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Assessment of Italian energy policy through the study of a photovoltaic investment on greenhouse

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The production of energy from renewable sources is a form of energy production that has less impact on the environment than the traditional one. For the farmer this new form of production represents an opportunity, especially for the economic benefits that can produce, both in terms of the incentives provided by the public operator and for higher revenues, deriving from the energy sale and/or the saving generated by self-consumed energy, that help to integrate the farmer's income. In this paper, we analyzed a case study of a farm that has realized a grid-connected photovoltaic (PV) system on greenhouse. In particular, firstly the farm profitability and subsequently was estimated in order to assess the efficiency of the energy policy adopted by the Second Conto Energia in Italy; it the minimum feed-in tariff starting from which the entrepreneur has an economic advantage to realize the PV system was determined. Results show that PV system relegates to a marginal role, the cultivation of agricultural products compared to energy production and that government PV remuneration policies far outweigh the minimum threshold that makes advantageous the investment.

Key words: Feed-in tariff, profitability, breakeven point.

INTRODUCTION

In recent years, the legislator has paid particular attention to the multifunctional role of the farm. The legislator's goal is to increase the farm competitiveness through diversification of income opportunities. Among these we can mention the energy production from renewable sources, agritourism and other activities involved with farming. Nevertheless, it has not to forget that the farmer is required to produce agricultural products and thus the production of goods and services related to agriculture must be considered to supplement his income or reduce production costs (Santeramo et al., 2012; Tudisca et al., 2011; Nardone et al., 2009).

Renewable energy sources such as hydropower, biomass, geothermal, wind and solar represent a viable alternative to traditional fossil fuels both for the benefits in terms of reduced impact on the environment and for their ability to be renewable and not subject to depletion (Ciorba et al, 2004; Pearce, 2002).

The green energy, moreover, limiting the consumption of fossil fuels and reducing the release of greenhouse gases into the atmosphere, contributes to the achievement of targets set by the Kyoto Protocol, avoiding sanctions for signatory States in case of defaults (Karakosta et al., 2012).

In this context a key role is played by agriculture that, through its activities and peculiarities, lends itself to the

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Table 1. Evolution of Italian PV systems (GSE, 2013).

Regions	Installed capacity (kW)						Plants	
	1st CE	2nd CE.	3th CE	4th CE	5th CE	Total	Num.	Average size (kW)
Apulia	26,331	1,273,878	182,640	909,155	34,215	2,426,219	33,039	73
Lombardy	7,753	757,342	151,593	841,364	30,194	1,788,246	67,394	27
Emilia R.	14,055	678,493	151,951	707,325	29,803	1,581,627	44,219	36
Veneto	7,168	690,346	105,001	631,458	29,717	1,463,690	63,997	23
Piedmont	6,394	603,242	124,336	595,611	28,558	1,358,141	33,596	40
Sicily	9,682	375,005	117,059	535,119	62,004	1,098,869	31,341	35
Lazio	7,696	410,864	155,777	440,743	33,907	1,048,987	26,252	40
Marche	9,713	423,848	123,048	396,533	15,601	968,743	16,918	57
Tuscany	8,028	247,459	72,946	283,218	17,340	628,991	24,399	26
Abruzzo	3,960	201,284	57,557	315,974	14,923	593,698	11,708	51
Sardinia	6,722	176,745	61,483	288,170	14,741	547,861	21,920	25
Campania	7,778	164,794	62,260	280,250	17,773	532,855	16,062	33
Umbria	5,722	165,028	51,547	183,879	3,913	410,089	11,258	36
Friuli V. G.	2,209	167,958	39,013	175,521	11,918	396,619	22,193	18
Trentino A. A.	11,108	202,591	32,113	116,893	1,728	364,433	18,155	20
Calabria	10,738	104,881	26,773	199,441	20,156	361,989	14,091	26
Basilicata	16,955	83,821	24,490	166,651	36,727	328,644	5,483	60
Molise	540	40,645	16,862	91,112	1,322	150,481	2,528	60
Liguria	833	32,746	4,815	33,107	1,184	72,685	4,298	17
Aosta valley	46	6,767	1,927	8,322	605	17,667	1,509	12
Italy	163,431	6,807,737	1,563,191	7,199,846	406,329	16,140,534	470,360	34

achievement of these objectives in environmental, economic and social terms (Chel and Kaushik, 2011).

The expansion of the energy sector related to renewable sources is due mainly to the development of PV sector, thanks to the advantageous remuneration policies available in various countries (Sarasa-Maestro et al., 2013; Badcock and Lenzen, 2010). This has attracted the interests of many small investors and especially of large financial groups that have decided to invest in solar energy (Szabó et al., 2010), assuming a capital role in European energy policies (Bürer and Wüstenhagen, 2009).

Over the last years in Italy it has been registered an exponential growth of PV industry, involving also the primary sector through the realization of PV systems on ground or buildings. In this way Italy has became the second country in Europe for cumulative installed capacity behind Germany, and the first relatively to 2011 (EurObserv'ER, 2013), creating also from 2002 to 2010 more than 100,000 jobs, of which about 20,000 direct employees with an average age under 35 years (ANIE-GIFI, 2011).

According to data provided by Gestore dei Servizi Energetici (GSE, 2013) in Italy, starting from the First Conto Energia (CE), despite the continuous reduction applied to PV incentives, there has been a continuous development of the PV industry, realizing 470,360 PV systems, which correspond to an installed capacity of 16,140,534 kW (Table 1). The First CE has been characterized by a capacity of 163,448 kW. This value is not so much due to lack of knowledge among investors of high return on investment, but rather to the fact that the incentives were granted only to PV systems that produced electricity for self-consumption only.

The PV sector, in fact, has had a full achievement with the Second CE, through which it has been installed a total capacity equal to 6,807,737 kW. The Third CE has been characterized by an installed capacity of 1,538,505 kW, while the Fourth CE has reached 7,199,846 kW. The decrease in the Third CE is essentially attributable to its short implementation period, which has allowed the installation of an exiguous number of PV plants. The Fifth CE, finally, having entered into force by few months, denotes an installed capacity of just 406,329 kW.

Sicily is the sixth region for installed capacity and in recent years, has increased its incidence at the national level in terms of installed capacity per feed-in scheme, passing from 5.9% of First CE to 15.3% of Fifth CE. These data can be correlated to favorable climatic conditions of the Island that, facilitating the production of energy from PV systems, permit to mitigate the lower revenues due to the gradual reduction of the FiT granted for the amount of generated electricity.

In Sicily 60% of installed capacity is attributable to PV plants installed on ground, followed by installations on buildings (24%). The PV systems installed on greenhouses and/or roofs/covers constitute 12% of the Sicilian capacity, generating an electricity production second only to that found in Sardinia (GSE, 2012).

The placement of PV modules on greenhouse avoids the heavy debate on the destination of land use because, unlike the ground systems, it does not subtract area for the cultivation of agricultural products for very long periods (at least twenty years) and it does not compromise the soil fertility (Vieri, 2012). In this case, in fact, the PV panels installed on greenhouse can represent a solution to the problem, encouraging the development of solar panels more transparent and selecting suitable PV plants for this particular production system, characterized by a poorly bright environment (Poncet et al., 2012). The large availability of surfaces guaranteed by greenhouses and farm buildings can be exploited by farmers respecting the environmental and landscape equilibrium of territory for the benefit of a new environmentally sustainable image of their agricultural activity (Mekhilef et al., 2013).

In order to better understand the causes of the PV systems diffusion in Italy, this paper initially has estimated the profitability of a farm located in Sicilian northwestern coast that produces electricity by PV panels installed during the Second CE. This paper differs from previous studies (Kadowaki et al., 2012; Ureña-Sánchez et al., 2012), because the greenhouse roof area is totally covered.

Subsequently, in order to assess if the PV incentive was reasonable compared to the goal of Second CE (to ensure a fair remuneration of the investment and management costs of PV systems), it has been determined the minimum feed-in tariff (FiT) starting from which the farmer has an economic advantage to realize the PV investment.

Photovoltaic remuneration policies in Italy

The widespread diffusion of PV systems within the Italian territory coincides with the approval of regulatory interventions aimed at incentivize the electricity produced by PV panels, better known as Conto Energia (CE), at its 5^{th} edited version today. The CE is a feed-in scheme aimed at the promotion of energy production from PV systems in accordance with Directives 2001/77/EC and 2009/28/EC. This feed-in scheme incentives the electricity produced in Italy by grid connected PV systems, with a nominal capacity greater than 1 kW.

The PV incentive depends on the size of the PV system, technology, PV type and other factors (origin of the materials used for its construction, replacement of roofs/covers from which Eternit or asbestos has been completely removed, etc.). Eligible for the CE are individuals, organizations, public institutions, non-commercial entities, owners of single or multiple housing units. CE, which grants a feed-in tariff (FiT) for energy produced by PV systems over a period of 20 years, has became operational with the entry into force of the Ministerial Decrees of 28 July 2005 and 6 February 2006 (First CE), that have introduced the revenue grants for electricity production, replacing the previous government financing system based on non-refundable grants allocated to PV system.

With the Second CE (D.M. 19/02/2007), the Italian Ministry of Economic Development has set new standards to incentivize electricity production by PV systems commissioned within 31 December 2010. Among the main changes introduced by the Second CE there are the application of the FiT on all produced energy and not merely on that self-consumed, the simplification of bureaucratic practices to obtain public grants and the tariff differentiation based on the type of architectural integration, as well as the PV system size.

In 2010 it has entered into force the Third CE (D.M. 06/08/2010), applicable to PV systems commissioned between 1 January 2011 and 31 May 2011, that has defined the following system categories: (a) PV plants (divided into “PV systems on buildings” or “other PV systems”); (b) integrated PV plants with innovative features; (c) concentrating PV plants; (d) PV plants with technological innovation.

Law no. 129 of 13/08/2010 has ruled that tariffs provided for Second CE could be granted to all investors that have completed the installation of PV systems by 31 December 2010 and came into operation within 30 June 2011. The publication of Law 129/2010 has effectively extended until 30 June 2011 the Second CE, originally intended to run out at the end of 2010 for the entry into force of the Third CE.

The Fourth CE (D.M. 05/05/2011) has been published on 12/05/2011. It set out the mechanism of incentives for the electricity production from PV systems commissioned between 1 June 2011 and 31 December 2016.

All these four regulatory interventions include feed-in tariff as type of remuneration policy to encourage PV installations. This kind of tariff provides a fixed-price contract per kWh of generated energy for a twenty years period, to which it has to be added the revenue from the electricity fed into the grid, subjected to price fluctuations. In alternative the electricity fed into the grid can be economically offset with the value of electricity withdrawn from the grid service (net metering).

The major benefit of FiT is that private independent producers receive a long-term minimum guaranteed price for the electricity they generate. This kind of incentive tariff is common in many EU countries (Germany, Austria, Czech Republic, Spain, France, Netherlands, Portugal and Switzerland) and according to some studies (Couture and Gagnon, 2010; Del Río, 2008; Lesser and Su, 2008) appears to be the most effective method to increase the diffusion of the energy generation systems, as it ensures a long-term investment with a low risk for investors, regardless any future price fluctuations in the energy

Figure 1. PV greenhouses of the case study.

market.

Over the years, with the succession of feed-in schemes, there has been a sudden expansion of the PV industry that has led to a reduction of price for the PV systems, decreased of 50% in Europe during the last five years (EPIA, 2011), and to an increase of the objectives set by the legislator. In fact, despite the public authority only a short time ago had set a target of 8 GW at national level by the end of 2020, the legislator raised the ceiling to 23 GW of installed capacity from PV panels to be achieved by 2016 (MSE, 2010).

For these reasons the legislator has tried to find a solution to balance the level of public support with the costs of technologies, giving stability and certainty to the market. To this end tariffs have been reduced in a few years with a succession of different regulatory interventions, reflecting an inadequate forecast of PV industry development and potential. Despite the uncertainty of the public action, in contrast to the findings of some studies (Lüthi, 2010), the development of PV industry in Italy has not experienced significant breaks.

The last feed-in scheme adopted by Italian government has been the Fifth CE; it entered into force after that the annual indicative cumulative cost of incentives has reached 6 billion euro. Incentive tariffs of this feed-in scheme are granted to PV plants (divided by type of installation), building integrated PV plants with innovative features and concentrating PV plants.

Unlike the previous support schemes, the Fifth CE (D.M. 07/05/2012) grants an all-inclusive FiT to the share of net electricity injected into the grid and a premium tariff to the share of net electricity consumed on site. The Fifth CE will cease to have effect 30 days after reaching indicative cumulative costs of incentives of 6.7 billion euro per year. According to some estimates, the industry expects that it will be reached in May 2013 and as a result the Fifth CE will end in June 2013 (Aniketos, 2013).

Case study

The analyzed case study concerns a small farm (equal to 1.50 ha) managed directly by the farmer and his family, located in the Sicilian northwestern coast, that has realized in 2010 a PV system on greenhouses during the Second CE. In this area, the average annual radiation is favorable for the installation of PV systems grid-connected.

The investment has involved the construction of six lean-to greenhouses that occupy one third of farm surface (0.50 ha). The remaining part of the surface (1.00 ha) is destined to a crop rotation between tomato (spring-summer species) and cauliflower (autumn-winter species).

The species cultivated in greenhouses is the white asparagus[1], which is well adapted to poorly light conditions due to the solar panels. The greenhouses have a length of 50 m and a width of 8 m; the lean-to greenhouses have optimum slope and azimuth (Figure 1). Since at the time of the investment realization there was no restriction on the cover of greenhouses with solar

[1] The economic life of asparagus in greenhouse is equal to ten years; the planting phase is two years.

panels[2], each slope has been completely covered by solar panels and it generates a capacity of 50 kW (about 8 m²/kW). Overall, therefore, the installed capacity on the six greenhouses is equal to 300 kW.

For the realization of the PV system have been used multicrystalline silicon panels, a less expensive material than the monocrystalline one, because of the simpler manufacturing process required, even if slightly less efficient (Kalogirou, 2009).

The investment has required a total expenditure of € 1,170,000, of which € 120,000 come from the entrepreneur's funds and € 1,050,000 financed through a bank loan for a depreciation period of twenty years at the annual interest rate of 3.65%. The entrepreneur's capital has been used for the construction of six greenhouses, while the bank loan has financed the purchase and the installation of PV panels, equal to 3,500 €/kW.

For the purpose of energy production, an electricity production of 1,500 kWh kW^{-1} $year^{-1}$ had been considered (ENEA, 2006); the annual PV electricity yield generated by the system is assumed to decrease every year by 0.8% (Danchev et al., 2010; Lasnier and Ang, 1990). In this way the analyzed PV system, during the twenty years, generates an annual average electricity production of 417,387.19 kWh.

METHODOLOGY

For the purposes to assess the profitability of the detected case study, the farm profit, had been determined through the economic balance of the farm (Prestamburgo and Saccomandi, 1995; Guerrieri et al., 1995; Iacoponi and Romiti, 1994). Since the case study concerned a farm that, despite the installation of solar panels, continues to produce agricultural products and that the energy produced is accounted as an activity related to agriculture, unlike other studies (Daniele, 2011; Canali, 2009; Daniele et al., 2008), for the profit determination we have considered costs and revenues deriving from both the PV system and agricultural activity, analyzing the farm as a whole. Revenues related to the agricultural activity have been calculated by multiplying the production of the three crops cultivated in the farm for their sale prices referred to 2011/2012 crop year.

For the calculation of the electricity production revenues, the average annual energy production of the plant during the incentive period was considered (twenty years), considering a FiT equal to 0.422 €/kWh and an average sale price of electricity generated amounting to 0.10 €/kWh.

The farm costs have been divided into: Materials and services coming from outside the farm regarding to productive factors which have a rapid financial replenishment cycle, quotas of reinstatement, maintenance and insurance of durable capital, depreciation quota related to the bank loan, taxes, remuneration of human labor, compensation for intellectual work, interests on advanced capital by farmer during the crop year, on durable capital and land value.

In the economic evaluation process for the determination of reinstatement quotas, a period equal to twenty years, coinciding with the time frame during which the PV incentives are granted was considered. The annual insurance and maintenance costs of PV panels amounted to 1% of their total investment cost.

After calculating the farm profit, the aforementioned rapid diffusion of PV systems in Italy that exceeded the legislator's expectations was considered, for determining the minimum price of FiT starting from which the entrepreneur has a convenience to realize the investment.

To this purpose the breakeven point was calculated, that is the point where revenues are equal to costs (Laspidou and Charisiou-Kalliantopoulos, 2012; Pulkrábek et al., 2012).

The breakeven point has been determined through the following formula:

$$V_a + V_e = K \quad (1)$$

where: V_a = agricultural production value; V_e = electricity production value; K = total costs. The electricity production value is given by sum of value of energy sold to the grid and the revenues deriving from the incentive tariff:

$$V_e = KWh \cdot p_e + KWh \cdot FiT \quad (2)$$

where: KWh = average annual electricity generated by the PV system; p_e = electricity sale price;
FiT = feed-in tariff.

According to Equation (1), this means:

$$V_a + KWh \cdot p_e + KWh \cdot FiT = K \quad (3)$$

According to Equation (3), the minimum feed-in tariff can be calculated using the following expression:

$$FiT = \frac{K - V_a - KWh \cdot p_e}{KWh} \quad (4)$$

In the Equation (4), the factors in the second member are constant except the costs. These, in fact, decrease at the progressive reduction of the incentive tariff that affects on taxes and interests on the advanced capital by farmer during the crop year.

RESULTS AND DISCUSSION

The economic analysis of the case study showed a farm profit amounted to € 112,709.74 (Table 2). As regards farm revenues it has been registered a value equal to € 236,050.11. This value is composed for the most part of electricity production revenues deriving from PV panels, which represented 92.3% of farm revenues, registering a marginal incidence of agricultural activity (7.7% of total revenues). Among electricity production revenues, the main item is represented by PV incentives with a value of € 176,137.39, constituting 74.6% of total revenues, while electricity sale amounted just for 17.7%. Data showed that the farm profitability, after the PV investment, is closely linked to public incentives granted by feed-in scheme.

Farm costs amounted to € 123,340.37 and the main item is represented by quotas that with a value of € 94,486.49 constituted 76.6% of total costs. This value is essentially due to the depreciation quota (60.7% of total cost) aimed to pay off the bank loan necessary for the purchase and installation of PV panels, despite the investor

[2] It should be noted that currently, with the Fifth Conto Energia, PV panels can be installed only on 30% of the total area of greenhouse coverage, upon reduction of the tariff granted.

Table 2. Economic results of case study[a].

Items	Euro/year	%
Revenues (A)	**236,050.11**	**100.0**
Agricultural production	18,174.00	7.7
Electricity sale	41,738.72	17.7
PV incentives	176,137.39	74.6
Costs (B)	**123,340.37**	**100.0**
Materials and services	8,100.80	6.6
Quotas	94,486.49	76.6
Taxes	8,068.68	6.5
Human labor	8,501.20	6.9
Intellectual work	726.96	0.6
Interests	3,456.23	2.8
Profit (A-B)	**112,709.74**	

[a]Our processing of directly collected data.

Table 3. Economic results according to TiF (euro)[a].

TiF	Costs	Revenues
0.125	121,676.94	112,086.12
0.130	121,704.94	114,173.05
0.135	121,732.94	116,259.99
0.140	121,760.95	118,346.92
0.145	121,788.95	120,433.86
0.148	**121,807.38**	**121,807.38**
0.150	121,816.96	122,520.80
0.155	121,844.96	124,607.73
0.160	121,872.96	126,694.67
0.165	121,900.97	128,781.60
0.170	121,928.97	130,868.54

[a] Our processing of directly collected data.

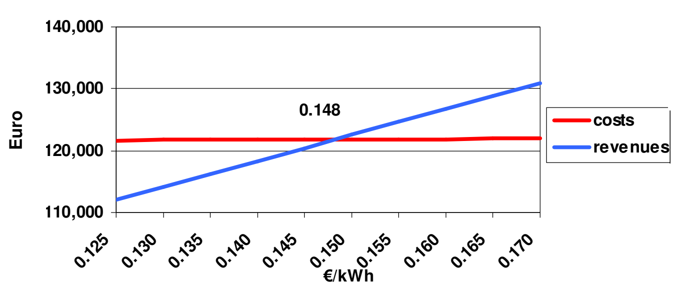

Figure 2. Breakeven point determination.

has obtained a low interest rate.

Among costs, the second item in relative terms is given by the remuneration of human labor, which accounted for 6.9% of total costs, followed by costs related to materials and services coming from outside the farm (6.6%); both items are correlated exclusively to the management of farm crops. Taxes represented 6.5% of the total cost and are due mainly to the farm energy production. Interests and intellectual work, finally, overall accounted just for 3.4% of farm total costs. As the economic analysis showed that the farm profit is due largely to the PV incentives, as mentioned previously, it has been determined the minimum FiT starting from which the farmer obtains a positive profit from the investment realization.

Data in Table 3 showed that in the case of Second CE the breakeven point between costs and revenues is obtained for a price of the FiT equal to 0.148 €/kWh.

If the FiT corresponds to this value, farm costs and revenues are equal to a value of € 121,807.38, obtaining a null profit and setting the intersection between revenues straight line and costs one (Figure 2).From results appears evident that value of farm costs does not denote substantial changes at varying of FiT. This is due to fact that incentive tariff affects only the taxes and interests on the advanced capital, but not the other cost items. Ultimately, under the minimum FiT determined, the farmer would not have advantage to realize the investment, while with higher values he would obtain a positive profit.

This highlights the high profitability of the PV system, which is granted by an FiT substantially higher, equal to 0.422 €/kWh. Therefore, the analyzed case study has showed that the FiT goes far beyond the targets of feed-in scheme, denoting an inefficiency of public spending for PV energy policy.

Conclusions

The Italian PV development over the last years has not had significant interruptions after the entry into force of the Second CE.This sudden and unexpected growth is mainly attributable both to the reduction of the PV installation costs and the high government incentives granted to entrepreneurs that, despite the financial crisis, have identified in PV industry a sector with a low risk and high profitability. This trend has also affected the agricultural sector, from which it derives 13% of installed capacity of Italian PV plants. In this context, the aim of the paper has been to assess the profitability of a Sicilian farm that, during the Second CE, has installed PV panels on greenhouses. The high farm profitability, observed in the case study, is attributable to substantial revenues deriving from the electricity sale and especially from the FiT. These revenues represent the majority of farm revenues, relegating to a marginal role the agricultural activity. The economic convenience of PV investment analyzed is evident if it considers that the minimum FiT starting from which the farmer obtains a positive profit (equal to 0.148 €/kWh) is far less than one granted by the Italian government (0.422 €/kWh).

Considering the goals of the CE, according to which the FiT had to ensure a fair remuneration for investment and operational costs, the results of this study show an inefficiency of public spending for PV energy policy. In particular, it has been noted that the PV investment was characterized by high government incentives that go far beyond the targets of feed-in scheme.

The high values of these incentive tariffs, in fact, have inducted the legislator to their continuous reshaping, with a succession within a few years of various feed-in schemes, reflecting a poor forecast of the evolution and potential related to PV sector. Moreover, Italian Government has not expected a reduction of PV panels price so much fast and continuous, causing financial speculations and paying at great cost the growth of PV sector.

However, if on the one hand the PV energy policy has involved an inadequate public spending, as the same targets could be achieved with a lower use of public funds, on the other hand it must be highlighted that it has reached and exceeded in a short time the legislator's objectives in terms of installed capacity, creating also new job opportunities.

Ultimately it is hoped that future policies in terms of energy from renewable sources will favor the self-consumption, creating in the territory a network of small energy producers. This auspice should be taking into account if we consider that the price of PV technologies is expected to decrease while the energy price is expected to increase in the future. In this way the installation of PV systems should represent an activity aimed at supplement the farmers' income reducing costs related to energy supply, especially for greenhouse specialized crops that entail high energy costs, and avoiding to cause a radical transformation of the business core from agricultural to energetic one.

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ABBREVIATIONS:

PV, Photovoltaic; **CE,** Conto Energia; **FiT,** feed-in tariff.

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