Evaluations of Wind Potential in Dobrogea Plateau

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Abstract -The paper analyzes the existing wind potential in Dobrogea Plateau, in South-East Romania which is one of the richest parts of Eastern Europe regarding renewable natural energy resources, wind and solar. The study is based on direct activity of authors in assessing wind energy resources throughout Dobrogea area and also from our experience, and measurements made over a period of 4 ÷ 5 years of a potential wind for more wind parks which will develop in the area. An actual solution is also considered for a possible application as a result of the evaluations done in the vicinity of the commune of Nalbant.

Key-words: wind turbine, impact, noise, capacity factor, wind potential, performance coefficient.

1 Introduction

The purpose of this paper is to evaluate the opportunity of placing a wind farm in the north of Dobrogea, in the proximity of the commune of Nalbant, taking into account the fact that producing energy from renewable sources is a priority at international level. An evaluation of the impact this farm may have on the environment is also considered [1,2,4].

2 Evaluations of Wind Resources

This paper analyzes the data measured on the location in the vicinity of Nalbant, in the south of Dobrogea. The possibilities to develop a wind farm in the area are evaluated. For this purpose, estimations were realized for the production of energy for five types of wind turbines (Table 1). As a result of the study, a correction factor was determined and it must be applied to the estimated production (corrected production) in order to have a clear image on the energy potential (capacity coefficient).

The values presented are for the ideal case. The turbine is placed on the position of the measuring tower and no losses are taken into account.

These can be:

- Location: depending on the number of turbines, their position and distance compared to the dominant wind.
- Electric: depending on the number, type and length of the electric cables for the connection between the turbines and the national network. These are generally between 3-5%.
- The power curve guarantee by the producer: the producer guarantees a minimum of 95% of the turbines power curve.
- Turbine availability: any producer guarantees a turbine availability of 97% by the maintenance contract.

Table 1. The production of energy

TURBINE	Estimated production [GWh]	Production adjusted [GWh]	Capacity factor [%]
Vestas V90 3.0MW	10.332	9.650	36.7
Vestas V90 2.0MW	8.970	8.378	47.8
Siemens SWT 2.3MW	9.666	9.028	44.8
Nordex N100 2.5MW	11.020	10.293	47
Enercon E82 2.0MW	8.746	8.169	46.6

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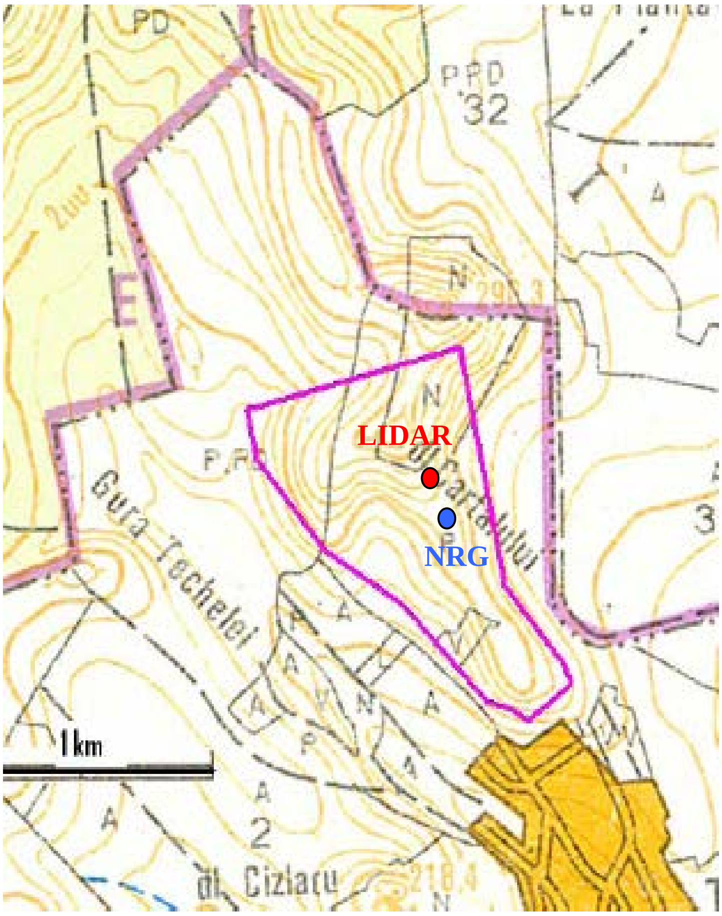

Fig. 1. Location measurement:
LIDAR red and NRG blue

Figure 2. Measurement Equipment LIDAR laser (close-up) and NRG (distant view)

3 Data Acquisition

The measurements were accomplished outside the commune of Nalbant (fig. 1) at an altitude of 263 m, with two types of acquisition systems:

- A laser measurement system types LIDAR (fig. 2);
- A NRG SYSTEM, installed on a 40m-tall pole. (fig. 2)

Within the analysis process, the climatologic data obtained by satellite (NCEP/NCAR) were correlated to the ones determined by actual measurements in the field using specialized software developed by Sander&Partner, Switzerland, called The Experts Tool.

The software is extremely specialized, being destined for specialists in the field and it permits the visualization or export of measurements for wind and the design of diagrams and wind maps for certain areas. It can be used in parallel with other software programs such as WindPro (which has in its database approximately 200 types of turbines), WindFarmer, etc [5].

Data quality was verified using the statistical analysis [5]. The correlations with the measurements done in the field were accomplished using the following methods: MCP, K-S-tests, Weibull Check, Q-Q-Diagram.

Further on, a part of the most import data for the study will be presented:

- The average daily values of wind speed at the following heights: 40, 60, 80, 100 and 120 m (fig. 3);
- The variation of the ratio between the daily average and the speed measured at the following heights: 60, 80, 100 and 120 m (fig. 4);
- The vertical profile of the wind at 40 m and the 30° sectors, the calculation was made for speeds exceeding 4m/s, while the sectors with less than 50 measurement points were not taken into account (fig. 5).
- The vertical profile of wind, and the turbulence intensity was calculated for speeds over 4 m/s. That is the minimum speed acceptable as wind turbines working regime (fig. 6).

- Wind rose obtained after a re-analysis of the climatologic data obtained from NCEP/NCAR (fig. 7);
- Wind energy at 60 m based on the NCEP/NCAR data (fig. 8).

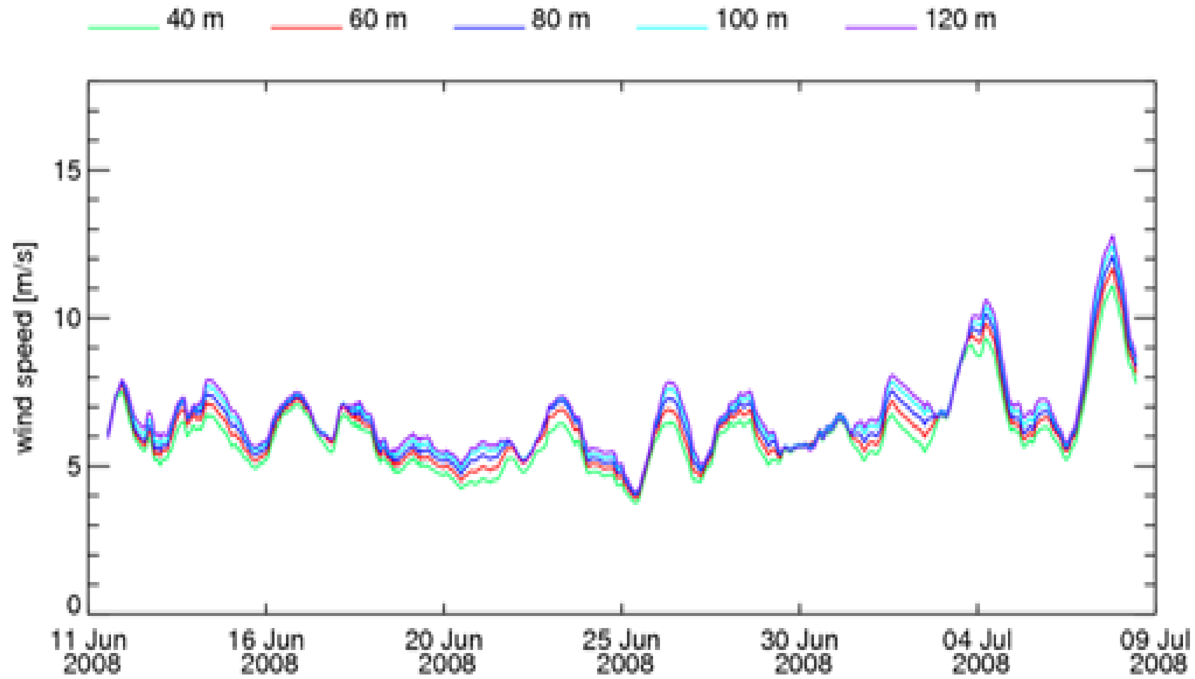

Fig. 3 Daily average values of wind speed at the following heights: 40, 60, 80, 100 and 120 m.

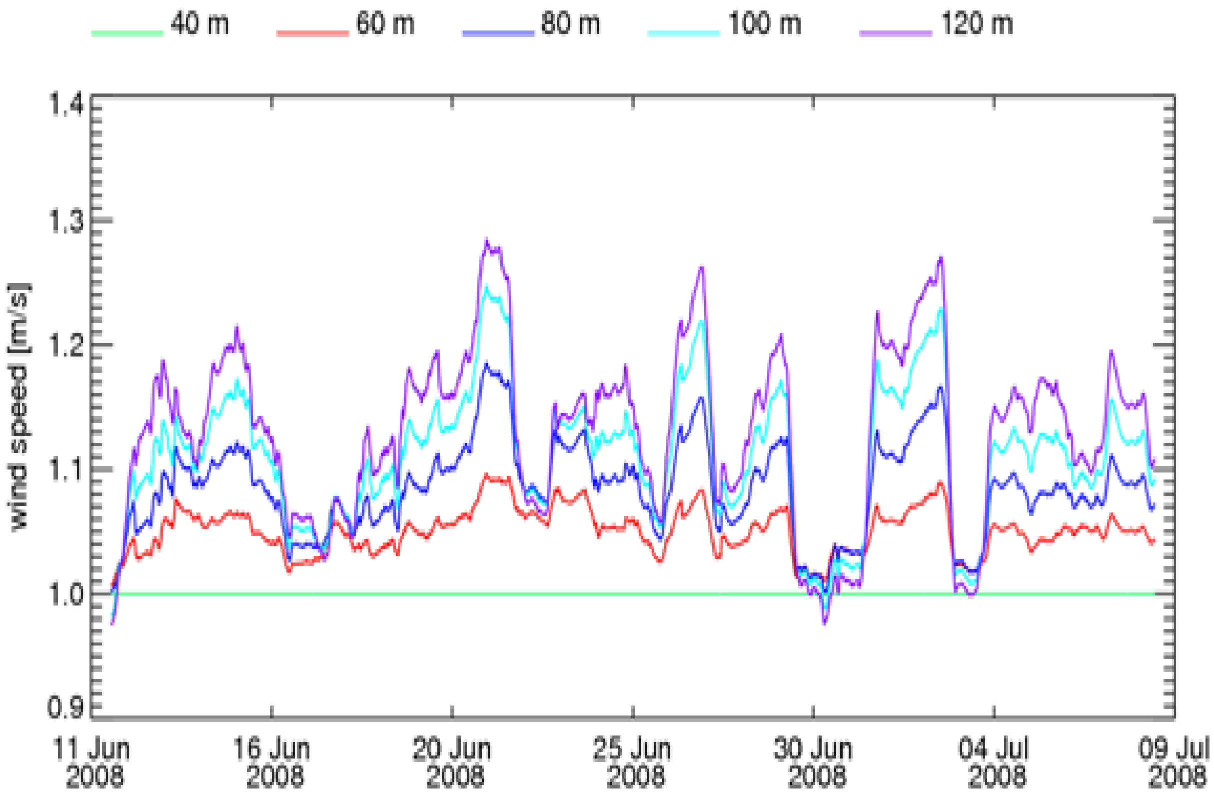

Fig. 4 The variation of the ratio between the daily average speed and the speed measured at the following heights: 60, 80, 100 and 120 m.

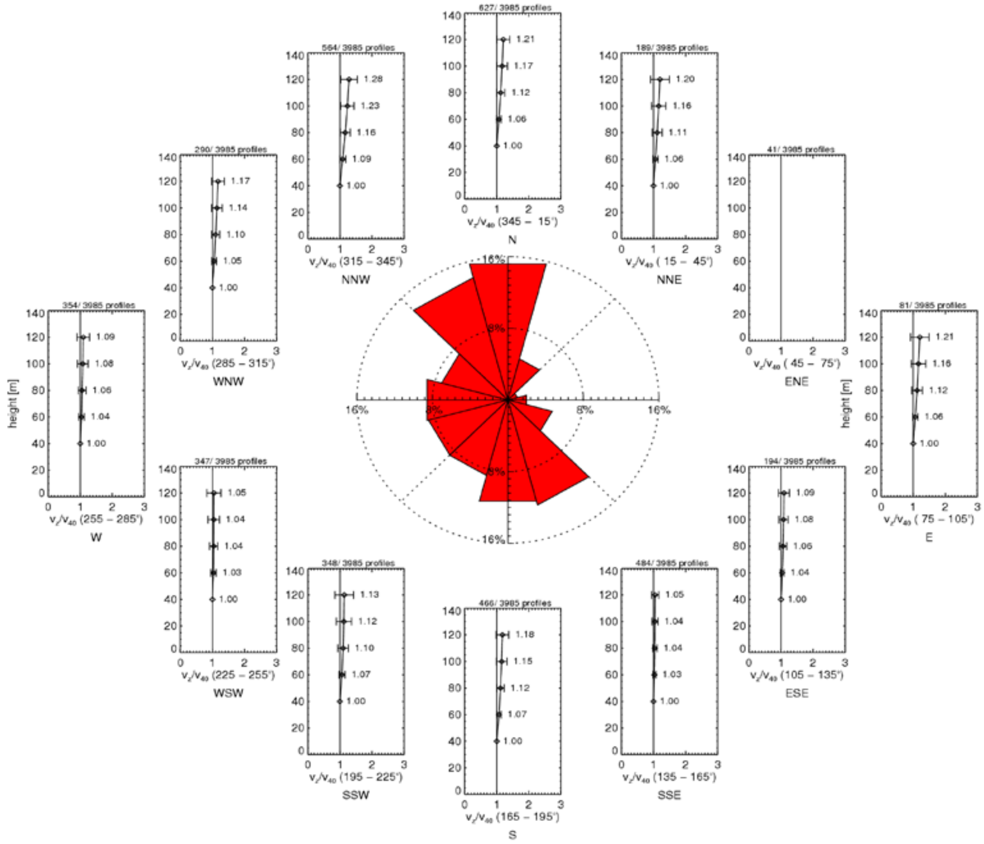

Fig. 5 Vertical profile of wind at 40 m and 30^o sectors

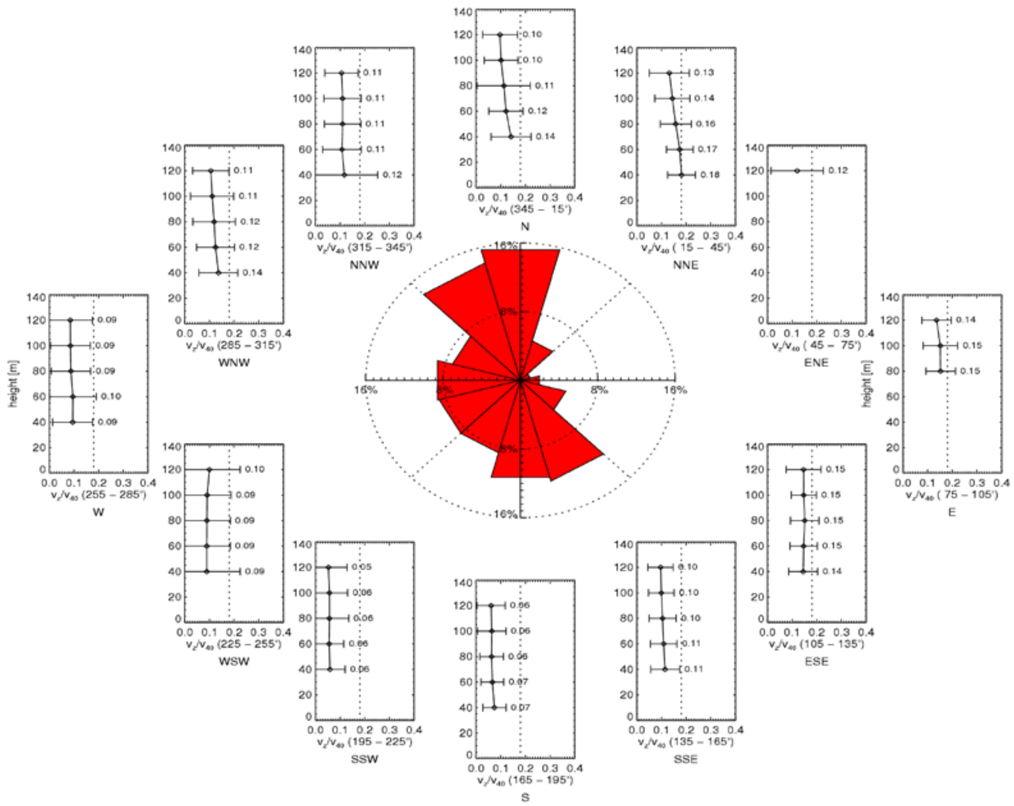

Fig. 6 Vertical profile of turbulence at 40 m and 30^0 sectors

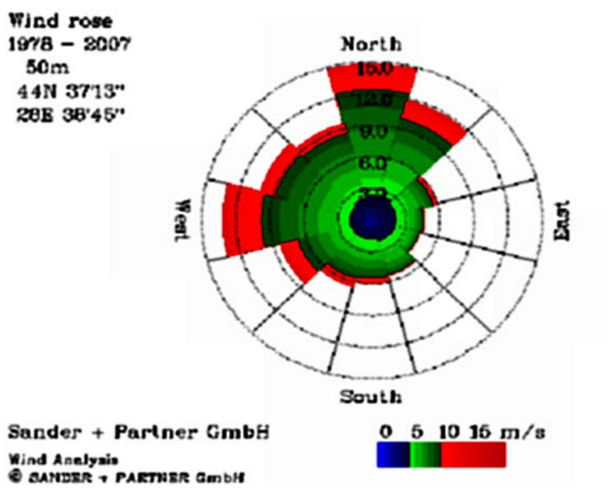

Fig. 7 Wind rose based on the NCEP/NCAR data.

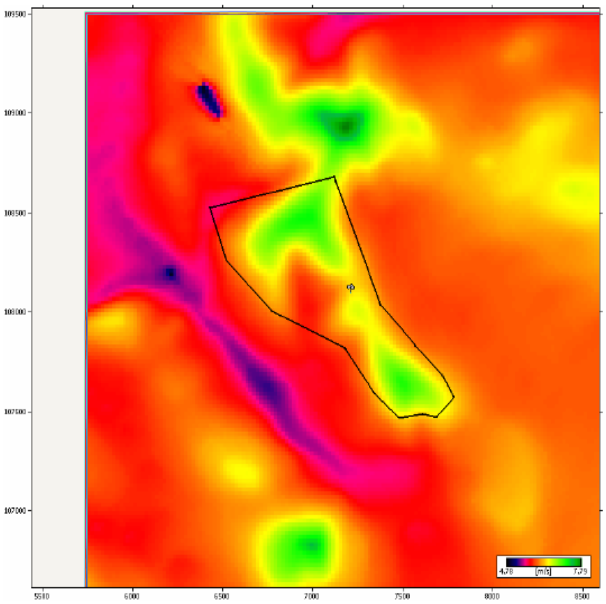

Fig. 8 Energy of wind at 60 m based on the NCEP/NCAR data.

4 Calculation of the Wind Tturbines

Wind energy is in fact the recoverable kinetic energy of the air which crosses a section S. The power associated to this kinetic energy is:

$$P_{vant} = \frac{1}{2}\rho S v^3 \qquad (1)$$

where: ρ - air density; v – the speed on the air masses.

This power cannot be used completely because part of it is lost through the friction between air and the blades, for the overcoming of the local resistances determined by the passing of the air through the rotor blades. In these conditions, the power generated by the wind turbine can be calculated with the relation:

$$P_{turbina} = \frac{1}{2}C_p \rho S v^3 \qquad (2)$$

where: C_p – performance coefficient;

The performance coefficient was introduced by Betz's theory. This theory indicates the maximum energy that can be used by one wind turbine, starting even from the best turbines with two or three blades, with horizontal axis. This cannot exceed 59% of the wind energy, which means that $C_{p\ max}$ (theoretically) is 0.59. For a good wind turbine, C_p is at the most 0.3 ÷ 0.4.

According to Betz's theory, which shapes the passing of the air through the turbine blades (figure 9), the power developed by a wind turbine is given by the relation:

$$P_T = \rho S V^2 (V_1 - V_2) \qquad (3)$$

V1 – wind speed before the turbine; *V* – wind speed in the proximity of the wind blades; is about a few m/s (~ 10 m/s); *V2* – wind speed after the wind blades take over the kinetic energy.

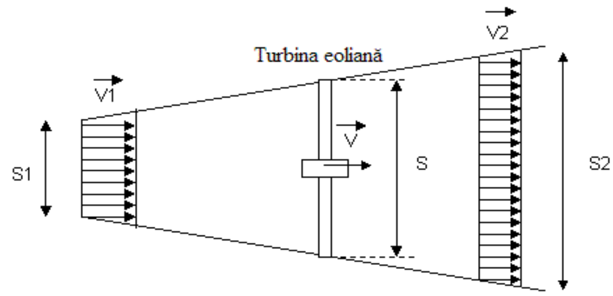

Fig. 9 Calculation scheme.

5 Evaluation of the Noise Impact

Among the negative effects of wind turbines, the most known ones that affect the environment are the noises and the vibrations. When a turbine functions, the noise is generated by:

The functioning of the gear box;

- The functioning of the electric generator;
- The functioning of the wind blades.

The electric generator and the gear box cause an insignificant noise. The measurements accomplished by specialists for powers over 2.0 MW indicated that

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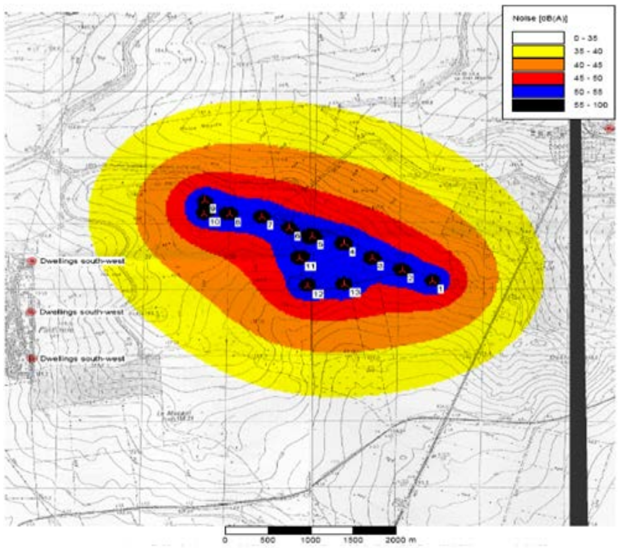

Fig. 10 Curves of constant noise levels estimated for the studied location

the noise measured was 40÷45 dB at a distance of 200m in open field. The noise decreases proportionally with the power generated by the turbine (according to the wind speed).

The noise generated by the rotation of the blades is also proportional to the wind speed, temperature and air density. Thus, the calculations realized for the determination of the noise level according to an algorithm given by the German standard in the field, DIN ISO 9613-2, emphasized different noise levels depending on: turbine power; wind speed and distance and height to the turbine [3].

For turbines with nominal power of 2.3 MW, at a wind speed of 10m/s, the calculation result was 104.5 dB in the close vicinity (10 m) and 35÷45dB (over 500 m), the measurement height being 5.0 and 10 m.

For the estimation of the noise level at different distances from the wind turbines to be installed in the location analyzed based on an algorithm to calculate the noise, a map of the constant noise curves can be elaborated (figure 10). The conclusion is that the noise level is within the limits recommended by the environmental legislation in the field [4].

6 Conclusions

The studied location offers optimum conditions for the installation of a wind farm from all the points of view (wind potential, economical efficiency, environmental and social impact), being one of the most suitable locations in the North of Dobrogea.

The economic impact given by the functioning of the wind farm in the mentioned area is completely beneficial. This benefice is given by the clean energy obtained without air pollution, by the new jobs of high professionalism, much lower costs for the exploitation, maintenance and repairs than in the case of energy obtained by conventional technologies.

The factor of population health is also positively influenced because the production of energy does not generate noxious gases and the global warming effect is reduced, which has a positive effect on people's health.

In what regards the ecological impact, it was analyzed by its effects on the flora and fauna in the area. The conclusion was that the local vegetation is characteristic to arid steppe zones and it is not affected by the wind turbines.

In what regards the influence of the wind turbines in the area, a minor effect is estimated in connection to the bird fauna [1,2]. The statistics show that the major effect can be manifested in the first stage of functioning. Otherwise, the birds will adapt and avoid the possible danger.

Obtaining electric energy by conventional technologies has a general negative effect on all the environmental factors that affect the entire biosystem of the Earth. Similarly to other European countries, a minor and temporary negative effect must be accepted for greater and long-term benefices.

As the wind turbines are placed at considerable distances from the urban or rural localities and also from economical agents, the noise impact is insignificant.

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