Demonstration of Good Practices to minimize impacts of Wind farms on Biodiversity in Greece - Presentation of the project LIFE12BIO/GR/000554

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Abstract
At the end of 2015 the total installed wind power capacity in Greece was of 2.152 GW with an electrical output from wind generation of 3.5 TWh, a contribution to the national electric demand of 7.1%. Despite the continuously increase of the installed wind farms Greek wind energy will have to increase significantly in order to reach the target of 7.5 GW by 2020 set by the National Renewable Energy Action Plan. This objective will consequently lead to a drastic growth of wind farms in Greece which possibly will increase the impacts causing on biodiversity by the operation of wind farms, in regional and potentially on national level. The extent and severity of these impacts greatly depends on proper wind farm sitting, relevant environmental permits, mitigation measures adopted, and in extreme cases on the effectiveness of compensation measures applied.
The present paper focuses on the work implemented within the LIFE project entitled "Demonstration of good practices to minimize impacts of wind farms on biodiversity in Greece, LIFE12BIO/GR/000554" which aims to demonstrate, state-of-the-art methods and approaches that will improve the compatibility of wind farm development, with the EU biodiversity conservation targets, and to develop prescriptions and guidelines that will enable Greek state authorities and wind farm developers to effectively plan, implement and regularly evaluate the performance of the mitigation technologies. In addition the progress of the wind energy in Greece during the last decade and its benefits will be presented in this paper.
Keywords: wind farms, wildlife, biodiversity, early warning systems

1. INTRODUCTION

The project "Demonstration of good practices to minimize impacts of wind farms on biodiversity in Greece, LIFE12BIO/GR/000554" started in 2013 and will end in 2017. It aims to demonstrate state-of-the-art methods and approaches that will improve the compatibility of wind farm development with the EU biodiversity conservation targets and develop prescriptions and guidelines that will enable Greek state authorities and wind farm developers to effectively plan, implement and regularly evaluate the performance of the mitigation technologies, for the benefit of affected biodiversity, with special reference to birds and bats. More specifically the project targets at demonstrative implementation of integrated approaches in post-construction mitigation, to reduce impacts on biodiversity, in accordance with EU guidance document "Wind energy development and Natura 2000" and on the basis of available novel and modern methods and technologies. The assessment of the extent to which the use of modern methods and technologies can reduce the impacts on biodiversity, whilst maintaining the power output of wind farms, has also examined and important outcomes have been achieved.
In addition, within the project several activities concerning the purchase, installation and testing of the early warning systems and mitigation technologies, demonstration and training activities as well as public awareness actions have been realized. Project's demonstration actions are implemented at the demonstration wind farm site - Park of Energy Awareness-PENA of CRES, the only

demonstration wind farm in the country, which provides practical education and training for wind farm and renewable energy issues in university students, engineers and other stakeholders in Greece. Figure 1 presents a view of the 3.01 MW CRES demonstration wind farm in Keratea Attikis. CRES wind farm started its operation in 2001 while PENA is open for the public from 2008. The wind farm consists of five (5) wind turbines of different technologies, two (2) prototypes and three (3) commercial of nominal capacities from 500 kW to 750kW each. Two of the wind farm's wind turbines, a VESTAS V47/660kW and a NEG MICON/750 kW are used for the testing of the operation and performance evaluation of the early warning systems, such as of the video-based DTBird system, thermal imagery, ornithological radar and of four different models of bat detectors.

Furthermore, the project website www.windfarms-wildlife.gr provides information on the progress and the results of the project. One of the most important deliverables of the project available at the project's site, is the Good Practice Guide (GPG), which aims to provide an up-to-date overview of the available good practices for the mitigation of impacts of wind energy development on aerial biodiversity, more specifically on birds and bats, based on the available methods and technologies which have been already successfully applied in practice.

Figure 1. View of the 3.01 MW CRES demonstration wind farm at Keratea Attikis, Greece

2. WIND ENERGY PROGRESS IN GREECE

EU has adopted an ambitious plan of increasing the proportion of renewable energy to 20% of the total energy production by 2020. The wind energy is one of the main renewable energy sources to achieve this objective.

In Greece, during the last decade, there is a significant increase of wind farms installations and obviously in wind power capacity. At the end of 2015 the total installed wind power capacity was of 2.152 GW with an electrical output from wind generation of 3.5 TWh, a contribution to the national electric demand of 7.1%. Figure 2 presents the yearly rise of wind capacity in Greece from 2005 to 2015.

Despite the continuously increase of the installed wind farms Greek wind energy will have to increase significantly in order to reach the target of 7.5 GW by 2020 set by the National Renewable Energy Action Plan [1]. This objective will consequently lead to a drastic increase of wind farms which in certain cases may pose a threat to biodiversity on local, regional and potentially on national lever. In order the effort to reduce emissions of greenhouse gases and the dependence on fossil fuels do not generate impacts on the biodiversity, several measures have to be taken in consideration when planning a wind farm. The extend and severity of the possible impacts on the biodiversity greatly depends on the:

- proper wind farm siting,
- relevant environmental permits,
- mitigation measures adopted, and in extreme cases on the
- effectiveness of compensation measures applied.

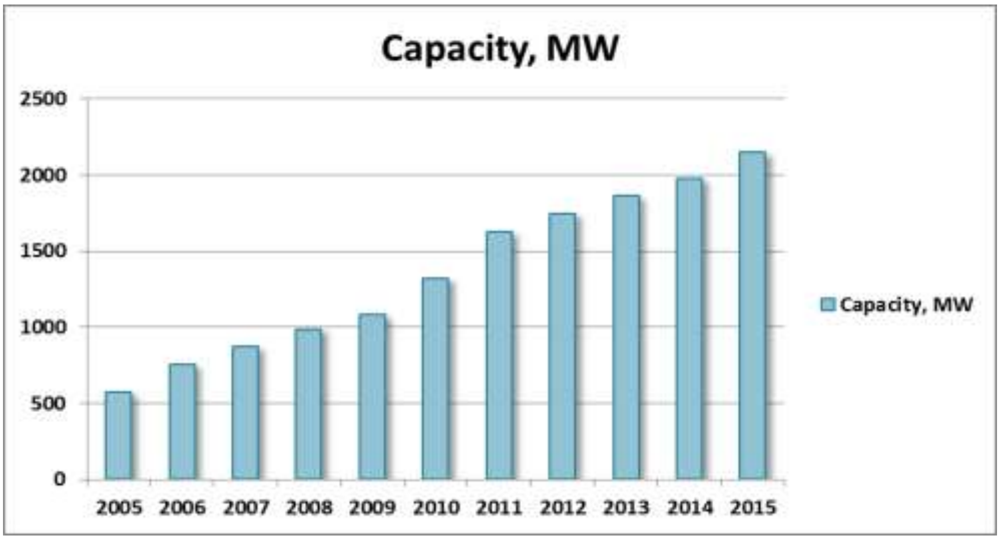

Figure 2. Wind capacity growth in Greece, [2]

The evidence available in a wide range of scientific studies and technical reports worldwide indicates that appropriately sited and well-designed wind energy developments do not in general pose a significant threat to biodiversity. On the other hand there are cases of wind energy developments which caused significant negative impacts to biodiversity.

3. THE CURRENT SITUATION IN GREECE

There is a wide range of possible interactions between the biodiversity and wind farms, including their associated infrastructure (e.g. access roads, powerlines, meteorological masts, etc.) which may lead to significant impacts to wildlife. Biodiversity groups which have been identified as most sensitive to wind farm impacts include birds, bats, marine mammals and certain vulnerable habitat types. In general there are five main types of potential impacts of wind farms on wildlife and habitats. These impacts are as follows:

- Collision risk, leading to direct mortality
- Disturbance and/or displacement of sensitive species
- Habitat loss or degradation
- Barrier effects, causing changes in flight patterns
- Indirect effects on species habitats and prey species

These impacts vary greatly among different wind farms and for that reason the assessment of the impacts and their mitigation must be carried out on case-by-case basis. The above impacts may be significantly enhanced due to cumulative impacts of multiple wind farms or other developments or human activities within the same area.

In Greece, the framework for the assessment of the impacts and their mitigation is set by the Environmental Impact Assessment (EIA) and may be further supported, if required, by the Appropriate Assessment (AA). The EIA and AA are carried out by the wind farm developer, in order to consider their results in the planning of the project, and avoid, reduce and mitigate its impacts. In addition these assessments provide the authorities with means of evaluating the impacts of the project before it is approved. In case there are other more suitable alternative solutions a project plan might need to be redesigned. If despite its expected significant impacts on biodiversity,

the project is approved (due to e.g. overriding public interests) appropriate mitigation and compensation measures need to be designed to be applied. The design of measures to prevent and mitigate impacts of wind farms on biodiversity, of monitoring plans as well as compensation measures, if required, is a constituent part of the Appropriate Assessment.
The general specifications and requirements for the EIA and AA, particularly for the developments involving protected areas, species or habitats have been set legally both at the EU and the national level. In addition and support of this legal framework, different various guidelines and good practice guides have been produced to provide further information on the implementation of EIA for wind energy developments, in relation to Natura 2000 network, birds and bats, [3].
In addition to the above documents, the implemented within this project Good Practice Guide (GPG) further provides a review of available modern methods and technologies, which have been developed during the last decade, and allow for a significant enhancement and improvement of efficiency mitigation of impacts of wind farms on birds and bats. In addition the Geographical Decision Support Tool which is also being developed within the project will allow key stakeholders to plan actions related to impacts of wind farms on biodiversity.
Within the last years more than 20 new wind farm applications have been approved in Greece, under the strict provision of involving modern mitigation technologies to minimize biodiversity impacts. However, there is a significant lack of knowledge, experience and know-how in planning for biodiversity compatible wind farm operation and in the application of modern technologies and methods for site Environmental Impact Assessments, post-construction monitoring and mitigation measures. For this purpose the operation of modern technologies, including radar, thermal imaging, video surveillance and bat detection, has been demonstrated at CRES demonstration wind farm at Keratea Attikis, as well as, in private wind farms.

4. EARLY WARNING SYSTEMS AND MITIGATION MEASURES

Modern technologies and best practices can help to avoid and/or to reduce to a tolerable level the impacts of the wind farms on the biodiversity during their design, construction and operation. An important issue during the operation of the wind farms is the use of the so called “early warning systems”, which allow the continuous observation of the birds and simultaneously the control of the operation of the wind turbines, aiming on the prevention of possible collisions.

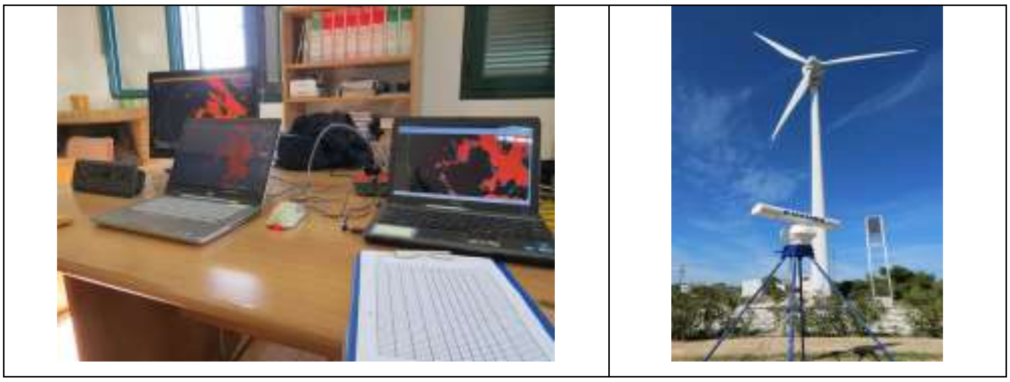

Figure 3. Demonstration of the ornithological radar at CRES Wind farm

These systems are in operation in several countries, such as in the USA, Spain, The Netherlands, Norway, U.K., and in recent years also in Greece.
The use of the early warning/monitoring systems such as:

- ornithological radars, (see Figure 3)
- video surveillance systems (DTBird system), (Figure 4)
- thermal cameras (Figure 5),
- bioacoustic monitoring systems (bat detectors and sound recorders), (Figure 6, 7)

along with traditional methods of data collection (e.g optical observations), and information on the responses of birds to wind turbines in the management and operation of wind farms, can help to reduce the impact on birds and biodiversity during the operation stage, as well as significantly improve the biodiversity data on the space use within a planned wind farm site during the planning stage, thus allowing for a better siting and design of the wind farm as well as improved design of the potential mitigation measures to be applied.

An ornithological radar, which is custom adjusted commercial marine surveillance radar is being demonstratively used at CRES as well as other commercial wind farms in Greece to evaluate its applicability as an early-warning system at wind farms with different bird species composition and different landscape types. The radar is used for detecting and tracking both local bird movements as well mass migratory movements, day and night. Based on the international experience and experience gained through the application of the radar system in Greece, the optimal operation of the radar is in collaboration with a team of field ornithologist, where the radar detect birds at distances of several kilometers away from the wind farms, which the field ornithologist identify species and assess the collision risks for each bird or bird flock which enters the wider area of the wind farm.

In Greece there is limited experience and available data on the performance of radar systems in areas with intense birds' migration. However, in the literature there are important references which prove the importance of their use. An indicated example concerns with the Straits of Gibraltar, the main point of concentration for soaring birds migrating between Europe and Africa. In this case a study was carried out at 13 wind farms at Tarifa, Cadiz, Spain, before and after selective turbine stopping programs were carried out to mitigate bird mortality, [4, 5]. Griffon vultures (Gyps fulvus) was the most-frequent species involved in wind farm caused mortality. The surveillance program focused on approximately 10% of the wind turbines which have be identified as most dangerous. Through this shutdown of demand procedure the Griffon vulture mortality was reduced by approximately 50%. This was achieved through 4408 turbine stops per year (during 2008-9), equivalent to a mean of 18.06 stops per turbine. The median duration of stops was on an average of 6h per year which leads to an average reduction of energy production by only 0.07%. This case demonstrates that shutdown on demand involving a limited number of wind turbines posing the greatest collision risk to birds can greatly reduce collision mortality, with a minor reduction of overall energy production.

Figure 4. The DTBird system at NEG MICON/750 kW wind turbine at CRES Demonstration wind farm

The DTBird system is a semi-automated system that detects flying birds in real time, and takes automatic actions, such as bird Warning and Dissuasion procedures to scare birds away from the wind farm, or wind turbine stop to control the operation of specific wind turbines in case of increased risk of bird collision with wind turbines. More analytically the operation of the system consists of the five following actions:

- detection continuously monitors surveillance area and detects flying birds in real time.

- dissuasion emits warning and dissuasion signals to birds flying in moderate/high collision risk areas.
- stop control sends a stop signal to the wind turbine according to collision risk of birds.
- collision control detects and records potential collisions.

Based on the data from the operation of the DTBird system at NEG MICON wind turbine at CRES wind farm the total duration of automatic stops of the operation of the wind turbine (WT) was around 4 hours at a period of 8 months. According to DTBird manufacturer's experience the stops duration of the wind turbines with DTBrid systems around the world vary from 2 to 20 hrs/WT/year with an average below 8 hrs./WT/year, including the time required for the reactivation of the wind turbine.

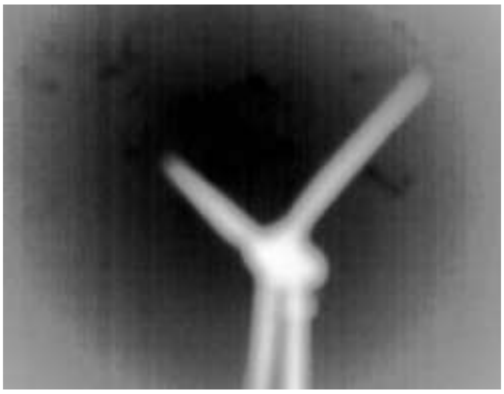

Figure 5. Observations with thermal camera at CRES demonstration wind farm

In addition, identification of bird species recorded by the system, as well as the identification of false positives or false negatives is done manually by properly trained ornithologists who allow for the optimal setting of the system's operation, as well as, for the production of automated reports of the system's operation. Furthermore, the operation of the system needs to be accompanied by regular carcass searches around wind turbines, to verify the levels of bird mortality, if any.
The bat detectors/recorders are ultrasound recording units used to recording bat calls. As it is known bats use high frequency calls normally beyond the range of human hearing to built-up a sound picture of their surroundings to move, orientate and hunt

Figure 6. Installation of a bat detector system at VESTAS V47/660 kW wind turbine at CRES demonstration wind farm

The echolocation system enables them to wing their way through the dark night hunting the smallest of insects. A bat detector makes these echolocation calls detectable and audible to humans- and because different bat species hunt different prey and are different sizes they make different calls which can help to identify species and activities of bats. This way it is possible to identify bat hotspots and the period of main activities and adjust the wind farm operation accordingly.

In this project three different models of bat detector of automated bat detectors/recorders have been installed and operated in two wind turbines (NEG MICON, VESTAS/V47) of CRES wind farm in order to test and evaluate their performance, as well as to determine the bat activities at wind turbine rotor heights. In addition a mobile bat detector is used to record bat activities at ground level and to allow for the comparison of bat species composition and activities at ground level vs. rotor height.

Figure 7. Installation of a bat detector system at NEG MICON/750 kW wind turbine at CRES demonstration wind farm

5. CONCLUSIONS

The development of wind power offers promise of contributing to renewable energy portfolios to reduce greenhouse gas emissions from carbon-based sources, which contribute to accelerating climate change. Given the projected growth of wind power generation, it is crucial that future analysis of the impacts of wind energy development consider population effects for species of bats and birds which are considered sensitive to impacts of wind farms. These impacts can be eliminated first of all with the proper siting of the wind farms. When properly sited the impacts can be further reduced with the use of early warning systems and mitigation measures, when these are required. The work implemented within the LIFE project LIFE12BIO/GR/000554 will contribute in the successful growth of the wind farms and on the minimization of their impacts on biodiversity in Greece and in other Mediterranean countries.

6. AKNOWLEDGMENTS

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