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INCREASING PERFORMANCE IN AGRICULTURE THROUGH THE USE OF RENEWABLE ENERGY SOURCES

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Abstract: Agriculture is a vital field of human activity. It remains the only source of food, an important supplier of raw materials for industry and at the same time a significant outlet for its production. At the global level, as in any economic field of activity, the competition is significant, some countries having a considerable advance (based in particular on the use of advanced technologies) compared to less developed countries. One method of cost efficiency is the use of renewable energy sources. The article presents some solutions for optimizing the exploitation of the wind potential.
Keywords: agriculture, wind turbine, numerical simulation, economic efficiency

1. INTRODUCTION

In the knowledge society, which is rapidly following the industrial one, economic growth performance is supported by investments and innovations (Kahn, K. B., 2018; Ortiz–Villajos, J. M., Sotoca, S., 2018; Geissdoerfer, M., Vladimirova, D., Evans, S., 2018). This fact is also valid for agriculture, where there are gaps between the performances obtained by farmers from different countries, as a result of the different degrees of implementation in their activity of the best and latest existing technologies. The promotion and realization of investments and innovations in agriculture is based on access to new information generating added value (Devaux, A., Torero, M., Donovan, J., Horton, D., 2018; Cameira, M. D. R., Santos Pereira, L., 2019; Morkovkin, D., Hutarava, I., Ogloblina, et al, S., 2020). This new information is generated by university centers, research institutes and other public and private research bodies. For the transfer of knowledge from knowledge–generating units to farmers, it is necessary to strengthen public–private partnerships (Yost, M. A., Sudduth, K. A., Walthall, C. L., Kitchen, N. R., 2019; Yost, M. A., Sudduth, K. A., Walthall, C. L., Kitchen, N. R., 2019; Hermans, F., Geerling–Eiff, F., Potters, J., Klerkx, L., 2019; Thorpe, J., 2018). A possibility of increasing the economic efficiency of farms can be represented by the use of renewable energy sources. Research institutes are still developing new solutions for the most efficient use of the wind potential.

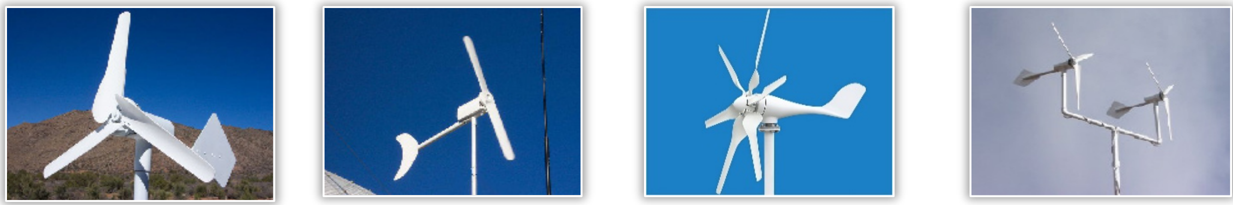

Figure 1 – Small wind turbines with horizontal axis (www.amazon.com)

Worldwide there is a large number of wind turbine models. For small farms, the most useful models of wind turbines are those of low power, both with vertical and horizontal axis. There are models of vertical axis turbines with two three or even more blades. Some of the turbines with a horizontal axis, of small dimensions, are shown in figure 1.

An elegant and novel solution of the vertical axis turbine is shown in figure 2. The turbine is called QR5 and its use is recommended even in urban areas, where the wind often changes direction. It is a silent turbine and has been designed according to aerospace technologies. For an average wind speed of 5.8 m/s, it is estimated to obtain 9,600 kWh annually. The design leads to silent and vibration–free operation.

Figure 2 – Small wind turbine with vertical axis

Figure 3 – Small wind turbine with vertical axis, QR5 model

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The wind turbines shown in figure 3 are of Finnish design (Graham, W. R., Pearson, C. E., 2022). The turbines were designed in such a way that they work even in cloudy weather conditions. The manufacturers state that this type of turbine generates more electricity than conventional turbines of similar size. The turbines do not cause the death of birds, they are very silent and start working from wind speeds of 3.3 m/s. The installations, due to the advantages presented, can be located in rural areas.

2. MATERIALS AND METHODS

Such wind turbines can be placed within farms. However, their correct choice and optimal location are essential conditions for maximizing economic efficiency (Hossain, M. L., Abu–Siada, A., & Muyeen, S. M., 2018; Lundquist, J. K., DuVivier, K. K., Kaffine, D., Tomaszewski, J. M., 2019; Abdelsalam, A. M., El–Shorbagy, M. A., 2018). The wind turbine must be located so that the influence of other buildings or obstacles is minimal. For this, farmers can turn to researchers, who through mathematical modeling and numerical simulations can determine the optimal location of the turbine. For example, the authors designed their own model for determining the optimal distance for the placement of the wind turbine.

The model was run in the FlexPDE program. It was considered a permanent movement with eddies.

It was considered that in front of the wind turbine there was an obstacle located at different distances of 24 and 9 m, respectively.

3. RESULTS

Some of the obtained results are presented further in figures 4 and 5 (Moga I. C., 2009).

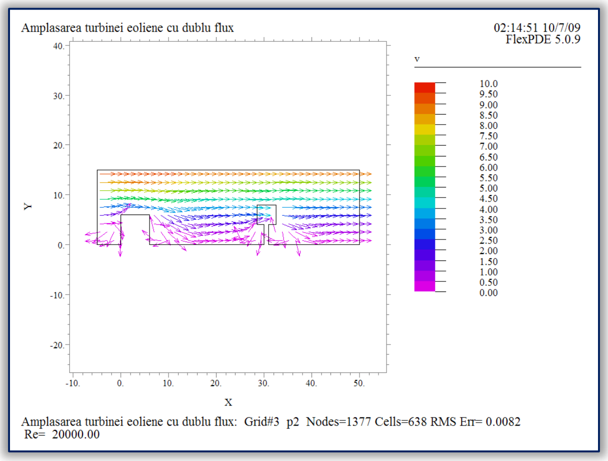

Figure 4 . a – Placement of the wind turbine at a distance of 24 m after the obstacle

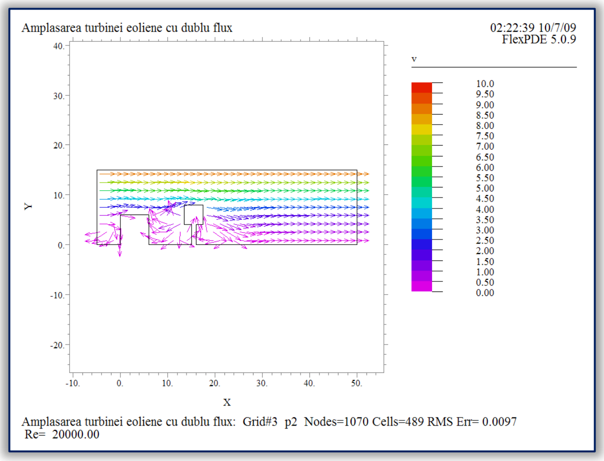

Figure 5. a – Placement of the wind turbine at a distance of 9 m after the obstacle

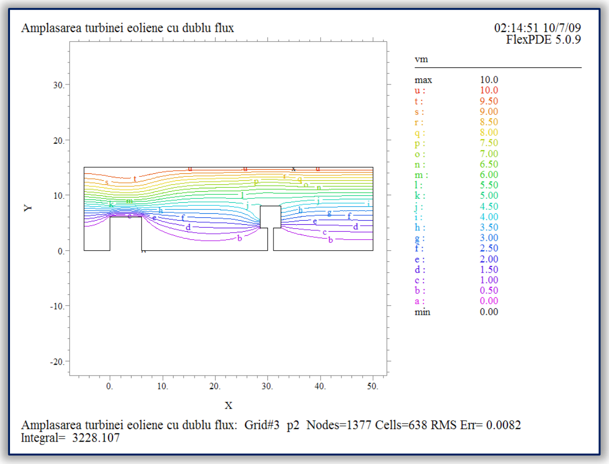

Figure 4. b – Placement of the wind turbine at a distance of 24 m after the obstacle

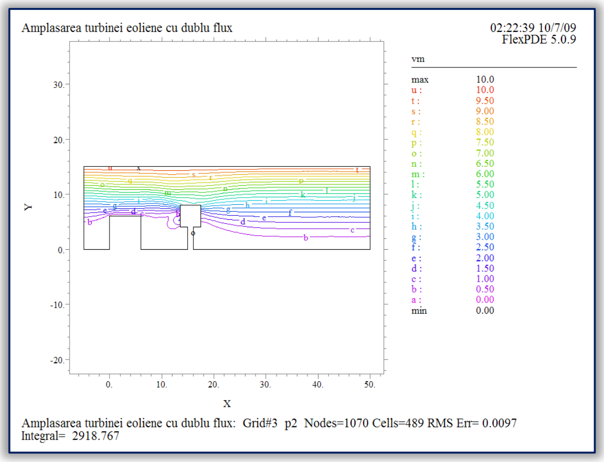

Figure 5. b – Placement of the wind turbine at a distance of 9 m after the obstacle

From the results presented in figures 4 and 5, both the current lines and the direction of the velocity vector can be observed. The current lines are disturbed by the obstacle in front of the rotor, but up to the wind turbine it is observed that the influence of the obstacle is reduced.

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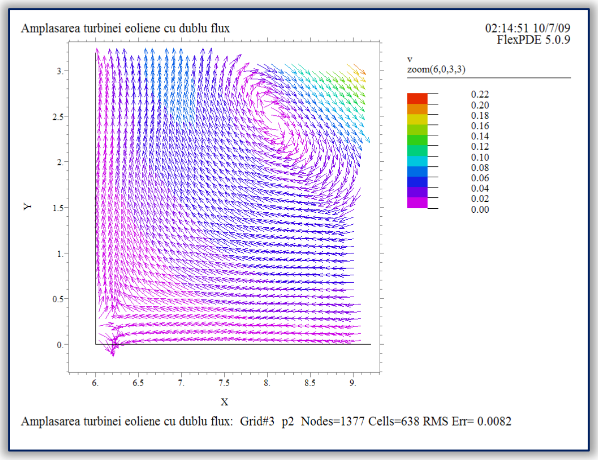

Figure 6 – Location of the wind turbine at a distance of 24 m after the obstacle (zoom with the vortex formed immediately after the obstacle)

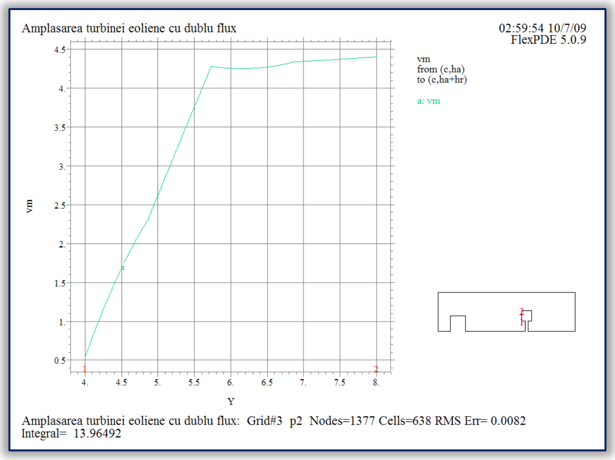

Figure 7 – The value of the wind speed at the moment of interaction with the wind turbine rotor

4. CONCLUSIONS

The exploitation of renewable energy sources is essential in order to obtain high economic performance in agriculture under the conditions of significant competition on the market. It is very important that the wind turbine is correctly located to obtain high performances. Public–private partnerships between farmers and research units can lead to increased economic, environmental and even social returns. The best available technologies can be transferred from research to farmers. An example of potential collaboration between farmers and researchers is the one presented in this article where the utility of using numerical simulation programs for the optimal location of the wind turbine is demonstrated. The results obtained as a result of mathematical modeling and numerical simulations are confirmed by the specialized literature. The existence of vortices that appear before and after obstacles was also demonstrated in the present case. Increasing and decreasing the distance at which the turbine is located from certain obstacles definitely influences its operation. The minimum distance from which the wind rotor can be located, for the case studied in the present chapter, is 20 m. If the distance is smaller, the rotor must be elevated. A large number of simulations is necessary for an optimal placement of the wind turbine because, in addition to the height ratio, the wind speed must also be taken into account. In the presented cases, it was considered that the wind speed at 15 m from the ground is 10 m/s. For other wind speeds other numerical simulations are required. The designed program can be modified so as to obtain numerical simulations for other height ratios, as well as for other wind speeds. The research of the team of authors will continue concurrently with the efforts to intensify public–private partnerships in the field of agriculture.

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