SOCIEDAD ESPAÑOLA DE ORNITOLOGIA

Effects of wind turbine power plants on the avifauna in the Campo de Gibraltar region

Summary of final report

EFFECTS OF WIND TURBINE POWER PLANTS ON THE AVIFAUNA IN THE CAMPO DE GIBRALTAR REGION

SUMMARY OF FINAL REPORT

This project has been carried out under contract between the Environmental Agency of the Regional Government of Andalusia and the Spanish Ornithological Society (SEO/BirdLife)

This summary is based on the Final Report of the study presented to the Environmental Agency on 7 July 1995

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1. INTRODUCTION

In the past years, the development of several windfarm facilities for the industrial exploitation of wind power in the south of the province of Cadiz and the impact of this exploitation on the conservation of the exceptional natural values of the region, has raised great controversy among the Regional Government, electric companies, environmental associations and conservation agencies, as well as with the media and other social groups.

The possible impact on the avian population, within an area of international importance for birds, was from the start one of the main conflicts that stood between this renewable energy and the conservation of nature. However, conservationists also pointed out the cause for alarm of the possible effect on other natural values of the region.

On the other hand, the fact that the majority of these windfarms had been built within the Natural Park of Los Alcornocales, also declared as Special Protection Area for birds, without objectively considering the possible negative impacts of this clean energy, intensified the polemic and even lead several conservation agencies to file numerous administrative and penal charges, along with a complaint to the Environmental Agencies of the European Commission.

Under these circumstances, the Regional Government of Andalusia supported, in 1993, a study regarding the effect of wind turbine structures on the avian population. Almost simultaneously the City Council of Tarifa and the Regional Government of Andalusia financially supported a Special Management Plan of the Wind Power Plants of Tarifa.

The results of both studies would provide the Regional Government with information to establish the basis for a more rational regulation of the future exploitation of this renewable energy, highly necessary, reducing to a minimum the possible negative effects on the avifauna, though a closer study of the impact on other natural values of the area would also be considered as necessary. Though these projects were to be, from the start, complementary in many aspects, different problems have put a stop to them due to the fact that the Special Plan has been discontinued.

This paper is an extensive summary of the Final Report of the study "Effect of Wind Turbine Power Plants on the Avifauna in the Campo de Gibraltar Region" conducted by the Spanish Ornithological Society (SEO/BirdLife) and financially supported by the Environmental Agency of the Regional Government of Andalusia which assigned a budget of 5,750,000 Pts. (about 48,000 US Dollars) to this project. The Final Report was completed in early June 1995. It is necessary to point out that, due to the available resources, the study is based exclusively on breeding and medium to large soaring birds and most specifically on the migratory species of the area. It has not been possible to evaluate the probable impact on small species nor to analyse to a great degree, certain aspects of the problem.

This study is the first related to this subject, to be carried out in Spain under an accurate and detailed framework, which on another hand has been thoroughly studied in the Unites States and several European countries; and could serve to establish the guidelines for similar surveys in other Spanish regions.

2. WIND ENERGY IN THE CAMPO DE GIBRALTAR REGION: PRESENT SITUA TION AND SHORT TERM PROJECTS

In accordance with the National Wind Map, the area of the Strait of Gibraltar has a highly important wind potential along with Galicia, the Ebro Valley, Cataluna and the Canary Islands. Regarding the industrial exploitation of this energy, the first experimental wind farm of the region was installed in the Municipal District of Tarifa, a nationally fabricated prototype with a power of lOO K w , presently removed. Since then, a total of five windfarms have been developed in the above-mentioned municipal district (although one of these, a smaller one, is situated within another larger one). Presently there are a total of 268 wind turbines operating, with six different turbine types, that represent an installed power of 30 Mw, and form the largest wind turbine development in Europe (summing up the data from KW T ARIF A, there are 373 wind turbines with a total of 69,54 Mw). The following paragraphs briefly describe the different windfarms of the area that are presently operating:

Parque Eólico de Tarifa ***(Ta rifa Windfarm):*** Located near the N-340 road (km 88), two kilometers from Tarifa and outside of the Natural Park of Los Alcornocales, began operating in May 1988 and has 3 turbines ECOTECNIA 12/30 (30 Kw), 1 ECOTECNIA 20/150 (150 Kw) and 1 ECOTECNIA 20/200 (200 Kw), with a power of 440 Kw. Property ofENDESA - IDAE. It is an experimental windfarm with no power lines. It has undergone transformations since its opening. At first it had 10 turbines ECOTECNIA 12/30. In 1989 and 1993 the present turbines started operating.

Parque Eólico de Monteahumada ***(Montea huma daWindfarm):*** Located in the Puerto de la Canada, in the Natural Park, and inaugurated in 1989. Presently has 7 turbines MADE AE-20 (150 Kw) which deliver 1050 Kw ofpower. Property ofENDESA, an experimental windfarm (with no power lines) which at first had vertical axis turbine types that were later removed. Also, three turbines MADE AE-30 with 300 Kw each, have been constructed and are presently being tested.

Parque Eólico del Sur ***(PESUR Windfarm):*** Located in the Paraje de Los Zorrillos, in the Natural Park, started operating on 28 October 1992 and has 150 turbines AWP 56- lOO (lOO Kw), 34 turbines MADE AE - 20 (150 Kw) and 12 meteorological and lightning towers adjacent to the tutbine rows. It includes a power substation with overhead power lines of 17.6 km which connects to the main grid in a substation situated in Algeciras. The remaining power lines are

underground. It has an installed power of 20.1 Mw and is property of the Wind Society of Andalusia. Two turbines A WP 56 - 100 have been removed and substituted by a prototype of 300 K w that is presently under an experimental phase.

Parque Eólico de Levantera ***(Leva ntera Windfarm):*** Situated within PESUR, started operating in November 1992. Presently has 5 wind turbines AWP 56- lOO (lOO Kw) and 1 MADE AE -20 (150 Kw). The remaining structures are shared with PESUR and has an installed power of650 Kw. Property of the City Council of Tarifa.

Energía Eólica del Estrecho ***(E3 Windfarm):*** Located in the Sierra de Enmedio, in the Natural Park. Started to operate on 22 November 1992 and consists of 50 turbines ECOTECNIA 20/150 (150 Kw), 16 MADE AE - 23 (180 Kw) and 4 meteorological towers adjacent to turbine rows. It includes a power substation with overhead power lines of 6.7 Kms that connect with the substation in PESUR. The remaining power lines are underground. The installed power is of 10.4 Mw and it is property of the Wind Society of Andalusia.

Turbines in all the windfarms are aligned in rows and basically have a north-south orientation, in such a way that they are able to optimize the utilization of the dominant winds of the area. Also, the majority of the turbines are located on the crests of the mountains and hills, in order to benefit from the increase of wind speed due to the "slope effect". The useful winds for the turbines are those that blow with a speed that ranges from 5 to 24 meters/second.

The productive windfarms developments only have overhead power lines that run from the substation in E3 and connect with that of PESUR, to later connect with the main grid near Algeciras. The total length of the transmission lines is of 24.4 Kms.

Presently, a new windfarm facility, under the name "KW Tarifa" is being developed by KENETECH, in the Dehesa de la Ahumada, specifically in Cerro Gordo, Cerro de la Ahumada and Puerto Hondo, and foresees the installation of 90 wind turbines of 300 Kw each (it was officially opened in September 1995).

There are also other several projects which aim to expand some of the existing windfarms and also construct new facilities in other areas within the Municipal District of Tarifa:

- Cortijo de La Joya (PEE S.A.) 12 turbines of 500 Kw (NTK - 500/37)
- Cortijo La Cañada del Caballo (PEE S.A.) 10 turbines of 500 Kw (NTK - 500/41)
- Tahivilla (Sociedad Eó1ica de Andalucia) lOO turbines of300 Kw (A-300)
- Arroyo Viñas (Desarrollos Eolicos S.A.) 67 turbines of300 Kw (A-300)
- Ampliación de E3 (Sociedad Eólica de Andalucia) 30 turbines of 200 Kw (ECOTECNIA 24/200) and 12 of300 Kw (MADE 30/300)

- Puerto de Bolonia (Desarrollos Eólicos S.A.) 68 turbines of300 Kw (A-300)
- Sierra de Fates (Desarrollos Eólicos S.A.) 70 turbines of300 Kw (A-300)
- Puerto de Facinas (Desarrollos Eólicos S.A.) 30 turbines of300 Kw (A-300)
- El Espino (Desarrollos Eólicos S.A.) 65 turbines of300 Kw (A-300)
- Matatoros (Desarrollos Eólicos S.A.) 74 turbines of300 Kw (A-300)
- Loma del Polear (Desarrollos Eólicos S.A.) 81 turbines of300 Kw (A-300)
- Arroyo de Ramos (Desarrollos Eólicos S.A.) 72 turbines of300 Kw (A-300)
- Loma del Aguila (Desarrollos Eólicos S.A.) 30 turbines of300 Kw (A-300)
- Sierra del Ojen (Desarrollos Eólicos S.A.) 71 turbines of300 Kw (A-300)
- Sierra de Salaviciosa (Desarrollos Eólicos S.A.) 33 turbines of300 Kw (A-300)

Related with these and other less advanced projects, there is an undetermined number of meteorological towers that belong to different companies, with the aim to study the wind energy potential in the mountains and sierras where there are placed.

These new projects, some of which are in their last stage of construction, will account to a total of915 wind turbines which will, in short term, almost multiply by 4 those already present. It is therefore necessary to consider the accumulating effect of the impact that, each project could represent, as a highly important aspect in the future planning of this industrial exploitation of wind energy in Tarifa and in the Campo de Gibraltar region.

3. SUMMARY OF THE STUDY CONDUCTED BY SEO/BirdLife

3.1. OBJECTIVES

The main objectives of the project that is summarized here, were to study the impact of the turbines and the associated structures (eg. power lines, meteorological towers, etc.) on soaring birds in several existing windfarm developments, and to prepare a series of recommendations (less harmfullocations, mitigating measures, etc.) for the construction of new windfarms or for the expansion of those already operating, taking into account other projects that are being carried out. Different subobjectives were taken into consideration:

- Research on the ornithological importance of the area, based on a bibliographic revision, specially for soaring birds (both breeding and migratory ones).
- Revise the effect of windfarm facilities on birds based on surveys carried out in other countries.
- Detect the mortality of birds that could occur in the selected windfarms or other effects on the avian population, paying special attention to the following factors:

  - Quantify the mortality and study the behaviour of soaring birds in the surroundings of the windfarm developments.

- Identify and analyze the causes and factors related to this mortality or those that could affect the behaviour of the birds: weather, location and characteristics of the structures, etc.

- Determine possible alterations in behaviour, habitat use, impact on feeding zones, breeding or roosting sites of breeding birds.

- Analyze changes in the routes and behaviour of migratory birds.

- Valuation of the "Special Management Plan of the Wind Power Plants of Tarifa" (final name of project) carried out by the company INERCO and,

- Suggest intervention proposals: mitigating measures to reduce the mortality of birds; zoning of the Municipal District of Tarifa based on the Special Plan and a monitoring programme of the effect of windfarms on avifauna.

3.2 METHODS

Due to the resources available for this project, field work was focused on detecting the mortality of only medium - large birds, mainly soaring birds, and not being able to evaluate the impact of these windfarms and associated structures (including transmission lines) on smaller birds, mainly Passeriformes. Bird behavior in relation to the turbine structures was also observed.

The study was conducted in the only two productive windfarms (PESUR -including that ofLevantera- and E3) that account to a total of256 turbines.

Different sample sites, to search the ground for injured or dead birds, were randomly selected in both windfarms. A total of87 wind turbines were selected, representing 34% of those present in both windfarms. The meteorological towers adjacent to the selected turbines were also included as part of the sample sites, along with different sections of power lines that summed 13 km (54% of the total length).

The field work was conducted during a one-year period (from 15 December 1993 to 15 December 1994), with weekly checks of the selected power lines, though the wind turbines, in general, were checked twice a week.

Three tests were also conducted during the year to evaluate, throughout the different seasons, the effect of predators and to assess the ability of observers in detecting dead birds.

The behavioural study was monitored by establishing different flight characteristic categories (distance from wind turbines) in the area of influence (250 meters) and types of reaction, in order to analyze the data and its relation to the type of flight, flight height, strength of the wind and relate it to a higher or lower "Risk Rate".

For the species affected by the windfarm facilities, it has only been possible to calculate correction factors (and therefore estimate total mortality based on the results of the sample sites) in the case of the Common Kestrel. For the Griffon Vulture, the number of birds found during the field work (on and off sample sites), has been considered as the total mortality rate due to its easy detectability and the long periods it remains in the fields, without calculating correction factors in this case.

For the rest of the large species, it is not possible to calculate these factors due to the small sample obtained and the figures registered have been considered as mortality.

3.3. RESULTS

During the field work, 82 birds were found after collision with windfarm facilities. A total of 65 of these were large birds, mainly soaring species, including one Ciconiiforme, 64 diurnal raptors and 2 nocturnal birds of prey. Other 17 birds, of the Orders Galliformes, Cuculiformes and Passeriformes, were found dead by collision. The species found (in several cases old dead bodies) are listed below in a decreasing order, including those that died during the field work (fresh carcases) in brackets:

Species	*PESUR*	*E3*	*POWER LINES*	*TOTAL*
Griffon Vulture	39 (28)	4 (2)	0	43 (30)
Common Kestrel	12(12)	0	12(12)	
Other Groups	9 (9)	0	8 (8)	17(17)
Lesser Kestrel	3 (3)	0	0	3 (3)
Short -toed Eagle	2 (2)	0	2 (2)	
Eagle Owl	I (I)	I (I)	0	2 (2)
Black Kite	I (I)	0	0	I (I)
Cattle Egret	0	0	I (I)	I (I)
Unidentified Raptor	I (I)	0	0	I (I)
Total	***68 (57)***	***5 (3)***	***9 (9)***	***82 (69)***

All birds (except six injured ones) were found dead and with clear signs of having died after colliding with a wind turbine or with the power lines (no case attributed to electrocution was recorded). No distinction is made between injured or dead birds that were found because all are excluded from the natural population.

Evidence shows that there are a greater number of accidents involving turbines in which the death of the bird may not take place, and this cannot be quantified in a survey under these characteristics. This statement, for example, is supported by the following facts: a vulture was recorded to be hit by the blades of a wind turbine and flew out of sight (later not being able to find its dead body) and other vultures were seen to be missing an exceptionally large number of feathers to account it towards the natural sequence of moulting in birds.

A total of 59% of the vultures that were found dead, were attributed to collisions with turbines located in the areas of the Tesoro and Los Zorillos (PESUR). There are significant differences in mortality regarding the different turbine rows. 28 of these turbines (top of the Tesoro Mountain, nQ 2038 to nQ 2045; and Southern half of Los Zorrillos, nº 1069 to nQ 1077) are responsible for 57% of the accidents suffered by vultures from 15 December 1993 to 15 December 1994.

In 22 cases of accidents involving vultures, it was possible to determine the day they occurred. In 8 cases, at a certain time during the day the wind reached a maximum speed of8 meters/second; in 12 cases the wind reached this same speed during various hours and in two cases the wind blew at a speed of over 8 meters/second.

Calculations show that the number of vultures killed per turbine per year for each windfarm is in PESUR, 28/190 = 0.147; and in E3, 2/66 = 0.03, indicating that it is 4.9 times higher in PESUR.

In mid-June 1994 the rubbish dump of Tarifa was closed. Consequently vultures stopped concentrating around the area where the dump was situated. However, not taking this detail into consideration, observation has indicated no change in habitat use because these birds continue to approach the nearby mountains and hills (Bujo, Tesoro, Puerto Hondo, Gordo, Ahumada, etc.), with the same frequency as before the dump was closed.

The large number of vultures in the area, and the accidents occurred, were not, as some have stated, a direct consequence of the existing dump. The important breeding population of this species in the Campo de Gibraltar Region and the presence of a great number of wintering and migratory birds explain this high density. In fact, after the dump was closed, five vultures died in PESUR before 15 December 1994, the day the field work ended.

Only mortality correction factors related to the search efficiency of observers and effect of scavenger removal were calculated for the PESUR windfarm during three seasons (winter, spring migration and autumn migration), because in E3 and along the power lines, no medium sized birds were located within the sample sites, and it was assumed that all large birds, injured or dead, were found. However, due to the reasons indicated in point 3.2, it was only possible to estimate the corrected mortality for Common Kestrels, which accounted to 49 birds.

If only medium-large birds are taken into account, total mortality (observed + estimated) in the studied windfarms during the field work, has been:

	A	*B*	*C*	*D*
Common Kestrel	12	8	49	49
Griffon Vulture	30	7	--	30
Lesser Kestrel	3	0	--	3
Short-toed Eagle	2	2	--	2
Eagle Owl	2	0	--	2
Cattle Egret (wires)	I	I	--	I
Black Kite	I	I	--	I
Unidentified Raptor	I	I		I
Total	***52***	***20***	***--***	***89***

A: number of accidents occurred from 15 Dec. 1993 to 15 Dec. 1994
B: number of accidents occurred from 15 Dec. 1993 to 15 Dec. 1994 in the sample sites
C: estimated mortality with correction factors
D: total mortality

Estimations give a mortality of 0.38 birds/turbine/year for all the species found in both two windfarms combined (0.49 and 0.05 birds/turbine/year in PESUR and E3 respectively). In the case ofmedium-large birds the mortality rate is 0.34 birds/turbine/year in both windfarms combined (0.45 and 0.05 birds/turbines/year in PESUR and E3 respectively).

All the raptor species that suffered accidents (diurnal and nocturnal) are protected species under the national legislation (RD 439/90) and the international legislation (Annex I, Directive 79/409/EEC, except Common Kestrels).

On the other hand, 3,832 sightings of vulture flights (sedentary and/or migratory) have been recorded near the turbines of PESUR, 15% of which lead to risk situations. Risk situations can occur with the same probability in any group of turbines when the conditions of the wind and

the flight characteristics are the same. The wind speed, the type of flight and flight altitude, significantly modify the probability of a risk situation occurring in this windfarm. Soaring flights with F2 winds (Force 2: 4.6-8.5 meters/second) and crossing flights, when starting below blade height, are the types of flight that have a higher Risk Rate. Only in 2% of the total recorded flights, the vultures clearly changed their flight when approaching the turbines.

However, only 3% of the flights of vultures in E3 (977) were determined to be risk situations. The altitude at which the flight takes place significantly affects the degree of danger of these flights through E3. The same type of flight at the same altitude but with a different wind force is not significantly more dangerous. Crossing flights, when starting below blade height, are the type of flights that have a higher Risk Rate in this windfarm.

Therefore, the different mortality rate found in PESUR and E3 can be considered to be caused by a more dangerous behaviour (type of flight) of vultures in PESUR, which is determined by the location of this windfarm (wind-relief interaction). The presence of carrion near the turbine rows involves an additional risk factor .

For the rest of the breeding species, the number of recorded flights and reactions observed, was much lower, and specific analysis was not possible.

In PESUR, 736 sightings of migratory birds were registered during spring migration. A total of 78 of these occurred at a short distance to the turbine structures and 66 occurred under soft breeze conditions, with the turbines not operating. Very few observations (26) were recorded in this season in E3.

During the autumn migration, 7949 sightings of soaring migratory birds were registered in PESUR, although only 48 flights took place within a distance of 5 meters of the turbine structure and in 8' cases, between two of them. Only in six cases some type of reaction was observed. The number of observations in E3 was much smaller, as in fall migration. A total of 803 sightings of flights were registered, all with a distance of over 5 meters of the nearest turbine structure.

Regarding the roosting sites of sedentary birds, only Griffon Vultures frequently use them in the area. The Bujo and Tesoro Mountains, at present with installed wind turbines of PESUR, were both used in the past as a regular roosting site by this species. The roosting site in Cerro Ahumada has also disappeared due to the construction works of a new windfarm development. It is difficult to evaluate the effect that the loss of these roosting sites can have on the vultures of the area.

The limitations of this study have not allowed an adequate evaluation of the effect on small species, which can be important in regards to the observations carried out.

By comparing the results obtained in other countries, the most relevant aspects of this study are the following:

- The number of birds found dead in Tarifa is very high in regards to the figures obtained in other studies carried out in Europe (303 dead birds in 108 windfarms, during several years) or in the United States (182 dead birds in Altamont Pass - 7340 turbines- during two years).

- Almost all recorded deaths in Tarifa occurred on days with high visibility, the opposite of what is mentioned in studies carried out in Holland.

- - The results in Europe conclude that the effect on the behavior of birds and the loss of habitats, associated to windfarm facilities, are far more important than the accounted for direct mortality due to collisions. Observation in Tarifa contradicts this generalization.

3.4. ZONING

Preliminary criteria can be proposed for possible future developments of new windfarms or for the expansion of those already operating, until the "Special Management Plan of Wind Power Plants in Tarifa", which will put into action the zoning required, is completed.

The different aspects taken into account, include the results obtained in this study as well as the requirements of the present legislation and the recommendations established by different associations in the United States and England as a guideline already used in other countries for these kind of plans. The criteria proposed are the following:

1. In protected natural sites, it should be necessary to consider the zoning established by the Management Plans and Rector Plans, and the restrictions established within these, as well as the objectives that justify its construction and the effects of the windfarms on these sites. In any case, protected sites should not be included in the development plans of wind energy , except for exceptional cases in which, according to the zoning that could be established by the "Special Management Plan of the Wind Power Plants of Tarifa", the detailed surveys that were to be conducted regarding the local behaviour of the birds and the mitigating measures that were to be put into practise, one could expect a minimum impact on the avian population and other natural values.

2. In unprotected natural sites, but considered to have international importance (Important Bird Areas), as is the case of most of the region of Campo de Gibraltar, these wind power facilities should only be authorized if, after conducting a complete study on the local behavior of birds, as proposed below; one could expect a minimum impact on the avifauna.

3. The development of new windfarms in areas which are not included in protected natural sites and those unprotected but of international importance, should be subjected to an Environmental Impact Assessment as established by the law in Andalusia.

Throughout this project, it has been seen that it is necessary to learn more of the behaviour of the birds, specially soaring species, in the areas in which there are future plans for the construction of a new windfarm. If this information were to be applied in a pre-construction phase of the windfarms, it would be possible to minimize the accidents these birds have with the turbine structures. Therefore, before authorizing the construction of a new windfarm in an Important Bird Area, or in exceptional cases within a protected site, it would be necessary to carry out a complete study of avian habitat use in the area. The study should include at least an annual cycle in order to evaluate the situation in each season. In this case, the proposal is an outline of what a study under these characteristics should include, based on the experience obtained in past surveys:

a) Study of the sedentary avifauna. In this section, special attention should be given to the behaviour of vultures and kestrels,~ as these have been until now the most affected species. The study should include a survey of avian habitat use in the specific site, if any, as well as the dangerous areas and the weather conditions that enhance this danger. Also, if the new windfarm is located in steppelands or cultivated areas, it would be necessary to study the behaviour and the habitat use the birds (Great Bustards, Little Bustards, Cranes, etc.) make of the surroundings of the windfarm.

b) Study of the migratory avifauna- Studies should be made of the frequent routes of these birds in the site, during both prenuptial and post nuptial migration in order to check if the new turbine rows would interfere in these routes, and under what meteorological circumstances (mainly wind conditions) these interferences would occur.

c) Design and planning of the windfarm. Once the behavioural patterns of the birds in the area have been studied, planning of the location of the wind turbines should leave corridors or open areas free of turbines in those sites where there is a clear possibility of danger for these birds. Likewise, the velocities at which the turbines start and stop should be programed, based on the different site use by birds, depending on the wind speed. F or example, if a certain area is seen to cause problems under specific wind conditions, a turbine could be installed there as long as it is stopped when these weather conditions take place.

d) Monitoring programme. Once the windfarm begins to operate, a monitoring programme must be started in order to quantify the possible mortality of birds and the causes of this mortality. Once the problem, if it exists, is determined, new mitigating measures should be designed and adopted if necessary (see section 3.5)

3.5. MITIGATING MEASURES

The only efficient way to avoid or reduce to a minimum the mortality of birds in windrarms is to conduct preliminary and thorough studies of the proposed sites.

Based on the results obtained, vultures have been the large-sized birds most affected in 1994 in the studied windfarms. It has been proved that more accidents occur in certain groups of turbines, and that risk situations occur more frequently on certain days and under certain meteorological conditions. Thus, in order to reduce the number of accidents, several mitigation measures have been proposed in the studied windfarms. The Environmental Agency must verify that the windfarm companies are putting them into practice, and also that the effectiveness of the measures is evaluated with a series of consecutive surveys. If they should result to be effective, they should be applied to the windfarms in which frequent risk situations or mortality of birds has been detected.

1) On 28 November 1994, SEO/BirdLife presented the following proposal to the Environmental Agency of the Regional Government of Andalusia and to the Wind Society of Andalusia. Though this proposal was presented before the study was concluded, it was proposed once its possible effectiveness had been determined with the intention of carrying it through and evaluating it immediately after the present study was finished. Though it was not accepted, it is still a priority to test its effectiveness. The proposal consists in modifying the wind speed at which the following turbines begin to operate:

- Cerro del Tesoro: nº 2038 to nº 2045
- Los Zorrillos: nº 1069 to nº 1077

The minimum speed of the wind for these turbines to start operating must be 8.5 meters/second, although speeds of9 meters/second would be more effective for this measure, which would help reduce risk situations.

2) Since many risk situations for vultures occur when there is carrion near the turbines, and since it would be relatively easy to adopt a series of measures in these cases, this aspect should be taken into consideration. When carrion is detected near a turbine row, the people in charge of the monitoring program (operators of the windfarm, wardens of the Environmental Agency or specialized technical staff employed for these tasks), should do the following. If carrion is found before vultures spot it, it should be taken to a suitable area far away from the windfarm, in order to avoid a dangerous situation. However, if they have already started to approach the carrion, leading them to a dangerous situation, the control office of the windfarm must be informed in order to stop the turbines that are considered to be most dangerous. After, the carrion should be

taken to an area far away from the turbines, so as to avoid any other dangerous situation for the vultures.

3) When turbines produce high mortality (as occurs in this case in Cerro del Tesoro and Los Zorrillos) and when other mitigating measures (such as the modification of the velocity at which the turbines start operating) are not proved to be effective, they should be removed and taken to a different location that would cause less risks. This measure has also been proposed in other countries in which other measures have been tested to reduce the mortality of birds in windfarms:

- Painting blades of the turbines to make them more visible to the birds, though there are no conclusive results so far. New experiments in this field are presently being developed by KENETECH.

- Reduction of the food supply, in the case of vultures and other carrion eaters, by fencing large surrounding areas near the turbines that would avoid the presence of livestock.

- Use video cameras to register accidents involving wind turbine structures which have previously been involved in other collisions, in order to obtain information that would allow applying new mitigating measures.

Regarding the typology of turbines, many variables are involved (height of the tower , length of blades, rotation speed, distance between towers, etc). Since it is not possible to compare different models in one same place, it is not possible to determine if some models are more dangerous than others in the area of Tarifa, and so it is impossible to suggest the convenience of using one type or another. Regarding the rest of the structures, power lines and meteorological towers, it does not seem necessary to adopt new mitigating measures.

3.6. MONITORING PROGRAMME

In these type of studies, it is not only important to consider the number of injured or dead birds but also learn on the causes of the accidents that these birds have with turbine structures. Therefore, an adequate monitoring programme should include the possibility of a complete study of this aspect. It would be interesting to continue compiling data regarding the accidents that occur in both windfarms and in other ones. In this respect, monitoring programs are already contemplated as part of Environmental Impact Assessments determined by the legislation in force.

The proposal that some authors make is that the interactions between birds and turbines should be subjected to a control of at least a two-year period after the construction of each windfarm. This monitoring survey should evaluate any accidents that occur, in order to determine

if the windfarm (or some turbines) should be modified in order to prevent new accidents or if any other mitigating measure is needed.

In this case, taking into account that the studied windfarms are located within a Special Protection Area and a Natural Park, and that they are causing the death of protected species, the Environmental Agency should establish, with the aid of power companies, a mechanism which could guarantee that the monitoring programme is carried out. This, considered to be extremely important when dealing with new construction projects, should be included in the Special Plan that is presently being conducted. Collaboration could be determined under the following conditions:

- Windfarm operators would register all data of injured and dead birds: species, turbine, date, hour, weather conditions, etc. Also, if an accident is sighted, a written report should be submitted explaining how it occurred. The wardens of the Environmental Agency would periodically compile this information.

- At least once a month all turbine rows should be checked at the base and some 20 meters on each side in search of vultures and other medium-large soaring birds, in order to locate those (most probably not all individuals) that have not been previously recorded under the former method. This monthly check should be carried out by at least two people (wardens or technical staff of the Environmental Agency, or a specialized team of people hired for this task) in order to cover both parks in the same day.

- Power lines should be checked periodically (the different sections included in the sample sites in this study or any others that may be chosen) in order to detect any birds killed by collision or electrocution.

- All information obtained shall be submitted to the technical staff of the Environmental Agency in order to analyze the data. This aspect results highly important regarding new construction projects and it should be contemplated by the Special Plan that is in progress. In the initial document of the Special Plan (Information, Analysis and Diagnosis) that was presented to the Regional Government of Andalusia in 1994, this was already mentioned.

Due to the fact that the Special Plan has been discontinued, it is necessary to consider that it is not possible to legally demand preliminary studies of least a one-year period for new windfarm locations in Tarifa, apart from the Environmental Impact Assessments and the surveillance plans required by law.

4. CONCLUSIONS

Avian mortality by collisions with turbine structures in PESUR and E3, and with power lines during the study period (15 December 1993 to 15 December 1994), and taking into account the estimations calculated for Common Kestrels, is estimated to be 106 individuals (97 due to wind turbines and 9 due to power lines) and of this total figure, 89 are large to medium sized birds (88 due to wind turbines and I due to electric lines). The most affected species were Common Kestrels (49 birds) and Griffon Vultures (30 birds). The systematic search for injured birds was focused on large-medium species. If smaller sized species had been included, mortality figures would have been higher, having seen the results obtained.

Registered mortality has been significantly different for each studied windfarm; 93 % of the vultures killed and 100% of the Common Kestrels killed, were found in PESUR. In the case of the vultures, mortality difference (0.147 birds/turbine/year in PESUR and 0.03 in E3) is due to the different behaviour of these birds in both windfarms.

Registered mortality is considered to be quantitatively and qualitatively important, because 83% of the mortality corresponds to raptors, all of which are protected species, and the total number ofmedium-large birds killed per turbine per year is 0.34 for the two wind farms combined (0.45 for PESUR and 0.05 for E3).

Weather conditions can vary notably from one year to another and therefore alter mortality rates. Thus, registered winds in 1993, mainly in autumn, were overall stronger than those in 1994 as the high figures of PESUR indicate for that year. Registered mortality in 1994 can therefore result to be different to that of other years under different weather conditions.

It has also been proved that the degree of danger of the turbine structures is not homogeneous throughout a windfarm. In PESUR, 57% of the vultures killed were attributed to only 28 of the 190 turbines in the windfarm. This is also why the figures obtained cannot be applied to mortality in other windfarms.

In regards to the behaviour of these birds, the percentage of flights within a distance of 5 meters to the turbines was 7.25% in PESUR and 3.29% in E3, which corresponds to a probability risk in PESUR two times higher than in E3. For example, in the case of Griffon Vultures, Risk Rate in this study was calculated to be 0.15 in PESUR and 0.03 in E3; which results to be five times higher in PESUR.

The survey has proved that the real incidence (registered mortality) and the potential incidence (probability of risk) on birds is significantly higher in PESUR. This is due to the characteristics of the sites in which each windfarm is located (wind-relief-route flight interaction of the birds).

The scarce effect, of both windfarms studied, on migration of soaring birds in 1994 is attributed to the fact that, though most birds have followed routes very near the windfarms, the location of the turbines are such that they do not interfere with these routes. Therefore, the behavioural and migratory route study precisely determines the danger of a specific area as a future site for the construction of a windfarm.

The differences previously mentioned prove that the most efficient procedure to avoid impact on the avian population is to selectively determine the sites of windfarms and turbines, through previous detailed studies. This preventive measure should most specifically be required for natural protected sites (Natural Park, SPA, Natura 2000 Network) and areas of special ornithological interest (Important Bird Areas) as occurs in the study area, where the installation of industrial wind power plants should be avoided, at least until the Special Plan is completed.

Consequently the "Special Management Plan of Wind Powered Plants in Tarifa" is essential to guarantee a suitable planning of this resource through restrictive zoning, requirement of previous studies of the proposed sites in the preliminary stages of the project and establishment of monitoring plans to determine the impact of windfarms on birds during exploitation stage and the effectiveness of the mitigating measures applied.

To reduce the important mortality detected in PESUR, the recommended mitigating measure consists in delaying the start of the turbines that cause most danger to birds until wind speed reaches 8.5 meters/second. If this proved not to be effective, the removal of these turbine structures should be considered.

SEO/BirdLife has not been able to carry out the preliminary evaluation of the above-mentioned Special Plan, nor the proposal of zoning established under contract for this study because this Plan has been presently discontinued due to the lack of financial support since 1994.

Because of the high mortality rates and high probability risks registered in this area of international importance for birds, an accumulative effect can occur if the projects of installing new windfarm facilities are carried through (a total of 915 turbines, which almost multiply by four the present ones) . This could represent in the future, a critical impact on the birds if an effective ordering plan for the industrial exploitation of wind energy, along with the application of the necessary mitigating measures, is not determined.

It is therefore important that the Special Plan is completed, and at least until then, no other authorization for the new development or expansion of windfarm facilities should be permitted in the Municipal District of Tarifa, based on the commitment made in the past by the Environmental Agency.

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6. MAIN REFERENCES

All the references that are quoted in the Final Report delivered to the Agencia de Medio Ambiente are not included in this summary . Only some of the most relevant ones related with different chapters of the work are included here:

Bernis, F. (1980). *La migra ción de la s aves en el Estrecho de Gibra lta r. Volumen I: Aves planeadoras.* Cátedra de Vertebrados. Fac. de Biología. Univ. Complutense, Madrid.

Beyea, J. (1994). *Birds, windpower a nd energy futu~res.* Presentation to Audubon's Asilomar Conference, March 27,1994.

Colson & Associates (1995). *Avian interactions with wind energy facilities: a su~mmary.* Report for American Wind Energy Association, Washington, USA.

Comisión Europea (1994). *Na tu~ra* 2000. *Zona s de Especia l Protección.* Comisión Europea. Documento XI/684/94-ES.

Crockford, N.J. (1992). *A review of the possible impacts ofwindfa rms on birds a nd other wildlIfe.* JNCC Report No 27. Joint Nature Conservat. Committee. Peterborough, UK.

De Juana, E. (Ed.) (1990). *Area s Importantes pa ra la s Aves en Espa ña* Monografia nº 3, Sociedad Española de Ornitología, Madrid.

Faanes, C.A. (1987). *Bird beha vior a nd morta lity in rela tion to power lines in pra irie ha bita ts.* U.S. Dep. Int., Fish & Wildlife Service, Report, 7: 1-24.

Fernández-Cruz, M.; Fernández, G.; González, E. & Paris, M. (1990). *Estudio poblaciona l de las aves del Estrecho de Gibraltar.* Informe inédito para la Planta Eólica del Sur.

Finlayson, C. (1992). *Birds of the Strait ofGibraltar.* T & A.D. Poyser, London.

LGL Ltd, Environmental Research Associates (1995). *Proceedings of Na tiona l Avian-Wind Power Planning Meeting,* Denver, Colorado, 20-21 july 1994.

Orloff, S. & Flannery, A. (1992). *Wind turbine effects on avia n activity, ha bita t use, a nd morta lity in Alta mont Pa ss a nd Sola no County Wind resource a rea s (1989-1991). Fina l Report.* Prepared for Planning Depts. of Alameda, Contra Costa and Solano counties and the California Energy Commission.BioSystems Analysis Inc., Tiburón, California.

Rand, M. & Clarke, A. (1990). *The environmental and community impacts of wind energy in the UK.* Wind Engineering, vol. 14, No 5: 319-330.

Rodríguez-Vizcaíno, F. (1994). *Visiónfinanciera. Jornada Técnica: Panorama actu~al de la energía eólica.* Ponencia en el Curso: Principios de conversión de la energía eólica. CIEMAT, 14-18 de noviembre de 1994, Madrid.

Telleria, J.L. (1981). *La migraciónde lasaves en el Estrecho de Gibraltar. Volumen II: Aves no planeadoras.* Cátedra de Vertebrados. Fac. de Biología. Univ. Complutense, Madrid.

Winkelman, J.E. (1985). Bird impact by middle-sized wind turbines on flight behaviour, victims, and disturbances. *Limosa,58:* 117-121

---------- (1992). The *impact of the Sep wind park near Oosterbierum (Fr.), on birds,* I: *collision victims,*. 2: *nocturnal collision risks,*. 3:*flight behaviour during daylight,*. 4: *disturbance.* RIN Reports 92/2-92/5. DLO-In stitute for Forestry an d Nature Research, Am hem.

SEO/BirdLife es una organización no gubernamental de Utilidad Pública, fundada en 1954 para la conservación de las aves y sus hábitats. Su trabajo en los campos de la investigación, la educación y la conservación, ha merecido el Premio Nacional de Medio Ambiente y el apoyo de miles de socios en toda España. Los problemas de conservación que SEO/BirdLife afronta son reales y urgentes. Para superarlos resulta vital el apoyo de todas aquellas personas a quienes importa nuestro futuro y el de la Naturaleza.

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