Doc.EUROBATS.AC24.5. Rev.1

# 24th Meeting of the Advisory Committee

Skopje, North Macedonia, 1 – 3 April 2019

# Report of the Intersessional Working Group on Wind Turbines and Bat Populations [1]

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[1] Recommended citation: UNEP/EUROBATS IWG on wind turbines and bat populations. 2019. Doc.EUROBATS.AC24.5. Rev.1. Report of the IWG to the 24th Meeting of the Advisory Committee, Skopje, North Macedonia, 1-3 April. Available online at https://www.eurobats.org/node/1571

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# 1 IWG MEMBERS AND SUB-GROUPS

**Members**

Luisa Rodrigues (Portugal) (coordinator), Abdulaziz Alagaili (Saudi Arabia), Aliaksei Shpak (Belarus), Andrzej Kepel (Poland), Anna Nele Herdina (Austria), Branko Karapandža (Serbia), Branko Micevski (FYR Macedonia), Christian Voigt (Leibniz Institute for Zoo and Wildlife Research; Germany), Christine Harbusch (NABU; Germany), Daniela Hamidović (Croatia), Dina Rnjak (Croatia), Dino Scaravelli (San Marino), Eeva-Maria Kyheröinen (Finland), El Ayachi Sehhar (Morocco), Emrah Çoraman (Turkey), Fiona Mathews (United Kingdom), Gunārs Pētersons (Latvia), Herman Limpens (Dutch Mammal Society; The Netherlands), Hubert Krättli (Switzerland), Jacques Pir (Luxembourg), Jan Collins (BCT; United Kingdom), Jasja Dekker (BatLife Europe; The Netherlands), Jean Matthews (United Kingdom), Joana Bernardino (Portugal), Johanna Hurst (Freiburger Institut; Germany), Joris Everaert (INBO; Belgium), Katherine Walsh (United Kingdom), Kirsty Park (Stirling University; United Kingdom), Laurent Biraschi (Luxembourg), Laurent Schley (Luxembourg), Lothar Bach (Germany), Marcel Schillemans (Dutch Mammal Society/Zoogdiervereniging; The Netherlands), Marcus Fritze (Deutsche Fledermauswarte; Germany), Markus Melber (Bundesverband für Fledermauskunde; Germany), Marie Nedinge (Sweden), Marie-Jo Dubourg-Savage (SFEPM; France), Mirna Mazija (Association for Bat Conservation Tragus; Croatia), Mounir Abi-Said (Lebanon), Niels de Zwarte (Bat Group Netherlands and Natural History Museum Rotterdam), Noam Leader (Israel), Pascal Moeschler (Switzerland), Per Ole Syvertsen (Norway), Petra Bach (Germany), Rita Bastos (CITAB/UTAD; Portugal), Robert Raynor (United Kingdom), Ruth Petermann (Germany), Ştefan Mǎntoiu (Institute of Speleology "Emil Racoviţǎ"; Romania), Thierry Kervyn (Belgium), Triinu Tõrv (Estonia), Üllar Rammul (Estonia), Wael Shohdy (Egypt), Zuhair Amr (Jordan)

**The IWG thanks Paola Reason (Arcadis) for comments on "Sensitivity maps" and for proofreading the report.**

**Subgroups**

To simplify the work, several sub-groups were created:

| Task | Coordinator (c) and members |
|---|---|
| Compilation of data on bat mortality per country | Marie-Jo Dubourg-Savage (c)<br>Lothar Bach |
| List of monitoring studies done in Europe | Anna Nele Herdina (c)<br>Laurent Biraschi<br>Marie-Jo Dubourg-Savage |
| Collect national guidelines | Andrzej Kepel (c)<br>Branko Mićevski<br>Dina Rnjak<br>Jan Collins |
| Implementation of mitigation and post-construction monitoring | Daniela Hamidović (c)<br>Branko Micevski<br>Per Ole Syvertsen |
| Impact of mortality rate on populations | Jasja Dekker (c)<br>Lothar Bach<br>Rita Bastos<br>Emra Çoraman<br>Marcus Fritze |
| Maximum foraging/commuting/migrating distances and heights of species | Marie-Jo Dubourg-Savage (c)<br>Eeva-Maria Kyheröinen<br>Dina Rnjak |

| Task | Coordinator (c) and members |
|---|---|
| | Zuhair Amr<br>Christine Harbusch<br>Joris Everaert |
| Comparing measurement of activity at ground level and rotor height | Lothar Bach (c)<br>Jan Collins<br>Johanna Hurst<br>Marie-Jo Dubourg-Savage<br>Petra Bach<br>Ştefan Mantoiu<br>Thierry Kervyn<br>Joris Everaert |
| Small Wind Turbines | Kirsty Park (c)<br>Lothar Bach |
| Offshore windfarms | Lothar Bach (c)<br>Herman Limpens<br>Jasja Dekker<br>Ştefan Mantoiu |
| Wind farms and forests | Johanna Hurst (c)<br>Christian Voigt<br>Christine Harbusch<br>Andrzej Kepel<br>Branko Karapandža<br>Fiona Mathews<br>Lothar Bach<br>Thierry Kervyn<br>Ruth Petermann<br>Marcus Fritze<br>Branko Micevski |
| 200m buffer distance to habitats particularly important for bats | Branko Karapandža (c)<br>Noam Leader<br>Mirna Mazija<br>Marcus Fritze |
| Sensitivity maps | Ştefan Mantoiu (c)<br>Noam Leader<br>Mirna Mazija<br>Marcus Fritze<br>Joris Everaert |
| Mitigation and compensation measures | Joana Bernardino (c)<br>Branko Karapandža<br>Dino Scaravelli<br>Lothar Bach<br>Luisa Rodrigues<br>Ştefan Mantoiu<br>Thierry Kervyn<br>Marcus Fritze |
| Deterrents, technical mitigation systems and automated monitoring systems | Lothar Bach (c)<br>Branko Karapandža<br>Dino Scaravelli<br>Luisa Rodrigues<br>Marcus Fritze<br>Joris Everaert |
| Use of dogs vs humans during carcass searches | Dina Rnjak (c)<br>Fiona Mathews<br>Petra Bach<br>Ştefan Mantoiu<br>Joris Everaert |
| Estimation of bat mortality based on carcass searches; | Rita Bastos (c) |

| Task | Coordinator (c) and members |
| --- | --- |
| the choice of the best estimator for Europe | Dino Scaravelli<br>Jasja Dekker<br>Joana Bernardino<br>Petra Bach<br>Ştefan Mantoiu |
| Summary of the bibliography on wind turbines and bats (2018-2019) | Marie-Jo Dubourg-Savage (c)<br>Laurent Biraschi<br>Marcus Fritze |

# 2 COMPILATION OF DATA AND PRACTICE FROM EUROPE

## 2.1 COMPILATION OF DATA ON BAT MORTALITY PER COUNTRY

The following table updates the data per species and per country regarding bat fatalities found both accidentally and during post-construction monitoring studies from 2003 to the end of 2018. It reflects by no means the real extent of bat mortality at wind turbines as it is based only on reported fatalities to EUROBATS IWG members and not on the effective mortality that is calculated taking into account different sources of biases such as the survey effort, the removal of carcasses by predators/scavengers, the searcher efficiency and the percentage of the area really searched.

Available data show that up to now at least 30 species have been killed by wind turbines in EUROBATS range states (Table 1).

## Table 1. Reported bat fatalities in Europe (2003-2018) - State March 2019

| Species | AT | BE | CH | CR | CZ | DE | DK | ES | EE | FI | FR | GR | IL | IT | LV | NL | NO | PT | PL | RO | SE | UK | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Nyctalus noctula* | 46 | 1 | | 2 | 31 | 1200 | | 1 | | | 131 | 10 | | | | | | 2 | 16 | 85 | 14 | 11 | **1550** |
| *N. lasiopterus* | | | | | | | | 21 | | | 7 | 1 | | | | | | 9 | | | | | **38** |
| *N. leisleri* | | 2 | 1 | 21 | 3 | 180 | | 15 | | | 174 | 58 | | 2 | | | | 273 | 5 | 19 | | | **753** |
| *Nyctalus spec. & Nlei/Vmur* | | | | 1 | | | | 2 | | | 5 | | | | | | | 17 | | 8 | | | **33** |
| *Eptesicus serotinus* | 1 | 2 | | | 11 | 63 | | 2 | | | 29 | 1 | | | | 2 | | 0 | 3 | 1 | | | **115** |
| *E. isabellinus* | | | | | | | | 117 | | | | | | | | | | 2 | | | | | **119** |
| *E. serotinus / isabellinus* | | | | | | | | 98 | | | | | | | | | | 17 | | | | | **115** |
| *E. nilssonii* | 1 | | | | 1 | 6 | | | 2 | 6 | | | | | 13 | | 1 | | 1 | 1 | 13 | | **45** |
| *Vespertilio murinus* | 2 | 1 | | 15 | 6 | 145 | | | | | 12 | 1 | | | 1 | | | | 8 | 15 | 2 | | **208** |
| *Myotis myotis* | | | | | | 2 | | 2 | | | 4 | | | | | | | | | | | | **8** |
| *M. blythii* | | | | 1 | | | | 6 | | | 1 | | | | | | | | | | | | **8** |
| *M. dasycneme* | | | | | | 3 | | | | | | | | | | | | | | | | | **3** |
| *M. daubentonii* | | | | | | 7 | | | | | | | | | | | | 2 | | | | | **9** |
| *M. bechsteinii* | | | | | | | | | | | 1 | | | | | | | | | | | | **1** |
| *M. emarginatus* | | | | | | | | 1 | | | 2 | | | | | | | 1 | | | | | **4** |
| *M. brandtii* | | | | | | 2 | | | | | | | | | | | | | | | | | **2** |
| *M. mystacinus* | | | | | | 3 | | | | | 3 | 1 | | | | | | | | | | | **7** |
| *M. nattereri* | | | | | | 1 | | | | | | | | | | | | | | | | 1 | **2** |
| *Myotis* sp | | | | | | 2 | | 3 | | | 1 | | | | | | | | | 4 | | | **10** |
| *Pipistrellus pipistrellus* | 2 | 36 | 7 | 7 | 16 | 702 | | 211 | | | 930 | | | 1 | | 15 | | 323 | 3 | 11 | 1 | 46 | **2311** |
| *P. nathusii* | 13 | 6 | 6 | 50 | 7 | 1066 | 2 | | | | 285 | 35 | | 1 | 23 | 8 | | | 16 | 111 | 5 | 1 | **1635** |
| *P. pygmaeus* | 4 | | | 6 | 2 | 134 | | | | | 172 | | | | 1 | | | 42 | 1 | 5 | 18 | 52 | **437** |
| *P. pipistrellus / pygmaeus* | 1 | | 3 | | | | | 271 | | | 39 | 55 | | | | | | 38 | 1 | 3 | | | **411** |
| *P. kuhlii* | | | | 126 | | | | 44 | | | 199 | | 22 | | | | | 51 | | 15 | | | **457** |
| *P.pipistrellus / kuhlii* | | | | 12 | | | | | | | 0 | 1 | | | | | | 19 | | | | | **32** |
| *Pipistrellus* sp | 8 | 4 | | 60 | 9 | 91 | | 25 | | | 211 | 1 | | | 2 | | | 109 | 2 | 48 | | 12 | **582** |
| *Hypsugo savii* | 1 | | | 206 | | 1 | | 50 | | | 54 | 28 | | 12 | | | | 56 | | 2 | | | **410** |
| *Barbastella barbastellus* | | | | | | 1 | | 1 | | | 4 | | | | | | | | | | | | **6** |
| *Plecotus austriacus* | 1 | | | | | 8 | | | | | | | | | | | | | | | | | **9** |
| *Plecotus auritus* | | | | | | 7 | | | | | | | | | | | | | | | | 1 | **8** |
| *Tadarida teniotis* | | | | 10 | | | | 23 | | | 2 | | | | | | | 39 | | | | | **74** |
| *Miniopterus schreibersii* | | | | | | | | 2 | | | 5 | | | | | | | 4 | | | | | **11** |
| *Rhinolophus ferrumequinum* | | | | | | | | 1 | | | | | 1 | | | | | | | | | | **2** |
| *Rhinolophus mehelyi* | | | | | | | | 1 | | | | | | | | | | | | | | | **1** |
| *Rhinolophus* sp | | | | | | | | 1 | | | | | | | | | | | | | | | 1 |
| *Rhinopoma microphylum* | | | | | | | | | | | | | 5 | | | | | | | | | | **5** |
| *Taphozus nudiventris* | | | | | | | | | | | | | 3 | | | | | | | | | | **3** |
| Chiroptera sp | 1 | 1 | | 48 | 1 | 77 | | 320 | 1 | | 317 | 8 | 2 | 1 | | | | 120 | 3 | 7 | 30 | 9 | **946** |
| **Total** | **81** | **53** | **17** | **565** | **87** | **3701** | **2** | **1218** | **3** | **6** | **2588** | **200** | **33** | **17** | **40** | **25** | **1** | **1124** | **59** | **335** | **83** | **133** | **10371** |

*AT = Austria, BE = Belgium, CH = Switzerland, CR = Croatia, CZ = Czech Rep., DE = Germany, DK= Denmark, ES= Spain, EE = Estonia, FI = Finland, FR = France, GR = Greece, IL = Israel, IT = Italy, LV = Latvia, NL = Netherlands, NO = Norway, PT = Portugal, PL = Poland, RO = Romania, SE = Sweden, UK = United Kingdom*

## 2.2 LIST OF MONITORING STUDIES DONE IN EUROPE

Annex 1 contains new data of studies done in Europe; this table is an addendum to Table 1 of EUROBATS Publication Series nº 3, Annex 3 of Doc.EUROBATS.AC14.9.Rev1, Annex 3 of Doc.EUROBATS.StC4-AC15.22.Rev.1, Annex 2 of Doc.EUROBATS.AC17.6, Annex 2 of Doc.EUROBATS.AC18.6, Annex 2 of Doc.EUROBATS.StC9-AC19.12, Annex 1 of EUROBATS Publication Series nº 6, Annex 2 of Doc.EUROBATS.AC20.5, Annex 2 of Doc.EUROBATS.AC21.8, Annex 2 of Doc.EUROBATS.AC22.10.Rev.1 and Annex 2 of Doc.EUROBATS.StC14-AC23.9.Rev.2.

## 2.3 COLLECTION OF NATIONAL GUIDELINES

Revised versions of National guidelines were published in Portugal (2017), Sweden (2017), France (2018) and the UK (2019).

A revised version of regional guidelines was published in Germany - Saxony Anhalt (2018).

In Norway, in a technical report (2017-2018) from the Norwegian Environment Agency to The Norwegian Water Resources and Energy Directorate (NVE), the agency that is authorized to issue wind energy development licences, a general reference to EUROBATS guidelines is given. This is still not an official nor legally binding document.

In Switzerland in 2018, after 4 years of consultation of a draft, the Swiss federal government decided not to publish any guidelines on bats and wind turbines. Stiftung Fledermausschutz intends to prepare guidelines in cooperation with the Association of the Cantons by the end of 2019.

In Macedonia BatLife Macedonia prepared the national guidelines in 2018. They were accepted by the Ministry but are still not publicly available.

In Israel, two official documents were prepared: guidelines for conducting surveys and assessment on the effects of large turbines on bats (formally accepted by the National Planning Commission); and draft guidelines on how to conduct carcass surveys (not officially accepted yet). Both are based on EUROBATS guidelines and contain references to this document. These national guidelines have not been published on the Internet yet.

The updated list of guidelines is presented below in Table 2 (links to some national guidelines have changed).

All focal points are kindly requested to report to the IWG any new national or regional guidelines.

## Table 2. List of national and regional guidelines as per answers to the questionnaire

| Countries | EUROBATS guidelines officially recommended | National guidelines exist | | |
|---|---|---|---|---|
| | | unofficial | officially recommended | available on-line (year of publication) |
| ***Parties*** | | | | |
| Albania | no | no | no | |
| Belgium | **YES** (as best practice)) | no | **YES** | **Flanders**<br>INBO guidelines, adjusted from the EUROBATS guidelines: https://pureportal.inbo.be/portal/files/11928837/Everaert_2015_EffectenVanWindturbinesOpVogelsEnVleermuizenInVlaanderen.pdf (2015)<br>**Wallonia**<br>DEMNA-DNF guidelines, adjusted from the EUROBATS guidelines: http://biodiversite.wallonie.be/servlet/Repository/28103.pdf?ID=28103 (2012)<br>**Brussels-Capital Region**<br>No separate guidelines, the one for Wallonia is recommended |
| Bulgaria | no | **YES** | no | http://www.nmnhs.com/downloads/brcc/bats-en.pdf (2008) |
| Croatia | **YES** | | | National guidelines were compiled in 2010 in accordance with EUROBATS guidelines published in Publication No. 3: Guidelines for EIA of wind turbines (includes bats): http://puo.mzopu.hr/UserDocsImages/Smjernice_vjetroelektrane_2010.pdf (2010)<br>EUROBATS guidelines - Revision 2014 are being officially recommended for pre-construction survey and post-construction monitoring in the scope of the Appropriate Assessment (AA) and Environmental Impact Assessment (EIA) procedure since their publication because national guidelines were not revised after 2010. |
| Cyprus | no | no | no | |
| Czech Republic | **YES** (with some local adaptations) | no | no | http://www.ceson.org/document/VtE_metodpokyn_fin.pdf (2012) |
| Denmark | no | no | no | |
| Estonia | no | no | no | |
| Finland | no | no | **YES** (section on bats very short, EUROBATS guidelines just listed in reference list) | http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/79057/OH_5_2016.pdf<br>or<br>https://paliskunnat.fi/lausuntopyynnot2016/YM_tuulivoimarakentamisen_suunnittelu_opasluonnos_30-8-2016.pdf (2016) |
| France | no | **YES** | **YES** | **Official general guidelines**<br>https://eolien-biodiversite.com/IMG/pdf/protocole_de_suivi_revision_2018.pdf (2018)<br>http://www.charente-maritime.gouv.fr/content/download/19109/131043/file/12%20Eolien%20St%20F%C3%A9lix%205%20annexe%2013%20Protocole_de_suivi_environnemental.pdf (2015)<br>**SFEPM guidelines**<br>presurvey:<br>http://www.sfepm.org/pdf/20160201_planification_V2.1.pdf (2016)<br>survey: https://www.sfepm.org/pdf/20160213_diagnostic_V2.1.pdf (2016)<br>monitoring: https://www.sfepm.org/pdf/20160213_suivis_V2.1.pdf (2016) |
| Georgia | no | no | no | |
| Germany | no | **YES** (for several federal states or companies) | **YES** (for some federal states and a national one on wind turbines in forests) | **Bavaria**<br>general on wind energy:<br>https://www.verkuendung-bayern.de/files/allmbl/2012/01/anhang/2129.1-UG-448-A001_PDFA.pdf (2011)<br>additional Information on wind turbines and bats:<br>http://www.naturschutzplanung.de/docs/FAQ_Fledermaeuse_Wi |

| Countries | EUROBATS guidelines officially recommended | National guidelines exist | | |
|---|---|---|---|---|
| | | unofficial | officially recommended | available on-line (year of publication) |
| | | | | ndkrafterlass_Bayern_2013_Lauris.pdf (2013)<br>**Baden-Wuerttemberg**<br>general decree on EIA for wind energy (just protected species mentioned):<br>https://wm.baden-wuerttemberg.de/fileadmin/redaktion/m-mvi/intern/Dateien/PDF/Windenergieerlass_120509.pdf (2012)<br>wind turbines and bats:<br>https://rp.baden-wuerttemberg.de/rpf/PR/Documents/rpf-ref56-windkraft.pdf (2006)<br>BUND and NABU:<br>https://rp.baden-wuerttemberg.de/rpk/Abt5/Ref55/Documents/55_beispiele_windenergie_artenschutzforum.pdf (2015)<br>**Hessen**<br>wind turbines and nature:<br>http://www.energieland.hessen.de/mm/WKA-Leitfaden.pdf (2012)<br>**Lower Saxony**<br>part 1:<br>http://www.umwelt.niedersachsen.de/download/96713/Planung_und_Genehmigung_von_Windenergieanlagen_an_Land_in_Niedersachsen_und_Hinweise_fuer_die_Zielsetzung_und_Anwendung_Windenergieerlass_Ministerialblatt_vom_24.02.2016_.pdf (2016)<br>part 2:<br>http://www.umwelt.niedersachsen.de/download/96712/Leitfaden_-_Umsetzung_des_Artenschutzes_bei_der_Planung_und_Genehmigung_von_Windenergieanlagen_in_Niedersachsen_Ministerialblatt_vom_24.02.2016_.pdf (2016)<br>**North Rhine-Westphalia**<br>general:<br>https://www.umwelt.nrw.de/fileadmin/redaktion/PDFs/klima/13_11_12_nrw_leitfaden_arten_habitatschutz.pdf (2013)<br>in forests:<br>https://www.umwelt.nrw.de/fileadmin/redaktion/PDFs/klima/leitfaden_wind_im_wald.pdf (2012)<br><br>**Rhineland-Palatinate**<br>general on wind energy:<br>https://mwvlw.rlp.de/fileadmin/mwkel/Rundschreiben_28_05_2013_.pdf (2013)<br>on birds, bats and proteced areas and wind energy:<br>https://lfu.rlp.de/fileadmin/lfu/Naturschutz/Dokumente/Artenschutzprojekte/Fledermaeuse/Fachgutachten_Artenschutz_LUWG_PGRheinhessenNahe_Text.pdf (2010)<br>https://lfu.rlp.de/fileadmin/lfu/Naturschutz/Dokumente/Erneuerbare_Energien/Naturschutzfachlicher-Rahmen-zum-Ausbau-der-Windenergienutzung-RLP_VSW-LUWG_2012.pdf.pdf (2012)<br>**Saarland**<br>http://www.saarland.de/dokumente/thema_naturschutz/Leitfaden_Artenschutz_Windenergie_Schlussfassung_19Juni2013.pdf (2013)<br>**Saxony Anhalt**<br>https://mule.sachsen-anhalt.de/fileadmin/Bibliothek/Politik_und_Verwaltung/MLU/MLU/04_Energie/Erneuerbare_Energien/Windenergie/181126_Leitlinie_Artenschutz_Windenergieanlagen_barrierefrei.pdf (2018)<br>**Schleswig-Holstein**<br>http://www.umweltdaten.landsh.de/nuis/upool/gesamt/windenergie/windenergie.pdf (2008)<br><br>**Thuringia**<br>https://www.thueringen.de/mam/th8/tlug/content/arbeitshilfe_fledermause_und_windkraft_thuringen_20160121.pdf (2015)<br>**Other**<br>BfN – in forests:<br>http://www.bfn.de/fileadmin/MDB/documents/themen/erneuerbareener |

| Countries | EUROBATS guidelines officially recommended | National guidelines exist | | |
|---|---|---|---|---|
| | | unofficial | officially recommended | available on-line (year of publication) |
| | | | | gien/bfn_position_wea_ueber_wald.pdf (2011) |
| Hungary | no | no | no | |
| Ireland | no | **YES** | no | https://www.batconservationireland.org/wp-content/uploads/2013/09/BCIreland-Wind-Farm-Turbine-Survey-Guidelines-Version-2-8.pdf (2012) |
| Israel | **YES** (recommendations are in national guidelines) | **YES** (for carcasses survey) | **YES** (preconstruction survey for big turbines) | Guidelines have not been published yet |
| Italy | no | no | no | |
| Latvia | no | no | no | |
| Lithuania | **YES** | | **YES** | Address not provided |
| Luxembourg | no | no | no | |
| North Macedonia | no | no | YES (not yet available) | Address not provided |
| Malta | no | no | no | |
| Moldova | no | no | no | |
| Monaco | no | no | no | |
| Montenegro | no | no | no | |
| Netherlands | no | **YES** | no | https://www.rvo.nl/sites/default/files/2014/02/Protocollen%20vleermuis onderzoek%20bij%20windturbines.pdf (2013) |
| Norway | **YES** | no | no | https://www.nve.no/Media/6806/faggrunnlag_flaggermus_publisert.pdf (2018) – p.12, general reference |
| Poland | no | **YES** (the NGOs guidelines 2009, 2009.2 and 2011 not up-dated, the draft of the official guidelines recommended by NGOs) | no (the draft of the official guidelines officially reco-mmended in other, general guidelines, but not officially published; commonly used) | **Draft of the official guideline** http://www.ansee.pl/wp-content/uploads/2015/09/Wytyczne_dotyczace_oceny_oddzialywania_elektrowni_wiatrowych_na_nietoperze.pdf (2013) **NGO guidelines** old, in English: http://www.salamandra.org.pl/DO_POBRANIA/Nietoperze/Guidelines_Poland.doc (2009.2) |
| Portugal | | | **YES** | http://www2.icnf.pt/portal/pn/biodiversidade/patrinatur/resource/docs/Mam/morc/2018-03-19-recomendacoes-parques-eolicos-out2017.pdf (2017) |
| Romania | no | **YES** | no | **NGO guidelines** on wind farms, with a chapter on bats: http://d2ouvy59p0dg6k.cloudfront.net/downloads/ghid_de_bune_practici_energie_eoliana_1.pdf (2016) on bats: https://lilieci.ro/wp-content/uploads/2017/05/ghid_APLR_impact.pdf (2008) |
| San Marino | no | no | no | |
| Serbia | no | **YES** | **no** | nature conservation and wind farms: http://www.rs.undp.org/content/dam/serbia/Publications%20and%20reports/English/UNDP_SRB_Nature%20Protection%20and%20Wind%20Farm%20Development%20in%20Serbia.pdf (2013) chapter about wind farms in national EIA guidelines for bats: http://www.nhmbeo.rs/upload/images/ove_godine/Promocije2011/bats_and_environmental_impact_assessment_web_lq.pdf (2011) recommendations about bats (with reference to EUROBATS guidelines) in EIA guidelines for wind turbines: https://www.unece.org/fileadmin/DAM/env/eia/documents/EIAguides/Serbia_EIA_windfarms_Jun10_en.pdf (2010) |
| Slovakia | no | no | no | |
| Slovenia | no | no | no | |

| Countries | EUROBATS guidelines officially recommended | National guidelines exist | | |
|---|---|---|---|---|
| | | unofficial | officially recommended | available on-line (year of publication) |
| Sweden | no | no | YES | Impact description and general guidelines for birds and bats: https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6467-9.pdf (2011) https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6740-3.pdf?pid=19704 (2017) |
| Switzerland | no | no | no | |
| Ukraine | no | no | no | |
| United Kingdom | no | **YES** | **YES** | **National guidelines** https://www.nature.scot/sites/default/files/2019-01/Bats%20and%20onshore%20wind%20turbines%20-%20survey%2C%20assessment%20and%20mitigation.pdf (2019) **Regional guidelines** Cornwall – general guidelines: http://www.cornwall.gov.uk/media/3626640/3-Onshore-Wind-V2-June-2013-cover.pdf (2013) Cornwall – single wind turbines: https://www.cornwall.gov.uk/media/3622897/Bat-survey-guidance-for-small-wind-turbine-applications-in-Cornwall-March-2011.pdf (2011) **NGO guidelines** Herefordshire Wildlife Trust: http://www.herefordshirewt.org/sites/default/files/hwt_wind_turbine_policy.pdf |
| ***Range states*** | | | | |
| Algeria | no | no | no | |
| Andorra | no | no | no | |
| Armenia | no | no | no | |
| Austria | no | no | no | |
| Azerbaijan | no | no | no | |
| Belarus | no | no | no | |
| Bosnia and Herzegovina | no | no | no | |
| Egypt | no | no | no | |
| Greece | no | no | no | |
| Holy See | no | no | no | |
| Iran | no | no | no | |
| Iraq | no | no | no | |
| Jordan | no | no | no | |
| Kazakhstan | no | no | no | |
| Kuwait | no | no | no | |
| Lebanon | no | no | no | |
| Libya | no | no | no | |
| Liechtenstein | no | no | no | |
| Morocco | no | no | no | |
| Palestinian Authority Territories | no | no | no | |
| Russian Federation | no | no | no | |
| Saudi Arabia | no | no | no | |
| Spain | no | **Yes** | **Yes** | https://www.seo.org/wp-content/uploads/2014/10/Guidelines_for_Assessing_the_Impact_of_Wind_Farms_on_Birds_and_Bats.pdf (2014) https://www.researchgate.net/publication/297357843_Directrices_basicas_para_el_estudio_del_impacto_de_instalaciones_eolicas_sobre_poblaciones_de_murcielagos_en_Espana (2013) |
| Syria | no | no | no | |
| Tunisia | no | no | no | |
| Turkey | no | no | no | |

## Examples of other guidelines:

EU Guidance on wind energy development in accordance with the EU nature legislation: http://ec.europa.eu/environment/nature/natura2000/management/docs/Wind_farms.pdf

Australia. New South Wales (draft 2011, bats mentioned): https://www.planning.nsw.gov.au/Policy-and-Legislation/~/media/1C3284EB49E244FEA7539B8FFFD3D9BA.ashx

Canada, Alberta: https://albertawilderness.ca/wp-content/uploads/20110919_doc_srd_wildlife_guidelines_ab_wind_projects.pdf

Canada, New Brunswick (post construction): https://www2.gnb.ca/content/dam/gnb/Departments/nr-rn/pdf/en/Wildlife/WindPower-PostConstructionBatAndBirdMortalitySurveyGuidelinesForWindFarmDevelopment.pdf

Canada, Ontario: https://dr6j45jk9xcmk.cloudfront.net/documents/2719/stdprod-088155.pdf

Canada, Saskatchewan: https://static1.squarespace.com/-WEP+guideline+V+5.0+-+SEARP++changes.pdf

USA, Arkansas: https://www.adeq.state.ar.us/poa/enterprise-services/industry/pdfs/wind_energy_bird_bat_guidelines.pdf

USA, Minnesota: https://files.dnr.state.mn.us/eco/ereview/avian-bat-protocols.pdf

USA, New York: http://www.dec.ny.gov/docs/wildlife_pdf/winguide16.pdf

USA, Fish & Wildlife Service: https://www.fws.gov/ecological-services/es-library/pdfs/WEG_final.pdf

USA, *Myotis sodalis*: https://www.fws.gov/midwest/endangered/mammals/inba/pdf/inbaS7and10WindGuidanceFinal26Oct2011.pdf

World Bank Group: https://www.ifc.org/wps/wcm/connect/2c410700497a7933b04cf1ef20a40540/FINAL_Aug%2B2015_Wind%2BEnergy_EHS%2BGuideline.pdf?MOD=AJPERES

Expert´s guidelines (Kunz *et al*. 2007): http://altamontsrcarchive.org/alt_doc/assessing_impacts_of_wind_energy_development_on_nocturnally_active_birds_and_bats_a_guidance_document.pdf

## 2.4 IMPLEMENTATION OF MITIGATION AND POST-CONSTRUCTION MONITORING

In considering recent conservation evidence on bat mortality, a questionnaire was devised to evaluate best practice and legislation that is implemented under the scope of UNEP/EUROBATS Agreement in order to mitigate high mortality rates across EUROBATS area. The questionnaire was distributed in 2017 and 2018 to 63 Range states. Of these, 27 completed questionnaires were returned to the Secretariat and analyzed (20 Parties and 7 non-Party Range states).

Conclusions of the analyses were that:

1. Post-construction monitoring is not applied in most operating windfarms across Western Palearctic, and usually is not obligatory
2. Monitoring is usually not done according to the EUROBATS Guidelines
3. Monitoring results and studies (including mortality rates) are not usually made public available and are therefore not available for further analysis; cumulative effect is therefore impossible to evaluate across the range
4. Mitigation measures are not applied in most range states

5. Mitigation measures are usually prescribed with no oversight by authorities
6. Monitoring of effectiveness of mitigation measures is almost non-existent.

All the above mentioned issues were tackled and incorporated in the new Resolution 8.4 Wind Turbines and Bat Populations adopted at the 8th Session of the Meeting of the Parties.

These issues were also presented as an oral presentation at the 14th European Bat Research Symposium (Hamidović *et al.* 2017).

Furthermore there were also addressed in the webinar organised by Tethys organisation (https://tethys.pnnl.gov/events/smart-curtailment-global-perspective) by Rodrigues (2018).

Hamidović D., C.C. Voig & L. Rodrigues. 2017. Bats and windfarm monitoring and implementation of mitigation measures across the Western Palaearctic, and what can be done? 14th European Bat Research Symposium (Donostia, The Basque Country 1-5 August 2017). http://www.ebrs2017.eus/EBRS2017_AbstractBook.pdf

Rodrigues L. 2018. Practical measures to save bats from dying in windfarms: smart curtailment - The European perspective. Webinar on Smart Curtailment - A Global Perspective. https://tethys.pnnl.gov/sites/default/files/2018-Luisa-Rodrigues-presentation-wren-webinar.pdf

# 3 REVIEW OF THE STATE-OF-ART

## 3.1 IMPACTS OF WIND TURBINES ON BATS AND ASSOCIATED RISK FACTORS

### 3.1.1 Impact of mortality rate on populations

The likely negative impact of wind turbine-related fatalities on bat populations is often discussed among stakeholders of the wildlife-wind energy conflict in Europe. In theory, bat populations are particularly susceptible to increased mortality rates, given the low fecundity of bat species and thus recruitment of juveniles in populations (Jones *et al*. 2003). Therefore, even minor increases in mortality risks might have large-scale effects on bat populations. The major difficulty in any demographic study seems to be the lack of required baseline data, e.g. of population sizes, recruitment and dispersal rates in the absence and presence of wind turbines. Even when such demographic parameters have been established for local bat populations over many years, it is difficult to distinguish between effects caused by wind turbines and those triggered by other confounding factors, such as changes in the management of local habitats, losses of daytime roosts, annual climatic fluctuations (e.g. increased winter mortality caused by a sequence of harsh winters) and global climate changes. The IWG is not aware of any recent papers demonstrating specifically an effect of wind turbines on bat populations. Yet, several review papers highlight to various extents the discrepancy between empirical data and the urgent need for synthesis (Köppel *et al*. 2014, Tabassum-Abbasi *et al*. 2014, Dai *et al*. 2015, Schuster *et al*. 2015, Smales 2015, Voigt *et al*. 2015, Arnett *et al*. 2016). Giavi *et al*. (2014) suggested that natural mortality rates of migratory bat species, such as *Nyctalus leisleri*, are low during migration. Two papers highlight the difficulty in connecting individual bats killed at wind turbines and the likely location of their local populations, particularly for migratory bats (Voigt *et al*. 2012, Lehnert *et al*. 2014). The higher percentage of females from distant places that were killed at German wind turbines suggest a potential large negative effect of the so-called German “Energiewende” on bat populations in Northeastern Europe (Voigt *et al*. 2015, Lehnert *et al*. 2014). Using a spatial modelling approach, Roscioni *et al*. (2013, 2014) combined species distribution models for bats with the spatial distribution of wind turbines at an Italian site that undergoes intense wind farm development. They modelled the likely incidence of each wind farm in bat flight corridors by overlaying existing and planned turbine locations on potential commuting corridors (Roscioni *et al*. 2014). A similar modelling approach was followed by Santos *et al*. (2013) for *Hypsugo savii*, *N. leisleri*, *Pipistrellus kuhlii* and *Pipistrellus pipistrellus* in order to generate predictive models to determine areas of probable mortality. Hedenström & Rydell (2013) showed in another model, based on simple assumptions that the planned increase of wind turbines in Sweden will have a negative effect on Swedish populations of *Nyctalus noctula*, even when the current number of wind turbines remains constant, if no mitigation measures are taken. Ferreira *et al*. (2015) investigated the impact of wind turbines on bat species using a spatially explicit agent-based model. They found a clear relationship between mortality events and the proximity between roosts and the location of the wind turbines. Chauvenet *et al*. (2014) used capture-mark-recapture to describe demographic rates for *Eptesicus serotinus* at two sites in England, investigating the transition rates between three stages: juveniles, immatures and breeders. Using an individual-based population dynamics model, they investigated the expected trajectories for both populations. They demonstrated the presence and scale of temporal variation in this species' demography and show how site-specific variation in demographic rates can produce divergent population trajectories (Chauvenet *et al*. 2014). Erickson *et al*. (2015) used branching models to study effects of different rates of mortality on a long-lived (low fecundity) and a short-lived (moderate fecundity) bat. This modelling effort showed that long-lived species may seem stable until a threshold of mortality occurs, after which even small increases in mortality will increase the risk of (local) extinction. Frick *et al*. (2017) too, used expert elicitation and population projection models to estimate the effects of wind turbines on populations. A recent report of Behr *et al*. (2018) explores the potential of using population models for estimating the effect of wind turbine mortality on bat populations in Germany, and the parameters required for such models, and concludes that the required data on the demography of relevant bat species is not available. In conclusion, site- or population- specific differences in demographic parameters may question the validity of extrapolating patterns observed in local studies to a broader spatial scale. Diffendorfer *et al*. (2015) developed probabilistic, quantitative assessment methods to assess the impact of wind energy development on wildlife populations. Their approach is based on fatality information, population estimates, species range maps, turbine location data, biological characteristics and generic population models. The model generates estimates of the relative risk and quantitative measures of the magnitude of the effect on species' population trends and sizes, yet this model has not been validated for any bat species. The authors concur that this model is based on simplifying assumptions and that consequently the outcome may suffer from sparse or unreliable empirical data. Indeed, the authors argue that bat fatality rates are influenced by multiple factors which may complicate any projections of models on the population level (page 16; Diffendorfer *et al*. 2015). Lastly, their model is not designed to implement management strategies regarding the wildlife-friendly development of wind energy, but rather for scientific purposes. More recently, Diffendorfer *et al*. (2017) present a broader methodology to assess population-level effects of wind energy facilities, using ecological knowledge, demographic models and the potential biological removal concept. However, again the authors stress that the data required to make the assessment may be currently lacking or is of insufficient quality for some species. A recent paper by May *et al*. (2019) takes a step back and discusses how choices in methodology of scaling up from individuals to the population level affect the estimates, and warns that even robust monitoring and advanced modeling might not capture the complex effects of wind turbines on wildlife.

The IWG is convinced that the development of studies at regional or local (particularly important for rare species) levels is vital, e.g. the promotion of wind turbine facilities in forested areas may affect in particular non-migratory bat species, e.g. those of the genus *Myotis*, so that population effects may be easier to detect. Bat surveys for impact assessment of wind farm projects should take into account the connectivity between wind turbine sites and breeding sites. Also, it is important to take into account the cumulative impact of all wind farms in the home range of a population. Note that such a home range in migrating species may be the area from the UK to the Baltic States or from Russia to Greece.


Arnett E.B., E.F. Baerwald, F. Mathews, L. Rodrigues, A. Rodríguez-Durán, J. Rydell & C.C. Voigt. 2016. Impacts of wind energy development on bats: a global perspective. In *Bats in the Anthropocene: Conservation of Bats in a Changing World* (pp. 295-323). Springer International Publishing.

Behr O., R. Brinkmann, K. Hochradel, J. Mages, F. Korner-Nievergelt, H. Reinhard, R. Simon, F. Stiller, N. Weber & M. Nagy. 2018. *Bestimmung des Kollisionsrisikos von Fledermäusen an Onshore-Windenergieanlagen in der Planungspraxis - Endbericht des Forschungsvorhabens gefördert durch das Bundesministerium für Wirtschaft und Energie (Förderkennzeichen 0327638E).* O. Behr et al. Erlangen / Freiburg / Ettiswil.

Chauvenet A.L.M., A.M. Hutson, G.C. Smith & J.N. Aegerter. 2014. Demographic variation in the UK serotine bat: filling gaps in knowledge for management. *Ecology and Evolution*, 4(19): 3820-3829.

Dai K.S., A. Bergot, C. Liang, W.N. Xiang & Z.H. Huang. 2015. Environmental issues associated with wind energy – A review. *Renewable energy*, 75: 911-921.

Diffendorfer J.E., J.A. Beston, M.D. Merrill, J.C. Stanton, M.D. Corum, S.R. Loss, W.E. Thogmartin, D.H. Johnson, R.A. Erickson & K.W. Heist. 2015. Preliminary methodology to assess the national and regional impact of US wind energy development on birds and bats. *US Geological Survey Scientific Investigations Report*, *506*.

Diffendorfer J.E., J.A. Beston, M.D. Merrill, J.C. Stanton, M.D. Corum, S.R. Loss, W.E. Thogmartin, D.H. Johnson, R.A. Erickson & K.W. Heist, 2017. A Method to Assess the Population-Level Consequences of Wind Energy Facilities on Bird and Bat Species. In: Koppel, J. (ed.). Wind Energy and Wildlife Interactions. Presentations from the CWW2015 Conference. Springer International.

Erickson R.A., E.A. Eager, J.C. Stanton, J.A. Beston, J.E. Diffendorfer & W.E. Thogmartin. 2015. Assessing local population vulnerability with branching process models: an application to wind energy development. *Ecosphere*, 6(12): article 254.

Ferreira D., C. Freixo, J.A. Cabral, R. Santos & M. Santos. 2015. Do habitat characteristics determine mortality risk for bats at wind farms? Modelling susceptible species activity patterns and anticipating possible mortality events. *Ecological Informatics*, 28: 7-18.

Frick W.F., E.F. Baerwald, J.F. Pollock, R.M.R. Barclay, J.A. Szymanski, T.J. Weller, A.L. Russell, S.C. Loeb, R.A. Medellin & L.P. McGuire. 2017. Fatalities at wind turbines may threaten population viability of a migratory bat. *Biological Conservation*, 209: 172–177.

Giavi S., M. Moretti, F. Bontadina, N. Zambelli & M. Schaub. 2014. Seasonal survival probability suggest low migration mortality in migrating bats. *PlosONE*, 9: e85628.

Hedenström A. & J. Rydell. 2013. Effect of wind turbine mortality on bat populations in Sweden: predictions from a simple population model. – Talk at CWE2013, Stockholm, 5-7 February 2013, Naturvardsverket rapport 6546:58.

Jones K.E., A. Purvis & J.L. Gittleman. 2003. Biological correlates of extinction risk in bats. *Am. Natural*, 161: 601–614

Köppel J., M. Dahmen, J. Helfrich, E. Schuster & L. Bulling. 2014. Cautious but committed: moving toward adaptive planning and operation strategies for renewable energy's wildlife implications. *Environmental Management*, 54: 744-755.

Lehnert L.S., S. Kramer-Schadt, S. Schönborn, O. Lindecke, I. Niermann & C.C. Voigt. 2014. Wind farm facilities in Germany kill noctule bats from near and far. *PlosONE*, 9(8): e103106. doi : 10.1371/journal.pone.0103106.

May R., E.A. Masden, F. Bennet & M. Perron. 2019. Considerations for upscaling individual effects of wind energy development towards population-level impacts on wildlife. *Journal of Environmental Management*, 230: 84-93.

Roscioni F., D. Russo, M. Di Febbraro, L. Frate, M.L. Carranza & A. Loy. 2013. Regional-scale modeling of the cumulative impact of wind farms on bats. *Biodivers. Conserv*., doi 10.1007/s10531-013-0515-3.

Roscioni F., H. Rebelo, D. Russo, M.L. Carranza, M. DiFebbraro & A. Loy. 2014. A modelling approach to infer the effects of wind farms on landscape connectivity for bats. *Landscape ecology*, 29: 891-903.

Santos H., L. Rodrigues, G. Jones & H. Rebelo. 2013. Using species distribution modelling to predict bat fatality risk at wind farms. *Biological Conservation*, 157:178-186.

Schuster E., L. Bulling & J. Köppel. 2015. Consolidating the state of knowledge: A synoptical review of wind energy's wildlife effects. *Environmental management*, *56*(2): 300-331.

Smales I. 2015. Fauna Collisions with Wind Turbines: Effects and impacts, individuals and populations. What are we trying to assess?. In *Wind and Wildlife* (pp. 23-40). Springer Netherlands.

Tabassum-Abbasi M.P., T. Abbasi & A.A. Abbasi. 2014. Wind energy: Increasing deployment, rising environmental concerns. *Renewable and sustainable energy reviews*, 31: 270-288.

Voigt C.C., A.G. Popa-Lisseanu, I. Niermann & S. Kramer-Schadt. 2012. The catchment area of wind farms for European bats: A plea for international regulations. *Biological Conservation*, 153:80-86.

Voigt C.C., L.S. Lehnert, G. Petersons, F. Adorf & L. Bach. 2015. Bat fatalities at wind turbines: German politics cross migratory bats. *European Journal of Wildlife Research*, 61: 213-219.

### 3.1.2 **Maximum foraging/commuting/migrating distances and heights of species**

In the framework of the Environmental Impact Assessment of wind farm projects, it is important to know the range of the different species encountered in the vicinity and the height at which they can fly. As an aid to evaluate the risks of a project for nearby colonies, the IWG on Bat populations and Wind Turbines presented a compilation of references showing for different bat species the maximum foraging and commuting distances from the roosts. The table has not been updated since 2016 and can still be found at https://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/AC17_Doc_6_IWG_wind_turbines_inc%20Annex%20I-II.pdf.

As a general rule, bat activity decreases with height above vegetation. Increasing the distance between the vegetation and the lowest tip of the blades should then be a general recommendation. Since wind speed is stronger at higher height, this recommendation is also in line with increasing the efficiency of electric production by individual wind turbines.

Since 2016 new survey methods such as the use of arrays of microphones at height connected to automatic recorders of ultrasound sequences have been used to determine bats' activity at heights and produce a collision susceptibility index (Roemer *et al*. 2017). In their study, the authors present the ratio of time spent at height per species and also compare the mean activity at ground and at height for each species.

Furthermore, as their weight is decreasing every year, some GPS can now be used for large bats such as *Nyctalus* species. For each fix they indicate bat's flight altitude above ground. This is how we know that in some areas *N. lasiopterus* flies up to 1200 m above ground (Thurow & Beucher 2018).

Roemer C., T. Disca, A. Coulon & Y. Bas. 2017. Bat flight height monitored from wind masts predicts mortality risk at wind farms. *Biological Conservation*, 215, 116-122.

Thurow A. & Y. Beucher. 2018. Foraging flights of the Greater Noctule, Nyctalus lasiopterus, New insights based on the GPS tracking technology. Poster at the 7th SECEMU conference, Gibraltar.

### 3.1.3 **Comparing measurement of activity at ground level and rotor height**

Budenz *et al*. (2017) tested whether *Barbastellus barbastellus* explore wind turbines and come close enough to the rotor blades to get killed. They found *B. barbastellus* regularly at heights of up to 20m (canopy height) and at one site up to 35m (above canopy), but not at 50 or 80m height. They conclude that it is unlikely that explorative behaviour may expose *B. barbastellus* to significant risk.

One paper about the relevance of a second microphone at the lowest tip of the rotor blade is in preparation.

Budenz T., B. Gessner, J. Lüttmann, F. Molitor, K. Servatius & M. Veith. 2017. Up and down: *B. barbastellus* explore lattice towers. *Hystrix,* 28(2): 272-276.

### 3.1.4 **Small Wind Turbines**

The subgroup was unable to find any new studies since the last report (Doc.EUROBATS.StC14-AC23.9.Rev.2).

### 3.1.5 **Offshore windfarms**

One *Vespertilio murinus* was recorded about 5km off the Belgian coastline on 19th of September 2014 (Brabant *et al*. 2016).

However, in a paper from Lüdeke (2017), dealing with good practice in impact assessment, mitigation and compensation in offshore wind energy planning bat are not mentioned at all!

In Germany the BfN/BMU project about offshore bat migration (BATMOVE) was active in 2018, and will continue in 2019, but no new report is available yet.

Brabant R., Y. Laurent, R.-M. Lafontaine, B. Vandendriessche & S. Degraer. 2016. First offshore observation of parti-coloured bat *Vespertilio murinus* in the Belgian part of the North Sea. Belg. J. Zool., 146(1): 62-65.

Lüdeke J. 2017. Offshore Wind Energy: Good Practice in Impact Assessment, Mitigation and Compensation. *Journal of Environmental Assessment Policy and Management*, 19(1). https://doi.org/10.1142/S1464333217500053

### 3.1.6 **Wind farms and forests**

A new publication deals with the habitat use and the collision risk of *Barbastellus barbastellus* in a wind park in Sweden (Apoznański *et al*. 2018). The radio-tagged bats flew at least 100m from the turbines and didn´t cross the turbine pads. Calls of bats were detected frequently at the forest edges 30m from the turbines, but rarely within 10m of them, and never at heights of 30 and 100m. Carcass searches in 1-week-intervals at ten turbines over three summer did not identify carcasses of *B. barbastellus* but three other species were collected. The authors conclude that wind parks are not incompatible with the effective conservation of *B. barbastellus.*

In 2017, a study was published that compares the activity at wind turbines in forests to those in open landscapes (Reers *et al*. 2017). The dataset included 193 survey years from 130 different turbines between 2008 and 2014. In total, 106 survey years were conducted at open landscapes, 87 at forest sites. In both habitats, at nacelle height the Nyctaloid-group (species of the genus *Eptesicus, Nyctalus* and *Vespertilio*), *Pipistrellus pipistrellus* and *Pipistrellus nathusius* were nearly exclusively detected, the Nyctaloid-group as dominant species. All three species/groups showed no significant differences between forest and open landscapes. The phenology didn´t show any differences between open landscapes and forests. Activity peaked between July and September, with that of *P. nathusius* peaking a little bit later than that of *P. pipistrellus* and the Nyctaloid-group. Comparison of measurements at nacelle height shows that curtailment schemes developed in open landscapes should also be valid for forest sites. The results indicate that the risk of collisions in forest is similar to that in open landscapes, but casualty surveys are now required to verify this

In a current project in Germany funded by the Federal Agency of Nature Conservation, the use of roosts and foraging habitats of maternity colonies of *Plecotus auritus* and *B. barbastellus* are analysed before and after the installation of wind turbines. The aim of the project is to find out if disturbances produced by the turbines lead to further habitat losses for forest-dwelling bats. Results are expected in the next years.

Apoznański G., S. Sánchez-Navarro, T. Kokurewicz, S. Pettersson & J. Rydell. 2018. Barbastelle bats in a wind farm: are they at risk? European Journal of Wildlife Research, 64: 43.

Reers H., S. Hartmann, J. Hurst & R. Brinkmann. 2017. Bat activity at nacelle height over forest. In: Köppel, J. (Hrsg.): Wind Energy and Wildlife Interactions - Presentations from the CWW 2015. –

Cham (Springer Verlag): 79-98.

### 3.1.7 **200m buffer distance to edge habitats particularly important for bats**

Within the scope of a comprehensive study of wind farms located in farmland across two regions in north-west France and their impacts on bats, among many other aspects and conclusions reported in several recent publications, Barré *et al*. (2018) have given an account of certain issues relevant to this subject. They have studied bat activity at hedgerows (207 sites) located at a distance of 0-1000m from 151 turbines of 29 wind farms. A significant negative effect of proximity to turbines on activity has been found for three species – *Barbastella barbastellus*, *Nyctalus leisleiri*, *Pipistrellus pipistrellus*, two groups (*Myotis* spp., *Plecotus* spp.) and two guilds (fast-flying: containing *B. barbastellus*, *Epesicus serotinus*, *Pipistrellus* spp., *Nyctalus* spp., and gleaner: containing *Myotis nattereri*, *Plecotus* spp., *Rhinolophus* spp.). Based on these findings, they conclude that EUROBATS Guidelines' recommendation of 200 m buffer (set to limit bat fatalities) is far from sufficient to limit the loss of habitat use. They also emphasise the fact that 89% of 909 turbines installed in north-west France do not comply with Guidelines' recommendation. These results could also indicate that, at forest sites, there is a functional loss of forest habitat beyond the clear-cut area.

Barré K., I. Le Viol, Y. Bas, R. Julliard & C. Kerbiriou. 2018. Estimating habitat loss due to wind turbine avoidance by bats: Implications for European siting guidance. *Biological conservation*, 226: 205-214.

## 3.2 **IMPACT MITIGATION AND MONITORING**

### 3.2.1 **Sensitivity maps**

A literature review has been published based on known bird and bat fatality sensitivity map approaches across the world (Bright & Muldoon 2017), discussing the specificity of each taxa, the differences between bird and bat habitat mapping, and the significance of the no go areas. These areas can be subjective based on the limited data that is available and the mapping approach used. An approach to regional sensitivity maps was developed in Aquitaine, France (LPO Aquitaine 2017), was developed in order to address future wind park developments, taking into account various environmental variables such as land use, cumulative annual precipitation values, cave and permanent hydrographic network density, light pollution, and a NDVI index (Normalised Difference Vegetation Index as a proxy for vegetation productivity). Presence of bat species was collected from various data sources and projects, and from the total of 25 species, only two were not taken into account due to lack of suitable data (presence points from April to October). Spatial autocorrelation was tackled by the use of 4km grid cells (mesh), which eliminated excess information from the models. GLM (Generalized Linear

Models) and MaxEnt methods were used to identify the habitat suitability for each species, and the final results were combined using Biomod2 R package, taking into account an evaluation of their robustness. The work generated pseudo-absence points (10000), taking into account the fact that real absence data for bats is hard to obtain, especially in such a small study region. The models were tested with 25% of the input presence points and ROC (AUC) indicator. Zonation was used to merge the datasets into a sensitivity map, weighting the habitat suitability models via a sensitivity index. The index was calculated taking into account the species´ IUCN category in France and the behaviour of the species in response to wind parks. A separate ultrasound monitoring campaign was used to validate the results, with detectors located at ground level and 90 m altitude. The study showed a good practice method that could be replicated at a much larger scale.

Recognising the increasing pressure for renewable energy development across Europe, the European Commission is supporting the development of a toolkit to inform renewable energy deployment that will help Member States develop Wildlife Sensitivity Mapping (WSM) within their own countries and regions. As part of the project led by Arcadis Belgium, supported by Arcadis UK in Consortium with ONDRAF / NIRAS and Birdlife (EC CONTRACT ENV.D.3/SER/2017/0002), the first workshop to develop a toolkit was organised on 22nd October 2018 in Brussels. One member of this sub-group took part in this workshop and stressed the importance of including bats (as a taxon significantly impacted caused by wind farm developments), and a recommendation made to contact EUROBATS for further insight and further activities. An example of sensitivity mapping for bats in the Flanders region (Belgium), and the challenges to improving their production, was also presented at this workshop (Everaert 2018). On November 28th 2018 a follow-up skype meeting, including some members of the IWG, took place. Several steps were recommended: the consultation of IWG´s reports, the presentation of the final version of the report to the IWG for comments, and participation in 24 AC. The development of the toolkit is a part of the larger project through which current European Commission Guidelines on Wind Energy and Natura 2000 will be updated, and a toolkit for the development of sensitivity maps will be developed. WSM will not replace the need for site-specific assessments; rather it will act as a guide in early-stage screening assessments.

Bright J. & C. Muldoon. 2017. Chapter 5: Spatial Planning. In R. P. Martin (Ed.), Wildlife and Wind Farms, Conflicts and Solutions, Volume 2 *Onshore: Monitoring and Mitigation* (p. 227). Exeter, UK: Pelagic Publishing.

Everaert J. 2018. Wind farm sensitivity map for birds and bats in Flanders (Belgium). Presentation at the European Commission workshop to develop a toolkit for EU member states on wildlife sensitivity mapping and renewable energy developments.

LPO Aquitaine. 2017. *Etude de la sensibilité à l'éolien de la biodiversité en Aquitaine*. 134 pages

### 3.2.2 **Mitigation and compensation measures**

Voigt *et al.* (2018) assessed the effect that the transition from conventional lighting to energy-saving light-emitting diodes (LED) at wind farms may have on bat activity and, consequently, on bat collision risk. The experiment was conducted between 10 August and 6 September 2016 at a major bat migration corridor in south-west Latvia. In an open area (meadow) located 100-200m from the Baltic Sea, the presence of migrating bats was measured (using ultrasonic recorders placed at a height of 5.3m above the ground) during 10-min light-on/light-off intervals to red or warm-white LED, interspersed with dark controls. The results showed that the response of migratory bats toward LED light was dependent on light colour. Red LED increased the flight activity of *Pipistrellus pygmaeus* and *P. nathusii,* which was not associated with increased feeding. Conversely, warm-white LED generally did not increase flight activity, but an increase in foraging activity was observed compared to dark controls. The authors call for caution in the application of red aviation lighting at wind turbines, as this light colour might attract bats, leading eventually to an increased collision risk for migratory bats at wind turbines. However, further studies testing bat-friendly lighting at wind turbines needs to be conducted before general management recommendations can be made.

Regarding the optimization of curtailment measures, Behr *et al.* (2018) have finished the RENEBAT III project, the last of the three successive research projects aimed at developing and implementing a curtailment algorithm for `bat safe´ wind turbine operation. Several years previously, they developed `ProBat´ – a software tool which calculates a turbine-specific cut-in algorithm based on two years of automated bat recording below the nacelle and corresponding wind speed data. The later stages of the project tested and improved the software. A general problem with bioacoustic detection devices is the limited range of the microphone which also varies depending on the species; it was recognized, for example, that the tool did not work as well at sites with high activity of *Pipistrellus nathusii* (a species with short call range). However, a new update of the tool is now available (www.windbat.techfak.fau.de/tools/probat.shtml). It differentiates the seasonal activity of bats and their collision risk for four natural landscapes and three different detector types. The estimated collision rates are based on new models and show bigger differences between different wind turbines, resulting in a broader range but overall increased shut-down times. Their model/scenario cannot rule out negative impacts of collisions with wind turbines on populations of *Nyctalus noctula* and *Nyctalus leisleri*. Therefore they recommend monitoring the populations of these two species very carefully, and they suggest that in some regions the threshold for tolerable fatalities should be set. In some regions, such as Thuringia, implementation of curtailment algorithm that results in <1 fatality/WT/year is recommended (though, as noted above, population impacts are difficult to assess).

For more about mitigation measures, namely automated systems to implement curtailment and to deter bats from wind turbines, please see section “Deterrents, technical mitigation systems and automated monitoring systems”.

To the best of our knowledge, no study has been published on the test and/or implementation of compensation/offset programmes for bats on the wind energy context, between 2018 and the beginning of 2019.

Behr O., R. Brinkmann, K. Hochradel, J. Mages, F. Korner-Nievergelt, H. Reinhard, R. Simon, F. Stiller, N. Weber & M. Nagy. 2018. *Bestimmung des Kollisionsrisikos von Fledermäusen an Onshore-Windenergieanlagen in der Planungspraxis - Endbericht des Forschungsvorhabens gefördert durch das Bundesministerium für Wirtschaft und Energie (Förderkennzeichen 0327638E)*. O. Behr et al. Erlangen / Freiburg / Ettiswil.

Voigt C., K. Rehnig, O. Lindecke & G. Pētersons. 2018. Migratory bats are attracted by red light but not by warm-white light: Implications for the protection of nocturnal migrants. *Ecology and Evolution*, 8: 9353–9361. https://doi.org/10.1002/ece3.4400

### 3.2.3 **Deterrents, technical mitigation systems and automated monitoring systems**

In the last year, several deterrent and technical mitigation systems have again appeared in Europe in the hope of reducing shut-off or curtailment events. For most of them, effectiveness hasn´t been proven yet.

For example, Topwind, Ammonit and Liquen Consultoría Ambiental (DTBat) offer automated acoustic detector systems installed below the nacelle, connected with the operating (Scada) system of the turbine. When bats are recorded, the rotor is stopped in real time. Optionally, the stop-trigger can be also linked to real-time environmental parameters. However, no test results are available, and thus effectiveness of these systems can’t be assessed yet.

EPRI (2017) has also presented a similar system that should reduce mortality by shutting down the wind turbines in a real time when bats are detected. In their report they present a test conducted at 23 wind turbines in USA. The system was programmed to shut down the turbines when wind was less than 3.5m/s. When the wind was between 3.5 and 8.0m/s and a certain threshold level of bat activity was reached, then the wind turbine was shut down for at least 30 minutes. In winds above 8m/s, or between 3.5 and 8m/s while bat activity below the threshold, the wind turbine operated normally. The test resulted in reduced overall bat mortality by 83 % and American *Myotis* species (e.g. *Myotis lucifugus*) mortality by 90%. There are no tests involving European species yet.

NRG tested a deterrent system in USA in cooperation with Bat Conservation International. Several deterrent systems were installed at the nacelle and the tower to cover large parts of the rotor swept area. In 2017, in most cases, numbers of fatalities were reduced. But in some cases (e.g. *Lasiurus borealis*, *Eptesicus fuscus*), the numbers of fatalities increased. There are no tests involving European species yet.

Lindemann *et al*. (2018) criticise the way curtailment parameters are determined. Their key point is that the RENEBAT tool ProBat, which was developed for wind turbines with 42m rotor blade length, is widely used at German wind farms. The newer generations of wind turbines have much longer blade lengths which means that the bioacoustic detection range e.g. for *Pipistrellus nathusii* is less than the blade length. RENEBAT II and III (Behr *et al*. 2015, 2018) tried to compensate for the different blade lengths statistically, though this procedure was not tested sufficiently (but see also chapter "Mitigation and compensation measures"). The longer rotor blades require an additional microphone at the lowest tip of the blade. Lindemann *et al*. (2018) also criticise the common practice in many German federal states to accept two fatalities/turbine/year as non-compliant with European legislation and not justified by population biology, thus posing a great risk for species conservation.

Several abstracts from the NWCC Wind Wildlife Research Meeting (2018) promise new technical mitigation systems, but too little information is presented to discuss those here.

Ammonit: http://www.ammonit.com/en/produkte/sonstiges/fledermausdetektoren

Behr O., R. Brinkmann, F. Korner-Nievergelt, M. Nagy, I. Nermann, M. Reich & R. Simon. 2015. *Reducing the collision risk for bats at onshore wind turbines (RENEBAT II) – Summary*. Leibniz Universität Hannover.

Behr O., R. Brinkmann, K. Hochradel, J. Mages, F. Korner-Nievergelt, H. Reinhard, R. Simon, F. Stiller, N. Weber & M. Nagy. 2018. *Bestimmung des Kollisionsrisikos von Fledermäusen an Onshore-Windenergieanlagen in der Planungspraxis - Endbericht des Forschungsvorhabens gefördert durch das Bundesministerium für Wirtschaft und Energie (Förderkennzeichen 0327638E).* O. Behr et al. Erlangen / Freiburg / Ettiswil.

EPRI. 2017. *Bat Detection and shutdown System for Utility-Scale Wind Turbines. – final report 3002009038 from The Electric Power Research Institute Palo Alto, CA*.: 98 pp.

Lindemann, V.C., V. Runkel, A. Kiefer, A. Lukas & M. Veith. 2018. Abschaltalgorithmen für Fledermäuse an Windenergieanlagen. *Naturschutz und Landschaftsplanung*, 50: 418–425.

Liquen Consultoría Ambiental (DTBat): https://www.dtbat.com/

NWCC. 2018. *Wind Wildlife Research Meeting – Presentation and poster Abstracts*. 66pp.

Topwind: http://www.topwind.nl/pages/en/systems/bat-protection-system.php?lang=EN

Velasquez J. & B. Morton. 2018. *NRG Bat Deterrent System* – presentation October 2018.

### 3.2.4 **Use of dogs vs humans during carcass searches**

Since the last report there have been no new published studies on use of dogs vs humans during carcass searches. In January 2019, Scottish Natural Heritage published guidelines "*Bats and Onshore Wind Turbines: Survey, Assessment and Mitigation*" (Anon. 2019), in which the use of suitably trained dogs with handlers is recommended as a more efficient and faster method of carcass searches in comparison to humans locating carcasses. In addition, it remains necessary to understand the natural rates of carcass removal by scavengers, and the efficiency of the dogs in detecting carcasses. The recommended methodology developed at Exeter University was presented in Appendix 4 of the document. Dog searches were also recognized as resource-demanding and that, where high searcher efficiency can be achieved in other ways (for example, where the ground is covered with very short grass and so is easy for people to search), then dogs may not be necessary.

The same conclusion was made in a systematic review by Barrientos *et al*. (2019) of searcher efficiency and carcass persistence in 294 infrastructure-driven mortality assessment studies. In this article, the competence of searchers (dogs and humans) and the size of the carcasses used were defined as the two most important components influencing searcher efficiency. However, despite the fact that dogs are more effective than humans, it is also stated that there is still little information to guide the standardization of searches with dogs, since daily fluctuations in temperature and humidity, the repeatability of sampling schema and other factors can limit a dog's proficiency.

Effectiveness of observers, whether human or dog, always needs to be monitored, and this should be repeated at every site. When there is low observer efficiency, the performance of all models designed to estimate true casualty rates is very poor.


Anon. 2019. *Bats and Onshore Wind Turbines: Survey, Assessment and Mitigation*. Scottish Natural Heritage, Natural England, Natural Resources Wales, RenewableUK, Scottish Power Renewables, Ecotricity Ltd, the University of Exeter and the Bat Conservation Trust (BCT). 39pp.

Barrientos R., R.C. Martins, F. Ascensão, M. D'Amico, F. Moreira & L. Borda-de-Água. 2018. A review of searcher efficiency and carcass persistence in infrastructure driven mortality assessment studies. *Biological Conservation*, 222: 146 –153.


### 3.2.5 **Estimation of bat mortality based on carcass searches; the choice of best estimator for Europe**

The software “GenEst” (Generalized Estimator) is now fully developed and available for practitioners (https://code.usgs.gov/ecosystems/GenEst/tags). GenEst is a R package that uses an add-on called *shiny* for a user-friendly graphical interface. Compared to the preceding estimators (e.g. Shoenfeld 2004; Huso *et al.* 2012; Korner-Nievergelt *et al.* 2015; Wolpert 2015), the main advantages of GenEst are its flexibility (e.g. it allows straightforward analysis of complex datasets that may include multiple carcass-size classes, detection probabilities that depend on environmental covariates, variable search schedules, and search coverage that varies with search unit) and its ability to account for estimation uncertainties in a novel way (Dalthop *et al.* 2018). GenEst software includes several modules (Simonis *et al.* 2018), namely for *(i)* data input (Searcher Efficiency, Carcass Persistence, Search Schedule, Density-

Weighted Proportion, and Observed Fatalities); *(ii)* estimation of searcher efficiency using maximum likelihood methods; *(iii)* estimation of carcass persistence based on survival analysis; and *(iv)* calculation of the number of bats killed (and confidence intervals) in a facility during a specific period of time, taking into consideration the fraction of the facility surveyed. The mortality estimates generated may then be split according to monitoring period (e.g. by season) and/or other variables of interest (e.g. by species or turbine). All estimates are presented in a summary table and graphically.

An alternative methodological approach was proposed by Péron *et al.* (2013) to assess bat and bird fatality at wind farms, using open-population capture-recapture models (herein called CRM estimator). A simulation study (Péron 2018) was recently conducted to compare the performance of CRM and four other estimators (including the estimator proposed by Korner-Nievergelt *et al.* 2015). The results show that the fatality estimates obtained using the CRM estimator were less biased, but the performance of all estimators declined when searcher efficiency decreased and when the number of carcasses available for detection decreased. Therefore, when zero or few carcasses have been detected, Péron (2018) recommends using the Bayesian approach proposed by Huso *et al.* (2015). This simulation study did not evaluate the performance of GenEst estimator since it was not fully operational yet. Besides, other methodological approaches may represent suitable options in the absence of detected carcasses (Bastos *et al.* 2013), namely through the construction of an algorithm adaptable to the particularities of each study site. Finally, Santos *et al.* (2017) found no differences in the success of detecting carcasses under different field monitoring protocols, suggesting that a reduction in monitoring periods and shortening the interval between searches could reduce bias in the estimations and increase the confidence limits of impact assessments associated with mortality estimates at onshore windfarms.

Nelson *et al.* (2018) evaluated the ability of carcass searchers to identify the sex of a bat based on its external morphology. The sex of *Lasiurus borealis* and *L. cinereus* carcasses (previously identified by 15 different searchers at a wind-energy facility) was confirmed through genetic analysis. The percentage of carcasses for which the identification of sex (based on external morphology) was correct decreased from 90% for those recovered within a day of death, to 65% within 2–3 days of death, and to 25% at >4 days of death. The percentage of misidentifications of the 108 fresh carcasses (collected within 24 hours of death) varied among searchers (0%–0.43%). These results suggest that: 1) fatality assessments using sex data (solely derived from external morphology) should be limited to fresh carcasses; and 2) additional training of technicians who search and identify bat carcasses may increase the accuracy of sex data obtained.

Concerning the conduct for field experiments to assess carcass persistence and searcher efficiency, Smallwood *et al.* (2018) pointed out the advantages of integrating the detection trials into the routine fatality monitoring, rather than conducting conventional trials, estimating carcass persistence and searcher efficiency rates separately. In integrated detection trials, carcasses are placed in the searched area (alike in conventional trials) but then all carcasses are left in the field indefinitely, so that they can be detected (on not) in following scheduled searches. According to the authors, this approach simulates more realistically the carcass detection probabilities and is more cost-effective (since conventional carcass persistence and searcher efficiency trials no longer need to be separately conducted). The full adoption of integrated detection trials may, however, be hindered by some practical issues, such as the unknown number of times a person (not involved in the regular carcass searches) may need to go to the wind farm to place carcasses throughout the routine fatality monitoring. Since small carcasses are not expected to last long periods, and trial carcasses should be placed in small groups (to avoid carcass saturation), a considerable number of extra visits to the wind farm may be needed to ensure that carcass detection is estimated based on a robust number of carcasses.

Bastos R., M. Santos & J.A. Cabral. 2013. A new stochastic dynamic tool to improve the accuracy of mortality estimates for bats killed at wind farms. *Ecological Indicators*, 34: 428–440.

Dalthorp D., L. Madsen, M. Huso, P. Rabie, R. Wolpert, J. Studyvin, J. Simonis & J. Mintz. 2018. *GenEst statistical models - A generalized estimator of mortality*. U.S. Geological Survey Techniques and Methods, book 7, chap. A2, 13 p., https://doi.org/10.3133/tm7A2

Korner-Nievergelt F., O. Behr, R. Brinkmann, M.A. Etterson, M. Huso, D. Dalthorp, P. Korner-Nievergelt, T. Roth & I. Niermann. 2015. Mortality estimation from carcass searches using the R-package carcass - A tutorial. *Wildlife Biology*, 21(1): 30–43. https://doi.org/10.2981/wlb.00094

Huso M., D. Dalthorp, D. Dail & L. Madsen. 2015. Estimating wind-turbine-caused bird and bat fatality when zero carcasses are observed. *Ecological Applications*, 25(5): 1213–1225. https://doi.org/10.1890/14-0764.1

Huso M., N. Som & L. Ladd. 2012. *Fatality estimator user's guide.* U.S. Geological Survey Data Series 729, 22 pp., https://dx.doi.org/10.3133/ds729

Nelson D.M., J. Nagel, R. Trott, C.J. Campbell, L. Pruitt, R.E. Good, G. Iskali & P.F Gugger. 2018. Carcass age and searcher identity affect morphological assessment of sex of bats. *Journal of Wildlife Management*, 82: 1582–1587. https://doi.org/10.1002/jwmg.21544

Péron G., J.E. Hines, J.D. Nichols, W.L. Kendall, K.A. Peters & D.S. Mizrahi. 2013. Estimation of bird and bat mortality at wind-power farms with superpopulation models. *J. Appl. Ecol.*, 50: 902–911. https://doi.org/10.1111/1365-2664.12100

Péron G. 2018. Process-based vs. ad-hoc methods to estimate mortality using carcass surveys data: A review and a note about evidence complacency. *Ecological Modelling*, 384: 111–118. https://doi.org/10.1016/j.ecolmodel.2018.06.021

Santos M., R. Bastos, D. Ferreira, A. Santos, A. Barros, P. Travassos, D. Carvalho, C. Gomes, H.M. Vale-Gonçalves, L. Braz, F. Morinha, M.N. Paiva-Cardoso, S.J. Hughes & J.A. Cabral. 2017. A spatial explicit agent based model approach to evaluate the performance of different monitoring options for mortality estimates in the scope of onshore windfarm impact assessments. *Ecological Indicators*, 73: 254–263. https://doi.org/10.1016/j.ecolind.2016.09.044

Smallwood K., D. Bell, E. Walther, E. Leyvas, S. Standish, J. Mount & B. Karas. 2018. Estimating wind turbine fatalities using integrated detection trials. *Journal of Wildlife Management*, 82(6): 1169-1184. https://doi.org/10.1002/jwmg.21468

Shoenfeld, P. 2004. *Suggestions regarding avian mortality estimation*. Report prepared for the West Virginia Highlands Conservancy, West Virginia, by Mountaineer Wind Energy Center Technical Review Committee. 6 p.

Simonis J., D. Dalthorp, M. Huso, J. Mintz, L. Madsen, P. Rabie & J. Studyvin. 2018. *GenEst user guide - Software for a generalized estimator of mortality.* U.S. Geological Survey Techniques and Methods, book 7, chap. C19, 72 p.. https://doi.org/10.3133/tm7C19

Wolpert R. 2015. ACME - *A partially periodic estimator of avian and chiropteran mortality at wind turbines*. Cornell University Library. https://arxiv.org/abs/1507.00749

## 3.3 SUMMARY OF THE BIBLIOGRAPHY ON WIND TURBINES AND BATS (2018-2019)

Annex 2 includes new references and is an addendum to Annex 1 of Doc.EUROBATS.AC20.5, Annex 1 of Doc.EUROBATS.AC21.8, Annex 1 of Doc.EUROBATS.AC22.10.Rev.1, Annex 1 of Doc.EUROBATS.StC14-AC23.9.Rev.2 and chapter 9 of EUROBATS Publication Series nº 6.

# 4 FINAL REMARKS

Results continue to show that mortality is highly variable between different sites and between different wind turbines within one wind farm. Besides that, mortality varies between years and this is why a minimum three-year mortality monitoring period during the operational phase is recommended, to assess impacts more accurately, and to avoid biases/influences unrelated to the wind farm. Consistency of monitoring protocols is critical to allow comparisons and determine cumulative impacts. Currently, monitoring schedules, time intervals between controls, and estimators for mortality rates, differ from one wind farm to the other and make comparisons impossible. Tests for predation and searcher-efficiency nor is correction made for the proportions of areas not sampled.

It is not possible to evaluate the impacts of wind farms without mortality data; yet very few countries have submitted the results of their monitoring programmes. This is essential if we want to assess the cumulative impacts of wind farms on local or regional bat populations. The IWG therefore again urges the EUROBATS Parties and non-Party range states to submit data on observed mortality (raw data rather than aggregated data in synthesis), monitoring programmes and research projects, papers and other references, national and regional guidelines, and all relevant supporting information (mitigation measures, compensation measures, deterrents, etc) to be able to make a pan-European assessment of the impacts of wind energy.

## Annex 1 - New studies done in Europe

(addendum to: Table 1 of *EUROBATS Publication Series no. 3*, Annex 3 of *Doc.EUROBATS.AC14.9.Rev1,* Annex 3 of *Doc.EUROBATS.StC4-AC15.22.Rev.1,* Annex 2 of *Doc.EUROBATS.AC17.6,* Annex 2 of *Doc.EUROBATS.AC18.6,* Annex 2 of *Doc.EUROBATS.StC9-AC19.12,* Annex 1 of *EUROBATS Publication Series no. 6,* Annex 2 of *Doc.EUROBATS.AC20.5,* Annex 2 of *Doc.EUROBATS.AC21.8,* Annex 2 of *Doc.EUROBATS.AC22.10.Rev.1, and Annex 2 of Doc.EUROBATS.StC14/AC23.9.Rev.2)*

| Study (author, year, area) | Time | Habitat types | Data on WTs | Methods | Results |
|---|---|---|---|---|---|
| Frey, K, Bach, L., Bach P. (2019), NW-Germany | 2017 & 2018 | grassland | 1 WT, E70, Nacelle height 113m | acoustic monitoring with 2 microphones (nacelle and 10m below the lowest tip of the rotor blade), all WT run with curtailment | low activity in 2017, high activity in 2018, *Nyctalus noctula, N. leisleri, Vespertilio murinus, Pipistrellus nathusii, P. pipistrellus, Plecotus* spec., new curtailment in July-mid of October |
| Bach, L. & Bach, P. (2019), NW-Germany | 2017 & 2018 | grassland | 4 WT, E101, Nacelle height 135m | acoustic monitoring with 2 microphones (nacelle and 10m below the lowest tip of the rotor blade), fatality search in 2018 to verify the curtailment worked out in 2017. all WT run with curtailment | low activity at nacelle height in both years, medium activity at the lowest rotor blade tips, no fatalities, *Nyctalus noctula, Eptesicus serotinus, Pipistrellus nathusii, P. pipistrellus, Plecotus* spec., contrary activity patterns in both years, new curtailment at 1 Wt, another monitoring year in 2019 for 3 Wt |
| Bach, L. & Bach, P. (2019), NW-Germany | 2017 & 2018 | grassland | 5 WT, E115, Nacelle height 135m | acoustic monitoring with 2 microphones (nacelle and 10m below the lowest tip of the rotor blade), all WT run with curtailment | at nacelle height: low activity in 2017, medium activity in 2018, medium activity at the lowest rotor blade tips, *Nyctalus noctula, N. leisleri, Eptesicus serotinus, Pipistrellus nathusii, P. pipistrellus, Myotis dasycneme, Plecotus* spec., new curtailment in July-mid of October |
| Bach, L. & Bach, P. (2019), NW-Germany | 2018 | grassland | 5 WT, E115, Nacelle height 135m | acoustic monitoring with 2 microphones (nacelle and 10m below the lowest tip of the rotor blade), all WT run with curtailment | medium activity at nacelle height, high activity at the lowest rotor blade tips, *Nyctalus noctula, Eptesicus serotinus, N. leisleri, Vespertilio murinus, Pipistrellus nathusii, P. pipistrellus*, new curtailment August -mid of October |

| | | | | | |
|---|---|---|---|---|---|
| Bach, L. & Bach, P. (2019), NW-Germany | 2018 | grassland | 2 WT, E115, Nacelle height 135m | acoustic monitoring with 2 microphones (nacelle and 10m below the lowest tip of the rotor blade), all WT run with curtailment | medium activity at nacelle height, high activity at the lowest rotor blade tips, *Nyctalus noctula, Eptesicus serotinus, Pipistrellus nathusii, P. pipistrellus, Plecotus* spec., new curtailment mid of July-mid of October |
| Frey, K. Bach, L. (2019, NW-Germany | 2018 | grassland | 3 WT, E101, nacelle height 99m | acoustic monitoring at nacelle height, all WT run with curtailment | medium - high activity, *Nyctalus noctula, Pipistrellus nathusii, P. pipistrellus, P. pygmaeus, Plecotus* spec., new curtailment mid of June end of October |
| Bach, P. Bach L. (2019), NW-Germany | 2018 | grassland, corn fields | 9 WT, 7 x E70 with nacelle height 64m and 2 x E82 with nacelle height 59m | acoustic monitoring with 2 microphones (nacelle and 10m below the lowest tip of the rotor blade), all WT run with curtailment | high activity at nacelle height and at the lowest tip of the rotor blade, *Nyctalus noctula, N. leisleri, Eptesicus serotinus, Pipistrellus nathusii, P. pipistrellus, P. pygmaeus, Myotis daubentonii, M. dasycneme, Plecotus* spec., new curtailment in May and July - mid of October |

**Annex 2 – Update to the list of references**

(updates Annex 1 of Doc.EUROBATS.AC20.5, Annex 1 of Doc.EUROBATS.AC21.8, Annex 1 of Doc.EUROBATS.AC22.10.Rev.1, Annex 1 of Doc.EUROBATS.StC14/AC23.9.Rev.2 and chapter 9 of EUROBATS Publication Series no. 6)


Anderson R. (2018). Automated classification of northern long-eared bat habitat using Google Earth Engine (poster). Presentation and Poster Abstracts, 12th NWCC Wind Wildlife Research Meeting.

Apoznański, G., Sánchez-Navarro, S., Kokurewicz, T. et al. (2018). Barbastelle bats in a wind farm: are they at risk? Eur J Wildl Res 64: 43.

Baerwald E. (2018). Landscape features associated with hoary bat fatalities at wind energy facilities (oral presentation). Presentation and Poster Abstracts, 12th NWCC Wind Wildlife Research Meeting.

Barré K., Le Viol I. Bas Y., Julliard R. & Kerbiriou C. (2018). Estimating habitat loss due to wind turbine avoidance by bats: Implications for European siting guidance. Biological Conservation 226: 205–214.

Bartuszevige A., Daniels A., Taylor K., Bogaerts M. & Carter M. (2018). Modelling potential risk of wind turbine placement in playa clusters in the western Great Plains and a path forward (poster). Presentation and Poster Abstracts, 12th NWCC Wind Wildlife Research Meeting.

Baumgartner E., Kauffman M., Bay K., Ciecka A. & Good R. (2018). Comparing searcher efficiency rates between dog and human searchers - a pilot study (poster). Presentation and Poster Abstracts, 12th NWCC Wind Wildlife Research Meeting.

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