South African Good Practice Guidelines for Surveying Bats at Wind Energy Facility Developments - Pre-construction

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GLOSSARY OF TERMS

Acoustic monitoring: Bat sampling conducted through recording and analysing echolocation calls.

Barotrauma: Physical damage to body tissue caused by a difference in pressure between a gas space inside, or in contact with the body, and the surrounding fluid.

Bat detector: Equipment capable of detecting and sometimes recording ultrasonic echolocation calls of bats.

Bat Pass: A single crossing of a bat through a bat detector's cone of detection. This can be displayed in the data by a single echolocation call or pulse or by a series of bat echolocation call pulses, known as a call sequence.

Blade: The aerodynamic surface of a wind turbine that catches the wind.

Civil Twilight: This is defined to be the time period when the sun is no more than 6 degrees below the horizon at either sunrise or sunset. The horizon should be clearly defined and the brightest stars should be visible under good atmospheric conditions (i.e. no moonlight, or other lights). One still should be able to carry on ordinary outdoor activities. Evening civil twilight begins at sunset and ends when the geometric centre of the sun reaches 6° below the horizon (civil dusk). Morning civil twilight begins when the geometric centre of the sun is 6° below the horizon (civil dawn) and ends at sunrise.

Clutter: Obstacles present in an area that can affect the flight behaviour of bats, bat call structure and recording of bat echolocation calls.

Colony: The term colony is used to identify a genetically related or socially interactive population of bats within an area that may associate within a number of roost sites during the annual cycle.

Echolocation: Use of ultrasound and the returning echoes to orient and navigate in the environment.

Harem: The mating and association of several adult females with one male.

Harp trap: Harp traps are composed of two (sometimes up to four) frames strung vertically with monofilament line. Bats attempting to pass through the trap are captured either by colliding with the exterior of the lines or by entering the space between the frames. Once captured, bats flutter down into a catch bag where they are confined until being removed for identification.

Maternity roost: A maternity roost is the structure within which pregnant females aggregate in summer to give birth to young. The bats may utilise the maternity roost up until Autumn, when they move on to winter hibernula.

Microphone sensitivity: The minimal amplitude required at a given frequency for a microphone to detect a sound.

Mist net: A finely woven large mesh erected to entangle and capture bats.

Nacelle: The body of a propeller-type wind turbine, containing the gearbox, generator, blade hub and other parts.

Population: A population is the number of individuals of a given species occupying a certain area of land over a certain period of time.

Pulse: A single emission of sound; i.e. a bat call.

Roost: This term has a dual application and is used to describe the structure (house, shed, bridge, tree, cave, etc.) within or on which a number of bats take shelter. Secondly, the bats within or on such a structure are also referred to as a roost of bats. 'Roost' does not infer a genetic or social association between the bats within a structure.

Sunrise: Sunrise is the instant at which the upper edge of the sun appears over the eastern horizon in the morning

Sunset: The time of sunset is defined in astronomy as the moment when the trailing edge of the sun's disk disappears below the horizon.

Wind energy facility: A group of wind turbines often owned and maintained by one company, also known as a wind power plant or wind farm.

Wind turbine: A device that converts kinetic energy from the wind, also called wind energy, into electrical energy in a process known as wind power.

EXECUTIVE SUMMARY

These good practice guidelines are based on information gathered and compiled from North America and Europe, with input from South African scientists and specialists. The guidelines present a summary of evidence relating to the known threats to bats from wind turbines, the international and national law and legislation that underpins the need to assess the impact of wind energy facilities on bats and the important ecosystem services bats provide in the South African context. Guidance is provided on preparing, planning and implementing bat pre-construction monitoring with respect to wind energy facility developments, survey techniques and interpreting results. Although not dealt with in detail, this document also includes some information on the need for the consideration of cumulative impacts, and post-construction monitoring. It is important to note that this document provides *guidance* and that each assessment should consider the scale of the likely impacts and take a proportionate approach.

Any deviation from the recommended survey guidelines should be acknowledged and motivated clearly. Such deviation should be informed by scientific knowledge, evidence and expertise. Financial or capacity constraints are not acceptable reasons for deviating from the minimum requirements.

1. INTRODUCTION AND SCOPE

This guidance is intended for all types of onshore wind energy facilities, from single turbines to multi-turbine wind energy facilities, regardless of size. The first edition of these guidelines were adapted from the second edition of The Bat Conservation Trust's Bat Surveys - Good Practice Guidelines, Surveying for Onshore Wind Farms (Hundt, L. 2011; editor), with the third edition incorporating significant changes and contributions from South African specialists. These guidelines seek to provide technical guidance for consultants charged with carrying out impact assessments for proposed wind energy facilities, in order to ensure that pre-construction monitoring surveys produce the required level of detail and answers for authorities evaluating applications for wind energy facility developments. It outlines basic standards of good practice and highlights specific considerations relating to the pre-construction monitoring of proposed wind farm sites for bats.

Although the guidance covers single large wind turbines and wind energy facilities (multiple large wind turbines), it is important that any assessment considers the scale of the likely impacts and takes a proportionate approach. The impact of a single large wind turbine will differ from that of a wind energy facility, not only regarding the likely direct impact on bats, but also because of the area of habitat affected and the infrastructure required. The relatively lower risk of a single or small number of turbines needs to be balanced against the suitability of the site for bats.

The objectives of this document are;

- To provide a brief summary of bat related issues associated with wind power development,

- Provide guidance on suggested minimum requirements for pre-construction monitoring for bats at proposed wind energy facility sites and
- Describe techniques for, and timing of, recommended pre-construction monitoring surveys.

1.1 Offshore Wind Energy Facilities

Offshore wind energy facilities are excluded from this guidance. Internationally, offshore wind energy facility survey techniques and standards are still in their infancy. Should proposed offshore developments occur within South Africa prior to the development of detailed guidance, a proportionate approach should be taken which considers the scale of the likely impact on bat populations. Survey design and effort should be informed by the scale of the likely impact of the development on the relevant bat populations.

1.2 Threats

Internationally, the impacts of wind turbines on bats vary depending on site selection, species and season. Bat fatalities may outnumber bird fatalities by 10:1 (Barclay *et al.* 2007) and fatality rates may be affected by turbine size (Barclay *et al.* 2007) and wind speed (low-wind nights associated with increased mortality (Arnett 2005; Arnett *et al.* 2008; Horn *et al.* 2008)). Through a synthesis of post-construction fatality surveys from 73 Wind Energy Facilities in Canada and the U.S.A from 2000-2012, Baerwald and Arnett (2013) calculated that 650,104 – 1,308,378 bats have been killed during this period. Other studies documenting bat fatalities at wind energy facilities include Smallwood (2013), who found that an estimated 888,000 bat fatalities occurred in 2012 in the USA and similarly, Hayes (2013) estimated that, in 2012, over 600 000 bats may have died as a result of interactions with wind turbines in the USA.

Most documented impacts include:

- Direct collision
- Barotrauma (mortality due to damage to bats' lungs caused by sudden change in air pressure close to the turning turbine blade; Baerwald *et al*. 2008 although the likelihood of this is now contested by Rollins *et al*. 2012).

Other impacts include:

- Destruction of foraging habitat (due to wind energy facility construction and habitat change)
- Displacement of bats from their foraging habitat (bats avoid the wind energy facility area)
- Barrier to commuting or seasonal movements (migrating routes) and severance of foraging habitat

Doty and Martin (2012), who have investigated a year of bat mortalities at the single turbine at Coega, Eastern Cape Province, and Aronson *et al*. (2013), who investigated mortalities at the Darling Wind Energy Facility in the Western Cape Province, are the only two systematic studies on the impacts of wind turbines on bats in South Africa. To date three operational wind energy facilities have been constructed in South Africa (Klipheuwel and Darling, both on the West Coast in the Western Cape Province and Coega, Eastern Cape Province). Many wind energy facilities are proposed and some are already nearing construction completion in South Africa, however, to date little research has been undertaken into the actual impacts of the construction and operations of wind turbines on bats and local bat populations in South Africa. Several pre-construction bat monitoring surveys have been completed and these studies are beginning to add to our understanding of the potential impact of wind turbines on bats in South Africa.

Both migratory and non-migratory bats are vulnerable to impacts from wind turbines. Internationally, a large proportion of fatalities occur during migration and the majority of bat carcasses recovered have been from migratory species. In North America, 80% of bat fatalities at wind energy facilities involve migratory species (Arnett *et al.* 2008), with fewer fatalities recorded for resident species. Recent studies from Europe and, more recently, South Africa, however, show turbine related fatalities of resident species in the summer months (Dubourge-Savage *et al*. 2009, Doty and Martin 2012 and Aronson *et al* 2013).

The full extent of migratory bat movements across South Africa is not yet fully understood, but is likely to be substantial. *Miniopterus natalensis* (Natal long-fingered bat) is known to migrate up to 260 km (Van der Merwe 1975) between summer maternity caves and caves used for mating and hibernation during the winter months. *Myotis tricolor* (Temminck's myotis) may undertake seasonal migrations similar to that of *M. natalensis,* although details are not yet fully understood (Monadjem *et al*. 2010). Similar patterns exist for *Rousettus aegyptiacus* (Egyptian rousette), which migrates hundreds of kilometres between caves near Tzaneen in Mpumalanga and caves along the KwaZulu-Natal coast (Jacobsen and du Plessis 1976). *Rhinolophus simulator* females also migrate to maternity roosts in spring (Wingate 1983). Seasonal appearances and disappearances of *Eidolon helvum* (Straw-coloured Fruit Bat) are likely to reflect responses of these bats to changing food supplies (Richter and Cumming 2008). Research by Richter and Cumming (2008) - which involved tracking four bats from the Kasanka National Park (Zambia) colony using satellite telemetry - showed that (i) individuals foraged up to 59 km from their roosts, (ii) one bat moved 370 km in one night, and (iii) one bat travelled a cumulative 2518 km in 149 days.

It is the potential barrier effect of wind energy facilities, barotrauma and direct collisions with blades that are seen to present the greatest threats to bats, especially migratory species. Until we have a better understanding of South African bat population levels and fluxes, bat ecology and migration, it is recommended that a precautionary approach is adopted.

Internationally, guidance has been produced which includes collision risk assessments for specific bat species of a particular country. This is not yet possible for South Africa, as insufficient information is available regarding flight heights, behaviour and movement patterns for many of the South African bat species. However, bat ecology to some extent, may provide some indication of the level of risk to South African bats from wind turbines, with open air foragers (e.g. *Tadarida aegyptiaca* (Egyptian free-tailed bat)) more likely to encounter turbines because of their higher flight heights, than clutter foraging species such as *Nycteris thebaica* (Egyptian slit-faced bat) which are known to forage close to vegetation.

Table 1 represents our best assumptions as to which families (or genera) will most likely be affected by wind turbines, through collision risk and barotrauma. It is important to note that this table of risk is not evidence-based, but rather an assumed likelihood of risk based on the foraging and flight ecology of the bats concerned. In addition, daily foraging and flight habits may vary significantly for species when migrating, and that all migrating species should be assumed to have a high fatality risk.

Table 1 The likelihood of the risk of fatalities affecting bats, based on broad ecological features, excluding migratory behaviour

Family / Genus	Relative Status	Likely risk of impact from wind turbine blades (direct collision/barotrauma)
Pteropodidae	Common – restricted distributions Some species known to move large distances	Medium – High
Molossidae	Common – widespread Species fly high enough to come into contact with turbine blades.	High
Emballonuridae	Common – restricted distributions Species fly high enough to come into contact with turbine blades	High
Rhinolophidae	Species with restricted distributions	Low
Hipposideridae	Species with restricted distributions	Low
Nycteridae	Common – widespread and restricted distributions	Low
Miniopteridae	Common – widespread and restricted distributions Some species known to move large distances	Medium – High
Vespertilionidae	Common – widespread and restricted distributions	
Pipistrellus	Species with wide or restricted distributions	Medium
Hypsugo	Wide, but sparse distribution	Low
Nycticeinops	Common throughout restricted distribution	Medium
Neoromicia	Species with wide or restricted distributions	Medium – High
Kerivoula	Species with wide but sparse distributions	Low
Scotoecus	Sparse distributions	Medium – High
Cistugo	Restricted distributions – species endemic to Southern Africa or South Africa	Low
Laephotis	Species with restricted distributions	Low
Glauconycteris	Species with restricted distributions	Medium – High
Myotis	Species with wide or restricted distributions; some species may move large distances	Medium – High
Scotophilus	Some with widespread or restricted distributions	Medium – High
Eptesicus	Wide, but sparse distribution	Medium

1.3 Published Guidance and Information

Much of the existing evidence for adverse impacts of wind energy facilities on bats comes from the North America and Europe. Useful information, including published research and successful mitigation measures for bats (e.g. Baerwald *et al.* 2009; Arnett *et al.* 2011 and others) can be obtained from the Bats and Wind Energy Cooperative (BWEC) at www.batsandwind.org.

There are currently several pieces of guidance relating to both survey standards and assessing the impacts of wind energy facilities for bats. One main guidance reference document is EUROBATS.

1.3.1 EUROBATS Guidance

The Advisory Committee of the 'Agreement on the Conservation of Populations of European Bats' (known as EUROBATS), has provided generic guidance for European countries on assessing the impact of wind turbines on bats (Rodrigues *et al.* 2008). The Eurobats guidance identifies that although most bats have been killed in the migratory periods, resident bats from local populations have also been affected; therefore pre-construction surveys should be undertaken throughout the active bat season. The guidance also states that the pre-construction assessment should identify bat species and any feature used by bats within the landscape. Further details can be found on the EUROBATS website (www.eurobats.org).

1.3.2 International environmental law and pertinent South African legislation

Global Principles, Convention on Biological Diversity, The South African Constitution and South African Environmental Legislation pertaining to environmental assessment, are all pertinent to the need to assess the impact of wind energy facilities on the ecology (including bats) at a local, national and international level.

Global Principles - Equator Principles

The globally recognised Equator Principles are applied when countries, such as South Africa, seek external funding for large projects.

The Equator Principles are a set of international principles that are a globally-recognized benchmark for assessing and managing social and environmental risks in project finance. The Equator Principles promote socially responsible conduct and sound environmental practices in relation to project finance initiatives. The benchmark seeks to provide a framework against which lending can be assessed, applying to all new project finance arrangements above US$10m. By adopting the Equator Principles, financial institutions commit to not providing loans to projects where the borrower cannot or will not comply with the social and environmental standards set out in Equator Principles policies and procedures.

The relevant Principle here is; Principle 2: Social and Environmental Assessment, which states:

For each project the borrower has conducted a Social and Environmental Assessment process to address, as appropriate the relevant social and environmental impacts and risks of the proposed project.

The Assessment should also propose mitigation and management measures relevant and appropriate to the nature and scale of the proposed project.

South African Constitution and the Philosophy of Environmental Impact Assessment

The global philosophy of environmental impact assessment (EIA) is that prevention (of environmental effects) is better than cure and that it takes account of concerns to protect human health; contributes, by means of a better environment, to the quality of life; ensures that the diversity of species is maintained, and maintains the reproductive capacity of the ecosystem as a basic resource for life.

'*The South African Constitution is the supreme law of the country and any law or conduct inconsistent with the Constitution is invalid. Through the inclusion of the environmental right into the Constitution, environmental law found a firm entrenchment into the South African Legal system with a sound basis and constitutional mandate for further development and improvement*.' (taken from van der Linde and Feris 2010).

The relevant Section in the South African Constitution Chapter 2 Bill of Rights Section 24. Environment, states that:

'Everyone has the right to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development'.

The Constitutional environmental right not only afforded every person with the entitlement to enjoy a right to an environment which is not harmful to their health and well-being, but also placed a constitutional mandate on government to protect the environment through reasonable legislative and other measures that:

- Prevent pollution and ecological degradation;
- Promote conservation; and
- Secure ecological sustainable development and the use of natural resources while promoting justifiable economic and social development.

In fulfillment of this constitutional mandate, government agencies have over the last decade revised and promulgated various laws pertaining to a range of thematic areas including environmental management, environmental impact assessment, air quality, biodiversity, waste management, mining, forestry, and water management.

Convention on Biological Diversity 1992

South Africa has ratified the Convention on Biological Diversity (CBD), which means that it has an international obligation to work towards conservation of its biodiversity. In terms of this Convention, conservation entails:

- The protection of species and ecosystems that warrant national protection;
- Sustainable use of indigenous biological resources; and
- The fair and equitable sharing of its benefits.

National Environmental Management Act

The National Environmental Management Act (NEMA) creates the fundamental legal framework that gives effect to the environmental right guaranteed in Section 24 of the Constitution of the Republic of South Africa, 108 of 1996. NEMA sets out the fundamental principles that apply to environmental decision making, some of which derive from international environmental law and others from the Constitution. The core environmental principle is the promotion of ecologically sustainable development. NEMA also reconfirms the State's trusteeship of the environment on behalf of the country's inhabitants.

National Environmental Management: Biodiversity Act 10 of 2004

(As last amended by National Environment Laws Amendment Act 14 of 2009)

The objectives of this Act (taken from van der Linde and Feris 2010) are:

a. *within the framework of the National Environmental Management Act, to provide for:*
    i. *the management and conservation of biological diversity within the Republic and of the components of such biological diversity;*
    ii. *the use of indigenous biological resources in a sustainable manner; and*
    iii. *the fair and equitable sharing among stakeholders of benefits arising from bio-prospecting involving indigenous biological resources;*
b. *to give effect to ratified international agreements relating to biodiversity which are binding on the Republic;*
c. *to provide for co-operative governance in biodiversity management and conservation; and*
d. *to provide for a South African National Biodiversity Institute to assist in achieving the objectives of this Act.*

This Act gives effect to ratified international agreements affecting biodiversity to which South Africa is a party, and which bind the Republic.

Convention on Migratory Species (also known as the Bonn Convention)

South Africa is a party to the Convention on Migratory Species, which aims to conserve terrestrial, marine and avian migratory species throughout their ranges (this includes *Miniopterus natalensis*).

1.4 Biodiversity Principles

Key principles underpin the consideration of biodiversity in EIAs, and indicate desired outcomes. They are dictated by international conventions which South Africa has ratified or signed, and reflected in accepted best practice world-wide:

- A long-term perspective of biodiversity should be adopted to promote intergenerational equity;
- Biodiversity should be protected, and natural capital maintained at or near current levels, with best efforts made to replace or offset loss ("no net loss" principle);
- Prevention of impacts on biodiversity is better than cure in terms of risk and investment of resources;
- Biodiversity issues should be integrated into decision-making;
- An ecosystems-approach to evaluating effects and impacts should be taken, recognizing that humans are a component of ecosystems on which they depend;
- The rights to an environment (including biodiversity) not detrimental to health or well-being must be respected;
- The requirements of international laws and conventions relating to biodiversity, as well as national and provincial legislation, should be met;
- Thorough and early consideration of alternatives is the optimum way to determine the best practicable environmental option to meet proposal objectives whilst preventing or avoiding loss of biodiversity;
- Resource use should operate within the regenerative capacities, whilst pollution/waste outputs operate within assimilative capacities of the natural environment;
- Both biodiversity pattern and process should be conserved;
- Ecosystem services should be safeguarded, giving due consideration to the costs of replacing these services should they fail;
- A risk-averse and cautious approach should be taken where either information and/or the level of understanding is inadequate, where impacts are unprecedented or where there is inherent uncertainty as to the significance of impacts, or there is an element of substantial risk of irreversible impacts which could lead to irreplaceable loss of natural capital;
- Traditional rights and uses of, and access to, biodiversity should be recognised, and any benefits of commercial use of biodiversity should be shared fairly.

1.5 Applications for Environmental Authorisations

Below are the relevant criteria to be taken into account by competent authorities when considering applications (taken from van der Linde and Feris 2010):

‘If the Minister, the Minister of Minerals and Energy, an MEC or identified competent authority considers an application for an environmental authorisation, the Minister, Minister of Minerals and Energy, MEC or competent authority must:

(a) comply with this Act;

(b) take into account all relevant factors, which may include:

(i) any pollution, environmental impacts or environmental degradation likely to be caused if the application is approved or refused;

(ii) measures that may be taken:

(aa) to protect the environment from harm as a result of the activity which is the subject of the application; and

(bb) to prevent, control, abate or mitigate any pollution, substantially detrimental environmental impacts or environmental degradation;

(iii) the ability of the applicant to implement mitigation measures and to comply with any conditions subject to which the application may be granted;

(iv) where appropriate, any feasible and reasonable alternatives to the activity which is the subject of the application and any feasible and reasonable modifications or changes to the activity that may minimise harm to the environment;

(v) any information and maps compiled in terms of Section 24 (3), including any prescribed environmental management frame-works, to the extent that such information, maps and frame-works are relevant to the application;

(vi) information contained in the application form, reports, comments, representations and other documents submitted in terms of this Act to the Minister, Minister of Minerals and Energy, MEC or competent authority in connection with the application;

(vii) any comments received from organs of state that have jurisdiction over any aspect of the activity which is the subject of the application; and

(viii) any guidelines, departmental policies and decision making instruments that have been developed or any other information in the possession of the competent authority that are relevant to the application’.

1.6 Summary

In summary, together these principles, pieces of international law and domestic legislation make it necessary to assess the impact of developments, such as wind energy facilities and prevent, control, abate or mitigate any substantially detrimental environmental impacts.

2. THE ECONOMIC AND ECOLOGICAL ROLE OF BATS IN SOUTH AFRICA

Bats (Order Chiroptera) comprise nearly one quarter of all mammalian species and are the second largest order of mammal (Simmons 2005). Bats are long-lived mammals and females often produce only one pup per year, resulting in a life-strategy characterized by slow reproduction (Barclay and Harder 2003). Because of this, bat populations are sensitive to changes in mortality rates and their populations only recover slowly from declines.

Bats provide important ecosystem services (Cleveland, 2006; Kunz *et al.* 2011; Boyles et al., 2011; 2013; Lopéz-Hoffman et al. 2014). They are major pollinators of fruiting trees, dispersers of seeds and controllers of insect populations, including those of agricultural pests. They have contributed substantially to medical research, to our understanding of radar and sonar and their droppings are highly prized in some parts of the world as fertiliser. A single small North American Little brown bat (*Myotis lucifugus*) can consume up to 1,200 small insects in an hour, almost 5,000 mosquito-sized insects a night per bat (Taylor 2000). A small colony of bats can therefore, consume over 200,000 insects in one night. In a study in Sacramento USA, it was reported that the presence of sufficient numbers of bats due to proximity to a bat roost reduced fruit crop damage to pears by corn ear moth, by 55% (Long *et al*. 1998). Exclusion of bats and birds from Indonesian cacao plants resulted in a 31% decrease in cacao production due to increased insect damage (Maas et al., 2013).

In Africa, as in other parts of the world, bats provide essential ‘ecosystem services’. Insectivorous bats provide essential services through maintaining a healthy ecological balance by means of natural insect control. Just a few local case studies currently exist. For example, in sugar cane monocultures in Swaziland, two species of molossid bats selectively foraged over sugar cane fields rather than natural vegetation (Noer et al., 2012). In the same area, based on next-generation DNA sequencing from faecal pellets, several local pest insect species (including the borer moth, Eldana saccharina) featured in the diet of these species (Bohmann et al., 2011). Based on next-generation DNA sequencing results, five out of six bat species tested in macadamia orchards in a Limpopo study contained DNA from the major pest of macadamia, green vegetable stinkbugs (Nezara viridula) (Taylor et al., 2013a). Seasonal activity of bats foraging in these same macdadamia orchards was correlated with the annual cycle of two stinkbug pest species (Taylor et al., 2013b). Stinkbugs of the Family Pentatomidae result in damage of up to R50 million per year in South African macadamia and avocado orchards (Schoeman et al;. 2013). Bats also play an important role in social health by combatting disease (e.g. malaria; see Gonsalves et al., 2013). Frugivorous bats provide seed dispersal (thus aiding forest regeneration) and pollination services. In a recent study at Amani in Tanzania, fruit bats were shown to disperse 20% of the local submontane forest trees for hundreds of metres (Seltzer, 2013). Unlike in South America where bats seem important in dispersing pioneer species in regenerating forests, fruit bats in Africa appear to play an important role in propogation of larger forest trees including species economically important for timber production (Muscarella & Fleming, 2007).

The potential loss of these ecosystem services should be considered when assessing the environmental impact of wind energy facilities. The possible loss of bat colonies could therefore potentially result in increased costs in pesticides and reduced agricultural productivity. **Table 2** summarises the likely economic importance of various bat families in South Africa most likely to be affected by wind turbines.

Table 2 Likely level of ecological importance of various bat families in South Africa, based on our current knowledge of the biology of these families

Family	Likely level of ecological importance	Comments
Pteropodidae	High	Pollination, seed dispersal, forest regeneration
Molossidae	High	Agricultural pest control (tendency for high abundance)
Emballonuridae	Medium	Agricultural pest control (Lepidoptera prey but low abundance)
Rhinolophidae	Medium	Agricultural pest control (prey consists of Lepidoptera and Coleoptera), but occurrence is localised, dependant on specific roost types.
Hipposideridae	Low to Medium	Agricultural pest control (prey consists mainly of Lepidoptera), but occurrence is localised, dependant on specific roost types and usually low numbers.
Nycteridae	Medium to high	Preys on a variety of invertebrates and occurrence is widespread.
Miniopteridae	High	Agricultural pest control (high concentrations around roosts), ecological role (almost only energy provider for cave ecosystems)
Vespertilionidae	High	Pest control, ecological role (tendency for high abundance)

Recent research suggests that the estimated value of bats to the United States agricultural industry is about US $22.9 billion/year and that the loss of bats in North America (due in part to wind turbines and white nose-syndrome) may lead to agricultural losses estimated at more than US $3.7 billion/year (Boyles *et al.* 2011). Just in south western United States, the pest control value of bats to cotton amounted to an average of US $12 million per year between 1990 and 2008, amounting to between 6 and 28% of the total value of the crop (Lopéz-Hoffman et al., 2014). In the USA wind operators have also been fined US $2.5 million as compensation for the impact on local biodiversity (Cuff 2010). It must, however be noted that wind energy facilities do hold the potential to provide certain financial and ecological benefits by ensuring farms remain financially solvent in the face of declining commodity prices and producing electricity with relatively little carbon dioxide emissions respectively.

An example of how the ecological and economic value of bats was recognised and supported occurred in the mid-1950s when the then South African Railways supervised the construction of two huge purpose-built structures designed to attract bats to roost in them – in effect 'bat houses'. They were built at Komatipoort on the border of Swaziland and Mozambique as a means of controlling the numbers of mosquitoes and hopefully the spread of malaria. To this day one 'bat house' is still occupied by a large colony of Angolan free-tailed bats (*Mops condylurus)* (Taylor 2000).

In most countries in Western Europe, over the past 20 years, the protection of bats and their roosts has become very strong and enforced by stringent legislation. Bats and their roosts, even when not occupied, are fully protected and offenders are prosecuted by fines or even custodial sentences. This legislation has been put in place because of the decline in the European bat fauna, and the recognition that bats are a very important, even vital, part of many ecosystems. Bats are a group of mammals we cannot afford to lose. In Europe, bats have been identified as indicators of the health of the environment and are now considered important indicators of biodiversity (Jones *et al.* 2009). Bats contribute to the overall maintenance of a healthy ecosystem.

3. PREPARATION AND PLANNING OF PRE-CONSTRUCTION MONITORING

In order to assess adequately the likely impact of a wind energy development on local bat populations, appropriate data are required. The overall aim of monitoring at proposed wind energy facility sites is to identify and assess the potential impacts that the proposed development will have on both local and regional bat populations, the essential information needed is described in **Box 1**. It is only then that the application can be successfully informed and where necessary, proposals for appropriate mitigation and or compensation drawn up. Short-term, ground level studies are not sufficient and should only be used in the Scoping Phase (as summarised in **Box 2** and further discussed in Section 3.1). Site selection and turbine localities should only be decided based on the results of a long-term pre-construction monitoring programme (as summarised in **Box 2** and further discussed in Sections 3.2 and 3.3).

Box 1 Essential information required from monitoring

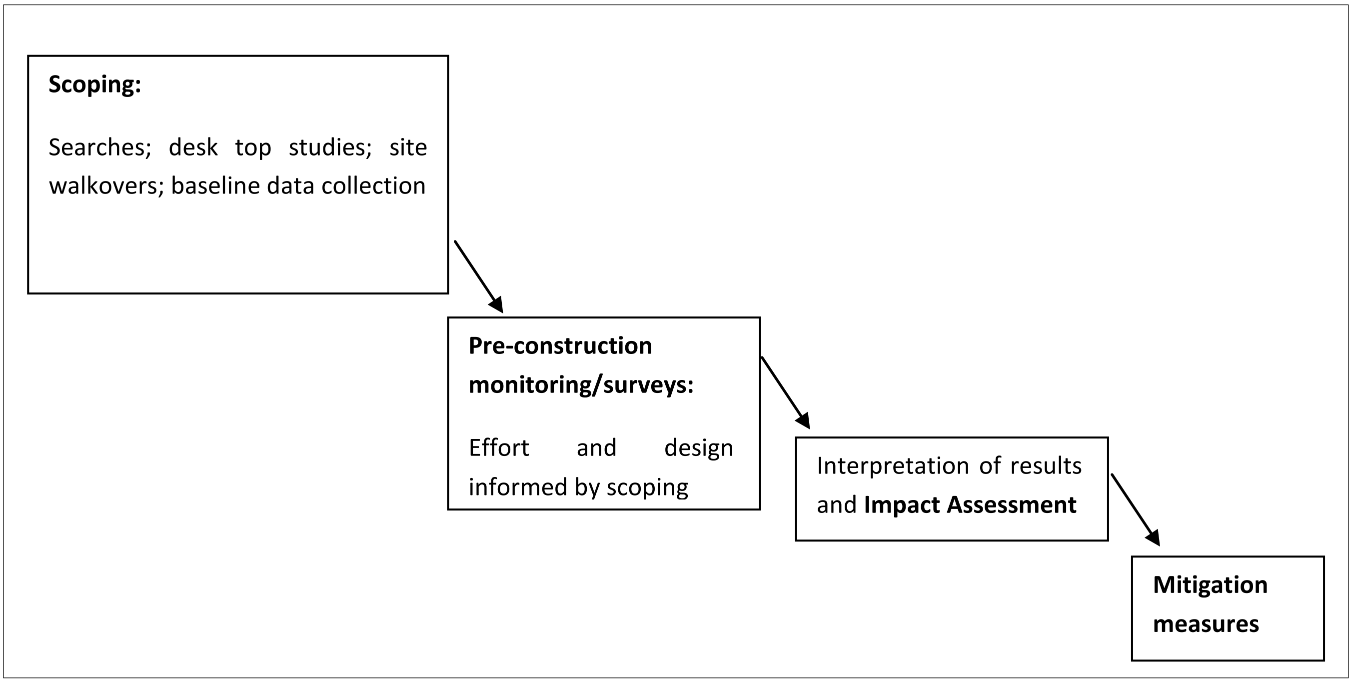
In order to assess the impacts correctly the following information is required:

- Assemblage of bat species using the site (noting higher, medium or lower risk species groups; see Table 1)
- Relative frequency of use by different species throughout the year
- Spatial and temporal distribution of activity for different species
- Locations of roosts within and close to the site
- Details on how the surveys have been designed to determine presence of rarer species
- Type of use of the site by bats - at and away from turbine locations, for example foraging, commuting, migrating, roosting etc.

Monitoring should be designed to gather the information listed in **Box 1** and provide all the relevant information needed for appropriate identification and assessment of the impacts of the proposed wind energy development on the local bat population. Pre-construction monitoring design and effort should be site-specific and will depend on the information gathered as part of the scoping study which should be conducted and assessed by the specialist.

Details of the EIA process in relation to bats and the sequence of actions are outlined in **Box 2**.

Box 2 EIA Process and Bats



3.1 Scoping

A key factor influencing the design of pre-construction monitoring methodology is information received from scoping studies: data searches, desktop studies (including literature reviews and site information from maps and aerial photographs), site walkovers and baseline data collection such as acoustic monitoring. The potential impacts of a wind energy facility development will be site-specific and will depend on the species and habitats present. The presence of rarer species, species of conservation concern and ecological importance, known roosts, or species that have been identified to be at risk of impacts, should be considered from the outset and pre-construction monitoring designed to address any potential impacts related to them. The scoping studies should aim to collate existing information on bat activity, roosts, and landscape features that may be used by bats.

In order to ensure that these aspects are sufficiently covered, a scoping study should *always* be undertaken for a proposed wind energy facility site. The scoping study should include the following:

- Collation and review of existing literature (including the latest research undertaken both locally and internationally); maps and aerial photographs; and habitat data (if available) to identify habitats which may be used by bats; data on bat distributions, roosts, bat sightings, migration routes, and likely foraging and commuting areas on or close to the proposed wind energy facility site.
- Search for any designated Protected Areas within 20km of the site.
- The scoping study should also include the proposed footprint of the development including any proposed access/haul roads and temporary construction or material storage areas or other associated development, as these can also have an impact, which could result in loss of roosts and/or foraging habitat.

A 'walkover' survey is an essential part of the scoping study. This is a 'ground truthing' exercise, where the site is traversed to search for the presence of features that may support bats such as trees, buildings, underground sites, vegetated cover, wetlands and linear features, including ridges and water courses. This will also allow an initial assessment to be made of the overall habitat quality and connectivity on the site and to identify likely areas of importance for bats (e.g. water bodies, riparian vegetation etc.). The walkover survey should be done by the specialist because information gathered during the walkover, together with the other data obtained from the scoping study, should be used by the specialist to inform the design of the pre-construction monitoring and the level of monitoring effort required. If possible, the use of a handheld or car-mounted bat detector(s) during the site visit may also provide some initial information on species present on the site and on areas/habitats being used by bats.

Although not a requirement for the scoping study (and often not possible in the time frames available for scoping studies), data on bat activity, through passive monitoring, could also be obtained and included in the scoping report. These data are not a requirement but would be beneficial in providing good information (e.g. activity patterns, species present, potential migration route through site, bat activity relative to weather conditions) which would help inform the level of effort required for the one year pre-construction monitoring.

A scoping report should list the potential impacts of the development and the data obtained should be used to inform the design of pre-construction monitoring methodology. However, although scoping desktop studies can provide some useful information, it is unlikely that all potential species and roosts will be known. Consequently, monitoring should be designed with this in mind, both to ensure coverage of the entire site and with the scope to investigate any rare or unusual records thoroughly as they come to light.

3.2 Design of Pre-construction Monitoring Methodology

"It is unrealistic to present an accurate and complete EIA for a specific wind energy development without taking into account the possible presence of bats throughout a timescale which reflects the full cycle of bat activity" - Rodrigues *et al.*(2008).

In South Africa, bats are active throughout the year and as such, **pre-construction monitoring should take place for a minimum period of one year** (12 consecutive months). Monitoring design and the level of effort required should be decided by the specialist concerned after a scoping study has been conducted. The minimum requirements for all pre-construction monitoring studies are detailed in **Table 4**. However, guidance on how much extra effort to invest in a study above these minimums is provided in **Table 3**.

This guideline document provides **guidance** on pre-construction monitoring techniques and the level of effort which may be required. In some instances deviations from the techniques and level of effort outlined in this document may be unavoidable, but these must be scientifically or practically (not economically or logistically) justified. **Financial or capacity constraints are not acceptable reasons for deviating from the minimum requirements.**

Any deviation from the recommended monitoring guidelines should always be acknowledged clearly in any reports and accompanied with a clear rationale that is scientifically or practically (not economically or logistically) justified.

Habitats and features on a proposed site that should inform the decision to undertake monitoring include:

- Buildings or other features or structures that provide potential as bat roosts, including, but not limited to, bridges, mines, caves, sinkholes, rock crevices etc.;
- Known roosts, especially important maternity roosts;
- Vegetated habitat (including non-indigenous (alien) forest plantations and agricultural land);
- Linear features, such as tree lines, topographical ridges, water courses with associated riparian vegetation, potentially used by bats as commuting/foraging/migrating routes;
- Any water bodies or wetlands, including manmade structures e.g. farm dams, swimming pools; and
- Within or adjacent to a Protected Area (as described in NEMA National Environmental Management: Protected Areas Act 57 of 2003).

Development on the sites with any of the features listed above, but not limited to these features, have the potential to impact bats and the potential impact of development is likely to increase the greater the number of features.

The additional techniques employed and level of effort for the pre-construction monitoring (apart from the minimum requirements in **Table 4**) will vary depending on the location of the proposed site, the characteristics of the site, the bat species present, potential use of the site by bats, and the size and associated risks of the development, and should be informed by the results of the scoping study. An overview of the factors a specialist should consider when designing pre-construction monitoring is provided in **Table 3**. **This table is not intended to be used as an absolute measure of survey effort required, but rather as an indication of the relative survey effort that may be required.**

Consideration should also be given to future changes in land use on the site. For example, a change from arable land to cattle pasture in habitats around wind turbines (following construction) could provide habitat of higher foraging quality for bats and lead to greater risk of mortality. This should be kept in mind when designing the monitoring to allow for assessment of any future impacts on bats as a result of a change in site management. For example, where mitigation and habitat enhancement for other ecological receptors is planned on-site an assessment of whether these measures may attract bats into the area following implementation should be considered. The potential effects of such operational site management should also be assessed.

Table 3 Overview of factors to consider when designing pre-construction monitoring methodology in relation to relative survey effort

Survey effort*	Habitat	No. of turbines	Type of roost
Lower	No feature that could be used by bats for roosting, commuting or migrating Small number of potential roosts, most likely less significant	One turbine	 Night roost
	Isolated habitat that could be used by foraging bats Isolated site not connected by prominent linear features or well vegetated areas		
	Several potential roosts in buildings trees or other structures Habitat could be used by foraging bats		
Medium	Site is connected to the wider landscape by linear features such as topographical ridges and water courses	Three or more turbines	Daytime roost (but not maternity)
	Habitat of high quality for foraging bats Site is connected to the wider landscape by strong linear features such as topographical ridges and water courses		
Higher	Site is close to known roost, or suspected/known migration route Confirmed presence on or adjacent to site, either roosting, commuting or migrating Buildings, trees, water bodies or other structures with features of particular significance (Sirami *et.al.* 2013)		Nursery roost Maternity Maternity roost/ Hibernaculum (winter roosts where hibernation occurs)

For further information on monitoring effort see Section 4.

4. MONITORING EFFORT

The impact of a single large wind turbine will differ from that of a wind energy facility (comprising multiple turbines), not only regarding the likely direct impact on bats, but also because of the area of habitat affected and the infrastructure required. The relatively lower risk of a single or small number of turbines needs to be balanced against the suitability of the site for bats. In large scale schemes, because of the area involved there may be more options for micro-siting and also for on- or off-site habitat enhancement schemes.

It is important that any assessment considers the scale of the likely impacts and takes a proportionate approach.

As summarised in **Table 3,** the design of the surveys and the level of effort required during the one year pre-construction monitoring should be site specific and should be informed by the scoping study, the location of the proposed site, the characteristics of the site, the bat species present, potential use of the site by bats, and the size and associated risks of the development.

Recommendations **of minimum standards of pre-construction monitoring effort** are provided in **Table 4.** Additional pre-construction monitoring effort should always be proportional to the likely impact of the development on local bat populations (where migration is suspected, regional populations may also be impacted upon) (**Table 3**).

Any deviations from the guidelines must be scientifically or practically (not economically or logistically) justified. **Financial or capacity constraints are not acceptable reasons for deviating from the minimum requirements.**

Table 4 Minimum standards of pre-construction monitoring effort to be undertaken over a minimum of a 12 month period.

	ROOST SURVEYS
Potential roosts	Daytime inspection and two dusk or dawn surveys
Known roosts	Roost surveys and conduct commuting route surveys.
	ACTIVITY SURVEYS
Survey period	The pre-construction monitoring period is **one year (12 months)** as a minimum. Surveys should provide robust representation of species assemblage, as well as seasonal activity patterns.
Survey area*	Should represent adequate coverage of the developable area (where turbine locations are not known, surveys should cover the maximum polygon that identifies the maximum size of all possible arrangements – see **Appendix 1**. that uses the biotope approach to determine the number of static detectors required)
Manual surveys**	8 nights of manual surveys through transects, spread evenly across all four seasons. Surveys should begin at evening civil twilight when conducted in the evening and last for at least 1.5 hours. For morning transect surveys, the survey must begin at least 1.5hours before civil twilight. If point sampling is used by the specialist, the reasons for deviating from transects must be well justified and enough sampling nights must be conducted to cover all the various biotopes on site for all four seasons each.
Static surveys ***	The survey period when data are collected should strive to be 100% but a minimum of 75% of one year of data for each site, **covering all four seasons** is acceptable (average over all static detectors deployed on the site). Lower periods may be considered acceptable if data gaps are reasonably and scientifically justifiable. Particular efforts must be made to cover as much of the Autumn and Spring seasons in order to collect data during the migrations and peak foraging and breeding times. Sampling locations must be representative of the developable area and all main biotopes on site. All microphones should be mounted >7m, with at least one within the rotor swept area. If the lowest rotor swept height is unknown or uncertain, then 50m is the minimum height for the higher microphone within rotor sweep. Static detectors must remain in a fixed location within each biotope throughout the 12 month monitoring period. Nightly monitoring periods should begin at sunset or 30 minutes before evening civil twilight and end at sunrise or 30 minutes after morning civil twilight and record this entire period. All data collected should be analysed, rather than a subset of the data. These times can be obtained relatively accurately from appropriate software programs such as Wildlife Acoustic's Songmeter Configuration Utility or Chris Corben's Anasun Application. **NB -** Although monitoring at exact turbine locations would be preferable, this may be impossible or very difficult because provisional layouts may change throughout the development process, especially in cases where developers wish to start pre-construction monitoring as soon as possible. Monitoring data should represent the maximum polygon of the development area. It is up to the specialist, after visiting and assessing the site and using the biotope approach described in **Appendix 1**, to propose where and how the static monitoring should happen in order to obtain data that adequately represents the area under development and which is appropriate to assessing the likely impact of the development on local bat populations across the different site locations in order to assist developers in layout design.
* should include ancillary developments (access roads etc. if known) and account for any light spillage, removal of vegetation etc.	
** sampling should be carried out to ensure that the data collected represent bat activity across the site	
*** in all instances where the developable area is uncertain, sampling locations should be spread evenly across the site	

5. PRE-CONSTRUCTION MONITORING TECHNIQUES

Pre-construction monitoring at proposed wind energy facility sites should be site-specific and designed to provide the information required to complete a full impact assessment (for details on what is required in a monitoring report see Section 7, **Box 3**). Monitoring will need to take seasonal, species, and geographical variation into account and will need to describe bat activity within the developable area and should cover the turbine locations within the site if these are known.

This Section of the document outlines the basic standards of best practice for each survey technique and highlights specific considerations relating to the monitoring of wind energy facilities. This requires data to be collected using complementary survey techniques designed to confirm and further inform any potential impacts initially identified in the scoping report. The main monitoring techniques required to collect this data fits into two broad categories: Roost Surveys and Activity Surveys. Each of these techniques to be described will provide information on different aspects of the site and its use by bats.

5.1 Roost Surveys

5.1.1 Roost Surveys- Identifying potential roost sites

At sites offering good opportunities for bat roosts, the survey should include a daytime inspection of any structures that can be examined for evidence of roosting bats (e.g. buildings, underground sites, caves, mines, trees). At least one survey should be carried out at these locations at dusk, with the aim of observing emergence at features assessed as providing high potential for roost sites.

Any other features that could not be inspected in detail, or require further survey and need to be observed at dusk, should be mapped. Any areas with high potential on or adjacent to (if access is granted) the site should be investigated further in order to identify potentially important roost sites. Although some of this information could have been collected during the scoping phase, roosts and roost occupancy may change seasonally and should be checked during each season.

5.1.2 Roost Surveys - Surveys at known roosts

Known roosts, identified in the scoping report or during initial surveys, should be surveyed to identify species roosting there and should include activity surveys to identify main commuting routes to and from the roost and the use of the site by bats throughout the year. The survey effort and methods required to gather this information will depend largely on how close the roosts are located to the site, the quality and quantity of commuting routes from the roost, potential foraging habitat in the area and whether species that are more reliant on specific commuting routes are present within the surrounding area. It must be noted that these may vary during the year as colonies may move regularly and some roosts may only be occupied seasonally.

If identified roosts are entered in order to identify species or estimate abundance important precautions must be taken to ensure the safety of both the specialist and the bats themselves (if you are unsure of the detailed safety precautions to be followed, please contact either the Gauteng and Northern Regions Bat Interest Group (www.batsgauteng.co.za) or Bats KZN (www.batskzn.co.za)). Although some of this information could have been collected during the scoping phase, roosts and roost occupancy may change seasonally and should be checked during each season.

5.2 Activity surveys

5.2.1 Manual surveys

Manual activity surveys such as walked or driven transects, are necessary to gain a spatial understanding of the bat species using the site and the features on site that the bats are using. Transects compliment the static monitoring points in terms of spatial coverage. They can also be used to identify key features, commuting routes and overall activity within and surrounding the site. Another method of manual sampling to compliment static monitoring is point sampling in key biotopes. If point sampling is used by the specialist, the reasons for deviating from transects must be well justified and enough sampling nights must be conducted to cover all the various biotopes on site for all four seasons each. These manual surveys DO NOT replace continuous static monitoring according the minimum requirements.

Broadband bat detectors (frequency division or full spectrum, not time expansion) should be used for manual activity surveys, either connected to a recording device or with a built-in recording capability, to ensure that all bat calls are recorded and can be subsequently analysed for identification to species or species-group level.

The number and length of transects or number of point sampling sites required to cover the main habitat features of the site will depend on the proposed size and complexity of the site. Sufficient transects or point sampling sites should be set up to ensure that all identified features that may be used by bats, as well as all biotopes present, are sampled within the first two to four hours after dusk. More than one transect may therefore be required to cover all areas and habitats of the proposed site in one survey session. If certain features or biotopes are identified by the specialist as not being significant to bats, and therefore were included in transects or point sampling sites, they should justify this decision.

Sampling points can be identified along the transect routes to divide the route into comparable Sections. These points should be evenly distributed in distance and amongst the habitats across the site and should include both pristine and transformed habitats (Sirami *et.al.* 2013). Bat activity should be recorded for a set amount of time at each sampling point (BCT recommend at least three minutes) and continually between points and should aim to represent and compare bat activity across the site. The number of bat passes (or similar in accordance with current best practice and technology) and species concerned should be recorded at each sampling point and between sampling points. The number of sample points will be dependent on the size of the site.

In order to ensure robust data collection, surveys should be undertaken from opposite directions throughout the year to allow for the differing emergence times of bat species. To ensure that data are comparable, transect routes should be kept as close to the original routes as possible.

With regards to the number of manual surveys which should be undertaken during the one year pre-construction monitoring period (**Table 4**), 8 nights of manual surveys/ transects, spread evenly across all four seasons is considered reasonable. Some sites may only need one transect to cover what they need in a night, other larger sites may require more transects to achieve this. Once again this will be up to the specialist to decide what is appropriate at a particular site.

The use of bat detectors connected to a GPS unit - which unequivocally indicates the exact transect walked and where each sampling point was, and can thus be used by any person instructed to walk the transect - may obviate the need for the specialist to conduct each of the manual surveys. Similarly, at sites where more than one transect will be needed to cover the area of the site, other people will be required to participate in the manual survey. Where other people are used in the monitoring protocol, this should be stated in the report together with their relevant experience and knowledge (Section 7, **Box 3**).

5.2.2 Static monitoring

Manual bat activity surveys only provide a snapshot of activity across a site and therefore, automated bat detector systems (remote acoustic monitoring) should be used to assess bat activity at proposed wind energy facility sites. These 'static detectors' provide an invaluable volume of data on the bats present on the site at a set series of fixed locations (representative of all biotopes present in a study site) and altitudes and are essential in order to gauge the relative importance of features and locations, and potential migratory routes and how these may change throughout the year.

Although static acoustic monitoring at exact turbine locations would be preferential in most cases this will be difficult because provisional layouts may change throughout the development process. In the favourable situation where developers wish to start pre-construction monitoring as soon as possible monitoring can be used to inform the design process. Static detectors need to be installed with the aim of identifying the amount of bat activity occurring in a habitat over the open ground, and in the rotor swept area. All microphones should be mounted >7m, with at least one within the rotor swept area. If the lowest rotor swept height is unknown or uncertain, then 50m is the minimum height for the higher microphone within rotor sweep. Static detectors must remain in a fixed location within each biotope throughout the 12 month monitoring period. This will allow a full 12 months of monitoring in order to compare seasonal variation within each biotope type. Static detectors need to remain in fixed locations in order to make data collected from microphones across the entire study period comparable to prevent interpretation and analysis biases and problems.

In order to assess the impact of temporary haul and access roads and storage compounds at proposed wind energy facilities, static ground level automated bat detectors may also be required.

The specialist should use their discretion to determine how many, and where, these static detectors should be placed.

A guide on how many detectors should be used for static monitoring is provided in **Appendix 1**.

The same model of static detector should be used for all static detector surveys on a single site if direct comparisons in activity between locations within the site are to be made. In addition, all detectors must be appropriately calibrated to account for variation between detector units and to allow a valid comparison of recorded bat activity across a suite of detectors (Larson & Hayes 2000). Specialists must be aware of specific microphone capabilities and limitations and must take this into account when setting the location and angle of the microphone. This may be within the developable areas, or at proposed turbine locations if they are known, or along linear features. Specialists should be aware of the constraints of bat detectors (e.g. microphone sensitivity and area of coverage) and should take these into consideration when designing the pre-constructions methodology. Constraints/limitations should also be listed in the report (**Box 3**).

Microphone(s) sensitivity must be monitored in the field during every site visit using an appropriate calibrator. The aim is to ensure correct bat detector and microphone performance. Calibration tests should be as standardised as possible and from a minimum distance of 10m. This is important as good practice and will enable more accurate comparisons between results from different sites. If sensitivity has been lost, the gain and sensitivity settings on the bat detector can be adjusted to compensate. Microphones should be replaced if the loss in sensitivity is significant - this will depend on the specific capability for each manufacturer.

5.2.3 Static surveys at rotor sweep height

There is a strong likelihood that the proportion and composition of species presence at height will differ from ground level, which could have significant impacts in relation to assessing impacts at sites with a high proportion of high-risk species (e.g. species commuting, migrating and foraging within the rotor swept area). Kunz *et al.* (2007) have shown that the correlation between bat activity estimates from pre-construction acoustic monitoring and post-construction bat fatality estimates is stronger as the bat detector is deployed at greater heights.

Depending on vegetation height at the proposed site, some bat species (e.g. open air foraging bats such as free-tailed bats - Molossidae) may only forage above the canopy and may not be recorded if monitoring is only conducted between 7m and 10m. This will account for species that forage both at ground level and those that forage up to a certain height. Static monitoring must be undertaken within rotor sweep height, in addition to monitoring between 7m and 10m to account for species that forage at different heights. Monitoring at additional heights on a meteorological mast can be added, but the distance between microphones on a single mast must enough to distinguish independent calls at each microphone. Where the proposal is to either clear fell areas or site turbines in small clearings (key-holing), pre-construction survey data may not be representative of the situation post-construction, as the habitat available for bats will change following construction. In these cases, it is also recommended that survey locations include vegetated areas and edges to provide information on the bat species assemblage and activity levels in these areas as a baseline for post-construction monitoring.

5.2.4 Affixing static detectors at height

There are several available techniques that can be used to fix static detectors at height. Appropriate methods will depend largely on the type of equipment available. Lattice meteorological masts are useful for installing detectors at height because they are easy to climb for installation and maintenance purposes.

In South Africa, developers are erecting meteorological masts on most sites that can be used to erect bat monitoring equipment. Ideally such masts are climbable lattice structures; however, some developers use pole structures that provide more of a challenge in terms of erecting equipment and maintaining microphones. Such challenges could be overcome through pulley systems or guy wire climbing systems. Other methods do exist and, if proven to be effective, can be used. Early engagement between specialists and developers can assist in overcoming some of these challenges.

Certain detectors will have limitations in their range depending on the methods employed and these should always be considered when designing a survey. New equipment and techniques are being developed and the choice of methods should be reviewed in the light of new developments. Another possible option for installing detectors at height, includes using portable towers or masts specifically located for bat detector use, as are used extensively in North America (Kunz *et al*. 2007).

5.3 Control Sites

There is much debate around the true value of control sites. The bird guidelines (Jenkins *et al.* 2012) recommend that monitoring data should be generated for both the broader impact zone of the proposed WEF, and for one or more comparable control sites. In this way, a comparison of data from pre- and post-construction monitoring can be calibrated in terms of an equivalent comparison for a suitable control area, and the effects of regional variation in environmental conditions can be filtered out of the resulting quantification of the actual impacts of the WEF. Whilst this could also add value to a bat monitoring assessment, there are too many uncertainties around the true value of this extra monitoring to justify control sites as a minimum requirement. It is an option that can be recommended for a particular site, if the specialist feels it is appropriate. The concerns regarding making the use of a control site for bat monitoring a minimum requirement are as follows:

- Finding a control site that is truly comparable to the study site, with a similar composition of biotopes will be very difficult, especially for very large sites.
- Most of the wind energy facility sites are extremely large. Hence, to cover double or one and a half of the bat monitoring equipment and survey effort required, will make these studies unfeasibly expensive and time consuming.

- Whilst there are various potential impacts on bats due to wind energy, such as roost disturbance, displacement from or loss of foraging habitat, fragmentation of migration routes, etc., the most severe impact identified to date, is large scale bat fatalities. A control site may inform on whether bat activity has decreased on site for natural reasons or as a result of the wind energy facility, however, it does not add value in terms of mitigating for fatalities. This can only be done through a combination of activity monitoring on site before and after construction and carcass searches in the operational phase.

It is suggested, that where the entire study area is monitored pre-construction, yet only a certain area of the site is developed, the remaining area that is monitored both pre- and post construction be used as the control. However, if a bat specialist does see value in a control site for a particular wind energy facility site, this can be included in their study proposal with the correct motivation.

5.4 Other Survey Methods

5.4.1 Cameras and Radar

Other methods for monitoring bats, such as infrared or thermal cameras and radar, have been suggested. For logistical and financial reasons, it may be impractical to use these at most wind energy facility sites, however, such methods can be used in addition to acoustic monitoring where the budget and suitability of the site allows.

5.4.2 Capture of bats

The capture of bats (mist-netting/harp-trapping) may be considered where call identification requires clarification and/ or other standard techniques (roost surveys and activity surveys) cannot deliver a robust impact assessment. **Capture and handling of bats should only be conducted by appropriately trained and experienced people.** For species with overlapping echolocation call parameters, particularly in certain species rich and diverse regions, live capture and release for identification purposes may be necessary. Trapping will also help assist in identifying non-echolocating fruit bats on site, as well as species that use calls of low intensity that are difficult to detect using acoustic monitoring techniques (e.g. *Nycteris thebaica*). Please see the Section 5.4 for more information on fruit bats. Live capture and release may also be necessary in order to obtain echolocation calls from released bats which can be used as reference calls for the acoustic monitoring. It should be noted that these methods are not a minimum requirement for pre-construction monitoring (except for sites where fruit bats are likely, there it is a requirement), but can be used *in addition* to the above-mentioned methods (roost surveys, activity surveys and acoustic monitoring) and cannot be used in isolation. Furthermore, whenever these techniques are used, it is important to remember that the sampling of bats will not be at the height of the turbine blades. Individuals using these methods must have training and/or experience in the safe, ethical and effective capture of bats **and possess the appropriate provincial permits to catch and handle bats in the area.**

5.4.3 Radio tracking

Radio-tracking may provide additional information on what areas of a particular site the bat is using and how it commutes or migrates between various areas (e.g. roost and foraging sites). However, radio-telemetry is expensive and may not be appropriate in certain habitats and for many species (e.g. many landscape features that will obscure the signal, resulting in very little data being collected because the bat cannot be 'located' and many bats are too small to put sensors on to). This is not a minimum requirement of the guideline, but can be used in addition to the recommended techniques.

5.5 Fruit Bats

In areas where scoping indicates the likely presence of fruit bats (Pteropodidae), intensive roost surveys should be undertaken to determine the presence of both cave-dwelling and tree roosting species. For *Epomophorus* species, nocturnal surveys involving listening for calling males should be undertaken, especially in the months of May and June (although calling can be heard throughout the year). These fruit bats can also be located by finding feeding spit-out under fruiting or feeding perch trees and can often be seen flying at night. Because *Rousettus aegyptiacus* echolocates, it may be picked up by acoustic recording equipment. *R. aegyptiacus* is a cave dweller; hence, roost surveys are also important for this species.

In areas where fruit bats are likely to occur, capture techniques such as mist-netting should be used to confirm their presence and to identify the species in the area.

5.6 Weather Conditions

General guidance for carrying out manual bat surveys (i.e. walked and driven transects and mist-netting where appropriate) suggests that surveys should only take place in optimum weather conditions, in order to maximise the likelihood of recording bats. It is advised to avoid heavy rain, strong winds and low temperatures, because bats are least likely to fly in these conditions and activity levels will be low. However, where static detectors are deployed for a number of days at a time, the selection of survey nights with ideal weather conditions is unlikely to be achieved for all survey nights. Data from windy or wet nights may also prove useful in determining how bat activity changes with weather conditions.

5.6.1 Measuring environmental parameters

During static monitoring, weather information should be recorded on site throughout the monitoring period. Data on wind speed, rainfall and temperature that is gathered over the entire year should be compared with the bat data (i.e. bat activity) of the site. This information is useful for data interpretation, impact assessment and mitigation recommendation purposes.

Basic weather conditions must also be recorded on nights when transects or live-capturing is conducted.

5.7 Timing of Monitoring

A summary of survey effort and timing of monitoring is presented in **Table 4**.

For pre-construction bat monitoring to be effective, proposed wind energy facility sites should be surveyed with static detectors for a period of 12 consecutive months, or longer, prior to the commencement of any construction activities on site. The development must take place within three years after the completion of the pre-construction monitoring, otherwise a new 12 month monitoring period must commence.

6. INTERPRETING RESULTS

Survey information should always be collected, recorded and analysed to provide information that can be applicable to the direct proposal for the site and assess the likely impacts throughout the year. One important component is the relative bat activity for the site.

6.1 Estimations of Bat Activity

Static detectors provide the raw data to estimate relative bat activity. There are a number of ways in which this can be determined but consideration should be made to the end results which is to achieve a robust impact assessment.

BAT ACTIVITY INDEX = BAT PASSES (or similar)/ UNIT TIME

A single bat pass is defined as a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2 ms. Single call fragments do not apply, only completed single pulses. Where there is a gap between pulses of >500ms in one file, this then represents a new bat pass. If it is thought that the bat passes are multiple recordings of the same individual, this should be noted.

Different detectors produce different quantities of data and various conversion software may produce a different number of bat activity units; hence, detector and conversion software used on site must remain consistent throughout the monitoring period. Bat activity data should be corrected for gaps in recording due to technical and/or other problems that may have been experienced during the monitoring period. An explanation of these corrections should be detailed in reports. Data must be normalised to sunset so that activity levels can be compared across sites and analysed within site to provide:

- an indication of seasonal variation in species activity and composition across the site. Site-wide information on bat distributions may provide useful information on which species are using which parts of the site;
- relative levels of bat activity recorded between 7m and 10m and within the proposed turbine swept path area. This can be done by comparing data collected on bat activity at height with ground-level data, and

- variations in activity and species composition at different wind speeds and other environmental parameters (temperature, barometric pressure and humidity) where these are available. This can be used to inform any future mitigation.

7. PRE-CONSTRUCTION MONITORING REPORTS

The following Section provides guidance on assessing the standard of pre-construction monitoring reports for onshore wind energy facilities. Additional information on EIA in South Africa is detailed in National Environmental Management: Biodiversity Act 10 of 2004, Chapter 5 of the National Environmental Management Act, 1998, Endangered Wildlife Trust's 'Environmental Impact Assessment Toolkit' and the Western Cape's 'Guidelines for Involving EIA Specialists'.

Before any wind farm facility development application can be considered, it is essential that sufficient information is received as part of the pre-construction monitoring report. **Box 3** outlines what should be included within this report. The level of survey effort and survey methods needed should be assessed on a case-by-case basis, using the guidelines detailed within this document. The minimum time period for pre-construction monitoring is 12 months, this is not negotiable. All reports should be available for scrutiny through the peer review process.

These are guidelines. Any deviation should always be acknowledged clearly in any reports and accompanied with a clear rationale that is informed by scientific knowledge, evidence, and expertise.

Box 3 Information to be Contained in the Monitoring Report

Expertise of specialist overseeing the work and expertise of other surveyors (where relevant). The specialist is legally required to be registered as a natural scientist with the South African Council for Natural Scientific Professions (SACNASP), according to the Natural Scientific Professions Act of 2003 . Where people other than the specialists are involved in the monitoring (e.g. walking manual transects, analysing recordings etc.), they should be listed and their relevant experience and knowledge described and any report they produce must be signed off by a SACNASP registered individual

Summary of Scoping study and how it has informed the pre-construction monitoring design methodology.

Pre-construction monitoring methods used, and acknowledgement and rationale should it have deviated from standard guidance. The equipment used should also be indicated.

Limitations of survey techniques and equipment accompanied by an assessment of the impact of these constraints. What factors, if any, could have restricted the quantity and quality of information collected

Monitoring information that includes:
Monitoring area: how was the study area selected and how does it relate to the site area

Date, time, and duration of monitoring: if non-standard monitoring methods are used, provide scientifically based justification – this would apply both for monitoring timings and monitoring methods.

Weather conditions during the surveys.

Distance of any bats from habitat features (as ambient light levels allow).
Map of developable area: and if known, potential locations, height, and sweep of proposed turbines.

Details and criteria used to identify and distinguish between bat species and/or groups

The estimated height of the bat activity (from observations, as ambient light levels allow or from detectors mounted on anemometer masts) should be recorded wherever possible:

- Low-flying therefore below blade; or
- High flying at or above blade height

This will allow for any changes in turbine height to be addressed. The exact heights of categories will depend on the size of the proposed turbines.

Composite map detailing the location of habitat features, the transects walked, static detector locations and their proximity to proposed wind turbine locations (where known) or other site features.

Map(s) detailing location of roosts and showing the result of the bat surveys detailing main foraging areas and commuting routes in the context of the developable area (or if known, turbine locations) . Details should be provided indicating differences in activity over the monitoring period, for example, monthly or seasonally.

Appropriate tables, which may include results of each transect survey giving times at each listening point and walks between listening points along with the number of passes and estimated number of each bat species recorded at each listening station and between listening stations; summary tables detailing total number of passes of each species or species group recorded at and between each listening station.

Estimates of bat activity index across the full development site. Bat activity levels should be calculated per unit time and described for different species or species groups where species or groups can be reliably separated from recordings. This would normally be done for both manual activity transects and static activity surveys separately.

Analysis and assessment of impacts (based on monitoring results and up-to-date published research) that includes:

- identification of identified species, their conservation status and likely impacts and assessment of the impact,
- bat activity in relation to habitat, height, wind speed and other environmental parameters,
- daily and seasonal variations in bat activity,
- consideration of the likely changes in land-use over the lifetime of the wind energy facility and consideration of other wind energy facility proposals that may have a cumulative impact on the proposal under consideration (where data are available to facilitate cumulative assessment within a reasonable timescale, it should be included in the assessment, but this should be already determined at proposal phase, so that the specialist can budget for the analysis of these data),
- recommendations for potential mitigation and /or compensation* should be included at this stage in order to assess the eventual impact of the proposal. Any mitigation measures proposed should be based on scientific evidence and discussed with the wind energy developer.

*Details regarding mitigation and/or compensation measures are outside the scope of this document.

8. CUMULATIVE IMPACTS

'C**umulative impact**, in relation to an activity, means the impact of an activity that in itself may not be significant, but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area' (taken from Regulations in terms of Chapter 5 of the National Environmental Management Act, 1998 Chapter 1 Interpretation and Purpose of these Regulations).

Consideration should be given to other wind energy facility proposals that may have a cumulative impact on the proposal under consideration, and under NEMA (Part 3 Applications subject to scoping and environmental impact assessment, 32 (2) (k) (i) Cumulative impacts) there is a requirement to assess these combined impacts. Cumulative impacts by all industries are considered and where information is available data is presented and impacts are assessed.

9. POST-CONSTRUCTION MONITORING

There is evidence to suggest that bat activity changes after turbine installation, possibly due to bats being curious, or being attracted to turbines or to insects around turbines. At present it is not known how southern African bats react to installation of turbines. A precautionary approach is therefore recommended and the effort and techniques employed should be assessed on a site by site basis. The aim of post-construction monitoring should be to assess changes in activity patterns, determine mortality at sites where impacts are predicted following installation and the operation of the turbines and provide additional information on any mitigation schemes. If the change is significant enough to have impacted the ability of the population to survive, breed or reproduce (including to rear their young), or be affected significantly in their local distribution or abundance, this puts the population of bats at risk. Because of their life-history characteristics, which includes low fecundity (or low rates of producing and raising young), bat populations are slow to recover from disturbances and declines, and mortality may occur. This in turn runs the risk of infringing the National Environmental Management: Biodiversity Act 10 of 2004 unless mitigation is implemented. Without information on how the bats' activity changes after installation and operation, effective mitigation cannot be proposed and instigated to reduce any substantive risk to bat populations.

The first two years of a wind energy facility's operation are the most important period in which to collect post-construction information, as this is when any change in bat activity and mortalities are likely to occur. It is suggested that a minimum of two year post-construction monitoring be undertaken (but auditing for impacts should continue throughout the lifespan of the facility). Where more severe impacts have been identified or predicted, an extended period of data collection may be needed to assess the effectiveness of any mitigation proposed. Post-construction monitoring will consist of acoustic monitoring within rotor swept height and regular carcass searches. Details regarding guidelines for post-construction monitoring are not provided in this document, but will follow in a separate guideline document.

10. BASELINE DATA COLLECTION AND STORAGE

In order to better inform future pre-construction monitoring methodology and mitigation measures, it is important that the current limited knowledge of the biology and ecology of many South African bat species, as well as the interaction between bats and wind energy facilities is addressed within the South African context. To this end, data collected during pre-construction (e.g. acoustic monitoring and roost surveys) and post-construction monitoring (e.g. carcass searches) at wind energy facilities, should be deposited with a designated coordinator at the end of the relevant data collection campaigns. This information is critical for our understanding of wind energy facilities and their impacts on bats in South Africa and, in addition to informing future guidelines, will inform future avenues of research. The DEA is in the process of commissioning SANBI, in co-operation with SABAAP, to develop a bird and bat monitoring data management tool.

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12. APPENDIX 1: Determining the number of bat static detectors required for monitoring at a site

Wind Energy Facility sites that are ≤5km2 (≤500ha) need only be monitored using one static acoustic bat detector connected to one microphone in turbine rotor sweep height and one microphone at >7m above ground level.

For WEF sites >5km2 (>500ha) and ≤35km2 (≤3,500ha), at least one bat detector should be assigned for each unique combination of vegetation and topography, and land-use and topography.

Vegetation types should be sourced from Mucina & Rutherford (2006). Land-use types should be considered when significant portions of a site have been transformed by e.g. crop cultivation, livestock over-grazing and alien plant invasion. Vegetation and land-use will often be correlated with topography, and low-lying areas (ravines and floodplains) will often be associated with water. Empty buildings and human settlements can be assessed using roost surveys, mist-netting and acoustic spot surveys.

For WEF sites >35km2 (>3,500ha), in addition to the minimum number of detectors for all unique combinations of vegetation, land-use and topography, one detector should be assigned for every additional 35km2 (3,500ha) comprising the site.

Thus each detector at a WEF site should record a fraction of the activity of bats flying within a radius around each detector of 3.3km or less, depending on local habitat diversity. This recommended ~3km radial "coverage" per detector is based on the finding by Jacobs & Barclay (2009) that House Bats (*Scotophilus* sp.) make foraging movements from their roosts of typically 1-2km, and occasionally up to 3km.

Additional bat detectors for a WEF can be assigned at the discretion of the bat specialist(s) performing a study. The following example helps to explain the recommended methodology:

Example 1

As shown in the **Table A1** below**,** five detectors would be assigned for all unique combinations of vegetation, land-use and topography at a hypothetical 315km2 (31,500ha) WEF site in the Karoo.

Table A1: Minimum number of bat detectors assigned for all unique combinations of vegetation, land-use and topography at a hypothetical WEF site in the Karoo

Vegetation types & Land-use types	**Low (ravines, channels, floodplains)**	**Elevation/Topography Medium (plains, gently undulating terrain)**	**High (ridges, hills, mountains)**	**Numbers of detectors**
Tanqua Wash				
Riviere	1	1		2
Tanqua Karoo		1	1	2
Cultivated fields	1			1
Numbers of detectors	2	2	1	5

In addition to the minimum five detectors for all unique combinations of vegetation, land-use and topography, four additional detectors should be assigned for the size of the site based on the following calculations:

In kilometres:
WEF = 315km2
5 detectors (for vegetation, land-use and topography) x 35km2 per detector = 175km2
315km2 - 175km2 = 140km2
140km2 / 35km2 per detector = 4 detectors
Total minimum number of detectors = 5 detectors + 4 detectors = 9 detectors
315km**2** / 9 detectors = 35km**2** per detector = area in a 3km radius around each detector

In hectares:
WEF = 31,500ha
5 detectors (for vegetation, land-use and topography) x 3,500ha per detector = 17,500ha
31,500ha – 17,500ha = 14,000ha
14,000ha / 3,500ha per detector = 4 detectors
Total minimum number of detectors = 5 detectors + 4 detectors = 9 detectors
31,500ha / 9 detectors = 3,500ha per detector

For many large WEF sites, the total minimum number of detectors might simply be obtained by dividing the total site size by 35 (if working in kilometres) or 3,500 (if working in hectares), as shown for the hypothetical Karoo WEF by the following calculations:

315km**2** / 35km**2** per detector = 9 detectors or 31,500ha / 3,500ha per detector = 9 detectors

Unfortunately, this simpler method of calculation is not recommended, as it may not be appropriate for sites with a high diversity of habitats, as demonstrated in the next example.

Example 2

For a hypothetical 140km2 (14,000ha) WEF site on the southern Cape coast, a total minimum of four detectors could be assigned by simply dividing the site size by the recommended ratio of 35km2 (3,500ha) per detector, as such:

140km**2** / 35km**2** per detector ≈ 4 detectors or 14,000ha / 3,500ha per detector ≈ 4 detectors

However, at least seven detectors should be assigned for all unique combinations of vegetation, land-use and topography, as shown in **Table A2**.

Table A2: Minimum number of bat detectors assigned for all unique combinations of vegetation, land-use and topography at a hypothetical WEF site on the southern Cape coast

Vegetation types & Land-use types	**Elevation/Topography**			**Numbers of detectors**
	Low (ravines, channels, floodplains)	**Medium (plains, gently undulating terrain)**	**High (ridges, hills, mountains)**	
Canca Limestone Fynbos		1		1
Southern Cape Valley Thicket	1			1
Cape Inland Salt Pans	1	1	1	3
Cape Lowland Alluvial Vegetation				
Groot Brak Dune Strandveld	1			1
Cultivated fields	1	1		2
Numbers of detectors	4	3	1	7

If seven detectors are assigned for all unique combinations of vegetation, land-use and topography, no additional detectors are required for the size of the site, and there would be approximately one detector for every 20km2 (2,000ha) comprising the site, as explained by the following calculations.

In kilometres:
WEF = 140km2
7 detectors (for vegetation, land-use and topography) x 35km2 per detector = 245km2
140km2 - 245km2 = -105km2, hence no additional detectors are required
Total minimum number of detectors = 7 detectors
140km**2** / 7 detectors = 20km**2** per detector = area in a 2.5km radius around each detector

In hectares:
WEF = 14,000ha
7 detectors (for vegetation, land-use and topography) x 3,500ha per detector = 24,500ha
14,000ha – 24,500ha = -10,500ha2, hence no additional detectors are required
Total minimum number of detectors = 7 detectors
14,000ha / 7 detectors = 2,000ha per detector

The examples demonstrate that when determining the total minimum number of bat detectors for a WEF site, both site size and habitat diversity must be considered. Thus each detector at a WEF site should record a fraction of the activity of bats flying within a radius around each detector of 3.3km or less, depending on local habitat diversity.