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ENERGY POTENTIAL EVALUATION FOR A WIND TURBINE USED FOR PUMPING

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Abstract: *Strong growth of the role of renewable sources in global energy systems has served as the basic reason for the development of methodologies for determining and predicting the energy content, for one or another area, to increase the accuracy and confidence of investors. Precisely for this reason was started the development and implementation of various programs to calculate the wind power potential. Currently one of the most widely used programs in the world and especially in Europe, is Wind Atlas Analysis and Application Program (WAsP) developed by RISO, Denmark. The aim of this work is to determine wind energy potential in the actual location of a wind turbine integrated in a pumping system of a village and identify new location with a higher wind energy potential in the same zone radius using WAsP program. Also were determined: the wind rose, the amount of energy that can be produced in the old and the new site by a 10 kW wind turbine for a year based on data from a weather station nearby, were obtained maps of: annual energy production, power density, the average wind speed, Weibull A and k coefficients and altitudes.*

Keywords: *wind atlas, WAsP program, wind energy potential, wind turbine, weather station.*

1. INTRODUCTION

Once the idea came to integrate a wind turbine in pumping system of a village, arose the question, how much energy will produce this turbine in a year or the extent to which the turbine will supply electricity pumping system. The reply to this question and others such as calculating the average wind speed, power density, wind rose, probability density function of wind speed can be given by using the model developed by EU countries, known as WAsP (Wind Atlas Analysis and Application Programs) developed by RISO, Denmark - under which in the 80s of the last century was calculated the potential for wind energy of the 15 states from Europe and (made) Wind Atlas based on the theory of air currents was made [1].

High efficiency WAsP program, the optimum price / performance has led several countries in Central and Eastern Europe to use it, and to estimate wind energy potential, drawing their own atlas, like the European one.

That is why for the determination of wind energy potential for our site and to make a preliminary forecast we will use WAsP programs.

2. WAsP PROGRAM METHODOLOGY

WAsP methodology applied for calculating wind energy potential is based on four main blocks such as:

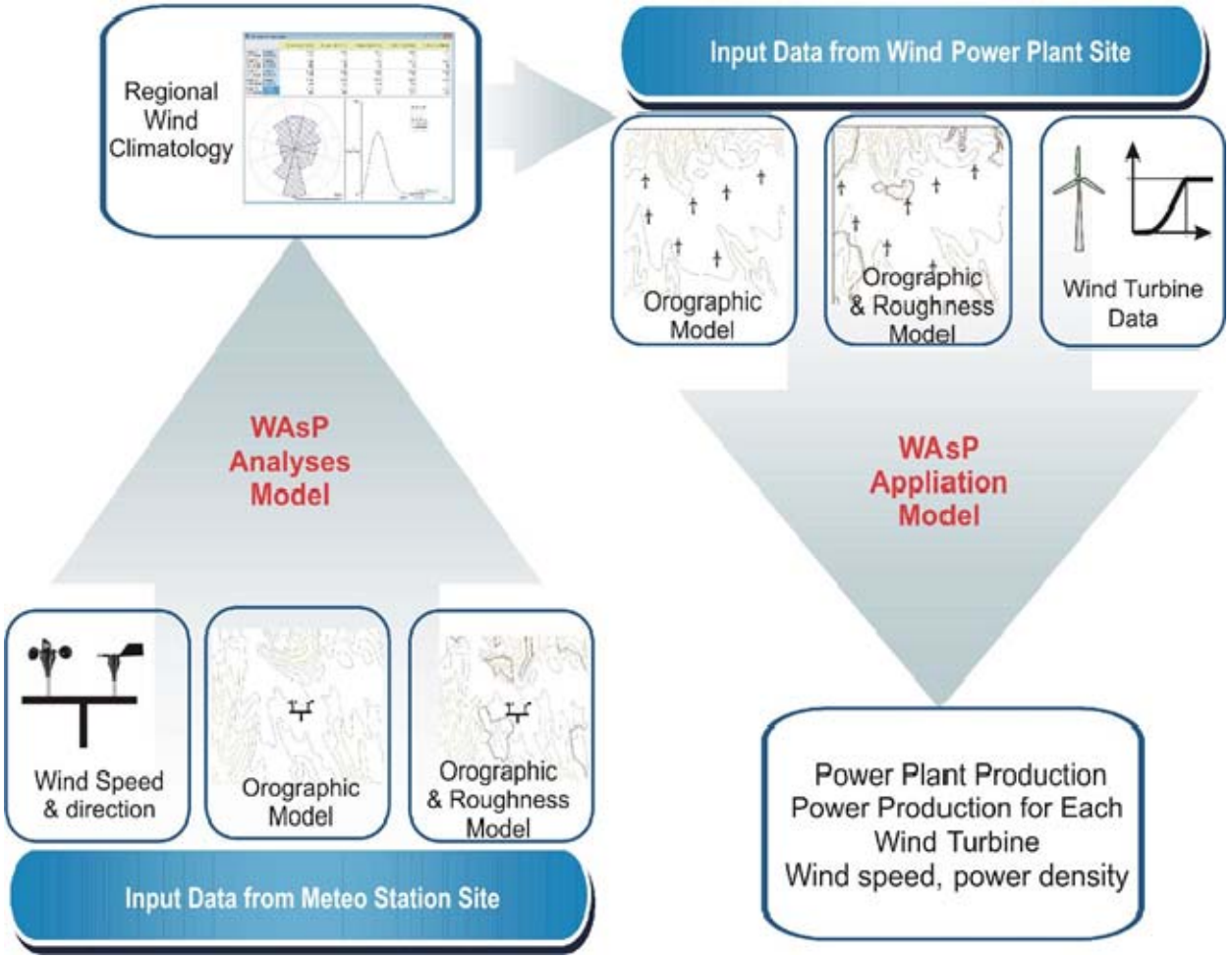

Figure 1. The schematic presentation of the wind atlas methodology of WAsP.

1. **Analysis of raw data**: This option enables an analysis of any time-series of wind measurements.
2. **Generation of wind atlas data**: Analyzed wind data can be converted into a wind atlas data set. In a wind atlas data set the wind observations have been "cleaned" with respect to site specific conditions and reduced to standard conditions.
3. **Wind climate estimation**: Using a wind atlas data set calculated by WAsP or one obtained from another source - eg the European Wind Atlas - the program can estimate the wind climate at any particular point by performing the inverse calculation as it is used to generate a wind atlas.
4. **Estimation of wind power potential**: The total energy content of the mean wind is calculated by WAsP. Furthermore, an estimate of the actual, yearly mean power production of a wind turbine can be obtained by providing WAsP with the power curve of the turbine in question.

In Figure 1 is a schematic presentation of the wind atlas methodology of WAsP. The program contains an analysis and an application part which may be summarized in the following way:

Analysis (↑): time-series of wind speeds and directions →wind statistics;
Wind statistics + site description→ wind atlas data.

Application (↓): wind atlas data + site description → estimated wind climate;
Estimated wind climate + power curve → estimated power production.

To calculate the electricity production of wind turbine or wind farm should be taken into consideration the following steps: first you need to create digital map by using the WAsP Map Editor 9, then create wind atlas by using the OWC Wizard option or WAsP Analyst Climate using raw data from weather station and also we need to build turbines feature by using the WAsP Turbine Editor. (Will be developed further describe each part including obtaining WAsP program entirely). Further descriptions will be developed for each part, entirely obtaining WAsP program.

2.1 Using the Map Editor. Map Editor option is used broadly in order to build a map format which would allow its use in calculations like power, power density, wind speed and other parameters of importance for wind applications.

Special attention should be drawn to Dead-Ends, Cross Points, LFR-Errors cells, especially after loading the map in this program and introducing roughness and orography these values must be zero otherwise the map will not be understood by WAsP program.

How is the orography presented?

- Orography is represented by height contour lines as on a paper map Figure 2.
- Each contour has the elevation above mean sea level as attribute.
- Each contour is represented by a number of points: connected line segments or polygons.

How roughness is presented, Figure 3?

- Roughness is represented by roughness-change-line;
- Each line has a pair of right- and left-hand roughness lengths (m) as attributes;
- Roughness change lines are also represented by a number of points.

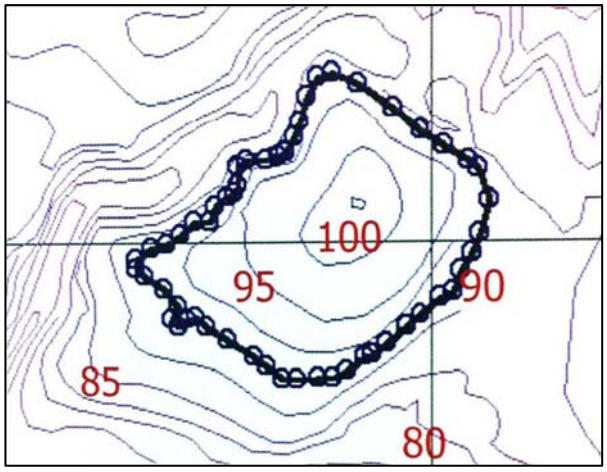

Figure 2. Representation of orography in the Map Editor

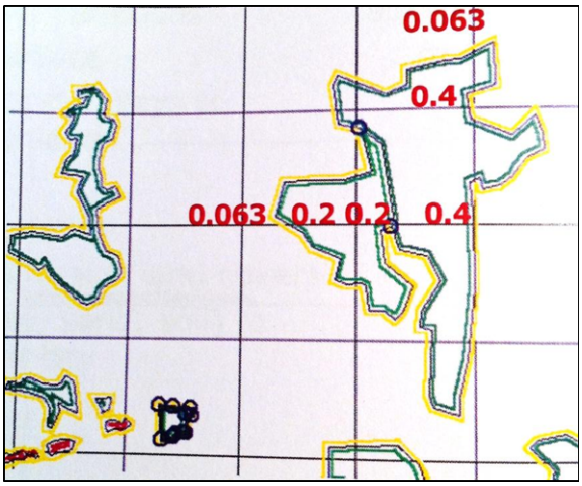

Figure 3. Representation of roughness in the Map Editor

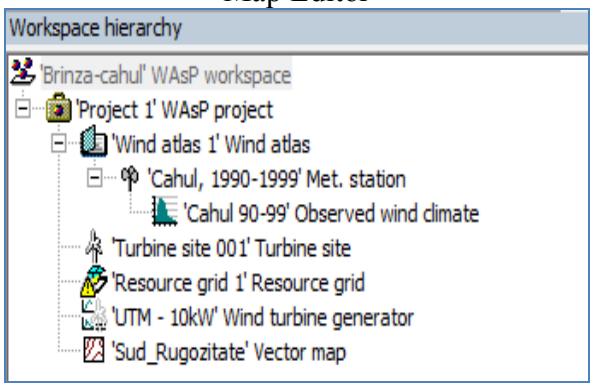

Figure 4. How to locate the map in the WAsP program

Next will be shown how to insert a folder in WAsP

- A folder is numbered as a member of the WAsP program in any of the following items, can be seen in Figure 4.
- It is possible to use one or more maps.
- It is possible not to use maps.

2.2 Using OWC Wizard and create wind climate. When you calculate the wind atlas based on meteorological data of a site WAsP program cannot use these data directly from the measuring device, but needs a certain format of the data. WAsP supported format can be obtained by processing data in OWC Wizard program or WAsP Climate Analyst.

OWC Wizard program is intended to create wind climate observation files *. tab, which would include wind speed and direction, based on raw data obtained from station observations, by turning them into data tables. In addition to this the program creates data in a format understood by WAsP, also has the trim function allowing the necessary data to remove or introduce some data sets, allows adjustment linearized.

2.2 Using WAsP Turbine Editor and turbines modeling. To calculate the power that might produce a wind turbine on a site should be known the turbine characteristic. In addition we need to know in what form we should have this feature that can be read by the WAsP program. All these requirements can be achieved with additional program WAsP Turbine Editor.

This program allows modeling wind turbine of any type and any size. The WAsP Turbine Editor makes it easy to establish the power and thrust-curve file needed by WAsP for calculating wind turbine power production, as well as the wake loss if the turbine is situated in a wind farm. The Turbine Editor can read and convert old Park *.trb files to a valid WAsP *.pow format and is further capable of reading and writing the new *.wtg format.

3. THE OBTAINED RESULTS

We have built wind turbine features of the village Brînza Cahul using the WAsP Turbine Editor, based on known data. Format issued by this program is understood by WAsP.

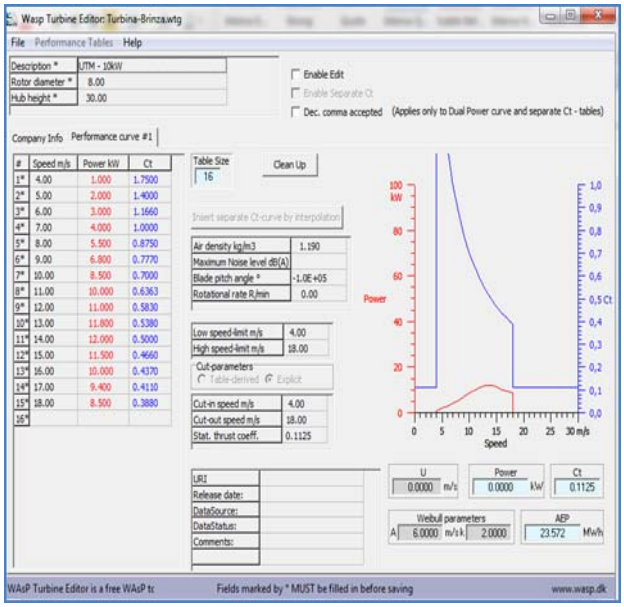

Figure 5. Wind turbine characteristic in WAsP Turbines Editor.

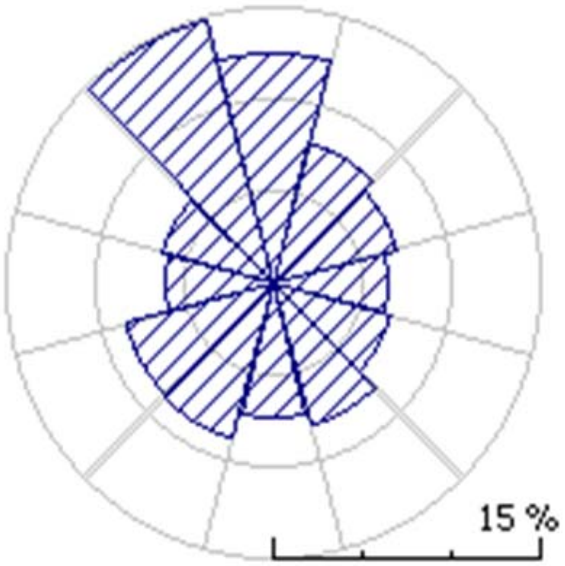

Figure 6. Wind rose for station Cahul

Using the OWC Wizard (observed wind climates) we got wind climate, which contains its speed and direction, based on raw data obtained from meteorological observation station. This program allows converting data obtained directly from measuring instruments or Microsoft Excel in an accessible format WAsP program. This program also allows the creation of a report on the processed data.

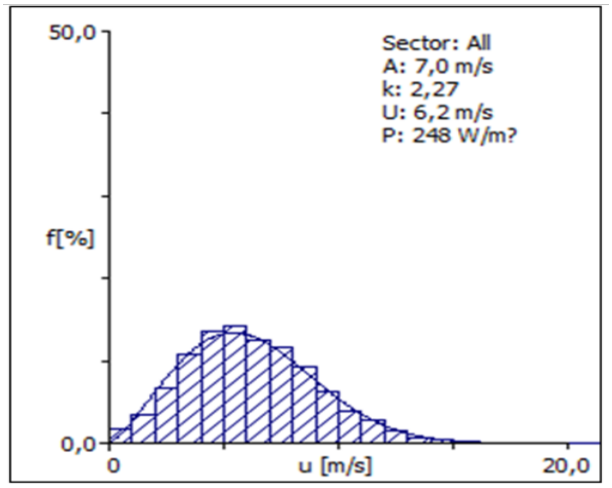

Figure 7.Weibull distribution for station Cahul

To enter the village Brînza roughness on the map and bring us a compatible format for WAsP we use WAsP Map Editor program.

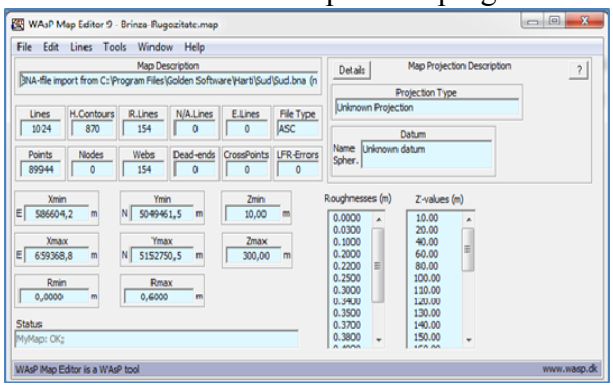

Figure 8. WAsP Map Editor program menu

Table 1 Amount of energy produced by wind turbine from village Brînza, every month during one year at 12 m height for the actual and new site.

Month	January	February	March	April	May	June	Julie	August	September	October	November	December	Annual
The amount of energy produced for the actual site, kWh	558,254	980,69	1022,75	1243,76	743,15	565,643	305,07	302,248	557,342	503,559	585,698	1135,45	9044
The amount of energy produced for the new site, kWh	562,41	1141,1	1141,3	1514,2	1104,6	1039,4	814,66	1057,1	924	606,4	1141,8	1270,9	14089

Table 2 Amount of energy produced by wind turbine for the actual and new location for a period of one year, at different heights.

Height	12	20	30	40
The amount of energy produced for the actual site, MWh	9,044	12,905	16,811	20,08
The amount of energy produced for the new site, MWh	14,09	17,93	21,06	23,8

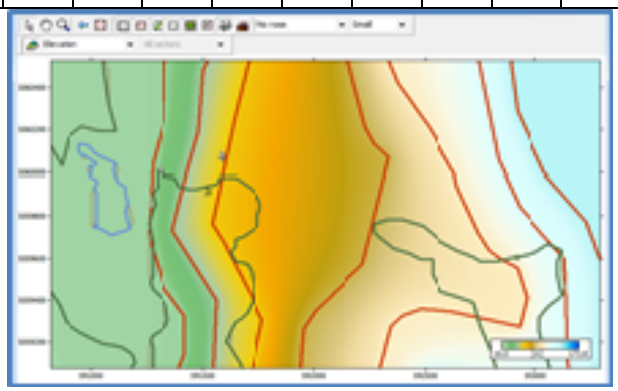

Figure 9. Map geographic height

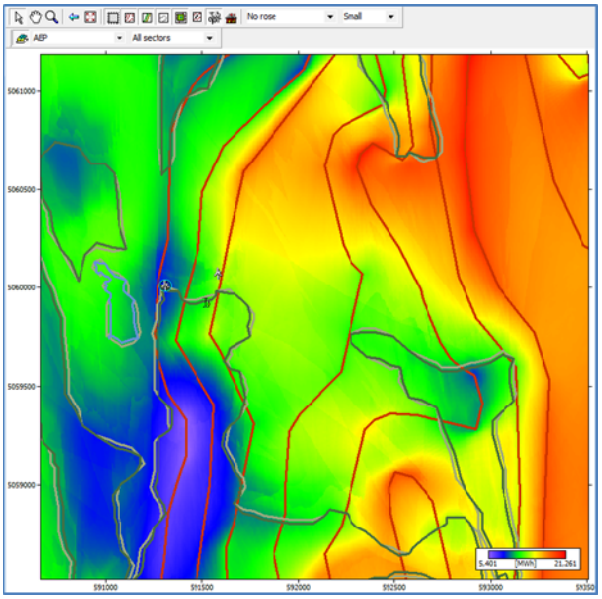

Figure 10. Annual electricity production map

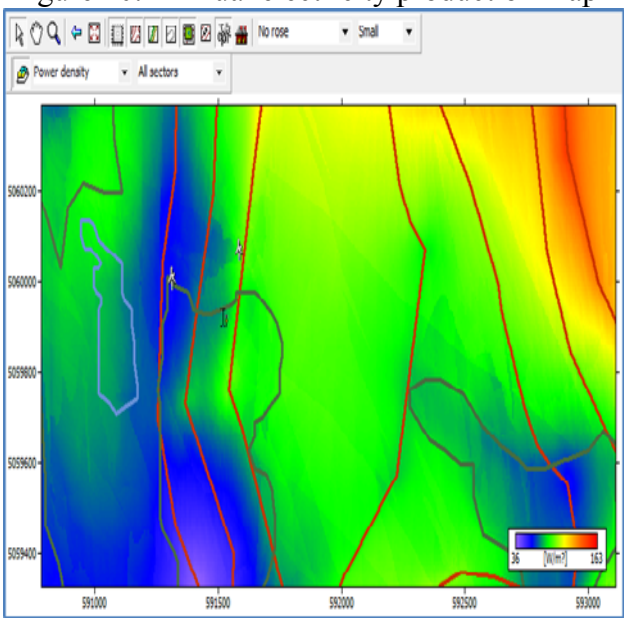

Figure 11. Power density map

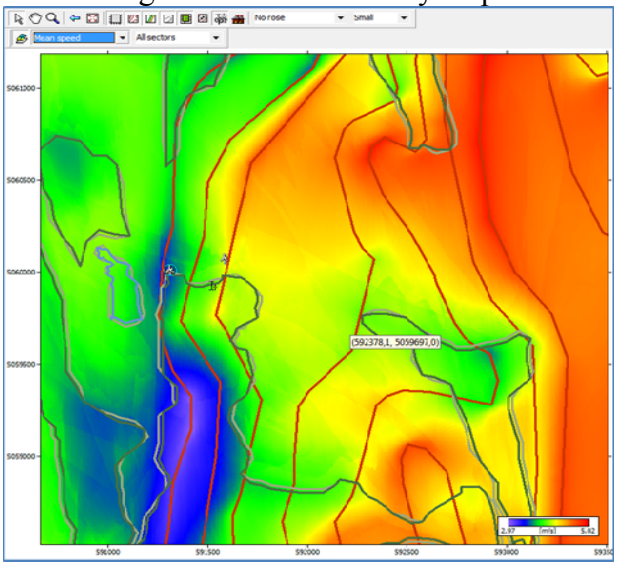

Figure 12. Average wind speed map

4. CONCLUSIONS

Theoretical and experimental investigations reveal the following conclusions:

a) Statistical data showed that Republic of Moldova has a wind energy potential that could cover to some extent energy requirements of pumping system that supplies an isolated rural area or a consumer.

b) Using the WAsP program we obtained the following results:

1. Wind rose for wind turbine site;
2. Annual amount of energy produced by wind turbine;
   - For existing real location - 9044 kWh;
   - For a new site – 14089 kWh;
3. Map of annual production of electricity;
4. Power density map;
5. Average wind speed map;
6. Geographic heights map.

c) Was determined to what extent the energy produced by wind turbine cover the needs, obtaining:

- For actual real site - 36,42 %;
- For a new site - 56,75 %;

ACKNOWLEDGEMENT

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