# ENVIRONMENTAL IMPACTS
## CAUSED BY EOLIC ENERGY

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### 1.-INTRODUCTION

Wind farms are industrial projects which meet the appropriate conditions in order to achieve a good environmental integration. They are endogenous activities derived from using existing resources and with good development expectations. At the same time wind farms optimize the relationships and the multiple use of the system. They respect the renewal rates of natural resources. They keep the environmental coherence of: ecosystems, habitats, landscape, environment offer and social demand. Wind farms are identified with clean non-polluting facilities or companies, without serious negative environment consequences, which create employment, and are independent from conventional fuels and produce wealth.

Eolic energy, used since long age, ows a great deal of its recent development to the fact that it is an energy production system where environment sustainability is joined with the use of a renewable natural resource. This turns it into the electric energy generation system, with highest possibilities of development. The initiative of installing wind farms in the Autonomous Region of Galicia is based upon the optimum eolic potential of the region (Galician Eolic Chart, 1988), which has been exploited since the seventeenth century, with the industrial development strategy induced after drawing up the new Energy Development Plans and, particularly, with the Galician Eolic Plan.

Since the Kyoto summit, where the limits for the emission of polluting gases were set up, different programmes in order to promote the use of endogenous energy sources have been developed both at the community and national levels. Examples of these programmes are: “The White Paper on Renewable Energies” of the EU, which

sets up the need that 12% of the primary energy demand be supplied with renewable energies by 2010; the "Plan for the Promotion of Renewable Energies" of Spain and the "White Paper on Energy", which estimates that the electricity production from renewable energies in Galicia reaches about 1,574 ktep (kiloton of oil equivalent) by 2010, which means an installed power of 6,067 MW (megawatts).

Initially, wind aerogenerators facilities to obtain electric power were not included among the cases of projects needing an Environmental Impact Assessment (EIA) nor in Directive 85/337/EC, nor in Directive 97/11/EC (in force form March 1999). However, in this last one, "Those facilities using wind force in order to produce Energy (Wind Farms)", appear in section 3 on Industry and Energy of Annex II, where those projects which in compliance with the environment standards set up and the applicable selection criteria may be subject to Environment Impact Assessment, are listed. The rules for the incorporation to European standards to the basic state legislation contributed nothing new till the enactment of the Royal Decree-Law 9/2000 dated October 6th, later modified by **Law 6/2001 dated May 8th,** which currently is included in the state basic legislation.

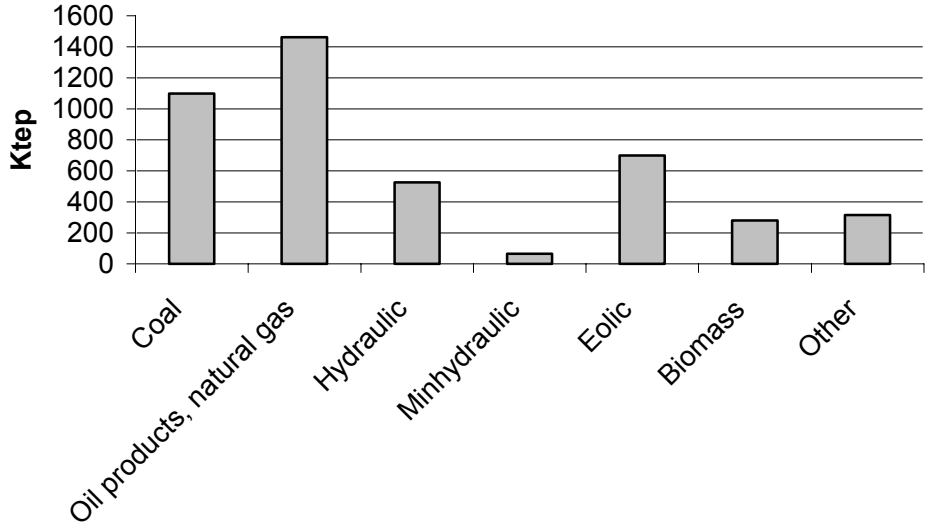
Though the Galician Eolic Sectoral Plan (1995) was formulated without formal environmental considerations, mainly taking into account the resource availability and the terms and conditions envisaged in higher energy development plans, Galicia was a pioneer in considering environmental studies in eolic projects. The Galician Government of Industry and Trade, through Decree 205/95 dated July 6th, whereby eolic energy use in Galicia was regulated, and with the aim of attaining a harmonic development and knowing the environmental impacts that such a facility may cause, set up the need to carry out a Environment Effect Study as a precautionary measure, or where appropriate a formal Environment Impact Assessment, for each wind farm pursuant to the regional regulations in force at that time (Decree 442/90 and Decree 327/91).

## 2.- BRIEF REFERENCE TO THE SITUATION AND PROSPECTS OF EOLIC ENERGY IN GALICIA

The main sources of **primary energy with native origin** which are exploited in Galicia, in order of importance are: coal, water, biomass, waste and wind. Coal and hydraulic energy alone accounted for the 77.19% of the Galician primary energy. Biomass and waste almost accounted for a 20% while eolic and minihydraulic energy, to this date, account for not very significant percentages, a maximum of 2%.

Taking into account the current and future exploitation trends of native and imported resources, fossil and non-renewable ones, as well as the increase in demand, the energy scene for 2010 emphasizes as most significant fact, the strong increase in the exploitation of eolic resources. The energy production from this source with an installed power of 257 MW was 30 ktep in 1998, and increased to 120 ktep in 2000. The installation of the 3,000 MW envisaged in the Galician Eolic Plan will imply a final energy available in the form of electricity of 700 ktep. Thus, by 2010 the 42% of the energy will be from native origin and with renewable nature. (Figure 1).

Figure 1. Estimation of energy and its source in Galician by the year 2010



## 3.- THE ASSESSMENT OF THE ENVIRONMENT IMPACT OF WIND FARMS

The application of the procedure of environment effect study, and even Environment Impact Assessment to the wind farm projects enabled to adapt and improve the actions resulting from this kind of facilities by applying corrective measures, both during the technical design stage, and during the performance and maintenance, as well as the implementation of follow-up and environmental monitoring plans of those environment indicators being affected throughout the operation time. But the procedure in itself was precarious and inadequate due to the scope and content of the studies, the working scale and the detail degree that the regulations required for this kind of assessments. Wind farms require the occupation of reduced portions of land, but distributed in very wide geographical areas, and therefore, environment assessments farm by farm did not solve the problems posed by the encumbrances of wide areas of land in Galicia, such as impacts on edaphic formations associated with floral communities of natural interest: turbophils and heaths so widespread in Galicia, alterations to the bird fauna community and socio-economic effects. Furthermore, despite all projects obeyed a higher planning system, pursuant to an administrative procedure granting the research licence in an area with preferential right to the installation, in many cases, the environmental features of the selected geographical area conditioned to a great extent the carrying out of the project, not only due to the existence of possible environmental protected values, but also due to the land geotechnical conditions themselves or the scarce bearing capacity.

Due to the enactment of the new directive, the development trends of the assessment procedures, of environmental impact assessment and the application of corrective measures as a whole, the environment assessment procedures for such projects were made under the point of view of the strategic Environmental impact assessment since 1997 in order to preserve environmental systems in general and promote sustainable development in particular. To this purpose, apart from performing precautionary environmental studies farm by farm, preventive studies were carried out mainly referred to interesting natural areas (LIC areas) and the preservation of priority natural habitats in the industrial estates selected by its eolic potential. This work determined on a first scale the delimitation of areas with different protection degrees.

The enactment of **Law 6/2001**, dated May 8th, amending Royal Decree Legislative 1302/1986 dated June 28th, introduces provisions aimed at clarifying, completing and improving regulations on the assessment procedure in the state basic legislation. In accordance with the articles of the regulations, "*Those facilities using wind force in order to produce energy (Wind Farms) having 50 or more aerogenerators or located less than 2 km from another wind farm"* are subject to compulsory Environmental Impact Assessment. (Paragraph i, Group 3 of Annex I).

Besides, a minimum compulsory content is envisaged for all studies comprising at least the following data:

a) *General description of the project and predictable requirements over time, regarding soil and other natural resources use. Estimate of the types and amount of waste, spillages and matter or resulting energy emissions.*

b) *A statement of the main alternatives under study and a justification of the main reasons for the adopted solution, taking into account environmental effects.* In practice, this implies the need of performing a strategic environmental impact assessment in the carrying out stage of the project.

c) *Assessment of the direct and indirect foreseeable effects of the project on population, fauna, flora, soil, air, water, climate factors, landscape and material assets including archaeological and historic artistic heritage..*

d) *Measures envisaged in order to reduce, eliminate or compensate significant environmental effects.*

e) *Environmental monitoring programme*

f) *Summary of the study and conclusions worded in easily understandable terms. Report, where appropriate, of the informative or technical difficulties found in its drawing up.*

Recently, the European Community has published **Directive 2001/42/CE**, on the Environmental Impact Assessment of Plans and Programmes. The aim is to achieve a high level of environmental protection and contribute to the integration of environmental values in the adoption of plans and programmes. This approach is stated in the **Decree 302/2001,** whereby the use of eolic energy in Galicia is regulated and article 7 provides for the analysis of the environmental effect and for the forecast of the development of a Business Eolic Plan on the territory planning.

## 4.- EOLIC CONDITIONS OF THE PROJECT

The installation of a wind farm requires some eolic operating conditions, regarding the quantity and the quality of the source. The exact definition of the aerogenerators alignment situation in the area which is going to be used for eolic purposes is determined according to the location features, which are capable of modifying the wind path and speed in the lower layers of the atmosphere and, as a result of it, diminishing the amount of energy that can be used, the performance and economic profitability of the facility. The eolic industry considers orography as something interesting for the case of speed up effects, tunnel effect and the hill effect, as well as land roughness and the influence of obstacles; factors that may decrease wind speed due to friction with the surface which may cause turbulence, thus diminishing the possibility of an efficient use of the wind energy in an aerogenerator and causing greater fatigue load, which involves turbine breakage and wear.

Once the areas for eolic use have been delimited on the land, from which isovents maps result, then, the technologies available are assessed with the best system of collection, performance, maintenance, etc. The process defining the number and location of aerogenerators in a wind farm is carried out in two subsequent stages: in the first stage an assessment of the turbines establishing the maximum yield in the farm is performed; then, losses due to trails between aerogenerators are valued, reducing its number to the profitable exploitation limit. Even in such event, it is appropriate to take into account that the electricity production in a wind farm is irregular, the same as the eolic source, which is variable in space and time.

## 5.- ENVIRONMENTAL IMPACTS

The environmental impacts which wind farms produce on the environment result form the need of occupying land, which can be considered of two types: absolute estate or irreversible occupation associated with: providing roads, laying of foundations, substation and control building and; easement occupation. Easement occupation refers to the eolic protection easement linked to the installation of elements which make

possible the compatibility of other land uses or the limitation of those uses with the purpose a proper exploitation such as: blade flight, wiring ditches and easement of access for electric lines. Speaking generally, we may say that a wind farm involves an occupation of land of 2,500 $m^2$/aerogenerator in absolute estate system and other 2.500-3.500 $m^2$/aerogenerator of eolic protection easement. Apart from the differences between the farms according to orographical formation, access arrangement and other, which are specific of each facility, we may say that the total encumbered area will reach 6,000 $m^2$/aerogenerator.

## 5.1.- NATURAL ENVIRONMENT IN MOUNTAIN AREAS

The environmental effects of a wind farm on the natural environment in mountain areas mainly appear in the project design stage; and to a lesser extent in the civil works stage of the wind farm.

Thus, the appropriate environment study is performed in the design stage: physical environment, biotic environment, socioeconomy and landscape, which includes determining and localizing the physical and biotic conditions existing in the scope of the farm estate. Experience shows that in most cases edaphic features and vegetation are the most affected environment unit types.

Tree formations are reforestations with fast growing species (*Pinus pinaster, P. radiata, P. sylvestris* and *Eucalyptus globulus*) on scrubland formation. In hardly accessible areas, there are remnants of native forest consisting of *Quercus robur*, which sometimes is properly preserved.

The native forest community is located in the bottom of valleys, mixed with gallery forest. It is sometimes extended over the adjacent scrubland in the shape of a strip formed by *Erica arborea*, as was found in the foothills of Serra do Xistral (Xistral Mountains). Since it is located in a trough and it is not easily accessible, it is not normally affected directly or indirectly by the planned facilities or infrastructures in wind farms, though it is included in environment studies since it has recognized interest.

As regards to plantations with the genus Pinus, we should emphasize the lower size of plantation plots of land and the mixture of species of the same genus in the same

geographical area. They enter into inland areas, reaching heights higher than eucalyptus, but they also have distribution height limitations, which is very obvious in the Serra do Xistral, probably due to the effect of intense wind and cold or both.

The analysis of its distribution and physiognomy in this area allows us to prove that one of the most widespread species in high areas is *Pinus sylvestris*, which is usually hardly developed in patches associated with shallow soils. In general, both trunk height and density of patches decrease with altitude, probably due to the wind effect. In the highest heights the growth habit of *Pinus sylvestris* hardly reaches 1 m, as can be seen in summits and higher parts of hillsides in mountains such as Carba, Leboreiro, Cume do Cabaleiro, etc.

The broadest patches of *Pinus sylvestris*, either of single species or frequently mixed with *P. pinaster* or *P. radiata*, are mainly located along troughs and in the lowest areas in hillsides, sheltered from wind and with proper conditions of edaphic humidity both in extension and considering the tree vigour and height. The widest areas being reforested with this species are located in the southeast area of Serra do Xistral, on the granite soils of the massif of A Toxiza (where the wind farms of Montemaior Norte, Montemaior Sur, Labrada and Terral are located). It is very common to see the trunks of those pines curved due to the evolution of erosive effects resulting from the hillside creeping, even in not so steep areas. The formation with a higher ecological interest is found in the estate of the Terral wind farm. It is a wide patch reforested with different pine tree species, mainly *Pinus pinaster* and *Pinus radiata*, with some trees of the species *Pinus sylvestris*. In the interior part of this formation we can find holly tree plantations (*Ilex aquifolium*) with a height from 5 to 10 meters, and are very common along path borders which lead to the inside of the wind farm estate.

The summit areas in the estates for eolic use are usually occupied by polyphytic prairies, scrubland formations, either by Atlantic wet heath or southern dry heath or turbophyl formations. All of them form priority habitats protected under Directive 94/43/EC, and sometimes are located in the scope of geographical areas classified in a precautionary protection system. In any event, traditional activities are developed in those areas according to the requirements of forest held in common tenancy introducing plantations where the alternative use is of farming nature with free cattle grazing.

## 5.2.- SOCIO-ECONOMIC ISSUES

The installation of wind farms in mountain areas is governed by the provisions envisaged in the appropriate Sector Plans, which the Xunta de Galicia (Galician government) passes pursuant to the Decree regulating eolic uses. In turn, those Sectoral Plans are currently developed by means of Business Eolic Plans, for each developer to build the appropriate project. In those Business Eolic Plans, the terms and conditions, research licence and the previous licence for the use in the determined location, are envisaged.

The activity implementation requires, among others, the agreement with the parties in order to occupy and use the territory, which is performed either by renting or purchasing the plots of land. The first case, renting the plots of land means quantifying it, which is variable in any event, but is always linked to the wind farm profitability, and is strictly estimated according to the energy generation ranges of each aerogenerator and can be reviewed according to the retail price index. The term of tenancy is 25 to 30 extendible years. The effective payment is made in different ways (fixed payment + variable amount according to production, fixed payments variable over time, payment of several annuities on cash and subsequent exemption period, …), in accordance with the owner's demands. This form needs the consent in order to occupy the necessary plot of land to build the wind farm facilities, and prohibiting all activities which may interfere with the operation of the farm.

The purchase of plots of land has been the less used alternative due to different reasons; First, due to the variability in the tenancy system and the size of lands, since one may find common tenancy forests, forests without being classified, private plots of land, even plots of land aimed at other uses, which sometimes are not compatible with installing the wind farm, such as mine research licences, subsoil mine uses, areas of hunting interest, forest plantations and/or assignment of territorial uses in Plans for regrouping small land holdings. The second reason is that the average life of wind farm facilities is estimated in 20 or 25 years, and therefore the need to purchase the plot of land is not justified and finally because plots of land not only belong to different owners (common tenancy and/or individuals), and have different uses, but also they are located in different municipalities, which hinders the procedure of availability, obtaining

licences, … Even in the cases when there is a change in the ownership, the owner is usually allowed to continue using the plot of land and to use the wind farm roads.

Despite wind farms and evacuation lines are declared public utility facilities, which leads to the possibility of compulsory purchase and urgent occupation, the compulsory purchase has only been carried out in singular cases where the legitimate owner was not known, the documents were contradictory, or there were unsolvable differences among owners, etc. and this method was used as a tool to overcome obstacles and not as a generic method.

As regard to economic taxation, which indirectly improves social conditions by increasing municipal funds, we should emphasize that it is not compulsory for the time being to pay the real estate tax for this kind of facilities. Apart from it, eolic facilities honour the tax on commercial and professional activities, which will probably be increased with the new reform bearing in mind the annual turnover.

The occupation of overhead transport lines of the eolic power generated in wind farms is also ruled by the facilities characteristics according to the necessary width for roads, the need to have location points for laying the foundations of bases and supports. In such a case, the forest value of the plot of land puts up the price of the occupation and the thinning and cutting of the road width for the electric line involves continuous maintenance and cleaning activities.

### 5.3.- LANDSCAPE ISSUES

Landscape as a natural resource is the synthesis of its components (physical, biological and human) which can be distinguished to the naked eye and can be defined as a whole and a part at the same time. Landscape is an environment variable forming a complex system, whose content is the result of integrating the whole of the geographical, environmental or territorial reality of the area under study, seen from above and from outside.

The unit under study is created from the geographical area occupied by the facilities, but it is not limited to the wind farm estate, but rather it comprises the visible

units from the facility point of view. The reason is that executing such a kind of projects improves the access to the farm locations and, therefore, the number of potential visitors, opening visibility basins from the point of view of the facilities.

The **landscape components** are those distinguishable aspects forming the territory which can be differentiated at first sight. We can make three groups: Physical ones (land forms, rocks, river beds or water sheets), Biotic ones (spontaneous or cultivated vegetation and isolated plants if they are relevant and Fauna, including domestic animals if they can be seen) and human Performances (the different types of structures performed by men, either isolated, extensive or lineal).

- Atmospheric conditions and the state of the sky which determine the degree of visibility of the other elements, as for instance, light, clouds, … as well as sounds in the landscape (rain, wind, waves, bird songs) and the scene comfort, which can be expressed in temperature and humidity.

The elements or **basic visual features** under consideration, are mainly Smardon aesthetic descriptors (1979), that is, colour, shape, line, texture, scale or size and space character, as we may see in figure 26 with the examples related to the different aspects that can be seen. These elements are defined by Gobster and Chenoweth (1989) as "abstractions of physical elements of the landscape which are combined in order to form patterns or models to the human eye".

Since landscape modifications introduced by installing aerogenerators are circumscribed to foundations and road construction occupying 1.5 % of the encumbered area, the biggest effect on the landscape is determined by exclusively aesthetic aspects which are analyzed by studying visibility basins.

## 6.- CONCLUSIONS

Impacts arisen out of the implementation work in a wind farm few times lead to substantial transformations in soil use, which are not resulting from opening and preparing the existing paths and trails. In fact, it is highly infrequent that the need to encumber in an irreversible way the surrounding conditions arises, since there is normally a dense network of ways, paths, trails, lanes and fire-breaks, which have

adequate size to allow machinery traffic in most cases. Furthermore, the activities of regrouping small land holdings lately carried out in some municipalities have opened big size lanes which are enough to allow for the construction of wind farms.

Nevertheless, the traffic of heavy machinery and heavy road vehicles which is necessary to build the farm (materials and components transportation), may influence the state of the road, the nearest population centres and the activities usually carried out. Despite it is not a big-size problem and with the purpose of preventing undesirable secondary effects, special attention is paid to this influences though they are not far-reaching during the works stage.

We should emphasize the positive effect that wind farm facilities may cause in mountain systems since it contributes to preventing forest fires, both within the farm estate itself as in the nearest areas. In the first case, it is a result of taking care that the vegetation growth, the accumulation of dry or exhausted material is not excessive, precisely with the purpose of preventing fires which may directly affect the facilities and in the second case due to the continuous presence of staff in the control centres in wind farms, who carry out a monitoring task.

Landscape effects are exclusively aesthetic and though the windmill visibility basins are very wide, it is not necessary to use screens in most cases, since the geomorphologic configuration of mountains and meteorological conditions are quite efficient screen systems.

As a result of it, we may infer that serious environmental conflicts are not posed between both types of uses, the eolic one and the environment forest and/or forestation, in the areas where wind farms are installed or in their influence areas, where climate, geomorphologic, edaphic factors limit somehow forest production.

With reference to the socio-economic aspect, nowadays, installing a wind farm implies a performance five to fifteen times higher to traditional performance, and it is also compatible with it. If we take into consideration the general profitability values for the different uses, we may state:

a) *The performance in ha. of forestry exploitation is around 130,000 ptas/year*

b) *The performance in ha. of livestock exploitation is around 30,000 ptas/year*

c) *The average occupation per aerogenerator in a wind farm is 0.6 Ha. Nowadays renting contracts are being paid 250,000 ptas/ aerogenerator per year.*

d) *The wind farm facilities do not restrict significantly the traditional uses of land, especially regarding livestock exploitation which is the most habitual use in wind farms locations.*

As a result of previous paragraphs, we should bow before the evidence of the high economic profitability, though temporary, of eolic facilities without knowing exactly what will be the future prospects for profitability and use of those summits which are currently being used for energy areas, since eolic facilities have undergone ups and downs throughout history, while the creation of new technologies was being fostered.