BIO-ENERGY FROM WINERY BY-PRODUCTS: A NEW MULTIFUNCTIONAL TOOL FOR THE ITALIAN WINE DISTRICTS

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Abstract

This paper aims to investigate if the legislation will allow the production of energy from winery by-products and how this can contribute to multifunctionality of the wine makers' income. A medium size winery was selected and an anaerobic digestor process was simulated using the company's data. The main methods of financial evaluation were studied to create information to see if the project concepts were valid. The results highlight the positive level of earnings that the project will generate due to the high level of methane included in the pressings that could be transformed in energy, the short period needed for obtaining methane and the recent substantial level of government support both in Green Certificates and financing of the initial cost of the investments.

Key words: Biomass, winery by-products, multifunctionality, energy, wine district

1. Introduction

The growing interest of the International Community concerning the consumption of energy and its effects has created the Kyoto Protocol[1]. Until the recent energy crisis of 2008 which caused the enormous petrol price fluctuation the function of agriculture in the energy framework has been grossly under evaluated. Agriculture can play an important strategic role, giving multifunctional services to the European Community[2].

The need for renewable sources of energy is continuously more evident as the supplies of fossil fuels are being slowly consumed. At present it seems that biomass can not completely substitute fossil fuels. The advances of scientific research and the progressive miniaturisation of biomass energy plants are making a new scenario for the agricultural industry. The continued search for new sources of income by the farmers has now taken on a new dimension. Farmers can now decide if it is economically viable to produce, transform, sell and eventually manage the energy network. At the same time contribute to improve the green economy.

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[1] In the vast literature on the argument is noted "L'impresa agroenergetica", AA.VV. Gruppo 2013 (2009).

[2] The E.U. is the main consumer of energy after the U.S.A. Starting from 1990 the increasing annual rate of consumption is 0.55%. The 25 member states of the E.U. buy 54% of the energy that they consume from outside the community; petrol 42%, natural gas 23%, electricity 21% and renewable energy counts for 5%. Renewable energy in the E.U. is expected to produce 10% of the total energy consumed in 2020 and 13% in 2030[2]. Energy contributes 80% of the total green house gases (GHG) emissions.

This energy opportunity is a great input for the Agriculture Common Policy. Agenda 2000, the Fischler Reform and the Biomass Action Plan highlight the importance of these new energy tools. The E.C. Regulation 1782/2003 that recognizes the energetic function of agriculture considering the use of vegetal biomass, agricultural waste products – worked and un-worked – as models to encourage. Other energy opportunities have been created by other legislation tools[3]. The recent Italian bill of Parliament (D.D.L. n. 1195-B) approved July 9th that will become effective in a short while allows farmers to obtain public support, also for the initial costs of the investment. These incentives are therefore cumulative with specific government support recognized for the production of electric energy from biomass.

Although the policy framework urges the development of energy from renewable resources the cost analysis and financial benefits to the farmers are not yet clear. The uncertainty concerning the profitability of the investments and the generation of new income is still to be evaluated. This situation tends to create an investment speculation bubble[4]. From an economic point of view the cost-benefit model is restricted by public support and fixed prices.

2. The aims of the research and the reasons for the choice of the wine sector

The aim of the paper is to evaluate through a concrete case study the validity of investing in an energy plant to recover enological by-products for the production of energy. Here it is proposed to utilize the pressings of grapes in a biomass power plant to produce electric and thermal energy.

There are defined reasons for the choice of the sector and the resources to be transformed into energy. In the wine sector there are some unresolved problems which the present paper wishes to highlight and discuss. On the other hand there are emerging factors that could be very important for the production of biomass energy from wine by-products.

Positive factors are represented by:

- in 2013 contributions for the distillation of wine pressings will finish (wine C.M.O.);

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[3] The recent Health Check of November 2008 reconfirms the "decoupling" that induced the energy culture. The Green Certificates and the transfer of public incentives destined for the agricultural industry who produce new renewable energy sources have been moved from the first to the second sector of the Common Agricultural Policy. The Rural Development Plans are one of the main economic programming instruments to encourage agro-energy (note the measures 121, 123, 311, 321). Following the Health Check, the challenge of agro-energy has obtain ulterior importance in the policy of the second sector. Foreseeing with the E.U. Regulation n. 74/2009, the obligation of revising the Plan of National Sustainability (PSN) before June 2009 to include into regional plans the support of projects in the field of renewable energy.

[4] See Vaciago (2008).

- public incentives for the agro-energetic sector were previously at the national level. Now the legislation has changed and local government bodies are responsible, making the system more user-friendly for wine producers;
- competition in the improvements in the quality of wine has caused the dramatic increase in heating and refrigeration costs for wine, lowering profit margins;
- the economic crisis has reduced sales and prices;
- the price of pressings of prestigious wine (in this case Amarone) has been reduced because the spirits market is at an all time low[5].

Negative points are represented by:

- the present use of enological by-products and the control of them by the Common Market Organisation (C.M.O.) regulation that obliges all producers of wine to give them to authorized distillers; recently E.C. Regulation 479/2008 allows the by-products of wine to be used for energy;
- the wine sector compared to other agricultural sectors has not needed to search for other incomes because of the high profit margins linked to the value of the products;
- the multifuncionality related to the wine industry such as agri-tourism, restaurants, etc. have been much more synergic to the production system than the production of energy;
- the difficulties linked to the supply chain, transport and plant costs, the organisation of new unknown technology, poorly defined regulation concerning permits are factors that create suspicions in the wine industry.

The pro's and contro's for the investment in biomass energy plant seem to be balanced but in reality the positive policy attitudes completely change the scenario showing that pressings are an important income tool.

3. The legislative and economic framework

The E.C. Regulation 479/2008 concerning the common market wine organisation that modifies the previous E.C. Regulation 1493/1999 will become effective on August 1st 2009. The use of wine pressings is seen, from the policy makers' point of view, as a potential threat for human health, market competition and environmental pollution[6]. For this reason the E.U. legislation has always foreseen as a general rule the withdrawal of the by-products of wine making and other operations which transforms wine grapes. This action is controlled as laid down by art. 12 paragraph 2 of the E.C. Regulation 479/2008.

As well as the above legislation, E.C. Regulation 555/2008 allows the distillation of the by-products as an alternative method. Article 23 section 7 of the above mentioned

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[5] In the case of Amarone pressing the price changed from 111 euro per ton to 11 euro, which is the price for the normal pressings.

[6] Italian legislation prohibits the by-products of wine to be used as natural fertilizers in the fields (according to D. Lgs. 217/2006) or as rubbish (according to D. L. 99/1992).

legislation permits the member states to oblige the wine makers to supply to the distillers all the by-products of wine making. Article 26 section 8 is a legislation concerning particular cases in which wineries destine pressings to produce spirits. This framework is summarised in figure 1.

As you can see Italy has opted for a mandatory distillation system. The wine makers are obliged to take their by-products (pressings and dregs) to the distillery and thus the distillery is obliged to take the by-products. When the pressings and dregs are consigned to the distillery it is decided which disposal process to use.

The first process, concerning only pressings, which are distilled into spirits (grappa). European legislation has fixed for Italian farmers a support equal to 450 euros per hectare in 2009 lowering to 350 euros per hectare in 2012 when the support finally finishes. The second process, concerning dregs and pressings, which produce industrial alcohol and/or energy. In this case the support is paid to the distillers which transform the by-products into raw alcohol that has an alcohol level equivalent to 92% volume[7].

Here emerges a big difference concerning the previous wine C.M.O. The minimum price guaranteed by the E.U. to the producers for the distillation of by-products finalised to industrial and/or energy use was eliminated. Therefore because there is no longer financial support from the E. U. the price of pressings and dregs are much lower than in the past. After the distillation process the pressings can not be used to make other wine but a solid mass of pressings remains. This part is generally used by the distillers to produce compost and fertilizers, animal feed or fuel[8].

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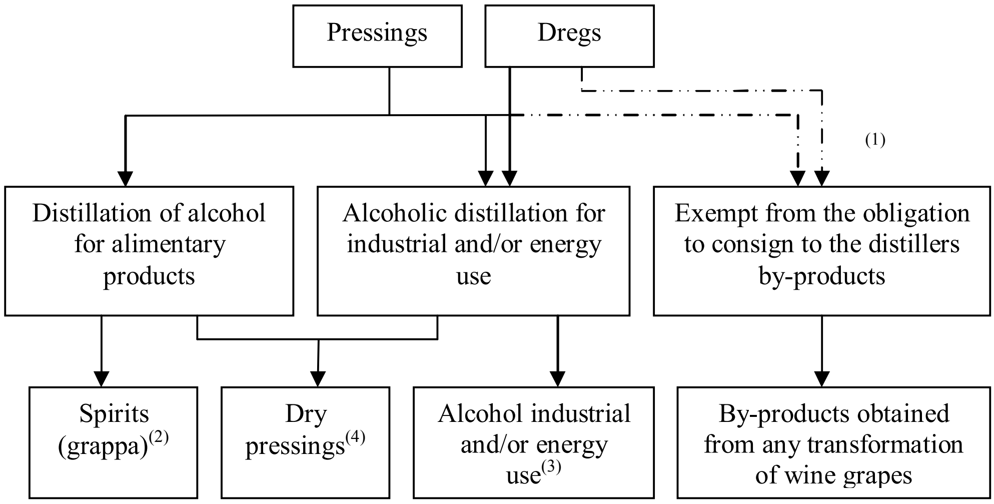
[7] Italy has fixed the entity of help equal to the maximum level consented 1,1 euro/%vol/hectolitre for raw alcohol obtained from the pressings and 0,5 euro/%vol/hectolitre for raw alcohol obtained from the dregs. The cost of transport is fixed at 0,016 euro/Kg and is included in this price. They should be transferred from the distillers to the producers if they carry out the delivery.

[8] For this purpose the art 2-bis of the Law n. 205 December 30th 2008 declares that dry pressings and their components derived from the process of vinification and distillation are considered by-products as fixed by the D. Lgs. n. 152/2006 (Unique Text on the Environment).

Figure 1 – New opportunities for by-products distillation



[1] Option suggested by the Authors to derogate from the obligation of distilling according to Ministerial Decree n. 301 December 27th 2008.
[2] Support recognised to the wine cellars according to art. 26 E.C. Regulations 555/2008.
[3] Support recognised to the distillers according to art. 24 E.C. Regulations 555/2008.
[4] The dry pressings are considered as by-products according to Law n. 208 December 30th 2008 and are not subject to the legislation on rubbish.

This actual situation concerning the management of winery by-products could be modified by new Italian regulation. Art 5 D.M. 301 December 27th 2008 presents a list of cases whereby the wine makers are not obliged to give by-products to the distillers[9]. On the basis of the above legislation new opportunities for wine makers have arisen. Now the question is if it is worthwhile from an economical, social and environmental point of view for the wine makers to create bio-energy or to maintain the present by-products disposal system.

4. Methodology and the process the used in the case study

The winery where the analysis has been conducted is situated in the Valpolicella wine district. This case study has been selected for different reasons. It is a medium size wine cellar (70 hectares of vineyard) that represents a model that can be easily adapted for other wine growing areas in Italy. As well as commercialising different product lines (amongst which are the prestigious brands of Amarone and Recioto)

[9] The producers actually "are exonerated from the obligation of consigning, but are obliged to have the products removed paying disproportionate duties". The category that enters in this above mentioned list are individualised by a governmental directive.

the winery processes wine on behalf of other wine producers. The size of the activity allows the winery to use state of the art technology.

Amongst the different technology available for the valorisation of energy starting from wine by-products, has been selected the anaerobic digester process for the production of biogas from pressings. The advantages that this process allow are linked to: i) the production of biological methane and humus; ii) the total recovery of carbon dioxide; iii) the elimination of extra ecological pollution with the stabilization of organic substances; iv) the recovery of water in the biomass.

To reach the objectives proposed in this paper a private cost-benefit analysis has been utilized. As argued by Campbell and Brown (2003), the financial analysis is a common technique from which a business can choose different alternative projects.

The private focus is coherent with the European farmers' multifunctional role and it is justified by the farmers' continuous search for new incomes. The multifunctional agriculture issue is often linked to public goods (environment, occupation, health, etc.) because their intrinsic value can influence the feasibility of projects. Moreover, according to the literature summarized by Sen (2000), the application in the case study here considered by a general cost-benefit approach struggles with the need to give a value to different public goods (some of them with widespread effects) through the usual market mechanisms. The aim of reducing uncertainties only takes into account, benefits and costs that have a present or future market value.

Three valuation methods have been used. Firstly, the Net Present Value (NPV) formula[10] has been adopted to actualise the cash flow of the project. Secondly, with the Internal Rate of Return (IRR) technique[11] the return for the capital invested has been calculated. Thirdly, the Pay Back Period (PBP) method[12] has been utilised to calculate the number of years in which total expenditure is covered by positive cash flows.

5. Results

Table 1 presents the data of the process of an anaerobic digester of pressings. It is shown that this biomass typology gives two advantages. The first concerns a short period of the process (21 days) compared to the standard 40-60 day necessary for

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[10] Net Present Value (NPV)= $\sum_{t=1}^{n} C_t/(1+i)^\wedge t$ where: *t* represents the expiry date; C_t is the positive/negative financial flow at the time t; *i* is the discount rate of the operation.

[11] The IRR is calculated by solving the equation NPV=0 in observance of the variable *i*.

[12] The PBP is calculated by solving the equation NPV=0 in observance of the variable t given a fixed rate *i*.

the digestion of cow sewage. The second concerns the higher concentration of methane (80-84%) compared to the standard 64% of cow waste.

The expected specific electrical production is equal to 300 kWh per ton of pressings and it is based on laboratory estimation (Araldi *et al.*, 2009). This is a low estimation but it is believed a larger plant will produce much more energy than the estimated figures. The expected electrical production is estimated equal to 239,400 kWh/year, while the expected thermal production, taking into account auto-consumption, is estimated equal to 311,220 kWh/year.

Table 1 – Availability of pressings and expected energy potential of the case study

	Quantity	Unit of measurement
Availability of pressings	798	ton/year
Expected specific electrical production	300	kWh/ton
Expected electrical production	239,400	kWh/year
Expected thermal production	311,220	kWh/year
Biogas yield	160	m^3/ton
Methane concentration in the biogas	80-84	%
Duration of the process	21	days

Source: Elaboration of company data

The pressings production is concentrated in the months August-October when the first stage of wine making is finished. In the Valpolicella district wine making usually continues until the end of February. This long production time scale helps resolve certain problems linked to the pressings storage activity. Basis on the data reported in table 1 the installation potential of the processing plant is hypothesized at 55 kWh which is the right size for internal consumption for a period of 6 months a year (Reggiani, 2009). The process will be started with the first pressings of white grapes at the end of August. The production of biogas will produce energy for the wine cellar in October. The thermal energy in that period is used to keep the temperature of the tanks at a constant level and for hot water and heating needs.

Table 2 presents the estimation of the energy production of the plant and the energy consumption of the company in the period September 2008 – March 2009. As can be seen, a higher level of energy consumption is characterised in this period. The climate conditions in the Valpolicella district and specific wine making techniques create the need for higher energy consumption. It concerns costs that are extremely high for the company budget about 120,000 euro a year for electricity and about 18,000 euro a year for thermal energy. About 70% of the electricity needs and 100% of the thermal needs will be met by the biomass plant in the considered period.

Table 2 – Comparison between plant energy production and winery energy consumption during the period of vinification

Period	Quantity equiv. biogas (ton)	Prod. energy el. (kWh)	Consum. energy el. (kWh)	Prod. energy thermal (kWh)	Consum. energy thermal (kWh)	Cover el. needs (%)	Cover thermal needs (%)
Sept.	-	-	84,554	-	20,124	-	-
Oct.	163	40,777	135,440	53,010	81,478	30	65
Nov.	163	39,462	95,485	51,300	51,333	41	100
Dec.	163	40,777	422	53,010	60,776	-	87
Jan.	103	40,777	69,321	53,010	40,554	59	100
Feb.	103	36,831	15,987	47,880	71,846	230	67
Mar.	103	40,777	29,055	53,010	31,676	140	100
Total	798	239,400	345,710	311,220	357,787	69	100

Source: Elaboration of company data

Table 3 presents the flow sheet of the project. The energy produced will be entirely used to cover the energetic needs even if in some months of the year electricity will be sold to the net at an estimated price of 0.095 euro/kWh. The majority of annual revenues come from the sales of Green Certificates which are calculated on the base of the biomass energy produced. In this case instead of the market price received from the Green Certificates contribution these have been substituted by the tariff "everything included" consented by the bill of the Italian Parliament D.D.L. n. 1195-B approved by the Senate July 9th. The cost of electricity including the tax is estimated at 0.18 euro/kWh, while thermal energy is calculated at 0,05 euro/kWh.

Table 3 – Expected annual revenue of the investment

Period	Prod. energy el. (kWh)	Consum. energy el. (kWh)	Revenue from tariff "everything included" (euro)	Revenue from selling el. (euro)	Revenue from not buying el. (euro)	Revenue from not buying thermal energy (euro) [(1)]
Sept.	-	-	-	-	-	-
Oct.	40,777	135,440	11,418	-	7,340	2,651
Nov.	39,462	95,485	11,049	-	7,103	2,565
Dec.	40,777	422	11,418	3,834	76	2,651
Jan.	40,777	69,321	11,418	-	7,340	2,651
Feb.	36,831	15,987	10,313	1,980	2,878	2,394
Mar.	40,777	29,055	11,418	1,114	5,230	2,651
Total	239,400	345,710	67,032	6,927	29,966	15,561

[(1)] Estimated values

Source: Elaboration of company data

Table 4 presents the estimated investment costs. The initial cost of the plant (385,000) is obtained multiplying the specific electrical potential installed (55kW) by 7,000 euro/kWh (average cost indicated in literature for plants of this type, Reggiani 2009). In the estimation of annual maintenance cost (8,000 euro) are also included administrative costs. A part time employee is needed whose costs are estimated as 17,500 euro. The EBITDA is equal to about 94,000 euro. From the data it can be seen that almost 56% of annual revenues generated by the project are obtained from public support[13]. As has been noted, the choice of the disposal of pressings in the wine cellar for the production of energy results as being much more convenient for wine makers compared to the option of consigning to a distiller. From the sale of pressings to the distiller the winery has obtained only 8,768 euro in 2008 which is much less than 94,000 euro of EBITDA that the company can obtain using the pressings.

Table 4 – Investment costs

	euro
Initial cost of the plant	385,000
Annual maintenance cost	8,000
Annual personnel cost	17,500
Expected total annual revenue	119,486
EBITDA	93,986

Source: Elaboration of company data

The financial evaluation of the investment, presented in table 5, is the results of the following hypothetical conditions:

- public support is equal to 40% of the investment according to the bill of the Italian Parliament D.D.L. n. 1195-B;
- average annual cost of energy and revenue from sales of electricity during the 15 years of the investment are equal to a rate of +1,5% annually (Nova, 2009);
- capital debt rate equal to 7,5% annual and hypothetical inflation cost equal 2% annual;
- tariff "everything included" equal to 0,28 euro per kWh produced from biomass;
- hypothesis zero revenue from pressings withdrawn by the distillery;
- internal consumption equal to 70% of electricity produced;
- duration of the investment is equal to 15 years.

The winery must invest only 231,000 euro compared to the original figure of 385,000 to start the project. The Net Present Value (N.P.V.), measuring the actualised value of the plant, is greatly positive (570,804 euro) compared to 385,000 euro (tab.4). The Internal Rate of Return (I.R.R.) is stated at 68% and is completely unreachable if compared to other investments with the same risk level. The Payback Period, which

[13] 56% is calculated dividing revenue from tariff "everything included" by expected total annual revenue.

measures the break-even time of the investment, is equal to 2,5 years. It can be considered a very good result.

Table 5 – Financial evaluation of the investment **with** revenue generated by the tariff "everything included"

Evaluation Methods	
Net Present Value (NPV)	570,804 euro
Internal Rate of Return (IRR)	68.0 %
Payback Period	2,5 years

Source: Elaboration of company data

Table 6 – Financial evaluation of the investment **without** revenue generated by the tariff "everything included"

Evaluation Methods	
Net Present Value (NPV)	32,837 euro
Internal Rate of Return (IRR)	10.0 %
Payback Period	8,7 years

Source: Elaboration of company data

From the comparison of the results of table 5 and 6, it is shown that, as expected, bio-energy from winery by-products is highly profitable only with public support. If the revenue generated by the tariff "everything included" is not taken into account or the plant is not supported in the initial costs (as it was before the bill of Italian the Parliament D.D.L. n. 1195-B) the financial convenience of the investment is not so evident. The N.P.V. without the support offered by the tariff "everything included" is still positive (32,837) but much lower than before. The I.R.R. from 68% goes down to 10% and the Payback Period goes from 2,5 years to 8,7 years.

6. Conclusion and suggestion for further research

This analysis is based on an alternative interpretation of Italian legislation concerning the use of wine pressings and new opportunities offered by the recent bill of the Italian Parliament D.D.L. n. 1195-B allowing public support of the investment initial costs. For this reasons the paper has indicated the following positive points linked to the model:

- thermal energy, which usually is more a problem than an advantage in biomass plants because it requires an accumulation system, can be a helpful support in the wine cellar production;
- biogas made from pressings is higher in methane than from other agricultural by-products and it is available in a short period;
- high level of earnings is guaranteed as long as the substantial level of government support will be assured due to positive externalities function of the agriculture activities.

At a policy level the main implications are represented by:

- reducing energy costs will create more competitiveness for the Italian wineries;
- the multifunctional level of the wine makers will increase if, as has been suggested in the present paper, the E.U. legislation will allow the use of pressings instead of delivering to distillers.

Future research opportunities are:

- the production of a bio-energy model that can be easily adapted for a network of wineries in the wine district;
- not only pressings but other wine sector biomass products can be inserted into the model;
- the biomass project will be integrated researching into the compatibility of other technology (e.g. electrical solar panels);
- the model could be studied for both public and private partnership projects;
- the analysis of the impact of this kind of project on the well-being of the local community (environment, occupation, health, etc.).

Literature

1. AA.VV. (2009). L'impresa agroenergetica. Ruolo e prospettive nello scenario "2 volte 20 per il 2020". Quaderno April 2009. Gruppo 2013. http://www.gruppo2013.it Accessed 23 June 2009.
2. Araldi, F., Failla S., Restuccia A. and Zagni M. (2009). Vinacce: da scarto industriale a risorsa per produrre biogas. Informatore agrario. Supplemento 10/2009.
3. Bringezu, S., Ramesohl, S., Arnold, K., Fischedick, M., von Geibler, J., Liedtke, C. and Schütz, H. (2007). Towards a sustainable biomass strategy. Discussion Paper No. 163. Wuppertal Institute. http://www.wupperinst.org. Accessed 23 June 2009.
4. Campbell, H. and Brown, R. (2003). Benefit-Cost Analysis. Financial and Economic Appraisal using Spreadsheets. Cambridge University Press.
5. Cozzi, M. (2008). Agro-energie in Basilicata: un approccio analitico per la valutazione dei costi di trasporto. Aestimum 53: 51-74.
6. D.D.L. (2009). Disegno di legge del Senato n. 1195-B "Sviluppo Economico", approved July 9th, Roma.
7. D.M. (2008). Decreto Ministeriale n. 301 "Disposizioni di attuazione dei regolamenti (CE) n. 479/2008 del Consiglio e (CE) n. 555/2008 della Commissione per quanto riguarda l'applicazione della misura della distillazione dei sottoprodotti della vinificazione", December 27th, Roma.
8. Duffield, J. A. (2008). Bio energy in a Global Environment: Discussion. American Journal of Agricultural Economics 90: 1239-1240.
9. E.C. (2008). 2020 by 2020. Europe's climate change opportunity Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions; COM(2008) 30 final. European Commission, Brussels.

10. E.C. (2008). Commission Regulation No. 555/2008 laying down detailed rules for implementing Council Regulation (EC) No. 479/2008 on the common organisation of the market in wine as regards support programmes, trade with third countries, production potential and on controls in the wine sector. European Commission, Brussels.
11. E.C. (2008). Council Regulation No. 479/2008 on the common organisation of the market in wine. European Council, Brussels.
12. E.C. (2008). Proposal for a directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources; COM (2008) 19 final. European Commission, Brussels.
13. Eidman, V. R. (2007). The Promise and Challenge of Bio energy: Discussion. American Journal of Agricultural Economics 89: 1311-1312.
14. Hazell, P. and Pachauri, R. K. (2006). Bio energy and agriculture: promises and challenges. 2020 Vision for Food, Agriculture, and the Environment 2020. Focus No. 14. Washington DC: International Food Policy Research Institute (IFPRI).
15. Nova, A. (2009). Investire in Energie Rinnovabili: la convenienza finanziaria per le imprese. EGEA. Milano.
16. Petersen, J. E. (2008). Energy production with agricultural biomass: environmental implications and analytical challenges. European Review of Agricultural Economics 35: 385–408.
17. Reggiani, A. (2009). Bio-energy from wine pressings. Draft. Milano.
18. Sen, A. (2000). The Discipline of Cost-Benefit Analysis. Journal of Legal Studies XXIX: 931–952.
19. Senauer, B. (2008). Food Market Effects of a Global Resource Shift Toward Bio energy. American Journal of Agricultural Economics 90: 1226-1232.
20. Stern, N. (2006). Stern review: the economics of climate change. Cambridge, UK: Cambridge University Press.
21. Tyner, W. E. and Taheripour F. (2007). Renewable Energy Policy Alternatives for the Future. American Journal of Agricultural Economics 89: 1303-1310.
22. UN-Energy (2007). Sustainable bio energy: a framework for decision makers. Paper of UN-Energy, an inter-body working group of the United Nations. Rome: Food and Agriculture Organisation of the UN.
23. Vaciago, G. (2008). Alimentari ed energia: ancora una bolla? Working Paper No. 7. Gruppo 2013. http://www.gruppo2013.it Accessed 23 June 2009.