

Alternative methods to mitigate wind turbine collisions for vultures and other soaring birds

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Introduction

The fast pace of development within the wind power industry continues to grow, with numerous major developments in the late stages of planning or already underway (Windustry 2015). The ongoing problem of bird mortalities associated with wind turbine collisions can thus be expected to increase, particularly in situations where development permission has already been granted in sensitive areas. Whilst a number of mitigation methods and new turbine designs are currently available there are a number of drawbacks related to their efficiency of operation or timely implementation (Desholm 2003, Duchamp 2014, Kelly & Fielder 2008, May *et al.* 2012, May *et al.* 2015). A review by May *et al.* (2015) on 26 different post-

construction measures currently available to reduce bird mortality at wind farms suggests that those directly altering turbine speed or effecting temporary shutdowns may prove to be most effective. Approaches that aim to alter bird behaviour, including those that provide visual and sound based cues, may also prove to be effective to some degree (May *et al.* 2015). However increasing the attractiveness of areas surrounding a wind farm may well be the preferred option to draw bird species away from turbines (Goodwin 2013, Martin *et.al* 2012, May *et al.* 2015).

Considerations

It is widely known that bird flight is strongly related to meteorological conditions, and flight patterns have long been used to gather qualitative

information in this regard (Treep *et al.* 2016, Woodcock 1940). Wind farms are often situated on mountain ridges or hillsides in order to make optimal use of prevailing winds. Soaring birds such as vultures are attracted to these areas in search of orographic updrafts, which they utilise by circle soaring, straight-line soaring or lee wave soaring (Bildstein 2006, Goodwin 2013). Within their southern African range, Bearded Vultures *Gypaetus barbatus meridionalis* actively select ridge tops and upper slopes and predominantly fly at a height that places them at a high risk of collision with turbines. A similar situation exists with the Cape Vulture *Gyps coprotheres* (Rushworth & Krüger 2014).

Research suggests that wind farms also have the potential to significantly affect near-surface air temperatures (Baidya Roy & Traiteur 2010). In addition, turbulent eddies generated in the wake of the rotors enhance vertical mixing of air, significantly affecting the vertical distribution of temperature and humidity as well as surface sensible and latent heat fluxes (Baidya Roy *et al.* 2004). Under natural conditions, thermal eddies are generated by differential heating of the ground resulting from the upward flow of

warm air and downward flow of cool air (Koch 2006). Soaring birds take advantage of the energy in buoyant warm air within thermals to gain and maintain altitude whilst expending minimal energy. They then use the potential energy to glide to the next thermal (Bildstein 2006, Koch 2006, Rüppell 1977, Van Loon *et al.* 2011). It has widely been recognised that vultures are attracted to thermal activity, and the potential of using 3D location data from Eurasian Griffons *Gyps fulvus* for estimating wind velocity as well as the strength of thermally driven uplift has recently been explored by meteorologists (Treep *et al.* 2016). Tandem flight behavior in Cape Vultures appears to be more prevalent on days with high thermal or orographic wind activity (Goodwin 2005). As eddies produced by turbine blades closely resemble those within natural thermals they thus have the potential to attract vultures and other soaring birds, particularly on days of reduced thermal activity (Goodwin 2013).

Turbines traditionally employed for commercial power production are commonly in the 2 MW range and the full installation cost is in the region of US \$3 - \$4 million per turbine (Windustry 2015). For most wind farm projects, current business

models and budgets have been based on the average twenty year life span of the standard wind turbine models currently available. In addition each subsequent generation of turbines (based on improvements to these standard designs) has incurred lower repair and maintenance costs, making their ongoing use an attractive option (Wind measurement International 2017). Alternative turbine designs such as Vortex Bladeless[®] incorporate a vertical bladeless cylinder, which oscillates or vibrates. This configuration offers a promising alternative, being environmentally friendly as well as providing substantial savings in manufacturing and operating costs compared to conventional wind turbines (Vortex Bladeless 2015). However, as with any new technology, these are not without their drawbacks, including concerns related to the design and efficiency of power production (McKenna 2015). As such, these alternatives may take some time to gain popularity within the industry, which suggests that the phasing out of conventional risk-prone technology would be a lengthy process of at least twenty years in many cases.

Whilst there are a number of technical options available for collision mitigation in standard

design turbines including avian radar systems and other video based detection systems, all experience some drawbacks. These may include relatively high installation and operational costs, modification to existing structures and control interfaces (with possible warranty implications) as well as poor reliability related to exposure to the elements and difficulty in the identification of species involved (Desholm 2003, Duchamp 2014, Kelly & Fielder 2008, May *et al.* 2012). Implementation of these systems often entails abrupt braking of wind turbines, which results in costly wear and tear to braking systems and other turbine components, as well as having a negative effect on electricity production, which could be considered impractical and counterproductive. Indeed, it has been implied that their only practical use is to assist developers in obtaining planning approval for wind turbines in potentially sensitive habitats (Duchamp 2014). Various painting trials have also been conducted on turbine blades in order to enhance visibility to birds, although few have proven to be completely effective (Nazzaro 2006). A specific evaluation of the DTBird[®] video-system at the Smøla wind-

power plant in Norway revealed that in White-tailed Eagles *Haliaeetus albicilla* a great deal of flights detected in the area were within the rotor-swept zone. Most of these were direct flights, although a significant number of soaring and circling flights were detected. However the reliability of the system was questionable, with considerable downtime recorded for one of the units employed for the study (May *et al.* 2012).

The southern African population of the Bearded Vulture and Cape Vulture in the Maloti-Drakensberg range are at significant risk associated with proposed wind-farm developments (Rushworth & Krüger 2014). The use of GPS tagging and subsequent spatial analyses of Bearded Vulture movements in the Lesotho highlands and Drakensburg escarpment in southern Africa has suggested poor positioning of two proposed wind farms and that the location of one of these should be reconsidered to reduce the impact on this species (Reid *et al.* 2015). Thus, if developers and authorities cannot be persuaded to site wind farms in areas of reduced potential impact to these birds, then novel or alternative methods for mitigation will be required. Since increasing the attractiveness of areas surrounding a

wind farm may be the preferred option to draw soaring birds away from turbines, alternative physical applications should be explored in this regard.

Alternative Mitigation Methods

Asphalt pavement surface temperatures may reach up to 70 °C in summer, creating a rise in temperature of the air above. This is commonly referred to as the ‘heat island effect’ (Bobes-Jesus *et al.* 2012). The temperature profile in asphaltic paving is affected directly by the thermal environmental conditions to which it is exposed. The primary modes of heat transfer are incident solar radiation, thermal and long-wave radiation between the pavement surface and the sky as well as heat transfer between the pavement and air in direct contact with the surface. The direction of the heat transfer is upward from the pavement as deep sky temperatures typically are significantly lower than pavement surface temperatures (Yavuzturk *et al.* 2005). A possible mitigation method could thus be to exploit this effect via the provision of extensive asphalt paved areas at a suitable distance adjacent to relevant wind farm developments. Rising heat from these areas would provide

alternative thermal lift to attract vultures (and other soaring birds) away from impact zones. These inert asphalt surfaces may negate the need for any interference with daily turbine operations and could possibly also double as lay-down storage or parking areas. As a variation on the theme above, solar panels could be installed adjacent to wind farm developments to provide this alternative thermal lift for soaring birds. Solar photovoltaic panels are mainly dark in colour with very low albedo and high emissivity, typically absorbing about 85% of the incoming light, of which 15% is converted into electricity, whilst the remaining 70% of the energy is converted into heat (Golden *et al.* 2007). Due to this, the possible installation of photovoltaic arrays could prove to be a viable alternative, as this would provide additional electrical generation capacity along with rising hot air and thermals, which would also negate the need for interference with normal turbine operation. However, these possible alternatives would bring their own disadvantages, including additional power infrastructure for solar photovoltaic installations, which would need to be positioned and routed appropriately. Similarly, additional infrastructure can cause

localised reduction of natural ground cover, which would reduce suitable habitat and foraging areas for both birds and other animals present in that area. Monitoring potential effects of such installations might become possible in the near future in rural Australia, where an estimated 1000 MW of potential opportunities to add solar installations alongside existing wind farms has already been identified. This capacity is expected to double by 2020 (ARENA 2016). Observations on the behaviour of the Wedge-tailed eagle *Aquila audax* in these areas may prove useful in the assessing the suggested alternative methods discussed above.

Conclusion

The potential risk posed to vultures and other soaring birds by existing and proposed wind farm developments may remain for the foreseeable future. Whilst the most suitable methods of mitigation remain the initial location of potential developments to less sensitive sites, and the use of more ‘eco-friendly’ turbine technology, mitigation at existing sites, or developments in the late stages of planning may require some novel thinking.

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