CONCEPT OF A DECISION SUPPORT SYSTEM FOR PRODUCERS OF ENERGY FROM BIOMASS

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Abstract: *The general concept of the Decision Support System facilitating choices concerning the size of equipment as a selection criterion the minimization of cost per unit of production was assumed. The system for raw material producers is based on models describing correlation between working conditions, technological parameters, prices of machines and the form of their use (individual or multi-farm) and the operating cost of farm machinery.*

Keywords*: DSS, biomass, farm, production, energy*

Introduction

The production of biomass for energetic purposes gives many advantages both to agriculture and to the national economy as a whole. It helps to better use the production factors, such as land, labor and capital. Development, on the larger scale, the production of energy carriers from renewable sources will be followed - directly or indirectly - by the necessity of changes concerning most of actors active in rural areas, starting from farms and ending on energy supply networks. The production of energy from biomass will be a factor stimulating the development of the rural infrastructure. The construction of new plants necessary for energy production will involve, at the first stage, the increase in duties of the local construction companies with a chance to enlarge their activity and offering new jobs. In the second stage, after launching the biomass energy business, the new jobs for local population will appear. More wide use of energy from biomass would be favorable for environment conservation. Replacement of a part of fossil energy by the renewable one would help to limit the emission of greenhouse gases.

In spite of many advantages of economic, social and ecological nature, the use of biomass as a renewable source of energy is not large enough in Poland. There are several barriers hampering the utilization of biomass for energy purposes. They are associated with:

- natural conditions,
- technology,
- economic aspects,
- policy factors.

Natural barriers limit the possibility to cultivate particular energy crops to regions with adequate soil and climate conditions. Technological barriers are connected with rotation constraints as well as with insufficient experiences in use of different processing technologies under specific Polish conditions. That causes some risks in application.

The most serious are economic barriers, resulting from relatively high costs of biomass energy production, risk connected with unstable economic situation, changes in prices of fossil energy (especially petrol products), instability of fiscal policy, fluctuations in exchange rates, unstable market situation and shortage of financial sources in agriculture.

In the field of policy, the contradictions between interests of different copartners of energy sector make the promotion of biomass use difficult. Besides, in some cases there is a lack of national standards concerning use of biomass for energy, and - in general - lack of the legal system friendly for producers and users of renewable energy sources in Poland [Grzybek, Pawlak 2002].

To overcome those barriers, the rationalization on all stages of production and utilization of energy from biomass is necessary. Convenient decision support systems (DSS) could help to solve this problem.

The objective of this paper is to present the concept of the DSS intended as a tool that can be used to improve the efficiency of biomass energy production. A special attention will be paid to the production of raw materials for energy.

Factors effecting the efficiency of production of biomass for energy

The economic efficiency of biomass energy production can be improved after rationalization of production systems. Efficient information and advisory systems for farmers and biomass energy producers are needed. The proper organization should enable the good utilization of facilities used to produce the energy and to minimize the costs and loses. In the case of biomass the minimization of costs per unit of mass of the row material is very important.

The profitability of biomass production depends on many factors, and particularly on:

- yields and quality of biomass,
- prices of product and means of productions,
- quality of soils and efficiency of yield creative inputs,
- level of intensity of production,
- kinds of technologies,
- organization of production process and form of utilization of machinery.

The efficiency and profitability of production of the energy from biomass depends on scale of production. The bigger the plants are, the sufficient profitability is easier to achieve. On the other hand, higher concentration of production means larger area from which the row material is going to be collected, what is strictly linked with transport costs. This fact should be taken into consideration in Poland, where the farms are small and the road system is not excellent.

The rationalization on the level of means of production, both for agriculture and for energy plants is very important. During last members meeting of the Club of Bologna [2003] one of the sessions was dedicated to the subject of manufacturing and management cost reduction of tractors and agricultural equipment. Production costs in the farm machinery industry can be effectively reduced through the application of specific modern management methods. In particular, significant advantages can be obtained from:

- a more rational internal organization of factories,
- standardization of machines and their components,
- modularization,
- increased interchangeability of components, so as to reduce the cost of after-sales service and spare parts.

One particular area of increasing interest is the use of electronics and mechatronics to accomplish more appropriate and cost-effective agricultural management. There is also the necessity of differentiating the design approaches for the industrialized and emerging countries [Reid, Norris, Schueller 2003].

Improving internal organization is necessary to reduce research and development costs, and taking greater care in the selection of dealers, who must have the most modern and appropriate equipment for answering the needs of purchasers [Niemeijer 2003].

Modularity and the deployment of electronics and Information Technology (I.T.) as means of reducing costs at both the industrial and agricultural level become more and more important [Kobayashi 2003].

In order to shorten the development cycle of innovative products, the "Simultaneous Engineering" (S.E.) method has been developed. The point of this

method is that the various phases of production process are carried out concurrently by interdisciplinary teams working in collaboration. The greatest advantage afforded by the S.E. method is a faster development cycle for new products, which must be extensively tested in the field. This fieldwork - coupled with the involvement of dealers - becomes more and more important as the complexity of machines increases [Harms 2003].

Complexity of interrelations between particular factors effecting the efficiency of inputs connected with biomass energy production is a reason of growing role of a good information [Pellizzi 1993]. Information becomes one of the most important factors deciding about a success in any human activity. In our case it should comprise data on market prices of inputs and products, characteristics of machines to be used, enabling rational choice, requirements of energy crops regarding soil, climate, fertilization etc., and last but not least - about state and regional policy, as well as about the legal situation.

The development of production of the biomass for energy will be possible under condition of overcoming several barriers. Therefore, technological, organization and political measures should be undertaken to promote their application. The technological measures consist in improving the performance of implements both for production of raw material and its processing into a renewable energy carrier. Also the implementation of warrants and safeguards as well as precise formulation of contracts for deliveries of production means will decrease the risk in the field of the production of energy from biomass.

In the field of policy and legislation the formulation of relevant standards, formulation and implementation of the legal system concerning the use of renewable energy sources will be necessary. In Poland, the legislative proceedings are under way to create the law concerning the production, distribution and utilization of renewable energy carriers from biomass. Evaluation of efficiency of the development of fuels friendly for environment in macroeconomic and microeconomic prospect has been taken into consideration during formulation of the law. The proposal of the law includes a system concept to develop the production and the market of biomass energy in Poland. Legal regulations concerning the performance of the market of the row materials production, as well as processing, storing and turnover of energy carriers from biomass on home market are included in the proposal of the law. Important item concerning the supply of biofuels on the market is ensuring the necessary quality by determination of appropriate requirements towards the energy carriers from biomass. The appointment of unit authorized to decide in quality matters is planned. The proposed law provides the appointment of mutual consultation commission for advisory, harmonization and agreements in all cases concerning biomass producers, processing activity and dealers.

A concept of the Decision Support System

The progress in agricultural engineering, more and more advanced technological developments in this field and necessity to ensure the high efficiency of inputs cause that the rational strategies should be involved both for producers and users of adequate technical means. To elaborate such strategies, the Decision Support Systems are needed. They should enable the appropriate choice of the production system, selection of farm machinery sets for farms and contractors, choice of system of use of farm machinery (individual or multi-farm), planning the capacities of farm machinery factories and of the products assortment, planning the capacities of repair shops and stocks of spare-parts.

The economic efficiency of biomass energy production can be improved after rationalization of production systems. Efficient information and DSSs for farmers and biomass energy producers are needed. The proper organization should enable the good

utilization of facilities applied to produce the energy and to minimize the costs and loses. In the case of biomass the minimization of costs per unit of mass of the row material is very important. The cost per unit of production can be minimized by 1) appropriate choice of machine (type, size); 2) optimal utilization procedure taking into account local operating conditions; 3) choice of kind of biomass to be used as a raw material, comformably to natural conditions (Figure 1).

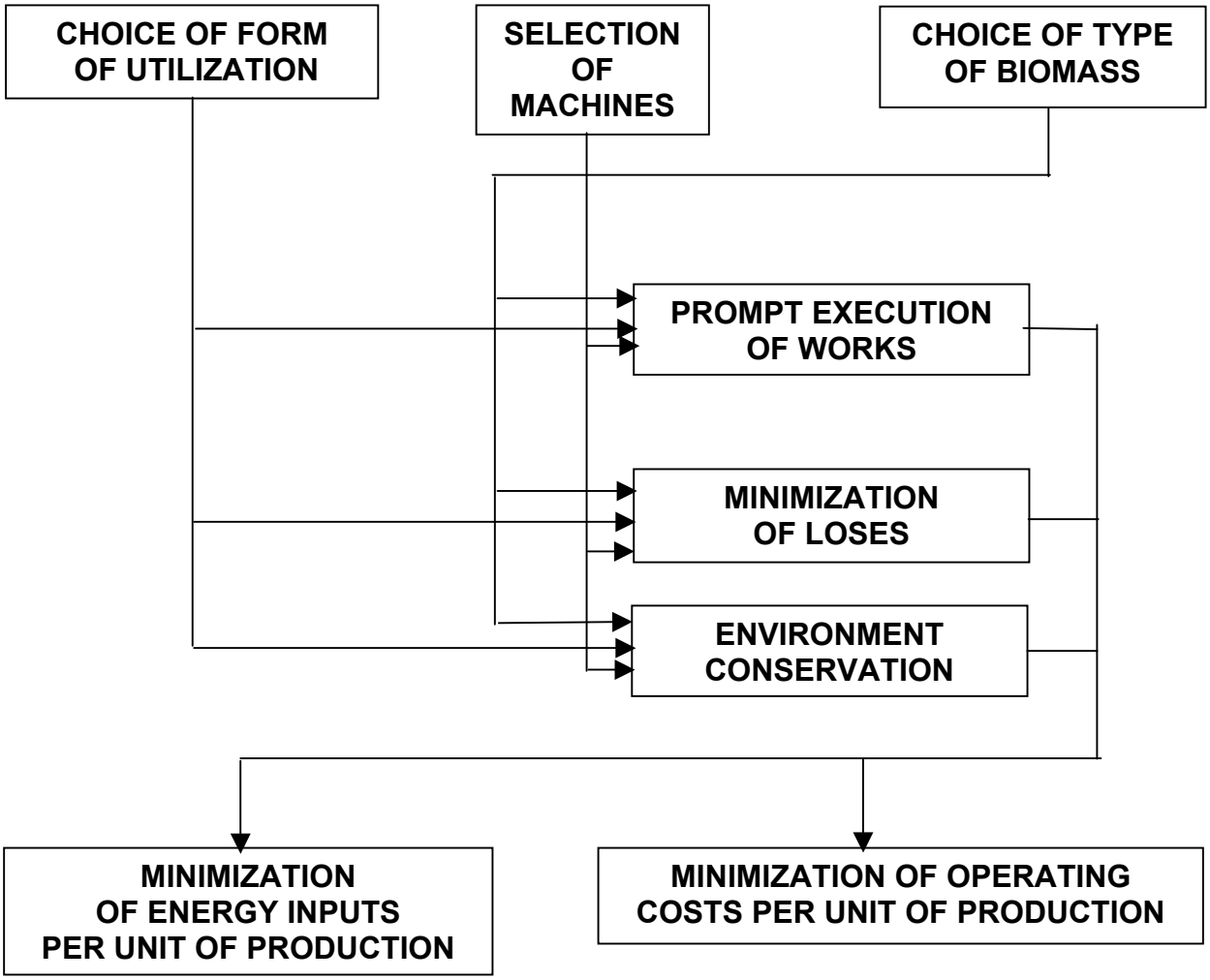

Figure 1, Role of the decision support system

An accurate optimization analyses should be undertaken both concerning the production of raw material (biomass) and the final product (energy carrier). On the farmers' level different forms of co-operation should be considered in order to make the production processes more efficient. One of ways is multi-farm use of machines making possible the better advantage of the capital potential and reduction of fixed cost of mechanization. Co-operation is also needed on the level of storage and turnover of product. When comparing the individual and multi-farm machinery use system, the eventual risk of losses incurred because of not completing the work on time is taken into consideration.

The databases are necessary when making decisions about buying machines and choosing the system of their use.

In the Decision Support System facilitating choices concerning the size of equipment as a selection criterion, the minimization of cost per unit of production was

assumed [Pawlak 1993]. The system for raw material producers is based on models describing correlation between working conditions, technological parameters, prices of machines and the form of their use and the operating cost of farm machinery. This element is shown as the "database on operations" at the Figure 2. It comprises a set of formulas. Some examples are shown below.

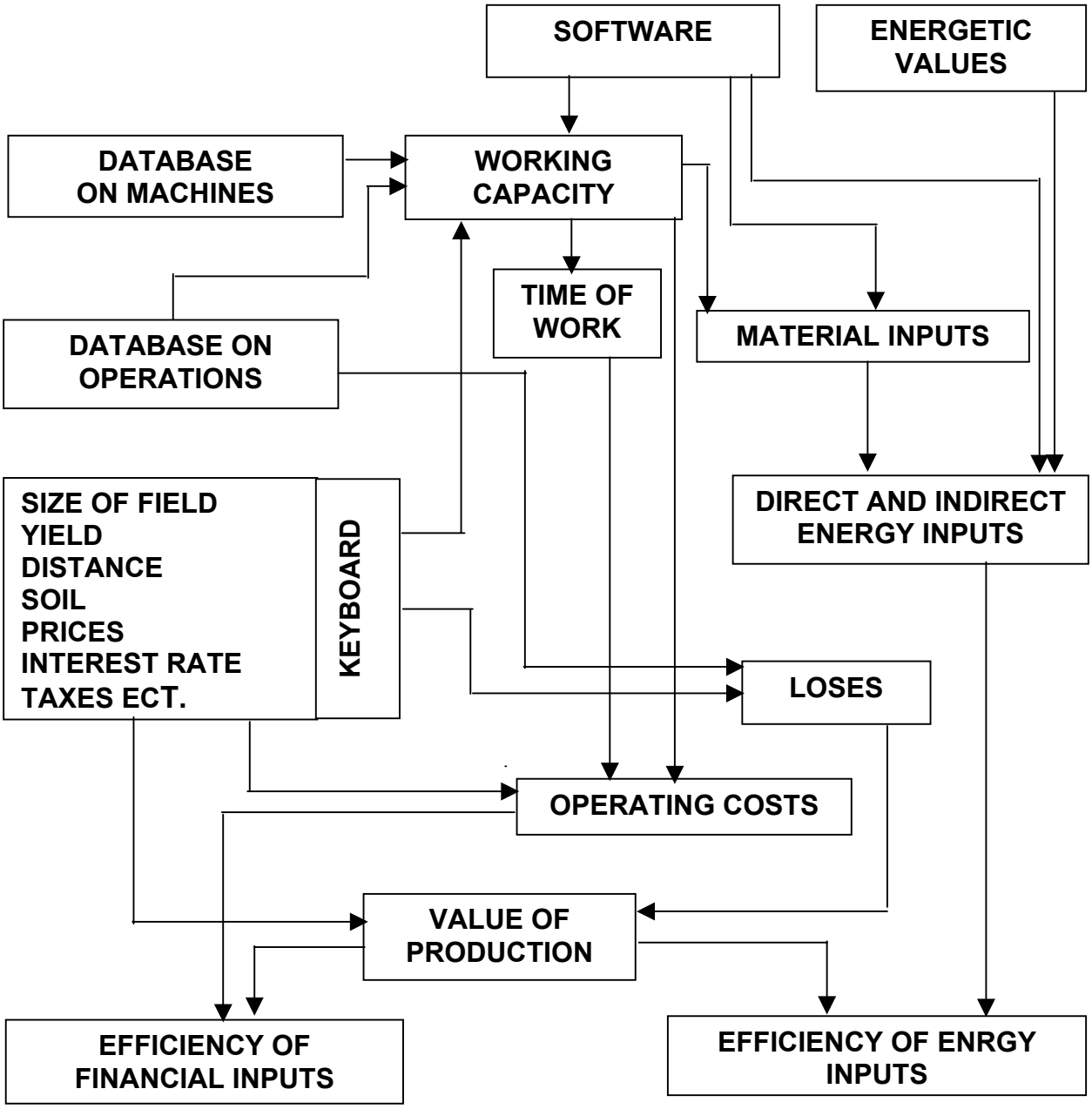

Figure 2. Scheme of the Decision Support System for biomass producers

The formula describing correlation between distance to the field, working width, working speed, transport speed, size of field and the working operation capacity when ploughing has a form:

$$Wo = 0{,}08784\ x_1^{-0{,}0418}\ x_7^{0{,}86598}\ x_8^{0{,}62951}\ x_9^{0{,}07915}\ S^{0{,}14092} \qquad (1)$$

where: Wo - working operation capacity, (hectares/hour)
x_1 - distance to the field, (km)
x_7 - working width, (m)

x_8 - working speed (km/hour)
x_9 - transport speed (km/hour)
S - size of field, (hectares)

The unitary cost per 1 hectare of ploughing can be calculated using the following formula:

$$Co = \frac{S}{Wo} Cu^1 + \frac{S}{Wo} Cu^2 \qquad (2)$$

where: Co - operation cost per unit of work completed, (zl/hectare)
Cu^1 - cost per unit of time of plough operation, (zl/hour)
Cu^2 - cost per unit of time of tractor operation, (zl/hour)

On the bases of economic analysis, the system can also assist in decisions concerning the purchase of second-hand machines. One of the elements of such an analysis is the calculation of the maximum acceptable price. The maximum acceptable price Cm^1 for a second-hand machine with an engine can be calculated using the following formula:

$$Cm^1 < \frac{T^1(Ke - 1.05 Zp^1 Cp) - n^1 Ku}{1 + \frac{n^1 0.5I}{100} + k^1} \qquad (3)$$

where:
Ke - unitary operating cost for the new machine, (zl/hour)
T^1 - approximate use of the second-hand machine in the period from purchase until the end of its useful life (hours)
I - interest rate, (%)
k^1 - estimated relation between the second-hand machine repair costs during its useful life T^1 and the price of the second-hand machine
Ku - insurance and tax per year, (zl)
n^1 - useful life of the second-hand machine, from purchase until it is scraped, (years)
Zp - unitary fuel consumption by engine of the second-hand machine per hour of operation time, (kg/hour)
Cp - price per unit of fuel, (zl/kg)

The maximum acceptable price Cm^{1*} for a second-hand motorless machine can be established using the following formula:

$$Cm^1 < \frac{T^1(Ke - n^1 Ku)}{1 + \frac{n^1 0.5I}{100} + k^1} \qquad (4)$$

The purchase of the second-hand machine is economically justifiable if the offered price is not higher than the maximum acceptable price.

Unstable market situation causes that relation between prices of particular goods change frequently. Therefore, apart from the analysis basing on monetary units another one, basing on embodied energy units is advisable. In such analysis direct and indirect energy inputs are considered. In the proposed concept of DSS this approach is also included, as presented on Figure 1.

Conclusion

The role of the Decision Support System facilitating choices of equipment and form of its use dynamically grows. The information system and the Decision Support Systems should be currently adjusted and actuated and must be friendly for users. The close cooperation between different units and institutions is necessary to make the system updated and efficient. The involvement of Ministry of Agriculture and other Government bodies, research institutes, statistical offices, market institutions, producers of farm machinery and other units is needed so that the system could be efficiently operated.

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