**MARCH, 2014**

**SHUTDOWN PROTOCOL AND MITIGATION MEASURES FOR BIRDS AND BATS**

**Eolica del Sur Wind Power Project**

**Inter-American Development Bank**

**July 11, 2014**

# **INTRODUCTION**

The Energía Eólica del Sur (EES) Wind Farm Project (“the Project”) and the selected sites (Juchitan and El Espinal Municipalities) are located within the Isthmus of Tehuantepec, an area of global significance for migratory birds, which use this corridor to migrate from the Atlantic Coast to the Pacific. The Isthmus has been classified as Endemic Bird Area (EBA) by Birdlife International. Observations conducted in other wind farms of the region indicate that about 200 bird’s species is present at some point during the year. Seventy seven species of bats are known from the Isthmus of Tehuantepec based on a literature review (Villegas Patraca 2013). Of these 77 species, 43 have been documented from areas on or adjacent to the Project.

The present document developed by the Inter-American Development Bank (IDB) aims to define the strategy and the mitigation plan to be implemented by EES to prevent birds’ and bats fatalities caused by the Project’s operation. Per the credit agreement, Schedule 6.12 - Environmental and Social Provisions, the Shutdown Protocol and Mitigation Measures for Birds and Bats is part of the Environmental and Social Requirements for which the Borrower must comply with.

**Section one** of the document presents the central measure to proactively avoid impacts on birds which consist in the implementation of an early warning detection system for incoming significant flocks of birds during the migratory seasons.

**Section two**, details the mitigation measures to be implemented for both birds and bats on an ongoing basis. The measures selected had demonstrated their effectiveness in minimizing and mitigating birds and bats fatalities at other wind facilities.

**Section three**, presents the additional measures that will be taken if level of fatalities of birds and bats turns out to be significantly high despite the implementation of basic mitigation measures. EES will adhere to an adaptive management approach in mitigating impacts; the section describes the triggers for such additional measures and defines the parameters of application.

# **SECTION I. DETECTION SYSTEM**

* 1. OBJECTIVES
1. Implement a system to detect early on situations of high risk of collisions; and
2. Proceed to a preventive selected shutdown of few turbines to avoid collisions.
	1. METHODOLOGY

**Initiation and timeframe**

The highest probability of bird’s collisions is during the peak migratory periods (April-May and most importantly in October). Per the information recorded in other wind farms in the Isthmus of Tehuantepec, approximately 80% of the fatalities in a given year occur during the month of October and around 75% of those fatalities occur at nighttime. The patterns observed also indicates that fatalities are higher and positively correlated with the passage of a cold front (rain, thunderstorm) which decrease visibility conditions for birds.

As such, following the start of operation and for the entire duration of the two migratory periods i.e. Spring (usually April-May) and Fall season (October)[[1]](#footnote-1)1 for the duration of the life of the Project, EES will proceed to the implementation the detection system.

At the completion of two years of post-construction monitoring protocol, fatalities data will be evaluated by IDB and a determination will be made on the need to continue the detection for the spring migration. EES will follow guidance of the IDB on this matter and until it is specifically waived by IDB, the detection system will be implemented for both migratory periods.

**Implementation**

The early warning detection system aims to proactively prevent collisions of birds by proceeding to a selective shutdown of the turbines when a **risk situation** is identified. A **risk situation** is defined as one in which there is a potential for a significant number of birds to collide with the turbines. Birds flying in the direction of the turbines and at an altitude exposing them to collision either with the blades or the rotor are at risk to collide. The V90 3 MW turbines which will be used for the EES Project have a hub height of 80m, a rotor diameter of 90m and blades of 44m long. The collision risk zone lies then anywhere between 36m and 124 m (see fig.1).

Risk situation will be detected by a team of observers duly trained and equipped with night vision googles. EES will install tower of observations in order to be able to conduct bird’s visual detection from fixed point. The towers of observation will be of a maximum height of 8 m and will be installed in central places in both polygons. More than one tower per site may be required. Observations will be conducted during few hours at dawn, nighttime and dusk. More observation efforts would be put during the passage of a cold front. EES will adjust its observation strategy once the wind farms enter into operation.

F**igure 1. V90 3 MW- Collision Risk Zone**

****

**Steps leading to a shutdown of selected turbines**

1. During the migratory periods, if the observers visually detect a risk situation, a yellow level alert is set. A call to the operations center is made to prepare for a potential upcoming shutdown and turbines numbers are identified.
2. In case staff note the approaching flock of birds are maintaining their flight direction and altitude and they are at about 1 to 2 km distance of the turbines an ***Orange level alert*** will be set.
3. At less than 500 m distance, the order to shut down specific turbines should be given to the operations center and a ***Red level alert*** is set.
4. The operations center executes the shutdown of selected turbines
5. After the risk of collision has been mitigated the operation center shall turn on the turbine again.

**Post-evaluation**

Following a shutdown, a post-evaluation will be made; EES will fill up an information sheet containing the following elements:

* Date
* Start time of the shutdown
* End time of the shutdown
* Name of the person who authorized the shutdown
* Numbers of turbines shutdown
* Location of these turbines
* Weather conditions
* Discussion on the efficiency of the shutdown (after a shutdown,

visual observations on the ground from the base of the tower to a radius equivalent to the height of the tower plus 30 m, will be conducted to search for birds carcasses).

The information gained over time from the post-evaluation phase will help to build a stronger approach to bird’s wind turbines interactions.

The early warning detection system and its application on the field will be the object of a trial period during the first year of operation. The preventive selective shutdown of turbines is believed to be efficient to significantly avoid bird’s collisions without materially impacting the energy generation capacity of the wind farm as it will be temporary.

It has been documented that weather conditions such as heavy rains and thunderstorms affect the visibility of birds to detect structures, higher level of fatalities had been observed in other wind farms under these conditions. The IDB acknowledge that such weather conditions do also represent a challenge for the staff on the field to detect incoming flock of birds and as such the early warning detection system carries its limitations.

The next section presents a series of mitigation measures that will need to be implemented by EES on top of the detection system.

# **SECTION II: MITIGATION MEASURES FOR BIRDS AND BATS**

Over the years, a series of mitigation measures were implemented worldwide to tackle birds and bats collisions due to wind turbines generators (WTGs). Nevertheless, the issues of birds/bats collision with WTGs remains site-specific as many factors can have an influence the rate of collisions such as the wind farm layout, WTGs design (height, rotor speed, cut-in speed etc.), topography, presence or not of a migratory corridor, weather conditions and, presence or not of other wind farms in the vicinity of a given site.

Aside the implementation of the early warning detection system, EES will adhere to a robust set of mitigation measures to avoid, minimize and mitigate potential impacts that could be caused by collisions with the WTGs. The measures can be classified into two categories, preventive and corrective. Table 2 describes the measures and provides details for their implementation. The measures prescribed are based on best industry practices and experience learned by the IDB on efficient mitigation measures for wind farms in Oaxaca.

**Table 1. Set of Mitigation measures for birds and bats**

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Mitigation measures** | **Project phase**  | **Comments** |
| Preventive | EES will install the Bat/Avian Curtailment program within the VestasOnline Business (VOB) | Pre-construction  | If curtailement activities are required to reduce avian/bat fatalities, this program will permit to EES to activate shut down of turbines and increase of cut-in speed. |
| Preventive  | EES will continue to undertake pre-construction birds and bats studies.  | Pre-construction  | These studies will be used to identify presence of species of concern, evaluate their behavior and use of the site and, to evaluate risk. Such studies should be conducted during the key period of the Fall 2014, Spring 2015 and Fall 2015.  |
| Preventive  | EES will install mitigation devices such as the aerial marker spheres (orange balloons) on the guy wires of the meteorological towers.  | Pre-construction | The guy wire of the met towers had caused significant fatalities in other wind farms as it is poorly visible. Increasing the visibility of the guy wires will contribute to limit fatalities. The spacing between the spheres should be about 100 m. |
| Preventive | EES will install on each nacelles only red blinking light. No steady white burning light will be installed on the nacelles.  | Construction | Vestas do offer red blinking lights. It has been documented that steady burning white light confuse night flying birds and cause collisions. This type of light also attracts insects which attracts bats.  |
| Preventive  | EES will install a lighting system on the two substations (El Espinal and Juchitan) that is carefully designed.  | Construction  | Lights should be downward facing. An operational system should be implemented to ensure that the strict minimum of steady white lights required per Mexican regulations are left on at night.  |
| Preventive  | EES will only keep the strict minimum numbers of meteorological towers (masts) required on the sites.  | Construction | Unnecessary met towers should be dismantled once all the wind speed data had been gathered. |
| Preventive  | EES will install line marking devices on the transmission line 230 kV -115 kV segment under its responsibility.  | Construction  | It has been documented that birds do usually collide with the highest component of the transmission line with the earth wire (also called shield or ground wire). Increasing the visibility and thickening of this wire is key in reducing fatalities. Suspended fixed devices such as the Firefly should be privileged and installed each 50 m apart on the earth wire.  |
| Preventive  | EES will implement a post-construction monitoring protocol of birds/bats fatalities for an initial duration of three years following the start of operation.  | At the start of operation | The results will help to determine the patterns of birds/bats fatalities such as problematic turbines, highest periods of fatalities, species affected etc. Overall, results will help to refine the mitigation measures and the need to implement additional one. See Annex 1 for a detailed guidance on the post-construction monitoring protocol to implement.  |
| Preventive | EES will proceed to regular maintenance of artificial pond of water near the turbines.  | Throughout operation | Water bodies attract birds and bats, maintenance of ponds created by heavy rain accumulation will be conducted.  |
| Corrective  | ESS will proceed to a selective shutdown of turbines | Operation | This measure will only be implemented if the results of post-construction monitoring demonstrate detrimental effects on birds (see Section 3). |
| Corrective | EES will eliminate free- wheeling on selected turbines  | Operation | This measure will only be implemented if the results of post-construction monitoring demonstrate detrimental effects on bats ( See Section 3). |
| Corrective  | EES will proceed to adjustments in the increase of the cut-in speed for selected turbines  | Operation | This measure will only be implemented if the results of post-construction monitoring demonstrate detrimental effects on bats (see section 3). |

**SECTION III: ADAPTIVE MANAGEMENT**

Operating a wind farm in a region with an important migratory route pose certain uncertainties in terms of level of fatalities expected. Impacts on the avian fauna will only be known with certainty after the completion of the post-construction monitoring (the search for carcasses). An adaptive management approach is therefore required through the life of the Project.

At the completion of three years of continuing post-construction monitoring, the IDB will evaluate the data and determine if there is a need to trigger additional measures to curb the level of fatalities. The decision will be guided by the specific management triggers listed below:

* IUCN Red List status of impacted taxa;
* Other national or international conservation listing sattus of impacted taxa;
* Potential for impacted specie to experience significant population level impacts as a result of the observed mortality;
* The observation of species or risk issues at the site that were not identified during the preconstruction risk assessment and which warrant significant consideration with respect to environmental impacts; and
* Fatality impacts significantly high.

**For birds,** measures will require a mandatory selective shutdown of turbines up to a maximum of 10% of the turbines for a maximum of 4 hours per day between 10pm and 6 am up to a period of 15 consecutive days between September 15 and October 31.

**For bats*,*** measures will require (a) an increase of the cut-in speed up to 5.5 m/s for up to a maximum of 10% of the turbines for a maximum of 4 hours per day between 8pm and 6 am for  up to a period of 8 consecutive weeks between August 15 and October 15, and, (b) the permanent elimination of free-wheeling of up to 25% of the turbines.[[2]](#footnote-2)4

It is worth mentioning that these additional measures had been developed in light of the information accumulated on birds and bats fatalities patterns observed in other wind farms in the Isthmus of Tehuantepec. The data collected indicates that 80% of bird’s fatalities occur during a two weeks window in the peak fall migratory period between September 15 and October 31. More than 75 % of the fatalities also occur during a 2-4 hours period at nighttime. The fatalities were also positively correlated with the presence of a cold front i.e. 1-3 days after the passage of a cold front; fatalities were much higher due to poor visibility. The data also clearly demonstrate that a very small amount of turbines were responsible of the majority of the fatalities. For bats, the data indicates that mid-August til mid-October is the period of the year in which fatalities are higher. The data also point out that free-wheeling is an important source of fatalities. Such fatalities were higher during nights of low wind speeds i.e. below 4.5m/sec. For birds, also a small amount of turbines were responsible of the majority of the fatalities.

**ANNEX 1**

**Post-Construction Monitoring Protocol of birds/bats fatality**

 **Methodological Guidelines required to be followed**

#### 1. Study Initiation and Duration

#### Carcass searching should be initiated as soon as possible after the initiation of operation of all turbines within the wind facility. As specified in Table 2, projects classified as Category A will require study durations of at least three continuous full years of monitoring, while Category B projects will require a minimum of two continuous full years of monitoring. The Eolica del Sur Project falls into a Category A. Additional years of post-construction monitoring may be added if unexpected high mortality or other adverse wildlife impacts are encountered (see section “adaptive management triggers”).

**2. Search Frequency**

Searchers will search each selected search turbine once per day every 1-2 day during the fall and spring migratory season and once per day every day for one continuous week per month during the non-migratory seasons. After a period of two years of monitoring, the need to continue the search during the non-migratory seasons will be re-assessed.

**3. Selection of Turbines to be Searched within the Wind Facility**

Carcass searches are to be conducted at different numbers of turbines for differently sized projects, as specified in Table 2 which presents minimum expected numbers of searched turbines. If a subsample of turbines is to be searched, turbines should be randomly selected if the habitat conditions within the landscape of the wind energy facility are relatively homogeneous across the facility. If a wind site is heterogeneous, and contains habitats of particular wildlife risk concern, turbines should be selected non-randomly for searching in order to cover all habitat types and areas of specific concern, and a larger proportion of turbines should be selected for searching. If the potential search areas beneath the turbines are dominated by substrates of high-moderate searchability such as bare dirt, search areas beneath individual turbines will be relatively large, encompassing most or all of the entire potentially searched area. This will result in longer search times required for individual turbines, and the number of turbines selected for searching is expected to be at or near the minimum requirement indicated in Table 1. If instead the potential search areas beneath the turbines are dominated by substrates of low searchability such as steep slopes, or tall and/or dense

vegetation, search areas beneath individual turbines will be relatively small, encompassing small portions of the entire potentially searched area, such as the immediate turbine pad and access road. This will result in shorter search times required for individual turbines, and the number of turbines selected for searching is expected to be larger than the minimum requirement indicated in Table 2.

**4. Selection and Measurement of Search Areas Beneath Turbines Selected for Searching**

Once turbines have been selected for searching, specific search areas should be defined based on field surveys of the searchability of vegetation or other substrates within a radius of the searched turbines equivalent to the height of the turbine tower plus 30 meters. Ground conditions within this search area should be designated to visibility classes as defined in Table 1, and the area to be searched should be restricted to the entire within the potentially searched circle that falls within the easy and moderate visibility classes. In cases of extremely dense vegetation, search areas may be restricted to relatively clear areas such as access roads and turbine pads.

Table 1. Visibility Classes of Searching Substrates below Wind Turbines.

|  |  |  |  |
| --- | --- | --- | --- |
| **Visibility Class** | **Percent Vegetation Cover** | **Vegetation Height** | **Search** |
| Easy | > 90% bare ground | < 15 cm tall | Yes |
| Moderate | > 25% bare ground | < 15 cm tall | Yes |
| Difficult | < 25% bare ground | 15 to 30 cm tall | No |
| Very Difficult | Little or no bare ground | Higher than 30 cm tall | No |

During an initial setup visit, the searcher should use a tape measure and GPS unit to map the searchable portion of the potentially searched circle under the turbine, with sufficient detail to calculate the total amount of area within the easy and moderate visibility classes (= actually searched area) within the potentially searched area under the turbine. The proportion of area searched parameter in the fatality estimator (**Ax**) will be calculated as the sum of the total actual search areas divided by the total potentially searched area (circles) under all turbines selected for searching. Search areas should be redefined, remapped, and these statistics recalculated as needed if the seasonality of plant growth results in significant changes in the amount of area within the low-moderate searchability classes over the course of the study.

**5. Basic Search Procedure**

Within the selected and mapped actual search areas, establish parallel transects at a distance of no more than 5 m apart throughout the entire area, marking transects and endpoints with flags as necessary for ease of transect location during searching. Walk along each transect moving from one side of the search area to the other, at a rate of approximately 45 to 60 m per minute,

visually scanning both sides out to 2 to 3 m on each side for avian and bat casualties. Weather permitting, turbine ground searches should be initiated at or near sunrise.

At the beginning of each search of a plot, the field technician should use a pre-prepared field sheet to record basic environmental conditions at the beginning of the search, including the following:

* Turbine number
* Time of day
* Observer name
* Approximate temperature
* Approximate wind speed
* Approximate cloud cover
* Presence of precipitation

**6. Field Procedure for Documenting a Discovered or Rediscovered Carcass**

If a dead bat or bird is found during carcass searching, the technician should place a flag near the carcass and continue the search until the search area is completely searched. After searching the entire plot, the searcher should return to each carcass for data gathering. If the carcass has not been discovered on a previous search (newly discovered carcass), the field technician should assign the carcass a unique carcass ID number, photograph the carcass (see below), attach an unobtrusively-colored tag containing the unique carcass ID number to the foot or leg, to unambiguously label the carcass as a previously discovered carcass for future searches, and then fill out a standardized fatality data sheet, leaving the carcass where it was initially found when data gathering is complete. If the carcass contains a tag with a carcass ID number, indicating that it is a rediscovered carcass, the field technician only needs to fill out a fatality data sheet, and leave the carcass where it was found. Sample fatality data sheets will contain, at a minimum, the following information:

* Carcass identification number
* Species of carcass (if identifiable by field technician)
* Date and time carcass was discovered (or rediscovered)
* New carcass or previously discovered (persistent) carcass?
* Searcher identification
* Turbine plot identification
* General weather conditions
* Substrate visibility class (easy, moderate)
* Habitat type of the area surrounding the search plot
* Distance and compass direction from the turbine
* Age and sex of carcass (when possible)
* Reproductive condition (when possible)
* Carcass condition (fresh, rigor, decomposed, intact, scavenged, feather spot, etc.)
* Estimated time of death (e.g., < 1 day, < 2 day, 3 to 5 days, > 5 days)
* Carcass position (face-up or down, sprawled out or balled up, etc.)
* Current and recent weather patterns
* Add photos (optional)
* GPS position of carcass

All carcasses should be photographed on their initial discovery for subsequent identification purposes. Using protective gloves to protect the technician from injury if the animal is not actually dead, and to reduce possible human scent bias on carcasses, manually position the carcass for a series of photographs to be specified by the taxonomic identification experts, based on the specific areas of the animal that should be photographed in order to capture the features that will enable the taxonomic expert to identify the animal. The technician should also write the individual carcass ID number on a small piece of paper, and position the paper, as well as a 10cm graduated ruler to be visible, but not obscuring key parts of the carcass in all photographs. At a minimum, required photographs will normally include the following:

* Entire dorsal surface of animal
* Entire ventral surface of animal
* Spread tail, dorsal and ventral views (birds), or dorsal and ventral view of tail and tail membrane (bats)
* Facial profile close-up
* Head-on facial close-up
* Dorsal and ventral views of spread wing

**7. Expertise, Training, and Supervision of Carcass Searching Personnel**

Two types of personnel will be required in order to conduct the post construction monitoring Protocol, as follows:

* Carcass search technician. These technicians must be capable of performing the carcass searching fieldwork described in this Protocol. Required skills of carcass searchers include the following:
	+ Ability to perform fieldwork for long periods of time (up to 8 hours with breaks) under rugged field conditions
	+ Ability to operate a GPS unit and digital camera
	+ Oral and written communication skill sufficient to understand and follow fairly detailed and specific procedural instructions for fieldwork, as outlined in this Protocol.
* Expert scientist. One or more expert scientists are required for the following components of the carcass searching study:
	+ Taxonomic expert identification of discovered bird and bat carcasses from photographs
	+ Quantitative skill sufficient to perform the required calculations of taxon- and season-specific estimated mortality rates using the formulae presented in this protocol
	+ Oral and written communication skill sufficient to summarize and interpret results, describe procedures and methods, and produce periodic reports describing all aspects of the post-construction fatality monitoring study.

EES should hire personnel trained in conducting standardized avian and bat mortality ground searches.

**8. Required Equipment**

The following equipment will be required to conduct the post-construction monitoring Protocol presented in this report:

* Personal protective equipment for all field personnel
* Vehicle for accessing all field sites
* GPS unit with 1m or better precision for documenting carcass locations and relocating them on subsequent visits
* Digital camera for photographing discovered and rediscovered carcasses
* Weather-proof field notebooks and writing implements
* Bite-proof gloves for handling found birds and bats that may still be alive
* String for use as an unobtrusive marker for found carcasses
* Flags for marking carcass search transects
* Tape measure for taking measurements of the dimensions of search areas
* 10 cm graduated ruler

**9. Mortality Rate Calculations**

To estimate mortality on a facility-wide scale, a modified version of the Jain et al. 2008 estimator should be used as follows:

|  |  |
| --- | --- |
| **C =** |  c |
| **(Ax\* Sc \* Se \* Pt)** |

where,

**C** = the overall estimated fatality at the wind farm;

c = the number of carcasses found during the searches;

Ax = the proportion of area searched beneath turbines (actual area searched/total maximum searchable area beneath turbine)

Sc = the proportion of carcasses remaining unscavenged for searchers,

calculated as:

 

 where *p* = the observed average carcass persistence time of found carcasses at the site, calculated empirically from rediscoveries of previously found carcasses

Se = searcher efficiency (use 0.80 for large birds, and 0.60 for small birds and bats)

Pt = the proportion of turbines searched (number of turbines searched/the total number of turbines in the wind facility)

This equation should be applied, and fatality rates estimated separately for each month, and for each of three taxa, as follows: small birds, bats, and large birds. This subdivision will enable fatality rates to be lumped across months and taxa as desired.

**10. Annual Reporting**

EES should provide an annual birds/bats fatality report to IDB; presenting the results of the year’s monitoring effort in both summarized and complete form. This information should be attached as an Annex to the Annual Environmental and Social Compliance Report. At a minimum, the birds/bats fatality report will contain the following information:

1. Range of carcass searching dates covered by the report
2. Complete descriptions of the field procedures implemented, including maps of the study site showing all searched turbines, and dates and locations in which all field sampling was conducted
3. Complete list of personnel involved with conducting the work and producing the report
4. Total number of individual birds and bats that were discovered during the carcass searches, broken out by month and by species, and showing IUCN and all other relevant conservation status and/or listing information for each species discovered during the searches, as well as migrant or resident status of each species
5. Complete data on rediscoveries of previously discovered and marked carcasses, as used to develop average carcass persistence times for the mortality estimates
6. Summary graph of bird and bat mortality by turbine number, useful for identifying which turbines are causing the highest mortality levels
7. Mortality rate calculations, including the formulae, and all raw data and parameter values used to produce them, broken out separately by month and by small birds, large birds, and bats, as well as lumped into annual and monthly rates for birds, bats, and all wildlife
8. Interpretation of observed bird and bat mortality patterns in relation to preconstruction environmental risk predictions, and general conservation and environmental impact considerations associated with the project.
9. Discussion of whether observed bird or bat fatality levels should trigger adjustments in either the monitoring protocol or the operation of the Project. Specific adaptive management triggers includes, but not necessarily limited to the following:
* IUCN red list status of impacted taxa;
* Other national or international conservation listing status of impacted taxa;
* Potential for impacted species to experience population level impacts as a result of the observed mortality;
* The observation of species or risk issues at the site that were not identified during the preconstruction risk assessment and which warrant significant consideration with respect to environmental impacts; and
* Fatality impacts significantly high.

|  |  |  |
| --- | --- | --- |
| **Project categorization**  | **Category A** | **Category B** |
| **Study Duration** | **Three Years** | Two Years |
| **Carcass Search Frequency** | Every 1-3 days during principal migratory periods. Daily for one week per month during other times of year, year-round. |
| **Minimum Number of Turbines Searched****2****[[3]](#footnote-3)5** | Number of turbines in project → | 1–10 | 11–20 | 21–40 | 41–60 | 61–90 | 91–120 | **121 +** |
| Number turbines searched → | all | 10 turbines | ½ 50% of all turbines | 20 turbines | 30% of all turbines | 30 turbines | **25% of all turbines** |
| **Search area subsampling** | Searching restricted to easy to moderate visibility class habitats (Table 1) within a circular area around the base of the tower with a radius equivalent to the height of the tower plus 30 meters.  |
| **Selection of turbines**  | Homogenous habitats (randomly)Heterogeneous habitats (non-randomly in order to cover all habitat types found within the wind farm)  |
| **Scavenging bias correction** | Use a value of **Sc** calculated as follows, where *p* = the observed average carcass persistence time of found carcasses at the site |
| **Detectability bias correction** | Use the following values for Se: 0.6 for small birds and bats, 0.8 for large birds |
| **Mortality estimator** | **C = c / (A \* Sc \* Se \* Pt)** |

**Table 2. Summary of the post-construction monitoring protocol**

1. 1 Each year the beginning/end of the migration periods may vary by few weeks, EES will adapt its system from year to year in order to ensure that the two periods are covered. [↑](#footnote-ref-1)
2. [↑](#footnote-ref-2)
3. **2****5** Minimum numbers of turbines searched represent the expectation for high carcass detectability substrates in relatively homogeneous habitat, where the greatest level of subsampling of turbines within the wind farm is expected to occur. For projects in more heterogeneous habitats, or habitats with lower amounts of high-moderate visibility substrate located beneath turbines, higher proportions of turbines should be searched. [↑](#footnote-ref-3)