BLADE PATTERNING GUIDELINES

GUIDANCE NOTE FOR AVIAN SPECIALISTS RECOMMENDING PATTERNED BLADES AS A MITIGATION TO REDUCE AVIAN IMPACTS AT SOUTH AFRICAN WIND FARMS

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SAWEA
South African Wind Energy Association

AN INITIATIVE OF THE SOUTH AFRICAN WIND ENERGY ASSOCIATION, BIRDLIFE SOUTH AFRICA AND THE BIRDS AND RENEWABLE ENERGY SPECIALIST GROUP

BirdLife South Africa
Giving Conservation Wings

1. AIM

This document provides guidance to avian specialists wishing to recommend blade patterning to mitigate bird strikes, especially raptors, at South African wind farms. It aims to promote consistency in the application of blade patterning by Independent Power Producers (IPPs), Eskom and their designated avian specialists within South Africa, based on the latest avian scientific research and the requirements of the South African Civil Aviation Authority's (SACAA) Alternative Means of Compliance (AMoC)[1].

In practice, the patterning design and the number of blades to be patterned at a particular site should be determined by an appointed Avifaunal Specialist (registered with the South African Council of Natural Scientific Professions (SACNASP)), taking into consideration site-specific requirements, species present on site, site-specific avifaunal risks and the latest scientific evidence regarding patterning, augmented by results from patterning tests at operational wind farms across South Africa.

The patterning recommended here is based on published international studies regarding birds and their ability to see and avoid turbines with high-contrast colours applied to white turbine blades, as well as a pilot project undertaken in South Africa (2023 – 2024) (Birds & Bats Unlimited 2024). As a new field of passive mitigation, it is important that avian specialists use evidence-based best practices to mitigate avian fatalities by recommending appropriate colours and patterns for turbine blades.

2. BACKGROUND

Following a SAWEA briefing note on Considerations for Blade Patterning as a Mitigation Measure to Reduce Avifaunal Collisions with Wind Turbines in South Africa[2] (Morkel et al. 2023), SAWEA motivated to the SACAA for a blanket approval to allow all wind farms an AMoC to pattern blades. This request was approved by the SACAA on 18 January 2024, allowing IPPs to deviate from white (as required by the current regulations[3]) and apply a "different colour" to their turbine blades to reduce bird strikes.

Condition 5.1 of the AMoC approval requires that "the final designs of the alternative markings must be submitted to the SACAA for consideration and approval, prior to implementation". The SACAA have indicated that final designs must be accompanied by a full motivation of such markings from a SACNASP-registered avifaunal specialist ensuring that the markings achieve the purpose of the AMoC approval.

Recognising the benefit of standardising submissions to the SACAA, this paper has been drafted to assist avian specialists in recommending designs appropriate to reducing bird strikes based on the best available science in this field.

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3. RATIONALE

Birds, particularly raptors, are highly susceptible to impacts by spinning turbine blades (Thaxter et al. 2017, Perold et al. 2020). Experiments in the lab indicate that increasing contrast by painting one turbine blade black increases the chances that raptors will react to spinning blades. The single blade is assumed to reduce "motion smear" (lack of reaction on the retina to a fast-spinning blade: Hodos 2003) by breaking up the "blur".

By experimenting with different patterns, McIsaac (2001) found that two large black stripes across a blade were more conspicuous to raptors in the lab than plain white, plain grey, multiple zebra stripes or longitudinal stripes. This was confirmed in the first field trial several years later in Norway by May et al. (2020), which significantly reduced all bird fatalities by 72% by painting two-thirds of one blade solid black at four turbines. Umoya Wind Farm near Hopefield, Western Cape, employing patterns (i.e. two stripes) rather than a solid design, released preliminary, but promising results in July 2024, complementing these studies (Birds & Bats Unlimited 2024).

Further trials involving different species, environments and blade patterns are encouraged to determine this new mitigation's general applicability and effectiveness.

72 The percentage by which bird fatalities were reduced when painting two-thirds of one blade solid black in a field trial.

[1] The AMoC application was submitted in terms of Civil Aviation Regulation (CAR) 11.04.6, read with CAR 11.04.2 and 11.04.3, for turbine blades at wind farms not conforming strictly with CATS 139.01.30 (3) (b), in which SAWEA sought approval for deviation. [2] https://www.birdlife.org.za/wp-content/uploads/2023/09/SAWEA-Birdlife-BARESG-Blade-Patterning-Media-Briefing-Note_Final_14092023.pdf [3] CATS 139.01.30 (3)(b) requires that rotor blades, nacelle and the upper 2/3 of the supporting mast of a wind turbine shall be painted white, unless otherwise indicated by an aeronautical study.

4. GUIDELINES FOR BLADE PATTERNING

The following guidelines for patterning turbine blades are understood to be acceptable to the SACAA[4]:

4.1. Colours

- The turbine blade should be painted Red to comply with the SACAA regulations, and both the front and back of the blade must coloured[5].

4.2. Number of blades patterned

- A single turbine blade patterned in accordance with the terms of the AMoC approval is currently considered the best means of reducing motion smear (Hodos 2003). However, if multiple blades are patterned, the pattern must be asymmetrical (**see Figure 3 below**). That is, the pattern on the following blade must be positioned in different sections of the blade to produce a flicker effect[6] to increase conspicuousness (Martin and Banks 2023).

4.3. Patterning

- The pattern should be either (i) alternating red-white-red-white bands from the blade tip to the base, with each band representing 25% of the blade's length (**Figure 1**) or (ii) three quarters (¾) of the blade painted solid red (**Figures 2**).

- A striped patterning design (like Hopefield) and a solid pattern (like Smøla) may give different results, but both are acceptable designs.

- While no field tests of thermal load have been undertaken, a patterned design, as opposed to a solid design, may reduce any differential heating of the blade (because the white sections will reflect light). Thus, wind farms in hot environments might prefer a pattern to a solid colour.

- Alternative approaches to blade patterning that do not align with the above guidance are not recommended as suitable avian mitigation. For example, simply painting turbine blades with a colour other than those stipulated above, especially just the tips, is not recommended.

Similarly, all three blades should not be patterned identically; this approach is unlikely to break up motion smear and does not guarantee that birds will see and avoid them. "Aviation Stripes" used on some turbines, for example, in China, were not designed to be more visible to birds. They are designed to warn pilots of distances to the closest airports or to warn pilots of nearby wind farms. These are not recommended for bird mitigation (**see Figure 4**).

- Applying a narrow strip on the leading edge of turbine blades un-patterned (i.e. white) for Leading Edge Protection (LEP) is sometimes unavoidable and required by the manufacturer. This is not expected to reduce the effectiveness of blade patterning, provided it does not exceed 1-2% of the blade width.

4.4. Number of patterned turbines within the wind farm

The number of turbines patterned within the wind farm can be approached in two ways:

- Some turbines can be left un-patterned to act as controls as part of a nation-wide experiment to test the effectiveness of blade-patterning for different species in different environments (without controls, background fatality rates are difficult to determine), or

- All turbines can be patterned to minimise conservation concerns. This approach is unlikely to contribute to any experimental verification (because of the lack of control turbines), but it may be necessary where the wind farm occurs near particularly sensitive sites.

VISUAL ILLUSTRATION OF BLADE PATTERNING

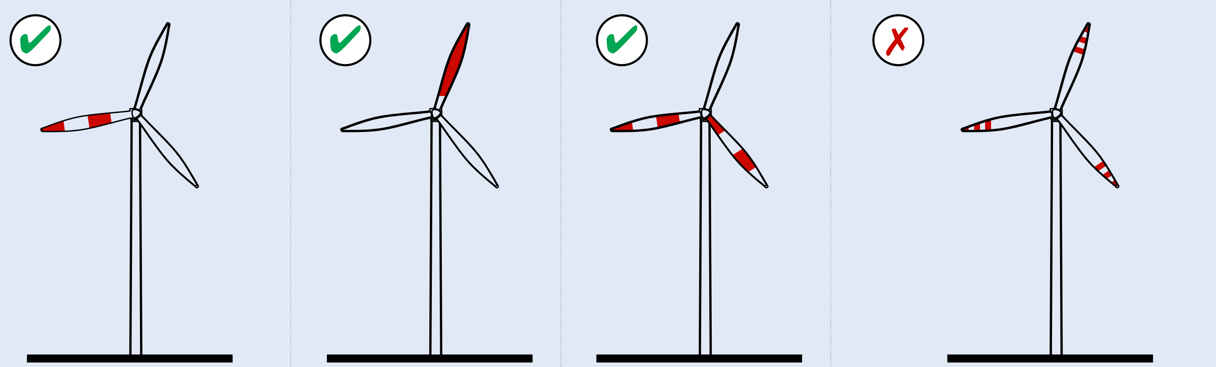

FIGURE 1 – Alternating red-white-red-white bands from the blade tip to the base, with each band representing 25% of the blade's length are acceptable.

FIGURE 2 – Red paint covering two-thirds of an entire blade in a solid design, as shown, is also an acceptable pattern.

FIGURE 3 – Two blades patterned in an asymmetrical fashion are acceptable.

FIGURE 4 – Aviation stripes on blades cover ~20% of the surface and are not recommended as an avian mitigation. They have not been tested on birds and are unlikely to disrupt "motion smear" as the pattern occurs on all three blades

[4] Based on the approved AMoC application which was submitted by SAWEA in terms of Civil Aviation Regulation (CAR) 11.04.6, read with CAR 11.04.2 and 11.04.3, for turbine blades at wind farms not conforming strictly with CATS 139.01.30 (3) (b). [5] As the colour 'red' aligns with colours referenced within the CAA regulations and AMoC approval, and that 'red' provides enough of a contrast from white to be visible to birds, this guidance note speaks only to the use of the colour red. Other colours, which may be deemed acceptable from an avifaunal perspective, such as black, would be subject to a separate application for AMoC with the SACAA. [6] Not to be confused with 'shadow flicker' which is the repetitive casting of shadows from turbine blades as they pass between the line of sight between a receiver and the sun.

4.4.1. Experimentation

Because only two field tests have been undertaken utilising patterned blade mitigation (one in Norway: May et al. 2020, and one in South Africa: Birds & Bats Unlimited 2024), BirdLife South Africa and BARESG encourages IPPs to help test blade patterning for effectiveness as a mitigation in different environments. To this end, half turbines in medium to low risk areas (or for operational farms, high fatality turbines) should be patterned, and the other half left un-patterned as controls. The same approach should be applied to low-risk areas (or low fatality turbines) with half to be patterned, and half as controls.

It is for the appointed SACNASP registered Avifaunal Specialist (in consultation with a recognised statistician, if required) to advise on the experimental/statistical design for a programme of blade patterning and associated carcass monitoring at the wind farm. Taking account of all relevant site, species and project specific factors, appropriate statistical tests must be applied to the fatality results to evaluate the effectiveness of the mitigation over a 24-month period. This experimentation may involve different (but appropriate) patterning designs applied to single and/or multiple blades as, detailed above.

4.4.2. All turbines patterned

In cases where wind farms are planned or operational near high-risk areas for threatened species, BirdLife South Africa and BARESG do not recommend the experimental approach. High risk areas are defined for some species by specific guidelines (e.g. Pfeifer and Ralston-Paton 2018, Simmons et al. 2020, Ralston-Paton and Murgatroyd 2021), VERA modelling (Murgatroyd et al. 2020) or Flight Risk/Collision Risk Modelling (Colyn and Froneman 2023). Wherever roosts, breeding colonies, or other sensitive areas for red data birds occur within the home range of that species, all blades should be patterned. Killing such species at control turbines is not acceptable and will incur future costs for additional tiers of mitigation. In these cases, BirdLife South Africa and BARESG suggest that all turbines should be patterned for conservation purposes. However, avoidance of High-Risk areas should first be prioritised and blade patterning should be complemented with additional mitigation until blade patterning as a stand-alone mitigation has been proven to be effective.

5. CONCLUSION

The methods presented above provide a simple yet robust set of guidelines to standardise appropriate blade patterns, colour, and number of patterned turbines within South African wind farms, based on the available science and existing approvals with regard to the AMoC.

It is for the appointed SACNASP registered Avifaunal Specialist, taking full responsibility for the careful consideration of these guidelines, to determine the appropriate mitigation for the applicable site, and to avoid inappropriate actions that could undermine the concept and potential of this promising mitigation measure.

This document should be appended to the avian specialist's letter of endorsement which needs to accompany all final designs of the alternative markings submitted to the SACAA for the final design approval as per condition 5.1 of the AMoC.

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