A Decision Support System (DSS) for Project Management in the Biodiesel Industry

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The European biodiesel industry is currently facing several challenges affecting the profitability of investment projects in the industry. Among these challenges are higher prices for oilseeds, which are the main input for biodiesel production, lower fiscal support by national governments for biodiesel producers and high price volatility of oil markets. Thus identifying all opportunities for optimizing the value chain and lower the production cost of biodiesel is a main requirement for an efficient project management in the biodiesel industry. The paper addresses this topic by developing a decision support system tailored to the needs of Romanian investors in biodiesel production. The system optimizes the main activities of the biodiesel value chain and supports the decision making process at management level. In addition the DSS enables the user to perform sensitivity analysis based on varying various input parameters.

Keywords: *Biodiesel, Investments, DSS, Optimization, Management*

1 Introduction

This paper assesses the potential of implementing a decision support system (DSS) at firm level in the Romanian biodiesel industry. It also highlights the usefulness of a DSS in this industry with the help of a short case study.

The first part introduces the concept of DSS as defined in the literature. The second part makes an overview of current DSS designed for the biodiesel industry and identifies their main shortcomings and improvement needs.

The third part introduces the elaboration steps of the DSS "Biopur.OLT.SYS", which was designed by the author for better management of investment projects in biodiesel production. This part includes also a description of the mathematical model for optimization of production cost, which is part of Biopur.OLT.SYS.

The fourth part stresses the advantages from using Biopur.OLT.SYS at firm level with the help of a short case study. A hypothetical investment project called *Bio_Eficienta_1* serves this purpose.

The paper ends with concluding remarks on using the DSS and improvement recommendations for future research in this area.

The European biodiesel industry has recorded considerable growth rates both in production and consumption terms. This was mainly a consequence of the support granted by the European Union (EU) and member states to biodiesel producers, which took the form of exemptions from fuel taxes and subsidies granted to farmers for harvesting crops for biodiesel production. Main driver for this support was the aim of the EU to reduce the dependency of the European economy on imported oil and to limit the negative effects on the environment from consumption of energy in transports. The interest of investors in biodiesel took off after the issuance by the EU of Directive 30/2003 [4], which stated clear targets for consumption of biodiesel and advised national governments to implement supporting schemes for biodiesel production in their own countries.

However due to the higher production cost compared with regular diesel the price of biodiesel is uncompetitive in the fuel market. This corroborated with the national governments reducing or withdrawing the fiscal support for biodiesel could seriously affect the profitability of investment projects in the industry.

Based on this identifying and fully exploiting all potentials to achieve cost reductions in biodiesel production is necessary. Biopur.OLT.SYS helps the management of a biodiesel plant in selecting best alternatives for structuring the biodiesel value chain.

2 The concept of DSS

DSS are information systems designed to support users in solving various management issues, with the objective of improving the decision process at firm level [2].

Regardless of the category to which a DSS belongs, the process of designing and implementing such a system follows several stages within a well defined working framework [1] (Figure 1). The first stage corresponds to the initiation and the conception of the DSS based on the structure of the decision process and on the needs of the decision makers [5]. The usefulness of a DSS depends on whether it is able to solve a real management issue with an impact on the profitability of an investment project. Depending on the complexity of the DSS this stage requires also an elaborate plan for the conversion of the DSS into a readily usable form.

The next stage of the DSS development involves the elaboration and development of the informatics application. This requires sketching the system architecture, building the system with the help of specialized software programs, testing the initial beta versions and preparing a user guide of the informatics application.

The last stage concerns the integration of the DSS and of the informatics application on which the system bases in the IT infrastructure of the firm. During this stage decision makers familiarize themselves with the objectives of the application and its features.

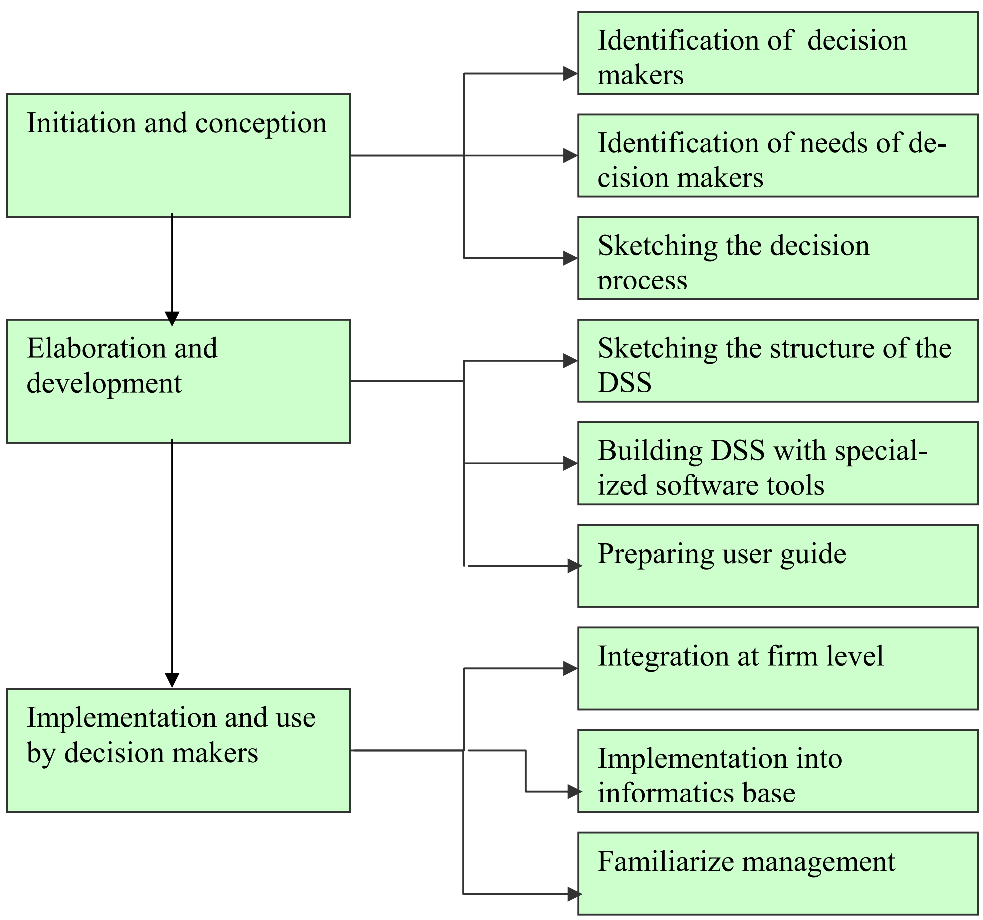

Fig. 1. Stages for designing and implementing a DSS

3 DSS in research for the biodiesel industry

Enabling a high profitability of investment projects in biodiesel production depends on identifying optimization potentials of production processes, which enable the accomplishment of competitive advantages compared to other competitors from the industry or to competitors from the oil industry. Among the optimization potentials are: the enhancement of input processing and of the technological process of converting oilseeds into biodiesel, or conceiving functional and effective supply and distribution systems.

Academic research in the biodiesel industry includes a limited number of DSS for structuring activities in the biodiesel value chain and improving project profitability. Most of the papers analyzed on DSS in the biodiesel industry focus on assessing the programs for promotion of biodiesel (e.g. exemption of fuel taxes, subsidies for agricultural producers), estimating the impact on the environment from the use of biodiesel, analyzing the potential of the industry to reach the market shares set as objectives by the EU or estimating the impact of future production technologies on the biodiesel industry.

Kerdoncuff [6] develops a DSS for optimizing the supply chain of biodiesel, from the acquisition of raw material to the actual production, with the help of a single period model and the technological relationships resulted from experimental research. The main disadvantage of his research lies in the lack of an integrated analysis, as it ignores the distribution of the final product and its impact on the profitability of projects.

The supply with raw materials in the biodiesel production takes place with the help of *Geographic Information Systems* [3]. These systems first map potential sources for supply of raw materials through geographic coordinates. After this the system selects supply sources based on ensuring a minimum cost of supply for a certain production level of biodiesel. The cost of supply includes both the acquisition of raw material, which means the price paid to the supplier, and the cost of transportation of the purchased quantities of raw material from the source to the production plant. The DSS selects a certain source only when this offers a lower purchase price than sources with similar raw material types, and the distance, usually measured in km, from the source to the biodiesel plant is as small as possible. The latter ensures a low transportation cost for the investor.

Lensink and Londo [8] use the DSS "BioTrans" to assess the economic viability of first and second generation technologies for biodiesel production. The system establishes the optimal distribution of biodiesel production stemming from different technologies for which biodiesel consumption levels reach EU targets at a minimum cost. BioTrans has a European focus, which means that the transportation cost of raw material is incurred both within national borders and EU wide in case of import-export of biodiesel between member states. The main disadvantage of BioTrans lies in its rather general focus on production cost of biodiesel at national level, which ignores differences in production costs from building plants in various locations within the same country. The general focus of BioTrans provides little help to individual investors in biodiesel production, but is a useful tool for evaluating national policies for promotion of biodiesel.

Parker et al. [9] develops a mathematical model for selecting production locations and for configuration of the logistical system in the biodiesel industry on the West side of United States of America. The DSS considers the whole value chain from the geographical distribution of sources for feedstock (oilseeds, animal fats, used cooking oil), the selection and transport of raw material from the supply sources to the production plant, the conversion of raw material into biodiesel and the distribution of the final product to the commercialization centers. The objective function of the model is the maximization of the annual profit from the production and distribution of biodiesel. The model of Parker et al. carries out the optimization of the biodiesel production depending on a single exogenous biodiesel price, but the price experiences a high regional variability. Moreover the model of Parker considers the profitability of the whole biodiesel industry, but offers little support for optimizing the investment project of an individual producer.

4 Elaboration of Biopur.OLT.SYS

Biopur.OLT.SYS is a single period decision support system, which targets especially the management of investment projects at firm level and relies on mathematical models. It provides an assessment of the cost of biodiesel production in Romania, based on input from market and management, and an insight into the cost categories and their reduction potential.

The DSS structures different activities from the value chain of biodiesel into working modules, each assigned with optimizing a certain activity. The main link between the activities is the common objective of obtaining a minimum production cost of biodiesel.

Main activities optimized in Biopur.OLT.SYS are: supply, production and distribution. The system starts with feedstock procurement and transportation to the plant, conversion of feedstock into biodiesel, and distribution of the final product and of the auxiliary output products.

In addition the system supports the initial investment decision regarding the location of the future production plant, as well as the selection of the appropriate production capacity for high capacity utilization at minimum cost. Main criteria for selecting the production location are: availability and low price of feedstock, as well as a developed distribution channel for the biodiesel product. Secondary criteria for location suitability are the access to local government support, skilled workforce, and a low price for utilities. However Biopur.OLT.SYS considers only the main criteria for site selection, which has a long term impact on the profitability and the survival of investment projects.

The system models the particular case of investment projects with own crushing facilities of oilseed into vegetable oils, which reduces the dependence of the producer on feedstock markets. Such a case implies a vertical integration of the biodiesel producer into part of feedstock production.

Moreover distribution of biodiesel takes place in Biopur.OLT.SYS only directly at fuelling stations, which corresponds to the commercialization of biodiesel in a pure form (B100). Though this distribution segment is currently not available in Romania, it is widely used in advanced biodiesel industries such as Germany. Alternatively producers sell biodiesel to large refineries carrying out the mandatory mixing of biodiesel with regular diesel, but this option does not allow for an independent and sustainable development of the biodiesel industry.

The DSS is applicable especially to the Romanian biodiesel industry, but can be easily adapted for biodiesel industries from other countries.

The system considers the first generation of production technology for biodiesel, which bases on oilseed crops as raw material. Adaptations of the DSS to higher generation production technologies are possible, but higher generations do not enable, at current know-how, production of biodiesel at industrial levels. Henceforth the main raw materials modeled in the DSS are: sunflower, rapeseed and soya. Other oilseeds, despite efficiently utilized in biodiesel production, do not represent viable solutions as feedstock as they can not be harvested in Europe due to unfavorable climatic conditions (e.g. jatropha oilseed requires a tropical weather for harvesting).

Biopur.OLT.SYS helps structure the activity of feedstock supply for a given production quantity of biodiesel, within a give time period, with following input: selection of feedstock type (e.g. sunflower, rapeseed, and soya), quantities procured of each feedstock type, procurement sources for feedstock, optimization and computation of procurement cost. In determining the procurement cost the system considers both the acquisition price of feedstock and the transportation cost of the purchased quantities to the production plant. The importance of the procurement cost lies in its significant contribution to the final cost structure of biodiesel (e.g. approximately 80%).

The production activity of biodiesel refers to structuring the production flow in a way that the cost is at a minimum without affecting the quality of the final product. The production activity encompasses all the costs related to implementing the production recipe of biodiesel other than the expenses incurred with the acquisition of feedstock, which are part of the procurement activity.

The distribution activity relates to the selection of the most profitable distribution centers so the biodiesel production brings a maximum of income for the producer. In selecting the distribution centers Biopur.OLT.SYS accounts for the distribution price obtained by the producer, which is an income item, and the distance required to transport the quantity of biodiesel to the distribution source. The latter determines the transportation expense. Based on this optimizing the distribution activity implies commercializing the whole quantity of biodiesel produced within a given time frame for a maximum price with a minimum transportation cost.

The transport costs associated with the feedstock and the distribution of the final product take fixed transport distances between sources of feedstock or centers of distribution and the location of the plant. Sources of feedstock supply and centers of distribution of biodiesel are individual counties in Romania, so each county has its own potential of being a feedstock source or a demand center for biodiesel. Transportation takes place from the centre of the counties selected for supply or distribution to the production plant. The only transportation method considered in Biopur.OLT.SYS is by truck, as this is readily available for a Romanian biodiesel producer. The transport costs include both the expense of transporting the purchased feedstock from the supply source to the biodiesel plant, as well as the expense related to the distribution of biodiesel from the plant to the fuelling stations. The transportation cost depends on the distance in km, as well as on the form of the product transport (e.g. solid for feedstock and liquid for biodiesel).

Figure 2 presents the decision process within the activities of biodiesel production.

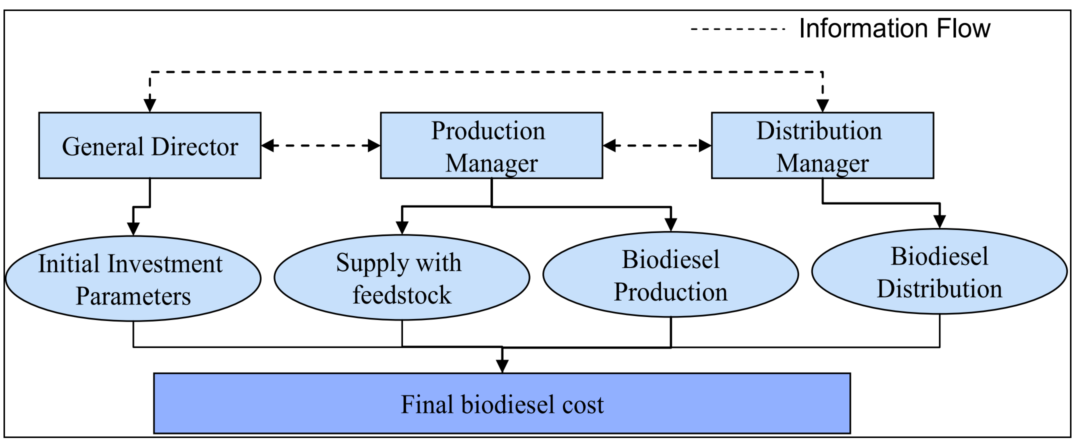

Fig. 2. Decision process within the biodiesel activities

The mathematical model behind the DSS has as objective reaching a minimum cost of production for biodiesel, considering the restraining conditions imposed by the user and market constraints. The global function of minimization is a collection of sub-functions, where each sub-function deals with a separate activity from the value chain of biodiesel production. The link between the sub-functions is the value of the biodiesel quantity established by the user for a certain period. The time horizon resumes to a single period, which can be longer than one year.

The mathematical model supports the investments in biodiesel through finding the most favorable alternatives in making management decisions. The mathematical model uses the notations presented in Table 1 for input variables and in Table 2 for output variables.

Figure 3 gives the activities fluxes encountered in structuring the production of biodiesel and their interaction in Biopur.OLT.SYS.

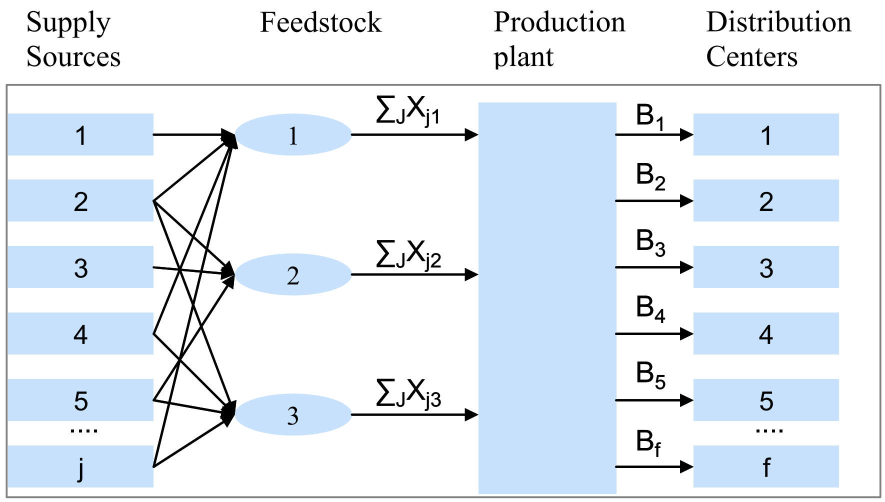

Fig. 3. Activities fluxes in Biopur.OLT.SYS

The objective function of the mathematical model consists in minimizing the unit cost of biodiesel production for an investment alternative selected by the user. The assessment of the different alternatives in the decision making process takes place through the optimization results of the production cost associated with each alternative

$$\textbf{Minim } C_{total} = \textbf{Minim } C_{supply} + \textbf{Minim } C_{production} + \textbf{Minim } C_{distribution}$$

The supply cost refers to payments made by the producer for covering the necessary quantity of oilseed in order to obtain the biodiesel quantity B_{total}. These payments depend on the selected types of oilseed ($i_{entering}$), on the associated acquisition prices (P_i), on the quantities acquired from each selected type and from each source (X_{ij}) and on the delivery costs to production plant *b*. Delivery costs depend on the distance between the source of supply and the plant (d_{ij}) and on the transportation cost per km for a regular transport of 5 tons oilseed (c_a).

$$C_{supply} = \sum_i \sum_j (X_{ij} * P_i + d_{ij} * c_a/5.000)$$

Table 1. Input variables in Biopur.OLT.SYS

t	- time period considered for analysis	- number of days
T	- time period for actual biodiesel production within one year	- number of days ($T \leq 330$ days)
B	- location of production plant – name of county in Romania	
Inv_0	- initial investment in fixed assets and site preparations at location b	- EUR
P_{am}	- time period for depreciation of fixed assets	- years
Q	- daily production capacity	- liters/day
i	- type of oilseed used in biodiesel production – rapeseed, sunflower, soya	
I = 1,..,i	- total of oilseed types used in biodiesel production	
P_i	- acquisition price of oilseed of type *i*	- EUR/kg
j	- supply source of feedstock	- county
J= 1,..,j	- total of supply sources with feedstock	- county

d_{ij}	- distance required for transporting feedstock *i* from source *j* to production plant *b* - km
Pla_{ij}	- maximum available feedstock *i* from supply source *j* in period *t* - kg
c_a	- transport cost of purchased feedstock for a regular transport of 5 tons - EUR/km
μ_i	- conversion factor of oilseed *i* in biodiesel - %
f	- distribution location of biodiesel - county
$F = 1,...,f$	- total of distribution locations - county
P_M	- delivery price of methanol - EUR/kg
C_M	- quantity of methanol used for production of 1 liter of biodiesel - kg
A_{CC}	- other chemical costs incurred for obtaining 1 liter of biodiesel – EUR
S	- salary costs for operating personnel - EUR
A_{CP}	- other production costs (maintenance, repairing) expressed for 1 liter of biodiesel - EUR
A_{CA}	- other administrative costs (secretary, bookkeeping, cleaning) expressed for 1 day of production – EUR
E	- efficiency of production personnel - quantity of biodiesel "produced" in 1 day by a worker - liters
W	- energy consumed in production - kW
c_w	- acquisition price for one unit of kW - EUR
B_f	- estimated quantity of biodiesel demanded by center *f* - liters
d_f	- distance from production location b to distribution point *f* - in km
P_f	- price of biodiesel at distribution point *f* – EUR/liter
c_b	- transportation cost of biodiesel for a single delivery of 20 thousand liters –EUR/km
P_g	- distribution price of glycerin resulted from production -EUR/kg
g	- glycerin resulted from biodiesel production -%
G	- quantity of glycerin resulted from production - kg
Ps_i	- distribution price of oil cake resulted from crushing of oilseed into vegetable oil *i* - EUR/kg

Table 2. Output variables in Biopur.OLT.SYS

B_{total}	- quantity of biodiesel produced during *t* at location *b* - liters
B_{yearly}	- quantity of biodiesel produced during *T* at location *b* - liters
$i_{entering}$ - I	- types of oilseed selected by the DSS for achieving the production plan during time *t*
$j_{entering}$ - J	- selected supply sources - counties
X_{ij}	- quantities of oilseed *i* purchased from source *j* for production of biodiesel quantity B_{Total} - kg
$f_{entering}$ - F	- distribution centers of biodiesel selected by Biopur.OLT.SYS - counties
$B_{fentering}$	- quantity of biodiesel demanded by centre $f_{intrare}$ - liters
s_{ned}	- quantity of biodiesel left undistributed in time t - liters
c_{supply}	- acquisition cost with oilseed in time *t* - EUR
$c_{production}$	- production cost of biodiesel quantity B_{total} in time *t*, excluding expenses related to the purchase of oilseed - EUR
$c_{distribution}$	- distribution cost of production of biodiesel in time *t* – EUR
V_g	- income from selling glycerin - EUR
V_s	- income from selling oilcake - EUR
V_b	- income from distribution of biodiesel in period *t* - EUR

The production cost contains all cost categories directly linked to the technological process of production and the administrative costs for operating the production location. These include the consumption of methanol and other chemical costs, salary costs, energy utilization, other production costs, administrative costs and costs related to the depreciation of the initial investment in fixed assets.

$$C_{production} = B_{total} * (P_M*C_M + A_{cc} + C_w*W + S/e + A_{CP}) + t*A_{CA} + (Inv_0/P_{am})*(B_{total}/B_{yearly})$$

The distribution cost includes all payments made by the producer for the transport of the commercialized quantities from the production plant *b* to each distribution centre ($f_{entering}$). These payments are determined by the distance to each delivery point (d_f) and by the transportation cost per km for a standard delivery of 20 thousand liters biodiesel (c_b).

$$C_{distribution} = \sum_f (d_f * c_b * B_f /20.000)$$

Furthermore the model has following restrictions:

- The maximum available quantities of a certain oilseed type in Romania is the sum of the available feedstock at the supply source included in Biopur.OLT.SYS ($\sum_j Pla_{ij}$).
- The quantity X_{ij} of feedstock purchased of a specific type *i* and from a specific source *j* is limited to the maximum available quantity of that feedstock (Pla_{ij}). A similar constraint applies to the total quantity purchased from a specific type of oilseed
  $X_{ij} \leq Pla_{ij} ; \sum_j X_{ij} \leq \sum_j Pla_{ij}$
- The quantities of feedstock purchased ($\sum_i\sum_j X_{ij}$) depend on the planned production quantity of biodiesel for the period *t*. Based on this the producer knows initially only approximately the necessary quantity of feedstock, but has a clear objective regarding the level of production (B_{total}). The structure of the raw material, as well as the quantities bought of each type, are established through the DSS based on the acquisition price, the distances from each source to the plant and the conversion factor μ_i, which is specific for each type of oilseed.
  The formula for computing the structure of purchased feedstock is:
  $\sum_i\sum_j X_{ij} * \mu_i = q * t = B_{total}$
- The maximum demand for biodiesel for the production realized within the time period *t* is the sum of the quantities of biodiesel demanded by each distribution centre ($\sum_f B_f$).
- The quantity of biodiesel actually distributed to the centers selected by the DSS ($\sum_f B_{fentering}$) is maximum equal to the total demand for biodiesel ($\sum_f B_f$). A similar condition applies at the individual distribution centre. The final selection of the distribution centers takes place based on the distribution price for each centre (P_f) and the distance from the plant to the centre (d_f).
  $\sum_f B_{fintrare} \leq \sum_f B_f ; B_{fintrare} \leq B_f$
- The quantities of biodiesel distributed in period t ($\sum_f B_{fintrare}$) depend on the realized production so these quantities are limited to the available quantities on inventory at plant *b*. For the particular case of undistributed quantities at the end of period *t* the variable s_{ned} is used.

$\sum_f B_{fintrare} \leq B_{total} ; \sum_f B_{fintrare} + s_{ned} = B_{total}$

For the detailed analysis of the profitability reached by the investment project following additional variables are introduced:

- The total income obtained from biodiesel commercialization consists of the monetary flows resulted from the commercialization of the produced quantities of biodiesel and the sale of auxiliary products. Main auxiliary products from the crushing of oilseed into vegetable oils and the production of biodiesel are oilcake and glycerin.
  $V_{total} = V_b + V_g + V_s ;$
  $V_b = \sum_f B_{fentering} * P_f ;$
  $V_g = B_{total} * g * P_g ;$
  $V_s = \sum_i X_{ij} * (1- \mu_i) * Ps_i$
- The average acquisition price of feedstock (Q) is expressed on liter of produced biodiesel as the relation between

the cost of supply C_{supply} and the produced quantity B_{total}.

- The average distribution price of biodiesel (D) is expressed as the relation between the income obtained from the sale of biodiesel ($\sum_f B_{fentering} * P_f$) and the total quantity distributed ($\sum_f \mathbf{B}_{\mathbf{fentering}}$) .
- The profitability of each distribution centre (M_f) is the difference between the income obtained from the respective centre and the cost of biodiesel delivery to that centre (P_f - $d_f * c_b$ /20.000)
- The average profitability of the distribution is computed as the relation between the sum of the income obtained from all selected centers ($\sum_f B_{fentering} * M_f$) and the total quantity distributed ($\sum_f B_{fentering}$).

5 DSS application

The DSS is applied through a case study based on a hypothetical investment project called *Bio_Eficienta_1*. The production plant locates in the county of Valcea (randomly selected) and the daily production capacity reaches 18 tons of biodiesel. For this capacity an annual utilization rate of equipments of 100% is implied. For the purpose of EU comparability of costs in future research all values are expressed in EUR currency, using an exchange rate of 4.3 RON for 1 EUR.

The supply of feedstock takes place from 42 potential sources of oilseed supply, corresponding to 42 counties in Romania. A similar approach applies for the commercialization of biodiesel at 42 centers. Distances for the computation of transport cost, both delivery of feedstock and distribution of biodiesel, are based on the transport route supply source/distribution centre and center of Valcea county.

The supply of feedstock relies on three types of oilseeds available in Romania: rapeseed, soya and sunflower.

The raw materials entering the production process are: feedstock (oilseed), methanol and sodium methoxide used as a catalyst during the trans-esterification process of producing biodiesel.

The values assigned to input variables in the project *Bio_Eficienta_1* are shown in Table 3, while Table 4 presents the assumed maximum quantities of each type of oilseed per source of supply, Table 5 the assumed demand of biodiesel coming from each centre and Table 6 the assumed prices charged by the producer for biodiesel distribution at each center.

Table 3. Values of input variables used in *Bio_Eficienta_1*

t	- 330 days
T	- 330 days
B	- Valcea
Inv_0	- 2.7 Million EUR
P_{am}	- 10 years
Q	- approximately 18 thousand liters/day
i	- rapeseed, sunflower, soya
P_i	- rapeseed: 0.29 EUR/kg - sunflower: 0.27 EUR/kg - soya: 0.28 EUR/kg
j	- 42 counties in Romania
d_{ij}	- computed by DSS based on a GIS system
Pla_{ij}	- Table 4
c_a	- 0.58 EUR/km
μ_i	- conversion factor: sunflower: 40% rapeseed: 42% soya: 20%
f	- 42 counties in Romania
P_M	- 0.44 EUR/kg

C_M	- 0.11 kg methanol/liter biodiesel
A_{CC}	- 0.023 EUR/liter biodiesel
S	- 28 EUR/day/worker
A_{CP}	- 0.007 EUR/liter biodiesel
A_{CA}	- 442 EUR/day
E	- 800 liters biodiesel/day/worker
W	- 0.32 kWh
c_w	- 0.07 EUR/kWh
B_f	- Table 5 - liters
d_f	- computed by DSS based on a GIS system
P_f	- Table 6
c_b	- 1.3 EUR/km
P_g	- 0.3 EUR/kg
g	- 10%
Ps_i	- price of oilcake depends on the oilseed from which it was obtained and is expressed in EUR/kg: - from rapeseed: 0.2 - from sunflower: 0.1 - form soya: 0.2

Table 4. Assumed maximum quantities of each type of oilseed per source of supply (in tons)
Source: Adapted data provided by the Romanian National Institute of Statistics [11]

	Sunflower	Soia	Rapeseed		Sunflower	Soia	Rapeseed
Alba	1.066	85	718	Hunedoara	9	17	68
Arad	5.011	256	1.368	Ialomita	18.424	1.101	19.668
Arges	4.127	228	2.107	Iasi	7.972	1.650	5.038
Bacau	1.212	20	1.531	Ilfov	2.824	38	1.133
Bihor	6.813	1.317	1.527	Maramures	232	0	0
Bistrita-Nasaud	232	0	0	Mehedinti	2.362	0	896
Botosani	9.236	9.174	3.098	Municipiul Bucuresti	0	0	0
Braila	22.875	2.846	16.087	Mures	996	284	289
Brasov	0	119	99	Neamt	3.405	458	4.291
Buzau	11.809	33	7.488	Olt	11.177	11	8.308
Calarasi	19.878	5.220	18.965	Prahova	3.798	0	2.673
Caras-Severin	1.172	0	68	Salaj	610	0	31
Cluj	1.015	291	333	Satu Mare	5.058	576	1.230
Constanta	23.453	686	20.987	Sibiu	80	85	114
Covasna	0	0	34	Suceava	429	260	275
Dambovita	1.938	14	1.151	Teleorman	21.219	0	16.464
Dolj	11.979	0	7.558	Timis	13.123	527	5.044
Galati	11.809	967	6.396	Tulcea	8.821	386	14.183
Giurgiu	10.053	3.355	8.338	Valcea	15	0	0
Gorj	0	0	0	Vaslui	7.061	9	9.185
Harghita	0	0	0	Vrancea	2.116	64	2.058

Table 5. Assumed demand for biodiesel from each center (in tons)
Source: Based on diesel consumption in 2010 [10] assuming a 5% share of biodiesel

1 ALBA	2,800
2 ARAD	4,600
3 ARGES	5,232
4 BACAU	4,077
5 BIHOR	4,337
6 BISTRITA-NASAUD	1,903
7 BOTOSANI	2,366
8 BRAILA	2,222
9 BRASOV	4,459
10 BUZAU	3,603
11 CALARASI	2,216
12 CARAS-SEVERIN	2,387
13 CLUJ	4,559
14 CONSTANTA	6,566
15 COVASNA	1,644
16 DAMBOVITA	3,444
17 DOLJ	7,121
18 GALATI	3,783
19 GIURGIU	1,943
20 GORJ	2,499
21 HARGHITA	2,213
22 HUNEDOARA	3,991
23 IALOMITA	1,927
24 IASI	4,846
25 MARAMURES	3,373
26 MEHEDINTI	2,282
27 MURES	4,613
28 NEAMT	3,284
29 OLT	4,039
30 PRAHOVA	5,321
31 SALAJ	1,641
32 SATU MARE	2,681
33 SIBIU	3,756
34 SUCEAVA	4,140
35 TELEORMAN	2,342
36 TIMIS	4,695
37 TULCEA	1,505
38 VALCEA	4,119
39 VASLUI	2,485
40 VRANCEA	2,334
41 BUCURESTI-ILFOV	18,201
Total	**155,550**

Table 6. Assumed prices charged by the producer for biodiesel distribution at each center (in EUR/liter biodiesel)
Source: Average diesel prices in 2010 [6] after subtracting an excise tax of 0.23 EUR/liter and a profit margin for the fuel station owner of 5%

1 ALBA	0,72
2 ARAD	0,77
3 ARGES	0,74
4 BACAU	0,64
5 BIHOR	0,78
6 BISTRITA-NASAUD	0,69
7 BOTOSANI	0,73
8 BRAILA	0,81
9 BRASOV	0,74
10 BUZAU	0,78
11 CALARASI	0,77
12 CARAS-SEVERIN	0,75
13 CLUJ	0,75
14 CONSTANTA	0,82
15 COVASNA	0,70
16 DAMBOVITA	0,72
17 DOLJ	0,61
18 GALATI	0,72
19 GIURGIU	0,76
20 GORJ	0,64
21 HARGHITA	0,77
22 HUNEDOARA	0,77
23 IALOMITA	0,70
24 IASI	0,74
25 ILFOV	0,81
26 MARAMURES	0,70
27 MEHEDINTI	0,76
28 MURES	0,65
29 NEAMT	0,75
30 OLT	0,69
31 PRAHOVA	0,73
32 SALAJ	0,68
33 SATU MARE	0,77
34 SIBIU	0,79
35 SUCEAVA	0,63
36 TELEORMAN	0,67
37 TIMIS	0,64
38 TULCEA	0,59
39 VALCEA	0,76
40 VASLUI	0,67
41 VRANCEA	0,73

In order to analyze the results obtained from using Biopur.OLT.SYS the breakdown of the unit cost of biodiesel production is shown in Figure 4. The supply costs of feedstock makes out approximately 77% of the total unit cost, from which the importance of this cost category can be observed. The production cost, which includes the specific consumes for the technological process, accounts for approximately 22% to total unit cost, while the distribution cost (transport expenses to the distribution centers) represents 1%.

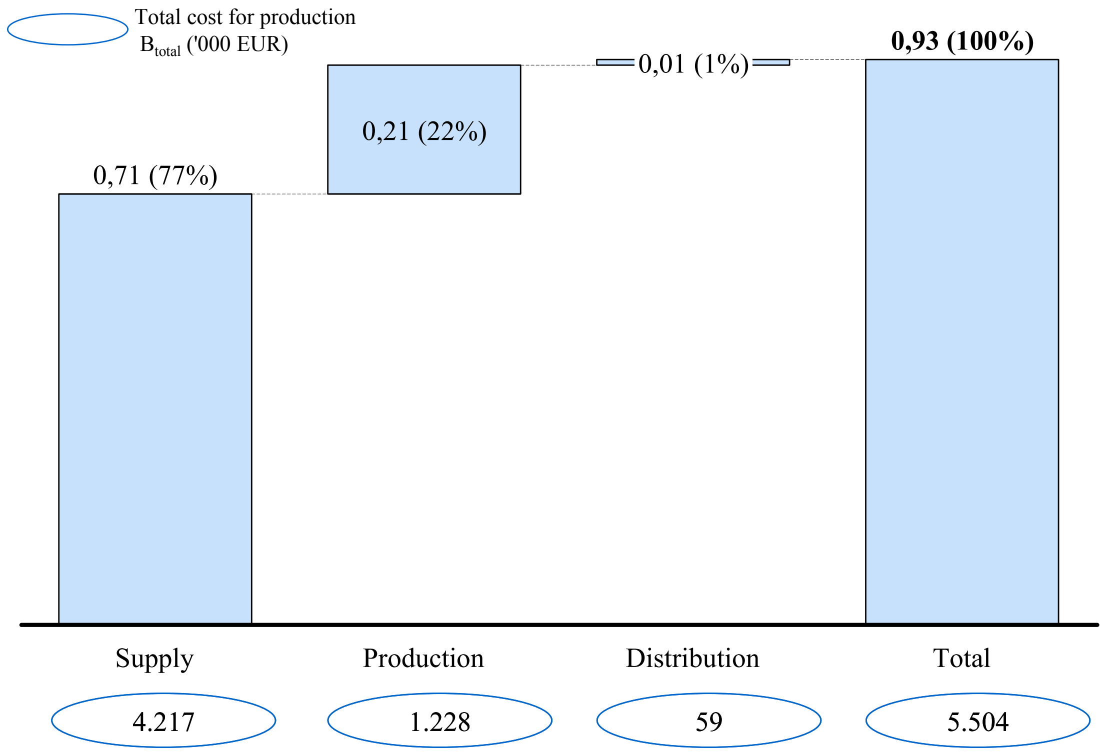

Fig. 4. Breakdown of unit cost of production for biodiesel in *Bio_Eficienta_1*

Due to the great influence of supply costs on the competitiveness of biodiesel, the optimization and detailed analysis of their variability are main attributes of management.

Despite the high contribution of production costs to the total cost of biodiesel, the producer can only minimally influence this category. The low influence by the producer comes from the technological restrictions of the equipment and the rather fixed production recipes.

Distribution costs depend on the commercialization centers selected by Biopur.OLT.SYS and on the associated transport distances from the centers to the production location. However the impact of this cost category is reduced, which leads to a lower attention by management compared with the supply cost.

Following the optimization performed with Biopur.OLT.SYS the unit production cost is approximately 0.9 EUR/liter biodiesel with approximately 0.7 EUR/liter thereof representing supply costs. Included in figure 4 are also the total costs for reaching the production level of biodiesel $\mathbf{B_{total}}$ during period t – 5,504 thousand EUR.

Figure 5 presents the structure of all activities within period t:

- the sources of supply are Valcea, Arges and Olt. Out of these sources Arges and Olt cover the main supply of feedstock. Valcea ensures just a small part of feedstock as it has a low availability of oilseed;
- the DSS choose sunflower and rapeseed as raw materials. The selection of sunflower and rapeseed is based on the high conversion factors for these oilseeds;
- the quantity of biodiesel is fully commercialized to the distribution centre Bucuresti/Ilfov. This centre was selected for its high price of distribution (Table 6) and the closeness to the production plant in Valcea.

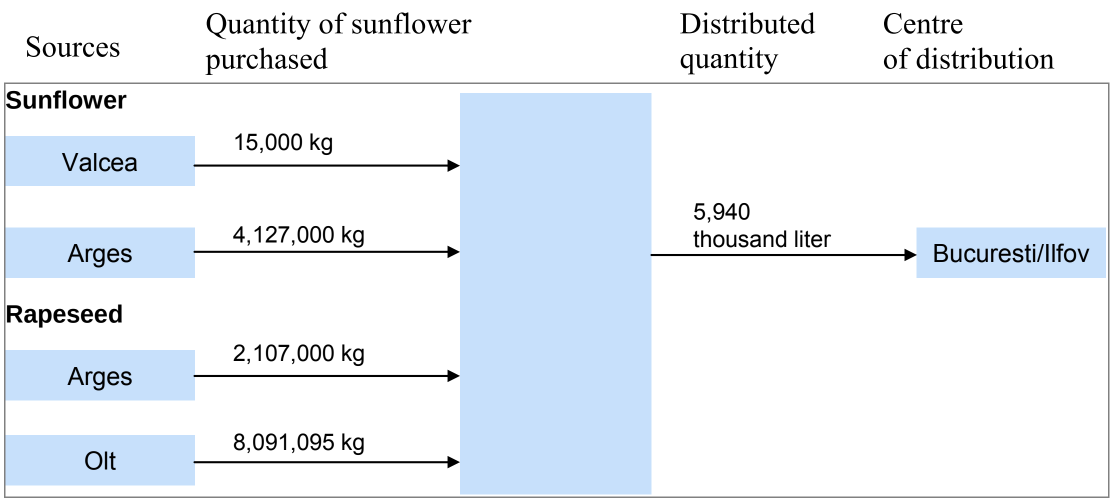

Fig. 5. Structure of activities within period t

Regarding the distribution of income from the sale of biodiesel and of auxiliary products produced during period *t* these are as follows:

- income from biodiesel: 4,807 thousand EUR
- income from glycerin: 152 thousand EUR
- income from oilcake: 791 thousand EUR

Furthermore the high impact of income from oilcake on total income can be observed.

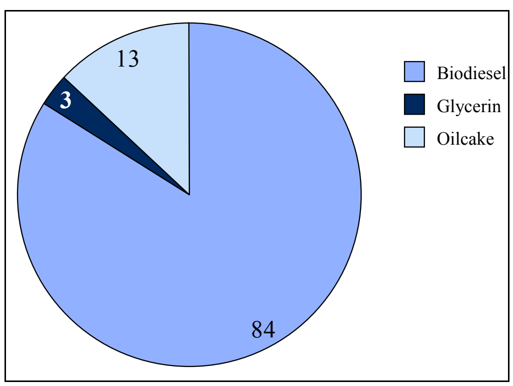

Fig. 6. Distribution of the income obtained from sale of products in period t (in %)

Figure 6 presents the percentage distribution of all income categories. Based on this income from biodiesel makes out the main share with a contribution of 84% to total income, but income from sale of oilcake has a high share to total income with 13%. Moreover income just from biodiesel (4,807 thousand EUR) does not fully cover the total production cost (5,504 thousand EUR), which implies a negative profitability from the sale of this product category. Thus obtaining a positive profitability from the investment project *Bio_Eficienta_1* depends on commercializing the auxiliary products, especially the oilcake, at high prices.

6. Conclusions

The European biodiesel industry is currently facing great pressure from rising prices of oilseeds and a reduction of national government support. Based on this investment projects in the industry have to identify all potentials in order to reduce the production cost of biodiesel and maintain a high competitiveness of biodiesel even in the absence of government support. Biopur.OLT.SYS is a system designed by the author to help identify and assess all potentials within the value chain of biodiesel production. The system helps the management of a biodiesel producer in structuring important activities within the value chain, making best decisions from available alternatives and reducing total production cost to a lowest possible under current technological and market constraints.

The main advantage of Biopur.OLT.SYS is the broad range of activities considered and optimized within a single system, as well as the modeling of the main income and cost categories.

Despite designed for the Romanian biodiesel industry and first generation technologies based on oilseeds, the system can be easily adapted for biodiesel industries from other countries or higher generation production technologies.

From the application of the DSS on a case study for a hypothetical production of biodiesel in the county of Valcea resulted the high contribution of supply cost to total production cost of biodiesel, as well as the significance of income from sale of auxiliary products (oilcake and glycerin) for obtaining a positive profitability from investment projects. Moreover with the help of Biopur.OLT.SYS the production of biodiesel at a location with low feedstock availability, such as Valcea county, was possible.

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