DOCKETED

Docket Number:	09-AFC-07C
Project Title:	Palen Solar Power Project - Compliance
TN #:	201838
Document Title:	Palen Solar Holdings, LLC's Review of Potential Bird Deterrent Strategies for Large Scale Solar Facilities
Description:	N/A
Filer:	Marie Fleming
Organization:	Galati | Blek LLP
Submitter Role:	Applicant Representative
Submission Date:	3/7/2014 8:48:10 AM
Docketed Date:	3/7/2014

REPORT
Review of Potential Bird Deterrent Strategies for Large Scale Solar Facilities

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March 6, 2014

TABLE OF CONTENTS

Introduction

Many methods exist for deterring birds from a specific location. Selection of methods is based on the targeted bird species, cost, effectiveness, potential for habituation, the amount of automation and required maintenance, how proven the technology is, and how applicable it is for a large scale solar facility. Generally, deterrents are used to startle and disperse birds by representing danger such as a predator, evidence of a predator attack, or some novel item that is unfamiliar to the bird. Deterrents may be visual, auditory, physically irritating, or involve active pursuit. Methods to detect incoming birds also vary, ranging from human observers to sophisticated radar systems paired with automated deterrent devices. Here we review a range of deterrence and detection methods and their applicability to solar facilities, but focus on thermal power systems.

Mortality Concern

Avian and bat mortality concerns at the solar thermal facilities are associated with collision with structures such as the heliostats, fences, towers, and overhead lines, as well as potential mortality due to passage through the solar flux area near the tower. Deterrent methods to employ would depend on the type of facility component (tower compared to heliostat).

Visual Deterrents

Several visual deterrents are used to prevent birds from landing in an area. They may be especially useful for deterring birds from near the heliostats.

Balloons

Helium-filled balloons painted with big eye spots and tethered to stationary places are simple deterrents. Effectiveness was found to vary by species (Bishop et al. 2003). For example, European starlings and house sparrows were effectively deterred while American robins and species of orioles, oystercatchers, and waterfowl were not affected. Balloons may be an effective low-cost, short-term strategy because they are easy to deploy and move, but birds may habituate to them. Balloons may deflate with time, deteriorate in sunlight, are easily damaged (e.g., strong winds), and tethers will need to be checked regularly (Bishop et al. 2003). If winds pushed a balloon into the solar flux it may burst.

Balloon-aided and Tethered Kites

A tethered balloon can be modified with the attachment of a kite below the balloon. This creates a predator-like appearance and can create wind-induced noises that deter smaller birds likely to avoid raptors. Kites can be designed to look like actual birds of prey (e.g. Birdbusters 2012). Effectiveness is site- and product-specific and similar to that of balloons, above. Large birds such as hawks and eagles likely will not be deterred and may attempt to attack the kite, especially if it looks like a raptor. Kites may also be deployed without a helium balloon by tethering them to a pole. These kites work best in strong or variable winds.

Enhanced Effigies/Scarecrows

Birds are known to respond to life-size models of humans and scarecrows. These are generally inexpensive and are most effective when they are frequently relocated due to habituation by targeted birds (Bishop et al. 2003). Some success has been shown with pop-up models and those that show motion, particularly when accompanied by startling sounds. Crows, vultures, and some waterfowl have been deterred with auditory and motion-enhanced effigies (Beland and Martin 2011).

Eagle Eye

The Eagle Eye is an eight-inch tall pyramid-shaped structure covered in reflective materials that spins via a battery- or solar-operated motor atop a pole or other structure (Birdbusters 2012). It reflects constantly-changing beams from sunlight in a pattern that startles and disorients birds. The beams are roughly 150 feet long (WCS 2013). The reflective surface needs to be cleaned regularly as airborne particles dull the surface, reducing its reflectivity (Bird Barrier ® 2014).The constant flashes of light could visually impair low-flying aircraft near the project area and annoy nearby people (Bird Barrier® 2014), but this may not be of concern for a remotely-placed project. The effectiveness of mirrors and reflectors as a bird scaring technique is variable (Bishop et al. 2003), and is best suited for near-flying birds, so strategic placement would be important for large solar arrays.

Lasers

Lasers are used to deter birds in low light conditions (e.g., at night), especially to flush birds from roosting sites. They work well with large flocks of birds, especially when combined with sound (Barry Clark, pers. comm.). The effectiveness can be maximized by selecting the proper light color/wave form and targeting species most likely to be influenced. Researchers obtained a 90% reduction in roost use by double-crested cormorant (Glahn et al. 2000) while deterrence only lasted up to 20 minutes for rock pigeons, mallards, and American crows in other studies. European starlings and brown-headed cowbirds were not dispersed with lasers (Beland and Martin 2011). Lasers were used to effectively disperse several thousand gulls roosting on lakes close to a military airfield in England (Baxter 2007). Because lasers are only efficient under low-light conditions, they would have little utility for dispersing birds during the day (e.g., raptors and whooping cranes). Lasers could also be used to activate other bird-scaring devices: for example, if a bird broke the laser beam by flying through it, this could trigger the deterrent, functioning as a virtual fence (Gilsdorf et al. 2011; Jachowski et al. 2013).

Lights

Lights such as strobe, barricade, and revolving units have shown some results in scaring birds. Migrating birds were found to react to searchlight beams at distances of 200–300 meters (m). Pulsing white and wavelength-specific aircraft-mounted light was tested during daylight conditions on captive brown-head cowbirds, Canada geese, European starlings, herring gulls

(*Larus argentatus*), and mourning doves (*Zenaida macroura*; Beland and Martin 2011). Cowbirds were the only species that exhibited a response to the landing lights, but responses were sporadic. A floating solar-powered rotating beacon reduced the number of ducks visiting a sewage pond at night by 90%. Lights are easy to deploy and require little maintenance, and are most effective at night. Their ability to scare birds at night varies by species. Therefore, lights are best used with other deterrent methods (Bishop et al. 2003). In a review of literature, Clarke (2004) found that a directional strobe light was the best deterrent in terms of cost and effectiveness.

UV Light-reflective Paint

Results of a study indicated that there was no difference in bird use, mortality, or risk between turbine blades of wind turbines painted with a UV-light reflective gel-coat and those painted with conventional paint, although the noncontrolled experimental design limited statistical inferences (Young et al. 2003). The opportunity exists at solar facilities to further research on the effectiveness of UV light-reflective paint on deterring birds, especially if a proper experimental design is used, such as a before-after-control-impact design (Morrison et al. 2008).

Auditory Deterrents

The intent of auditory deterrents is to create a loud, startling sound and evoke reactions in birds similar to avoidance of predators, defended territories, and unknown dangers.

Air Cannons and Pyrotechnics

A modern exploder, resembling a small cannon, consists of a bottled gas supply, separate pressure and combustion chambers, an igniting mechanism, and a barrel to direct and intensify the noise of the explosion (Beland and Martin 2011). Blackbirds, waterfowl, cormorants, and gulls have been deterred with air cannons at cropfields and landfills (Harris and Davis 1998, Bishop et al. 2003). To alleviate habituation, exploders should be moved every 1 to 3 days. For species that avoid humans (e.g., waterfowl), effectiveness may be enhanced by use with a CO2 driven pop-up scarecrow (Beland and Martin 2011). Strategic placement is important, as effective coverage of four to 24 acres has been reported (Harris and Davis 1998). Project owners will want to be cognizant of placement to limit nuisance impacts to sensitive off-site and non-target noise receptors (sound level reported at 130 decibels; [Bishop et al. 2003]). Pyrotechnics are similar to air cannons but also include a visual stimulus such as a flash of light or burst of smoke. They have long been used to effectively deter birds, including raptors, in a variety of situations (e.g., GDNR 2001).

Distress Signal Call Systems

Birds respond to the distress calls of other birds and predatory species by leaving the area. Audio bird deterrents mimic these calls which are species-specific, and the method is based on sound biological principles (Bishop et al. 2003). Birds are slow to habituate, as their response is ingrained. Distress calls may be most effective against flocking species. Bird types shown to be effectively deterred include black-crowned night herons, corvids, gulls, and waterbirds (Beland

and Martin 2011, Bishop et al. 2003). These deterrents could be used in conjunction with other devices such as radar, unmanned aircraft, and a long range acoustic device (see below). Broadcasts should have adequate signal strength and clarity to effectively mimic the real sound (Bishop et al. 2003).

UltraSonics

This product is designed to produce sounds for animals with hearing ranges above 20 kilohertz. Evidence shows that ultrasonic devices do not deter birds and that birds do not hear in the ultrasonic range (Erickson et al. 1992). Therefore, this is not a viable option for birds, but might be considered for deterring bats.

Active Pursuit

Dogs

Trained dogs may be used to flush birds away from the project area near the ground. Dogs have been successfully used at airports, golf courses, and agricultural lands (Bishop et al. 2003). One dog and trainer can deter birds from about 50 km^2. Birds are not likely to habituate to dogs. Birds that naturally occur close to the ground, such as waterbirds and waterfowl, have been effectively deterred by dogs in previous efforts, but birds that spend much of their time flying, such as raptors and passerines, may not be dissuaded by canine pursuit.

Falconry

Abatement falconry involves a falcon and trainer that haze birds that fly close to the project site. Falconry has been used to deter birds at berry fields, airfields, and landfills, and birds are less likely to become habituated to falcons compared to other methods (Bishop et al. 2003). Falcons must be flown regularly to be effective, and use is restricted in poor weather conditions.

Unmanned Aircraft Systems (Drones)

Unmanned aircraft (UA), commonly known as drones, are remotely-piloted aircraft. The system includes UA and operator interface and is an emerging technology that can be used to manually and perhaps automatically deter birds. Birds habituate relatively slowly to UAs and effectiveness is improved if the UA looks like a raptor. However, at least one instance was recorded where an eagle attacked a UA (e.g., Carlson 2013). UAs have been used to deter Canada geese at parks (Aerial Perspective 2014). Training is necessary, and FAA regulations allow a recreational exception for use of UAs under 400 feet and within visual/radio sight of operator (Watts et al. 2010).

Detect and Deter Systems

Researchers are developing two-part systems that can detect individual or groups of birds using radar or cameras and then direct deterrents (e.g., cannons, distress calls, and lasers) directly at the detected birds. Although these systems may be more costly than simpler methods, they may be more effective because habituation is less likely and interactions may result in a form of aversive conditioning (Ronconi and St. Clair 2006). Biologists or monitors could also be used to detect at-risk birds. Radar detection systems have an advantage over human observers when species or taxonomic group identification is not critical, and radar has a greater range than human-based observers and can detect birds at night. Radar detection systems were found to be significantly effective for ducks and geese; more than 90% of detections were of target species (waterfowl and ducks confirmed with visual sightings; Ronconi and St. Clair 2006). Stevens et al. (2000) found that detect and deter systems were successful with waterfowl at power plant ponds in Wyoming and that flight direction, altitude, and likelihood of landing were different between trial and control ponds. These systems can be relatively expensive and may have long term high maintenance costs. However, research, refinement of methods, and experimentation is necessary for improving on the ability of the detection systems to be selective in target identification (e.g., targeting a specific bird group or size of bird).

Detect systems alone can quantify the level of activity and may be useful in documenting bird behaviors such as avoidance relative to facility components. Radar and other remote sensing techniques for directing management actions are currently in their infancy of development and more work is needed to make the systems practical. We discuss some of the complete systems that have been used and marketed as Detect and Deter systems.

Three main types of radar antenna are typically used for wildlife applications, each defined by the microwave frequency band of the electromagnetic spectrum that they occupy: X-band (8 to 12 GHz), S-band (2 to 4 GHz), and L-band (1 to 2 GHz; Larkin 2005). X-band antennas are the most common system used in radar ornithology, largely because their short wavelength (2.4 – 3.75 cm) provides the highest resolution, a benefit for detecting small targets. Disadvantages of the X-band antenna are its relatively small detection radius (usually 1.5 km for bird studies), and it is the most susceptible radar antenna to clutter by insects due to its high resolution. DeTect typically employs an S-band antenna for continuous horizontal surveillance, paired with an X-band antenna positioned vertically to continuously capture flight heights. The longer wavelength of the S-band antenna (7.5 – 15 cm) provides a greater range (usually 11 km for bird studies) and is less likely to detect insects. However, it may also miss some small birds (e.g., passerines) depending on the range and settings. SRC is the only company to use an L-band antenna, which has the longest wavelength (15 -30 cm), and therefore has the greatest detection range (18 km for bird studies) and least spatial resolution of the three systems. SRC states that their BSTAR system can detect objects as small as a crow, so this system may be most applicable for studies focusing on larger birds, such as waterfowl, waterbirds, and most raptors. Due to its long wavelength, the L-band antenna does not detect insects or rain, making it one of the only system that can operate very successfully during precipitation.

These next sections specifically discuss some companies and systems that are available on the market and briefly describes information on what is known about the effectiveness of each.

Bird Avert

BirdAvert™ (Peregrine Systems 2014) is an on-demand radar-activated system comprising a marine radar (Furuno 1942 Mark 2, 1-2 m antenna, 4 kW output, 9•410 GHz, X-band) linked to a computer station which then activates deterrents (cannons or human effigies) via radio signals. This associated software allows the system to be customized to target a specifically-sized bird and direction, which may be useful for periods of migration. BirdAvert was found to be effective at deterring waterfowl from landing on oil sands tailings ponds, and cannons were a better deterrent than human effigies and simulated peregrine falcon calls (Ronconi and St. Clair 2006).

BSTAR

The BSTAR Avian Surveillance and Warning System uses an L-band antenna and is a 360-degree, all-weather (including during rain) detection and tracking device designed to operate from a single stationary radar station with no moving parts (Ryan 2011). BSTAR's ability to detect biomass (size) of birds and its low susceptibility to insect clutter is emphasized. It can be combined with deterrent devices such as air cannons, effigies, and lasers. It is promoted for use at airports and military installations and is currently being evaluated for use at the Dallas Fort Worth International Airport, but results have not been made public (Ryan 2011). It is designed to classify low-flying, slow moving birds, while suppressing stationary clutter (SRC Inc. 2014), which may be useful for differentiating infrastructure like heliostats. The customizable BSTAR software is designed to display the distance of moving birds on a three-dimensional map and to provide automated reports. An optional thermal/visual camera can be integrated with BSTAR to allow the human operator to observe and potentially identify targets, perhaps decreasing the number of false alarms.

Furuno Model Radar

The Furuno Model Radar system (model FR8100D; X-band) was used to detect in-coming birds at contaminated ponds in Wyoming and trigger a series of deterrents to prevent landing. (Stevens et al. 2000). Deterrents included bird distress calls, pyrotechnics, and chemical repellents dispersed as a form of bird tear gas. The chemical repellents were used only if the audio methods failed to prevent birds from approaching. The number of mortalities (mostly waterfowl) on the ponds was reduced by 77–86% relative to the average number of mortalities in the 3 previous years when no deterrents were deployed. Some evidence was found that flight paths of birds were altered, habituation was avoided, and this method was not considered to be labor-intensive.

Long Range Acoustic Device (LRAD) and Merlin

The long range acoustic device (LRAD) was developed as a distance hailing and crowd control device and is a powerfully focused beam system that can direct deterrent sound in narrow beams (~30°, up to 140 decibels) towards bird targets (Matkovich et al. 2010). LRAD can have an effect on birds out to 1 km (Kelly 2009). DeFusco (2007) describes use of an LRAD paired with radar to deter birds, including raptors and blackbirds, at a waste management facility, but results of the study were not presented. DeTect (2012) states that they have pioneered the use of the LRAD technology for bird control as both a manually directed control device and auto-actuated device with the MERLIN radar system. The MERLIN system is fully automated, and typically uses an S-band antenna for surveillance paired with an X-band antenna mounted vertically to capture flight altitude data. At a tailings pond LRAD deterrents were successfully activated by the radar tracking system 95.5% of the time, and 76% of the birds were successfully deterred from landing on the pond. Birds groups deterred by the system included gulls, shorebirds, waterfowl, loons, terns and herons (Matkovich et al. 2010). The MERLIN system can also be used with bird distress calls, lasers, and conventional devices (propane cannons, bioacoustics, and effigies; DeTect 2012).

DTBIRD, Adaptive Conservation Technology (ACT) and BirdsVision

The Adaptive Conservation Technology (ACT) system developed by Volacom® (2014) uses thermal imaging to detect and identify incoming birds and pulsed and direction high decibel sound to deter birds. We are unable to locate any data on the actual use of ACT but are aware of some tests being considered. BirdsVision (2011) is another group that has developed a bird detect and deter system, and has shown effectiveness of deterring waterbirds from nesting on transmission towers in Delaware. DTBIRD is another company that has developed integrated detect and deterrence systems using cameras and sound. Based on information presented by Birdsvision and DTBIRD, their system provides an automatic stand-alone device that detects, identifies and deters birds at sensitive areas, at all weather, day and night (day only for DTBIRD), all year round.

Bird Strike Defense Robot

Scientists in South Korea have developed a detect-and-deter system for airports that uses an unmanned ground vehicle (UGV) as its platform (Falconer 2012). Similar to unmanned aircraft, this device is mobile and able to move towards birds and remotely-controlled by a human. It can also autonomously return to locations. Up to four UGV's can be controlled from one station. The UGV is used to detect birds with telescopic and thermal imaging cameras and is outfitted with multiple bird deterrent devices including lasers and directional acoustic wave transmitters (Kim et al. 2011).

Other Types

Irritant Fogging

A fine mist containing a bird repellent such as methyl anthranilate (MA; a compound considered non-toxic to humans and also known as synthetic grape flavoring) can be sprayed to repel birds, similar to tear gas use on human crowds (Engeman et al. 2002). It is an irritant to the mucus membranes when inhaled by birds (Vogt 2001); the fog disperses quickly and effectiveness is dependent on droplet size and bird breathing rate. Birds do not seem to habituate to MA. MA aerosol was highly effective at deterring low-flying swallows and killdeer from an airfield in Florida (Engeman et al. 2002). Birds that respond to MA fog include European starlings, common grackles, blackbirds, cowbirds, gulls, Canada geese, and mallards from locations such as electrical substations, structures and buildings, airports, golf courses, parks, and around lakes (Engeman et al. 2002, Natural Forces 2009). Droplet size should be monitored as wet applications may harm vegetation (Natural Forces 2006).

Magnetism

It is widely thought that birds use the earth's magnetic field as a compass to assist navigation during migration (Wiltschko and Wiltschko 2005). Some research has been conducted on the disruption of magnetic orientation in birds (Wiltschko et al. 2007). Future research on this untested hypothesis could be to test the ability of this phenomenon to deter birds by creating a magnetic field around a specific area to encourage them to fly in a different direction.

Conclusions

Several systems and methods have been developed to deter birds from areas. Due to habituation by birds and typically wide coverage of solar projects, more than one deterrent strategy may be necessary for a solar thermal power system. Visual and auditory deterrents may be useful to deter landing waterfowl and waterbirds, while the more-sophisticated radar-based detect and deter systems may be better at dissuading flying birds such as raptors from passing through areas of very high solar flux.

Timing of deterrents used to repel, haze, and frighten birds influences effectiveness. To combat habituation and re-occurring presence of birds, any deterrent action should be highly responsive and immediate to the extent possible. For example, a cannon firing repeatedly without any variation in timing or direction quickly loses its potential to scare birds (Bishop et al. 2003). Random or animal-activated devices may reduce habituation and increase the time of protection over nonrandom (i.e., systematic) devices.

The effectiveness of any technique varies with the bird species and habituation will eventually occur with any scaring technique that is not reinforced by a demonstration of actual danger. Constantly changing the appearance and location of a scaring device should help to prevent rapid habituation. An effective bird control program with existing devices should involve the use of several techniques in a random fashion.

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