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Analysis of the Economic and Application-Related Sustainability of Biofuels - A Case Study

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Abstract

Biofuels represent for the European Union an important energy source, and their production has been encouraged by a series of policies aimed at controlling oil prices, reaching the security of the energy supply and cutting the greenhouse gas emissions.
This paper deals with the production of biofuels from the point of view of its economic sustainability and of the effects that the EU directives have had on the Italian productive context.
Besides, this paper presents the outcome of an empiric study based on the economic sustainability of the production of rapeseed intended to fuel a new power plant. The study, conducted in the territory of the Viterbo Province (Italy), singles out the various types of rapeseed seeds that best adapt to the climatic-environmental features of the territory and, based on their yield and the production target of the new power plant, ascertains the land area to be reconverted or to be devoted to this type of crop.

Keywords: Biofuels, Sustainability, Economic analysis

1 Introduction

Biofuels can be distinguished according to their sustainability and observation of the EC guidelines of the 2008/28/EC decree of April 23 2009 , concerning the decrease of the total energy consumption before 2020. The priority, however, is to find a solution to the tri-fold problem food, energy and environment [1], that is, it is necessary to clarify how the impact on the environment and the benefits associated with the use of biofuels could be managed within the limits of economic systems, considering the growing demand of food and energy.

New methodologies have been developed in order to fill the gap between the production efficiency and the environmental impact in the long period: the analysis of the total life cycle LCA-Life Cycle Assessment) has resulted congruous to the analysis of the environmental performances of the biofuels and to the comparison with alternative systems of production adopted in order to identify the criticalities, opportunities for a positive development, and the selection of the raw material [2]. Further research, though, is necessary to redirect decision makings towards a more inclusive target including agriculture, environment and energy policies [3, 42, 44, 45].

Many experts ask for new methods for the evaluation of the sustainability of the production systems, of biofuels that would allow the coherent and univocal adoption of specific international criteria, using a multi-criteria approach. Biofuels, being obtained by edible and non-edible or genetically modified plants, or deriving from bacteria, must be valued according to their productivity, depending on the typology of the raw material and the efficiency of use of the soil, reduction of the greenhouse gases, the use of the by-products such as fertilizers, animal feed, production of chemical products, potential extension of the cultivated land, in particular of those with a low productivity and not to the detriment of those necessary to food production, impact on water sources, on biodiversity, on production costs and on local economies [4], use of the soil related to both direct and indirect effects of change, respecting environmental features, protection of living species [5], requisition of organic carbon, and the agricultural development with the possibility of larger investments in new technologies, International competitivity, and reduction of imported goods [6].

The extant literature presents conflicting opinions in relation the properties of biofuels of first and second generation. It is true, though, that a biofuel can be defined either good or bad only referring to one specific feature [7], among the many aforementioned, contextualized both at a global level and a regional and local one. [8]

A study conducted using a Globiom dynamic model, including agriculture, bioenergy and forestry, has shown a factual decrease of both green house gases and of water consumption following the change in the use of the soil, for second-generation fuels, but not for the first-generation [9]. Other studies have shown, then, a far greater trust in second-generation biofuels maintaining that an alternative sustainable fuel should derive from renewable, non-edible biomasses [10]. However, uncertainty is often related to the variability of production costs, the yield of the cultivated land, the typology of the seeds used. Furthermore, limits are imposed by outdated technologies and by the application of conversion processes[11]. One example is offered by the production of biofuel derived from algae that presents a high yield in terms of energy conversion, a reliable and continuous fuel supply, and the reuse of the salt and water waste and biofuels resulting neutral in the production of CO2 and not dangerous and highly biodegradable[12].

However, new technologies are necessary to implement a process that will support the separation of the algae from its components, that would not use intensive but sustainable energy [13].

Other analyses have confirmed the efficiency, in terms of sustainability, of first generation fuels, such as castor oil, fostered by well known transformative technologies [14] that has shown a strong influence on the reduction of CO2, CO, palm oil, characterized by its productivity [15], colza oil, highly efficient in energy production terms, also grown with organic fertilizers [16].

A study on palm oil, soy, sunflower, cotton and colza seeds, has shown that this latter is by far the most sustainable growing. Conversely, the palm presents a higher efficiency and lower renewability, with a strong dependence on agro-chemical substances (fertilizers). A more adequate management of the resources is then necessary to reduce the use of those that cannot be renewed[17], along with a finalizing of the processes involving the use of plants and seeds genetically modified, further technological development that would allow the use of organic waste in the food and forest field [18] , also in the light the efforts made to maximize the return in the process of conversion of waste vegetable oils [19]. Furthermore, the implementation of the projects for the production of biofuels in the underdeveloped countries would eventually lead to the increase of the exportations, the increase of incomes, due to more favorable natural conditions, land, water availability, and low labor costs. [20].

The aim of this work is to estimate the economic value of seeds used for the biodiesel production in a specific agricultural area in Italy. In particular this study means to simulate an economic sustainability model applied to the Viterbo Province for the production of 12,000 t/year of rapeseed oil intended to feed a new power plant for electric energy production. The biofuel economic study is derived from colza crops of the main types of hybrid seeds.

2 Economic considerations

In the production of first-generation biofuels, further to the 2003 reform of the Common Agricultural Policy (CAP) [21], the support to the income of farmers is no longer tied up to their agricultural production, and they may respond freely to the growing demand for energy crops. Furthermore, the reform has introduced a special "aid to energy crops" scheme, while maintaining the possibility of using land that is under mandatory set-aside provisions for growing non-food crops. In the past, only a limited group of energy crops could be granted aids, through the land set-aside scheme. The reform offered farmers the possibility of growing a variety of energy crops, including short rotation and other perennial crops.

As far as Italy is concerned, it has been estimated that the demand for biodiesel and bioethanol will reach 6 million tons in 2020, 12% of the estimated total requirement for the 27 EU Countries.

In the past, the National Biofuel Program (PROBIO) worked out by the Ministry for Agricultural and Forestry Policies in compliance with article 3 of Law no. 423 of February 12, 1998 concerning "structural and urgent measures in the agricultural, citrus and zoo technical sectors" had been adopted to start implementing national actions resulting from the application of the determinations adopted by the Kyoto conference for reducing gas emissions.

Nowadays, the Italian strategy for using biofuels throughout the territory is based on:

- transposition of the European reference law with a view to attaining the objectives set by the EU;
- the provision relative to the setting up of adequate forms of incentives.

In particular, reference is made to Directive 2003/30/EC [22]transposed into Italian law by the 2007 Financial Act [23] which outlines a clear and accurate roadmap starting from 2008 (with the target of blending a 2% share of biofuels to the total quantity of gasoline and diesel) and ending in 2010 with the new Directive 2009/28/EC[24].

3 Material and methods

The realization of this study required a prior analysis of the relevant literature with a view to gaining an insight into the various rapeseed production and cultivation techniques [25,26,27,28,29,30,31,32]. The resulting information was integrated by the outcome of a series of interviews conducted with the main agricultural consortiums and trade associations of the Viterbo Province. This allowed obtaining data relative to the productivity (q/ha of rapeseed) of the Viterbo Province soils and the sale prices charged for rapeseed at a local level. With reference to this final aspect, even the rapeseed trading prices in the Paris trading desk have been analyzed. The variable considered in the analysis, seed production, cost of seed, typology of seed, yield, have been defined in agree with Hanegraaf et al., 1998; Hill et al., 2006; Silva Lora et al., 2011 [3, 33, 4].

Considering a production target of 12,000 tons of refined oil, the territorial area needed for rapeseed growing has been calculated in an inverse manner based on the pressing yield.

A bibliographic analysis conducted on the magazines of the agricultural sector and the official national surveys made by Coldiretti (National Farmers Federation) [34], have allowed setting at 44% the percentage yield resulting from the pressing process. The required rapeseed production turned out to be 27,270 tons (t).

3.1 Climatic, environmental and territorial features of the Viterbo Province

From a climatic and phytoclimatic point of view, the Viterbo Province is characterized by a sub-humid Mediterranean situation where the scarce precipitations are generally offset by high water soil retention. Generally, the temperature in the wintertime does not drop below 0 °C for more than five consecutive days, while the temperature reported in the summertime is generally higher than 25 °C [35].
The Province may be roughly divided into two climatic zones; a zone that feels the effects of the Mediterranean, and a tempered zone. In particular, with reference to the Map of the Phytoclimate in the Latium Region [36,37,38],the climate changes from the lower meso-Mediterranean thermotype with a rather dry ombrotype, to the lower mountain thermotype with humid ombrotype that only characterizes the area of the Cimini Mountains, through aspects of transition that fall within the Mediterranean area and the tempered area.
It stands to reason to say that the positive geo-climatic conditions of the territory, connected with a high level of specialization of the workers and a reduction of the profits linked to the traditional crops, make the entire area of the Viterbo Province territory particularly suitable for extensive cultivations of energy crops, with special regard to rapeseed.

3.2 Economic-target study

This study means to simulate an economic sustainability model applied to the Viterbo Province for the production of 12,000 t/year of rapeseed oil intended to feed a new power plant for electric energy production.
Hence, an analysis of the main types of hybrid seeds present on the international, national and local markets allowed singling out eight main seed typologies (The choice has been made based on the climatic and environmental characteristics of the territory of the Viterbo Province (Italy) and the availability of the seeds at authorized local retailers.). Due consideration was given to the yield levels in terms of productivity of the soil under rapeseed crop, and the sale prices were evaluated based on the prices quoted by the Paris trading desk and the prices charged by local agricultural consortiums. The subsequent step was an evaluation of productivity, determining – based on the mean crop yield – the required number of hectares (ha) to be cultivated in order to meet the yearly target of refined oil. Hence, the study singled out the most profitable type of seed to be used inside the territory under consideration.

4 Results and discussion

Various types of seed, both hybrids and traditional varieties, are available on the market for the cultivation of rapeseed. Table 1 shows exclusively those seeds that present the best characteristics in terms of yield and seed cost per ha.
The seed cost has been estimated based on the information provided by the seed producing companies or by the territorial consortiums that had been suitably contacted. This allowed to relate the cost of the seeds to the reference measurement unit, that is a hundred kilos for hectare (q/ha).
The rapeseed production yield is conditioned by the climatic differences of the territory, the geographic position (North-Center-South) and the seasonal trend, determining a crop productivity variance between a minimum and a maximum level. This is the reason why the reference standard adopted for the purpose of this study is the mean value between these two values.

Table 1 - Hybrid seed data

Company-Consortium	**Type of seed**	**Seed cost** ***€/ha***	**Yield[5]** ***(ha)***
Consorzio di Tuscania - Il Colza	Hybristar	72,00[1]	20-30 q/ha
Consorzio di Nepi- Il Colza	Hybristar (No OGM)	76,00[2]	20-30 q/ha
	Hybristar	76,00	20-30 q/ha
Pioneer	PR44D06	52,00	20-35 q/ha
	PR45D03	52,00	20-35 q/ha
	PR46W14	49,00	20-35 q/ha
SIS (Società Italiana Sementi)	Pluto	90,00[3]	38-50 q/ha
	Pulsar	80,00 € [4]	25-45 q/ha

Source: our processing of data from the manufacturer / dealer of rapeseed.
[1]The price is estimated on the basis of information provided by the consortium.
[2] The price is estimated on the basis of information provided by the consortium.
[3] Source: our processing of data provided by the rapeseed producers.
[4] Source: our processing of data provided by the rapeseed producers.
[5] Source: Rivista di agraria.org

After having determined the harvest target and the average yield of each hybrid typology, the actual acreage to be farmed had to be calculated in hectares (ha). This initial calculation has shown that the hybrid Pluto succeeds in meeting the production requirement with 43% less land than the highest value reported for the Hybristar seed. Indeed, the acreage under crop is a strategic element that needs to be taken into account not only in relation to costs, analyzed in the paragraphs below, but also in view of the higher probability of finding a limited number of farmers willing to reconvert their fields or to use them to grow rapeseed and, therefore, of ensuring the production level provided for by the model.

Table 2 – Summary data relative to the total seed cost

Company-Consortium	Hybrid typology	Harvest target *(t)*	Average yield being considered (q/ha)	Amount necessary for cultivation purposes (*ha)*	Provincial territory %	Seed cost *(€/ha)*	Total seed cost (€)
Pioner	PR46W14	27,270	27.5	9,916	2.75%	49	485,901.82
Pioner	PR44D06	27,270	27.5	9,916	2.75%	51	509,040.00
Pioner	PR44D03	27,270	27.5	9,916	2.75%	51	509,040.00
SIS - Società Italiana Sementi	Pluto	27,270	44	6,198	1.72%	90	557,795.45
SIS - Società Italiana Sementi	Pulsar	27,270	35	7,791	2.16%	80	623,314.29
Il Colza	Hybristar	27,270	25	10,908	3.02%	72	785,376.00
Il Colza	Hybristar (no OGM)	27,270	25	10,908	3.02%	76	829,008.00
Nepi Consortium – Il Colza	Hybristar	27,270	25	10,908	3.02%	76	829,008.00

Source: our processing of data provided by the rapeseed producers of the Viterbo Province.

Analyzing the resulting data in terms of the “seed cost” and “ha” binomial, show that the highest cost relates to the Hybristar (Consorzio Nepi – Il Colza), while the lowest cost relates to the Pioner PR46W14 hybrid, with a 41% saving.
However, if the data calculated up to now are compared with the territorial size, that is to say, with the acreage needed to reach the production level that has been set, we get a further aspect that has to be taken into consideration: the surface requirements. Considering that the overall extent of the Viterbo Province is equal to 361,2 ha, from an initial comparison of these data, it may be affirmed that, given the required area, which ranges from a minimum value of 1.7% to a maximum value of 3%, the production objective may be reached quite easily.
Having recourse to the Pluto hybrid, the surface to be cultivated drops by 43% with respect to the maximum Hybristar value.
With the data analyzed up to now, there is no possibility of determining the most convenient hybrid in terms of costs. In fact, the cost of the seed and the q/ha yield do not allow making a sustainable economic choice. This is the reason why a number of hypotheses have been made:

- The main Variable Costs (Table 3) have been determined. The attributed value has been estimated taking into consideration the costs relative to light tilling, preparation of the sowing bed, fertilization, sowing, packing down, weeding, fertilization, harvesting, total tilling, cost of fertilizers, various transport operations, chopping of crop residues, diesel. Given the typology and the characteristics of these cost items, a proportional increase with respect to the size of the area to be cultivated has been assumed. This is the reason why the Total Variable Cost used to represent that item has been estimated at 500.00/ha (This value results from an estimate calculated on the basis of such costs as light tilling, preparation of the sowing bed, fertilization, sowing, packing down, weeding, fertilization, harvesting, total tilling, cost of fertilizers, various transport operations, chopping of crop residues, diesel).

- The Fixed Costs of production have been neglected owing to the fact that they are attributable to the different characteristics of the individual producers in relation to their managerial capacity and the infrastructures/equipment available to the agricultural entrepreneur/farmer.

If these data are associated with the rapeseed selling price, which amounted to € 37.50 (average price calculated for the main Consortia of the Viterbo Province), it may be affirmed that the Pluto hybrid is the most suitable type of seed in terms of yield, seed cost and variable costs.

The sum of the costs (cost seed + variable cost) proves to be the lowest owing to the high seed yield (44 q/ha) that allows reducing to a considerable extent the acreage to be used for cultivation purposes, increasing the profit margins and, above all, reducing the number of farmers to be involved in the production. In any event, given the area of the Province territory (1.7%) needed for the crop, the production objective initially set may be reached quite easily.

Table 3 - General summing up of data

Company - Consortium	Hybrid typology	Amount necessary for cultivation purposes	Provincial Territory %	Seed cost *(€/ha)*	Total seed cost (€)	Variable Costs (€)	Total cost (Seed cost + Variable costs)	Sales revenues *(€)*
Pioner	PR46W14	9.916	2,75%	49	485.901,82	4.958.181,82	5.444.083,64	10.226.250,00
Pioner	PR44D06	9.916	2,75%	51	509.040,00	4.958.181,82	5.467.221,82	10.226.250,00
Pioner	PR44D03	9.916	2,75%	51	509.040,00	4.958.181,82	5.467.221,82	10.226.250,00
SIS - Società Italiana Sementi	Pluto	6.198	1,72%	90	557.795,45	3.098.863,64	3.656.659,09	10.226.250,00
SIS - Società Italiana Sementi	Pulsar	7.791	2,16%	80	623.314,29	3.895.714,29	4.519.028,57	10.226.250,00
Il Colza	Hybristar	10.908	3,02%	72	785.376,00	5.454.000,00	6.239.376,00	10.226.250,00
Il Colza	Hybristar (no OGM)	10.908	3,02%	76	829.008,00	5.454.000,00	6.283.008,00	10.226.250,00
Consorzio Nepi – Il Colza	Hybristar	10.908	3,02%	76	829.008,00	5.454.000,00	6.283.008,00	10.226.250,00

Source: our processing of data provided by the rapeseed producers

5 Model limits

The limits of the model are connected with the estimates of the soil productivity

and the yield that result from the mechanical harvesting and the seed pressing, since these factor prove to be conditioned to a considerable extent by the variability of the atmospheric phenomena, the different soil composition and the geographic location of the land. This is the reason why a mean reference level has been defined with a view to determining the level of productivity of the soil (q/ha). Quite naturally, this evaluation can be viewed as a theoretical forecast within the context of the proposed feasibility study.
Fixed production costs have not been considered in the model, owing to the fact that they are attributable to the different characteristics of the individual producers in relation to their managerial capacity and the infrastructures/equipment available to the agricultural entrepreneur/farmer.
The Variable Costs are the result of the estimate of the costs per ha relative to light tilling, preparation of the sowing bed, fertilization, sowing, packing down, weeding, fertilization, harvesting, total tilling, cost of fertilizers, various transport operations, chopping of crop residues, diesel. This estimate is obtained by summing up the cost of each item; it has been assumed that the increase in these items is proportional with respect to the increase in the acreage of the area to be cultivated.

6 Conclusion

Raising the share of biofuels falls among the objectives that the European Union has approved within the “climate-energy” package of reforms known as the “20-20-20” strategy. The latter provides for a 20% reduction in EU greenhouse gas emissions, a 20% improvement in the EU's energy efficiency and raising the share of EU energy consumption produced from renewable resources to 20% by 2020.
Indeed, the recent passage of new laws [39]. in our Country has paved the way for a new phase in the development of a national biofuel industry , along with several other energy supply strategies, including the installation of photovoltaic systems [40]. The grain supply chains are getting reorganized in order to make the most of this opportunity and new industrial research applications may offer unquestionable benefits resulting from the reuse of crop wastes and the sustainability of production, as well as benefits from an economic point of view.
This feasibility study has highlighted the potential of the Viterbo Province , well known for its disposition to the use alternative sources of energy production due to the presence of thermal basins [41,42] territory for rapeseed cultivation and the use of the latter as biofuel to meet the energy requirements of a small-sized power plant.
The analysis of the various seed varieties has allowed comparing yields, soil productivity and the acreage required to reach the target amount. The (variable) costs, estimated in respect of each variety, have been related to the average price charged in the reference period.

The outcome of the analysis has rewarded the characteristics of the Pluto hybrid, as the high seed purchase cost was offset by a high yield and high returns. Indeed, this hybrid has been singled out as the one that is best suited to an intensive cultivation of rapeseed intended to fuel a plant for electric power production.

References

[1] D. Tilman, R. Socolow, J.A. Foley, J. Hill, E. Larson, L. Lynd, S. Pacala, J. Reilly, T. Searchinger, C. Somerville and R. Williams , Beneficial Biofuels, The Food, Energy and Environment Trilemma, *Energy Science*, **325** (2009), 270 - 271.

[2] J. Malça, A. Coelho and F. Freire, Environmental life-cycle assessment of rapeseed-based biodiesel: Alternative cultivation systems and locations, *Applied Energy*, **114** (2014) , 837 - 844.

[3] M.C. Hanegraaf, E.E. Biewinga and G. Van Der Bijl, Assessing the ecological and economic suastainability of Energy crops, *Biomass and Bioenergy*, **15** (1998), 345 - 355,.

[4] E.E. Silva Lora, J.C. Escobar Palacioa, M.H. Rochaa, M.L. Grillo Renóa, O.J. Venturini, O. Almazán del Olmo, Issues to consider, existing tools and constraints in biofuels sustainability assessments, *Energy*, **36** (2011), 2097 - 2110.

[5] D.L. Karlen, M.J. Mausbach, J.W. Doran, R.G. Cline, R.F. Harris, G.E. Schuman, Soil Quality: A Concept, Definition, and Framework for Evaluation, *Soil Science Society of America Journal*, **61** (1997), 4 - 10.

[6] A. Demirbas, Political, economic and environmental impacts of biofuels: A review, *Applied Energy*, **86** (2009), S108 - S117.

[7] G. Venturi, Sostenibilità dei biocarburanti di prima e seconda generazione: fra certezze e dubbi, *La Chimica & l'Industria*, **6** (2011), 70 - 75.

[8] A. Elbehri, A. Segerstedt and P. Liu , Biofuel and the sustainability challenge: A global assessment of sustainability issues, trends and policies for biofuels and related feedstocks, *Trade and markets division food and agriculture organization of the united nations*, Rome, 2013.

[9] P. Havlı´ka, U.A. Schneider, E. Schmidc, H. Bottcher, S. Fritz, R. Skalsky´, K. Aoki, S. De Carae, G. Kindermanna, F. Kraxner, S. Leduc, I. McCalluma, A. Mosnier, T. Sauer and M. Obersteiner, Global land-use implications of first and second generation biofuel targets, *Energy Policy*, **39** (2011) 5690 - 5702.

[10] V.B. Borugadda, V.V. Goud, Biodiesel production from renewable feedstocks: Status and opportunities, *Renewable and Sustainable Energy Reviews*, **16** (2012), 4763 - 4784.

[11] R.E.H. Sims, W. Mabee, J.N. Saddler, M. Taylor , An overview of second generation biofuel technologies, *Bioresource Technology*, **101** (2010), 1570 - 1580.

[12] P.M. Schenk, S.R. Thomas-Hall, E. Stephens, U.C. Marx, J.H. Mussgnug, C. Posten, O. Kruse, B. Hankame, Second Generation Biofuels: High-Efficiency Microalgae for Biodiesel Production, *BioEnergy Research*, **1** (2013), 20 - 43.

[13] K. Sander, G.S. Murthy, Life cycle analysis of algae biodiesel, *International Journal of Life Cycle Assessment*, **15** (2010), 704 - 714. 10.1007/s11367-010-0194-1

[14] F.Halek, A. Delavari and A. Kavousi-Rahim, Production of biodiesel as a renewable energy source from castor oil, *Clean Technologies and Environmental Policy*, **15** (2013), 1063 - 1068.

[15] T.O. Rodrigues, A. Caldeira-Pires, S. Luz, C. A. Frate, GHG balance of crude palm oil for biodiesel production in the northern region of Brazil, *Renewable Energy*, **62** (2014), 516 - 521.

[16] M.T. Firrisa, I. Van Duren and A. Voinov, Energy efficiency for rapeseed biodiesel production in different farming systems, *Energy Efficiency*, **7** (2014) , 79 - 95.

[17] F.Takahashi, E. Ortega, Assessing the sustainability of brazilian oleaginous crops - possible raw material to produce biodiesel, *Energy Policy*, **38** (2010), 2446 - 2454.

[18] A. Eisentraut, Sustainable Production of Second Generation Biofuels Potential and perspectives in major economies and developing countries, *International Energy Agency* , 2010.

[19] M. Carlini, S. Castellucci and S. Cocchi, A Pilot-Scale Study of Waste Vegetable Oil Transesterification with Alkaline and Acidic Catalysts, *Energy Procedia*, **45** (2014), 198 - 206.

[20] M. Schut, M. Slingerlandb and A. Lockec, Biofuel developments in Mozambique. Update and analysis of policy, potential and reality, *Energy Policy* , **38** (2010), 5151 - 5165.

[21] F. Fischler, Speech delivered at the CAP Reform Committee on Agriculture and Rural Development, *Press Release Rapid*, Brussels, 2003. SPEECH/03/356.

[22] Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents, *Official Journal of the European Union*, 15.2.2003.

[23] D. Lgs. 30 maggio 2005, n. 128 (in G.U. n. 160, 12 July 2005). Attuazione della direttiva 2003/30/CE relativa alla promozione dell'uso dei biocarburanti o di altri carburanti rinnovabili nei trasporti.

[24] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union, 5.6.2009.

[25] E.E. Biewinga, G. Van Der Bijl, Sustainability of energy crops in Europe, a methodology developed an applied, *Centre for Agriculture and Environment*, Utrecht, 1996.

[26] M. Carlini, S. Castellucci, S. Cocchi, A.Manzo, Waste Wood Biomass Arising from Pruning of Urban Green in Viterbo Town: Energy Characterization and Potential Uses, *Lecture Notes in Computer Science*, **7972** (2013), 242 - 255.

[27] G. Caserta, V. Bartolelli and G. Mutinati, Herbaceous energy crops: A general survey and a microeconomic analysis, *Biomass and Bioenergy*, **9** (1995), 45 - 52.

[28] C.M. Gasol, J. Salviac, J. Serrac, A. Antòn, E. Sevigne, J. Rieradevall and X. Gabarrell, A life cycle assessment of biodiesel production from winter rape grown in Southern Europe, *Biomass and Bioenergy* , **40** (2012), 71 - 81.

[29] A. Mosiño, Producing energy in a stochastic environment: Switching from non-renewable to renewable resources, *Resource and Energy Economics* , **34** (2012), 413 - 430.

[30] E.M. Mosconi, Opportunity and function of energy wholesale market in Italy, *Rivista Giuridica dell'ambiente* , **18** (2003), 1101 - 1110.

[31] P. Paar, W. Röhricht and J.Schuler, Towards a planning support system for environmental management and agri-environmental measures-the Colorfields study, *Journal of environmental management* , **89** (2008), 234 – 44.

[32] L. Pari, A. Assirelli, A. Suardi, V. Civitarese, A. Del Giudice, C. Costa and E. Santangelo, The harvest of oilseed rape (Brassica napus L.): The effective yield losses at on-farm scale in the Italian area, *Biomass and Bioenergy,* **46** (2012), 453 - 458.

[33] J. Hill, E.Nelson, D.Tilman, S.Polasky and D. Tiffany, Environmental, economic , and energetic costs and benefits of biodiesel and ethanol biofuels, *PNAS*, **103** (2006), 11206 - 11210.

[34] E.M. Shahid, Y. Jamal, Production of biodiesel: A technical review, *Renewable and Sustainable Energy Reviews* , **15** (2011), 4732 - 4745.

[35] E Cozzolino, V. Leone, Colza da olio per filiere agro-energetiche, *Rivista di agraria*, **72** (2012).

[36] Provincia di Viterbo, *Rapporto sullo stato dell'ambiente*, 2008. www.provincia.vt.it/agenda21/Indice_Rapp2008.asp.

[37] C.Blasi, Carta del Fitoclima del Lazio, Regionalizzazione e caratterizzazione climatica, *Latium Region, Agriculture and Forestry Councillorship, Civil Uses*, Rome "La Sapienza" University, Department of Vegetal Biology, 1993.

[38] C. Blasi, Il Fitoclima del Lazio, *Fitosociologia* , **27** (1994), 151 - 175.

[39] Decree Law no. 100 of April 23, 2008; 2007 and 2008 Financial Acts; Adoption of Directive 2009/28/EC.

[40] E.M. Mosconi, M. Carlini, S. Castellucci, E. Allegrini, L. Mizzelli, M. Arezzo di Trifiletti, Economical Assessment of Large-Scale Photovoltaic Plants: an Italian Case Study, ICCSA 2013, *Springer, Lecture Notes in Computer Science*, **7972** (2013), 160 - 175.

[41] M. Carlini, S. Castellucci, Efficient energy supply from ground coupled heat transfer source, ICCSA 2010, *Springer-Verlag Berlin Heidelberg, Lecture Notes in Computer Science*, **6017** (2010), 177 - 190.

[42] Colantoni A., Allegrini E., Boubaker K., Longo L, Di Giacinto S., Biondi P. New insights for renewable energy hybrid photovoltaic/wind installations in Tunisia through a mathematical model. *Energy conversion and management*, **75** (2013), 398-401.

[43] M. Carlini, S. Castellucci, Modelling the vertical heat exchanger in thermal basin, ICCSA 2011, *Springer Heidelberg Dordrecht London New York*, *Lecture Notes in Computer Science*, **6785** (2011), 277 - 286.

[44] Marucci A., Monarca D., Cecchini M., Colantoni A., Allegrini E, Cappuccini A. Use of semi-transparent photovoltaic films as shadowing systems in Mediterranean greenhouses, *Lecture notes in computer science*, **7972** (2013) 231-241.

[45] Petroselli A, Biondi P, Colantoni A, Monarca D, Cecchini M, Marucci A, Cividino S., Photovoltaic Pumps: Technical and Practical Aspects for Applications in Agriculture, *Mathematical problems in engineering*, **2012**.

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