THE DEVELOPMENT OF PHOTOVOLTAIC SYSTEMS IN ITALY: THE FEED-IN TARIFF

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Abstract

Solar energy, in particular the photovoltaic technology, for the production of energy, is undergoing a noticeable diffusion at international level, thanks to incentive policies of governments that recognise its obvious advantages and appreciate the aid that this technology can provide to reduce greenhouse gases in the atmosphere and the dependence from fossil fuels.

This paper evaluates the potential for the development of the photovoltaic technology that, unfortunately, is still one of the most expensive renewable energies. For this reason, it is extremely important to consider its economic and financial aspects.

The analysis focuses on the Italian market, where great expectations have been generated by the approval of the decree that introduces a new type of incentive called feed-in tariff ("Conto energia"). A specific software has been implemented that evaluates the economic benefits obtained when this incentive is used for different types of investments in photovoltaic facilities The results show the effective superiority of such incentive compared to others that have been used in the past.

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Riassunto

L'energia solare, in particolare la tecnologia fotovoltaica, per la produzione di energia, sta vivendo una notevole diffusione a livello mondiale, grazie soprattutto a politiche di incentivazione dei governi. che, ne riconoscono i vantaggi indiscutibili e vedono in essa un utile alleato per diminuire le immissioni di gas serra nell'atmosfera e la dipendenza dai combustibili fossili.

Questo lavoro valuta le potenzialità di sviluppo della tecnologia fotovoltaica purtroppo ancora una delle più costose fra le energie rinnovabili, per cui è importante considerarne gli aspetti economici e finanziari.

Si analizza con particolare approfondimento il mercato italiano, in fermento per le grandi aspettative generate dall'approvazione del decreto che introduce una nuova forma di incentivazione detta in "conto energia". Per valutare questo decreto si è ricorso alla creazione di un software specifico, che permette la valutazione economica di alcune tipologie di investimento in impianti fotovoltaici, nel caso in cui si ricorra a questa forma di incentivazione. I risultati ottenuti confermano l'effettiva superiorità di questo modello di incentivazione rispetto alle altre forme utilizzate nel passato.

Keywords: Renewable energies, photovoltaic technology, incentives, feed-in tariff

Introduction

The alarming escalation of oil prices, the continuous increase for the demand of electrical energy and the growing dependency from other Countries for energy supply have intensified the development of strategies to overcome these issues. Although the energy sector is a vital one, it has always been amongst the most polluting but nowadays, it has become evident that renewable energy sources can provide new basis for the energy sector, and at the same time assure a sound sustainable development. Unfortunately, the cultural approach that would allow the public opinion and managers to realize the advantages of renewable energies is still scarce (1).

The photovoltaic (PV) technology allows the direct transformation of the energy associated with solar energy into electrical energy. It takes advantage of the so-called photovoltaic effect based on the properties of some semiconductors, which after being appropriately treated and doped at the inter-phase, can generate electricity when exposed to solar radiation without the use of any fuel.

The basic component of the system is the photovoltaic cell; the PV modules (commonly called PV panels) consist of 36 or more cells connected in series, on a strong and flexible structure that guarantees several years of operation even under extreme external conditions. PV modules connected either in parallel or series may be arranged in arrays, which in turn, connected in parallel make up the photovoltaic generator that delivers the desired power. Transfer of energy from a PV power station to the final users takes place by means of others devices, necessary to convert the direct current generated into alternating current. The assembly of all these devices is called BOS (Balance of System) whose yield is generally about 85% of the installed power.

The most popular solar electric panels commercially available today are made from silicon and are divided into three main categories, based on how they are manufactured:
single-crystal silicon, multi-crystal silicon and amorphous silicon.

A newer technology that has arisen from the computer industry is thin-film PVs, which can be of two different types: amorphous silicon and copper indium gallium diselenide (CIGS). The PV community forecasts that the single-crystal silicon technology will maintain its key role at least up to 2010 (2).

In Italy, the first evidence of interest, from single scientists, towards PV technology can be traced back to the 60s but is only after the oil crisis of 1973 that this interest became a reality through wide range PV development programs, some of which became part of the "Focused Energy Plan"[1] promoted by the Italian National research Council.
Unfortunately, during the 80s and 90s growth in the sector was less than expected while research and production of PV modules showed an irregular scenario. The commitments within the framework of the Kyoto Protocol and the sudden increase in price of crude oil have seen the emergence of an active debate on renewable energies.

Applications and potential of PV technology

Since PV systems are modular they are extremely flexible, allowing their utilisation in numerous applications: there is no limit for the power of facilities, except for the area being used for their installation.

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[1] Piano Finalizzato Energetico

They can be classified in two main categories, i.e. stand-alone and grid-connected, which can in turn be separated into:

- *Photovoltaic power plants*: they are typically formed by hundreds or thousands of large PV modules connected in series/parallel, installed on the ground and supported by concrete and steel structures. In 2006, the largest PV power plant in the world has been completed in Germany (Erlasee -Arnstein) with an installed power of 12 MW.
- *Systems integrated into the building design*: PV arrays are increasingly incorporated into new domestic and industrial buildings as a main or as subsidiary source of electrical power.

PV technology is ideal for electricity production on a small scale (micro-generation) thus reducing losses that derive from energy transport over long distances (usually around 7% of the total energy transferred). It shows a great versatility and is suitable for many different applications showing a series of advantages. The most important are: the quality of the energy produced, its modularity, the avoided emissions, its reliability and life time, the potential of electricity supply for isolated households. During 50 years of research the PV cells technology and the silicon microelectronic technology have been intertwined, exchanging knowledge that has benefited both of them. Currently the World Bank and several international organisations consider that PV cells will play an important role for the supply of electrical energy to developing Countries (3).

The operating disadvantages are related to the intermittence of electricity produced that is due to the alternating cycle of day and night, to the variation in solar intensity with the seasons and to meteorological hazards.

It can be asserted that the PV technology has matured since prices of PV modules have decreased by 20% while attaining a twofold increase of generated electrical energy.

Unlike fossil fuel based technologies, solar power does not lead to any harmful emissions during operation, but the production and disposal of the panels may entail some minor amount of pollution. Comparing electricity production deriving only from fossil fuels with that produced from solar radiation, the result is an abatement of greenhouse gases equal to 0.8 - 0.9 kg of CO_2 for each kWh generated (4).

Photovoltaic market trends and incentives

The worldwide installed PV power has reached 5000 MWp in

2005 of which 1400 MWp PV cells produced during the year 2005 (+15% with respect to 2004). The scenario envisaged by EPIA/Greenpeace foreseees for 2025 an approximate electricity production of 589 TWh. This implies that in the next 20 years there could be sufficient electricity produced from solar energy to satisfy 20% of the world requirements. In recent years the market for PV cells and modules displays an average annual growth rate of more than 35%. The development of the PV industry has been so remarkable that has produced profits of approximately five billion Euros only in the European market. This striking development is the result of two important developments: the expansion of the German market that for the first time has surpassed the Japanese, and the new industrial policy for the PV sector of the Chinese republic.

The international annual trade of PV modules will increase from 1.4 GWp in 2005 to more than 55 GWp by 2025. This represents a 40-fold growth that will entail a noticeable rise of profits for producers and, at the same time a cost reduction for users.

To maintain such growth it is necessary a continuous development and implementation of new technologies. The experience of the past has shown that it is essential to have a firm collaboration between the industrial and the public sector in order to achieve a larger penetration of electricity from PV modules within the energy mix at all levels: national, regional and international (5).

Figure 1 shows the international percentage market shares for the PV sector in different areas.

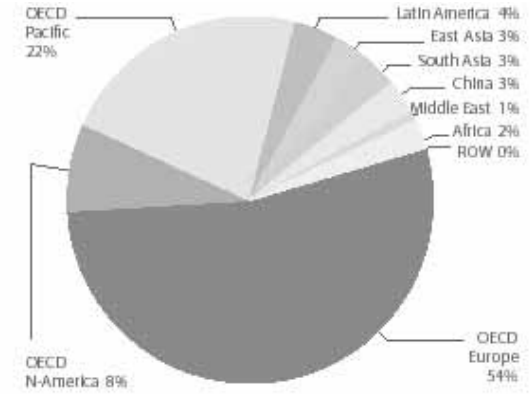

Fig. 1 - International percentage market shares for the PV sector

Source: Generazione Eolica e Solare, Elettricità rinnovabile e posti di lavoro: prospettive globali e italiane, Greenpeace, Ises Italia, 2006

The EU countries are adopting measures to reach the objectives that have been set by the White Paper on Renewable energies (6). In 2005 the PV installed power, in the EU, has been more than 645 MWp, which is equal to a growth rate of 18% with respect to 2004. For the first time the capacity limits for the industrial production of PV modules has been reached; in fact the current demand has not been satisfied for the reason that exists a permanent shortage of silicon (7).

In the EU as a whole, by January 2005 there were more than 1,793 MWp of photovoltaic modules installed, value that corresponds to the electric demand of 600,000 households with an average consumption of 3,000 kWh/year (8).

In 2004, the German government introduced the first large scale feed-in tariff system, under a law known as the EEG[2], which resulted in explosive growth of PV installations not only in Germany but also all over the world. The significant changes generated by this system have favoured a positive scenario for investment, which explains why the European quota of PV products has increased from 20% to 26%. To maintain this level the EU photovoltaic sector will have to continue its growth in the coming years but this will only be possible if policy measures that ensure the economic return of the investments are adopted (9). To fill the existing gap between renewable and non-renewable energy sources it is important to devise a system of incentives able to stimulate both the demand and the supply sides.

The PV Italian market

The first attempts of incentive mechanisms for photovoltaic structures have been the laws N° 9 and 10 of January 1991 that liberalised the on-site production of electrical energy whose excess production could be sold to the local electric utility (ENEL) at a fixed price. These laws were an example of investment subsidies whereby authorities refunded part of the cost (70-75%) of installation of the system. The subsidies could be provided in the form of capital or interest payment, tax credit, fiscal bonus or facilitated financing.

The "Roof-Top Programme", launched in 2001, represents one of the most significant measures of direct incentives in support of grid-connected photovoltaic in Italy. It consisted of investment subsidies conferred as capital account with no refund required and managed by the Italian

[2] Erneuerbare-Energien-Gesetz

Ministry of Environment and by the Regions. As a whole the Ministry and the local authorities provided a total budget of 135 milions Euros. Unfortunately, despite a very high public demand, the Programme experienced a rather slow growth due to enduring bureaucratic difficulties. As a consequence, by the end of 2005, only over 14 MW out of the anticipated 21 MW had been installed.

Nevertheless, the "Roof-Top Programme" provided some benefits: developed the interest for an little known technology, allowed a reduction of about 15-20% of the market price for PV modules, favoured the creation of new firms and of the gradual, although slow, development of new markets (10).

After years of a stagnating situation, the Italian market is now showing signs of a renewed vivacity thanks to the introduction of a new feed-in tariff ("Conto Energia").

✓ By the end of 2006 the total PV installed power was 60 MWp, which signifies an increase of 50% with respect to the power installed in 2005.

✓ The national global trade of the PV sector amounts to 35 millions of Euros, of which 60% is exported mainly to Germany.

The PV research and development activities are carried out by ENEA[3] and CESI[4] with the support, in some cases, of universities, industries and some National Research Council (CNR) institutes. The most important Italian manufacturer of PV modules is Enitecnologie, previously known as Eurosolare, with a production capacity of 3 MWp/year.

The feed-in tariff ("Conto energia")

The purpose of incentive policies for the photovoltaic sector should be to promote its development even if the cost of PV is still significantly above grid parity, allowing it to achieve the economies of scale necessary to reach grid parity. The result of these policies will be an increased national independence for energy supply, high-tech job creation and reduction of CO_2 emissions (11).

The Legislative Decree 387/03, later integrated by the Ministerial Decree of July 28th 2005 (12), implements the European Directive

[3] Ente per le Nuove Tecnologie, l'Energia e l'Ambiente

[4] Centro Elettrotecnico Sperimentale Italiano

2001/77/CE (13) for the promotion of energy from renewable energies. The Decree defines the PV feed-in tariff for facilities in the range between 1 and 1000 kW grid connected and installed after September 30th 2005. This new type of incentive has given high expectations for the PV market. In fact while the investment subsidy may be simpler to administer, the main argument in favour of feed-in tariffs is that it promotes energy quality.
Investment subsidies are paid out as a function of the nameplate capacity of the installed system and are independent of its actual power yield over time, so reward overstatement of power, and tolerate poor durability and maintenance.

Feed-in tariffs reward the number of kWh produced over a long period of time, allow to overcame the bureaucratic burden typical of Public bids and the discontinuity of investment subsidies, assure the financing and thus implementation of projects and guarantee the homogeneity of rules at national level. Furthermore, with feed-in tariffs the financial burden instead of falling upon the taxpayer as with investment subsidies, the extra cost is distributed across the utilities' customer base.

The Ministerial Decree of February 6th 2006 (14) did not change the principles of the incentive scheme and the tariffs value but introduced some new points. The most important are:

- The National goal of cumulated nominal power to install by 2015 increases from 300 to 1000 MW
- The total power allowed for incentive increases from 100 to 500 MW
- The incentive authorized for facilities of P<50 kW increases from 60 to 360 MW (60 MW/year)
- The incentive authorized for facilities of P>50 kW increases from 40 to 140 MW (25 MW/year)
- The application deposit for facilities of P>50 kW changes from 1,500 to 1,000 €/kW
- The deposit required from Public bodies for facilities of P>50 kW is revoked
- The annual decrease of the tariff for applications after 2006 changes from 2% to 5%
- The thin film modules, previously excluded, are now allowed (amorphous silicon)
- There will be an increase of 10% of the incentive tariff if the photovoltaic modules are integrated in newly built or renovated dwellings.

The Ministerial Decree of February 19th 2007 (15) is the latest improvement to the incentive scheme for PV facilities that substantially modifies the strategic approach of the previous decrees, introducing advantages that should stimulate the diffusion of the photovoltaic technology. This latest decree will be the basis for the discussion that follows.
First of all, the support system comprises two complementary elements:

- a feed-in tariff for the whole electricity produced by the PV plant (defined for twenty years and annually revised), which is controlled by a central Body (the "Soggetto Attuatore") nominated by the AEEG (the Electricity Authority).
- the value of the electricity produced by the PV plant, which, for VAT registered owners can either be used on the premises, on "Net metering" or sold to the local utility grid (at the current market price). For non registered owners only "Net metering" applies and the eventual excess of energy is not remunerated but credited for the following year.

The 2007 (16) and 2008 (17) National budgets no longer allow the IRPEF[5] reduction of 41% for private owners of facilities, as it was the case in previous years.

GSE[6] (previously GRTN[7]) acts as he Central Manager of the National transmission network whose functions are: the evaluation of the applications received and the disbursement of the feed-in tariff.

The Decree also establishes that incentives are determined by the nameplate power of PV facilities:

1) *Facilities in the range from 1 kW to 20 kW*: take advantage of the 20 years incentive that is equal to the energy produced multiplied by the feed-in tariff. In addition, the photovoltaic power employed on the consumers' premises and/or on "Net metering" will be deduced from the electricity bill. This deduction depends from the tariff defined in the supply contract (with an average value of 0.13-0.18 €/kWh).

Furthermore it will be possible to sell the excess energy produced to the local utility grid at a price defined by the Authority with the deliberation n.34 of 2005 and equal to 0.095 € for each kWh supplied (and up to 500,000 kWh/year)

2) *Facilities in the range over 20 kW*: take advantage of the same

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[5] Imposta sul reddito delle persone fisiche (Income tax)
[6] Il Gestore dei Servizi Elettrici
[7] Il Gestore della Rete di Trasmissione Nazionale

incentive as in the previous case but "Net metering" is not allowed. The deliberation n.34 of 2005 (18) by the Authority regulates the selling price of exceeding energy to the local grid with the following limits:

- ✓ From 0 to 500 MWh/year 95€/MWh.
- ✓ From 501 to 1,000 MWh/year 80€/MWh.
- ✓ From 1,001 to 2,000 MWh/year 70€/MWh.

The feed-in tariffs also change as a function of the degree of building integration for PV modules, classified as follows:

a) PV modules not-integrated in buildings - modules installed on the ground and modules that are not coplanar to the supporting surfaces.

b) PV modules partially integrated in buildings - modules that do not substitute the material of the supporting surfaces and are installed: on flat roofs and terraces of existing buildings, coplanar to the supporting surfaces or to elements of urban and route equipment.

c) Building-integrated PV modules - modules that are effectively: roofing shells, building façades, covering of shelters, pergolas and canopies, substitutes of transparent or semi-transparent surfaces, substitutes of noise absorbent barriers, etc.

The existing limit of 1000kW is abolished and the feed-in tariffs have decreased with respect to the previous Decrees. Their values are listed in Table 1.

TABLE 1

FEED-IN TARIFFS (IN EUROS) AS A FUNCTION OF ARCHITECTURAL INTEGRATION

Facilities	Not Integrated	Partially Integrated	Integrated
From 1 to 3 kW	0.40	0.44	0.49
From 3 to 20 kW	0.38	0.42	0.46
More than 20 kW	0.36	0.40	0.44

These tariffs are valid until the 31st December 2008 and will not be changed for 20 years, are not linked to the rate of inflation and will be reduced of 2% for every successive year following 2008.

From 2009, new decrees will be published every two years in order to update tariffs. Should the publication fail, the tariffs applied will be those valid in the year 2010 until a new Decree is published.
The new Decree has also introduced additional benefits to the feed-in tariffs for the following specific applications:

- A 5% premium if a large part of the electrical energy produced is used on the premises (more than 70%) for non-integrated facilities of more than 3 kW.
- For some Public buildings the premium is equal to 5% for facilities installed on schools, Public health centres, Public structures in towns with less than 5000 inhabitants.
- For integrated facilities installed on agricultural farms and in the case of eternit removal the premium also equals 5%.

Another advantage introduced by the new Decree is for the case of facilities that operate on "Net metering", which can benefit of bonuses when coupled with an efficient energy use. If the facility is already functioning, technical improvements should reduce the energy consumption of at least 10%. Then from the following year, the bonus (that cannot be greater than 30%) will be a percentage increase of the feed-in tariff equivalent to half of the energy saving attained.

Facilities that have either applied or obtained tax deductions for the recovery of historical heritage structures cannot profit of incentives and bonuses.

The available data on the trends and the results of the incentive system, periodically published by GSE, show that the development of the first three months for 2005 have been exceptional with a power of 87 MW for the 2872 applications accepted (78% of the 3668 applications received), with the following share: 47 applications for facilities with power greater than 50 kW and 2825 applications for facilities of power less than 50 kW. The GSE data, published at the end of August 2007, reports that 12,433 facilities have been accepted for the incentives, 7,550 have started the modules installation and 3,283 are already working.

According to the latest Decree of February 2007, it is envisaged to reach a maximum cumulated power installed of 3 GW by 2016 with an intermediate phase at 1.2 GW. Once this threshold attained, there will be a revision of the incentive system.

Evaluation of the investment in a photovolatic facility

Evaluating the feasibility and the benefits deriving from the adhesion to the feed-in tariff (“Conto energia”) has implied analysing the investment results for various sizes of photovoltaic facilities, according to the rules established by the Decrees already mentioned. In this context, the discussion will focus on the latest Ministerial Decree of 19/02/07 but also the previous Decrees have been analysed in order to allow a comparative evaluation. Furthermore, the same investment has been evaluated in three different typical locations: Milano, Roma and Bari since the results depend on the level of solar irradiation and thus vary considerably according to the geographical location of the facilities.

The analysis is based on the cash-flow method (19), considering as output flows the initial investment added to the management and maintenance costs. The input flows are energy savings equal to the benefits obtained from the incentive tariff for each kWh produced added to savings deriving either from the use on the premises or from the sale of the energy produced. All this parameters are considered at their net value and taking into account the capital depreciation.

Clearly, an analysis if this type implies assumptions about the trend of some economic variables in the next years. This is true in particular for the rate of inflation that has been assumed equal to the actual levels of 2%, and the rate of inflation of energy commodities that is closely related to the price of fossil fuels (for which a value of 4% has been assumed).

One of the critical variables has been the choice of a definition for "i" (rate of interest) for which we have assumed the weighted average cost of capital (WACC) that considers the opportunity cost of the capital itself and the cost of the debt capital. The I.R.R. (Internal Rate of Return) is the value of "i" that converts the net current value equal to zero.

Another technical variable, apparently insignificant but that has a large incidence for large facilities, is the loss of efficiency of the photovoltaic module throughout the years. Good brands are able to guarantee a gradual loss of 0.8/year.

A last and most important point to consider is the cost of a photovoltaic facility. PV modules, generally, represent 40% to 60% of the whole facility price; the rest of the cost includes the electrical components and the labour cost of installation. In general, the cost of a photovoltaic facility is inversely proportional to its dimension and may vary between 5000 €/kWp to 8000 €/kWp. In this analysis the costs proposed are the average ones

available in the Italian market.

All these and other minor variables have been considered during the development of a specific software, essential part of the present analysis and that is able to evaluate: investment cost, net current value, internal yield rate and payback period for each type of photovoltaic facility. The software has been developed using Microsoft Excel for Office XP. Some of the most significant results are discussed in the following paragraphs.

Facilities in the range from 1 kW to 3 kW:

-Photovoltaic facilities of 2 kWp:

The analysis for this specific case is based on the hypothesis of total consumption on the premises of the energy produced by an integrated facility, 100% financed with private capital. The results shown in Table 2 elucidate the fact that in the regions of Central and Southern Italy the installation of a photovoltaic facility offers a net economic advantage, i.e. a secure return of the initial investment and energy savings during the whole life time of the plant (estimated at more than 35 years). On the other hand, in Northern Italy the choice of installing a photovoltaic facility of small dimensions would be mainly based on environmental and ethical reflections. The results are directly correlated to the price of the facility and to the current interest rates. In fact, if the price of the facility was 8000 euros instead of 7500, the Pay-back period would be more than 20 years.

TABLE 2

EVALUATION OF THE INVESTMENT FOR A PHOTOVOLTAIC FACILITY OF 2 KWP

DATA:	Milano	Roma	Bari
Number of kW			2.00
Production of kWh/year per kW installed	1064	1376	1522
Efficiency loss/year			0.8%
Facility cost/kW (VAT included)			€ 7,500.0
Management costs/year			€ 30.00
Maintenance costs/year per facilty cost			1.00%
Electricity cost/ kWh (households)			€ 0.18
Electricity cost/ kWh (enterprises) net of VAT			€ 0.13
Inflation rate			2.00%
Inflation rate for energy commodities			4.00%
feed-in tariff/ kWh			€ 0.49

IRES[8]	34.0%
Interest rate of the owners' capital	5.00%
Interest rate of the debt capital	8.00%
capital /debt ratio	100.00%
Starting year	2007

INVESTMENT RESULTS:	MILANO	ROMA	BARI
INVESTMENT COST:			
Households without IRPEF deduction	€ 15,000.00	€ 15,000.00	€ 15,000.00
Businesses	€ 13,500.00	€ 13,500.00	€ 13,500.00
W.A.A.C. weighted average cost of capital	5%	5%	5%
N.P.V: net present value			
Households without IRPEF deduction	€ 715,27	€ 6097.58	€ 8616.22
Businesses	€ 3765.86	€ 6985.84	€ 8492.62
I.R.R: internal rate of return			
Households without IRPEF deduction	5.55%	9.37%	11.01%
Businesses	9.99%	13.47%	14.95%
Pay-Back Period (anni)			
Households without IRPEF deduction	18.57	12.15	10.49
Businesses	9.39	6.54	5.73

Photovoltaic facilities in the range from 3 kW to 20 kW

- *Photovoltaic facilities of 19.9 kWp*

The analysis for this specific case is based on the hypothesis of 100% consumption on the premises of the energy produced by a partially integrated facility. The results of Table 3 show that the installation of a photovoltaic facility of 19.9 kWp gives superior economic results if compared to a smaller facility because of the minor cost for each kWp produced. The investment is quite appealing in Central and Southern Italy both for businesses and for households, while in Northern Italy it is interesting only for businesses. However, the investment must be evaluated taking into account the fact that feed-in tariffs decrease with the increase in power (0.42 euro/kW). The cost of the facility is assumed to be 6,200 euro/kW

[8] Imposta sul reddito delle Società (Company revenue tax)

TABLE 3

EVALUATION OF THE INVESTMENT FOR A PHOTOVOLTAIC FACILITY OF 19.9 KWP

INVESTMENT RES ULTS:	MILANO	ROMA	BARI
INVESTMENT COST:			
Households without IRPEF deduction	€ 123,380.00	€ 123,380.00	€ 123,380.00
Businesses	€ 111,042.00	€ 111,042.00	€ 111,042.00
W.A.A.C. weighted average cost of capital	6.50%	6.50%	6.50%
N.P.V: net present va lue			
Households without IRPEF deduction	€ 5,251.27	€ 47,996.40	€ 67,998.93
Businesses	€ 27,783.76	€ 53,112.28	€ 64,964.73
I.R.R: internal rate of return			
Households without IRPEF deduction	7.02%	10.97%	12.69%
Businesses	11.18%	14.75%	16.29%
Pay-Back Period (anni)			
Households without IRPEF deduction	18.54	11.76	10.08
Businesses	9.57	6.59	5.76

Photovoltaic facilities in the range over 20 kW

- *Photovoltaic facilities of 50 kWp*

Facilities in this range have to be registered as "Electrical shop" and possess a VAT number, which excludes private households from the incentive. The feed-in tariffs are those already shown in table 1 while the price for selling the energy produced is fixed by AEEG at 0.095 €/kWh.

The basic assumption is that the investment is entirely financed by debt capital with a rate of interest equal to 8% and 100% energy consumption on the premises. The results obtained are as follows:

	Milano	**Roma**	**Bari**
NPV	34,966.08 €	87,586.29 €	112,209.86 €
IRR	11 %	14 %	16%
Payback period	12.38 years	8.06 years	6.95 years

- Photovoltaic facilities of 1000 kWp

The last case evaluated is the one of a photovoltaic facility of approximately 1000 kWp. For an investment cost of 5,499,587.50 €, the net investment value in the case of complete consumption on the premises of the electricity produced, the IRR and the payback periods are shown in Table 4.

TABLE 4

EVALUATION OF THE INVESTMENT

DATA:	MILANO	ROMA	BARI
Type of modules			185 Wp
Efficiency			14.30%
Capture surface (m²)			1.3
Price/module			€ 610.50
Coefficient plan -investment-construction			€ 2.20
Number of panels			5405
Surface of the system (m ²) *only for panels without shaded areas, otherwise the surface doubles*			7026.5
Number of Kwp			999.925
Production of kWh/year per kWp	1064	1376	1522
Loss of efficiency/year			0.8%
Cost of the facility per kWp (keys in hand)			€ 5500.00
Annual maintenance costs per facility cost			1.00%
Electricity cost/ kWh (businesses) net of VAT			€ 0.13
Rate of inflation			2.00%
Rate of inflation for energy commodities			4.00%
Tariff for energy sold to the grid			€ 0.070
Feed-in tariff/ kWh			€ 0.36
IRES			34.00%
Interest rate of the owners' capital			5.00%
Interest rate of the debt capital			8.00%
Capital/debt Ratio			0.00%
Starting year			2007
Percentage of self -consumed energy			100.00%

INVESTMENT RESULTS:	Milano	Roma	Bari
INVESTMENT COST:	€ 5,499,587.50	€ 5,499,587.50	€ 5,499,587.50
WAAC: weighted average cost of capital	8.00%	8.00%	8.00%
NPV: net present value	€ 612,130.10	€ 130,115.21	€ 2,106,480.03
IRR: internal rate of return	10%	14 %	15%
Payback Period (years)	12.99	8.43	7.26

FOR A PHOTOVOLTAIC FACILITY OF 1000 KWP

For the same type of facility but having the objective of selling all the energy produced to the local grid, the net present value (NPV) is 68,270.00€ in Milano, 926,777 in Roma, and 1,328,514,73 in Bari. The IRR are respectively: 8%, 12% and 13% while the payback periods are 18.56, 10.38 and 8.72 years.

Conclusions

Public policies to stimulate the photovoltaic sector, and other renewable energies, are justified because the pollution generated by fossil fuels implies costs in terms of environmental damage and health hazards, which are external to the market mechanisms, but that are paid by the whole society as a decline in the quality of life.

For the PV technology, one of the crucial steps for the development of the sector is the ability to appeal a large spectrum of stakeholders, in particular investors and retail suppliers. At the same time, it is important to spread the message that electricity produced from solar energy leads to several advantages at the social, economic, industrial and ecological level for all the areas that actively promote its use (20).

As previously discussed, the advent in Italy of the feed-in tariff should act as an incentive to start-off the photovoltaic market, after years of stagnation. The results previously presented show the superiority of this type of incentive when compared with other forms that had been used in the past. In the long term, the objective of this tariff is to create the conditions that will eliminate in a short time the technological gap with respect to other Countries. This will be obtained through the establishment of a strong internal demand that will regenerate the National industry. In this context the increase of the maximum power allowed for incentives from 500 to 1200 MW, as stated in the latest Ministerial Decree of February 19th 2007 (3000 MW by 2016), is a clear indication of the government intention for the achievement of such objective.

The analysis carried out in the present research has shown that the successive Decrees have increased the investment benefits for photovoltaic facilities (for a given nameplate power). As an example, if the rules established by the Decree of July 28th 2005 are considered, the following values for the Pay-back period in the case of photovoltaic facilities of 2 kWp are obtained:

Pay-Back Period (years)			
Households without IRPEF deduction	22.27	13.16	11.27
Businesses	10.56	7.22	6.30

On the other hand, for the same type of facility but according to the rules of the latest Ministerial Decree (February 19th 2007) the results are as

Pay-Back Period (years)			
Households without IRPEF deduction	18.57	12.15	10.49
Businesses	9.39	6.54	5.73

follows:

This increased investment benefits are also obtained for all other sizes of facilities and parameters (such as NPV and IRR), which proves the superiority of the latest Decree as an incentive mechanism, in particular for integrated facilities.

The important issue, particularly in the Italian context, is that any feed-in-tariff system must also combine attractiveness of conditions with long-term investor security to ensure the creation of strong demand and sustainable market growth. Administrative procedures, such as authorisation and grid connection, must be rigorous and at the same time efficient, avoiding uncertainties and long lead times for promoters/investors. All these conditions are compulsory to complement a feed-in-tariff system in practice and to achieve its goals.

Policies to develop the demand for the PV technology must go in parallel with measures to also promote the development on the supply side. For example, it has been shown in other Countries that the combination of different instruments (e.g. grant, soft loan and/or liability exemption by the state) is usually highly motivating for investors (21).

A long term strategy is required, to assure potential investors about the stability of the PV sector, including the definition of reliable technologies that can assure the expected results for energy production and which should become investment priorities both for the internal market and for export.

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