Abstract: Insuring a sustainable development of wind energy production and consumption is challenging and highly important for achieving of EU 20/20/20 goals for Bulgaria. Wind energy has been seen as a clean and environmentally friendly in comparison with conventional energy sources, but there are still some conflicts between wind energy project development and environmental protection goals that should be enlightened and solved. One possible way is to enhance the process of wind energy projects’ location identification. The current research is focused on identification and classification of criterion that could be used in this process. The legal requirements regarding wind energy projects’ location are analyzed and presented. Additional requirements regarding environmental protection and biodiversity conservation are identified and defined as criterion. A set of measurable indicators related to each criteria is established and proposed in this paper.

Keywords: WIND ENERGY PROJECTS, LOCATION, CRITERIA, ENVIRONMENT

1. Introduction

The increasing renewable energy share in energy production and gross final energy consumption is a global sustainable trend. The Worldwide installed wind energy capacity shows 4.47-fold rise for the period from 2008 to 2017. The installed wind energy capacity in the European Union (EU28) increased from 63,865 MW in 2007 to 171,244 MW in 2018 year, which is nearly 2-fold rise. The same trend is observed in Bulgaria: the installed energy capacity in 2007 was estimated to 114 MW while in 2018 reaches 699 MW [7,17]. This impressive 6.13-fold growth is in line with the achievement of EU20/20/20 targets pointed out by the 2009/28EC Directive of the European Parliament on promotion of use of energy from renewable sources [6]. In the conditions of rapid and dynamic development of wind energy in our country appears the objective need of detailed review of the process of wind energy projects’ disposition determination. Creation of methodology for potential wind energy projects’ location assessment is an opportunity for sector’s optimization and avoidance of conflicts in the “energetics-environment” interaction. The wind turbines’ lifetime, estimated to 20-25 years, together with the eager of the investors to insure a definite internal rate of return, lead to the need of the WEPs location selection, based on long-term environmental alterations assessment [10]. Obviously the potential land use conflicts should be taken into consideration.

The present research aims to fill in some of the existing gaps in WEP sector as well as decision makers.

2. Criteria for Wind energy projects potential location assessment

To achieve and maintain sustainable development of wind energy in Bulgaria is essential to balance the economic efficiency with social and environmental goals. In order to ensure long –term sustainability of WEP a set of criteria that fully covers the process of potential WEP location assessment and exact WEP disposition determination is required. The understanding of interaction and interdependence of economic, technical and environmental factors is a key precondition for WEP location assessment optimization.

The reassurance of renewable energy production with the purpose of insuring energy independence, deduction of greenhouse gas emissions and climate change combating is transposed by Directive 2009/28EC of the European Parliament on promotion of use of energy from renewable sources. This interaction already has a legal performance. The EU legislation related to wind energy as part of renewable energy was transposed in the Bulgarian law for energy by renewable sources at the end of 2011. Other regulations inforce correlate to environmental protection and agricultural territories’ protection, urbanization and urban territories. Numerous restrictions regarding WEP development have been introduced in Bulgaria, such as:

- Prohibition of WEP construction closer than 500 meters from regulated territories under the law for servitudes;
- 35 meters minimum distance to forests;
- 200 meters minimum distance to protected forests;
- 100 meters minimum distance to lakes/rivers;
- Maximum 600sq,m of agricultural land for foundation construction and adjoined infrastructure.

The already existing restriction and prohibition by the Bulgarian law are out of the context of the present research. The existing regulation has an imperative character and only WEP territories with building permit are a subject of evaluation of proposed criteria.

To highlight the main proper conditions for WEP development on certain territory a set of criteria is propose. It includes three main groups of criteria: economic, technical and environmental. In Bulgarian practice many of the problems with WEPs’ territorial disposition selection originate from the fact that the assessment process lay down only on economic analysis. A social-economic evaluation and assessment of the value of ecological assets is not performed at all. Thus, we adopt an analytical approach with defragmentation of criteria, so they specifically cover the economic, technical and environmental aspects. At the same time the practice requires more detailed and precise overview and assessments of the conditions under which the WEPs will be developed during the whole life-cycle of the project. That leads us to the detailisation of the proposed groups of criteria requirement. Thus, further decomposition of the main criteria is conducted and classification of criteria is presented on Fig.1. The proposed criteria are out of the specifically prohibited by the Bulgarian legislation restrictions. Three groups of interconnected criterion are definitively underlined: i) economic ii) technical and iii) environmental. The WEPs’ location assessment requires analyses at least on the above-mentioned criteria and further synthesis. The evaluation of each criteria fulfillment demands observation, monitoring and analysis of number of parameters.

The group of economic criteria, as proposed, includes: Wind potential; Initial cost; Maintenance cost; Preferential prices/feed in tariffs.
Fig. 1 Criteria for WEP location assessment and selection

Beneath “Wind potential” criterion achievement we recognize the presence of wind potential, meeting the qualitatively and quantitatively requirement. It is a predominant condition for WEP development on certain location. So, the vector realizations of the variables wind speed, velocity and density, compared to the defined minimum requirements for WEP development, manifests the level of criterion’s completeness.

“Initial cost” criterion accomplishment suppose that the initial investment, including project purchase fee, project development cost and equipment and construction price, is acceptable and admissible from the investor’s perspective. In order to assess the initial expenses on the project additional factors such as project grid connection fee should be evaluated too.

“Maintenance cost” comprises the annual wind project’s maintenance. The parameters of interests are operational costs, scheduled and unscheduled fees for reconstruction. The administrative burdens are considered in the frames of “Initial cost” and “Maintenance cost” criterion.

“Preferential prices; Feed in tariffs” aims to feed the evaluate expecting internal rate of return (IRR) calculation. Another parameter with significant importance is the state guaranteed period for purchase of the produced energy.

The group of technical criteria is broken down to: Grid connection availability; Grid connection capacity; Geological base; Accessibility and transport infrastructure.

“Grid connection availability” stays to manifest the presence of electrical grid in the area of interest. This criterion alone is not equal to wind energy projects’ grid connectivity because the presence of grid does not guarantee the availability of capacity for connection and transfer of energy to the end consumer.

The “Grid connection capacity” is set as a criterion, comprising the presence of free grid capacity and connectivity allowance. The fulfillment of each of those criterion is necessary condition, but only simultaneously jointly achievement of both insure the grid connection of wind projects.

“Geological base” includes the possibility for foundation and installation of wind turbines which weight and base have to be precisely planned on appropriate Earth layers. The parameters of interests are stability of the base and predetermined ease of construction work.

“Accessibility and transport infrastructure” has a multiple means. From one side the WEP’s accessibility is crucial for its construction and is highly important for the project maintenance. The wind turbine elements are over-dimensions and require roads via which special vehicles can pass through. On the other side all year round accessibility is needed for the annual maintenance which insures the WEP proper operation.

More parameters could be added to the proposed one but these are considered as the minimum required for the purpose of initial selection of wind project location.

Due to the fact that the economic and technical criteria are well known in practice the interest in the article turns upon the environmental one. The assessment of ecosystem services is an expensive, time taking and challenging task. That’s how easy the environmental protection goals and environmental responsibility of organizations drop back as criterion of WEP location determination process. The objective need of simple, clearly defined environmental criterion revealing the interconnection and interdependence between WEPs’ development and environmental protection is obvious.

The group of environmental criterion, as proposed, includes: Protected areas; Natura 2000 sites; OIP/vulnerable bird life; Forest ecosystems. The concerns regarding wildlife and natural habitats preservation are taken into consideration. While the economic and technical criteria simply a presence and preference, the environmental suggests absence or avoidance.

For the purposes of current classification the “Protected areas” criterion is fulfilled when the potential wind project location stays off-protected areas and buffer zones.

“Natura 2000 sites” require avoidance of NATURA protected areas as well as buffer zones around them. In accordance to Bulgarian practice we accept the minimal buffering range of 900 meters.

The Ornithology important places (OIP) spread over the marked and overlapped with Natura 2000 areas, the migration routes, especially the one with narrow migration front. No matters that OIP aren’t necessarily special protected areas, from investor’s perspective, those sites are risky especially when vulnerable bird species are in high abundance.

The high ecologic importance of the “Forest ecosystems” imposes their presence among the environmental criteria, no matter of their legislative status.

Environmental criteria cover the field of direct and indirect interaction between wind energy and environment.

3. Interaction between wind energy projects and environment in Bulgaria

No matter that wind energy is considered as relatively clean energy, with low water consumption [16], saving green gas house emissions there still are some conflicts between wind energy projects’ development and environmental protection goals that shouldn’t be neglected. Despite that Bulgaria takes less than 1% of European territory, the country is one of the EU member states with richness preserved biodiversity. Proclaimed sites for nature protection and preservation, excluding NATURA 2000 zones, are over 1000. The number of reserves with conservational significance counts to 90. General ban on WEP construction is imposed on-reserves..

Bulgaria obtains the second richest ornithological biodiversity in Europe [14]. It’s confirmed by the fact that 78% of the European common bird life including 12 globally endangered by extinction species are presented in Bulgaria [12, 13]. In this context our country is internationally responsible for the protection of vulnerable and threaten of extinction bird species.

In Bulgaria the number of wintering birds of European conservation concern exceeds 200 species [12, 11]. Among them is the Red- breasted goose (Branta ruficollis). Almost the whole world population winters in Kraymorska Dobrudzha. 114 ornithology important places (OIP) are appointed by Birth Life International in Bulgaria. In addition 118 Bulgarian sites (22.6% of the national...
territory) are a part of the largest network of protected areas - Natura 2000. The map of NATURA 2000 protected zones is presented on Fig. 2. These zones are established to ensure the long-term survival of Europe's most valuable and threatened species and habitats, listed under both the Birds Directive and the Habitats Directive. In Bulgaria the OIP and Natura 2000 sites generally are overlapping territories.

**Fig. 2 Protected sites by NATURA 2000 in Bulgaria**

The main birds' migration routes in Bulgaria are: Via Balcanica, Via Aristotelis and Via Pontica, which is the second largest migration route in Europe. Via Pontica, crosses the western Black Sea region via Bulgarian Black Sea coastline, entering up to 100km inland. Over 620 000 soaring birds traverse to South Africa via Bulgaria. Annually 78 % of the world population of white stork /*Ciconia ciconia*/*, the whole Europe population of pink pelican /*Pelecanus onocrotalus*/ as well as 24 species threatened with extinction [12, 11]. The geographical migration regions division are presented on Fig. 3.

**Fig. 3 Migration regions on the territory of Bulgaria with studied sites [10]**

In practice the interaction between WEP development and environment often results in land-use conflicts. The main reason is the territorial overlap between regions with high wind potential and high birds abundance.

For the period of 2003-2009 in Bulgaria 2840 applications for wind energy installations are presented in the Regional inspections of environment. 83 % of them are realized without evaluation of the environmental impact (EEI). [9, 2] Most of the applications are for single wind generators or for less than 7 wind generators in a farm which is used EEI to be avoided. This is one of the flaws which the Ministry of environment found in the procedures. Using this disadvantage some investors administratively "transforms" their large-scale project into small-scale projects [11, 10].

Till August 2015, 3233 are the applied wind generator investor intends only on the territory of Regional inspection for protection the environment – Varna. The realized intends are 401, 245 of which are located in protected zones [15]. Despite the EU court practice for not allowing disturbance of habitat or anxiety in OIP, in Bulgaria after its acceptance as a EU member state, construction of wind farms in IOP and in Kaliakra /Dobrudzha/ was allowed [11, 20].

The Ministry of Environment and Water already accepted some legislative prohibition and provisional restriction due to WEP permission for construction in some areas as Dobrudzha, East Rodophy maintain and Bourgas region purposing protection and minimizing the risk for sensitive to wind generators bird species. Temporal and permanent restrictions regarding WEPs construction are inforce for numerous individual NATURA sites, showed on figure 4 in purple. The blue markings corresponding to the areas with mean wind speed over 4m/s.

**Fig. 4 Map of restrictions on WEP construction territories and wind potential map [11]**

The WEPs development is put in disadvantaged situation in Bulgaria by the legislative acts of this kind. At the same time the world practice without doubt proves that encouraging investors to introduce and implement environmentally responsible approach in WEP development is a step in the right direction.

### 4. Conclusion

The prosed set of criterion and classification does not claim to be exhaustive. It represents an open flexible system, applicable to wind energy projects development, supporting the decision makers in the initial phase of WEPs' potential location assessment and disposition selection. The differences of national legislative requirements regarding WEP development easily can be introduced to the proposed classification.

The implementation of so classified criterion offers to the practitioners a wider perspective allowing them to take into account the full scale of aspects regarding WEPs' disposition and to balance economic and environmental demands and sustainability of the project. The complex achievement of the set of criteria could be evaluated properly only as a dynamic equilibrium, taking into account the use and non-use value of the nature, vulnerability of the assets and the overall added value of project.

The creation of methodology for WEPs’ location assessment, based on proposed set of criteria is a subject of team future work.
5. Literature

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