University of Udine – Department of Agro-Industrial Economics

1st International Symposium on Sunflower Industrial Uses

THE COGENERATION FARM

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Abstract

Increasing demand for energy, growing scarcity of fossil fuel and environmental concern have stimulated the policy makers in US and Europe to search for alternative sources of energy and the agricultural sector can be a viable solution to this problem. The analysis is addressed to study the agro-industrial chain to produce biofuel including farms and industrial plants, as though it were an "island economy" that is a net energy exporter only if the energy and economic values of the biofuel and its co-products exceeds that of all direct and indirect energy inputs. In specific the analysis is dedicated to economic, energetic and ecological aspects of the energy cogeneration approach that complete the Island model and demonstrate to be more sustainable to afford competitively the economic and energetic problems. This model is based on sunflower crop used to produce biodiesel, while the co-product sunflower meal is used in the dairy production, the wastes are recycled in biogas production to generate electricity and heat and the final residual compost is used for fertilization. This integrated farm energy cogeneration project (IFECO) requires to analyze the different steps of the agro-industrial chain and to afford investments in energetic plants and operating costs; to manage the integrated agro-indusstrial energy chain more skilled labour is requested; hence the convenience to operate IFECO will depend on the capacity to organize and coordinate the many activities performed at different chain steps, with achievement of scale and scope economies. The macroeconomic targets as occupation, value added, imports of energetic products, inflation, justify the public intervention in programs directed to biodiel defiscalization and supports of the energetic productions as soybean, sunflower and others. The results obtained from IFECO suggest that the total energy produced by sunflower chain is significantly superior to the energy spent, the economic gain is reflected in a considerable increase in the annual income and value of land from capitalization of permanent net farm income; finally the life cycle GHG savings from displacing the fossil fuel (reduction in CO, VOC, PM10, SO_x, No_x) is a valuable contribution to ameliorate the ecological condition of the biosphere that must be considered as a market value if the Kyoto Protocol will be applied.

Key words: Renewable energy, Biodiesel, Cogeneration, Sunflower,

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1 – Introduction

The environmental concerns about fossil fuels and energy security have spurred the search for renewable energy and convinced the policy makers to incentive the domestic biofuels production. To be a viable substitute for a fossil fuel, an alternative fuel must have: i) superior environmental benefits over the fossil fuel it displaces, ii) be economically competitive with it, iii) be producible in sufficient quantities to make a meaningful impact on energy demands, but it should also provide a net energy gain over the energy sources used to produce it.. According to a study published by Hill and others[2] in the Proceeedings of the National Accademy of Sciences, USA based on data from farm balance, farm energy, fuel prices, it was demonstrated that the Biodiesel from Soybeans produces usable energy and reduces greenhouse gases more than the Corn-based ethanol, making it more deserving of subsidies. The authors demonstrate the positive balance of energy, the economic competitiveness and the possibility to produce large amount of biofuel without competing with traditional food markets; specifically, while the ethanol yields 25% more energy that the energy requested for production, the biodiesel balance is active for more than 93%. Regarding the emission the biodiesel releases just 1%, 8.3% and 13% of the agricultural Nutrogen, Phosphorus and pesticide pollutants per ner gain energy. The greenhouse gas emission compared to fossil fuels, are reduced by 12% with bioethanol e 41% for biodiesel. The advantages of biodiesel respect the ethanol are the lower agricultural input (the need of Nitrogen fertilizer for Soia is almost zero) and better conversion of feedstock to fuel. The limits of biofuel are the supply: even investing the entire agricultural land to produce Soybean and Mais, the biofuels supply would satisfy only the 12% of gasoline and 6% of diesel demand. Transportation biofuel such as synfuel hydrocarbons or cellulosic ethanol, if produced from low-input biomass grown on agriculturally marginal land or from waste biomass, could provide much greater supplies and environmental benefits than food-based biofuel**s**.

Many US and EU farmers and their professional Associations are now in favour of the development of green energy markets from agricultural commodities. The US (see the *Clean Air Act Amendments (CAA) of 1990* and the *Energy Policy Act of 1992)* and EU support the biofuels development by reducing the rate of excise duty to pure or blended fuels. Back in 2003, the EU Commission adopted a Biofuels Directive setting indicative targets: b**y** 2005, the minimum share of biofuels should be 2 percent and should gradually rise to 5.75 percent by the year 2010 (these quantitative commitments set out have not been applied before 2005 in order to allow enough time to Member States to establish the needed production facilities). The mid term renewable energy targets programmed in the EU require to invest in the EU the 9% of the agricultural land of which: 1) for biodiesel 10 million Ha invested in oleaginous plants to produce 14 billion litres of biodiesel; 2) for ethanol: 5,1 million Ha invested in cereals (Mais, Sorghum) and 0,6 mio Ha to Sugar Beet to produce 13 billions litres of bioethanol .

2 - Market perspectives

In 2004, EU biodiesel production used about 4.1 MMT (million ton) of rapeseed, or 27%, of a record EU crop of 15.3 MMT. In 2004, the EU harvested oilseeds on an estimated 7.5 million hectares of which 60% was rapeseed, 29% sunflower-seed, and 4% soybeans.The EU Biofuel policy is more favourable to biodiesel production compared to ethanol due to climatic conditions that make the Oil production from Canola, Soybean and Sunflower more convenient to alcohol production and the higher productivity of biodiesel industrial process.

Prices quoted this year in major representative markets are 20% higher of the past year; the Canola Oil quoted at Rotterdam future in May 06 reached 680 $/ton Fob, an increase of 30% respect the past year. This market situation for Canola has determined the shift in demand for human consumption of Sunflower Oil that at current market conditions cost 160 $/ton less than Canola Oil. According with the estimates of European Biodiesel Board, the EU, biodiesel production in 2005 was 3.2 mio ton, an increase of 65% compared to 1.9 mio ton produced in 2004; for the year 2006 the production is expected to surpass 6 million ton and import decline from 850 to 700 thusand ton. Major producers are: Germany, 1.7 million ton obtained from Canola production (+61%); France, 492 thousand ton (+40%); Italy, 396 thousand ton (+ 24%); Cekia, 133 thousand ton; others, 494 thousand ton cultivated in France, followed by Hungary and Spain. For this year it is expected an increase of 2.2% in acreage, corresponding to 2.1 million hectares and the production estimated to increase + 7%. Romania and Bulgaria are the main extra UE producers of Sunflower.

While the oil yield per hectare obtained from different oilseed commodities fluctuate in a wider range between countries and regions, the basic productivity of the Palm Oil is a significant economic feature with a yield of about of 4 t/ha. In Europe, the rapeseed (assuming a 40% oil content and a gross yield of 3 t/ha) has an oil yield of about 2 t/ha and the sunflower seed (assuming a 45% oil content and a gross yield of 2.4 t/ha) has an oil yield of 1.08 t/ha while the high oleic variety has a yeld of 1.2 ton/ha almost the same as rapeseed in optimal conditions. To put in another way, one hectare of oil palm can meet the vegetable oil needs of 133 people compared with 40 people from one hectare of rapeseed and 19 people from one hectare of "traditional" sunflowers (assuming 30 kg per head annual seed

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oil consumption in the European). Actually, the economic role of sunflower production is more complicated, notably by ecology and joint production factors.

Tab 1 – Biofuel production by member states

	Biodiesel			Ethanol			Total		
Country	2002	2003	2004	2002	2003	2004	2002	2003	2004
Germany	534	848	1226	0	0	26	534	848	1252
France	432	424	413	114	102	129	546	526	542
Italy	250	322	379	0	0	0	250	322	379
Spain	0	8	15	223	201	246	223	209	261
Denmark	11	49	83	0	0	0	11	49	83
Czeck Republic	83	83	72	8	0	0	91	83	72
Austria	30	38	68	0	0	0	30	38	68
Sweden	0	0	0	64	64	64	64	64	64
Oland	0	0	0	83	76	45	83	76	45
United Kingdom	4	11	11	0	0	0	4	11	11
Slovak Republic	0	0	19	0	0	0	0	0	19
Lithuania	0	0	8	0	0	0	0	0	8
Intervention stock	0	0	0	0	87	110	0	87	110
Total	1344	1783	2294	492	530	620	1836	2313	2914

Source Eurobserver n. 167, May June 05

The USDA Outlook for the oil commodity production 2006/07 made in June 2006 confirmed the growth of Canola (Brassica Napus to 4,88 million hectares in the 25 EU countries. Also the Soybean investments were growing at a ratio of 12% from 273 to 305 thousand hectares while the expected production was estimated to reach 943 thousand ton. Sunflower acreage increased by 2.2 but the production increased by 7.4%.

Tab 2 – Outlook of the oil seed in the EU-25

Commodity	2005/06	2006/07	% Change
Investment in 000 Hectares: absolute values			
Soybean	0,273	0,305	11.72
Canola	4,762	4,876	2.39
Sunflower	2,017	2,062	2.23
Total	7,052	7,243	2.71
Production in 000 ton: absolute values			
Soybean	0,874	943	7.89
Canola	15,417	15161	-1.66
Sunflower	37,24	4000	7.41
Total	20,015	20104	0.44

Commodity	2005/06	2006/07	% Change
Investment in 000 Hectares: %values			
Soybean	3,87	4,21	8.78
Canola	67,53	67,32	-0.31
Sunflower	28,60	28,47	-0.46
Total	100.00	100,00	0.00
Production in 000 ton: % values			
Soybean	4.37	4.69	7.42
Canola	77.03	75.41	-2.10
Sunflower	18.61	19.,90	6.94
Total	100.00	100.00	0.00

Source: our elaboration on USDA data

In table 3 are reported the data about the average yield per hectare and the corresponding energy production of the most diffused cultivations of the oleaginous commodities in Europe.

Tab 3 – Production in ton per hectare and Energy conversion of major oil crops

Product	t/ha	Conversion ratio	Biodiesel* t	Energy MJ**	Co-products (t)	Energy MJ	Total
Canola	3.0	30-38%	1.08	39,420	Glycerine (0.09) Meal (1.02)	1,575 15,300	56,295
Sunflower	2,5	45%	1.25	40,150	Glycerine (0.11) Meal (1.25)	1,925 21,000	63,075
Soybean	3,4	20%	0.7	25,550	Glycerine (0.13) Meal (2.00)	2,275 30,000	57,825

* Biodiesel production is obtained from the transesterification reaction
** the following energy conversion index in MJ/ton were used: biodiesel: 36.500; meal: 15.000; glycerine: 17.500.
Source: our elaboration from different sources of data.

2 - Oil prices of biofuel commodities

The valuation of the oil component of most oilseeds is subject to a varying degree of pricing pressure from the main alternative source of vegetable oils. The major share of receipts from rapeseed and sunflower production is from the oil component and prices which usually follow that of palm oil working as a leading indicator of the oil market; though in the EU sunflower seed oil usually has premium over soyabean or palm oil. Price trends suggest the following considerations: prices of different commodities are growing through time and fluctuate quite closely as suggested by Pearson correlation coefficients and by the RMSE computed on the margins. The price time series seems to be cointegrated and the prices follow the leading indicator Palm price driving the other prices. This situation makes easier to predict the evolution of bio-fuel markets in the next years and the experts have statistical instruments to suggest to the farmers the best decisions to optimise the cultivation.

Tab. 4 – Price (cent/pound) of US vegetable oil and fats

			Oil price of different biofuel commodities (a)								
Year (b)	Soybean	Cotton-seed	Sunflower	Peanut	Maize	Rape	Lard	Ed. Tallow	Mean	S.D	C.V
94/95	27,51	29,23	28,1	28,9	26,47	28,55	N/A	N/A	28,13	1,01	0,04
95/96	24,7	26,53	25,42	40,3	25,24	29,05	21,7	21,56	26,81	5,97	0,22
96/97	22,51	25,58	22,58	43,7	24,05	25,68	23,02	23,01	26,27	7,16	0,27
97/98	25,83	28,85	27	49	28,94	28,83	19,46	20,69	28,58	9,05	0,32
98/99	19,8	27,32	20,15	39,74	25,3	22,48	14,66	15,14	23,07	8,05	0,35
99/00	15,59	21,56	16,68	35,39	17,81	17,1	13,64	13,21	18,87	7,16	0,38
00/01	14,15	15,98	15,88	34,81	13,54	17,56	14,61	13,43	17,50	7,14	0,41
½	16,46	17,98	23,25	32,52	19,14	23,45	13,55	13,87	20,03	6,28	0,31
02/03	22,04	37,75	33,11	46,7	28,17	29,75	18,13	17,8	29,18	10,00	0,34
¾	28,76	32,8	32,07	63,59	28,14	0	26,4	27,07	29,85	17,18	0,58

[a] Source: Ash *et al.* (2003).
[b] The year is beginning in October.

3 - The integrated farm energy cogeneration project (IFECO)

Economic, ecologic and energetic balances validate the farm strategy to produce renewable energy with the cogeneration approach defined an energy-efficient and environmentally-friendly method of producing at the same time different forms of energies likely: fuel, electricity (power), steam and/or heath in one process. With only one fuel it can be reached a system efficiency exceeding the 60%. Fuels used in cogeneration include natural gas, fuel oil, propane, bio-mass, bio-waste, and renewable energies such as wood, or wood waste. The purpose of this application is to demonstrate that the integrated farm cogenerative energy approach (IFECO) will contribute to a significant improvement in the economic and energy balance by integrating physical, chemical, biochemical and physiological processes (trans-esterification, photosynthesis, ruminant methabolism and microbiological digestion) to produce alternative energies from products generated by agricultural activities performed in a unique farm: oil, biofuel, meal, dairy products, biogas (heat and electricity), composts, marketable in different market outlets. This farm integrated in the Agro-Industrial chain will be able to increase the farm incomes and the energetic balance and will mitigate the greenhouse effect (GHG). This approach may require the collaboration between the government, industry and farmers to optimize the value of energy production and it is justified by domestic and international advantages: i) expected macro economic targets given by the contribution of agriculture to GNP and occupation, new jobs created along the agro-industrial chain, reduction in commercial deficit balance due to fossil oil imports, and creation of marketable intangible goods represented by the clean environment; ii) microeconomic targets represented by increase in farm incomes, more market opportunities for farm commodities, increase in land market value; iii) at international level are open new market opportunities for the new countries as Romania, Bulgaria, Slovakia, Serbia having great agricultural potentials.

The integrated farm energy cogeneration project (IFECO) focalize the different farm integrated activities that makes easier and less costly to transform the farm products into alternate forms of energies. The project includes:

1) the agro-industrial oil chain with: a) sunflower cultivation of high oleic varieties; b) industrial plant for mechanical extraction with crushing and chemical extraction with exane; c) the oil conversion in biodiesel. [3]With biodiesel production two co-products are obtained: the meal containing a lot of protein used for animal feeding and glycerine used in the cosmetic industry.

2) the dairy enterprise to use the sunflower meal to feed the cows;

3) the biogas plant to recycle the liquid and solid waste obtained from the dairy activity used: 1) to produce heat of which a quota is recycled in the farm and the rest is distributed to local communities; 2) to produce electricity with an electric generator to be sold to the General contractor. The organic residual of biogas fermentation is used as organic fertilizer. For this project, the cogeneration requires the sunflower cultivation that in Italy matches better with local agronomic and climatic conditions. The following conditions are required:
a minimum acreage dedicated to the cultivation of energy crops, sufficient to exploit the scale economies;
the constitution of a farm network to feed the industrial plants with a minimum efficient size to achieve scale economies;
the participation of farmers in biofuel chain decisions and profit distribution;
easy connection with the electric network and clear rules for energy payment (agreement with GRTE);
agreements with local communities for heating distribution and facilities;
participation of the institution in the cogeneration farm project.

4 – Life Cycle Environmental Effects.

Biofuel productions imply negative environmental impacts through movement of agrichemicals, especially nitrogen (N), phosphorus (P), and pesticides from farms to other habitats and aquifers. Agricultural N and P are transported by leaching and surface flow to surface, ground water, and coastal waters causing eutrophication, loss of biodiversity, and elevated nitrate and nitrite in drinking-water wells. Pesticides can move by similar processes. Data on agrichemical inputs for corn and soybeans and on efficiencies of net energy production from each feedstock reveal, after partitioning these inputs between the energy product and co-products, that biodiesel uses, per unit of energy gained, only 1.0% of the N, 8.3% of the P, and 13% of the pesticide (by weight) used for corn grain ethanol. Low levels of biodiesel blended into diesel reduce emissions of VOC, CO, PM10, and SO_x during combustion, and biodiesel blends show reduced life-cycle emissions for three of these pollutants (CO, PM10, and SO_x) relative to fossil diesel.

5 - The sunflower oil chain: energy input and cost

To represent the sunflower chain it is assumed the Ha as the reference unit measure for the computations. The sunflowers numbers are: 2,5/50/45; this means that from one hectare of sunflower high Oleic in normal condition it is obtained 2.5 t of seed and assuming the 50% of oil rent and a 95% of oileic acid from mechanical extraction the total amount of oleic acid produced from one hectare of sunflower is 2.5*.50 * .95 = 1.1875 and the meal is 1,313 t . The chemical extraction with exane will produce another 5% of oil equivalent to 1,313 * 0.05 = 65.65 kg; hence the total Oil produced is 1,253 t (50.12%), the integral meal is 1,247 t (49.88%) and the final sum is still 2.5 t. Without making a great error it can be assumed that the 50% of the seed weight is oil[4] and the other 50% is integral meal. If from the integral meal is taken away the tegument, the composition will be the: Oil = 1,253 t (50.12%) corresponding to 1,424 litres (see the density coefficient); Cleaned Meal = 1,105 t. (44.20%); Teguments = 0,142 (5,68%).

The trans-esterification reaction requires oil and methyl alcohol to produce bio-ester and glycerine in the following proportions: 1 t oil + 0,1 t. methyl alcohol + Catalyst = 1 t biodiesel + 0,1 t glycerine. For one Hectare invested in Sunflower it is obtained: 1,253 t biodiesel that has an energetic conversion ratio equal to 1:3.2 (US Ministry for energy) meaning that for each unit of fossil fuel consumed there are obtained 3.2 units of energy, by considering the all consumption of energy the ratio will reduce to 1:1.9. The conversion efficiency ratio will depends on genetics, photosynthesis, agronomic and climatic conditions.

[3] Experiences in Germany demonstrate that the Canola Oil can be used directly in endotermic combustion engine
[4] the oil weight is transformed in liter by using the density coefficient 1,145.

Tab 5 - Sunflower energy inputs * and costs per Ha

Item	Unit	Quantity	Kcal/unit	Kcal x 1000	Mj/Ha	MJ/liter	Cost $/Ha	Cost €/Ha
Production stage								
Farm household energy use	hour (a)	8,6	40,000	344	1,44	0,05	111,80	86,00
Machinery production	Kg (b)	15	24,000	360	1,51	0,04	95,00	63,05
Farm fossil fuel	liter ©	180	10,000	1800	7,54	0,22	93,62	82,00
Nitrogen	Kg	60	17,600	1056	4,42	0,13	35,00	26,92
Phosphorus	Kg	30	4,113	123	0,52	0,02	19	14,77
Potassium	Kg	34	3,176	108	0,45	0,01	11,33	8,72
Lime	1000 Kg	0	0,000	0	0,00	0,00	0,00	0,00
Seed	unit (d)	1 = 5 kg		450	1,88	0,06	27,00	20,77
Herbicide/pesticide	Kg	3	100,000	300	1,26	0,04	45,00	34,62
Electricity	Kwh	10	2,900	29	0,12	0,00	1,10	0,85
Crop and biofuel Transport	Kg	675	0,252	170	0,71	0,03	81,00	62,31
Total production stage				4740,38	19,85	0,60	520,05	400,00
Sunflower yield = 2,5 t/Ha	Kg	2500	2,000	5000,00				
kcal output/input				1,05				
Processing stage								
Sunflower	Kg	2500		16000		0,221	450,00	346,15
Electricity	Kwh	270		700		0,010	19,00	14,62
Steam	Kcal	1350000		1350		0,019	11,00	8,46
Cleanup water	Kcal	160000		160		0,002	1,30	1,00
Space heat	Kcal	152000		152		0,002	1,25	0,96
Direct heat	Kcal	440000		440		0,006	3,60	2,77
Losses	Kcal	440000		300		0,004	2,50	1,92
Stainless steel	Kg	300000		160		0,002	18,70	14,38
Steel	Kg	11		250		0,003	18,00	13,85
Cement	Kg	20		100		0,001	19,00	14,62
Total processing stage				19612		0,271	544,35	418,73

(a) assuming a person works 1800 hours/year, utilizes an average of 8 thosand liters of oil equivalent and labor paid $13/h or 10€
(b) Pimentel data, 1996; machinery is rorated per Ha and 10 year life cycle;
© caloric power is 10 thousand Kcal/l
(d) assuming 10 thosand kcal/kg

Tab 6 - Energy balance

Product	Input	Output	Rent
Biodiesel	0,27	1,00	3,70
Meal and Glycerine	0,60	0,66	1,10
Total	0,87	1,66	1,91

4.1 - The sunflower meal and the cattle diet.

The Sunflower meal is used in the cattle diet to integrate the daily quantity of protein to satisfy the daily nutritional intake of a cattle in lactation; a current diet includes 20 kg of fiber of which, 3.5 kg (17%) must be represented by protein intake, hence the annual consumption is estimated in 7.3 t of total fiber and 1.2 t of protein. Assuming a daily consumption of 1.5 kg of integral sunflower meal (3/7 of the proteic fraction) and 2 kg of clean sunflower meal (4/7 of the proteic fraction) the protein needs for one year is 0.50 + 0.65 = 1.15 t ; for this it is required to have 1,025 t of sunflower seed (41%) to produce the integral meal and 1,475 t (59%) to produce the clean meal. The suggested ratio between integral floor and clean meal is approximately .75.
The UF[5] requested by a cattle in lactation are 820 UF / ton dried matter that are supplied with:
Integral meal: 0.5 t * 820 = 410 UF = 5437.5 MJ; Clean meal : 0.65 t * 820 = 533 UF = 7115.5 MJ.
The caloric intake is measured with the relation: 1 UF = 2100 Kcal; it can be estimated the annual consumption of calories for a cow equivalent to $10*10^6$: or 10 Mega calories; the milk has a caloric value of 65 kcal/litre, the annual production is 10000 litres equivalent to 650 thousand and calories or 0,6 megacalories the the ratio between production and consumption is 1:10.
From the waste produced in one year by a cattle weighting around 600 kg it can be obtained 304 m^3 biogas.

Tab 7 - Values of biogas and energy.

Animal waste	Average Production (m^3/kg L.W.)*	Total production (m^3)	Total production (t)	Biogas (m^3)	Electric energy (kwh)	Total Electric energy**	Termic energy (kwh)	Total Termic energy **
Liquid waste	0,023	13,80	13,80	207	372,60	545,50 kwh (1.964 MJ)	745,20	1.091 kwh (3.928 MJ)
Solid waste	0,016	9,60	2,88	97	172,90		345,70	

* conversion coefficient by ERSAL (Ente Regionale di Sviluppo Agricolo della Lombardia) for the computation of the average annual production of animal waste http://www.aquanetpc.it/download/files/cd_01/7_modelli_IPNOA.pdf)
** 1 kWh = 3,6 MJ
Source: our elaboration from data of AA.VV., year 2005.

[5] UF is the unit measure of the caloric power of a ruminant diet

Tab 8 – IFECO Energy production

Items	Unit	1 Ha	10 Ha	100 Ha	1000 Ha
Sunflower seed production	t	2.50	25	250	2500
Oil production (extraction with crushing and exane)	t	1.25	12.5	125	1250
Meal production	t	1.25	12.5	125	1250
Cows (nc)	Number	2	20	200	2000
Electric power generator eg = kw/cow)	Kw	0,6	.66	.72	.80
Working time per year = h/day x gg)	Hour	5000	6000	6500	7200
Electric energy produced per year (nc x eg x h x 0.3)	MWh	1.8	23.8	280.8	3456.0
Termic energy produced per year	MWh	1.64	21.66	255.5	3145

Tab. 9 – Farm Production per Ha and per year.

	Unit measure	Production
1) Sunflower seed cultivation	t	2.5
Of which:		
Seeds for integral meal	t	1.025
Seeds for clean meal	t	1.475
Integral meal	t	.600
Clean meal	t	.650
Total meal	t	1.250
2) Dairy activity	Unit	1
Production of Milk (two cows)	t	20
Production of meat (two veal)	unit	2
3) Biogas production		
Production of slurry	m^3	13.80
Production of manure	m^3	9.60
Total Production of biogas	m^3	.304
Cows (nc)	Number	2
Electric power generator eg = kw/cow)	Kw	0,6
Working time per year = h/day x gg)	Hour	5000
Electric energy produced per year (nc x eg x h x .3)	MWh	1.8
Termic energy produced per year	MWh	1.64

Finally it is presented the total energy production per Ha and per year of the Biodiesel chain

Tab 10 - The energy produced from the Sunflower chain per Ha and per year

Energy produced per Ha and per year		
Item	Kcal x 1000	MJ
Biodiesel (1)	10 000	41.87
Sunflower meal (2)	1 760	7.12
Electricity from biogas	1 548	6.48
Termic Energy from biogas	1 410	5.90
Milk: 2 cows producing 20 t milk (3)	1 300	5.44
Total	16 018	66.82

(1) 1000 Kg of biodiesel has an energy equivalent of 9 million kcal.; assuming the production per Ha of 1,20 t the total energy is 1,20* 9 * 10^3 = 10 million kcal ;
(2) The sunflower meal contains 600 UF/ton and the energy of 1 UF corresponds to 2100 kcal then the energy value is 2100 * 600 * 1.4 =
1 Kcal = 4.18 Joule ; 1 Kwh = 860 Kcal =3.6 MJ = 3.6*10^6 J; see http://www.unit-conversion.info/energy.html
(3) the energy contained in the milk is 65 kcal/liter hence the total energy per Ha is 20000 * 65 = 1.3 million calories

5 – Economics of biogas production

For the economic analysis some assumption must be made about the investment and operational costs involved in biogas production: these costs change depending on technologies used, (ratio K/L) and plant size, management organisation, contractual relations and others. While the estimates about biodiesel production are sufficiently supported by empirical data , the biogas production and use are relatively recent: the fermentation efficiency depends on the substrate composition and control of environmental conditions . Slurry and manure are the final products of the animal metabolism; eventually mixed with other organic materials, like mais, grass, lard and others these are fermented in anaerobic process, (microbial digestion) to produce biogas. The amount of waste produced varies with the type of animal, but on the average it ranges between 60 and 85 kg (wet basis) per 1, 000 kg live animal mass per day in intensive production systems. The energy potential of these wastes is given by the volatile solids (organic matter) content, which ranges from 10 to 18% of the total wet waste or 75 to 85% of the dry weight (ASAE, 1997). The energy potential of the manure produced has been evaluated with the following formula: 12× 1012 to 25× 1012 Btu annually depending on the method used for conversion (Parker et al. 1997). This equates to 12 to 25 billion cubic feet of natural gas annually. The esotermic reaction is described as it follows:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + 886\ KJ\ (212\ Kcal)$$

The caloric power varies between 18,81 MJ/m^3 (4.500 kcal/m^3) and 27,17 MJ/m^3 (6.500 kcal/m^3) (BANDIERAMONTE *et al.*, 1998).

Here following are presented the results the results of a biogas production plant

Biogas production: technical evaluation

Cathegory	Cows
Nr heads	1000
Average live weight per head	650

Tab 11.1 - Sludge production of the herd

Sludge production					
Liquid		Solid total		Solid volatile	
kg/p.h./d	tot Kg/day	%	tot Kg/day	% d m.	tot Kg/day
55	55,00	10.06	5,831	90	5,247

d =	day
kg/p.h.*d =	kg per head per day
p.h. =	per head
SV =	solid volatile
d.m =	dried matter

Tab 11.2 – Fermentable material

Material introduced	Quantity introduced		Total solid waste		
	kg/day	%	%	change	kg
Milking water	40,001	42.1	3.00	0.5-3	1,2
Sludge	55,001	58	10.06	6-20	5,830

Tab 11.3 - Biogas and metane production

Solid volatile			Biogas Production			Metane production		
% d.m.	range	Kg	mc/kg SV	range	mc/day	%	mc/day	Total mc/year
85	65-90	1,02	0.35	0.32-0.36	357	58	207	75,555
90	65-90	5,247	0.35	0.32-0.36	1,835	58	1065	388,725

Tab 11.4 - Energy production

Generator efficiency	%	38
Termic energy used	%	40
Termic energy dissipated	%	10
Termic energy used	%	10
Termic energy dissipated	%	1
in use	hour/day	24
in use	day/year	340
in use	hour/year	8,16

Tab 11.5 Energy production

Electricity				Heating			
Power		Energy		Power		Energy	
Gross	Net	Day	Year	Gross	Net	Day	Year
kw e	kw e	kwh e	kwh e	Kw th	kw th	kw th	kw th
190	169	4,062	1,381	310,300	155,200	3,724	1,266

The energy market in Italy is regulated by law: presently the value of Green certificates (GC) is determined by the Legislative Decree n.79/99, (hereinafter named the "Bersani Decree"), that obliges all energy users or producers to insert, since the year 2002, in the national electric network at least 2% of the total amount of energy used in previous year in form of renewable energy. To obtain this result, interested operators are required to file the GC with the Administrator of the National Circuits Network (hereinafter the "Administrator"). A new law 239/2004 (Marzano Law) reduced to 50 MWh the amount of "Green Certificate", previously fixed to 100 MWh. The price of GC for 2004 was approximately 10 €cent/KWh and is currently increasing.

Tab 12 - Economic balance of Biogas production for 1000 cows

Voice	Unit value €/Kwh	Kwh	Total value	Note
Income				
Green Certificates	0,10892	1.80	.196	average
Self consumption			1,8	average
Electric energy sold	0,08	1.80	.144	AEEG 34/05
Electric energy purchased		0	0	average
Termic energy sold	0	1.64	0	average
Total Income			265,030	Year
Costs per head	€/day			
Maintenance	75.34		24,862	average
Biomass	0		0	average
Industrial water	0		0	average
Labor	0		0	average
Others			0	average
Total costs			24,862	Year
Net Cash flow				
Total Income			265,030	Year
Total costs			24,862	Year
net cash flow			240,167	Year
Investment				
Total			684,681	
State contribution			0,000	
Net investment			684,681	
PBP (Pay back period)			2.9	Year

6 - Evaluation of the Sunflower Biodiesel chain in Italy

The economic analysis is the balance of the different steps of the sunflower chain. The cost analysis is a full costing using the "activity based costing" scheme that allows to obtain the information about the costs of activities performed by the plants working at different steps of the Agro-industrial chain. The following assumptions are made:
i) values are referred to one Hectare and to the year 2005, ii) the farm is a dairy farm of average size estimated to 100 ha situated in Pianura Padana using the practice of cultural rotation; iii) the industrial plant for the oil production crushing plus chemical extraction has a working capacity of 50 thousand ton.

Tab. 13 – Products and market value for one hectare of sunflower cultivation

Product	Quantity (t)	Value €/ton	Turnover
Seeds	2.4	265	636 *
Oil (crushing and chemical extraction)	1.253	560	701,68
Meal (1-2% oil)	1.147	120	135,600
Total			837,280

*** price with integrations determined with the inter-professional agreement**

Tab 14 - Economic balance of biodiesel chain €/Ha

Income from:	€/Ha	%
Biodiesel (final product)	925,6	77,91
Glycerine (co-product 1)	142,4	11,99
Meal 1-2% oil (co-product 2)	120	10,10
Total income	1188	100,00
1 – Costs of phase 1: sunflower production (farming stage)		
Technical input*	141	
Of which seed for cultivation		
Custom hire/Machinery)	140	
Non machinery labor	15	
Land charge / rent	90	
Miscellanea	14	
TOTAL FARMING COST	400	100
2 – Cost of phase 2: oil extraction: mechanical and chemical (industrial stage 1)		
Material (Sunflower seed)	346	
Processing	72,58	80,00
Total Extraction Cost	418,73	100,00
3 - Cost of phase 3: trans-esterification (industrial stage 2)		
Material, reagent, energy	39,872	27,18
Labour (L)	21,36	14,56
Capital (C)	52,688	35,92
Taxes (T)	14,24	9,71
Overhead (SG)	18,512	12,62
Total Transesterification process	146,672	100,00

Tab 15 - Balance of the integrated energy cogeneration farm based on one Ha and two cows

Product	Production per year	Value in €/Ha
A) Income		
Sunflower seed	2,5 t/ha x 180 €/t*	450
UE integration	premium 1	45
Regional integration	premium 2	40
Milk	2*10 t x 320 €/t	6400
Meat	2 Calf Frison Breed	400
Electricity	1.8Mwh (price of GC = 10 c/Kw)	180
Total farm income		7525
B – Costs		
Sunflower cultivation	One Ha with hired labor/machinery	400
Dairy costs	Accounting data	3450
Electricity cost	Accounting data	200
Total cost		4050
Net farm Income		3475

This sunflower price is determined by the inter-professional Agreement between producers and industry
Source: data elaborated by the author from different sources

Assuming to participate in an integrated Agroindustrial chain managed as a cooperative organization; in this case the farmers will add the net income of the industrial chain. The total cost for industrial processing is 947 €/Ha but because farmers are involved in the business, the cost for seed is not considered to avoid duplication. the net income obtained by selling the industrial products (biodiesel + glycerine is 707.73 €/Ha and the net biodiesel income is 347.5 €/Ha, that will be added to net farm income to obtain 3622.5 €/Ha.
The nominal value of the Hectare ill be determined with the capitalization of the net farm income assuming a capitalization ratio equal to 5% to obtain a capital value equal to 65,500 € per Ha; including the biodiesel income the value wil increase to 72450 €/Ha

Voice	Chain management Independent	Cooperative
	Value €/ton	Value €/ton
Farm income (see table 11)	7525	7525
Farm cost	3475,00	3475,00
Net farm net income	4050,00	4050,00
Industry income Biodiesel + glyc.(1)	1068,00	1068,00
Industrial cost of which		
a) seed	450,00	
b) processing	72,58	72,58
c) trans-esterification costs	146,67	146,67
Total industrial cost	669,25	219,25
Net industrial income	398,75	848,75
Total net income		4898,75

(1) it is assumed the meal is given to farmers
Industrial net income

7 - Conclusion

With the integrated production system and the co-generative farm it is demonstrated the possibility to improve the economic, energetic and ecological balance; the farmers are playing a new role as producer and seller of different form of energies (fuel, foods, heating, electricity). The results obtained are very positive when compared with other farm activities and justify the higher investments and management skills required to manage this complex production system. These results are obtained in a quasy competitive situation: productions are subsidized and fuels are defiscalized according with the current law. Future improvement are expected by improving the scale dimension and the cohordination among the different chain stages. Future expectations are good: the demand for biofuel is very high and farm won't have to be worry if the biofuel policy will be in favour of farm productions. Finally according with Kyoto protocol the ecological benefits procured by green energy will be priced in future could offer another market opportunity.

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