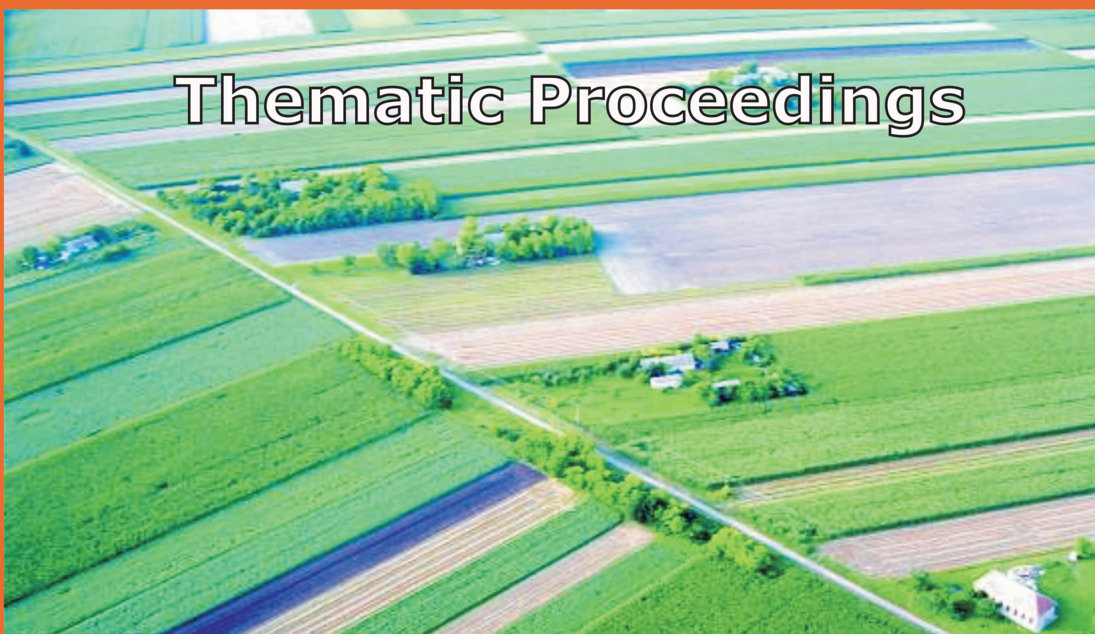
European Association
of Agricultural Economists

100th Seminar of the EAAE

DEVELOPMENT OF AGRICULTURE AND RURAL AREAS IN CENTRAL AND EASTERN EUROPE

Thematic Proceedings



Edited by
Danilo Tomić
Miladin M. Ševarlić

REGIONAL CHAMBER OF COMMERCE NOVI SAD

21st – 23rd June 2007
Novi Sad, Serbia

AAEC
Serbian Association
of Agricultural Economists

THE FEASIBILITY OF THE AGRO-ENERGY CHAIN

Franco Rosa[1]

1. THE ECONOMICS OF AGRO-ENERGY PRODUCTION

The agro-energy production is an integrated agro-industrial activity requiring higher investments in large-size plants to take advantage of scale economies. Haas et al. (2005) estimate a minimum of 40 million litres per year, using a continuous production facility or smaller batch plants requiring lower investments but higher operating costs. In the US the biodiesel production is still relatively recent and at an earlier stage of industrial development, but is rapid progress: from 2 million liters in 1999 to 344 million liters in 2005. Germany represents alone the 56% of the total production and three countries: Germany, France, and Italy cover the 84% of the total EU25 production. The production capacity largely exceeds the available supply of oil commodity and agricultural potential; usually the plants work at the 61% of the total capacity with a lower level in Italy (46%) and Spain (33%).

Table 1 Oil: Land area required to produce biodiesel to replace fossil fuel

Fossil diesel replacement rate %	Fossil diesel replacement 1000 ton	Biodiesel needed 1000 ton	Land area needed 1000 Ha		50% rapeseed 50% sunflower
			100% rapeseed	70% rapeseed 30% sunflower	
1	1200	1368	1382	1651	1831
2	2400	2736	2764	3302	3662
3	3600	4104	4146	4953	5493
4	4800	5472	5528	6604	7324
5	6000	6840	6910	8255	9155
6	7200	8208	8292	9906	10986
10	12000	13680	13820	16510	18310
15	18000	20520	20730	24765	27465
20	24000	27360	27640	33020	36620

[1] Franco Rosa, Professor of Agroindustrial Economics and Farm Management at the Veterinary School of Medicine, University of Udine, Via delle Scienze 208, 33100 Udine. email rosa@uniud.it Ph. Office: 0432-558314; mobile320.43.65.951; Email rosa@uniud.it

The bottleneck is given by the agricultural production limited by the available land dedicated to the energy crops production. To give an idea of the surface required to substitute fossil diesel with biodiesel to achieve the EU targets in the next table are reported the data needed using a combination of rapeseed and sunflower.

2. FARMER OPTIONS FOR THE BIODIESEL CHAIN

The farmers may have different options to produce crops to feed the biodiesel plants: each one implies different levels of profit and risk to be evaluated according with farmer's characteristics, attitudes toward risk financial resources available, and type of vertical integration. Here following are briefly discussed some options:

1) No chain: farmers operate individually by selling their oil seed production to the oil processing industry at the conditions settled by market or inter-professional agreement. Markets can be spot or future market: spot markets are used for daily transactions; the risk incurred by using this option is the prices fluctuate daily according with the level of market activity and the market control is almost un-existent. Future markets require higher level of organization; usually only large traders use this formula. The contractual agreement option settled at the beginning of the campaign will contemplate: delivered quantity, quality standards, definition of price-formula and compensation for climate adversities, price adjustment to market conditions at delivery date, arbitraging and penalties.
2) Self-consumption: farmers produce oil from a dedicated surface in a limited quantity for their own use; this is sometimes called the short chain oriented to take advantage of the fiscal provisions to promote the oil crops. The oil not consumed in farm can be sold to the industry or traders (short chain) with contract agreement or allocated in spot market.
3) Agro-industry chain: farmers agree to cooperate with the industry by forming an integrated group; this is an hybrid form of organization, the exchange relations, price and profit sharing are defined by contract agreements; usually the industry plays the role of principal while the farmers represent the agent with the principal defining the rules for seed delivery, price definition, quality standards, other contract provisions and take the market risk; the agents must follow these rules their marketing risks is limited because the entire farm supply will be allocated at a given bargained price eventually adjusted at the current market situation at the time of delivery. This type of organization works satisfactory if principal and agents agree to cooperate avoiding to play opportunistic game due to asymmetric information and transaction costs.
4) Direct management of agro-industry chain: farmer enter into the biodiesel business by forming a Society (the most common solution is the cooperative

form) managed by themselves to operate the entire chain on behalf of the farmers. Investment risk and profit are controlled by the farmers using professional managers.

These alternative options present opportunities and threats. The first solution doesn't require any specific investment in processing machinery (idiosyncratic industrial capital investment) neither requires to be bounded by the industrial management decision. The farmers maintain their independence and the only obligation consists in delivering an annual established quantity to the industrial partner.

The price of the fuel commodity is usually determined in advance with the inter-professional agreement signed between the representative organizations of farmers and industry, increased with the premium paid by the EC for the producers of renewable energy. Looking at the past experience this price is very close to the marginal cost of the most efficient farm that frequently doesn't cover the production cost of the smaller farmers.

The second solution appears to be more convenient since it reduces the costs of energy fuel used for farming operations, heating and electricity production. The farm fuel is convenient since the oil is produced and used by farmers without fiscal charges. The investment and operation costs for the oil press machinery are relatively low when the scale economies are fully exploited[1]. The risk is also limited because of the lower cost of capital invested in this enterprise. This solution is more convenient with respect to the fist one: the energy costs are continuously soaring up, and those farmers that have already experimented the mix of oil with traditional fuel or in purity (as some constructors are already proposing with engines of last generation) are generally satisfies.[2] This option limited quantity of oil sold in the market due to financial, managerial and logistic constraints. The third solution is prospected to be more convenient for the following reasons: i) demand of biodiesel is growing; ii) EU has given a preferential treatment to the biofuel and this policy wont change in the near future due to energy security and environmental considerations; iii) price of fuel is growing while the supply is declining and affected by internal conditions of the producing countries. This option requires a more advanced chain organization that is not required in the first

[1] A machine producing 100-200 kg of oil per hour approximately costs 100-200 thousand Euros depending on the type of machine and control system. In Germany are operating 200 plants most of them managed by group of farmers.

[2] From one cultivated hectare it is obtained from 1 to 1.5 thousand liters of biodiesel sufficient for nearly 100 hours of work with a tractor of average power (85 KW); for one year are requested from 10 to 15 Ha to produce the fuel quantity needed for the tractor working 1000 hours. In practice, the fuel produced in 10 Ha will be sufficient to run a farm of 50 Ha. Biodiesel can be used in its pure form (B100) or as a blend with fossil diesel at various ratios such as B20 (20 = 20% of biodiesel).

two options. The production of biodiesel requires to afford an industrial strategy based on the integration of operations (production, processing, storage, control, trading, arbitrage and marketing) performed at different levels (primary, industry, distribution). Farmers will be involved in a more complex hierarchical organization driven by a management oriented to achieve the maximum advantage by introducing technological innovation, scale economies and operating business through the countries in the international contest

3. THE BIODIESEL PRODUCTION: A CHAIN APPROACH

The size of the industrial biodiesel “continuous processing” is convenient starting from 30 thousand to 250 thousand ton of biofuel per year; this will require a supply from 30 to 250 thousand hectares. In Italy it is estimated that 1 million ha could be dedicated to biofuel crops that is the 15% of the total arable land located in the most productive geographic areas of the country. An accurate regional planning will required to decide the place where to produce and locate the industrial plants, their capacity, the amount of imported material to integrate local production with optimization of logistic costs: transport and storage.

Hence the preference is to produce energy crops in some specialized geographic areas where surface, climate condition and industrial facilities makes possible to feed the processing plants at minimum costs. It must be taken into account the agronomic problems: soil fertility, climate conditions and irrigation structures, rotation with surface available for crops, limits imposed to Nitrogen fertilization. The, the multi farming approach is the scheme for producing different form of energies with one or few agro-fuel commodities produced in one farm when the size is consistent with scale economies or in pooled farms forming specialized agro-energy cluster in specific geographic area, namely the biofuel district where it is possible to have the optimal conditions to produce at lower cost. The integration of biochemical and physiological processes (photosynthesis, trans-esterification, ruminant metabolism, microbiological digestion), generate different energies that contribute to increase the energetic balance and the final value added by supplying physical and intangible goods (reduction in GHG and green energy) sold in different market outlets. It is possible to simulate alternative scenarios of the integrated energy production by changing the level of variables included in IFE model. This represents a case study decision support system (DSS) to improve the chain performance by predicting the consequences caused by change of state variables.

The Biodiesel Chain offers the most interesting solution for production of differentiated products: oil for food or biodiesel, presscake for animal nutrition, glycerol for different uses. This chain includes three steps: Seed production (Farm enterprise M1), Seed processing (Industry module M2 step 1 and 2: Crushing and extraction with solvent) and Biodiesel production (Industry module M2 step 3). The Biodiesel chain is connected to the Zoo-technical chain: the press-cake can be used for feeding and following for Biogas production.

3.1. Stage 1 – Farm enterprise

Since the convenience to produce commodities dedicated to biodiesel production depends on specific chain organization, the information needed are the following:

- the production costs and revenue for the oil producing crops;
- the area dedicated to these crops since it will affect the scale dimensions;
- the dimensions of industrial plants;
- the price transfer mechanisms along the biodiesel chain;
- the contract agreements

The scale function relates the average cost fixed + variables to the size of the surface dedicated to the sunflower. By using a sample data of farms operating in North East it was possible to plot the following scale function for sunflower production where Y is the average cost and X is the volume of cultivation:

$$Y = 900 / (1 + 0{,}01X) + 0{,}0002\ X^2$$

900 is the constant and X is the dimensional variable represented by the number of hectare of the sunflower oil crop. This polynomial second degree function has some interesting properties: a rapid cost decrease in the first stage due to the rapid decline of the fixed costs for machinery, land rent, overhead costs with more efficient use of the other factors namely technical factors and labour. The second stage (delimited by the minimum and maximum break even between 84 and 1500 Ha) is characterized by relatively lower changes in costs; the final stage is characterized by growing costs due to the quadratic term. The minimum cost is obtained at 543 Ha however the minimum break even quantity at the present price fixed with the inter-professional agreement at 180 €/t plus the EC premium (180 x 2,5 + 45 = 495) is reached with 84 Ha and the maximum break even is obtained with 1500 Ha. The cultivation range between 84 and 1470 ha and the price line delimit the profit area and suggest the profitability of this culture: the risk is represented by negative profit that could be caused by the change in price due to market conditions affecting the variable cost and price. In this case the risk is relatively low due to the price fixed by contract agreement.

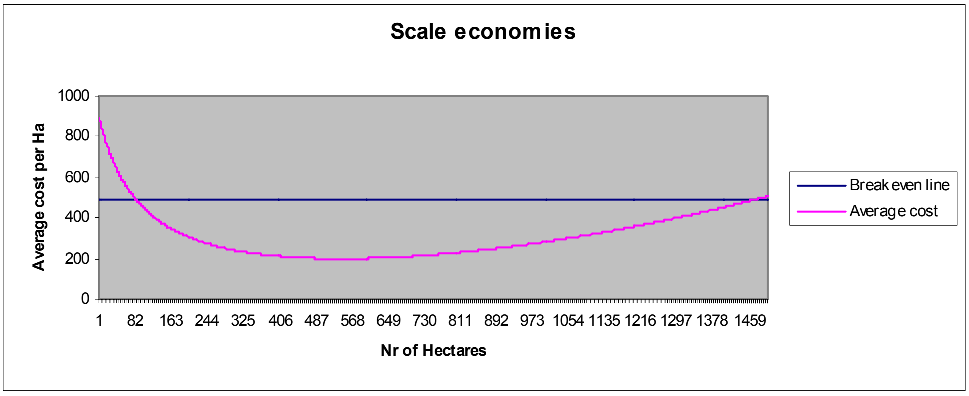


Figure 1 Scale economies of sunflower production

The MED (Minimum efficient dimension is found at 200 hectares and suggest the compromise between the production volume at break even point (salvage value = 84 ha) and the volume at minimum production cost (543 ha). In the IFEPO model the state variables are used dynamically to simulate different scenario solutions. Diseconomies of scale are assumed to be determined by transport costs and difficulties to manage efficiently the farm operation. It is quite frequent in Italy due to the land fragmentation for farmer to move for long distances to reach the plot and bear costs for deplacement, transportation, loss of time.

3.2. Stage 2 - Industrial analysis of biodiesel production

Biodiesel can be made using several feedstocks: soybean oil, cottonseed oil, corn oil, sunflower, rapeseed, peanut and any other type of vegetable oil. The higher the quality of the fat (the lower the Free Fatty Acid level), the greater the yield of biodiesel and the lower the processing cost. Therefore, when using soybean oil as feedstock for instance, a refined, bleached and deodorized (RBD), low free fatty acid level is preferred.

Other feed-stocks such as recycled restaurant grease and animal fat can be used to produce biodiesel. It should be noted that pre-processing of these items would be required to produce a biodiesel product that meets industry standards. The potential feedstock is relatively low in price and can be consistent in quality. However, it does have a higher free fatty acid level than RBD vegetable oil, which would reduce the processing yield. It also is more saturated than soybean oil, which would likely affect the pour point of biodiesel made from it, or necessitate fractionation or other additives for its use in colder temperatures. Whatever feedstock is used to produce biodiesel, the final product must meet ASTM requirements to become

EPA registered and meet the needs of the end-user. The current ASTM standard for biodiesel is ASTM designation: D6751 -02.

As with most production processes, feedstoock availability at acceptable price levels is a key component in the feasibility of biodiesel production. The highest quality biodiesel with the fewest low-value by-products can be produced from fully refined vegetable oil. This feedstock is available from commodity processors (soybean, sunflower, rapeseed) who convert seed into oil and meal, and further refine the oil by removing the phosphatides and other undesirable traits (degumming process).

There are three basic steps in the biodiesel production process: Transesterification. Methyl Ester Processing, and Glycerine Purification. These processes are shortly described:

1. Trans-esterification reaction – Oil reaction with methanol in presence of a catalyzer (i.e. sodium methylate) in a two stage process. After each stage the glycerine/water by-product is separated by gravity from the methyl ester product (FAME);
2. Methyl_Ester Processing - To further refine the methyl ester;
3. Glycerine Purification - To further refine the glycerine coproduct, the literature on the investment and operating costs of biodiesel plants has been evolving rapidly over the past 5 years. The general observation is that the costs structure of oil and biodiesel production are quite different: while the oil production requires consistent fixed costs for investments in machinery and relatively low operating costs, the opposite is the for biodiesel that requires limited investments in plants and higher costs in materials (alcohol and catalyser) to run the trans-esterification process.

4. COST ANALYSIS

The literature review suggest the investment cost per litre of annual capacity ranges from US$ 0,3/litre for a small plants to US $ 0,27/liter for plant with capacity between 20 - 40 million litres range and to US $ 0.13/litres of annual capacity for plants producing 100 million litres/year (Tiffany, 2001). The amount of feedstock required depends on the type and quality of oil used. For soybean oil, 850 Kg of degummed soybean oil is required to produce 1000 litres of biodiesel and similar conversions are for sunflower and rapeseed.

A recent study describes a computer model developed to estimate the capital and operating costs of a moderately-sized industrial biodiesel production facility (Haas *et al.,* 2004). The model assumes current production practices, equipment and supply costs. The model is based on continuous-process vegetable oil trans-esterification and ester and glycerol recovery. The authors state that purifying the glycerol to US Pharmacopoeia standards for food, pharmaceutical and personal care products is too expensive for a plant of this size. They model a more cost-effective alternative of partially purifying the glycerol, removing methanol, fatty acids and most of the water and selling the product (80% glycerol by mass) to industrial glycerol refiners. The US experiences (Shumaker et al, 2003) suggest the data reported in table 2.

Table 2 Average oil production cost in $/litre

Size mio liters/year	Investment mio $	Seed cost in cent/kg			
		28 cent	42 cent	56 cent	71 cent/kg
		Average production cost: $/litre			
2	1,2	0,66	0,79	0,92	1,04
11	4,4	0,45	0,57	0,7	0,83
57	12,3	0,38	0,5	0,63	0,75
114	19,2	0,37	0,5	0,63	0,75

Variable X = K/size were K is a constant value.

The above data are used to estimate the regression function of per unit cost of oil production to give evidence of the scale economies using different seeds prices and the graphic indicates for different seed process the cost tendency extrapolated from the cost function.

Regression 1 - seed price = 28 cents C = 0,38 + 1,04 X

Regression 2 - seed price = 42 cents C = 0,50 + 0,86 X

Regression 3 - seed price = 56 cents C = 0,63 + 0,72 X

Regression 1 - seed price = 71 cents C = 0,75 + 0,62 X

The evidence from this analysis and other empirical research works (AIM-AG, 2003) suggest the optimal scale economies are achieved with a plant of approximately 50 million liters capacity per year with continuous process; this requires the land supply equivalent of 40-50 thousand hectares. Biodiesel plant of smaller capacity are typically “batch process” requiring lower investment cost but higher operating costs per litter.

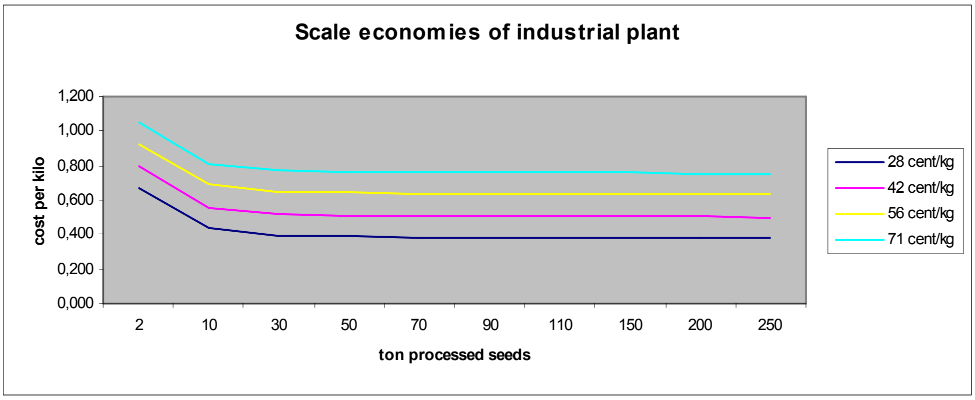


Figure 2 Scale economies for different seed cost.

For a plant of estimated capacity of 50 million litres (40.000 ton approximately) oil realized in continuous processing it is estimated an investment cost of about 19 million $ including the 5 million $ cost for the infrastructure and logistic facilities. The cost for crushing and chemical extraction (stand alone facility) is estimated to be another 19 million $ for a length of time about 10 year horizon. Hence the cost of the integrated facility (oil crushing + trans-esterification) the entire cost is estimated 38 million $ for an estimated 10 year life cycle and a capacity of 50 thousand ton of oil processed in continuous production. The following tables 8,9 and 10 report the costs for biodiesel production with a plant producing annually approximately 50 million liters.

5. FINANCIAL ANALYSIS

The productive investment produce a stream of annual net revenues for a number of years that represent the horizon of the capital; hence the convenience of capital investment is based on the expected future stream of net cash flow from investment. It is assumed the future net cash flow are not all equivalent: the longer we have to wait to have a real cash in the hands, the smaller is the value the more is needed to wait to have the money in the pocket, this means that to spend this expected future sum immediately we have to anticipate it now by renouncing to the interest this sum is potentially able to generate for the next three years. This requires to use the discounting factor that is $1/(1 + r)^n$ where r is the interest value used to discount and n the number of years of the capital horizon. The ratio "r" represents the opportunity cost to invest into the project instead of investing into an alternative financial investment in bank, if the bank investment is 5%.

Tab 8 - Financial analysis of 10 year horizon plan

Investment value (C° in billion $)	38000000
Discount rate	0,04
Discounted cash flow	44572400
NPV = Σ? = 1.n $(CF/(1 + r)^n$ - C°	6572400,2
IRR: rate for ? ? = 1.n $(CF/(1 + r)^n$ = C°	
PBP = 10 years	7,46%

Financial Analysis for Integrated Facility, 10 year time horizont : plant capacity 50 million liters

	Year									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total Product Value Per Bushel	**8,420**	**8,240**	**8,410**	**8,460**	**8,740**	**8,990**	**9,270**	**9,510**	**9,690**	**9,780**
Feedstock Cost Per Bushel	**6,28**	**6,58**	**6,98**	**7,24**	**7,5**	**7,73**	**7,97**	**8,15**	**8,35**	**8,52**
Income	25638232	25078627	25604856	25760890	26610430	27357745	28221336	28959557	29482786	29776686
Cost	**14929657**	**15653605**	**16535485**	**17225385**	**17841989**	**18383480**	**18949355**	**19387424**	**19851839**	**20261601**
Gross Margin	**10708575**	**9425021,7**	**9069371,4**	**8535504,8**	**8768440,2**	**8974265,2**	**9271981,3**	**9572133,2**	**9630947,6**	**9515085,5**
Gross Margin Per liter oil	**0,214**	**0,189**	**0,181**	**0,171**	**0,175**	**0,179**	**0,185**	**0,191**	**0,193**	**0,190**
Operative Cost										
Maintenance	97490	99537	102723	105907	109190	112684	116403	120011	123852	127815
Utilities	344782	352022	363287	374549	386160	398517	411668	424430	438012	452028
Chemicals	321004	327745	338233	348718	359528	371033	383277	395159	407804	420854
Labor & Benefits	456539	466126	481042	495955	511329	527692	545106	562004	579988	598548
Insurance cost	61060	62150	64139	66127	68177	70359	72681	74934	77332	79806
Total processing cost	1280875	1307581	1349424	1391256	1434385	1480286	1529135	1576538	1626987	1679051
General/Administration (SGA)	447028	456415	471021	485622	500677	516698	533749	550295	567905	586078
Total Operating & SGA	1727902	1763997	1820444	1876878	1935062	1996984	2062884	2126834	2194892	2265129
Depreciation Expense	735359	735359	735359	735359	735359	735359	735359	735359	735359	735359
Loan Expense	425627	425627	425627	425627	425627	425627	425627	425627	425627	425627
Total Processing Cost	2888889	2924983	2981431	3037864	3096048	3157970	3223870	3287820	3355878	3426115
Less Startup Cost Contingency	985469									
Add Blender's Credit ($0,264 $/liter)	528402	528402	528402	528402	528402	528402	528402	528402	528402	528402
Add Bioenergy Program ($0,341/liter)	396301	1500000	0	0	0	0	0	0	0	0
Net Processing Income before taxes	7758921	8528440	6616342	6026042	6200794	6344697	6576513	6812715	6803471	6617372
Taxes	1551784	1705688	1323268	1205208	1240159	1268939	1315303	1362543	1360694	1323474
Net Cash flow	6207136	6822752	5293074	4820834	4960635	5075757	5261210	5450172	5442777	5293897
Net Cash flow per liter oil	0,124	0,136	0,106	0,096	0,099	0,102	0,105	0,109	0,109	0,106

The pro forma analysis for the integrated facility at baseline prices is presented in Table 8 as long with the cash flow analysis. With the cash flow analysis it is calculated the internal investment rate, at which the DCF = C° equal to 7,5 while the actual discount rate used for the actualization was 4%. Cumulative discounted cash flows become positive only at the end of the capital cycle. Since the 4% discount rate a positive net present value has been obtained equal to 6572400,2 and the internal rate of return is equal to 7,5%.The financial feasibility analysis for the integrated biodiesel plant where the oil commodity is purchased and processed into biodiesel and a vertically integrated facility where seed are crushed into oil and meal and the oil is used to produce biodiesel. A ten-year time horizon is assumed for this analysis. Projections of prices for biodiesel, soybeans, soybean meal, soybean oil, and glycerine are used in the financial feasibility analysis. The projections are used to calculate product values (per bushel value for the products in the biodiesel plant (biodiesel, glycerin and feedfat) plus soybean meal, hulls and lecithin for the integrated facility). These are combined with the annual feedstock cost projections to predict an annual gross margin. Capital cost projections of $38 million investment for the integrated facility is the baseline for the investment analysis. The present values of cash flows are calculated al a discount rate of 5%. The measure of the flow of returns from capital investments is the most common methods of appraising the long period performance of investment.

With a ratio the measure is a-dimensional and the values must be compared either though time for the same enterprise (time series approach or intra-firm approach) or in the cross-sectional approach also named inter-firm comparison; in this last case we can compare the performance of a homogeneous group of enterprises.

CONCLUSIONS

The biodiesel chain is able to improve the results of farm management if the all chain can work properly. This means that farm and processing industry must be integrated and the size of farm and industry must be appropriate to achieve scale economies. For farmers the minimum size to achieve scale economies was estimated to be 400 hectares with extreme break even level respectively at 35 and 1464 Hectares. The industrial plant considered was a continuous processing plant with a capacity of 50 million liters; the three values: DCF, IRR, PBP suggested a lower rent of investment and considerable investment risk due to higher costs of labour, depreciation and administration . Nevertheless this approach supported the evidence that the three basic conditions of agro-energy could be fulfilled if: i) dimension of the plants (farm and industrial) are appropriately selected to obtain scale economies, ii) the agro-industrial operations are integrated; iii) the management of the processing plant must be accurately evaluated.

REFERENCES

1. AIM-AG – Agri-Industry Modeling and Analysis Group, (2003), “Economic Feasibility of Producing Biodiesel in Tennesse”, Report prepared for Tennesse Farm Bureau, USDA Rural Development and others,
2. Canadian Agricultural New Uses Council, (2004), “ Biodiesel and Other Chemicals From Vegetable Oils and Fats”, Agriculture and Agri-Food Canada.
3. Enguidanos M., A. Soria, B. Kavalov, P. Jensen, (2002), “Techno-economic analysis of bio-diesel production in the EU: a short summary for decision makers”, EU Commission Joint Research Center, Report EUR 20279 EN.

4. Hill J., E. Nelson, D. Tilman, S. Polasky, D. Tiffany, **(2006) "**Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels", Proceedings of the National Academy of Sciences.
5. Outlaw J., K.J. Collins, J.A. Duffield, (2005), "Agriculture as a Producer and Consumer of Energy", CABI Publishing Co., Cambridge MA.
6. Pimentel D., T.W. Patzek, (2005), "Ethanol production using corn, switchingrass, and wood; biodiesel production using Soybean and Sunflowers", Natural Resources Research, 14, pp 65-76.
7. Rosa F, (2006), "Energie rinnovabili dal settore agricolo: Network Analysis" in a cura di F. Rosa, "Sentieri dell'innovazione nel territorio, dinamiche di sviluppo ed aggregazione – Il caso Italia-Romania", Forum, Udine.
8. Shumaker G., et al, 2003, "A study on the feasibility of biodiesel production in Georgia. Center for Agribusiness and Economic Development, University of Georgia.
9. Van Gerpen J., D. Shrestha, (2005), "Biodiesel energy balance", Department of Biological and Agricultural Engineering, University of Idaho. Report.