15th European Biomass Conference

FROM RESEARCH TO MARKET DEPLOYMENT

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PRODUCTION OF BIOMASS RESOURCES, ASSESSMENT OF THEIR AVAILABILITY AND INTERACTIONS WITH FOOD PRODUCTION: A SUPPLY MODEL FOR THE REGIONAL SCALE

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ABSTRACT: In an ever widening global market the policies for the energy sector are constantly assuming a more important role. In terms of biofuels, the European Union appointment starts with the Directive 2003/30/CE that assembles the promotion of biofuels and other renewable fuels. The purpose of the present study is the evaluation of the potential biomass supply, as Renewable Energy, and the assessment of the supply's development following some future scenarios. The methodological approach has taken into consideration the possible changes in the economic variables of agricultural companies, the principal future trends of the Common Agricultural Policy and, finally, the effect of some forms of production "incentive" at the local scale. The suggested method was used in a case study in Lombardia (Italy) and it appears to be useful for facing a preliminary study to define more accurate local policy strategies. Acting on the government aid level the policy makers can see the results in terms of non-food crops' potential supply for energy purposes. In particular, the public support for biofuel demands creation could be the key element to giving value to the potential supply where there is an economic sustainability.
Keywords: biodiesel, economic aspects, set-aside agricultural land.

1 INTRODUCTION

In an ever widening global market the policies for the energy sector are constantly assuming a more important role. Not only in the industrialized countries but also in developing ones, energy is by now considered the decisive element to assure, in a middle to long range view, growth and competitiveness of industrial production. The constant growth of the oil prices, along with the necessity of guaranteeing the safety of provisions, have contributed to making governments aware of energy problems. Nevertheless, today more evidence comes up that the nations' energy planning and global strategies of development determine some environmental outcomes of non negligible account. It is also clear that the energy policy trends and strategies are played, by now, at the global level and that at a European level a coordinated answer from members states constitutes the only tool to reach effective solutions. More often, however, it is at the local level that the real feasibility and economic sustainbaility of the energy policy choices are decided, acting on the limited ability to influence the supply or, more easily, acting in an active way on the demand side. Therefore, it appears necessary to prepare informative tools and evaluations that, on one side, favor the growth of awareness regarding the energy matter and, on the other side, give suggestions to the decision makers about the usable elements for the formulation and sharing of the future energy policy choices.

Table I: The energy consuption (Kept) in Lombardia

	Agriculture	Industry	Transports	Houses	Total
Solid fuels	-	210	-	29	238
Petrol fuels	**413**	**628**	**6.976**	**1.943**	**9.961**
Natural gas	19	3.871	18	5.531	9.438
Renewable sources	-	16	-	213	229
Electricity	53	2.899	115	1.804	4.872
Total	485	7.624	7.109	9.520	24.738

2 CONTEXT OF REFERENCE

2.1 European Union

At the EU level, the first step toward the elaboration of a "Renewable Energy Strategy" goes back to 1996, to the work of the European Commission, with the adoption of the Green Book "Energies for the future: renewable sources of energy" COM(96) 576. It instigated a debate around the type and nature of which measures to adopt. In 1997, the White Paper for a Community strategy and Action plan was published, in which the European Union defined its own energy policy objectives: safety provisions (given through diversification), sources of competitiveness and, finally, respect for the environment.

In terms of biofuels, however, the European Union appointment is surely more recent. It is in fact with the Directive 2003/30/CE of the European Parliament, that the EU assembles the promotion of biofuels and other renewable fuels. The Directive foresees that member states would progressively introduce, into their own market,a biofuels percentage, increasing from 2% in 2005 to 5,75% by the end of 2010. It is up to each member state to choose its own objectives, even if those objectives have lower standards that those stated by the Directive.

2.2 The Lombardia Region

Lombardia shows an energy consumption per person was equal to 3,84 Equivalent Petroleum Tons (Ept) versus the 3 Ept Italian average, next to 3,8 Ept of the average European person. The primary energy supply structure in Lombardia is characterized by the total hydrocarbons importation (98,2%) destined for final consumption (58,5%) or electric energy production and heating (41,5%). From the year 2000 energy budget (Table I), the civil sector shows a greater energy consumption (38% of the whole final consumption) followed, with similar values among them, by the industry (31% of the total) and transport (29%). If, however, the consumption data are also analyzed in terms of energy sources, the situation appears different: in terms of oil products, in fact, we can observe that nearly the 70% of consumption is absorbed by the transport sector. Already from a first look, it appears evident that it is important for the Lombardia Region to adopt the unitary strategy for the sustainable development individualized by the European Union.

3 AVAILABILITY OF BIOMASS FOR BIODIESEL PRODUCTION IN LOMBARDIA

Departing from the above description of the regional energy sector, as it emerges from the Lombardia Regional Energy Program, it is necessary to investigate the potential of biomass (for energy purposes) supply structure. Such preliminary analysis, in light of the numerous questions set by future developments of biofuel incentive policy, has given origin to a close examination regarding the potential development of "agroenergy". Biodiesel production and to its contribution to the regional energy and agricultural system is also being examined in a middle-long term view. The first step in the evaluation of the potential biodiesel supply consists in the assessment of raw material (figure 1), the vegetable oil to be submitted to the transesterification process. In Lombardia the potential biodiesel production is derived from three principal sources: the grounds destined to oleaginous crops (colza, sunflower and soybean), the grounds left to rest (set aside) that could be cultivated with non-food crops for energy purposes and, finally, the exhausted oils that come from restaurants, food industries and from private houses. In regards to the first two sources (those properly agricultural), the maximum attainable production is initially expected in every Lombardia Province.

And upon a second analysis, through examining the parameters that influence the farmers' and policy makers' choices, the supply course can be analyzed through a prediction model.

3.1 The oleaginous crops

In Lombardia, according to the Istat data of the 2000 Agriculture Census, around 49.000 hectares (Table II) are allocated to oleaginous crops cultivation, corresponding to 6,8% of the sown surface and to 4,8% of the Used Agricultural Surface (UAS). Such value results are rather low because, traditionally, the most common crops in Lombardia are cereals. It must underlined that although each of the following crops are potentially usable, through oil extraction, a use for the biodiesel is not always found.

Of the nearly 50.000 hectares of surface cultivated with oleaginous crops (chart 2), the biggest part (86%) is destined for soybean cultivation followed, with a few more than 5.500 hectares, by the sunflower (11% of the total) and finally by the colza, a typical crop for energy, that with its 1.300 hectares, represents only the 3% of the total oleaginouse crops surface.

The soybean, a spring-summer crop diffused in the great zootecnical areas, can actually produce up to 4 tons of seeds per hectare from which 0.8 tons of oil are drawn; the colza has an autumn-spring cycle and is mainly grown in the Milan Province, where it is normally not irrigated, and it produces up to 3.5 tons of seeds per hectare, that after pressing, gives 1.2 tons of oil; the sunflower is common in the south-east irrigated zone of the Lombardia where it reaches productions of 4-5 tons of seeds that, thanks to a considerable oil yeld, it can give up to 1.6 tons of oil per hectare (even if an average of 1.4-1.5 tons/ha is reached).

3.2 The set-aside surface

According to the Istat data of the Agricultural Census (Table III), the surfaces destined to be set-aside in Lombardia add to a few more than 40.000 hectares, and they are mainly found in the southern part of the region. These surfaces "retreated" from the normal agricultural production, which are almost equal to the surfaces destined to oleaginous crops, constitute a possible "source" for biofuel production. Although they are not eligible for the so-called "carbon's credit", those crops can be devoted to non-food cultivation.

In fact, according to what was stated by the UE Common Agricultural Policy (particularly by arts. 55 and 56 of the Reg 1782/2003), a farmer that uses the set-aside

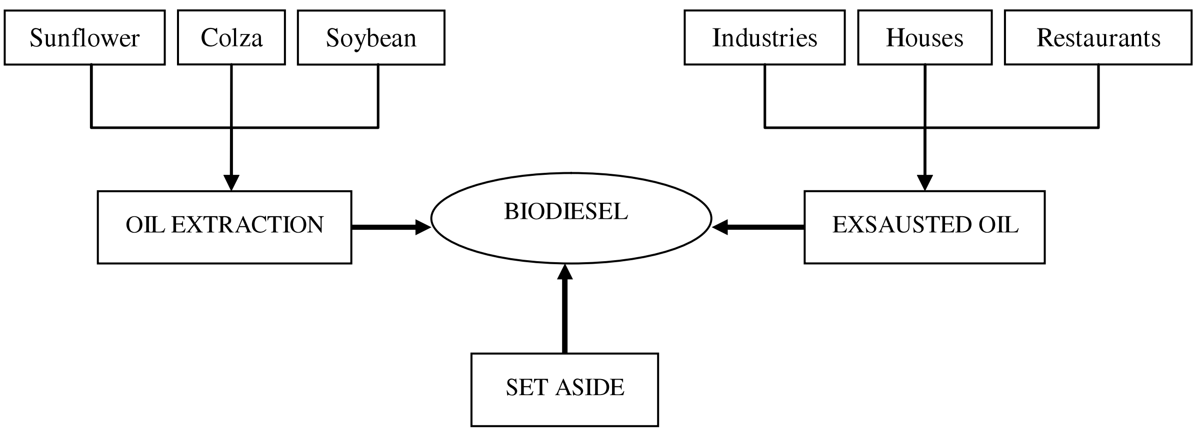

Figure 1: The biodiesel supply chain

surfaces to provide material (products not destined to the human or animal consumption) to be transformed, within the community, is not subject to the obligation of withdrawal.

Table II: The oleaginous crops (hectars) in Lombardia

Province	Colza	Sunflower	Soybean	Other	Total
Varese	0,04	1,52	150,26	-	151,82
Milano	609,11	530,60	3.606,91	34,31	4.780,93
Como	-	2,00	302,38	7,88	312,26
Sondrio	-	0,05	0,01	-	0,06
Lodi	40,60	270,58	2.737,22	6,30	3.054,70
Lecco	-	-	30,52	-	30,52
Mantova	166,36	1.025,36	19.967,95	72,07	21.231,74
Cremona	41,34	2.174,17	5.780,16	17,70	8.013,37
Pavia	90,56	353,57	2.929,29	17,76	3.391,18
Bergamo	62,80	181,47	2.181,15	-	2.425,42
Brescia	279,67	1.132,94	4.655,61	37,36	6.105,58
Lombardia	**1.290,48**	**5.672,26**	**42.341,46**	**193,38**	**49.497,58**

Table III: The set-aside land (hectars) in Lombardia

Province	Land on set-aside
Bergamo	2.031,41
Brescia	6.998,72
Como	348,79
Cremona	8.939,44
Lecco	196,00
Lodi	3.701,80
Mantova	6.804,76
Milano	4.638,72
Pavia	6.399,88
Sondrio	16,82
Varese	361,40
Lombardia	**40.437,74**

3.3 The potential biodiesel production

Starting from the data related to the agricultural surfaces mentioned in the previous paragraphs, it is possible to forsee the maximum biodiesel production that is potentially realizable in Lombardia (chart 2.3). With the assumption that the seeds of the three principal oleaginous crops (soybean, colza and sunflower) are employed for oil production, and that the whole set-aside surface is cultivated with sunflower (the crop with the best conversion index), we come to estimate a potential production of more than 100 thousand tons of biodiesel (chart 2.3) per year. Besides the potential supply value in absolute terms, it is interesting to analyze the contribution of each productive source in percentage terms (figure 2). For this reason, it is possible to notice that the greatest contribution (60%) comes from the set-aside land and continues with the soybean at a much lower percentage (29%). Sunflower and colza together contribute a rather limited quota (11%).

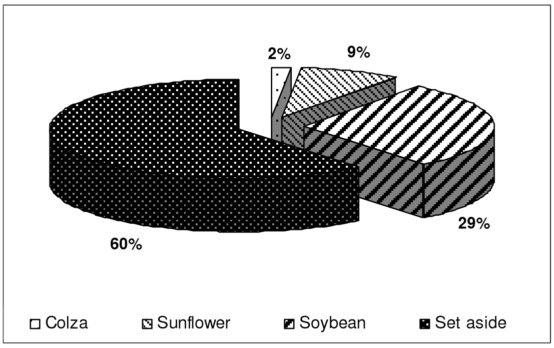

Figure 2: The potential supply (in %) per each source

4 THE SUPPLY MODEL FOR THE REGIONAL SCALE

The purpose of the present study is the evaluation of the potential biomass supply, as Renewable Energy, and the assessment of the supply's development following some future scenarios. The methodological approach for the individualization of the scenerios has take into consideration the possible changes in the economic variables of agricultural companies (with particular reference to the comparison of the biomass crop profitability to those typical of the Lomabardia area) and of the energy market; the principal future trends of the Common Agricultural Policy (CAP) and, finally, the effect of some forms of production "incentive" at the local scale.

4.1 The conceptual framework and prediction model description

The present model, starting from what elaborated by Antle and Stoorvogle regarding the offer of "Ecosystem service" prediction, considers the farmer's choice among two land use possibilities. Such choice is function of the farmer's wish to maximize the profit which, consequently, will choose the crop that guarantees the greatest economic return.

Table IV: The potential biodiesel production (tons/year)

Province	Colza	Sunflower	Soybean	Set aside	Total
Varese	0,06	2,74	120,21	-	123,01
Milano	852,75	955,08	2.885,53	8.349,70	13.043,06
Como	-	3,60	241,90	-	245,50
Sondrio	-	0,09	0,01	-	0,10
Lodi	56,84	487,04	2.189,78	6.663,24	9.396,90
Lecco	-	-	24,42	-	24,42
Mantova	232,90	1.845,65	15.974,36	12.248,57	30.301,48
Cremona	57,88	3.913,51	4.624,13	16.090,99	24.686,51
Pavia	126,78	636,43	2.343,43	11.519,78	14.626,42
Bergamo	87,92	326,65	1.744,92	3.656,54	5.816,03
Brescia	391,54	2.039,29	3.724,49	12.597,70	18.753,02
Lombardia	**1.806,67**	**10.210,07**	**33.873,18**	**71.126,52**	**117.016,50**

Assuming, therefore, that the cultivation A provide an economic return Ra and the option B produces a return Rb, the difference of the respective incomes can be defined as the criterion that drives the farmer's choice (Sj):

$$S_j = Ra_j - Rb_j$$

$$S_j = \Delta R_j \qquad (1)$$

Sj therefore represents the difference of profitability of the two crops performed into the j-th territorial area. It must be remembered that the profitability of the crops is "space dependent" or it is a function of the case study's geographical position. It is in fact clear that, for instance, the income produced by a planeland irrigated crop is different from that produced by the same crop under non-irrigated conditions or in a hilly area. On the basis of equation (1) it is possible to affirm that if Sj > 0 the farmer will choose crop A, otherwise, option B will be chosen.

It has to be remembered, however, that we proceeded to a simplification regarding the passage costs from one option to the other. Antle and Stoorvogle remember, in fact, that the passage from any land use to another one can carry out some costs, defined as "cost of adjustment" [2]. These costs can, upon first analysis, concern capital investments, but also, more often, they are necessary for "learning" about the new crop management to be adopted. It is therefore necessary to add this factor in the evaluation of the possible alternatives for land use. Defining Ca the costs of "adjustment", the formula (1) comes, therefore, modified as it follows:

$$S_j = \Delta R_j - Ca_j \qquad (2)$$

However, additionally to such objectives costs, a series of behavioral factors that can influence the farmer's choice (to effect one or the other option) also exists. Literature indicates that the farmer's choice can be influenced by a lot of variables [1], such as the farmer's individual characteristics (age, sex, degree of education), the technical-economic characteristics of the farm [1] and, most importantly, the perception that the farmer has of the connected risk to one or the other land uses [13]. To this point it is necessary to define Ctj as "Costs of Transition" and to insert them in the equation (2) as following:

$$S_j = \Delta R_j - Ca_j - Ct_j \qquad (3)$$

Recalling what has previously been shown, the farmer will choose option A when Sj > 0 or when Rj > Caj + Ctj. In other words, crop A will be preferred to B when the difference of the produced incomes is greater than the costs (real and "perceived") to pass from one option to the other.

In a competitive situation, without the intervention of incentive factors, the farmers will allocate the land use among the two options following the course of Sj. Nevertheless, it must not be forgotten that the local government, with the purpose of stimulating one production or the other, could come forth in support of the supply. In this case, the farmers would be given some payments, or other forms of incentive, if the farmers decide to use crop A. Then taking into consideration this possibility, it is necessary to introduce the variable I, defined as "Public Incentives", therefore modifying the formula (3) as it follows:

$$S_j = \Delta R_j - Ca_j - Ct_j + I \qquad (4)$$

Now, to determine the supply of good produced by crop A, it has been reinforced that this is function of Sj and, therefore, it is possible to estimate it from the Sj analysis. Then, if Sj = 0 the supply will be equal to zero as the farmer will allocate the land with crop B, while if Sj > 0 the supply of each farm will be given from:

$$F_j (Sj) = E_j \bullet R_j \qquad (5)$$

where Ej is the surface (in hectares) of crop A and Rj is the territorial average yield.

Having now considered the factors that influence the farmer's choice, it is possible, adding the individual offers, to determine the market supply at the regional scale (Fr):

$$F_r (S_j) = \sum_{i=1}^{n} (E_i \times R_i) \qquad (6)$$

4.2 Case Study: data modeling and issues

To verify the effect of the practical application of the introduced framework and prediction model, we decided to proceed with the elaboration of a case study for the Lombardia Region which has brought about the following results. In particular, the predominant potential contribution of the set-aside grounds has been analyzed in more detail, and the parameters have been set which influence the farmer's choices and estimate the biodiesel supply course following their variation. It has been considered therefore the farmer's choice, in terms of land use, as an alternative among two possibilities: to leave the ground "to rest" with the set-aside regime or to cultivate it with an oleaginouse crop (which has been isolated in the sunflower, see par. 3.3) for the biodiesel production.

The previous text has shown that the farmer will choose to cultivate sunflowers if he foresees a greater economic return than if were to choose an alternative land use (set aside). So far the examination of the crops' economic return is the first step to foreseeing the land allocation and, therefore, the supply at the regional scale.

To be thorough, the technical-economic data it has been used, as source, from some previous studies which have shown the course of the principal interesting variables. As a reference for the calculation, the homogeneous areas form the Lombardia "Regionalization Plan" have been selected. Such approximation surely introduces an "error variable", however, it allows us to come to a first assessment of the potential production and to the comprehension of where the choice of the crop dedicated to the biodiesel production will be more probable.

4.3 Sj calculation

From 1992 the Common Agricultural Policy (CAP) has been the object of a deep reform process whose objective can be seen from a price support policy to an ampler strategy of income support. In this sense, with the Middle Term Review, the payment system and organization for the "set-aside" has been modified. Today set-aside rights are assigned to farms, that were obligated to be set-aside in the period 2000-2002. To be able to make a profit from this payment, the farmer must not cultivate an area equal to the assigned rights. However, the maintenance of good agronomic conditions of such grounds must be guaranteed, and the cultivation of "non-food" crops is permitted. Such entity payment rights (Rbj) are commensurate to the sum receipts in the reference period (years 2000-2002). They were calculated by multiplying the "Regionalization Plan" yield by the amount of 63 Euros/ton.

It must be restated that in the set-aside case the costs for the maintenance of good agronomic conditions have been considered void, and, therefore, the income produced by the option B is equal to the amount of the rights of withdrawal (see table V). For each phase of option B, that is the sunflower cultivation, the technical-economic aspects of great interest for the study's scope have been considered. In particular, the sunflower cultivation has been proposed because it fits with the regional "agricultural environment", and because it allows one to get the greatest yield in oil for biodiesel production. Within the Probio study the production techniques and the economics aspects of the production have already been analyzed (table VI), therefore some of the data proposed in such study as starting point for the following elaborations has been used.

Table V: Calculation of the set-aside payment

LOMBARDIA	Cereals average yield	Set aside payment (€/ha)
Milano pianura	7,05	444,09
Bergamo pianura	7,03	442,64
Brescia pianura	7,80	491,21
Pavia pianura	7,75	488,50
Cremona pianura	8,25	519,81
Mantova pianura	6,76	425,88
Lodi pianura	7,05	444,09
Media Pianura	7,19	465,17

Table VI: Summary of the crop managment

Cultural operations
Plowing
Manuring 1
Manuring 2
Pre-seeding refinement
Seeding
Hydraulic managment
Harvesting

The different complexity, that characterizes the sunflower-biofuel chain, gives the opportunity to the farmer to express different incisive entrepreneurship, concerning the energy product obtained. In fact, the farmer can stay at the sector's border line, sticking with chain contracts and producing raw materials (the seeds) for industrial transformation. Or the farmer, doing a first transformation in the agricultural context, can produce both raw oil and "fat panel" for livestock feed. Finally, pushing a business's capability from purely agricultural into the agro-energy sector, the farmer can proceed to the oil's transformation into electric energy.

In this case, we will consider the simplest possibility, that is that the farmer produces only the seeds to start the following industrial process. For the Raj calculation the sale price of the sunflower seeds is considered equal to 180 € /t, while the cultivation costs have been imputed equal to 263,1 € /ha. The yields, in terms of seed tons per hectare, have been drawn from the Regionalization Plan since it reflects the average situation of the areas being examined. The adjustment costs Caj has been considered equal to zero because the passage from one option to the other doesn't need any particular investment. In fact, the cultivation (chart 4.2.2) can be performed with machines that are usually owned by every farmer. In regards to the transition costs Ctj it must be underlined that the assessment of such value can be very important, if not conclusive, because the farmer has to choose between the sunflower cultivation (to which a certain level of risk is connected) or the simple and risk-free set-aside (to which a government payment corresponds). Such parameters have been set and divided into two variables: Ct1which takes into consideration the possibility of a negative event that would be able to bring down the crop (estimated on the basis of the assured prices) and Ct2 which holds, instead, some risk of enterprise (valued on the basis of the farmer's profit). Finally, a non-incentive

Table VII: Sj calculation in the Lombardia case study

LOMBARDIA	Cerals average yield	Oleaginous average yield	Ra set-aside	Seed income	Cultivation costs	Rb sunflower	ΔRj	Ct1	Ct2	Sj
Milano pianura	7,05	4,66	444,09	839,16	263,10	576,06	131,97	28,80	33,57	69,60
Bergamo	7,03	5,00	442,64	900,00	263,10	636,90	194,26	31,85	36,00	126,4
Brescia pianura	7,80	5,00	491,21	900,00	263,10	636,90	145,69	31,85	36,00	77,84
Pavia pianura	7,75	4,19	488,50	754,92	263,10	491,82	3,32	24,59	30,20	-51,47
Cremona	8,25	4,74	519,81	852,66	263,10	589,56	69,75	29,48	34,11	6,16
Mantova	6,76	5,00	425,88	900,00	263,10	636,90	211,02	31,85	36,00	143,1
Lodi pianura	7,05	4,66	444,09	839,16	263,10	576,06	131,97	28,80	33,57	69,60
Media Pianura	7,19	4,78	465,17	855,13	263,10	592,03	126,85	29,60	34,21	63,05

situation was considered, and therefore the entity of the incentives I considered was equal to zero. The result of the elaboration is shown in chart 4.2.3, where it is possible to observe that some homogeneous areas show negative values of Sj (Pavia) or close to zero (Cremona). It therefore shows that the option of sunflower cultivation on land that could be destined instead to the set-aside is not convenient. In these two zones it is expected that the supply of such products, without government aid, won't find great success. In the other three homogeneous areas (Milan, Lodi and Brescia) the results show, instead, an intermediary situation in which Sj does not reach such elevated values as those of the last two homogeneous zones (Bergamo and Mantova).

5 CONCLUSIONS

The introduction of competitive mechanisms in the energy sector and the sources of provision differentiation is a non-elusive requisite for new technology development and innovation. But from the analysis results it is obvious that the support to the Renewable Energy Sources of agricultural origin is essential for concluding a "maturation" process that can lead to great social, economic and environmental benefits. In fact, it can be observed that although some economic sustainability exists for some "energy crops", this potential supply is not translated into a real supply. Only a coordinated and joined support policy can allow the formation of a suitable "building capacity" in those sectors that are traditionally "weak". So to avoid having the Renewable Energy industry “suffer”, the new technologies, without managing to create a self-production ability and know-how, are able to compete with the international productions. The evaluations coming from the results represent a possibility to think about the definition of incentive policies for the biomass production and their use as energy sources. The present work suggests that the potential biomass supply for energy purposes must be studied following the desired spatial distribution of profits (spatial distribution of the economic convenience). With the proposed model it is possible to study in which areas one or another option is preferable, managing to define the territorial course of the criterion that drives the farmer’s choices. If we thought about a redistribution of the agricultural assistance, beginning in 2013, the use of such methodologies will become more necessary.

The suggested method, even if founded on some approximations, appears to be useful for facing a preliminary study to define possible scenarios for more accurate local policy strategies. With the availability of data for the analysis, it can also be possible to study incentives at local level. Acting on the I variable (or the government aid level) the policy makers can see the results in terms of non-food crops’ potential supply for energy purposes. In particular, the public support for biofuel demands creation (which encourages farmers) could be the key element to giving value to the potential supply [8] where there is an economic sustainability. It seems that the proposed study can constitute an aid for the answer to a question that is often asked: is the tie to the energy biomass development an economic problem, or is it to impute the scepticism and the lack of entrepreneurship in the sector? [8]. As pointed out by the spatial distribution of the economic return variable, there exist some areas where the biofuels production could effectively be stimulated without intervening with direct help to farmers, but by simply sustaining the demand. This is easily attainable also thanks to the control that the public very often practices in the sector of the public transport, managed by the municipal firms.

The present study is distinguished, finally, thanks to the possibility of appraising the Sj spatial distribution as a first step toward the definition of possible "agroenergy districts." In fact, a territory is able "to express" a rural district if some conditions are verified, such as enough entrepreneurial density in the sector of examination, coherent institutional actions, and a suitable "know-how". The model could represent a preliminary analysis aimed at verifying the above-mentioned economic prerogatives (income of the crops devoted to energetic purposes). It can be subsequently possible, at the regional scale, to verify the other information necessary to plan the strategic orientations for the development of an agro-energy chain.

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