SOFTWARE FOR EVALUATION OF AGRICULTURAL FARM ENERGY POTENTIAL

SOFTWARE PENTRU EVALUAREA POTENȚIALULUI ENERGETIC ÎNTR-O FERMĂ AGRICOLĂ

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Abstract: *In the context of increasing energy prices and the reduction of world fossil fuels reserves it is necessary to use other available energy sources. Agriculture represents an important source of renewable energy sources and in the same time an important energy consumer. Agricultural farms, for vegetal, animal or mixed production have the possibility to use their own sources of energy to meet their requirements, sources which are available as secondary products or even waste. On one hand, using this energy sources enables the farmer to obtain the energetic independence of the farm and, on the other hand, to reduce the energy costs and eliminates the impact of waste to the environment (animal farms can use the manure for biogas production). In order to correctly identify the farm energy potential and to select the optimal solution for its capitalization, it is necessary to carry out the energetic balance sheet witch provides the required information. The present paper presents a software program that offers the possibility of proper evaluation of the farm energy potential. The software is flexible, easy to use and because it's modular structure it can be easily adapted to any type of farm, for vegetal, animal or mixed production. The results obtained from the input data are presented in a table format making them easy to read and understand. The energetic balance sheet contains the required information about the energetic potential. This newly developed software is meant as a useful tool for the farmers, allowing the correct and efficient evaluation of their own farm's energetic potential.*

Rezumat: *În contextual creşterii preţului la energie şi a diminuării rezervelor mondiale de combustibili fosili este necesară utilizarea altor surse de energie disponibile. Agricultura reprezintă o importantă sursă de energie regenerabilă şi în acelaşi timp un mare consumator de energie. Astfel, fermele agricole de producţie vegetală, animală sau mixtă au posibilitatea utilizării propriilor surse energetice disponibile în ferme sub formă de produse secundare sau deşeuri pentru acoperirea necesarului energetic al fermei. Utilizarea acestor surse de energie oferă fermierului, pe de o parte, obţinerea independenţei energetice a fermei şi pe de altă parte scăderea costurilor cu energia şi eliminarea problemelor de impact asupra mediului (în fermele animale dejecţiilor putând fi utilizate pentru producerea de biogaz).Pentru identificarea corectă a disponibilului de energie al fermei şi alegerea soluţiei optime de valorificare a acestuia, se impune realizarea unui bilanţ energetic care oferă informaţiile necesare. Astfel în lucrarea de faţă se prezintă un program de calculator care oferă posibilitatea evaluării corecte a potenţialului energetic al fermei. Programul este flexibil, uşor de utilizat şi datorită structurii sale modulare poate fi uşor adaptat pentru orice tip de fermă, vegetală, zootehnică sau mixtă. Rezultatele obţinute în urma prelucrării mărimilor de intrare sunt prezentate sub formă tabelară fiind uşor de citit şi interpretat. Balanţa energetică obţinută conţinând informaţiile necesare despre disponibilul energetic fiind divizat atât pe tipuri de surse de energie cât şi ca valoare totală. Programul de calculator dezvoltat se doreşte a fi un instrument pentru fermieri, care să le permită acestora evaluarea corectă şi eficientă a potenţialului energetic al fermei proprii.*

Key words**:** *agricultural farm, energy sources, energy balance sheet.*
Cuvinte cheie: *fermă agricolă, surse de energie, balanţă energetică.*

INTRODUCTION

The Romanian's total agricultural land in 2005 was 14741.2 thou hectares, of which 63% (9420.2 thou hectares) arable land [1]. So, agriculture represents a major energy consumer from the total national energetic consumes. The structural changes in the Romanian agriculture during 1990-2003 led to a distribution of more than 96% of the farming land to private ownership, which led to the formation of small or average farms.

The main type of farm is the small household, with an average area of 1.8 hectares of farming land, representing 53% of the total farming land. Farming companies have an average area of 282 hectares and account for 43% of the farming land (RGA - 2002 country level).

From the total of 4,462,221 individual farms which have the surface of agriculture land of 7.71 millions ha., 52.4% have the surface of agriculture land smaller than 1 ha, and 42.1% have the area of agriculture land between 1-5 ha, represent subsistence farms and semi-subsistence farms (RGA – 2002, country level).

The organization of the farmers into farming associations or into small and medium sized family farms has led to a slight increase of the mechanization of the agricultural sector between 1999 and 2005 (figure 1). Increases of energy consumption in farms are direct consequence of development of farms. The increasing of agricultural farms costs are induced by increasing of the energy consumption and of the price energy from conventional sources (oil, natural gas).

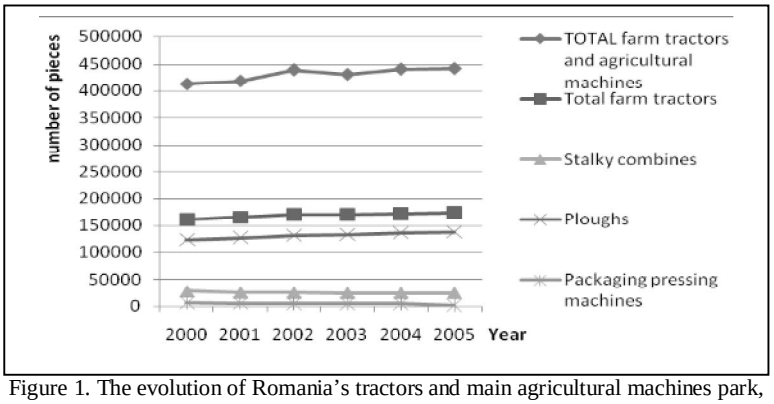


Figure 1. The evolution of Romania's tractors and main agricultural machines park, between 2000 and 2005

In this context, farmers are needed to us the available energy sources from farms, like secondary products or vegetable wastes. Renewable energy sources available in the farms offer the possibility to realize the farms energetic independence, and on the other hand the decreasing of energy costs and the elimination of the environmental impact problems (manure can be us for biogas production, in the animal husbandry farms

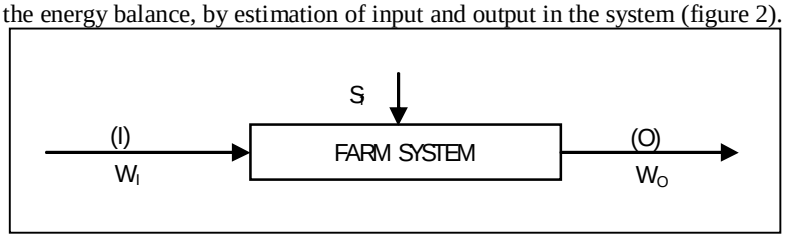
The correct identification of farm energetic potential and selection of optimum uses methods of the energetic potential impose to realise an energetic data sheet. So, an software for evaluation of agricultural farm energy potential are an useful device for farmers. The software offers for farmers the possibility to choose an optimal available energetic sources management methods and the possibility to realize an energetic independency of the farm.

MATERIAL AND METHODS

The software for evaluation of agricultural farm energy potential was developed using a mathematical method developed for evaluation of the energy input and output potential [2].

The method is based on systemic analysis, in which the agricultural processes are considered as a global system, with the generic title "FARM" and the specific activities (grain production, plant production, maize production, livestock etc.) are defined as subsystems. The system is limited to a farm. This method allows relating the outputs and inputs, by quantifying all the elements of the process.

The evaluation of energy potential for a global system FARM is accomplished by analysing the energy balance, by estimation of input and output in the system (figure 2).



The inputs (I) of the system consist of a function of energy input (W_I), or the total energy consumption associated to all activities (processes) in the farm. The output (O) of the system, represents the gross energy output (W_O), produced as a result of the processes and S_f – represent other specific features (characteristics) of the system which characterize the overall processes of the FARM system. It may include: soil proprieties, technology applies in the farm processes, climate characteristics etc.

The developed software has a modular structure, depend on the analyzed farm category. So, the software has three independent modules (figure 3.a): vegetal farm, animal husbandry farm, and mixed farm (vegetal and husbandry farm). Each independent module has specific windows (figure 3.b) which include the input data need to calculate the energetic data sheet.

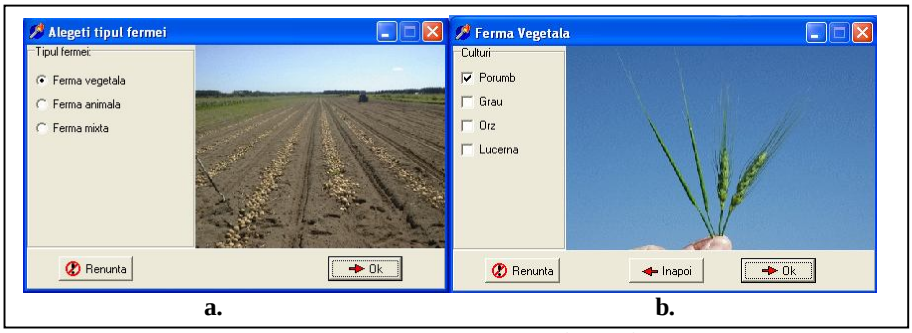


Figure 3: a. - The modular structure of the software;
b - The chosen of a crop category in a grain production farm.

The simplified logical scheme of the software for evaluation energetic potential in an agricultural farm is showed in the figure 4.

The input data are specific for the farm activity and must be introduce in "Input data" windows. The windows have a few data sheet correlated with the subsystems of the FARM system. For a crop production farm that are: energy input associated to farm machinery, energy input associated to fertilizer, energy input associated to biocides, energy input associated to crop propagation, energy input associated to irrigation, energy input associated to transportation and storage, energy input associated to manpower. The software calculates the

output data, using input data. For a crop production farms that are: the energy embodied in the main production and in the secondary products.

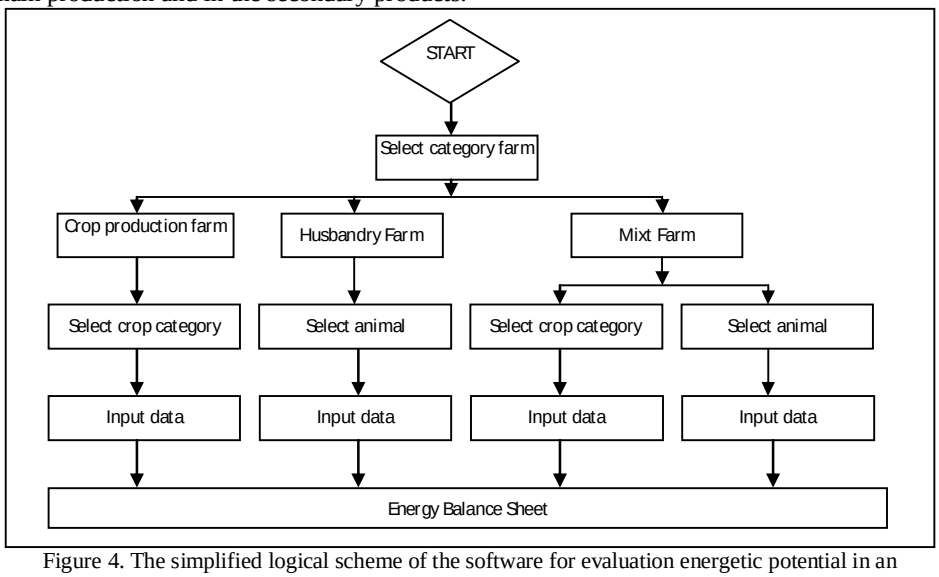


Figure 4. The simplified logical scheme of the software for evaluation energetic potential in an agricultural farm

The results are showed in an energetic balance sheet. The energy consumption and the quantity of available energy are divided by the category. So, the farm's activities with the high energy consumes and the available energy potential in farm can be identified using data from energetic balance sheet and the results can be us for farms energetic flux optimised.

SOFTWARE APPLICATION

Using the software products an energy balance analysis was developed for maize crop (the main product is the seed maize). The characteristics used for the calculation of input data are showed in table 1.

General data needs (fig.5) for calculated input data are the next structure:

– Data refer to total area cultivated (fig.5a): 1 hectares [ha];

– Type of soil: chernozem – no irrigation;

– Data refer to fuel characteristics (fig.5b): Diesel with H_c = 47,8 [MJ/kg];

– Data refer to chemical fertilizers (fig.5c) (the energy input associated to fertilizer application was included in the energy associated to farm machines): N (energy content 78,1 MJ/kg, fertilizer mass per ha – 100kg/ha), P_2O_5 (energy content 17,4 MJ/kg, fertilizer mass per ha – 50kg/ha, K_2O (energy content 13,7 MJ/kg, fertilizer mass per ha – 60kg/ha).

– Atrazin was used as herbicide (5kg/ha, 190 [MJ/kg]);

– Data refer to seed (fig.5d): energy content of seed – 100 [MJ/kg]; seed mass – 20 [kg/ha]; seed production (seed humidity – 15%) – 7000 [kg/ha] with 13 [MJ/kg] calorific energy;

– Data refer to dry vegetal material production (fig.5d) – 5200 [kg/ha] with 14,7 [MJ/kg] calorific energy.

Using the input data and mathematical method the software calculates the energy balance in the FARM. The energy balance of maize crop is presented in figure 6. The energetic

data are measured in MJ.

Table 1

The main characteristics used for the calculation of input data for maize technology production

Operation	Operating equipment	Mass of equipment [kg]	$A_{mat} + A_{manf}$ [MJ/kg]	A_{rep} [MJ/kg]	Diesel fuel consumption [L/ha]
Plowing	Tractor - U650	2500	138	10	30
	Plow - PPx30	990	180	6	
Seedbed preparation	Disk harrow - GDx3,4	1250	149	6	9x2
Seed planting	Seeder - SPC6	700	133	6	5,5
Fertilizer distribution	Centrifugal spreader	950	129	6	2
Cultivation	Cultivation equipment	3000	110	10	15
Herbicides spraying	Spraying Machine	800	128	6	3
Harvesting	Combine C12	4500	116	10	18

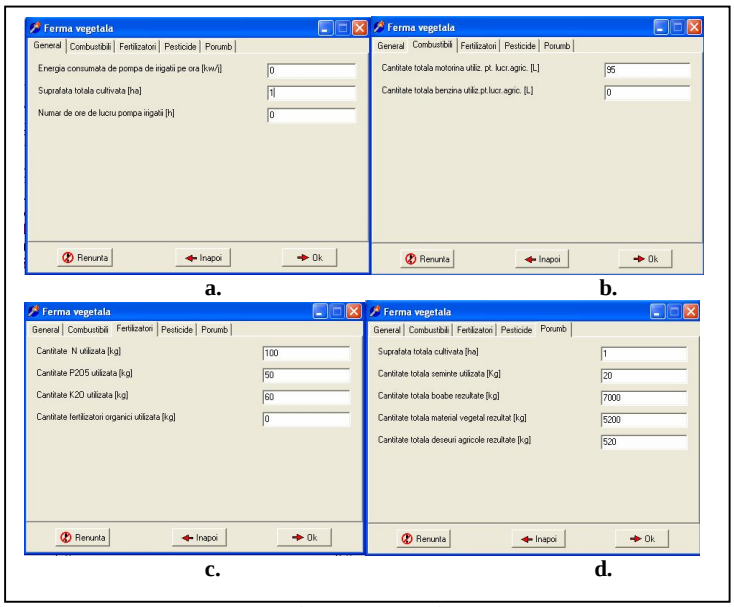


Figure 5. General data needs for input data of the system FARM calculate:
a. total area cultivated, b. fuel characteristics, c. chemical fertilizers characteristics; d. data refer to seed and vegetal material

The analysis of the data in the energetic balance sheet shows that in the case of corn crops, the energetic balance sheet is positive. The energy embodied in the vegetal mass is about 76.440 MJ/ha. So, the energy embodied in the vegetal material is equivalent as 1.975 l Diesel fuels (energy content 38.7MJ/l), 1.846,37 28m^3 natural gas (energy content 41.4 MJ/kg), 21.233,33 kWh electricity or 2.531,12 kg coal (energy content 30,2 MJ/kg). This allows us to conclude that the vegetal products can be used as a viable unconventional renewable energy source. The energy embedded in the vegetal product can be converted into thermal energy for warm water or farm and household heating, or electrical energy. The vegetal products can also be used as raw materials in biogas plant, mainly in mixed farms where manure is also produced.

Figure 7: Energy balance of maize crop. W is expressed in [MJ].

In the case of multiple cultures analysis, a comparison between these crops can be accomplished in order to obtain data regarding the efficiency of the exploitation of secondary products as a source of alternative energy.

CONCLUSIONS

By analysing the available data regarding the consumed and produced energy in agricultural farms, one can conclude that the agriculture sector is a big energy consumer, but in the same time it can become a viable unconventional energy source.

Farmers have to perform an energetic analysis of the consumption and availability of energy in their farms in order to determine their farms energy potential. The software developed and presented in this paper can become a useful tool for them. By analysing the data obtained in the energy balance sheet generated by this software application they can identify the activities with high energy consumption and take action to reduce these energy consumptions. On the other hand, they can identify the categories of secondary products which can be used as an unconventional energy source in the farm. This way, farmers can take decisions regarding the energy use and production in their farms and try to achieve energetic independence.

A development of the presented software is recommended as a future research possibility by creating a database of necessary information to analyse more types of crops and animal husbandry.

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