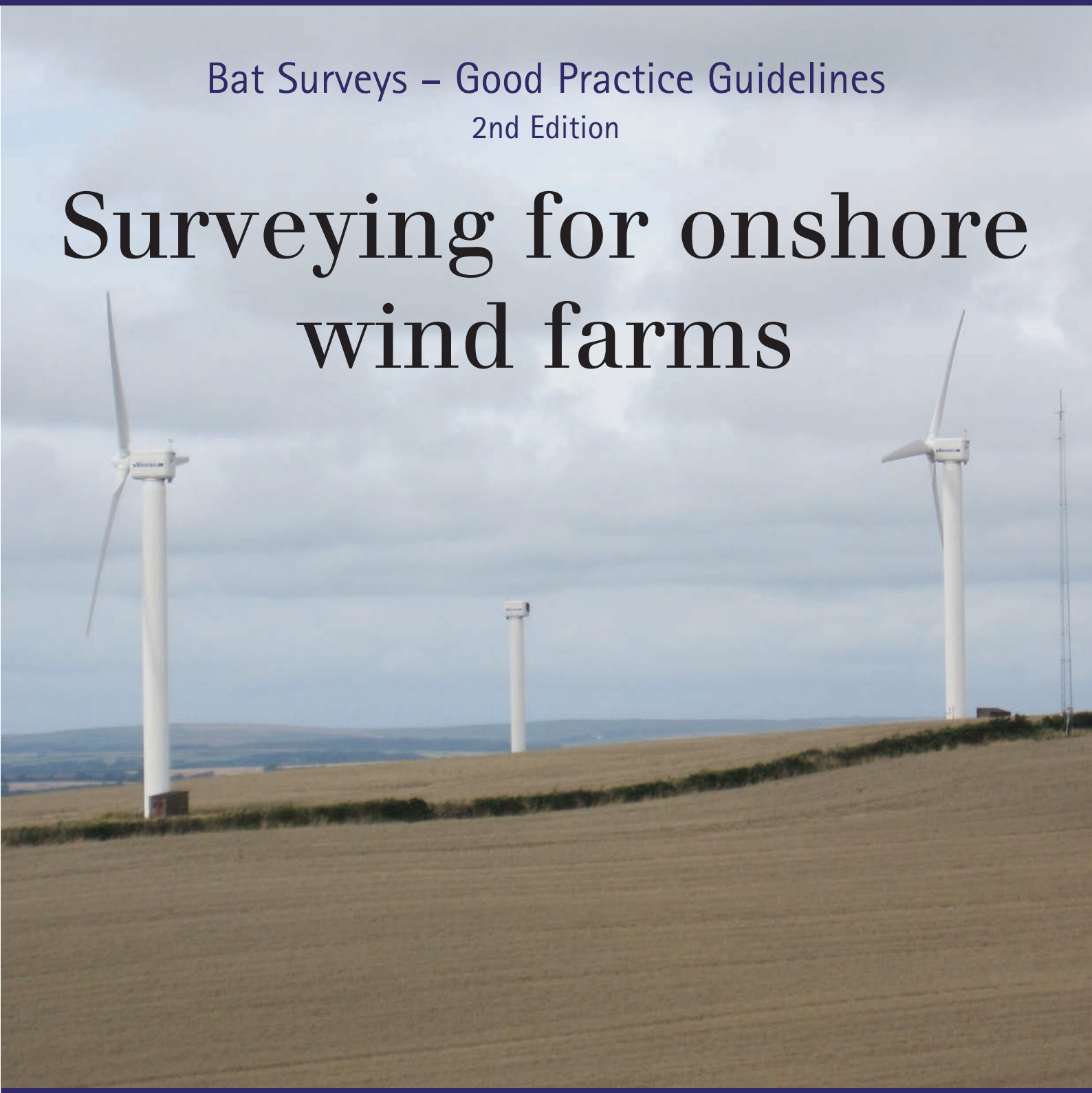
Bat Conservation Trust

Bat Surveys – Good Practice Guidelines

2nd Edition

Surveying for onshore wind farms



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Surveying for onshore wind farms

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Contents

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1 Introduction and scope

This guidance has been drafted to form an individual chapter of the revised Bat Surveys Good Practice Guidelines. It can form a stand alone document, but will also be incorporated into the 2nd edition. It is intended for all types of onshore wind farm for which bat surveys are required, from single to multi-turbine developments.

Although the guidance covers both single large (> 250kw) wind turbines and wind farms (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 may differ from that of a large multi-turbine wind farm, 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 (e.g. proposals for a single turbine in an area of high bat activity or preferred foraging habitat could pose a greater risk than several turbines in an area of low or no bat activity). Offshore wind farms and micro-turbines are excluded from this guidance, although brief reference is made to them.

Offshore wind farms

There is still uncertainty as to the extent to which bats use offshore areas in the UK. Studies from the UK and Europe are beginning to provide evidence of seasonal movement of Nathusius' pipistrelle across large areas of water such as the English Channel and the North Sea[1] and foraging or movements by species such as Daubenton's bat, pipistrelle bats, noctule, Leisler's bat and serotine over the sea[2]. In some instances local records and observations made during scoping surveys may indicate that bats, particularly those at high risk to turbine collision are likely to be at risk from the proposed offshore development. As a precaution it is advised that the need for surveys should be considered on a case by case basis.

This chapter does not cover survey for offshore wind farms in great detail, as survey techniques and standards are currently still in their infancy. Proposed offshore wind farm sites may be surveyed using similar activity survey methodologies, but will require the surveys to be undertaken in a number of different ways depending on the site. Methods used include boats, temporary offshore platforms or using radar from coastal structures. Where deemed necessary, the surveys should primarily concentrate on possible migration routes rather than foraging areas and be undertaken during spring (April/May) and autumn (August/ September), unless bats found on offshore areas such as nearby oil rigs and islands indicate their presence at any other time of the year.

Micro turbines

This guidance does not cover recommendations for survey in relation to micro turbines[3], although concerns remain about their possible impacts on bats. The production of best practice guidance is likely to be required following changes to permitted development regulation, which will vary between the devolved UK countries and pending the results of research currently underway. Evidence suggests there is potential for micro turbines to impact on bats particularly in instances where the turbines are installed in close proximity to roosts[4]. It is therefore recommended that potential impacts on bats from micro-turbines are assessed on a site by site basis. Surveys should be undertaken if it is considered that there is likely to be a significant impact on bats, particularly when records suggest a roost is located in close proximity to the turbine or initial site surveys identify potential foraging areas.

1 Russ J. M., Hutson A. M., Montgomery W. I., Racey P. A. & Speakman J. R. (2001) The status of Nathusius' pipistrelle (*Pipistrellus nathusii* Keyserling & Blasius, 1839) in the British Isles. *Journal of Zoology*, 254, 91-100.

2 Ahlen I., Baagoe H.J. & Bach L. 2009. Behaviour of Scandinavian bats during migration and foraging. J Mammalogy 90(6):1318-1323. & Ahlen I, Bach L.,Baagoe HJ., Petterson J., 2007.Bats and offshore windfarms studied in southern Scandinavia, Report Number 5571. Stockholm, Sweden: The Swedish Environmental Protection Agency.

3 For the purpose of this guidance note, micro turbines refers to installations of less than 50kW

4 BCT (2007) Micro-turbine bat mortality incidents (June 2007). http://www.bats.org.uk/pages/microgeneration_issues.html

Current published guidance

To date there is little evidence from the UK to determine the impact of wind turbines on bats and bat populations. Much of the existing evidence for adverse impacts comes from the USA/Canada and Europe. There are currently several pieces of guidance relating to both survey standards and assessing the impacts of wind farms on bats. The two main reference documents most relevant to the UK are from EUROBATS and Natural England. These are described in more detail below.

EUROBATS Guidance

The Advisory Committee of the 'Agreement of 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[5]. The EUROBATS guidance identifies that although most bats have been killed by collision with rotor blades in the late summer/autumn, resident bats from local populations have also been affected. Pre-construction surveys should therefore 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).

Natural Englands joint publication with Countryside Council for Wales and Scottish Natural Heritage – Interim Guidance on Bats and Onshore Wind Turbines

All parties to the EUROBATS Agreement are urged to develop their own national guidelines. However, as Britain currently does not have a sufficiently developed evidence-base to inform national guidelines, interim guidance has been drawn up by Natural England that interprets the EUROBATS guidance into a UK context[6]. Natural England has also produced interim guidance for single large turbines[7]. These guidelines are likely to be subject to review in the future and an updates should be sought from the relevant Statutory Nature Conservation Organisations (SNCOs).

BCT guidance for wind farms

This chapter of the Bat Survey Good Practice Guidelines seeks to build on the current European and SNCO guidance to provide a greater level of detail and technical guidance for consultants charged with carrying out impact assessments for proposed wind farms, to ensure they can carry out surveys to produce a sufficient level of detail on the bat usage of a site to provide a well informed assessment of impacts for planners and authorities who may be determining a planning application.

It will outline basic standards of good practice and highlight specific considerations relating to the surveying of wind farms. More detailed information on the techniques employed should follow the guidance outlined within other chapters of the BCT Bat Survey Good Practice Guidelines.

Planning and Legislation

All species of British bat are afforded legal protection[8]. These pieces of legislation make it an offence to damage or destroy a bat roost; intentionally or recklessly obstruct a bat roost; deliberately, intentionally or recklessly disturb a bat to the extent that it is likely to impair their ability to survive, breed or reproduce, or to rear their young; or affect significantly its' local distribution or abundance; or intentionally[9] kill injure or take any bat.

5 Rodrigues L., Bach L., Dubourg-Savage M.J., Goodwin J. & Harbusch C. (2008). Guidelines for consideration of bats in wind farm projects. EUROBATS Publication Series No. 3.

6 Natural England (2009). Bats and onshore wind turbines: interim guidance. TIN051.

7 Natural England (2009). Bats and single large wind turbines: Joint Agencies interim guidance. TIN059.

8 In England and Wales, the relevant legislation is the Wildlife and Countryside Act (1981) (as amended); the Countryside and Rights of Way Act, (2000); the Natural Environment and Rural Communities Act (NERC, 2006); and by the Conservation of Habitats and Species Regulations (2010). In Scotland, the key legislation that applies is the Conservation (Natural Habitats &c.) Regulations 1994 (as amended). In Northern Ireland, bats are listed under Schedule 2 of the Conservation (Natural Habitats etc) Regulations (Northern Ireland) 1995 and in the Republic of Ireland, under Schedule 5 of the Wildlife Act (1976) and Schedule 1 of the European Communities (Natural Habitats) Regulations (1997).

9 "Deliberately or recklessly" in Scotland

The legal protection afforded to bats means they are often identified as key ecological receptors in formal and informal impact assessments. There is also evidence from Europe that species found in the UK are affected by wind farms in various ways. As such it is considered that wind farm proposals will need to address the potential impact on local bat species and populations. A prerequisite for any good impact assessment is a sufficient baseline survey that enables potential impacts to be assessed. This is particularly true for assessments of wind farms where there currently remains a degree of judgement as to the significance of impacts due to the insufficient research base and state of knowledge of bat populations in the UK.

2 Assessing the need for a survey

Guidance on assessing the need for a survey for bats on proposed wind energy sites is provided in the EUROBATS and SNCO guidance. Building on this advice we recommend that an assessment is made of the quality of the habitat and wider landscape and the potential for these areas to support bats. Things to consider in this assessment are:

- Extent and quality of habitat surrounding and on the site including: woodland, linear features potentially used by bats, waterways and water bodies
- Proximity of the proposed site to sites designated for bats (SSSI or SAC)
- Buildings or other features or structures that potentially support, or are known to support roosting locations of bat species that may use or cross the site

The factors outlined above provide indications of some of the features to consider when assessing the need for a survey for both wind farms and single wind turbines. More detailed information is outlined in Table 1. A proposed site with any of the features listed above has the potential to have an impact on bats. The potential impact is likely to increase in relation to the number and quality of features. It is recommended that any site with the potential to have an impact on bats should be surveyed prior to development.

If a site is assessed as having no need for a bat survey, evidence to justify the assessment should be provided or requested to support this assertion.

Potential Impacts

Studies in the US and Europe have shown that the impacts of wind turbines on bats vary depending on site selection, species and season.

Most documented impacts include:

- Direct collision
- Barotrauma (mortality due to damage to bats' lungs caused by sudden change in air pressure close to the turbine blade[10])

Other possible impacts include:

- Loss of foraging habitat (either due to wind farm construction or because bats avoid the wind farm area)
- Barrier to commuting or seasonal movements and severance of foraging habitat

10 Baerwald, E. F., G. H. D'Amours, B. J. Klug, and R. M. R. Barclay. (2008). *Barotrauma is a significant cause of bat fatalities at wind turbines*. Current Biology 18(16): 695–696.

Little is known about the impacts of wind turbines on bats in the UK as there have been no systematic studies to date. Only a small number of fatalities have been documented and these have been either during surveys for bird fatalities or ad-hoc finds[11]. Recent studies from Europe show significant levels of mortality in the summer months[12] and at lower wind speeds in late July to early October[13] and that bat mortality at fully operational turbines was, on average, 3.6 to 5.4 times greater than mortality associated with curtailed (i.e. non-operating) turbines[14].

There is some evidence seasonal movements of Nathusius pipistrelles in Britain[15]. In the absence of UK based scientific studies it is recommended that a precautionary approach is adopted to the potential impacts of turbines on bats until more is known. It is for this reason that, weather permitting, the proposed survey period is April to October.

Level of risk of killing or injury and impacts on local populations

The SNCO interim guidance on the potential impacts of onshore wind turbines on bats includes a collision risk assessment for British bat species. This is divided into two parts; first an assessment of the category level of risk of each species based on its ecology (including foraging distance and height of flight), and second an assessment of the populations likely to be most threatened incorporating information on population estimates. This guidance identifies three species to be at high risk at the population level: Nathusius' pipistrelle, noctule and Leisler's bat. However, other factors and aspects have been identified and the results of further research have been published since the production of the interim guidance. These should be considered in conjunction with the current guidance when assessing potential impacts and surveys.

A summary of bat fatalities in Europe[16], found that the three bat species with the most fatalities recorded were noctule, common pipistrelle and Nathusius' pipistrelle. Further studies[17] have since supported these findings, with recorded bat mortality predominantly comprising bats belonging to species groups adapted to open-air foraging; *Nyctalus*, *Pipistrellus*, *Vespertilio* and *Eptesicus* spp. The Rydell study also indicated that mortality increased with turbine tower height and rotor diameter, but was independent of the distance from the ground to the lowest rotor point.

The risk to local or regional populations will vary as bats and bat species are not evenly distributed across the UK. Risk assessments will be also be different for turbines with lower hub heights, and for different designs of turbines. All of these factors need to be documented and taken into account on a site by site basis for each set of surveys and impact assessment.

11 University of Bristol / BCT. (2009). *Determining the potential ecological impact of wind turbines on bat populations in Britain; Scoping and method development report*. Report to Defra. http://www.bats.org.uk/pages/wind_turbines.html

12 Dubourg-Savage M-J., Bach L., & Rodrigues L. (2009). See 3.

13 Rydell, Jens; Bach, Lothar; Dubourg-Savage, Marie-Jo; Green, Martin; Rodrigues, Luisa; Hedenström, Anders (2010). *Bat mortality at wind turbines in northwestern Europe*, Acta Chiropterologica, Volume 12(2), December 2010 , pp. 261-274(14)

14 Arnett EB, MMP Huso, MR Schirmacher & JP Hayes. 2010. *Altering turbine speed reduces bat mortality at wind-energy facilities.* Front Ecol E-nviron 2010; doi:10.1890/100103.

15 Russ J. M., Hutson A. M., Montgomery W. I., Racey P. A. & Speakman J. R. (2001) The status of Nathusius' pipistrelle (*Pipistrellus nathusii* Keyserling & Blasius, 1839) in the British Isles. *Journal of Zoology*, 254, 91-100.

16 Dürr & Dubourg-Savage (2009). EUROBATS 14th Meeting of the Advisory Committee Report: Rodrigues *et al.* (2009)

17 Rydell, Jens; Bach, Lothar; Dubourg-Savage, Marie-Jo; Green, Martin; Rodrigues, Luisa; Hedenström, Anders (2010). *Bat mortality at wind turbines in northwestern Europe*, Acta Chiropterologica, Volume 12(2), December 2010 , pp. 261-274(14)

Table 1: Overview of factors to consider when designing surveys and reviewing desk study / scoping survey results

Survey effort	Potential risk of mortality/ impact on bat population			
	Quality of habitat, number of features likely to contribute to potential mortality rates*	**Number of turbines**	**Species likely to use the site***	**Importance of roost of species likely to use site, which may be affected***
Lowest	No potential for roosting, foraging or commuting bats	1	None	
	Small number of low potential roost features		Low number, single low risk species	
Low	Low quality foraging habitat that could be used by small numbers of foraging bats	2 to 3		
	Isolated site not connected to the wider landscape by prominent linear features		High number, several low risk species	Local, Parish
	Buildings, trees or other structures with moderate-high potential on or near the site		Low number medium risk species	District
Medium	Habitat could be used extensively by foraging bats	4 to 8		
	Site is connected to the wider landscape by linear features such as scrub, tree lines and streams		High number, medium risk species	County
	Numerous suitable buildings, trees (particularly mature ancient woodland) or other structures with moderate/high potential on or near the site and/or confirmed roosts present close to or on the site.	9 or more	High number, single high risk species	National
High	Extensive and diverse habitat mosaic of high quality for foraging bats		High number several high risk species	
	Site is connected to the wider landscape by a network of strong linear features such as rivers, blocks of woodland and mature hedgerows.		High number all high risk species	International

* As outlined in current scientific research, SNCO guidance[18], BCT Bat Survey Good Practice Guidelines and IEEM – EcIA guidance[19]

It should be noted that the potential impact is likely to increase the greater the proportion to the number and quality of habitat features. Survey effort should therefore take this into account and represent the overall influence of all factors detailed in the table.

18 At the time of publication this was Rydell et al (2010): see 18

19 Wray S, Wells D, Long E & Mitchell-Jones T (2010) Valuing bats in ecological impact assessment, In Practice, No. 70, Institute of Ecology and Environmental Management

3 Preparation and planning of surveys

Resources required for surveys

It is important for those bidding for or commissioning survey work, to ensure that ecological consultants have sufficient resources and the skills to undertake specialist impact assessments. This may include sufficient specialised survey equipment such as bat detectors and recording devices for static and manual surveys, radio tracking and equipment for monitoring at height. Enough experienced trained staff will be required to properly assess the scope of site surveys, analyse the recordings, complete the impact assessment and provide detailed advice on impact avoidance, suitable mitigation, enhancement and compensation as appropriate.

The importance of meeting survey aims

The overall aim of surveying at proposed wind energy sites is to collect robust data to allow an assessment of the potential impacts the proposed development on the bat species present on and around the site. This information is vital to allow the wind developer to decide whether to proceed with a proposal and where appropriate, modify the proposed layout. It is only then that the proposed development application can be submitted and determined by the appropriate authority. Where necessary, proposals for appropriate mitigation, compensation and enhancement can be drawn up. The SNCO guidance outlines the basic information required from surveys. Box 1 provides more detailed guidance on the information needed from each survey to enable that impact assessment to be made. The survey will also provide baseline information with which the results of post-construction monitoring can be compared.

Surveys must be designed to meet these key aims and provide all the relevant information needed for appropriate identification and subsequent assessment of the impacts. Survey design will therefore vary depending on the habitats present on and around a proposed site and may need adjustment throughout the survey period to continue to meet the aims.

Box 1. Essential information required from survey

In order to assess the impacts of a wind farm or single turbine on bats, the following information is needed:

- Assemblage of bat species using the site, noting higher, medium and lower risk species groups
- Relative frequency of the site use by the different species throughout the active season
- The spatial and temporal distribution of activity for different species
- The nature of activity for different bat species, for example foraging, commuting and roosting (where possible)
- Details on how the surveys have been designed to determine presence of species of medium/higher mortality risk or species at risk of high impact at the population level as outlined by SNCO guidance and relevant scientific findings.

Scoping survey / Pre-survey data searches

A key factor that will influence the design of surveys is information received from pre-survey data searches. The potential impacts of a wind energy development will depend on the species and habitats present on the site. The presence of rarer species, known roosts or species that have been identified to be at risk of impacts should be considered from the outset and surveys designed to address any potential impacts related to them. The pre-survey data search 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 survey should *always* be undertaken for a proposed wind energy site.

The pre-survey data search should include (whenever possible) the following:

- Collation and review of the information potentially relevant to the site assessment including: literature, maps and aerial photographs, habitat data (if available) to identify the better quality habitats, data on bat distribution, roosts and bat sightings
- A data search of known bat records and roost locations: 10km for high risk species[20] and 5km for all other bat species. Any available information on the local/regional status of the bat species should also be sought where possible
- A search for any site designated for bats as a SSSI or SAC within 10km of the wind energy site.

The pre-survey search should also include the footprint of any proposed access roads and temporary construction areas or other associated development.

This information should then be used to compile a scoping report detailing the potential impacts of the development and any records received should be used to inform survey design. However, it must be noted that although data searches provide useful information, it is unlikely that all potential species and roosts will be known. Consequently, surveys should be designed with this in mind, both to ensure coverage of the appropriate survey area and with the scope to investigate any rare or unusual records thoroughly as they come to light.

A walkover survey is an essential part of the scoping survey. This will allow an initial assessment to be made of the overall habitat quality and connectivity, the potential for roosting on the site and to identify likely areas of importance for bats. Information gathered during the walkover should be used to inform the survey design.

Information on future land use

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

Pre-site selection baseline data

At the majority of sites a meteorological mast (met mast) will be installed at some stage to monitor the wind speed on the site. It is highly recommended that static bat detector microphones are installed (one at the base and one at turbine hub height, or as close as possible on the met mast to this height) at the same time as the met mast is erected whenever possible. Close liaison with wind developers will be required as met masts require planning permission and will typically be deployed as soon as permission is obtained, which may be during the autumn or winter. Met masts are typically erected by specialist companies who work to tight deadlines and therefore close liaison is essential.

20 As outlined in by most recent scientific research (at the time of publication this was Rydell et al (2010)) and SNCO guidance. (See 6 & 7).

This will provide initial data on bat activity at different heights at the met mast location, and allow analysis of how weather conditions affect bat activity through simultaneous collection of environmental data. There is a growing body of evidence to show that bat activity declines significantly in strong winds, low temperatures and heavy rain[21] and that these effects are likely to be magnified in open, exposed locations where turbines are likely to be located. Collection of a full season of bat activity data from a met mast within the proposed wind energy site would allow a detailed analysis of this kind to be carried out to compliment other survey data.

Re-powering

Many of the early wind farm developments pre-dated the requirement to undertake pre-construction bat activity surveys and post-construction monitoring. Some of these earlier wind farm development sites are now subject to proposals for re-powering (i.e. the replacement of turbines with new and often larger turbines). It cannot be assumed that re-powering existing schemes represents any lower level of risk than the construction of new schemes and the risk of any such proposals should be assessed before permission is given by the relevant body for replacement of turbines.

In cases where survey or monitoring at sites where re-powering is planned has been undertaken, the results should be used to assess whether the proposed changes at the site may increase the risk of bat mortality and what if any mitigation should be applied. In cases where no survey or monitoring has been undertaken, the methods proposed for new developments should be used as the basis for assessing the risk of re-powering.

4 Survey techniques and standards

Selection of survey techniques

Surveys at proposed wind energy sites should be designed to provide the information required to complete a full impact assessment as set out in Box 1. The surveys will need to take into account the spatial and temporal variation in bat activity of different species and will need to describe bat activity within the 'developable area'[22] and near proposed turbine locations (if fixed). Data should be collected using complimentary survey techniques designed to confirm and further inform any potential impacts identified as part of the pre-survey data search.

The surveys required to obtain these data fit into two broad categories: Activity Surveys and Roost Surveys. An overview of the different techniques that can be employed within these categories can be found in Box 2. Each of these techniques will provide information on different aspects of the site and its use by bats.

This section of the document will outline the standards of best practice for each survey technique and highlight specific considerations relating to the surveying of wind energy sites. More detailed information on the general techniques and equipment that can be used for different methods can be found in the BCT Bat Survey Good Practice Guidelines.

21 Rydell, Jens; Bach, Lothar; Dubourg-Savage, Marie-Jo; Green, Martin; Rodrigues, Luisa; Hedenström, Anders (2010). *Bat mortality at wind turbines in northwestern Europe*, Acta Chiropterologica, Volume 12(2), December 2010 , pp. 261-274(14)

22 The 'developable area' is the area within a proposed site or landholding where turbine may be located. This will be determined by fixed constraints such as radar, microwave links, noise, housing buffers, noise, roads, rights of way, underground services etc.

Box 2: Overview of main survey techniques

Activity Surveys - Manual surveys
Manual activity surveys such as transect surveys and commuting route surveys are necessary to gain an understanding of the range of bat species using the site and the features on site that the bats are using. These surveys should always be complimented by static detector surveys. Radio tracking may be necessary to monitor flight routes of some bat species accurately, but this should not be advocated unless data from preliminary surveys identify that this is necessary.

Activity Surveys - Static detector surveys at ground level
Manual bat activity surveys only provide a snapshot of activity on a site. Automated bat detector systems should also be used to assess bat activity at proposed wind energy sites. Static detector surveys provide an invaluable volume of data on the bats present on the site at series of fixed locations. Data collected provides information to gauge the relative importance of features and locations and how this may change throughout the relevant season. When assessing sites for proposed wind turbines the survey core period is April to October. This may change subject to where the site is in the country and prevailing weather conditions, particularly early in the season.

Activity Surveys - Static detector surveys at height
In addition to ground level static surveys, detectors can also be installed at height with the aim of identifying the amount of bat activity at this altitude. If surveying at height, detector microphones should be within the predicted rotor swept area.

Roost Surveys- Identifying potential roost sites
Surveys to assess and identify key areas for roosting areas such as buildings, and trees should be carried out. Any areas with high potential within 200m of the developable area should be investigated further (if access is granted) in order to identify potentially important roost sites. If identified as roosts then see below.

Roost Surveys - Surveys at known roosts
Known roosts of species that may cross or utilise the site that have been identified from the data search or during initial surveys should be surveyed to identify roost size and roost type. Activity surveys of roosts of high and medium risk species and/or roosts of district importance and above (see Table 1 and 2 for further details) may be required to identify whether the species are crossing or using the site throughout the active bat season.

Other Survey Methods
Vantage Point Surveys
In some circumstances where bats are appearing on site early in the evening such as noctules, vantage point (VP) observations from several location overlooking the site can be helpful to assess the number of bats, direction to the roost (sometimes actual roost locations), commuting routes and type of activity. These should start at least 30 minutes before sunset using binoculars and bat detectors with a high sensitivity. VP locations should be selected to maximise coverage of site. The need for this type of survey will be determined on a site by site basis.

Back tracking surveys
In some instances a back tracking survey to find a roost may be required as a follow-up to vantage point surveys or activity transects to determine location of roosts.

Infrared cameras, low light video and radar
Other methods such as low light video, infrared cameras and radar can also provide additional information. Low light video and infrared camera can be used to help identify potential roost sites to determine the need to follow up surveys. There is some evidence to suggest that radar could be used to track the movements of bats[23] but consideration should be given to the fact that infrared may not always give the range and field of view needed to provide robust information in open habitats. It is not recommended that these form part of a standardised methodology. However, such techniques may be appropriate for sites where particular potential impacts have been identified and more detailed, targeted surveying is required.

NB. More in depth guidance on the appropriate survey techniques can be found in later sections and in other chapters of the BCT Bat Survey Good Practice Guidelines

23 Larkin, R.P. and Szafoni, R.E. (2008). Evidence for Radar evidence for dispersed groups of migrating vertebrates at night. *Integrative and Comparative Biology*.Vol. 48, Issue1 Pp. 40-49.

Weather conditions

General guidance for carrying out bat surveys suggests that they only take place in optimum weather conditions in order to maximise the likelihood of recording bats if they use the site being surveyed. It is usually advised to avoid very heavy rain, strong winds, mists and dusk temperatures below 10°C. This guidance should be followed for transect surveys. However, where static detectors are deployed for a number of days at a time over a period of months 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 in these circumstances, providing some level of weather information is also available and/or recorded on the site.

Measuring environmental parameters

Whenever possible, data on wind speed, rainfall and temperature should be gathered over the entire season and compared with the bat activity of the site, particularly data collected from static detectors. This information could provide useful indications as to what parameters influence bat activity on the site and could feed into mitigation plans such as feathering turbines. Consideration should be given to installing a weather station on high risk sites where mitigation may be required to ensure a sufficient level of detailed information is obtained.

Timing and survey season

Manual surveys should commence at half an hour before sunset for a dusk survey and finish at sunrise for a dawn survey. Static detector surveys should commence half an hour before sunset and finish half an hour after sunrise to ensure that bat species that emerge early in the evening and return to roosts late, such as noctules, are included within the survey period.

Static detectors should be left in position to collect data during complete night periods as stipulated above. In cases where the sites have public access and the detectors may be subject to interference, security measures should be employed such as deploying detectors in locked boxes. Timers determining the start and end times of the survey should be regularly adjusted through the season to take account of the variation in night length.

When deploying static detectors for assessing wind turbines the core survey period is April to October (weather permitting)

In some instances it may be necessary to carry out surveys in March. Decisions to undertake surveys at this time should be influenced by geographic location of the site and the weather conditions for the year.

Methods

Roost Surveys

At sites offering good opportunities for bat roosts, the survey should include a daytime inspection of any structures and trees for evidence of roosting bats. Any other features that could not be inspected in detail or require further survey and need to be observed at dusk should be noted and mapped. These should be surveyed separately (if possible) and not as part of an activity survey. Sites with evidence of roosting by species that utilise or cross the site may be subject to additional surveys as outlined by SNCO and BCT guidelines.

If significant roosts are known or located during these surveys, activity surveys should be undertaken that identify whether the population utilises or crosses the site, including any key commuting routes from these roosts that are located either within or close to the wind energy site. The survey effort and methods required to gather this information will largely be dependent 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 always be noted that these may vary during the year as colonies may move regularly and their roosts occupied seasonally.

Activity Surveys - Ground level manual surveys

Broadband bat detectors (frequency division or full spectrum) should be used for all manual activity surveys, either connected to a recording device or with an in-built recording capability, to ensure that all bat calls are recorded and can be subsequently analysed for identification to species or species group level. Detailed information on the appropriate approach to designing manual transect surveys can be found in the BCT Bat Survey Good Practice Guidelines.

The number of transects required to cover the main habitat features of the site will depend on the proposed site's size and complexity. Sufficient transects should be set up to ensure that all features identified that may be used by bats are sampled within, or around 2-3 hours after sunset. More than one transect is therefore likely to be required to cover all areas as well as all habitats of the site in one survey session. Dawn surveys may also be useful, particularly for locating roosting bats, and can be used in combination with evening transect surveys over the course of a season.

Listening points can be identified along the transect routes to divide the route into comparable sections of distance and / or habitat. These points should be evenly distributed in distance and amongst the habitats across the site. These include habitats considered to be of low value to bats such as arable fields. Bat activity should be recorded for a set amount of time (at least 3 minutes) at each listening point and continually recorded between these points. The number of passes and the estimated number of bats should be recorded at each listening point and between listening points. The activity recorded can then be used to represent and compare bat activity across the site and within different habitats.

Surveys should be undertaken from opposite directions and started from different points along the route throughout the survey season. This is to allow for the differing emergence times of bat species and provide a more complete overview of bat activity across the site throughout the survey period. Transect routes should be kept as close to the original routes as possible.

There may be instances that require specialised survey techniques and experienced surveyors. These should be informed by the first year of baseline survey. For example, if there is a roost of a rarer or high risk species that may be vulnerable to impacts of the proposed development, further survey of roosts and/or radio-tracking may be appropriate to provide comprehensive information on the bats' use of the site. However, each situation should be assessed on its own merit relative to the level of additional information it will provide.

Activity Surveys - Ground level static surveys

Static detectors should be deployed in sufficient number or moved on rotation to enable collection of data on bat activity across the site in accordance with the guidance provided in Table 2. There are a number of ways in which this can be done and the best design will depend on the site size, habitat features present, size of developable area and number of potential turbine locations. If possible, static detectors should be used to monitor throughout the developable area including all potential turbine locations if known or fixed, plus additional locations identified as features that may be used by bats for comparison. To allow a valid comparison to be made, pairs of detectors should record simultaneously and over the same time period. For example, one detector is set up to record at a proposed turbine location, and a second set up to record simultaneously at the nearest feature identified as providing suitable habitat for bats. Both detectors are left to record for the same period of time to provide information on the relative importance of turbine locations within the proposed site.

Alternatively, if this is not possible, detectors could be set up on a grid system with detectors placed both within the developable area where turbines may be located and along features identified as part of the preliminary scoping. These designs will allow bat activity levels to be compared between open areas and areas with bat features across the site. The exact locations for static detectors may need to be adjusted following the manual survey findings. It is important to monitor interim results from surveys and adapt further survey work according to preliminary results to maximise the information collected on bat activity across the site.

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 made. In addition all detectors must be appropriately calibrated to allow for variation between detector unit and to allow a valid comparison of recorded bat activity across a suite of detectors[24]. Microphones should be directed at an angle of 45 degrees towards the target area. This may be the proposed turbine location, if within the developable area, or along a hedgerow if the survey aim is to record activity along linear features. Surveyors should be aware of the constraints of bat detectors and their modifications and should list them in their report along with an assessment of the impact of the constraints.

Activity Surveys - Static surveys at height

Research suggests that, with the exception of above the woodland canopy, the relative activity or number of species recorded is unlikely to be greater at height as opposed to ground level (at proposed turbine locations)[25]. However, the range of species recorded at height may differ from ground level, with a higher proportion of aerial-hawking species of bats recorded at height. This may be significant in relation to assessing impacts on sites with a high proportion of high risk (aerial-hawking) species.

The need for monitoring at height should be assessed on a site by site basis.

Woodland sites

In woodland sites some bat species, for example larger bats, may only forage above the canopy and may not be recorded if monitoring is only completed at ground level. It is therefore essential that wind farm turbines proposed in woodland areas (key holing turbines), static monitoring is undertaken above canopy height in addition to ground level monitoring at woodland edges or along rides. 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 woodland rides and nearby woodland edges to provide information on the bat species assemblage and activity levels in open and woodland edge habitats in locality to provide an indication on how bats may adapt to and use the new habitat created through turbine construction.

Affixing static detectors at height

There are several available techniques that can be used to affix static detectors at height. As with ground level surveying, static detectors should be placed as close as possible to the spot where the turbine is proposed to be sited and within the rotor swept path height. It should be noted that in many cases the exact location and specification of turbines may not be known, or subject to change. In these instances it is advised that, where practicable, data are collected at several site locations to enable a comparison of activity across the site and between locations. If using a met mast it is likely there will only be one or possibly two met masts which will be within the developable area, so may be limited to those locations.

24 Larson, D. J. & Hayes, J. P. (2000). Variability in sensitivity of Anabat II detectors and a method of calibration. *Acta Chiropterologica*, 2(2): 209-213.

25 Collins J. & Jones G. (2009) *Differences in bat activity in relation to bat detector height: implications for bat surveys at proposed wind farm sites. Acta Chiropterologica* 11: 343-350. & Behr et al. 2007 (Germany) and Grunwald & Schafer 2007 (Germany), cited in Rodrigues *et al.* 2008.

The appropriate method will depend largely on the type of equipment used. All bat detectors vary in their range depending on a number of factors including the type of microphone used and the detectability of different bat species. These factors should always be considered when designing a survey. New equipment and techniques are being developed. The choice of methods should always be reviewed in the light of new developments to ensure the most appropriate technology and equipment is used for each particular survey.

Met masts

In some instances a met mast will be installed to monitor the wind speed on the site. It is recommended that static detectors are installed at the same time as the anemometers are erected whenever possible at heights within the rotor swept area. This not only provides data on bat activity at heights affecting by the rotor sweep of turbines, but can provide comparable data on weather conditions from an early stage. This may only be possible once the site proposals have been made public as masts above 15 metre require planning permission. However, on sites with high numbers of high risk species this additional information may be valuable.

Other possible options for installing detectors at height include using portable towers or masts specifically located for bat detector use, as are used extensively in North America[26], or placing bat detectors on the nacelles of existing turbines where a site extension is proposed; a technique which has been trialled in Europe[27] and is being piloted in a UK research project[28]. The erection of masts greater than 15 metres require planning consent and as such may not be possible until the proposed scheme has been made public and planning permission can be sought. Masts at 15 metres or below are only considered to provide valuable data if the rotor swept area falls within this height. In addition, the use of helium-filled balloons, kites and kite balloons to monitor bats at height with static bat detectors has been trialled in the UK. The use of these types of balloons is likely to only give specific additional information to that collected from baseline surveys. The principal limitation is that balloon surveys usually can only be undertaken over a small number of survey nights due to the costs of setting up and hiring the balloons. The additional data may be useful for sites where a high level of bat activity has been recorded for high risk species. However, permission is required from the Civil Aviation Authority if balloons are to be flown above 30m agl.

It is recommended that before embarking on aerial surveys, the value of the additional data can be clearly justified.

5 Survey effort

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 may differ from that of a multi-turbine wind farm, 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 offsite habitat enhancement schemes.

It should always be considered that deviation from these guidelines of either an increase or a decrease in survey effort may be reasonable depending on the characteristics of the site, the species present and the size and associated risks of the development.

26 Kunz T, Arnett EB, Erickson WP, Hoar AR, Johnson GD, Larkin RP, Strickland MD, Thresher RD, & Tuttle MD (2007). *Assessing Impacts of Wind-Energy Development on nocturnally Active Birds and Bats: A Guidance Document*. The Journal of Wildlife Management 71: 2449-2486.

27 Sattler, t and F. Bontadina (2005) L'evaluation ecologique de deux secteurs d'installations eoliens en france sur la basse de la diversite et l'activite des chauves-souris. Unpubl. Report 41 pp.

28 See University of Bristol / BCT. (2009). *Determining the potential ecological impact of wind turbines on bat populations in Britain. Scoping and method development report.* Report to Defra, www.bats.org.uk

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

Surveys of known roosts identified from the data search or during initial surveys should follow guidance outlined in the BCT Bat Survey Good Practice Guidelines and accord with SNCO and BCT recommendations. However, additional surveys should be carried out to identify the main commuting routes of species which cross the site and that have been identified as potentially at risk of negative impacts. It is also important to understand any seasonal patterns of use. The level of survey effort required for these commuting surveys should be assessed in accordance with the activity survey guidelines.

Activity Surveys

Manual bat activity surveys only provide a small snapshot of activity on site but enable detailed information to be collected in most areas of the site and allow for additional visual observations to be made of bat activity. Static detectors (located correctly) can provide an invaluable volume of data on the bats present at the site and are essential in order to gauge the relative importance of features and locations, as well as nocturnal and seasonal patterns of activity. It therefore recommended that;

Manual activity surveys *and* static surveys at ground level should be carried out as a *minimum* at multiple turbine sites

Survey design will differ depending on the proposed location of the wind turbines and size of the site. However, consideration should be given to the spatial scale for the survey, which should closely reflect the size and number of wind turbines, potential use of the site by bats and how this may affect the timing of survey work. This is largely influenced by the complexity of the habitats within the site, its potential to support bats and any historical data pertaining to the site and the surrounding area. Guidance on how to assess this can be found in the BCT Bat Survey Good Practice Guidelines.

Table 2 provides recommendations of minimum standards of survey effort. Survey effort should always be proportional to the likely impact of the development on the species at the site.

Table 2: Minimum Survey Standards

	Site Risk Level (see factors detailed in Table 1.)		
	Low risk	**Medium risk**	**High risk**
	Roost Surveys i.e. roosts of high risk species and/or roosts of district importance and above (see Table 1)		
Potentially important roosts **Known roosts of species that may utilise or cross the site**	Follow SNCO guidance and BCT Survey Guidelines wherever possible, establish extent that bats utilise the site. This is particularly important for roosts of high risk species and/or roosts of district importance and above (see Table 1)		
	Activity Surveys		
Survey period	All surveys should provide data for one complete data season as a minimum **and** provide robust representation of species assemblage as well as nocturnal and seasonal activity patterns.		
Survey area*	50m + rotor radius from proposed developable area	50m + rotor radius from proposed developable area	100m + rotor radius from proposed developable area
Ground level manual surveys**	One visit per transect per season (spring, summer and autumn)	One visit per transect a month (Apr-Sept or April-Oct)	Two visits per transect a month (Apr-Sept or April-Oct)
Ground level static surveys**	**1-4 turbines per site:**		
	5 consecutive nights for each turbine within the proposed developable area, per season	5 consecutive nights for each turbine within the proposed developable area, per month	2 sets of 5 consecutive nights for each turbine within the proposed developable area, per month
	For sites with 5-10 turbines per site (number of nights remains as above):		
	20% of total number of turbines (min 4 locations)	30% of total number of turbines (min 4 locations)	40% of total number of turbines (min 4 locations)
	For sites with >10 turbines per site (number of nights reduced to 3 nights):		
	3 consecutive nights data per season. 10% of total number of turbines (min 5 locations)	3 consecutive nights data per month. 20% of total number of turbines (min 5 locations)	2 sets of 3 consecutive nights data per month. 30% of total number of turbines (min 5 locations)
	In all instances where the developable area is uncertain, sampling locations should be spread evenly across the site.		
Static surveys at height	As outlined above during the period between July-September[29], particularly woodland sites where key holing is proposed. In situations where balloons are deemed necessary: Minimum of 4 nights every month between July - September.		

*should include ancillary developments (access roads etc.) and account for any light spill, removal of vegetation etc.
** sampling should be carried out to ensure that data is collected to represent the activity across the site

29 indicated peak period of bat mortality - Rydell, Jens; Bach, Lothar; Dubourg-Savage, Marie-Jo; Green, Martin; Rodrigues, Luisa; Hedenström, Anders (2010) *Bat mortality at wind turbines in northwestern Europe*, Acta Chiropterologica, Volume 12, Number 2, December 2010 , pp. 261-274(14)

6 Interpreting results

Survey information should always be collected, recorded and analysed to provide information that can be applicable to the direct proposals for the site and assess the likely impacts throughout the year.

Year one baseline survey information should be used to assess whether there is a need for an additional survey effort and/or specialised techniques.

This will be influenced by the species composition of the site and the proposed development. Factors to consider are the vulnerability of the species to impacts of wind turbines and their local, regional and national population status.

Estimations of bat activity

The volume of data collected from static detectors provides a useful opportunity to estimate relative bat activity, known as a bat activity index for the site. This is calculated by dividing bat passes by time.

Bat Activity Index = bat passes / unit time

It is important to consider that there will be a significant difference in the results using hours or nights respectively, as the unit of time, due to the difference in night length through the year. A summary table should therefore present both passes per hour and passes per night. Data collected should be analysed to detail the total number of bat passes for each species or species group (depending on the level of identification possible from recordings) and relative bat activity for each survey location and also the whole site. Comparisons can be made between areas. This information can then be used to provide:

- An indication of seasonal variation in species activity and composition
- Relative levels of bat activity at ground level and within the proposed turbine swept path area. This can be done by comparing bat activity at height to ground level and bat species activity levels
- Variations in activity and species composition in relation to different wind speeds and potentially other environmental conditions, such as precipitation and temperature
- Site-wide information on bat distribution. For example, a comparison between activity levels in open areas where turbines are likely to be sited and adjacent habitat features, which can inform the location of turbines, as well as future mitigation and monitoring
- An indication of the nightly activity patterns for different species. For example, times of peak activity on site can indicate whether features are used as commuting routes, the proximity of the site to roosts and the importance of the site for foraging. In this respect, hours would need to be used as the unit of time in preference to nights

Species groupings and data should also be reported in relation to the vulnerability of the species as identified by recent studies[30] and SNCO guidance[31].

30 At time of publication this was Rydell, Jens; Bach, Lothar; Dubourg-Savage, Marie-Jo; Green, Martin; Rodrigues, Luisa; Hedenström, Anders (2010). *Bat mortality at wind turbines in northwestern Europe*, Acta Chiropterologica, Volume 12(2), December 2010 , pp. 261-274(14)

31 Natural England. *Bats and onshore wind turbines: interim guidance* & Natural England 2009. *Bats and single large wind turbines: Joint Agencies interim guidance*; TIN059 & TIN051.

7 Reviewing survey reports

This section aims to provide guidance on assessing the standard of survey specifically for onshore wind energy developments. Additional information on how to assess applications and meet statutory requirements is detailed in the Bat Survey Good Practice Guidelines and other SNCO resources.

Before any application can be considered it is essential that sufficient information is received as part of the survey report. Box 2 outlines what should be included within a survey report. The level of survey effort and survey methods needed should be assessed on a case by case basis using the guidance detailed within this document. It should always be considered that deviation from these guidelines of either an increase or a decrease in survey effort may be reasonable depending on the characteristics of the site, the species present and the size and associated risks of the development.

8 Post-construction activity surveys

There is evidence to suggest that bat activity changes after turbine installation. At present there is a lack of UK evidence to inform how bats in the UK react to installation of turbines. UK studies have been commissioned to ascertain the extent of the impacts on behaviours and mortality. Phase One of this study has been published; *Determining the impact of wind turbines on bat populations in Great Britain Phase One Report*[32]. Findings from the field work currently being carried out as part of Phase Two have not been completed. There are also scheduled updates and additions to the current EUROBATS guidance on onshore wind farms[33] that may elaborate on this further.

A precautionary approach to monitoring is therefore recommended and the effort and techniques employed should be assessed on a site by site basis. The aims of post-construction surveys should be to assess changes in activity patterns and provide additional information on any mitigation schemes. The first 2 years of wind turbine operation would be the most important period in which to collect post-construction information on changes in bat activity in relation to turbines. However, but changes in bat activity in relation to habitat modification and off-site enhancements may require monitoring over a longer period.

Where more severe impacts have been identified or predicted, a longer run of data collection may be needed to assess the effectiveness of any mitigation proposed and it may be necessary to undertake fatality searches.

In the light of impending research in this field, these guidelines do not go into the same level of detail for post development monitoring. A separate document will be produced incorporating advances in this area in due course.

32 University of Bristol / BCT. (2009). *Determining the potential ecological impact of wind turbines on bat populations in Britain; Scoping and method development report*. Report to Defra. http://www.bats.org.uk/pages/wind_turbines.html

33 Rodrigues L., Bach L., Dubourg-Savage M.J., Goodwin J. & Harbusch C. (2008). Guidelines for consideration of bats in wind farm projects. EUROBATS Publication Series No. 3.

Box 2 - Information needed in a wind farm bat survey report

- **Executive summary** briefly outlining the timescale of the survey, broad methods and brief summary of conclusions.
- **Relevant expertise and experience of each surveyor** and the licensed bat worker (where relevant) and bat specialist overseeing the work. Also the relevant experience and knowledge of those analysing the recordings.
- **Summary of desk study / scoping survey** and how it has informed the survey design
- **Survey methods used**, to include acknowledgement and rationale should it have deviated from standard guidance.
- **Limitations of survey techniques and equipment** accompanied by an assessment of the impact of these constraints.
- **Survey information** that includes:
  - Survey area: how was the study area selected and how does it relate to the site area.
  - Date, time and duration of surveys: if non-standard survey methods are used, the rationale for this is needed. This would apply both for survey timings and survey methods.
  - Weather conditions: at the beginning, end and during the surveys
  - Map of developable area: and, if known, potential locations, height and sweep of proposed turbines
  - Methods section:
    - Details and criteria: used to identify and distinguish between species or groups
    - Maps: detailing the location of habitat features of importance to bats, transect routes (listening points and routes between listening points,. if applicable), static detector locations, developable area and potential turbine locations (if known or fixed), other features and topography
  - Results Section:
    - Results Tables: Detailing 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.
    - Appropriate summary tables: detailing total number of passes of each species recorded at and between each listening station.
    - Static recording results and activity indices
    - Map(s): detailing the location of roosts, main foraging areas and commuting routes in the context of the developable area. Maps should also show differences in relative activity, both spatially and temporally across the site. For example, seasonally or between different static survey locations.
    - Estimates of bat activity index*- 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 from both activity transects and static detector surveys separately to allow comparison of different methods.
    - Constraints – what factors, if any, could have restricted the quantity and quality of information collected
- **Analysis and assessment of impacts** based on survey results and up to date published research (include all references: many wind turbine applications end up at planning inquiries, so it is essential that all statements within a report can be backed up by data or a published reference) that includes:
  - Identification of likely impacts and assessment of the impact
  - Bat activity in relation to wind speed and other environmental parameters
  - Seasonal variation in bat activity
  - Recommendations for mitigation and /or compensation, if required should be included at this stage as these are needed 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 developer. This should include analysis of habitat management for other species of wildlife and habitats that may affect bat activity e.g. draw bats into the area. The assessment and recommendations should also consider predicted land use for the life of the wind farm.

*Bat Activity Index = bat passes / unit time

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Bat Conservation Trust

The Bat Conservation Trust (BCT) is the only national organisation soley devoted to the conservation of bats and their habitats in the UK. BCT's vision is a world where bats and people live in harmony, and it is working to ensure these amazing mammals are around for future generations to enjoy.

Bat Helpline: 0845 1300 228
www.bats.org.uk