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Environmental impact & regulatory framework

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Mitigation measures for preventing collision of birds with wind turbines

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Technology for a better society

Background

- Bird collisions are a visible environmental impact of wind energy.
  - Particularly significant in areas with eagles (but not restricted to).
  - Collisions with static structure or rotating blades.
- Number of bird deaths varies greatly around the world: 0 to 40 deaths per turbine per year.
- Many efforts have been done to measure and mitigate the negative impacts.
- Reducing the number of collisions help to
  - Aid social acceptance.
  - Streamline the process for new installations.

Objective

- Review on technologies for prevention of bird collisions with wind turbines (WTs):
  - Minimization measures performed post-construction of the wind farm (WF).
  - Aim to identify advantages/disadvantages of the methods.
  - Outline the results of measures that have been demonstrated in the field.
- Measures are classified into:
  (a) Active.
  (b) Passive.

  Based on the need (or not) for an external source to trigger an action for collision avoidance.

[1] R. May, O. Reitan, K. Bevanger, S.-H. Lorentsen, and T. Nygard, “Mitigating wind-turbine induced avian mortality: Sensory, aerodynamic and cognitive constraints and options,” Renewable and Sustainable Energy Reviews, vol. 42, pp. 170–181, 2015.

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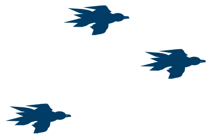
Overview

- Mitigation measures to reduce bird mortality are particularly complicated.
- Birds are exposed to collisions with the
  - static structure and the rotating blades.
- Species have different sensory faculties and behavioral aspects.
- There is not a single solution that can be applied to all sites and species.
- Proposed measures are:
  - Species-specific.
  - Tailored to the most collision-prone species at a certain location [1].



[2] M. Pescador, J. I. Gómez Ramírez, and S. J. Peris, “Effectiveness of a mitigation measure for the lesser kestrel (falco naumanni) in wind farms in Spain,” Journal of Environmental Management, vol. 231, pp. 919–925, 2019.

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Passive measures – Habitat management

- On-site alteration measures decrease the bird activity within the WF.
- Example: To reduce attractiveness of the vegetation around the WTs.
- Study case in Spain [2]: Tilled soil at the basis of 42% of 99 WTs.
- Target specie: *Lesser kestrel*.
- Duration: 2 years; Before-after analysis (before phase: 11 years).
- Results: Average reduction of 86% in the annual collision rates.

Figure – Tilled soil. Image by April Sorrow (UGA CAES/Extension) licensed under CC BY-NC 2.0.

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(+) Simple cost-effective measure.

(-) Results rely on the importance of the habitat for a specie, requiring huge modification in the area.

(-) Possibility of affecting non-target species.

[3] R. May et al., "Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities," Ecology and Evolution, vol. 10, no. 16, pp. 8927-8935, 2020. [4] B. G. Stokke et al., "Effect of tower base painting on willow ptarmigan collision rates with wind turbines," Ecology and Evolution, vol. 10, no. 12, pp. 5670-5679, 2020.

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Passive measures – Painting

- (a) To reduce motion smear of rotating blades, and (b) to increase contrast of the tower against the background.
- Study cases in Norway [3],[4]: (a) Four WTs with one rotor blade painted; (b)Ten turbines with painted tower bases.
- Target species: (a) *Soaring raptors*; (b) *Willow ptarmigans*.
- Duration: 3.5 years. Before-after analysis (before phase 7.5 years).
- Results: Average reduction of 70% in the annual collision rates for the study painting the blades, and 48% for the towers.

Figure – WT with rotor blade painted in black at Smøla WPP, Norway. Image by [3] licensed under CC BY 4.0.

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(+) Simple cost-effective measure (if blades are painted before WF construction).

(-) Less effective in low light levels.

(-) Less effective for species that constantly look down when flying (a).

[5] M. Ferrer et al., “Significant decline of griffon vulture collision mortality in wind farms during 13-year of a selective turbine stopping protocol,” Global Ecology and Conservation, vol. 38, p. e02203, 2022. [6] C. J.W. McClure et al., “Eagle fatalities are reduced by automated curtailment of wind turbines,” Journal of Applied Ecology, vol. 58, no. 3, pp. 446-452, 2021.

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Active measures – Turbine curtailment

- “Informed curtailment” is performed whenever a bird is detected in a high collision risk area or within a perimeter of the WF.
- Detection by human observers, radar and/or camera-based systems.
- Study cases in:
  - (a): Spain [5], 269 WTs and human observers. Target specie: *Soaring birds.* Duration: 13 years; Before-after analysis (before phase: 2 years).
  - (b): USA [6], 47 WTs with stereo cameras. Target specie: *Eagles*. Duration: 1.5 years; Before-after analysis (before phase: 4 years).
- Results: Average reduction of 65% in the annual collision rates.

Figure – Observation of birds by an ornithologist.

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(+) Effective measure during low light conditions (if bird is properly detected).

(-) Loss in annual energy generation.

(-) Might become expensive depending on sensor technologies used and number of units installed.

[7] K. O. Merz and J. O. G. Tande, “System and method for preventing collisions between wind turbine blades and flying objects,” International Patent Application WO 2016/200270 A1, 2016.

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Active measures – An alternative to shutdown

- Active control system of WT
  - Able to make small adjustments to the rotor speed (in real-time).
  - Birds can fly through the rotor swept area without being hit by the blades.
- SKARV concept [7] requires the bird detection
  - To perform a probabilistic estimate of flight path.
  - The WT rotational speed is modified by a small amount to minimize the probability of collision with marginal loss of power production.

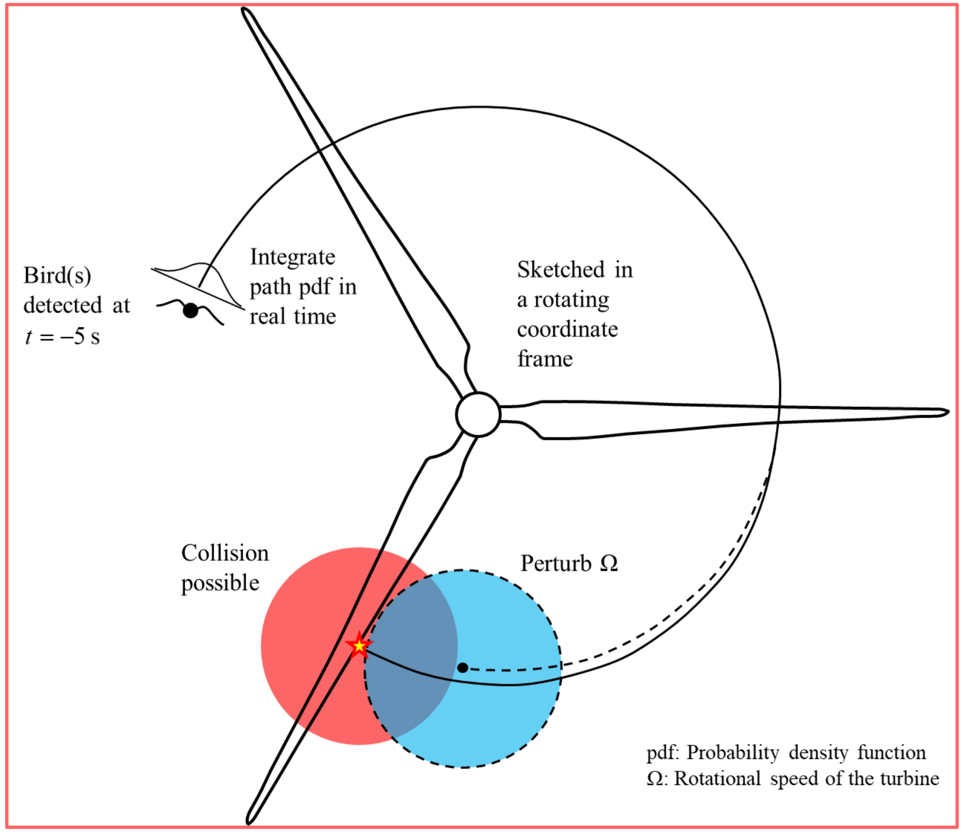

Figure – SKARV concept.

[8] H. T. Harvey & Associates, “AWWI Technical Report: Evaluating a commercial-ready technology for raptor detection and deterrence at a wind energy facility in California,” tech. rep., American Wind Wildlife Institute, Washington, DC, September 2018.

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Active measures – Deterrents

- Deterrents scare or frighten birds to prevent them from coming closer to the WTs.
- Examples: activation of audible and acoustic sounds, lights.
- Detection of birds by camera-based systems.
- Study case in USA [8]: Units with audible warning sound in 7 of 126 WTs.
- Target specie: *Golden eagles*.
- Duration: 9 months; Fatality risk estimation based on existing information on eagle activity.
- Results: Estimation of an average reduction of 43% in the annual collision rates.

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(+) Effective measure during low light conditions (if bird is properly detected).

(-) Signals may disturb nearby residents and non-target wildlife.

(-) Unpredictable effects on the bird’s flight trajectory.

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Conclusions

1) Different post-construction minimization measures have been proposed to reduce bird collisions with wind turbines.

2) To verify the effectiveness of a measure, a suitable experimental study, such as before-after control-impact experiments, is usually performed.

3) Overall, there is a limited number of published works that estimate the effectiveness of minimization measures in-situ.
   - This presentation summarized the experimental results of four measures.

4) The efficacy of the methods are calculated in terms of bird fatality reduction, but other important factors in the development of minimization measures are:
   - The effect on power production, disturbance to non-target wildlife and implementation costs.

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Thank you !

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