raptors are likely to forage over the entire site as their prey (reptiles, small mammals and smaller birds) whilst hovering occurs throughout.

Whilst Carnaby's Cockatoo may also be struck within the DE, IGE has located the wind turbines outside of the majority of CBC foraging habitat areas and in a direction the species is less likely to occur. Due to the updated wind turbine layout and the lack of foraging vegetation or water bodies within the disturbance footprint the risk of strike is greatly reduced.

Testing of remote-sensing technologies to detect bat and bird interactions is under evaluation or in use at a number of operational wind farms.

Additionally, the effective design and implementation, pollution prevention and control measures during construction to avoid / minimise adverse effects on aquatic habitats provide important foraging to species such as the common Sandpiper. With the proposed mitigation measures implemented residual impacts from disturbance during the construction phase would not be significant.

The design of the Proposed Development has been modified to reduce the potential effects on sensitive species. Particular consideration has been given to moving wind turbines away from areas of importance to CBC's.

The type and scale of the potential impacts of the proposed wind farm development on each species has been determined. Taking into consideration the conservation status, size and sensitivity of the populations affected and information available from the previous surveys.

Scientific literature regarding the vulnerability of the species to the range of potential impacts from onshore wind farm development.

Where there was uncertainty about the potential importance of the area for any particular species then this was accounted for in the assessment. For example, if there was suitable habitat present but no, or limited, presence of the species during the survey period and the realistic potential for use to increase in the future, then conservative assumptions were made in the sensitivity evaluation process. This provided the basis for a systematic, evidence-based assessment to be made of the potential impacts on each sensitive receptor.

14.1. Species impacts

No significant direct habitat loss was predicted for any species, taking into consideration the relatively small scale of permanent habitat loss from the construction of the wind farm. There is the potential for some degradation of surface waters (of importance to species such as CBC's example) as a result of siltation and potential chemical pollution during the construction process. However, it is considered reasonable to assume that good practice pollution avoidance and control measures, as set out in the outline Construction Environmental Management Plan, would be effectively designed and implemented. This would help to ensure that potential impacts are avoided / minimised and that significant effects from habitat degradation would be avoided for all species.

14.2. Bird Mortality

The risk of bird mortality from collision with the proposed wind turbines has been assessed using data gathered during systematic flight activity surveys and using a standard wind farm EIA collision risk model. Whilst collisions are predicted, the levels are not considered to be of concern at a population level beyond a local-scale for all species. There is some recognised additional uncertainty with respect to collision risk for CBC's and so a conservative approach has been taken in the assessment of potential effects for this species. A pre-construction and operational monitoring plan (for various species, including CBC's and conservation-listed migratory wading birds) is proposed

The comprehensive assessment and analysis of potential displacement effects indicate that the proposed AHP project will not lead to significant operational displacement of Carnaby's Black Cockatoo. The key reasons for this conclusion are:

- **Minimal Habitat Loss:** The direct impact on high-quality foraging habitat is minimal, with less than 5% of the development envelope affected.
- **Adaptive Foraging behaviour:** CBC has demonstrated the ability to adapt to environmental changes, utilizing alternative habitats as needed.
- **Effective Mitigation Measures:** Planned mitigation measures, including habitat restoration and the establishment of no-go zones, will further minimize any potential displacement impacts.

Overall, the proposed development is designed to ensure that CBC populations are not adversely affected by operational displacement, supporting the sustainable coexistence of wind energy production and conservation efforts for this endangered species.

The residual effects of decommissioning of the proposed wind farm are considered to be broadly similar to those during construction and are therefore not more than minor for all species and not significant. Prior to decommissioning, a thorough pre-works survey will be completed to determine the species present, their distribution and abundance and to inform the measures required to reduce any potentially significant impacts from disturbance and help ensure that the works proceed lawfully with respect to the legislation protecting foraging birds.

14.3. Cumulative Impacts

Careful consideration has also been given in the assessment to the potential for significant cumulative effects to occur from the Proposed Development in combination with existing and proposed wind farms in the wider region. The assessment considered information from published impact assessments where available. Species that were a focus for this aspect of the assessment include the Carnaby's Black Cockatoo. Effects on CBC's were considered initially in a local context and in terms of the wider regional breeding population.

In relation to potential cumulative wind farm displacement effects, taking into account two other proposed wind farms that could affect the same CBC territories as the Proposed Development, the combined predicted habitat loss was assessed as not significant for all territories affected and for the NHZ population as a whole.

The potential effects associated with the construction, operation and decommissioning of the Proposed Development that are the focus of this assessment are outlined below.

Potential effects that may occur during the operation of the wind farm include:

14.4. Potentially Significant Effects

- Disturbance to breeding, passage and wintering birds from supporting habitats, during construction works (for example, through human presence, vehicle movements, noise, dust, vibration, light);
- Short to medium-term loss and change to habitats through construction-related habitat damage (for example, from plant trafficking);
- Cumulative construction-related effects with other existing and proposed developments.
- Long-term loss of and change to habitats associated with built structures and new permanent access tracks;
- Risk of mortality from collision with wind turbines and other structures;
- Behavioural displacement from important supporting habitats due to the presence of the wind turbines;
- Potential effects on free movement (i.e. Potential barrier effects) to and from roosting, feeding and nesting habitats;
- Disturbance during maintenance and emergency works;
- Potential effects of habitat management within the wind farm area; and
- Cumulative operational-related effects with other existing and proposed developments.

Potential effects that may occur during the decommissioning phase include:

- Works associated with the dismantling of the scheme infrastructure resulting in physical damage to habitats supporting bird species of conservation concern;
- Disturbance to foraging birds arising from wind turbine dismantling and site restoration works; and
- Cumulative decommissioning-related effects arising from other existing and proposed developments.

14.5. Operational Collision Risk

No significant effects related to operational collision risk were identified for any receptor (i.e. local level effects only, risk of material demographic effects on regional populations would be avoided).

Assuming the proposed foraging bird protection measures, as set out above, are implemented effectively prior to and during the decommissioning works potential effects on birds would be minimised and there should be **no significant** residual effects for any receptor

There are no anticipated potentially significant cumulative effects on any another ornithological receptors.

There is the potential for the construction phase of Proposed Development to coincide with the construction of other wind farms. However, the locations of the construction sites should avoid any direct disturbance to known CBC foraging locations.

All proposals have committed to ensure that potential impacts on CBC's from construction disturbance is minimised through pre-works surveys and careful management of the works sites. There is also a legal requirement to ensure that foraging areas are avoided or not disturbed. The effectiveness of well-managed construction works avoiding significant long-term disturbance effects on CBC's is evident from the previous works completed for other Wind Farm and that this has not prevented the re-occupation and successful CBC's during and following construction

Table 4: Sensor Technologies

Single-Sensor Technologies	Multi-Sensor Technologies
<p>VARs: Near-Infrared Cameras</p> <p>Dtbird: Visual Or Thermal Cameras</p> <p>Dtbat: Thermal Cameras Or Acoustic Detectors</p> <p>ID-Stat: Acoustic Impact Sensor</p> <p>ACAMS: Stereo-Optic Visual Cameras With Fisheye Lenses</p> <p>B-Finder: Thermal Camera</p> <p>Thermal Tracker: Near-Infrared Cameras</p>	<p>WT-Bird: Accelerometer Impact Sensors And Near-Infrared Cameras</p> <p>ATOM: Thermal Cameras, Visual Cameras, And Acoustic Microphones</p> <p>Wind Turbine Sensor Unit: Accelerometers And Contact Microphone Impact Sensors, Visual And Infrared Cameras, And Acoustic Microphones</p> <p>MUSE: Horizontal Radar and Thermal or Visual Cameras</p> <p>TSAVA: Stereo Thermal Cameras And Acoustic Microphones</p>

VARs - Visual Automatic Recording System;

ATOM - Acoustic And Thermographic Offshore Monitoring System;

ACAMS - Aero fauna Collision Avoidance Monitoring System;

MUSE - Multi-Sensor (Formerly Known As TVADS);

TSVA - Thermal Stereo Vision Application.

15. Examples of Commonly Used Monitoring Methods

Acoustic detectors: record the vocalizations of bats within approximately 40 m and birds within 100 m. The range of detection will vary based on the frequency of vocalisation (i.e., lower frequency sounds travel farther), intensity, and orientation of the animal to the microphone. Data can be used to identify species or species groups, characterize seasonal and temporal activity patterns at a local scale, and relate such patterns to weather and wind turbine operational conditions.

Transect surveys: record observations of individual animals along transects. Birds flying or on the surface are included. The field of view may extend several hundred meters (yards) but will vary based on each observer or the binoculars used. Data can be used to determine presence, density, behavior, and flight height.

High-resolution digital aerial surveys: collect imagery from fixed-wing aircraft surveys over large distances (e.g. a wind energy facility and surrounding area). Surveys are conducted during daylight hours and require high-visibility conditions. Analysis can provide species abundance and distribution.


Cameras: provide observations of animals within the field of view. Visual and thermal cameras are used to record data for animals active during the day or night, respectively. The field of view will vary based on the type of camera, lens, and positioning on the turbine. Cameras can be positioned on the tower pointing up toward the blades or out toward the land, and on the rotor pointing along the length of the blades. Data can be used to assess behavioral interactions (e.g. attraction or avoidance) between bats or birds and wind turbines. Cameras can often distinguish between birds and bats but are generally not able to identify species.



Radar: tracks moving objects from a few to several hundred kilometers (or miles) away from a wind turbine, depending on the type of radar technology (e.g. antenna type, power of the radar signal, and radar wavelength). Data on flight height, flight direction, flight speed, and passage rates are recorded. Most radar technologies cannot distinguish between bats and birds, and some may not be able to detect smaller animals.


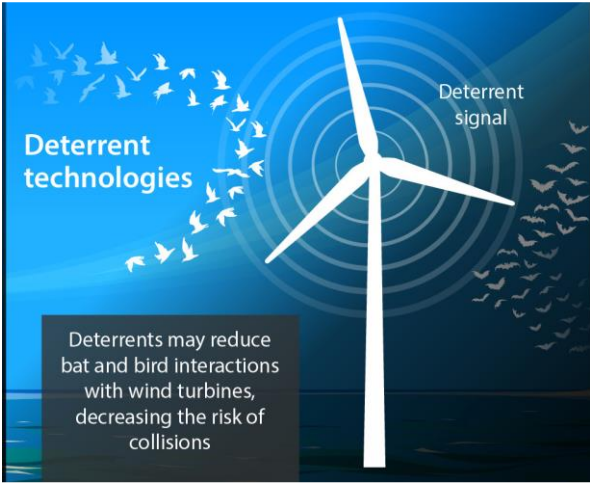
Strike Indicators: record collision events using sensors installed along the length of each blade. Sensors can include microphones and accelerometers. Data can be used to determine the timing of collisions, size of the object striking the blade, and where along the blade the collision occurred. Indicators cannot identify the type of animal (bird or bat) or species colliding with the blade.


Telemetry: provides information on movement patterns of tagged animals over time. Automated radio telemetry requires specialized receiving stations to record the presence of tagged individuals within a few to several kilometers (miles). Radio tags are small enough to use on most bats and birds. Satellite telemetry does not require receiving stations, but the weight of the tags limits their use to larger species and/or shorter tracking duration. Data can be used to identify flight paths, movement corridors, and high-use areas.



Table 5: Comparison of Mitigation Methods


Method	Labour Intensive	Effectiveness	Images
<p>Colouring blades black</p> <p>One method for reducing avian collisions with wind Turbines is to increase the visibility of the rotor blades.</p> <p>One study carried out by the Norwegian Institute for Nature Research from the 19th of February 2020 examined the effect of painting one of the three rotor blades black to reduce motion smear and therefor increase visibility.</p> <p>The painting was done at four wind turbines in the SolarWinds-power plant in Norway.</p> <p>The experiment and the searches ran for seven and a half years pre- and three and a half years post-treatment.</p> <p>At the treated turbines these numbers decreased from 11 to 6. The authors report that there has been an average 71.9 percent reduction in the annual fatality rate after the painting was conducted.</p> <p>The colouring of one rotor blade is a simple and highly effective method. The study proves that this method is universally applicable for horizontal axis turbines and should lead to similar results no matter the location of the wind power plant.</p>	<p>Low</p>	<p>high</p>	

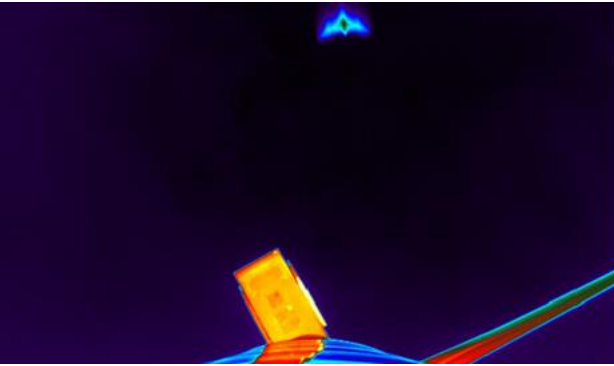

Method	Labour Intensive	Effectiveness	Images
<p>Tower painting</p> <p>Other than colliding with the rotor blades, birds do also collide with the tower base of wind turbines.</p> <p>In a study from the Norwegian Institute for Nature Research the effect of tower base painting on the collision rates of <i>Lagopus</i> (Willow ptarmigan) with the tower base is examined.</p> <p>The authors report a 48 percent reduction of recorded ptarmigan carcasses per search at the painted turbines relative to the control turbines.</p>	Low	Medium	
<p>Violet/ UV-Lighting</p> <p>A study conducted by the Norwegian Institute for Nature Research from 2017 tested if birds in night respond to violet and ultraviolet lighting. The basic idea for the experiments is, that many birds that collide with on-shore wind turbines are sensitive to ultraviolet light.</p> <p>Reports indicate that relative to the control nights, the light activity of the birds was reduced by both types of lighting. There was a 27 percent reduction when the ultraviolet light was on and a 12 percent reduction with the violet light on. In addition, a vertical displacement was present, with the birds increasing their average flight altitude by seven meters.</p> <p>Lasers and strobing lights have shown success for deterring birds but may also result in attraction or other behavioural/physiological changes.</p>	Low	Low	

Method	Labour Intensive	Effectiveness	Images
<p>Temporary shutdown: Curtailment</p> <p>The Department of Ethology and Biodiversity Conservation from Seville in Spain, among others, conducted a study at 13 wind farms in Tarifa, Cadiz, Spain before and after when selective turbine stopping programs were implemented.</p> <p>The authors recorded a reduction in the vulture mortality rate by 50 percent with a consequent reduction in total energy production by 0.07 percent per year.</p> <p>The study chosen to represent the method of temporary shut-downs reports promising results: minimal loss of energy production while significant reduction in avian fatalities.</p>	Medium	High	
<p>Auditory signals: Bio-Acoustic</p> <p>Another method to reduce bird-strikes on wind turbines or buildings in general is to alert the bird to the presence of an obstacle by means of an auditory signal.</p> <p>The experiment showed that the birds reduced their flight speed approximately 20 percent more when the sound field was present. The authors concluded that, the birds were only able to completely avoid the net when they got an acoustic warning signal, but they also reduced their speed significantly.</p> <p>Audible noise deterrents for birds typically are not successful, as individuals can become habituated to the sound.</p>	Medium	Low	

Method	Labour Intensive	Effectiveness	Images
<p>Ultrasonic deterrents mounted on the nacelle of wind turbines have mixed results for deterring bats and more research is needed to demonstrate consistent reductions in mortality.</p> <p>For bats, an ultrasonic (e.g. >20 kHz) sound might interfere with their sonar and be disorienting.</p> <p>Acoustic detectors Record the vocalisations of bats within approximately 40 m and birds within 100 m. The range of detection will vary based on the frequency of vocalization (i.e. lower frequency sounds travel further), intensity, and orientation of the animal to the microphone. Data can be used to identify species or species groups, characterize seasonal and temporal activity patterns at a local scale, and relate such patterns to weather and wind turbine operational conditions.</p>			
<p>Repowering</p> <p>One study suggested that increasing the tower height might actually reduce the bird mortality by over 70 percent.</p> <p>Smallwood et al. (2009) examined the effect that repowering of wind turbines had on the fatality rates of birds. In the study they compared estimates of fatality rates from between 1998-2003 and 2005-2007 and between a repowered wind project and old-generation wind turbines.</p> <p>It should be mentioned, that in the repowering project vertical axis turbines were replaced by horizontal axis turbines. Which lead to an insignificant rise in fatalities for specific bird species.</p>	High	Medium	

Method	Labour Intensive	Effectiveness	Images
<p>Radar Technologies</p> <p>The radar tracks moving objects from a few to several hundred kilometres away from a wind turbine, depending on the type of radar technology (e.g. antenna type, power of the radar signal, and radar wavelength). Data on flight height, flight direction, flight speed, and passage rates are recorded. Radar technologies are able to distinguish between bats and birds.</p> <p>During pre-construction, radars can be used as a reliable and long-term measurement tool, recording baseline data, gathering scientific data on bird movements in the planned wind farm area, including foraging and flight activity.</p> <p>Avian and bat radars continuously measure the number of birds that enter a pre-set range from wind turbines. When this number exceeds a threshold and depending on other factors including wind direction/strength, bird behaviour, time of the day etc., the system generates a shutdown command to either a group of turbines or an individual turbine, depending on the local situation and user requirements.</p> <p>The radar is a single sensor system, providing full 3D information of all avian targets, and surrounds. All birds project height information and there is virtually no 'cone of silence' above the radar space, offering full 3D coverage, height data for all bird trajectories, around the radar, at all times.</p>	<p>Medium</p>	<p>High</p>	 

Method	Labour Intensive	Effectiveness	Images
<p>SCADA Bird & Bat Mortality Risk Mitigation Systems For operating windfarms, Supervisory Control and Data Acquisition (SCADA) software functionality allows radar systems to operate as a real time bird and bat monitoring and a risk mitigation system.</p> <p>Radar software combined with Avian Radar Systems and other sensor data inputs including weather and visibility information delivers real-time radar-based turbine curtailment or deterrence to prevent bird mortality while maximising energy production.</p> <p>This system is proven bird and bat mortality risk technology in operational use at wind farms for protection of migratory birds, resident birds, raptors and bats.</p> <p>SCADA provides advance “early” warnings (Extending 2-12 km) to windfarm managers and operators of approaching migratory or individual birds and bats under mortality risk conditions and manually or automatically implements responses up to and including curtailment and idling of turbines.</p> <p>The system can operate autonomously and in all weather and visibility conditions, automatically idling individual, groups or all turbines when risk conditions are detected by the system, applying pre-programmed ‘risk rule sets’, restarting the curtailed turbines when the risk has abated.</p> <p>The software is fully compatible with all wind farm turbines and SCADA systems providing full development, integration, implementation and operational support which includes development of real-time remote operator interface displays.</p>	<p>Medium</p>	<p>High</p>	

Method	Labour Intensive	Effectiveness	Images
<p>Thermal Imaging: Radar</p> <p>Thermal image of a bat flying near a land-based wind turbine.</p>	Med	Med	 <p>A thermal image showing a bat in flight. The bat is represented by a bright, multi-colored shape (yellow, orange, and red) against a dark background. The background shows the blurred, colorful structure of a wind turbine.</p>
<p>Thermal Tracker</p> <p>Camera system for monitoring bats and birds at wind farms.</p>	Med	High	 <p>A photograph of a camera system mounted on a metal frame. The system includes a camera lens, a sensor, and various cables, used for monitoring bats and birds at wind farms.</p>

16. Collision Risk Modelling (Radar)

CRM's software use data collected by radar to identify the physical description of the species (e.g. body size and wingspan) and how the animal behaves around wind turbines (e.g. avoidance, flight height, flight speed, and activity periods).

Bird surveys are used to describe the number of birds passing through a region and the distribution of their flight height, speed, and patterns. Characteristics of the wind farm and turbines (e.g. blade length and rotor speed) and site conditions (e.g. geography and weather) are included to estimate the number of bird or bat collisions during a monthly or annual cycle.

The model predicts the probability that a mammal will be in the rotor swept area of a wind turbine as the blade passes through, then applies a species-specific avoidance rate to the interactions to determine the number of instances where an individual animal will be in that location instead of avoiding it. CRMs are flexible in scale and have been used to estimate population-level impacts at a regional scale or fatalities of a particular species at a proposed wind farm.

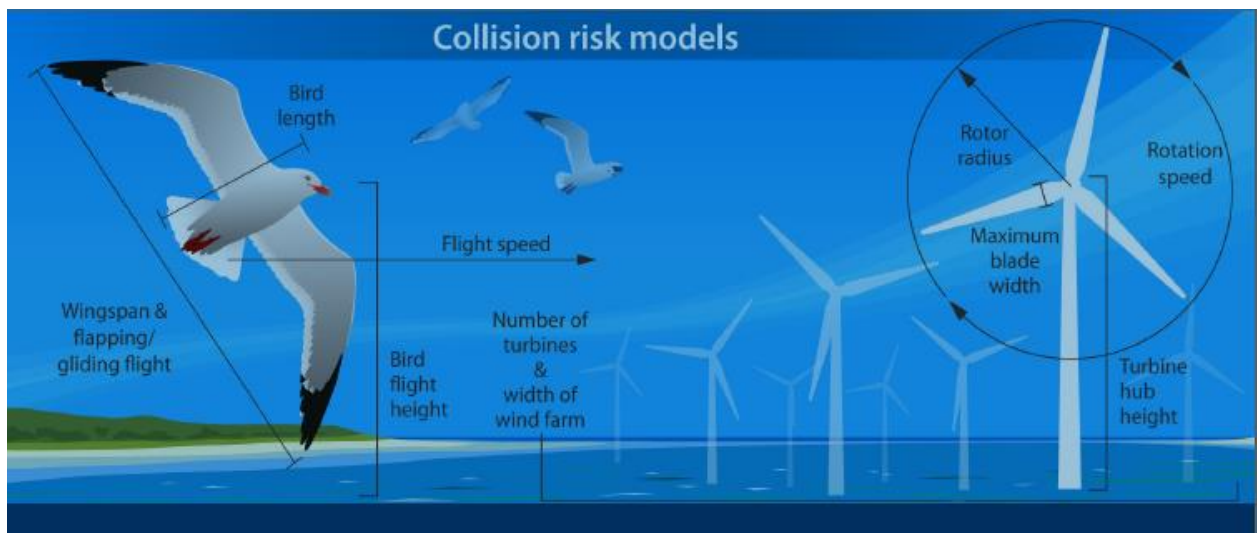


Figure 5 Collision Risk Models

Additional Variables: Bird Density, Avoidance Rate, Percent Nocturnal Activity, Rotor Pitch, Operational times parameters used in collision risk models. Graphic by the National Renewable Energy Laboratory.

17. Advantages of installing Avifauna Detection Radar on Site

Install Radar Systems to Detect and Monitor Bird Activity Near Turbines:

Avifauna detection radar systems provide real-time monitoring of bird activity in the vicinity of wind turbines.

These systems offer several significant advantages:

Early Warning System: The radar can detect birds approaching the turbines, providing early warnings to operators. This allows for timely interventions to prevent potential collisions.

Continuous Surveillance: Unlike human observers, radar systems can operate continuously, day and night, and in all weather conditions, ensuring comprehensive monitoring.

High Precision: Modern radar systems can distinguish between different bird species and sizes, allowing for targeted responses based on the specific risk levels of different birds, including endangered species like the Carnaby's Black Cockatoo (CBC).

Implement Curtailment Strategies During Periods of High Bird Activity to Reduce Collision Risks:

Curtailment strategies involve temporarily shutting down or slowing wind turbines during periods of high bird activity to prevent collisions. The advantages of this approach include:

Collision Reduction: By stopping turbine blades during high-risk periods, the risk of bird collisions is significantly reduced, protecting avifauna, particularly during migration seasons or breeding periods.

Data-Driven Decisions: The radar data provides insights into peak activity times, allowing for informed decisions on when to implement curtailment, optimizing both bird protection and energy production.

Dynamic Response: Curtailment can be activated dynamically based on real-time data, ensuring that turbines are only shut down when necessary, minimizing operational disruptions.

Ongoing Monitoring and Adaptive Management:

Continual monitoring and adaptive management are critical for the long-term success of bird conservation efforts at wind energy sites.

Regular Biodiversity Surveys: Conducting regular biodiversity surveys helps track CBC populations and their habitat usage, providing valuable data on the health and behaviour of the bird population over time.

Impact Assessment: Ongoing monitoring allows for the assessment of the impact of wind turbines on bird populations, ensuring that any negative effects are detected early.

Adaptive Management Strategies: Based on the results of the monitoring, management strategies can be adapted to mitigate unforeseen impacts. For instance, if a particular turbine is found to pose a high risk to birds, its operation can be adjusted accordingly.

Regulatory Compliance: Continuous monitoring helps ensure compliance with environmental regulations and conservation commitments, demonstrating responsible environmental stewardship.

18. Radar Technologies for Avian and Bat Detection in Wind Farms

IGE will be utilising 'Robin Radar' systems at the AHP wind farm for avian and bat detection, a sophisticated tool designed to provide comprehensive monitoring and data collection capabilities. These radar systems are critical for mitigating the risks posed to birds and bats by wind turbines, as they allow for real-time detection and tracking of wildlife movements. By leveraging this advanced technology, IGE can implement proactive measures to minimize potential impacts on local bird and bat populations, ensuring that the wind farm operates in an environmentally responsible manner.

Key Features of Radar Technologies:

Detection Range and Capabilities:

Range: Radar systems can track moving objects from a few kilometres to several hundred kilometres away from a wind turbine, depending on the specific radar technology.

Types of Radar: The performance and range depend on factors such as antenna type, power of the radar signal, and radar wavelength.

Data Collection:

Flight Parameters: Radars record data on flight height, direction, speed, and passage rates.

Species Differentiation: Modern radar technologies are capable of distinguishing between bats and birds, enhancing the accuracy of the data collected.

Pre-Construction Use:

Baseline Data: During the pre-construction phase, radars serve as reliable long-term measurement tools. They record baseline data and gather scientific information on bird and bat movements, foraging, and flight activity within the planned wind farm area.

Operational Use:

Continuous Monitoring: Avian and bat radars continuously measure the number of birds and bats entering a pre-set range from wind turbines.

Threshold-Based Actions: When the number of detected animals exceeds a threshold, the system can generate a shutdown command. This command can be tailored to shut down either individual turbines or groups of turbines, depending on local conditions and user requirements.

3D Tracking and Coverage

Single Sensor System: The radar is designed as a single sensor system, providing full 3D information on all avian and bat targets within its range.

Height Information: It offers continuous height data for all detected trajectories, ensuring comprehensive monitoring.

No 'Cone of Silence': There is virtually no 'cone of silence' directly above the radar, ensuring full 3D coverage at all times.

Application in Wind Farm Projects

Mitigating Turbine Blade Strike

Pre-Construction Monitoring

Baseline Surveys: Conducting thorough pre-construction surveys to gather baseline data on avian and bat activity. This data helps in understanding the movement patterns and identifying critical habitats within the planned development area.

Operational Monitoring and Management:

Real-Time Data: Continuous real-time monitoring of bird and bat movements around the turbines.

Threshold Alerts: Setting specific thresholds for bird and bat activity that trigger automatic turbine shutdowns to prevent collisions. This includes factors like wind direction, wind strength, and bird behaviour.

3D Coverage and Tracking:

Comprehensive Monitoring: Full 3D tracking provides detailed insights into the height, direction, and speed of all avian targets, ensuring that no significant activity goes undetected.

Height Data Utilization: Height data is particularly useful in understanding flight patterns and adjusting turbine operations to minimize strike risks.

Example Case: AHP Project

For the AHP project, integrating advanced radar technology offers several benefits:

Enhanced Safety for Carnaby's Black Cockatoo:

Monitoring Movements: Continuous tracking of Carnaby's Black Cockatoo to prevent turbine strikes.

Data-Driven Decisions: Using collected data to make informed decisions about turbine operation adjustments.

Minimised Impact on Migratory and Resident Species:

Seasonal Adjustments: Adjusting turbine operations during peak migration seasons based on real-time radar data.

Habitat Protection: Identifying and avoiding key flight paths and foraging areas to protect critical habitats.

Compliance and Conservation:

Regulatory Compliance: Ensuring adherence to environmental regulations and demonstrating commitment to biodiversity conservation.

Adaptive Management: Continuously updating and refining mitigation measures based on ongoing radar data and monitoring results.

Conclusion

The integration of advanced radar technologies within wind farm projects is a proactive approach to mitigating the risks posed to birds and bats by turbine operations. By providing comprehensive 3D tracking and real-time data collection, these systems enable effective management strategies that protect vulnerable species and ensure sustainable wind farm operations. For projects like AHP, radar technology will play a crucial role in balancing renewable energy development with the conservation of biodiversity.

19. Sustainability

Recyclable Offshore Wind Turbine Blades

Siemens Gamesa has established a target of producing fully recyclable turbine blades by 2030 and fully recyclable turbines by 2040. While it is currently possible to recycle 85% of a turbine, recycling the turbine's blades in a cost-efficient way has proved more problematic. This is due to the fact that dissolving the resin used to fuse the different elements of the blade together has not been possible.

The first six blades using the new resin were produced in Siemens Gamesa's factory in Aalborg, Denmark in 2021 after rigorous testing and qualification. Recyclable Blades have been installed on the German offshore wind farm Kaskasi throughout 2022 and manufacturing capacity is being expanded to fully commercialise the blades. It is expected that the Recyclable Blade can be utilised on large-scale wind farms by 2024.

The Siemens Gamesa Recyclable Blade is an important milestone in achieving the company's vision of fully recyclable turbines by 2040. If all new offshore projects leading up to 2050 are equipped with Recyclable Blades, more than 200,000 blades would be recycled, rather than ending up in landfill, thus significantly lowering Siemens Gamesa's environmental impact. Furthermore, being able to separate and recycle the blade materials instead of paying to dispose of them could transform some of the costs associated with decommissioning into revenue streams.

Figure 6 Siemens Gamesa Renewable Energy 2023



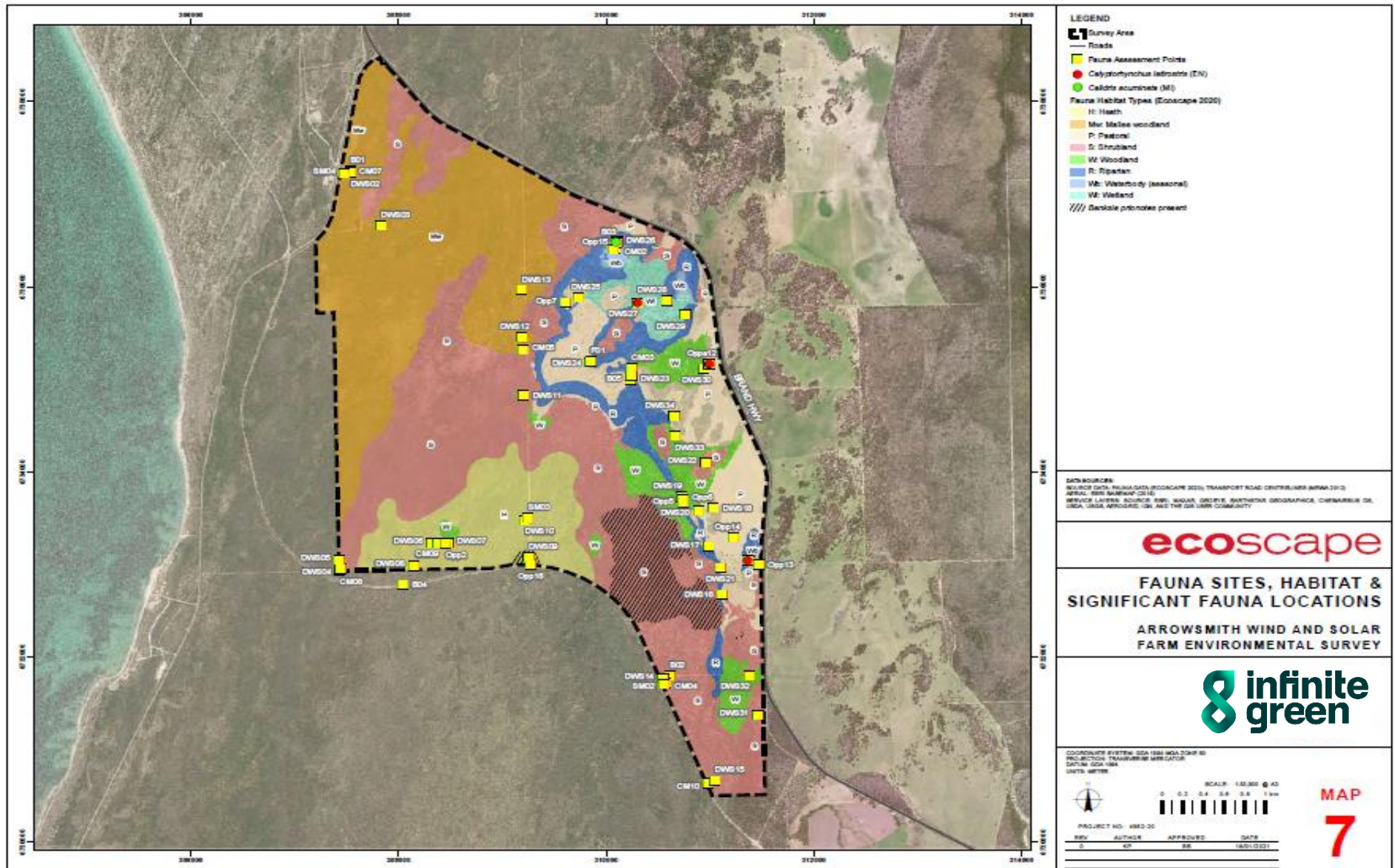


Figure 7 Fauna Significant Sites

20. Summary

The AHP project development envelope is not within the modelled breeding range of Carnaby's Black Cockatoo (Department of Sustainability Environment, Water, Population and Communities, 2021), however, but the site is likely utilised by the species for foraging (Williams et al., 2017), due to the occurrence of *Banksia sessilis* and *Banksia prionotes* within the Proposal area. Due to the potential presence of Carnaby's Cockatoo within the project area, IGE intend to deploy Avifauna radar technology to monitor avifauna behaviour.

Common methodologies applied at land-based wind farms for assessing bird/collisions and monitoring mortality rates include carcass surveys and long-term visual observations, typically conducted at the scale of a single wind farm. However, the accuracy of carcass counts can be compromised due to surveyor efficacy and the removal of carcasses by scavengers, potentially leading to an underestimation of the actual mortality rate. Moreover, carcass surveys can be costly and may be impractical in certain environments, such as agricultural fields, dense shrub habitats, and remote locations (Hu et al., 2018). These limitations highlight the challenges in accurately assessing the full extent of bird and bat collisions at wind farms and underscore the need for more reliable and efficient monitoring technologies.

To ensure that the benefits of renewable wind power generation are not outweighed by the mortality of protected avian and bat species, it is essential to assess and mitigate collision risks. An innovative onboard, integrated multi-sensor system has been developed to detect turbine collision events and provide detailed taxonomic information about the impacted species. This system is crucial for balancing renewable energy development with wildlife conservation.

Technology

IGE intend to utilise a 3D Radar Systems with dedicated Avifauna and bat radar detection system, integrating both horizontal and vertical radar transmissions with autonomous, stand-alone observation technology. This system was designed and optimised for selective turbine shutdown and as a bird mortality mitigation system for both wind farm monitoring and a bird migratory mapping tool.

Bureau Waardenburg, a pioneers in their field and the largest ecological consultancy in the Netherlands, were the first company to utilise this system, monitoring behaviour, behavioural patterns of flying birds in relation to man-made structures within a urban landscape (Robin Radar Systems, 2023).

Collecting and utilising data during windfarm operations will be necessary to understand behavioural patterns, distribution, and movement patterns of both bats and birds. During operations, monitoring data collected at the project site will be compared to previously collected ecological baseline data to determine fauna behavioural change if any.

Fixed surveys, high-definition aerial surveys, radar surveys, and telemetry will provide IGE with data showing movement patterns, species abundance, distribution, behaviour, passage rates, flight speed, and flight height of bats and birds within the project envelope. This data, combined with infrastructure design and specifications modelling, will be used to develop collision risk models (CRM's) to avoid collision or destruction of bird/bat habitat.

IGE will communicate technical specifications required for Australian environmental conditions to ensure radar technologies can be safely integrated within our project site.

Understanding windfarm impacts upon Avifauna, especially the endangered Carnaby's Black Cockatoo is critical. Radar has vastly increased the quality and accuracy of data with its ability to distinguish both mammals by size and shape. This information will provide IGE with a detailed profile of individual bird and bat species/types, improving our mitigation adaption.

Hardware: *The Radar Max has 360-degree rotation, resulting in track updates every second. This allows uniquely detailed 3D visualisation of bird/bat movement and flight paths, including data exports to Google Earth. Bird movements have the option to be displayed in either real-time on a PC or mobile platform (both iOS and Android).*

Software: *Avifauna 'bird viewer' software will be utilised to enable observation of Avifauna in real-time situational awareness, 24 hours per day. Graphical platforms will immediately generate and send graphical representations of bird/bat movement to the end user in real time.*

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