Bird migration monitoring in the Saint Nikola Wind Farm territory, Kaliakra region in autumn 2013, and analysis of potential impact after four years of operation

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SUMMARY

1. This report presents the comparative results of six autumn seasons of birds studies at the Saint Nikola Wind Farm (SNWF), with a focus on the impacts on migrating birds
2. Spatial and temporal dynamics in the numbers of different species passing through the wind farm territory during autumn migration 2013 (15 August to 31 October) are presented.
3. Data gathered from visual observations are analyzed.
4. The data from the autumn monitoring in the years 2008 to 2013 are used to investigate the potential change in species composition, numbers, altitude or the flight direction of birds observed in these 6 years at SNWF.
5. The variations in numbers of species, absolute number of birds, overall altitudes of flight and migratory direction of birds most sensitive to wind turbines do not indicate an adverse effect of the wind farm on diurnal migrating birds.
6. The Turbine Shutdown System probably contributed to a reduced risk of collision during all years of operation within infrequent periods of intensive soaring bird migration and provided a safety mechanism to reduce collision risk for single birds and flocks of endangered bird species.
7. The low number of victims of collision found during systematic searches for casualties under every turbine at an interval of 7 days or less in four autumn seasons does not provide evidence for additional mortality caused by SNWF that could be problematic to populations of any bird species migrating through the territory.
8. The results to date indicate that SNWF does not constitute a significant obstacle or threat, either physically or demographically to any of the populations of diurnal autumn migrants observed in this study.

INTRODUCTION

In NE Bulgaria, AES Geo Energy OOD constructed a 156 MW wind farm consisting of 52 turbines: the St Nikola Wind Farm (SNWF). In autumn 2008, SNWF did not exist; in autumn 2009 the facility was built but not operational (i.e. turbine blades were stationary), and in the autumns of 2010, 2011, 2012 and 2013 SNWF was operational. Several field studies have investigated the spatial and temporal distribution of migratory and breeding birds within this area in recent years; largely connected with the SNWF development

The main results of the autumn monitoring of bird migration in the vicinity of SNWF in previous years are published at: http://www.aesgeoenergy.com/site/Studies.html. In these studies, negligible collision mortality of migrating birds was found; either indicating a high avoidance rate of the turbines by migrating bird species, and/or the effectiveness of a Turbine Shutdown System (TSS), enacted during periodic and unusual peaks in migration traffic. An additional contributory factor to the low records of collision victims is that SNWF does not lie on a major migratory flyway, and so the number of birds at risk of collision is relatively low, even before the birds' likely high collision avoidance behavior and/or the consequences of the TSS's effect on collision reduction.

In respect of the migratory traffic, studies at SNWF demonstrate that strong fluctuations in numbers of different species were correlated significantly with wind direction so that periodic and infrequent westerly winds coincided with peaks in soaring bird migration activity. Previous reports of studies at SNWF clearly and repeatedly indicated that the wind farm is not situated on the main Via Pontica migration flyway within Bulgaria and that this main migration 'highway' lies to the west (summarized in Fig. 1; more detailed analyses are contained in previous reports on autumn migration published at: http://www.aesgeoenergy.com/site/Studies.html).

This conclusion of studies at SNWF, published on the aesgeoenergy.com website has been recently affirmed independently by Michev et al. (2012). Consistent with this, in a bird sensitivity map for soaring birds migrating over Bulgaria (page 97, Fig. 18, far left map showing raw model of bird migration intensity over Bulgaria:

http://natura2000.moew.government.bg/PublicDownloads/Auto/OtherDoc/276299/276299_Birds_120.pdf), SNWF is shown to underlie a small proportion of the migratory traffic, so that the vast majority of migration occurs to the west of SNWF, where the Via Pontica flyway evidentially and primarily occurs.

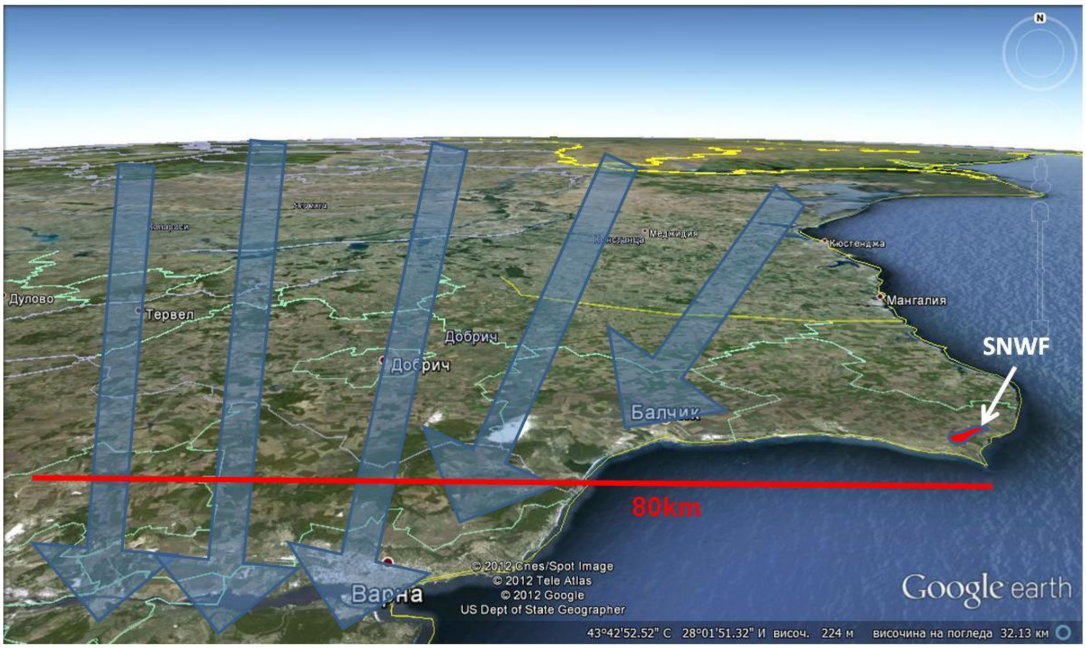

Figure 1. Schematic representation of the main autumnal migratory flyway - the Via Pontica (blue arrows), and the location of SNWF.

In the 2011 and 2012 autumn reports from the SNWF studies the major questions addressed were the potential for a barrier effect on birds migrating through the territory and the level of collision mortality of migrants. The analysis of the data until autumn 2012 showed no evidence for cumulative long term changes in the migratory bird fauna, and that recorded victims were few and substantially did not involve individuals of potentially vulnerable soaring species.

The present report updates the information on spatial distribution and temporal presence of birds in SNWF during autumn 2013 with, as in previous reports, special focus on soaring species deemed most sensitive to wind turbines.

METHODS

The study area

SNWF is located in NE Bulgaria, approximately three to seven kilometres inland of the Black Sea coast and the cape of Kaliakra. The wind farm lies between the road from the village of Bulgarevo to St. Nikola (municipality of Kavarna), and the 1st class road E 87 Kavarna – Shabla, as shown in Fig. 2. The SNWF area consists mainly of arable land involving small-scale cultivation of different crops (wheat, sunflower, rapeseed), heavily intercepted with tracks and wooded shelter belts.

Study duration and equipment

The study was carried out in the period 15 August – 31 October 2013. The surveys were made during the day, in a standard interval of time between 8 AM and 6 PM astronomic time. In the autumns 2008 – 2012 the study period was shorter covering a total of 45 days (15 August – 30 September); the period of the most intensive migration. The increase of the observation period in 2013 aimed, in conjunction with a concurrent extension of the TSS, to attain an even higher assurance level in the mitigation of collision risk with respect to all potentially sensitive bird species that may appear in SNWF until the end of October. The data collected in October 2013, during the extension period, were not used for comparative purposes as regards analysis in respect to the consistent periods of autumn monitoring at SNWF in previous years, 2008 – 2012. In other words, the records of birds made in October 2013 are not included in cross-year comparisons in the present report, so as to maintain consistency across the longer study period.

Radar observations were made permanently during the day time and for 15 minutes per every hour of the night (20.00 h – 05.00 h) during the whole period of the survey in 2013 according to the following scanning program:

Diurnal Radar Observations

1. Four minutes at 30 mills, or as low as ground clutter permits (equivalent to approximately 25-275 m elevation at 5 km distance);

2. The magnetron then rested for one minute, and then the measurement was recommenced.

Nocturnal Radar Observations

1. Four minutes at 30 mills; (equivalent to approximately 25-275 m elevation at 5 km distance);
2. Four minutes at 150 mills (equivalent to 675-825 m at 5 km distance);
3. Four minutes at 700 mills (equivalent to 3375-3625 m at 5 km distance);
4. The magnetron then rested for 48 minutes, and then the cycle was recommenced.

Visual observations were used in the analysis and comparison of different years and changes in absolute numbers of birds, altitudes of flight and directional distributions, to maintain consistency across years of study.

Basic Visual Observation Protocol

The autumn 2013 study involved direct visual survey of all passing birds from several observation points (Figure 2). Field observations followed the census techniques according to Bibby et al. (1992). Point counts were performed by scanning the sky in all directions. Height estimates and distances to the birds were verified with land mark constructions around the observation points previously measured and calibrated by GPS. The surveys were carried out by means of optics, every surveyor having a pair of 10x binoculars and all observation points were equipped with 20 – 60x telescope, compass, GPS, and digital camera.

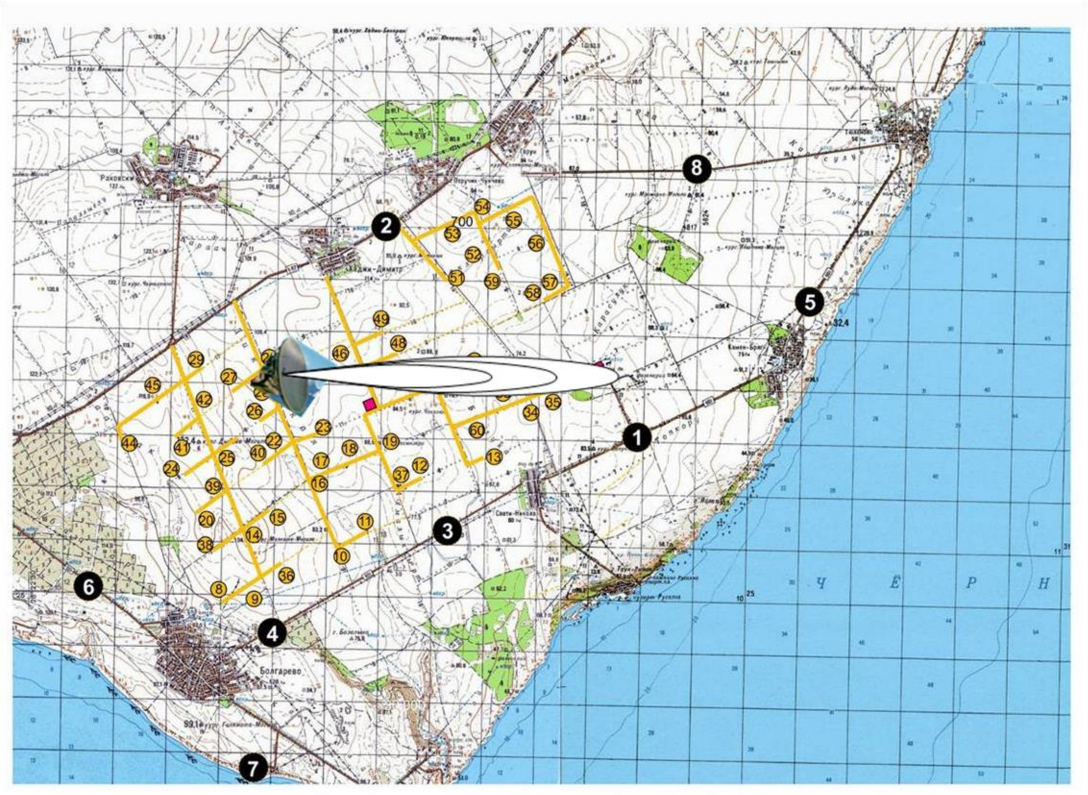

Figure 2. Locations of the wind farm turbines (numbered yellow dots), radar beam and the observation points (numbered black dots).

The basic temporal survey protocol was not changed in the period 2008 – 2013 (other than the temporal extension instigated in 2013) in order to allow comparable data between years. As noted in previous reports, 2009 was exceptional in the spatial survey protocol because the observation points were moved northward to test the early warning system (TSS) for approaching flocks of birds. The northerly shift in the observation points in 2009 means that many data of migratory metrics (notably, flight direction) were likely not comparable with the years before or since. In 2009, SNWF had been constructed but was not operational. In this respect, the necessary practical anomaly in the 2009 survey methods does not impinge on comparisons of SNWF's pre- and post-operational effects, since in 2009 the wind farm was not operational.

The observation effort was sufficient for coping with the volume of avian migratory traffic, and no observer was 'swamped' in time under the circumstances outlined by Madders and Whitfield (2006). All details about the specific visual observation protocol are presented in a number of previous autumn reports and in the Owner

Monitoring Plan (OMP) and will not be repeated here again: http://www.aesgeoenergy.com/site/images/21.pdf (studies page). All observers were qualified specialists in carrying out the surveys of bird migration for many years including previous autumn surveys at SNWF. Some of the observers are active members of the BSPB (BirdLife Bulgaria).

List of participants in the observations, 2013:

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Petia Dimitrova Karpuzova
Member of BSPB

Method of Collision Victim Monitoring

The collision monitoring methodology followed that developed in the USA for bird collision monitoring at wind farms (Morrison 1998). The detailed description of the protocol is given in the Owners Monitoring Plan (OMP http://www.aesgeoenergy.com/site/Studies.html.). Results of the monitoring were reported to the Regional Inspectorate of the Bulgarian Ministry of Environment and Waters in Varna every month during the first year of the operation. An annual report has been prepared based on the results of the monitoring after every year operation period of the wind farm (2010- 2013).

Statistical methods

The number of observed species, individuals as well as their average altitude of flight (by species and years) is presented in a number of tables for direct comparison across the autumn seasons of 2008 - 2013.

The altitude of migration in different autumn seasons was evaluated for significance by its mean value, standard error and standard deviation in data analysis software system STATISTICA (StatSoft, Inc. (2004, version 7. http://www.statsoft.com/). The mean flight direction as well as its significance level, for every species and group of species was calculated according to standard circular statistics (Batschelet 1981). Circular statistics was performed with Oriana (Oriana - Copyright © 1994-2009 Kovach Computing Services). This program compares two or more sets of circular distributions (directions) to determine if they differ. The tests were performed pairwise, so that each pair of samples was compared separately.

Many of the basic statistical parameters of circular distributions (directions) are based on the concept of the mean vector. A group of observations (or individual vectors) have a mean vector that can be calculated by combining each of the individual vectors (the calculations are explained in most books about circular statistics). The mean vector has two properties; its direction (the mean angle, **μ**) and its length (often referred to as **r**). The length ranges from 0 to 1; a higher r value indicates that the observations are clustered more closely around the mean than a lower one. Details about the Oriana software are available at: http://www.kovcomp.com/

Turbine Shutdown System (TSS)

The general principles, which provide a procedural checklist, were previously described in the 2010 autumn report (http://www.aesgeoenergy.com/site/Studies.html) The TSS protocol was followed in order to reduce collision risk during the extended period of study in autumn 2013, between 15 August and 31 October. Turbine shutdowns are ordered by the Senior Field Ornithologist or -when delegated to- field ornithologists in case of any perceived risk, such risk as per the discretion of the ornithologist.

RESULTS

Composition of species and number of birds passing through SNWF

As noted in the Methods, in 2013 the period of observation (and deployment of the TSS) was extended to beyond the period of most intensive migration, as was studied in previous years. The purpose of this extension (to the end of October, in 2013, rather than to the end of September, as in previous years) was to provide additional security that even in the time after the period of intensive migration (October), there was a mechanism through the TSS, if necessary, to reduce still further the collision risk associated with SNWF. In order to provide comparability between 2013 and previous years, however, to avoid bias associated with the extended observation period in 2013, the cross-year comparative data presented below are based on a comparable time period (15 August to 30 September) unless otherwise stated. Fundamentally, as will be elaborated on later in the Results, there was very little migratory traffic in October, as expected from the initial set-up of the autumn study period before 2008, and so the precautionary extension of the observation period in 2013 (to inform and potentially extend the value of the TSS) was just that – precautionary – and gives further reassurance that SNWF is minimizing potential effects on autumn migrants.

The occurrence of species across all years is presented in Table 1. A total of 119 bird species have been observed in the wind farm territory during the consecutive autumn seasons of 2008 to 2013. The number of observed species varied from 48 to 79 in different years. Most species (79) were observed in 2009 and 2012, the year when the wind farm had been constructed and in the third autumn after construction, respectively. There is no apparent difference in the number of species observed in 2008 (before the construction of the wind farm) and during the later period when the wind farm was present (2009 – 2013).

Table 1. List of species observed in the wind farm territory during period 15th August – 30th September in preconstruction (2008) and post-construction (2009, 2010, 2011, 2012 and 2013 in grey) periods of SNWF. Hatched cells represent the years when the species was registered in SNWF territory.

N	Species	2008	2009	2010	2011	2012	2013
1	*A. apus*	■	■	■	■	■	■
2	*A. arvensis*		■			■	■
3	*A. brevipes*	■	■	■	■	■	■
4	*A. campestris*		■			■	■
5	*A. cervinus*					■	■
6	*A. chrysaetos*			■	■	■	■
7	*A. cinerea*	■	■	■	■	■	■
8	*A. gentilis*	■	■	■	■	■	■
9	*A. heliaca*	■					
10	*A. melba*	■	■	■	■	■	■
11	*A. nisus*	■	■	■	■	■	■
12	*A. pennata*			■	■	■	■
13	*A. pomarina*	■	■	■	■	■	■
14	*A. pratensis*					■	■
15	*A. purpurea*	■	■	■	■	■	■
16	*A. trivialis*	■			■		
17	*B. buteo*	■	■	■	■	■	■
18	*B. oedicnemus*		■		■		
19	*B. rufinus*	■	■	■	■	■	■
20	*B. vulpinus*					■	■
21	*C. aeruginosus*	■	■	■	■	■	■
22	*C. cannabina*					■	
23	*C. canorus*					■	■
24	*C. carduelis*	■	■		■	■	■
25	*C. chloris*	■			■		
26	*C. ciconia*	■	■	■	■	■	■
27	*C. coccothraustes*	■			■		
28	*C. corax*	■					

N	Species	2008	2009	2010	2011	2012	2013
29	*C. cornix*						
30	*C. coturnix*						
31	*C. cyaneus*						
32	*C. frugilegus*						
33	*C. gallicus*						
34	*C. garrulus*						
35	*C. livia domestica*						
36	*C. macrourus*						
37	*C. monedula*						
38	*C. nigra*						
39	*C. olor*						
40	*C. palumbus*						
41	*C. oenans*						
42	*C. pygargus*						
43	*D. major*						
44	*D.syriacus*						
45	*D. urbica*						
46	*E. alba*						
47	*E. calandra*						
48	*E. garzetta*						
49	*E. hortulana*						
50	*E. melanocephala*						
51	*F. cherrug*						
52	*F. coelebs*						
53	*F. eleonorae*						
54	*F. naumanni*						
55	*F. parva*						
56	*F. peregrinus*						
57	*F. subbuteo*						
58	*F. tinnunculus*						
59	*F. vespertinus*						
60	*G. fulvus*						
61	*G. glandarius*						
62	*G. grus*						
63	*G. cristata*						
64	*H. daurica*						
65	*H. icterina*						
66	*H. pallida*						
67	*H. rustica*						
68	*J. torquila*						
69	*L. cachinnans*						
70	*L. collurio*						
71	*L. megarhynchos*						
72	*L. melanocephalus*						

N	Species	2008	2009	2010	2011	2012	2013
73	*L. minor*						
74	*L. ridibundus*						
75	*M. alba*						
76	*M. apiaster*						
77	*M. calandra*						
78	*M. cinerea*						
79	*M. flava*						
80	*M. migrans*						
81	*M. milvus*						
82	*M. striata*						
83	*N. percnopterus*						
84	*O. hispanica*						
85	*O. isabellina*						
86	*O. oenanthe*						
87	*O. oriolus*						
88	*O. pleschanka*						
89	*P. apivorus*						
90	*P. caeruleus*						
91	*P. crispus*						
92	*P. haliaetus*						
93	*P. leucorodia*						
94	*P. major*						
95	*P. montanus*						
96	*P. onocrotalus*						
97	*P. perdix*						
98	*P. pica*						
99	*P. viridis*						
100	*Ph. carbo*						
101	*Ph. collybita*						
102	*Ph. trochilus*						
103	*Pl. falcinellus*						
104	*R. riparia*						
105	*S. borin*						
106	*S. communis*						
107	*S. curruca*						
108	*S. rubetra*						
109	*S. vulgaris*						
110	*St. hirundo*						
111	*Str. decaocto*						
112	*Str. turtur*						
113	*T. nebularia*						
114	*T. tadorna*						
115	*Tr. ochropus*						
116	*U. epops*						

N	Species	2008	2009	2010	2011	2012	2013
117	*V. vanellus*						
118	*Ph. ochrurus*						
119	*Ph. phoenicurus*						
	Number of species	76	79	48	71	79	77

Examples of rare soaring species observed sporadically in some autumns are Common Crane, Griffon Vulture, Egyptian Vulture, Imperial Eagle, Golden Eagle, Red Kite, Saker Falcon, Lesser Kestrel and Eleonora's Falcon.

36 species were observed every autumn season in the period 2008 – 2013. Regular migrants through the territory included White Pelican, White Stork, Levant Sparrowhawk, Common Buzzard, Honey Buzzard and the Lesser Spotted Eagle. Three soaring bird species: Imperial Eagle, Dalmatian Pelican, and Lesser Kestrel were also registered as two, three and one individuals, respectively, only in autumn 2008. All three species are rare in general and these sporadic observations are probably unrelated to SNWF pre-construction and post-construction periods. By contrast, another 27 species of birds were not recorded in 2008, but observed in the longer (five years, to date) construction (2009) and post-construction periods (2010 – 2013). Among such species were, for example, many birds of prey like Golden Eagle, Saker Falcon, Black Kite; waders like Northern Lapwing, Green Sandpiper, Common Greenshank, Eurasian Stone-curlew; herons like Purple Heron, Great Egret, Little Egret; and many small passerine bird species. The occurrence of these species after construction should probably not be attributed to any beneficial effect of SNWF’s presence, but (again) to vagrancy.

Four new species in the SNWF territory were observed in autumn 2013. Syrian Woodpecker, Stock Dove, Common Crane and Crested Lark were observed from the constant observation points in the autumn 2013 for the first time. It is important to note that records of these new species was not due to the prolonged observation period in 2013, extending into October, because all were observed in the period comparable with the previous studies, 15th August - 30th September. The Common Cranes were observed on the 26th of September, 3rd and 4th of October as a single bird and two small flocks of 5 and 10 birds, respectively. Common Cranes are typical soaring migrants elsewhere in Bulgaria. The probable reason why this species was not observed in previous years at SNWF is the relatively low number of breeding areas of this species in the vicinity of the study area. The other three species (Syrian Woodpecker, Stock Dove and Crested Lark), observed for the first time in 2013, are common species for Bulgaria but their habitats are scarce around the observation points in our study. Nevertheless, the observed individuals of these three species most probably refer to local birds and should not be associated with autumn migration of soaring birds.

Two vulture species were registered only after the construction of SNWF. In the available literature concerning the region including standard forms of the nearby NATURA 2000 zones, the two species are not listed. The Griffon Vulture was observed in autumns 2010, 2012 and 2013. In 2013 Griffon Vultures were observed on 18th and 29th September at heights between 400 and 700 meters above ground level, crossing SNWF territory. The Egyptian Vulture was not observed in SNWF in 2013.

Absolute counts of soaring species which were most numerous, together with some additional species with high conservation value, are presented in Table 2.

Table 2. Numbers of birds recorded as passing through SNWF territory (primarily soaring water birds and birds of prey) in five autumn seasons of preconstruction (2008) and post-construction (2009 – 2013) periods.

Species	2008	2009	2010	2011	2012	2013
A. brevipes	95	210	976	290	94	650
A. chrysaetos			2	2	1	1
A. cinerea	120	259	26	40	56	70
A. gentilis	10	6	5	11	22	38
A. heliaca	2					
A. nisus	44	44	70	73	44	206
A. pennata			5	1	9	13

Species	2008	2009	2010	2011	2012	2013
A. pomarina	44	9	80	76	31	1966
A. purpurea		59	11	1	7	3
B. buteo	146	390	180	459	238	2345
B. oedicnemus		1		1		
B. rufinus	163	151	34	30	33	28
C. aeruginosus	327	268	341	271	179	473
C. ciconia	2998	87	24980	620	2525	11230
C. cyaneus	5	1		1		3
C. gallicus	29	19	18	25	60	88
C. macrourus	8	27	18	4	7	7
C. nigra	8	8	8	1	13	488
C. olor		1	3			
C. palumbus	10		1			
C. pygargus	32	17	111	151	55	82
E. alba			1	1	5	
E. garzetta		7				11
F. cherrug		7		2	1	
F. eleonorae	7			1	1	
F. naumanni	1					
F. peregrinus		2	4	1		5
F. subbuteo	48	125	120	96	66	88

Species	2008	2009	2010	2011	2012	2013
F. tinnunculus	138	357	45	120	67	103
F. vespertinus	11	180	1773	63	793	167
G. fulvus			1		1	2
H. pennatus	4	3	17	4	1	9
M. migrans	18	6	32	17	21	34
M. milvus			1	1		2
N.percnopterus					1	
P. apivorus	58	76	1549	152	115	4284
P. crispus	4					
P. haliaetus	15	13	14	12	7	13
P. leucorodia	117	83	56	48		59
P. onocrotalus	120	1190	252	277	1700	3285
Ph. carbo	267	354	494	75	131	
Ph.pygmaeus		19				
Pl. falcinellus	5	738				
St. hirundo		71				
T. tadorna		94			3	
Tr. ochropus		8			1	
V. vanellus			1			7
Total	4855	4890	31229	2927	6585	25760
Number of species	30	35	33	33	30	31

Obviously the number of species as well as the absolute number of birds crossing the wind farm territory did not decrease after the construction of turbines. The most numerous species of soaring migrants; White Pelican, White Stork, Levant Sparrowhawk, Common Buzzard, Honey Buzzard and Lesser Spotted Eagle dominate the autumn migration across all years monitored. The absolute number of these species per year widely varied (Figure 3). Only when –non prevailing- strong westerly winds coincided with the passage of soaring birds at the latitude of the wind farm, were migrating birds apparently carried towards the coast and hence higher number of birds were observed in the wind farm area. The numbers of all soaring bird species varied by years with no decreasing trend for after the wind farm was constructed and started its operation (Figures 3 and 4). For example, the years with the greatest autumn migration of soaring birds over the wind farm territory were 2010 and 2013 i.e. second and fifth year after construction of the turbines. In the autumn of 2013, along with the most numerous White Storks (11230), notable numbers of Honey Buzzards (4284), White Pelicans (3285), Common Buzzards (2345), Lesser Spotted Eagles (1966), Levant Sparrowhawks (650), Sparrowhawks (206) and Black Storks (488) also passed through or over the wind farm (Table 2). The 16 Common Cranes, a species observed for the first time in 2013, were registered passing over SNWF at altitudes between 200 and 500 m above ground level.

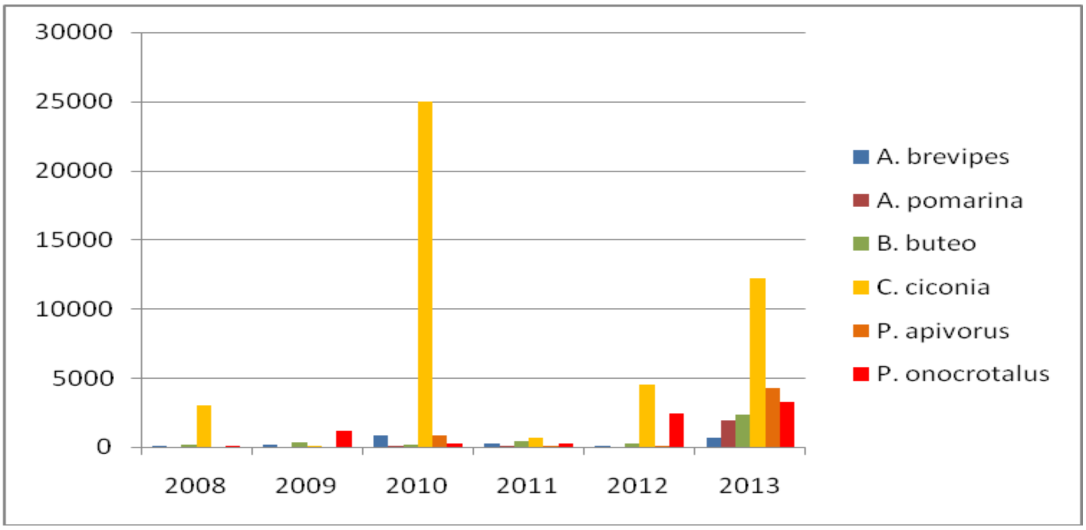


Figure 3. Variations in the total number of the most numerous soaring birds observed during autumn migration in five years: pre-construction (2008), construction (2009) and operational period (2010 - 2013) in SNWF.

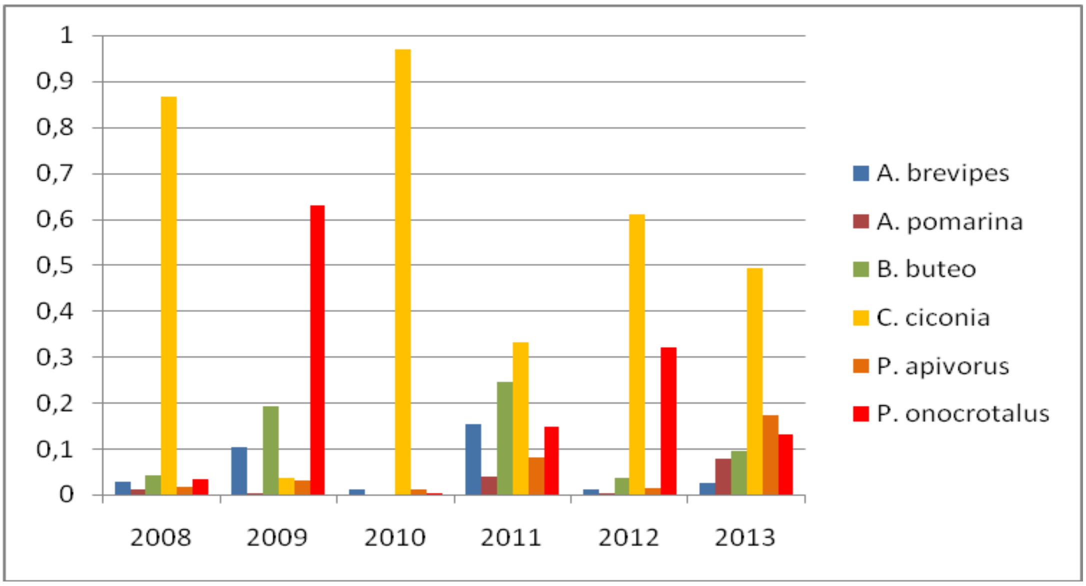


Figure 4. Proportional annual contribution of individual species (of the six most numerous soaring bird species recorded) to the total migratory traffic in and over SNWF in autumns 2008 – 2013. In most years, white storks (*C. ciconia*) were the most common migrant recorded.

Bee-eaters, swifts and swallows are other species that have occurred in relatively high numbers during all six years of SNWF monitoring. The recording of these species highly depends on the distance from the observer (in both vertical and horizontal visual planes) because of the small size of the birds (Table 3, and Figure 5). Therefore visual observations on these species are limited to a few hundred meters and cannot be considered as absolute numbers for a given area and at all altitudes.

Table 3. The proportion (in % of all registered) of detected Swifts, Swallows and Bee-eaters in relation to the distance to the birds.

Distance	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1500**
A. apus	87	5	1	6	1	0	0	0	0	0	0
A. melba	78	6	5	1	1	4	2	1	2	0	0
D. urbica	91	7	0	0	0	2	0	0	0	0	0
H. rustica	80	6	4	5	0	4	0	0	0	1	0
M. apiaster	67	9	8	6	2	5	1	0	1	1	0
Total	**74**	**8**	**6**	**5**	**1**	**5**	**1**	**0**	**0**	**1**	**0**

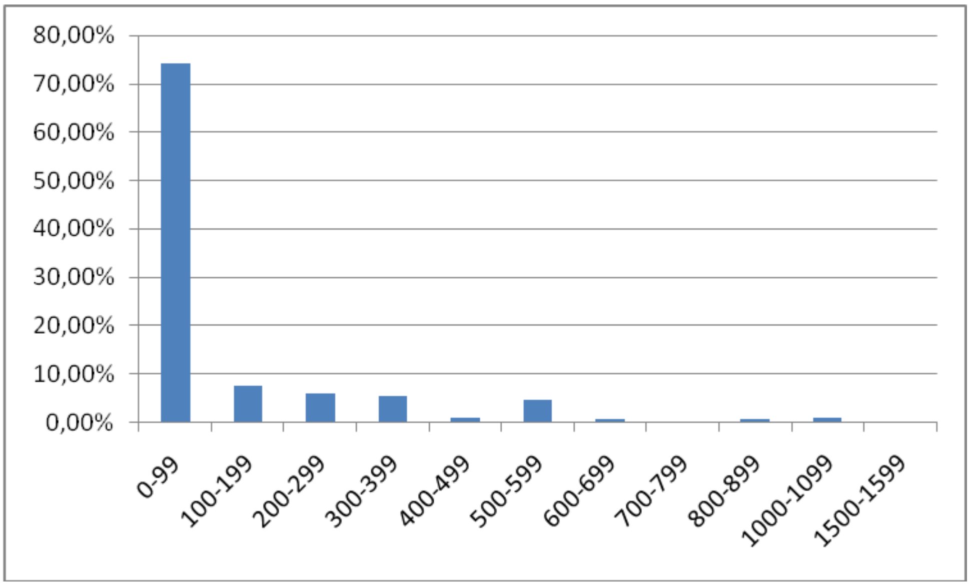


Figure 5. Relationship between distance and detection frequency of Bee-eaters, Swifts and Swallows according to the visual observations data for six autumn seasons in SNWF (n = 63635 observations).

Under the assumption that not all of bee-eaters, swifts and swallows crossing SNWF were detected the results on the numbers of bee-eaters and swallows (and other hirundines) registered in the period 2008 – 2013 are given in Table 4 below.

Table 4. The number of bee-eaters, swifts and swallows in SNWF in six autumn seasons as observed in the period 15 August – 30 September.

Species	2008	2009	2010	2011	2012	2013
A. apus	79	10	6	8	17	12
A. melba	515	16	536	234	47	127
D. urbica	1007	697		180	3	170
H. daurica	2	8		4	1	
H. rustica	2979	4234	1735	164	5994	815
M. apiaster	4625	3355	5024	2107	2733	5906
Grand Total	9207	8320	7301	2697	8795	7032

Altitude of autumn migration

Distribution of altitudes of birds recorded during autumn migration at SNWF was reported in reports for 2008, 2009, 2010, 2011 and 2012 available at: http://www.aesgeoenergy.com/site/Studies.html. The same species were used in order to keep a standard comparative approach in autumn 2013.

In order to examine whether there has been a change in the altitudinal distribution of birds between the pre-construction and the operational periods we have calculated the average altitude per year of all species of diurnal migrants regularly passing through the wind farm territory in autumn. In this report, data on average altitude of flights by species for the autumn 2013 are added, in Table 5.

Table 5. Average flight altitude, by species, of diurnal migrants observed in SNWF across five autumn seasons, 2008-2013: the years of commercial operation of the wind farm are highlighted in grey.

Species	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
A. brevipes	132	171	171	160	142	263
A. cinerea	201	239	263	386	190	344
A. gentilis	181	176	230	199	151	267
A. nisus	150	135	162	141	119	204
A. pennata	150	283	251	213	295	261
A. pomarina	244	273	234	234	241	353
B. buteo	165	199	206	197	158	278
B. rufinus	109	200	230	183	147	211
C. aeruginosus	158	139	235	150	128	222
C. ciconia	199	174	434	347	358	390
C. cyaneus	136	100		10		267

Species	2008	2009	2010	2011	2012	2013
C. gallicus	256	144	258	242	218	229
C. macrourus	251	90	240	195	86	188
C. nigra	462	325	375	350	388	382
C. pygargus	196	115	285	106	79	209
F. subbuteo	97	119	161	161	127	131
F. tinnunculus	49	96	109	70	79	67
F. vespertinus	106	106	224	289	121	139
M. migrans	175	183	166	152	233	243
P. apivorus	320	175	268	283	204	342
P. haliaetus	314	208	224	433		400
P. leucorodia	433	285	667	317		317
P. onocrotalus	100	159	417	400	265	263
Ph. carbo	180	179	277	271	254	265
All species	157	154	246	179	156	264

The comparative analysis showed that when summing across all bird species the flight altitude was higher in 2013 than in the other five autumn seasons of our study. An obvious difference was apparent only in average altitudes 2010 and 2013 compared with the average altitudes in 2009. The observed differences between 2010, 2011, 2012 and 2013 were less obvious but a relatively lower average in 2012 was apparent (Figure 6). In general no trend in the fluctuations of average altitude of the most numerous soaring bird species was registered after six years autumn migration monitoring in SNWF territory, including one pre-construction and five post-construction seasons.

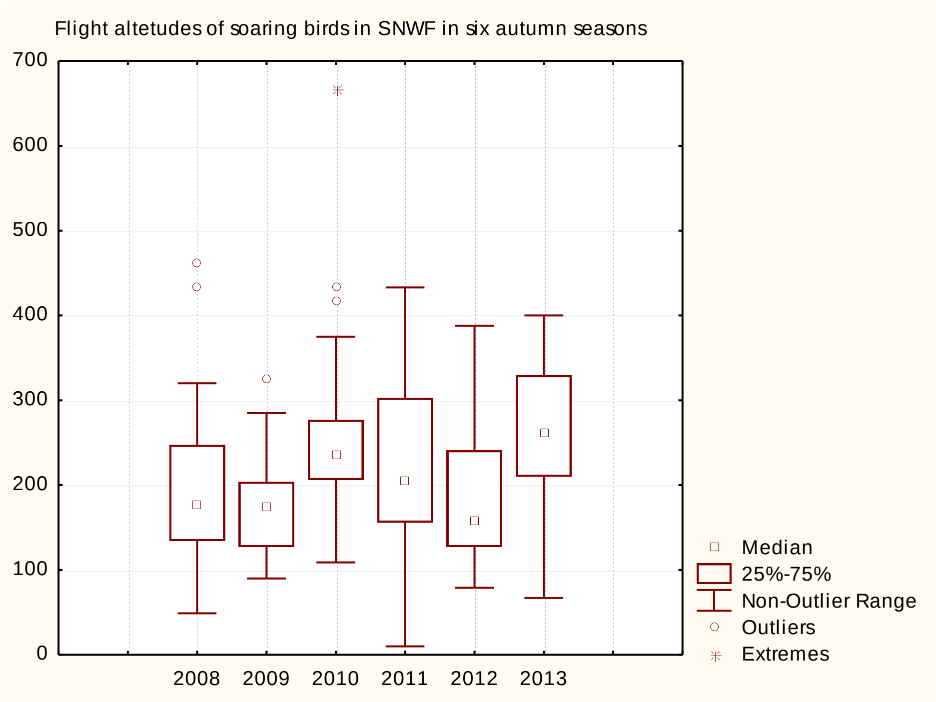


Figure 6. The median altitude of soaring bird migration in 2008, 2009, 2010, 2011, 2012 and 2013 with measures of variance. The species included in the calculations are presented in Table 5.

Observed flight altitudes of bee-eaters and swallows were analyzed despite the constraints on reliability imposed by visual observation, as mentioned earlier in the present report. Nevertheless, despite this caveat, it appeared that while the average observed flight altitude of bee-eaters and swallows varied widely across years there was no trend that could be attributable to the presence of SNWF (Table 6).

Table 6. Average altitude of flight during autumn migration of bee-eaters and swallows in the period 2008 – 20013 observed in SNWF.

Species	2008	2009	2010	2011	2012	2013
H. rustica	28	51	66	19	37	32
M. apiaster	73	68	128	71	83	66
Average per year	56	61	121	65	71	63

These results suggest that changes in the flight altitude of soaring migrants, bee-eaters and swallows have had no consistent character across years and do not indicate any impact by SNWF. Most probably climatic factors are likely to be responsible for the fluctuations in average altitude of autumn migration in this six year monitoring period. Regardless, any energetic consequences for migrants avoiding the turbines by way of a change in flight altitude will be immaterial to overall migratory energy budgets (Madsen et al. 2009, 2010) if they occur. Therefore there is no obvious evidence that SNWF is a reason for changes in behavior of passing migrating birds.

Direction of autumn bird migration

Taking all species of soaring birds that were relatively constantly-recorded across years (observed in at least three of the autumn seasons: Table 7) an analysis of flight direction across years involved 4454 observations. In this analysis each flock was considered as a single observation (datum) even if it consisted of, for example, 1000 or more individuals. The number of data (measurements of direction) for 2008, 2009, 2010, 2011, 2012 and 2013 were, respectively: 427, 1195, 1343, 696, 793 and 1870.

The mean recorded direction of the 24 species is presented in Table 7. It was already explained in previous reports why 2009 was apparently an exception because the observation points were moved northward in order to test an early warning system (TSS) for approaching flocks of birds. Prevailing directions of autumn migration observed in all six autumn seasons do not indicate changes in migratory direction through a response to SNWF in years when there was greater consistency in the location of observation points. The main direction of flights in all years illustrates the guiding role of the coast line (see Figure 2 and Table 7).

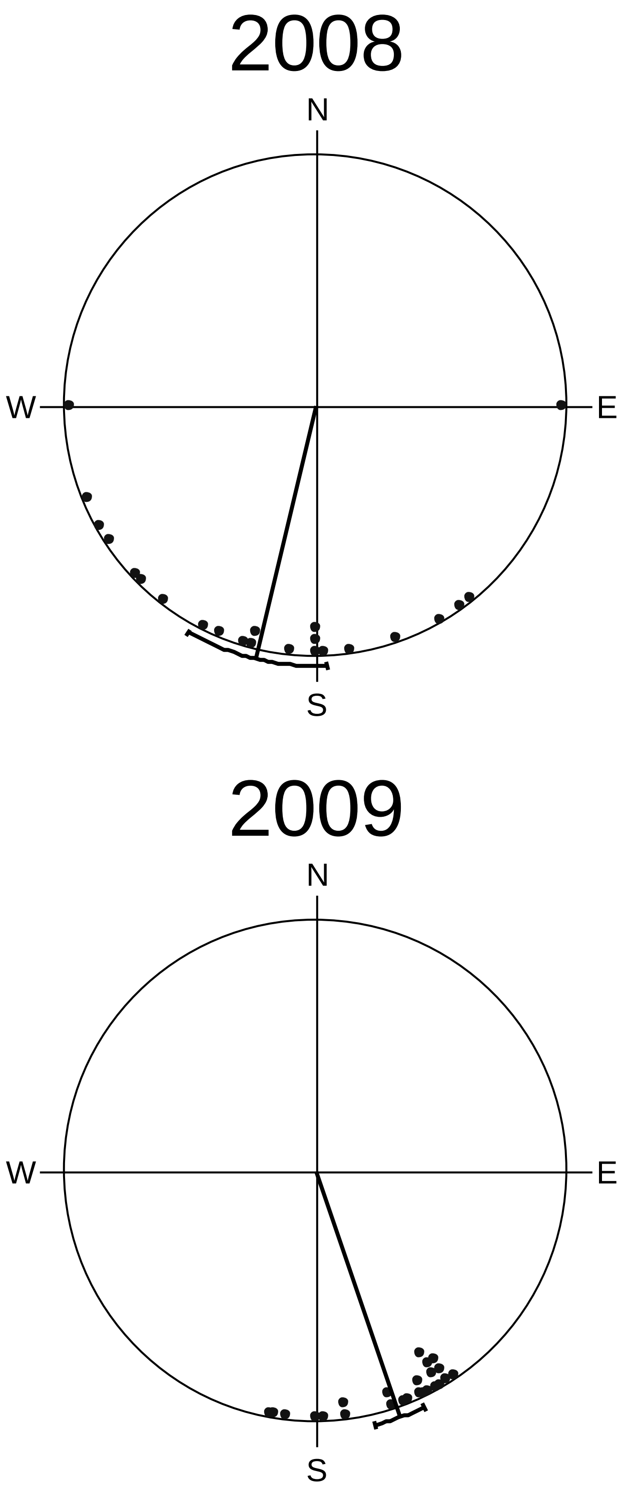
Table 7. Mean observed flight direction of autumn migration by species in different years. Directions are given in degrees starting from 0 (North).

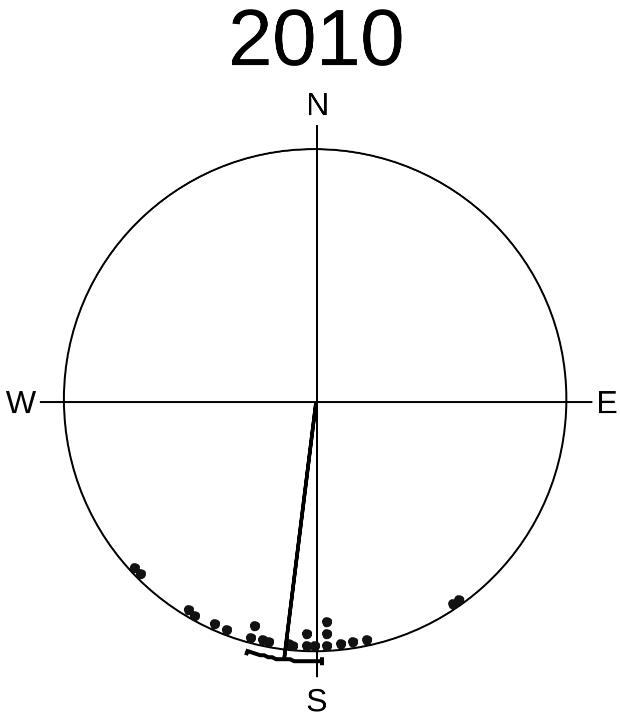
Species	2008	2009	2010	2011	2012	2013
A. brevipes	172	151	185	175	179	191
A. cinerea	248	178	146	138	203	167
A. gentilis	195	162	171	180	149	181
A. nisus	218	155	186	193	174	185
A. pennata	180	150	182	165	216	184
A. pomarina	225	173	204	183	193	214
B. buteo	195	150	177	179	179	198
B. rufinus	150	158	227	186	188	158
C. aeruginosus	197	150	191	188	175	199
C. ciconia	207	154	209	210	209	216
C. cyaneus	90	180		225		188
C. gallicus	203	150	144	151	129	159
C. macrourus	141	154	180	231	109	210
C. nigra	270	191	225	180	231	205
C. pygargus	237	148	182	183	174	194
F. subbuteo	186	148	174	196	196	188
F. tinnunculus	144	148	177	161	191	156
F. vespertinus	180	159	177	204	218	206
M. migrans	241	153	211	207	189	192
P. apivorus	227	187	201	200	208	204
P. haliaetus	161	190	168	198	169	199
P. leucorodia	180	173	195	180		180
P. onocrotalus		146	195	257	232	214
Ph. carbo	178	162	192	160	121	177
All 24 species	191	154	189	186	182	190

Table 8. Basic statistical parameters of empirical flight directions obtained from visual observations during five autumn seasons in SNWF territory for the 24 ‘core’ soaring bird species (see Table 7).

Variable	2008	2009	2010	2011	2012	2013
Number of species	23	24	23	24	22	24
Mean Vector (μ)	193,49°	161,115°	186,935°	188,292°	184,535°	190,319°
Length of Mean Vector (r)	0,79	0,969	0,939	0,906	0,853	0,957
Concentration	2,743	16,601	8,497	5,581	3,716	11,809
Circular Variance	0,21	0,031	0,061	0,094	0,147	0,957
Circular Standard Deviation	39,369°	14,285°	20,295°	25,526°	32,3°	17,052°

The circular (compass) distributions of flight directions of soaring birds are presented in graphs below for each year (Figure 7).




2010
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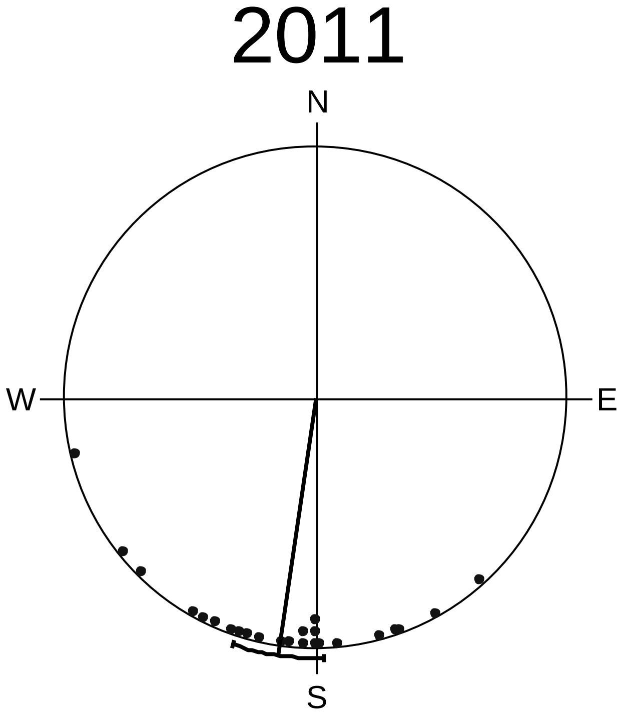
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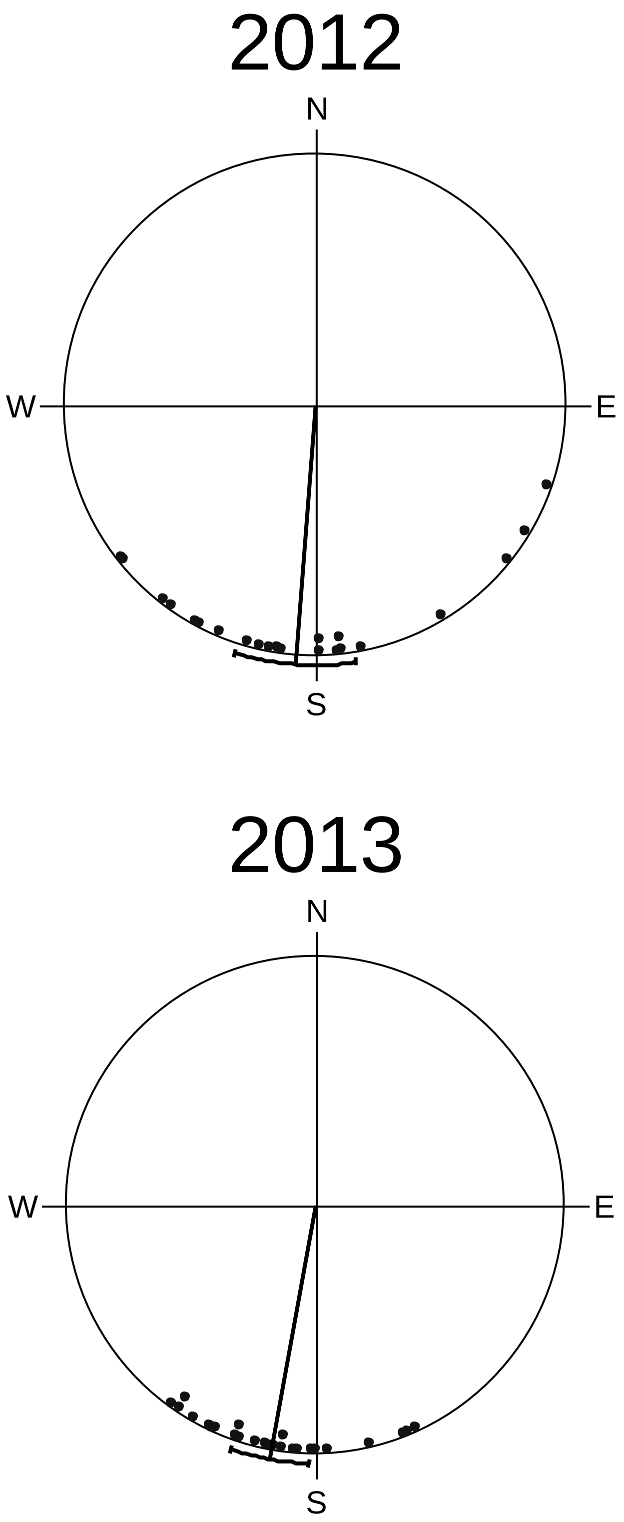


Figure 7. Graphical representations of the average flight directions of the 24 ‘core’ soaring bird species by year: each record = 1 species (see Table 8).

The direction of migration in 24 of most common and numerous soaring birds observed in SNWF territory in the last six years does not indicate any consistent annual deviation from the seasonal migratory direction after construction of SNWF. However, it is obvious from the descriptive statistics of flight directions (Tables 7 and 8, Figure 7) that 2009 was anomalous. This was undoubtedly due to a shifting of the observation points to the north in this year (see previous reports for details) and so the records of flight directions consequently differed. More formal statistical tests of these differences are given later in the present report. (Incidentally, nevertheless, while these records for 2009 do not allow a direct comparison with other years, they do suggest further that birds were not avoiding SNWF.)

Bearing in mind the limitations of visual observation described earlier in respect of smaller birds such as swallows and bee-eaters, analysis of the data for these birds may nevertheless serve to illuminate their behavior in SNWF territory. In order to reduce the level of subjective error in estimation of flight direction for species such as swallows and bee-eaters, which generally flew in dispersed flocks, the data were grouped in 16 (22.5 degree) sectors. Average results for the barn swallow and the bee-eater (most numerous species) are tabulated in Table 8.

Table 8. Average flight directions of barn swallows *H. rustica* and bee-eaters *M. apiaster* as observed in SNWF territory across five autumn seasons.

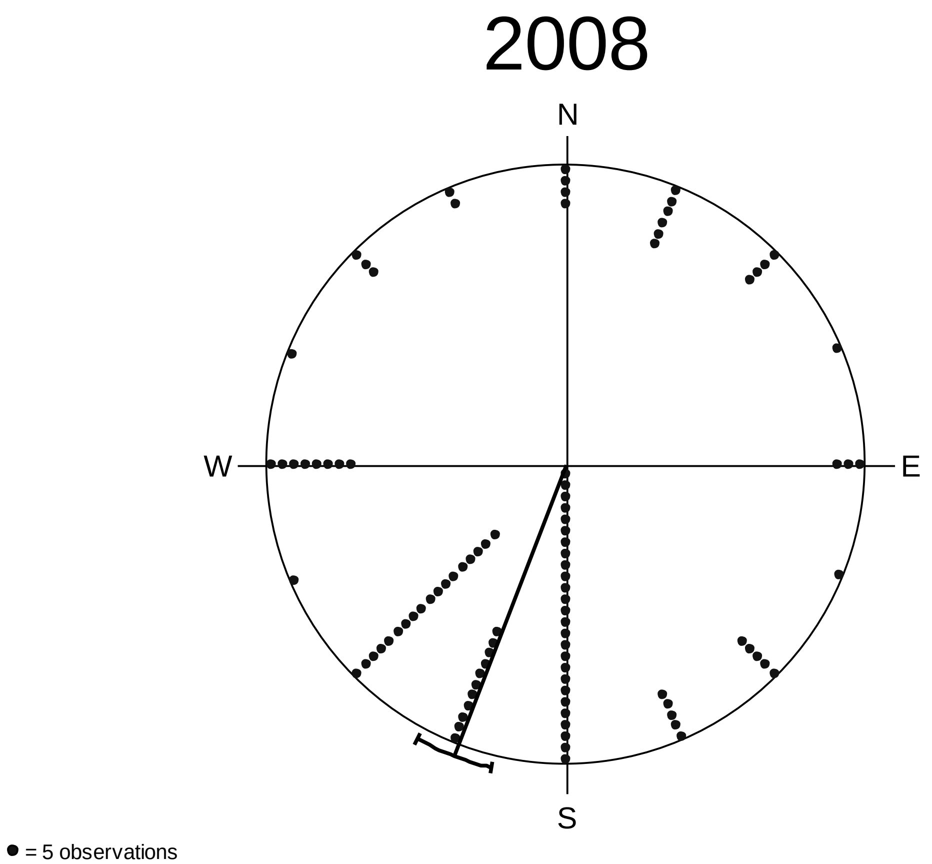
Species	2008	2009	2010	2011	2012	2013
H. rustica	158	144	204	169	172	150
M. apiaster	191	142	192	186	187	189

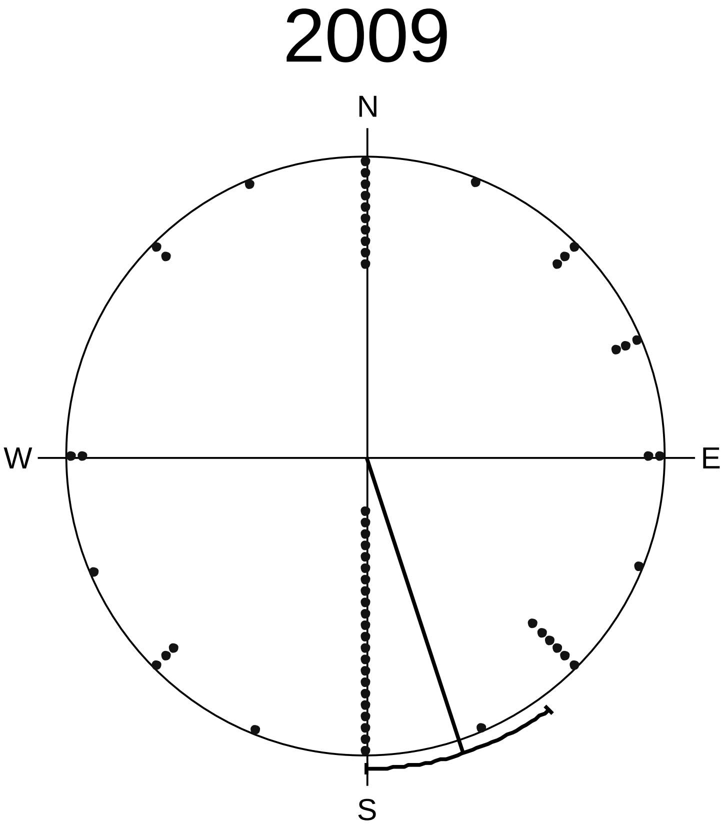
Further analysis of bee-eater *M. apiaster* flight directions in six years of autumn monitoring at SNWF is presented below through descriptive statistics (Table 9) and graphically (Figure 8).

Table 9. Basic statistical parameters of empirical flight directions obtained from visual observations during five autumn seasons in SNWF territory for the bee-eater *M. apiaster*.

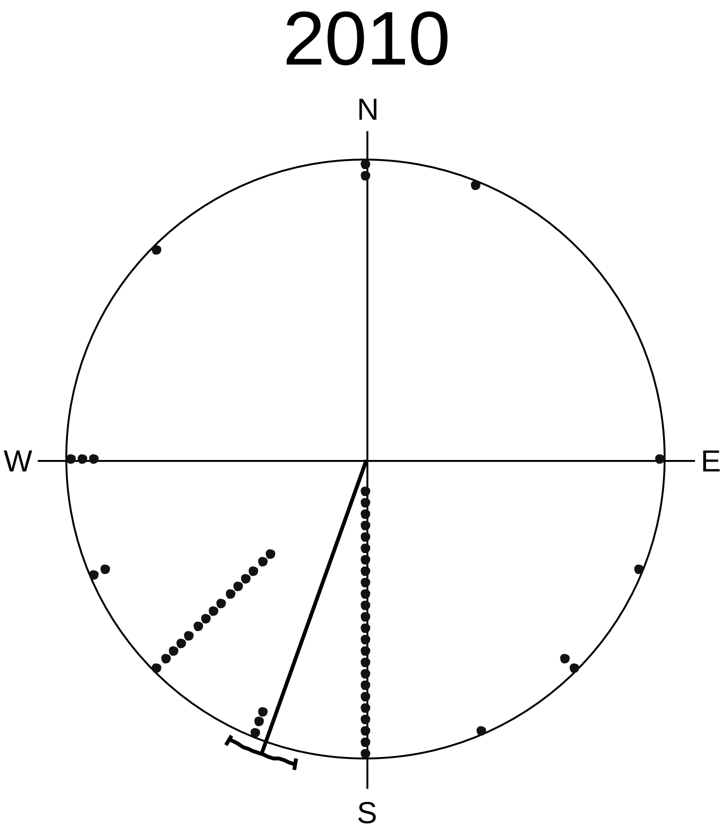
Variable	2008	2009	2010	2011	2112	2013
Data Type	Angles	Angles	Angles	Angles	Angles	Angles
Number of	461	213	159	100	108	176

Observations						
Data Grouped?	Yes	Yes	Yes	Yes	Yes	Yes
Group Width (& Number of Groups)	22,5° (16)	22,5° (16)	22,5° (16)	22,5° (16)	22,5° (16)	22,5° (16)
Mean Vector (µ)	201,237°	162,006°	199,725°	192,084°	199,845°	192,156°
Length of Mean Vector (r)	0,476	0,298	0,768	0,709	0,632	0,796
Concentration	1,081	0,624	2,516	2,062	1,649	2,818
Circular Variance	0,524	0,702	0,232	0,291	0,368	0,204
Circular Standard Deviation	69,802°	89,164°	41,682°	47,543°	54,855°	38,673°



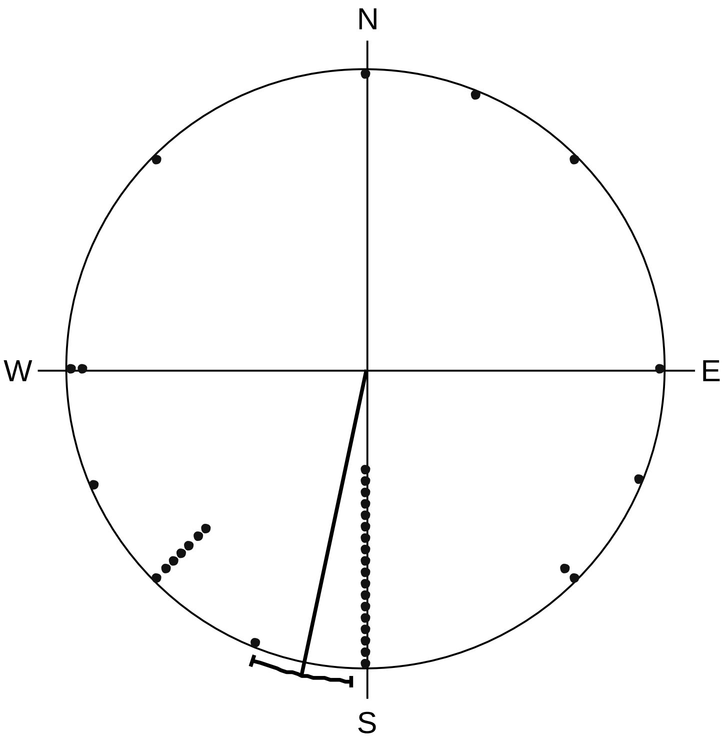


● = 4 observations



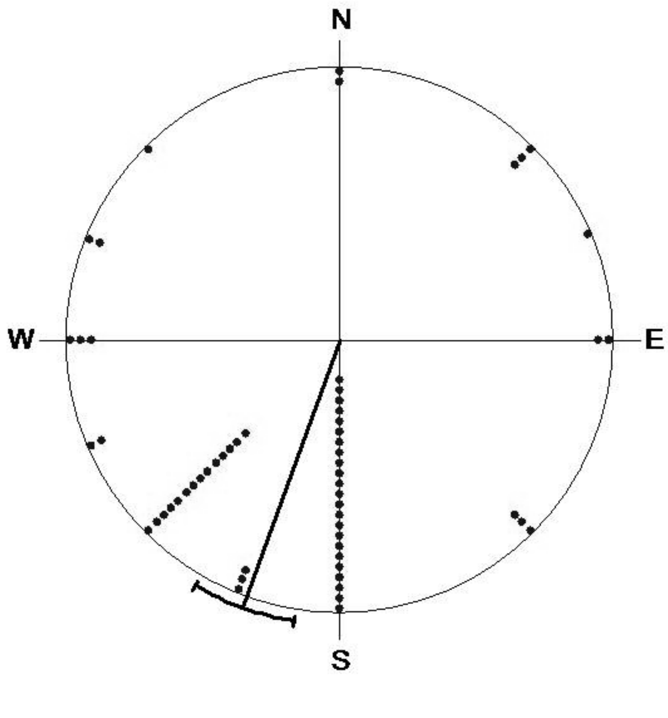
● = 3 observations

2011



● = 3 observations

2012



● = 2 observations

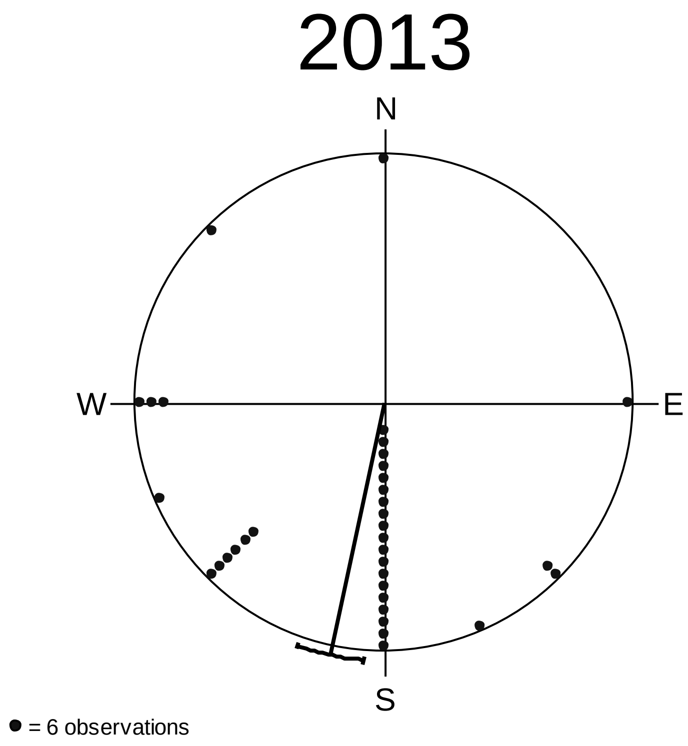


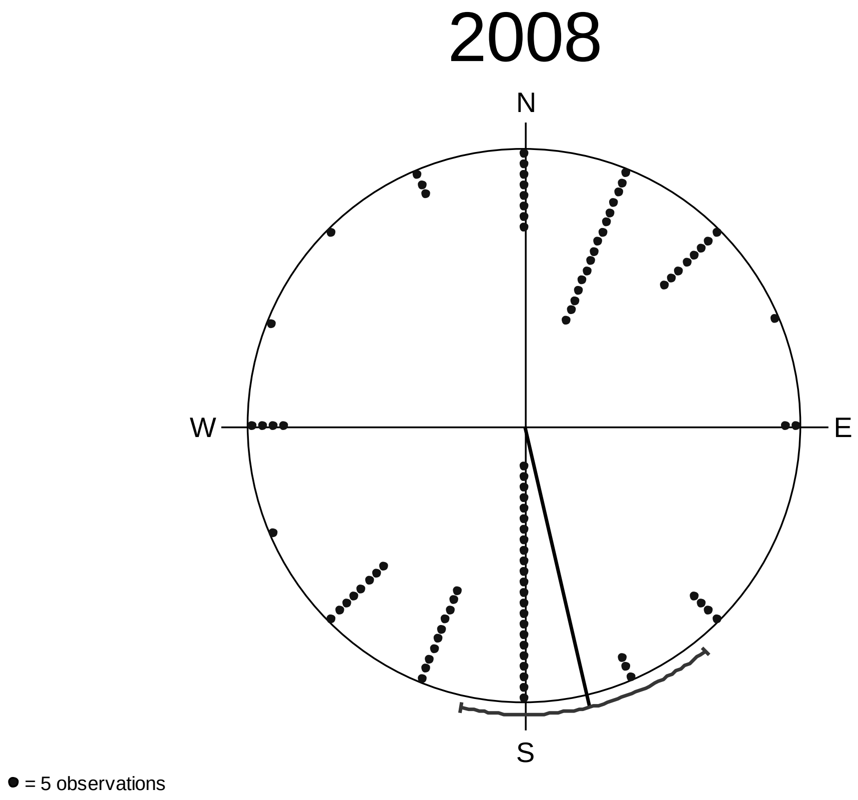
Figure 8. Graphical representations of the flight directions of bee-eaters by year.

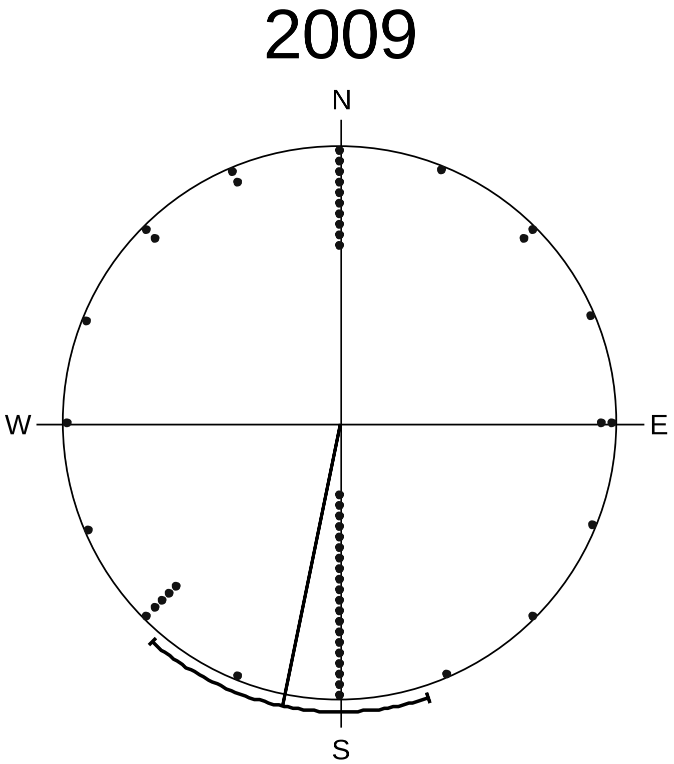
Further analysis of Barn Swallows *H. rustica* flight directions in six years of autumn monitoring at SNWF is presented below through descriptive statistics (Table 10) and graphically (Figure 9).

Table 10. Basic statistical parameters of empirically obtained flight directions of Barn Swallows after standard visual observations in six autumn seasons in SNWF territory (for details see the methods section).

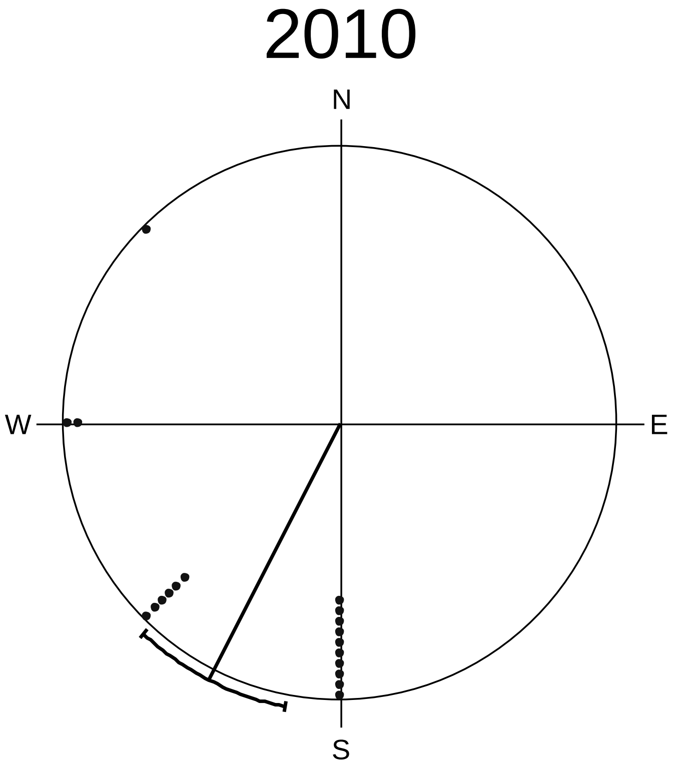
Variable	2008	2009	2010	2011	2012	2013
Data Type	Angles	Angles	Angles	Angles	Angles	Angles
Number of Observations	433	132	19	8	48	34
Group Width (& Number of Groups)	22,5° (16)	22,5° (16)	45° (8)	45° (8)	22,5° (16)	22,5° (16)
Mean Vector (μ)	167,036°	191,631°	207,178 °	173,083 °	174,061°	200,536 °
Length of Mean	0,147	0,233	0,822	0,624	0,37	0,6

Variable	2008	2009	2010	2011	2012	2013
Vector (r)						
Concentration	0,297	0,479	3,155	1,455	0,797	1,511
Circular Variance	0,853	0,767	0,178	0,376	0,63	0,4
Circular Standard Deviation	112,186°	97,802°	35,9°	55,655°	80,764°	57,875°

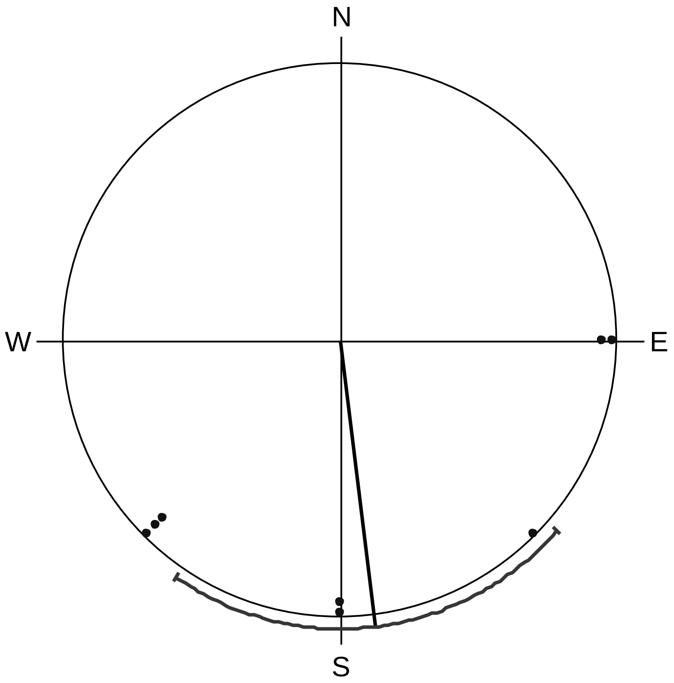




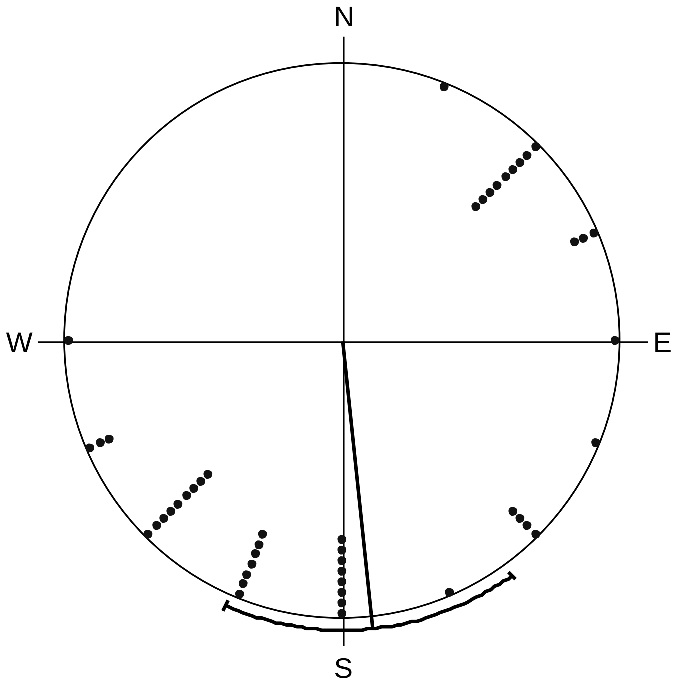
● = 3 observations



2011



2012



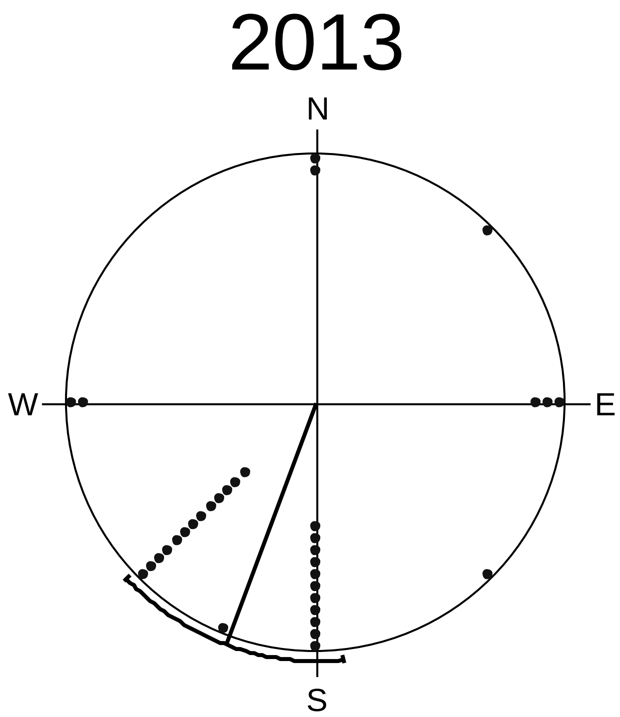


Figure 9. Graphical representations of the flight directions of Barn Swallows by year.

Circular statistics of observed directional distributions of Bee-eaters and Swallows largely corresponded to those obtained from soaring birds in the same periods. Barn Swallow flight directions were relatively less concentrated which reflected the feeding behavior of the species during migration, when feeding activity around observation points lead to registrations in multiple directions that did not always correspond with the broad seasonal migration direction in autumn.

Statistical comparisons of the directional distributions between the six autumn seasons for all soaring birds recorded in the season respectively are presented in Table 11. It is apparent from these comparisons that 2009 was an ‘exceptional’ year: mean direction of the autumn migration in 2009 was not only significantly different to that in 2008 (preconstruction), but also when compared to the direction in 2010, 2011, 2012 and 2013 (active operational) periods. As described above (Methods) these differences are most likely related to location of observation points in autumn 2009, which were moved northward in order to observe the behavior of the approaching birds in relation to testing the early warning system (TSS) for the first time in this season.

Table 11. Results of statistical analyses (Watson-Williams F-tests) comparing the directional distributions (vectors) for all flocks/individuals of soaring birds recorded across five autumn seasons. Significant differences are highlighted in grey.

F scores (lower half) and probabilities (upper half)						
	2008	2009	2010	2011	2012	2013
2008	-----	0,001	0,181	0,367	0,451	0,91
2009	11,012	-----	1,24E-06	7,71E-06	3,89E-05	7,31E-05
2010	1,809	25,553	-----	0,629	0,563	0,149
2011	0,82	21,511	0,235	-----	0,903	0,347
2012	0,571	17,91	0,336	0,015	-----	0,449
2013	0,013	16,534	2,107	0,888	0,576	-----

The pooled direction of autumn migration for all species across the five years of consistent observation points (autumn 2009 when the observation points were moved is excluded) does not deviate markedly from a southerly seasonal autumn migratory direction (as expected in the absence of the wind farm, and the location of study area), even though a deviational effect of the wind farm (in some form) should have been obvious, given the wind farm's presence in four of the five years of study (Figure 10).

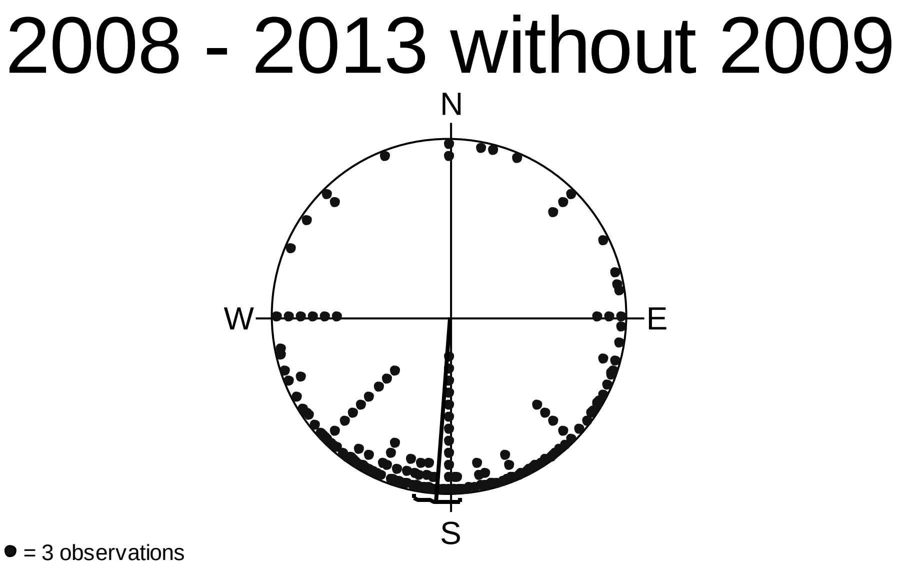


Figure 10. Pooled data on direction of autumn migration of all species across the five years of the study in SNWF territory.

The observations in autumn 2013 support all previous data collected since 2008 about directional preferences of migrating birds over SNWF territory. Overall, therefore, there is no evidence under the scale and form of analysis for a major directional change in the flight orientation behavior of autumn migrants (macro-avoidance) as a result of the wind farm. At the scales considered, birds that were observed to enter the vicinity of the wind farm did not demonstrate any macro-avoidance of the turbines which could thereby be considered as a change of migratory direction and, consequently, contribute to a major change in migratory route or any detrimental effect on energy budgets.

Spatial and temporal distribution of observed 'major' influxes of soaring migrants and Turbine Shutdown System

In autumn 2013, intensive soaring bird migration was observed mainly in the standard monitoring period 15th August – 30th September defined in previous reports (Figures 11 and 12). All the flocks subject to the TSS observed in SNWF during autumn 2013 were registered in August and September as in previous years of monitoring. The number of flocks of migratory birds in autumn 2013 was relatively higher than in previous years because of the influxes of soaring birds in days with westerly winds during the peak periods of soaring bird migration: such westerly winds were more frequent in 2013. Very few birds were recorded in October 2013, in the time when the observation period was extended (Figures 11 and 12).

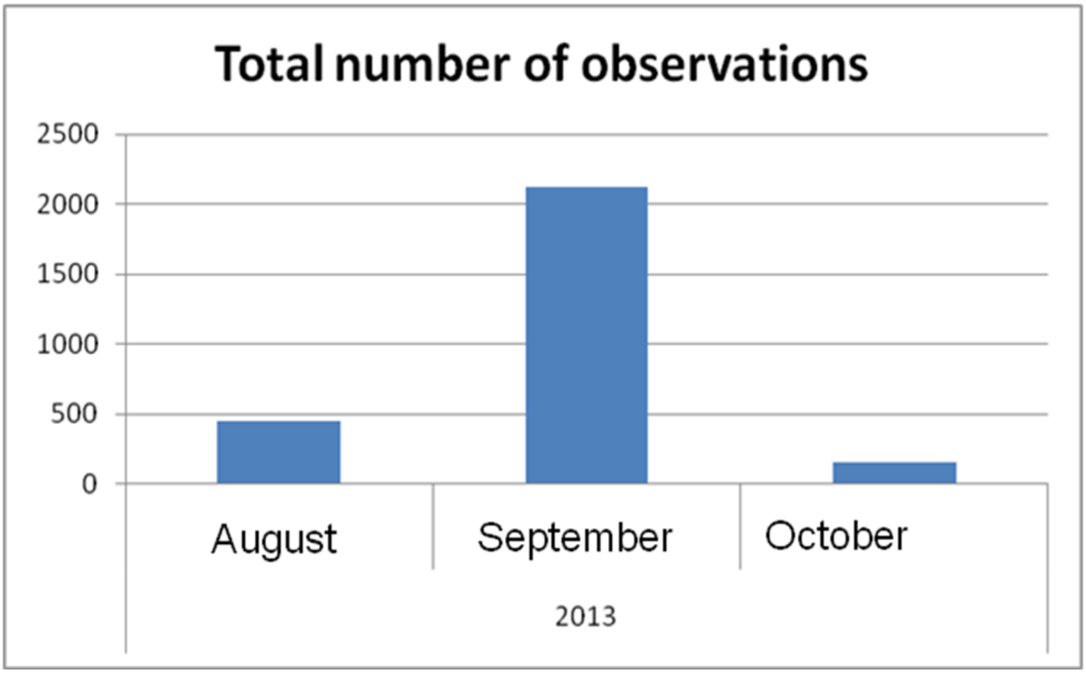


Figure 11. Distribution of all registrations of birds during the autumn season 2013.

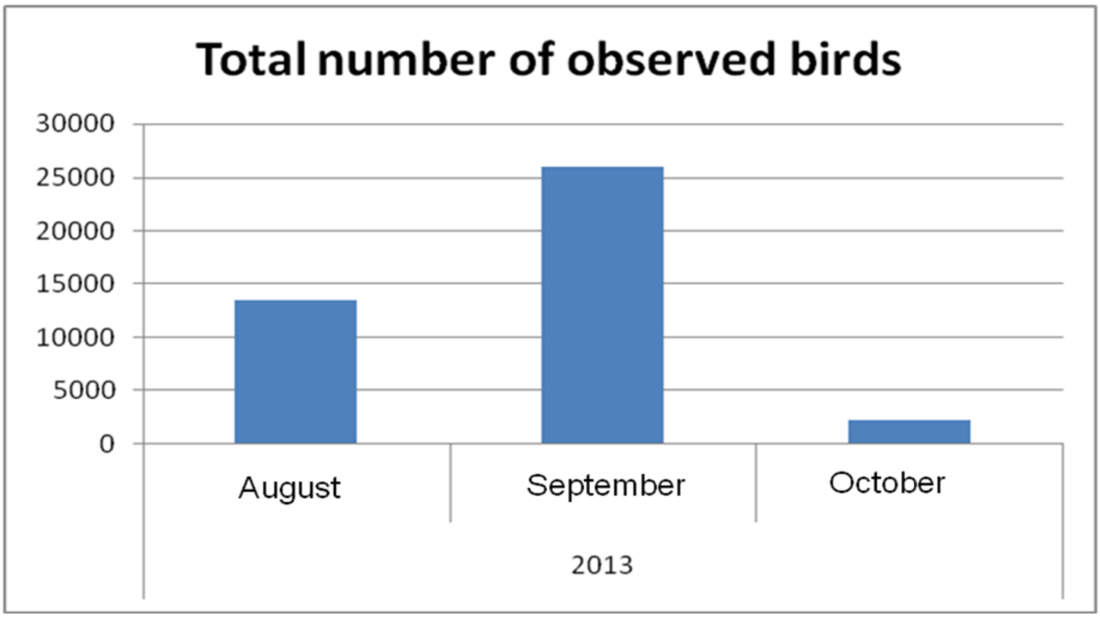


Figure 12. Absolute number of birds from 77 species observed in SNWF during autumn season 2013.

Non-prevailing westerly winds in certain periods of autumn 2013 resulted in relatively greater numbers of migrants observed in flocks, on: 30th August, 3rd , 4th 19th, 24th, 25th of September and 10th of October.

Table 12. List of observed 'major' influxes of soaring migrants in autumn 2013 at SNWF.

Date	Scientific name	English name	Number
30.08.2013	*Ciconia ciconia*	White Stork	6000
30.08.2013	*Pernis apivorus*	Honey Buzzard	around 1200 / day
30.08.2013	*Ciconia ciconia*	White Stork	180
30.08.2013	*Pernis apivorus*	Honey Buzzard	43
30.08.2013	*Pernis apivorus*	Honey Buzzard	360
30.08.2013	*Ciconia ciconia*	White Stork	172
03.09.2013	*Pernis apivorus*	Honey Buzzard	6
03.09.2013	*Milvus migrans*	Black Kite	3
03.09.2013	*Pernis apivorus*	Honey Buzzard	18
03.09.2013	*Ciconia ciconia*	White Stork	180
04.09.2013	*Pernis apivorus*	Honey Buzzard	around 150/day
11.09.2013	*Larus michahelis*	Yellow Legged Gull	60
14.09.2013	*Pelecanus onocrotalus*	White Pelican	250
16.09.2013	*Pelecanus onocrothalus*	White Pelican	2
18.09.2013	*Hieraaetus pennata*	Booted Eagle	1
18.09.2013	*Pernis apivorus*	Honey Buzzard	17
18.09.2013	*Pernis apivorus*	Honey Buzzard	22
18.09.2013	*Milvus migrans*	Black Kite	2
18.09.2013	*Ciconia nigra*	Black Stork	3
18.09.2013	*Gyps fulvus*	Griffon Vulture	1
18.09.2013	*Pernis apivorus*	Honey Buzzard	13
19.09.2013	*Aquila pomarina*	Lesser Spotted eagle	2
19.09.2013	*Pelecanus onocrothalus*	White pelican	1
19.09.2013	*Aquila pomarina*	Lesser spotted eagle	2
19.09.2013	*Pelecanus onocrothalus*	White Pelican	1
19.09.2013	*Ciconia nigra*	Black Stork	1
19.09.2013	*Ciconia ciconia*	White Stork	4
19.09.2013	*Pernis apivorus*	Honey Buzzard	48
22.09.2013	*Gyps fulvus*	Griffon Vulture	1
24.09.2013	*Pelecanus onocrothalus*	White Pelican	45
24.09.2013	*Pelecanus onocrothalus*	White Pelican	10
24.09.2013	*Aquila pomarina*	Lesser Spoted Eagle	2
25.09.2013	*Pelecanus onocrothalus*	White Pelican	22

The biggest flock observed in autunm 2013 was a flock of 6000 White Storks observed to fly parallel to, but west of SNWF, on August 30th. The latest flock of migrants was registered on 10th October when 10 White Pelicans were observed in the vicinity of SNWF. All TSS events related to birds took place in August and

September when most of the flocks passed (Table 12). The majority of flocks of soaring migrants as well as single birds of target species concerning the conditions of the TSS were observed under westerly wind conditions. This confirms previous data analyses from other years, presented in earlier reports (http://www.aesgeoenergy.com/site/Studies.html) indicating that SNWF is situated to the east of the main migratory flyway *Via Pontica* and so only occasionally hosts major numbers of migrants when -non prevailing- westerly wind conditions shift birds from the flyway.

Collision victim monitoring

The numbers of turbines searched during every autumn of operational period of the wind farm are presented in Table 13. The increase of total searches in autumn 2013 was due to the increased monitoring period, until the end of October.

Table 13. Number of carcass searches per autumn and turbine in the operational period of SNWF.

Turbine number	**Autumn 2010**	**Autumn 2011**	**Autumn 2012**	**Autumn 2013**	**Total searches**
8	6	8	8	10	40
9	6	8	7	10	40
10	6	7	10	10	43
11	6	7	9	11	44
12	6	10	9	11	48
13	6	9	9	9	46
14	6	9	7	10	46
15	6	9	7	10	47
16	6	6	9	10	47
17	6	6	9	12	50
18	6	4	8	12	48
19	6	8	9	12	54
20	6	9	10	12	57
21	1	6	8	10	46

Turbine number	**Autumn 2010**	**Autumn 2011**	**Autumn 2012**	**Autumn 2013**	**Total searches**
22	6	6	8	13	55
23	6	6	8	10	53
24	6	7	7	10	54
25	6	2	8	9	50
26	6	8	8	13	61
27	6	2	8	11	54
28	6	2	5	12	53
29	6	8	7	10	60
31	1	9	7	11	59
32	6	9	8	11	66
33	6	8	7	9	63
34	6	8	7	10	65
35	7	8	7	10	67
36	6	9	7	10	68
37	6	9	9	13	74
38	6	9	6	10	69
39	6	8	7	10	70
40	6	7	8	9	70
41	6	7	6	11	71
42	7	7	7	10	73
43	11	9	7	10	80
44	11	7	7	10	79
45	6	8	8	10	77
46	6	9	8	10	79
47	6	9	7	10	79
48	6	9	7	10	80
49	6	10	7	13	85
50	6	10	7	11	84
51	6	9	7	9	82
52	6	9	5	9	81
53	6	9	6	10	84

Turbine number	Autumn 2010	Autumn 2011	Autumn 2012	Autumn 2013	Total searches
54	6	8	7	8	83
55	6	9	7	10	87
56	6	8	7	9	86
57	6	9	7	8	87
58	6	9	7	9	89
59	7	9	7	9	91
60	6	9	7	11	93
Total	**315**	**404**	**389**	**537**	**1645**

Under this search regime during the autumn migration period, 11 remains of birds have been found that can be attributed to collision with turbine blades, from 2010 - 2013. In autumn 2013 two dead birds that could be attributed to collisions with turbine blades were found: one Common Swift (*Apus apus*) and one Golden Oriole (*Oreolus oreolus*) were discovered during systematic searches, on 22nd and 25th of August, respectively. The number of birds found dead under turbines from 2010 to 2013, and that could be attributable to strike with turbine blades, along with respective species' conservation status according to IUCN, are presented in Table 14.

Table 14. The number of carcasses found in periods of autumn migration during four years of operation of SNWF. For details see Methods and reports on the autumn migration period in previous years.

Species	Carcasses attributable to collision	Conservation status according to IUCN
Apus apus	1	Least Concern (IUCN 3.1)
Acrocephalus palustris	1	Least Concern (IUCN 3.1)
Delichon urbicum	2	Least Concern (IUCN 3.1)
Gyps fulvus	1	Least Concern (IUCN 3.1)
Hirundo rustica	2	Least Concern (IUCN 3.1)
Lanius collurio	1	Least Concern (IUCN 3.1)

Species	Carcasses attributable to collision	Conservation status according to IUCN
Larus ridibundus	1	Least Concern (IUCN 3.1)
Oreolus oreolus	1	Least Concern (IUCN 3.1)
Sylvia atricapilla	1	Least Concern (IUCN 3.1)
Total	**11**	

IUCN criteria were used for evaluation of bird conservation status because of the unknown origin of migratory populations in autumn when the movements of birds found dead can cover different continents. National criteria for the same species would be applicable for breeding populations of the same species in the breeding period in spring. The mortality rate at SNWF for four autumn seasons of carcass searches under every turbine every week resulted in 0.05 birds per turbine per migratory season in total, and cannot be remotely considered influential in the demographics of populations of any species recorded.

CONCLUSIONS

Additional data collected in the autumn 2013 by standard methods with consistent and comparable to previous years efforts confirmed the previous results and allowed evaluation of the long term effect of SNWF on bird migration. The long term monitoring in the same territory have allowed the following conclusions:

1. The numbers of species passing through the SNWF territory in autumn varied by year with no trend for a decrease after SNWF was constructed and started its operation (Table 1).
2. The absolute number of observed birds naturally varied by year but with no trend for a decrease after SNWF was constructed and started its operation (Table 2).
3. The altitude of flight varied by years but with no overall trend for an increase after SNWF was constructed and started its operation (Table 4 and Figure 6).
4. There is no evidence for change in migratory direction (avoidance) associated with the wind farm territory. At a gross scale, birds did not demonstrate macro-avoidance of the turbines that could be considered as a change of

migratory direction and, thereby, a change of migratory route (Table 7 and Table 11).

5. The occurrence of autumn migrants in all six autumn seasons was strongly correlated with typically short periods of a few days when strong westerly winds occurred.
6. During four years of wind farm operation, carcass searches during the autumn periods revealed a total of 11 collision victims. Records of collision mortality do not indicate any possibility of an adverse impact of SNWF on any bird population passing through the wind farm territory.
7. The application of the Turbine Shutdown System (TSS) may have had a significant contribution to the low level of direct mortality registered in the operational period of SNWF.
8. The substantial data collected in six autumn seasons indicate that the operation of SNWF does not constitute a major obstacle or threat, either physically or demographically, to populations of migrants passing through its environs.

REFERENCES

Batschelet E. 1981. Circular Statistics in Biology. Academic Press Inc., New York.

Bibby, C. J., Burgess, N.D. & Hill, D.H. 1992. Bird Census Techniques. London, UK: Academic Press.

Madders, M. & Whitfield, D.P. 2006. Upland raptors and the assessment of wind farm impacts. Ibis 148 (Suppl. 1), 43-56.

Masden, E.A., Haydon, D.T., Fox, A.D., Furness, R.W., Bullman, R., and Desholm, M. 2009. Barriers to movement: impacts of wind farms on migrating birds. ICES J. Mar. Sci. 66, 746–753.

Masden, E.A., Haydon, D.T., Fox, A.D., and Furness, R.W. 2010. Barriers to movement: modelling energetic costs of avoiding marine wind farms amongst breeding seabirds. Marine Pollution Bulletin 60, 1085–1091.

Michev T., Profirov L.A., Karaivanov N. P., Michev B. T. 2012. Migration of Soaring Birds over Bulgaria. 2012 Acta zool. Bulg., 64 (1), 33-41

Morrison, M. 1998. Avian Risk and Fatality Protocol. Report NREL/SR-500-24997. National Renewable Energy Laboratory. U.S. Department of Energy. 29