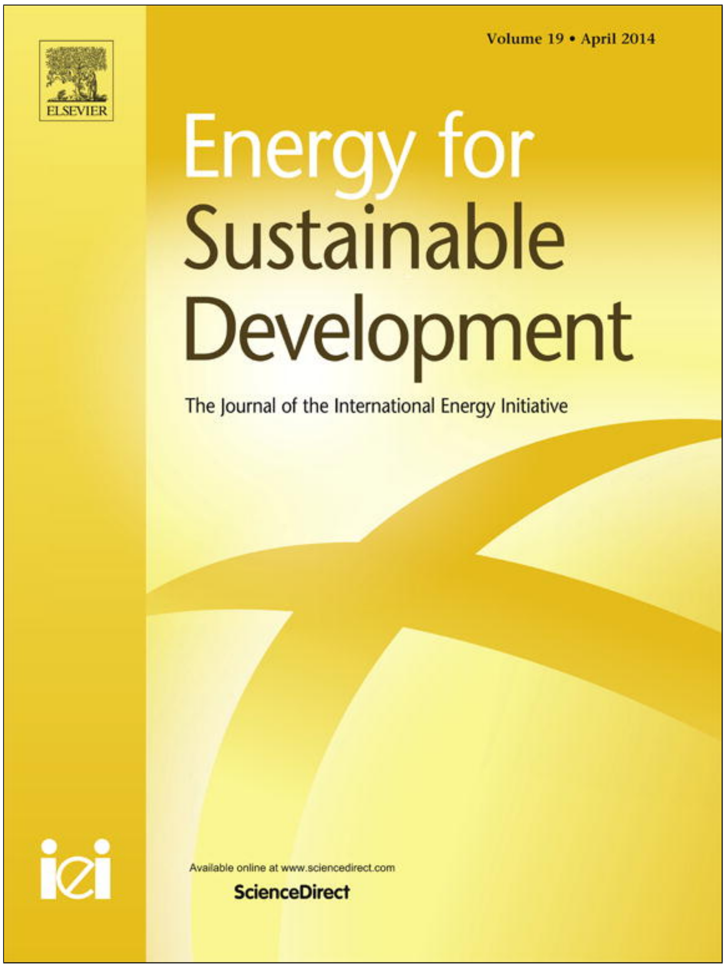
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Innovations in financing that drive cost parity for long-term electricity sustainability: An assessment of Italy, Europe's fastest growing solar photovoltaic market ☆

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ABSTRACT

Subsidy programs, such as feed-in tariffs, designed to make renewable technologies cost competitive with fossil fuels in electricity generation, have been effective in a number of nations. However, these subsidies can become very costly and they raise questions whether there are fair conditions for competition for different energy sources. As a result even effective programs face an uncertain future, changes in political support following the financial crises in Europe and the United States have demonstrated. In the case of solar photovoltaic energy, cost declines resulting from market-expansion schemes and the overall reductions in the price of photovoltaic cells have been significant particularly over the past decade. Yet, they have still left solar power up to 50% more expensive than conventional options. As an alternative in this paper we describe a financing tool based on a pollution abatement methodology. In developing this levelized cost of electricity framework we build a methodology to examine, and then utilize, the social costs and impacts of energy generation technologies. We find that as a means to bridge the cost gap between current conventional energy process and retail solar energy, a program based on a Property Assessed Clean Energy (PACE) loan program would, in the short-term, be an effective tool to accelerate grid parity between solar and conventional energy generation and in the long-term provides a theoretically and financially sound alternative to subsidy-based incentives.

Introduction

Over the past decade, the production of solar cells has grown by over 50% per year (IEA, 2011a). Global cumulative installed capacity reached 69 GW in 2011 (EPIA, 2012). This growth in production, in part a result of major market-pull policies in a number of states and countries, such as California, Japan, Germany, Italy and Spain, has driven down solar module costs by more than 50% between 2000 and 2011 (Solarbuzz, 2012), from prices averaging 5.5 $/peak watt in 2000 to as low as 2.5–2.0 $/peak watt today.[1] These values translate into photovoltaic (PV) electricity generation cost ranging from 0.16 to 0.35 $/kWh[2] in the Eurozone (EPIA, 2011).[3] By comparison average electricity prices for households range from 0.263 $/kWh in Italy, 0.325 $/kWh in Germany, 0.232 $/kWh in Japan and 0.116 $/kWh in the United States in 2011 (IEA, 2011b). Despite this gap, it is important to note that the photovoltaic electricity generation cost does not take into account for the transmission and distribution costs, while those costs are included in the residential electricity tariffs.

Bridging this remaining cost gap between solar and more conventional sources of electricity would provide more energy security, and can play a central role in meeting climate and health goals set in many nations. In March 2007 the European Union (EU) launched the “Climate and Energy Package”, which was adopted by the European Parliament in December 2008. The plan sets ambitious targets for the EU: by 2020, GHG emissions should be at least 20% lower than 1990 levels, energy efficiency should increase by 20% and the share of renewable in total energy consumption should reach 20%, respectively (EC, 2007), with a separate target for the transport sector of a 10% renewable energy share. Many analysts point to the progress made in Germany, which has seen dramatic growth in the share of renewable-based electricity supply obtained from solar power, averaging 15.6% of total kWh generated in 2011 (WG AGEE-Stat, 2012). In light of European energy targets, the widespread deployment of cost-competitive solar technologies is a priority for EU policy makers.

While feed-in tariffs (FiTs) continue to be a highly effective tool to promote solar energy in many nations, the incremental cost paid in a number of FiT schemes is expected to decrease. Countries gradually withdraw feed-in tariffs as technologies mature. For instance Germany

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[1] The majority (about 80%) of the companies surveyed are based in the United States, but most market globally. European dealers are the second largest surveyed group. The solar energy system product indices represent retail pricing for a single component.
[2] Exchange rate 1.28 EUR/USD.
[3] This study analyses five European countries, as they represent 82% of the European PV market: France, Germany, Italy, Spain and United Kingdom.

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decreased tariffs for solar photovoltaic (PV) generation as new capacity is installed, following the revision of Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz EEG) in 2009, which promotes renewable energy production in the country. In January 2010, FiT for solar PV decreased by 9% for roof systems and for on-site consumption, and by 11% for the remaining categories. Moreover, since January 2011 an additional reduction of 13% for PV-systems became effective (IEA, 2012).

As financial instability continues in Europe and recovery from the recession remains slow in the United States, a number of governments have reconsidered their solar incentive policies, which has resulted in slower rates of solar energy deployment in major markets, such as Germany and France. Conversely in Italy, where the FiT is still sufficient via the IV Conto Energia,[4] program solar installations tripled in 2011 relative to 2010 (EPIA, 2012). Fig. 1 shows solar PV installations from 2007 to 2011 in Germany, Italy and France, while Fig. 2 illustrates the European solar PV market share in 2011. Germany, Italy and France represent about 85% of the European solar PV market (Fig. 2).

Notwithstanding these efforts, the contribution of solar PV to renewable electricity supply in Europe and worldwide is still small, averaging 2% of the total electricity in the EU, while globally solar is only 0.5% of electricity demand, and 1% of the peak power demand (EPIA, 2012).

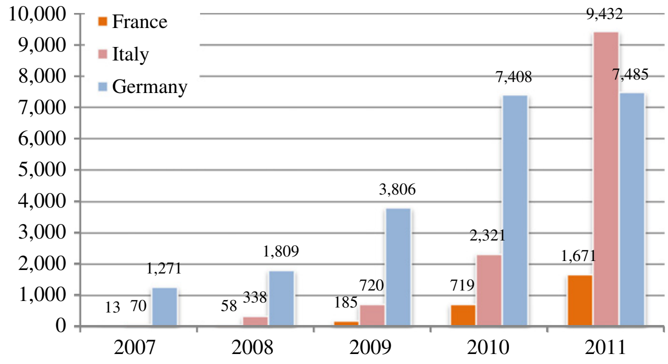


Fig. 1. European solar PV installations 2007–2011.

Solar photovoltaic (PV) could be a significant source of electricity production, especially in those countries characterized by abundant insolation, such as Italy, where daily average exceeds 5 kWh/m^2 in the south, and 4 kWh/m^2 in the north (Petrarca et al., 2000). High irradiation and a generous supporting scheme make solar PV system

[4] Italian Energy Agency (GSE, Gestore Servizi Elettrici) supports photovoltaic solar electricity generation under a feed-in tariff scheme ("Conto Energia"). The scheme is regulated by the Interministerial Decree of 19 February 2007. On March 2011, the Department of Economic Development authorized the "IV Conto Energia" that regulates the new tariffs and mechanism for solar photovoltaic production for the period June 2011–2016 (Table).

Feed-in tariff in Italy (period June 2011–2016)

Size	June 2011		July 2011		August 2011		September 2011		October 2011		November 2011		December 2011		I semester 2012		II semester 2012	
[kW]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]	On building [€/kWh]	Other [€/kWh]
1 ≤ P ≤ 3	0.387	0.344	0.379	0.337	0.368	0.327	0.361	0.316	0.345	0.302	0.320	0.281	0.298	0.261	0.274	0.240	0.252	0.221
3 < P ≤ 20	0.356	0.319	0.349	0.312	0.339	0.303	0.325	0.289	0.310	0.276	0.288	0.256	0.268	0.238	0.247	0.219	0.227	0.202
20 < P ≤ 200	0.338	0.306	0.331	0.300	0.321	0.291	0.307	0.271	0.293	0.258	0.272	0.240	0.253	0.224	0.233	0.206	0.214	0.189
200 < P ≤ 1000	0.325	0.291	0.315	0.276	0.303	0.263	0.298	0.245	0.285	0.233	0.265	0.210	0.246	0.189	0.224	0.172	0.202	0.155
1000 < P ≤ 5000	0.314	0.277	0.298	0.264	0.280	0.250	0.278	0.243	0.256	0.223	0.233	0.201	0.212	0.181	0.182	0.156	0.164	0.140
P > 5000	0.299	0.264	0.284	0.251	0.269	0.238	0.264	0.231	0.243	0.212	0.221	0.191	0.199	0.172	0.171	0.148	0.154	0.133

In 2013 feed in tariff and net-metering will be replaced by all-comprehensive tariff. The mechanism will be based on two different tariffs (€/kWh): tariff for energy feed into grid and tariff for energy consumed.

Size	On building		Other	
[kW]	Energy feed [€/kWh]	Energy consumed [€/kWh]	Energy feed [€/kWh]	Energy consumed [€/kWh]
1 ≤ P ≤ 3	0.375	0.230	0.346	0.201
3 < P ≤ 20	0.352	0.207	0.329	0.184
20 < P ≤ 200	0.299	0.195	0.276	0.172
200 < P ≤ 1000	0.281	0.183	0.239	0.141
1000 < P ≤ 5000	0.227	0.149	0.205	0.127
P > 5000	0.218	0.140	0.199	0.121

Reduction tariff:
II semester 2013: −9% I semester 2014: −13%;
II semester 2014: −13% I semester 2015: −15%;
II semester 2015: −15% I semester 2016: −30%;
II semester 2016: −30%

Additional premium (Calculated on basic tariff)	- Removing asbestos (0.05 €/kWh) - Installation on special area (5%) - 60% of components EU manufactured (10%) - Premium for energy performance (10%) - Local government < 5000 people (5%)

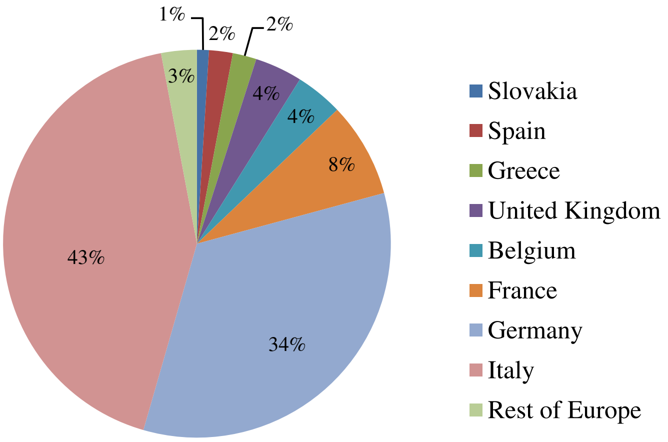


Fig. 2. European solar PV market share 2011 (%).

investments very attractive in terms of rate of return on investment (ROI). A high ROI means that the investment gains given by electricity savings, FiT incentive and a contribution based on the difference between injections and withdrawals of electricity into the grid (net metering scheme), exceed the investment cost and future costs, such as maintenance costs (Ameli and Kammen, 2012).

According to International Energy Agency forecasts, however, PV is projected to cover 5% of global electricity consumption by 2030, rising to only 11% by 2050 (IEA, 2011a, 2011b, 2011c). A number of groups, such as the European Climate Foundation (ECF, 2010) and the Renewable and Appropriate Energy Laboratory in California (Nelson et al., 2012), as well as the Melbourne Energy Institute (2010), however, foresee the need and the possibility of a carbon free future by 2050, where the share of solar energy should exceed 20% of total installed energy capacity. To achieve these goals, solar prices will need to fall more strongly than the current trends indicate and resolute policy action is needed to enhance a sustainable growth path.

To make the extent of the price gap explicit, and to identify financing methods capable of accelerating the elimination of this price gap, we begin by developing an abatement cost methodology to examine options to address the price gap of up to 45% that exists today between current conventional energy process and retail solar energy. We focus on the levelized cost of electricity (LCOE) methodology. In particular, we find that as a means to bridge this cost gap a PACE scheme, Property Assessed Clean Energy loan program would be a particularly effective tool to bring down solar costs to a grid-parity situation in the short-term period, and moreover particularly relevant for making solar energy investments sustainable in the long term.

This paper is structured as follows. The Levelized cost of electricity method section provides an overview of the levelized cost of electricity method. In the Achieving grid parity section we analyze the grid parity dynamics based on the LCOE method taking into account the PACE scheme for our Italian case study. Moreover, we also review the economic impact of feed-in tariff on national budgets. The concluding section provides a set of recommendations for future actions to spur the clean energy economy.

Levelized cost of electricity method

The conventional LCOE integrates all cost categories, e.g. investment, cost of financing, insurance, operations and maintenance. It provides a measure of the competitiveness of solar energy to conventional grid-supplied electricity on a technology lifetime basis. The LCOE provides the cost of PV generated electricity to be compared to other sources of electricity. It can be thought of the price at which energy must be sold for an energy project to break-even,[5] and is expressed as:

$$\mathrm{LCOE} = \frac{\mathrm{CAPEX} + \mathrm{NPV(OPEX)}}{\mathrm{NPV(EP)}} \tag{1}$$

where CAPEX, capital expenditure (investment cost); OPEX, operation and maintenance costs; EP, electricity produced; NPV, net present value. When computing the NPV of electricity produced, we assess the performance of solar PV system over its lifetime. We assume a degradation rate of 0.83% over the years, with a guaranteed lifetime of 80% of the initial performance after 25 years.

A more detailed assessment of financial parameters was adopted by the National Renewable Energy Laboratory (NREL) and the United States Department of Energy (DOE). The SAM[6] financial model simulates LCOE for residential and commercial projects as well as for Power Purchase Agreement initiatives. In this model, financial factors are included. This formulation is presented as:

$$\mathrm{LCOE} = \frac{\mathrm{NPC} + \sum_{n=1}^{N}\frac{\mathrm{LP}}{(1+d_r)^n} + \sum_{n=1}^{N}\frac{\mathrm{AO}}{(1+d_r)^n} - \sum_{n=1}^{N}\frac{\mathrm{RV}}{(1+d_r)^n}}{\left\{\sum_{n=1}^{N}\left[\frac{E_n * (1-d_s)^n}{(1+d_s)^n}\right]\right\}} \tag{2}$$

where NPC, net project cost (net upfront cost); LP, annual loan reimbursement; AO, annual operation expenditures; RV, residual value for the solar system; E_n, net-energy output first year; d_r, discount rate; d_s, system degradation rate.

We utilize this Eq. (2), to evaluate the break-even point for residential photovoltaic projects in Italy. The cost of PV generated electricity is computed by the LCOE method and compared to the electricity price for a typical household with average electricity consumption of approximately 2700 kWh/year (AEEG, 2011). The Total Life-Cycle Cost includes project capital investment cost, plus annual operation costs, extra costs (i.e. inverter replacement), insurance fees and the residual value of the investment. We take into account the electricity generated by solar system, using the following formula:

$$\frac{\mathrm{Energy}}{\mathrm{PeakPower}}\left(\frac{\mathrm{kWh}}{\mathrm{kW_p}}\right) = [\mathrm{PeakPower} * H * \eta * K] \tag{3}$$

where $\frac{\mathrm{Energy}}{\mathrm{PeakPower}}\left(\frac{\mathrm{kWh}}{\mathrm{kW_p}}\right)$, energy output; H, operating hours; η, system efficiency; K, correction factor (Azimuth south and 30° tilt).

The total electricity generated is computed taking into account losses due to the system, such as DC–AC loss, temperature, shading, reflecting and circuit losses which we list below as Eq. (4):

$$E_n = \frac{\mathrm{Energy}}{\mathrm{PeakPower}} * (\mathrm{DC{-}AC}_{\mathrm{loss}}) * (\mathrm{Temperature}_{\mathrm{loss}}) * (\mathrm{Shading, Reflecting, Circuit}_{\mathrm{losses}}) \tag{4}$$

where E_n, net-electricity generated; $DC - AC_{loss}$, inverter loss (loss due to the conversion from direct current DC to alternating current AC).

The analysis is based on solar irradiation and market data for the Marche region, as summarized in Table 1. The Marche region was chosen because irradiation values are similar to average values across all of Italy (AEEG, 2011). It is important to note that this case does not take into account differences among climate areas. All input parameters used in LCOE formula (3) are considered on an annual basis. They are summarized in Table 1.

Based on Eq. (3) and assumptions summarized in Table 1, we determined the current LCOE solar PV.

[5] Deutsche Bank Group "De-risking clean energy business models in developing country context", April 2011.

[6] Solar Advisor Model 2010, SAM 2010.4.12, https://www.nrel.gov/analysis/sam/, NREL.

Table 1
LCOE input parameters.

Input parameters	Unit	Value
Solar system		
Irradiation (Marche region)	kWh/m^2 (monthly)	Reported below*
Peak power	kW	3
Electricity produced first year	kWh/year	3985
Azimuth	Angle degree	0 (South)
Tilt	Angle degree	30
System life	Year	25
Annual performance degradation	Percent	0.83
General system losses:		
Inverter	Percent	6
Shading	Percent	2
Reflection	Percent	2
Circuit	Percent	1
Temperature	Percent	7
Incoherence performance	Percent	3
PV system cost		
Crystalline silicon (c-Si) modules[a]	€$_{2010}$/kW	1.7
Inverter	€$_{2010}$/kW	0.4
BOS cost factor	Percent	40
Annual operation cost	Percent	1
Installed cost	€$_{2010}$/kW	4
Financial parameter		
Annual growth rate for end user electricity price	Percent	3
Discounting rate	Percent	5.5
Interest rate[b]	Percent	7.01
Financing term	Year	10
VAT	Percent	10
PACE policy interest rate	Percent	5.5
PACE policy financing term	Year	20
Electricity price		
The electricity price is based on Italian Energy Authority data (average rate for 2700 kWh/year consumption)	€$_{2010}$/kWh	0.16

*

Province	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
AP	1.50	2.28	3.50	4.78	5.78	6.58	7.11	6.19	4.53	2.89	1.78	1.33
MC	1.53	2.33	3.47	4.89	6.31	6.81	7.06	6.03	4.58	3.06	1.78	1.33
AN	1.19	2.11	3.36	5.08	6.42	6.69	7.22	6.11	4.44	2.92	1.53	1.14
PU	1.11	1.94	3.36	4.83	5.89	6.39	7.06	6.06	4.33	2.69	1.50	1.08

Provinces: Ascoli Piceno (AP), Macerata (MC), Ancona (AN), Pesaro Urbino (PU).
[a] Crystalline silicon (c-Si) modules represent 85–90% of the global annual market today. C–Si modules are subdivided in two main categories: i) single crystalline (sc-Si) and ii) multi-crystalline (mc-Si) (IEA, 2010).
[b] Average interest rate applied in Italy for residential projects. We considered 10 banks which provided specific energy package.

We assumed that the investment project has been financed by a 10-year bank credit solution. Given the limited investment amount required (approximately 12,000 Euros), suitable financing provided by banks would generally not exceed a 10-year term. Solutions aimed at house purchases are typically characterized by a longer-term (i.e. 20 years). A study of financing solutions for solar PV provided by Italian banks was conducted (Table 2).

To compute the Total Life-Cycle Cost, we took into account the net present value of installation cost plus annual operation expenses (including inverter replacement in year 12 out of a 25 year lifetime) and

Table 2
Financing solutions for solar PV provided by banks.

Bank	Energy package	Nominal interest rate [%]	
		Spread	Interest rate
Banca delle Marche	“Mutuo fondiario per energia pulita e risparmio energetico”	3.5	Interest rate swap 6.76
Banca Etica	“Fotovoltaico 100”	2.95	Interest rate swap 6.21
Banco Popolare	Unsecured loan	–	7.52
	Secured loan	–	6.49
Unicredit	“Prestito chirografario per Impianto Fotovoltaico”	2.50	Interest rate swap 5.80
Ubi Banca	“ForzaSole”	–	6.75
Intesa San Paolo	“Prestito ecologico”	–	8.50
Monte dei Paschi di Siena	“PRS Ambiente”	–	10.95
BCC Roma	“Sistema Energia”	2.00	Interest rate swap 5.26
Emilbanca Credito Cooperativo	“Ecofinanziamento”	–	6.00
Banco Popolare Milano	“Credito fotovoltaico”	3.00	Interest rate swap 6.30
Average nominal interest rate applied			*7.01*

Note: After the introduction of feed-in tariff scheme, many banks designed specific energy financing package for solar PV. Banks reported in the table where selected among those signed agreement with Italian Energy Agency (GSE).

Table 3
Total Life-Cycle Cost (TLCC) break down.

	Net present value	Percentage value
Total Life-Cycle Cost	*€13,519*	*100* [%]
Annual operation expenditures plus inverter replacement	€635	4.69
System cost	€8779	64.94
Financing cost	€4105	30.36

Table 4
LCOE projections 2010–2020.

	LCOE [€/kWh]	PACE implementation [€/kWh]	EPIA max [€/kWh]	EPIA min [€/kWh]	+2% [€/kWh]	+3% [€/kWh]
2010	0.274	0.256	0.350	0.160	0.158	0.158
2011	0.254	0.238	0.320	0.150	0.162	0.162
2012	0.242	0.226	0.290	0.130	0.165	0.167
2013	0.230	0.215	0.270	0.120	0.168	0.172
2014	0.218	0.204	0.250	0.120	0.172	0.177
2015	0.206	0.193	0.240	0.110	0.175	0.182
2016	0.194	0.181	0.220	0.100	0.179	0.188
2017	0.182	0.170	0.210	0.100	0.182	0.193
2018	0.170	0.159	0.200	0.090	0.186	0.199
2019	0.158	0.148	0.190	0.090	0.190	0.205
2020	0.146	0.137	0.180	0.080	0.193	0.211

financing cost (numerator, Eq. (3)). The net electricity output is given by the net present value of electricity generated considering the annual performance degradation rate (denominator, Eq. (2)).

In 2010 average electricity retail price for a typical household in Italy was 0.16 €/kWh (AEEG, 2011), while the current LCOE solar PV computed is approximately 0.274 €/kWh. Grid parity thus requires a reduction of the current LCOE of about 0.114 €/kWh, or a 42% reduction. Our results show that without any climate policy in place or economic support schemes, solar technologies are not yet competitive with conventional grid-supplied electricity without the FiT.

Achieving grid parity

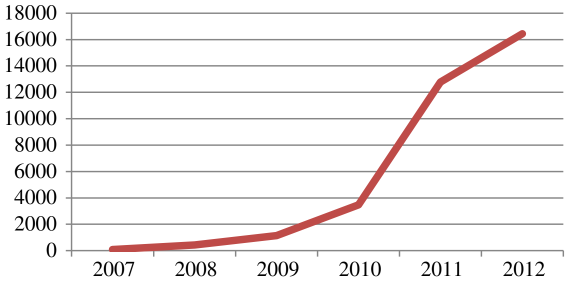
Breaking down the current LCOE, we identified three different cost categories: system cost that accounts overall system solar cost (Table 1); annual operational expenses that include maintenance costs plus the inverter replacement in year 12, and financing costs associated with the investment as we assumed financing covers total investment value. Computing the contribution of these categories, in 2010 the LCOE was robustly affected by PV module prices that accounts for 45–60% of total system costs according to EPIA (2011), Bony et al. (2010) and Yang (2010). Although cost competiveness (i.e. module, balance of the system) and performance ratio are key drivers that could reduce the LCOE, financing factors play an important role in decreasing the electricity generation cost representing around 30% of the current LCOE. An appropriate financing scheme can accelerate the convergence to the LCOE target (Table 3).

We undertook an assessment of future photovoltaic component prices as well as of the policy intervention based on the PACE scheme, Property Assessed Clean Energy. The PACE policy enables local governments to raise money through the issuance of bonds to fund clean energy projects. This program allows residential property owners to install energy efficiency measures, solar thermal, and solar PV, while paying for the cost over a 20-year period through a special tax, which is collected as a line item on the property tax bill. If the property is sold before the end of the repayment period, the new owner takes over the remaining special tax payments as part of the property's annual tax bill. This allows for longer repayment periods than many other financing options, making these investments more affordable for property owners (Ameli and Kammen, 2012; Fuller et al., 2009a, 2009b). PACE thus addresses the high initial cost of installing solar PV and the concern of some property owners that they will not get the full benefit of their investment if they sell the property. It is a powerful scheme for regional and national governments to reduce energy consumption and to cut emissions by reducing financing costs (More information regarding Property Assessed Clean Energy are available on http://rael.berkeley.edu/financing).

Determining PV electricity generation cost requires an assessment of how photovoltaic component prices will evolve in the next years. The main cost-driver affecting LCOE is the PV module price. Experience curves for solar PV systems available in the literatures have been analyzed to derive a learning factor based on assumptions on annual growth rates of PV installations. These curves are based on the theory that experience reduces costs and that as a result costs decline in logarithmic proportion to increases in cumulative capacity (Nemet, 2006). Experience curves for the module price display a historic learning rate of 22% in the range period 1976–2010. The cost per unit decreases by the learning rate for each doubling of cumulative production. Oscillations around this trend are mainly due to varying PV industry market dynamics and profit margin, ranging from 22.8% to 19.3% for the period 1976–2003 and 1976–2010, respectively (Breyer and Gerlach, 2013).

Utilizing the FiT financing scheme, Italy's recent PV growth rate has been remarkable (Fig. 3): PV cumulative installed capacity doubled each year, increasing by 1.6 GW in 2010 and by 5 GW in 2011 (GSE, 2012). The national cumulative PV capacity was equal to 12.758 GW on January 2012. We project a doubling of the current installation before 2015 and roughly 40 GW by 2020. This scenario is in line with estimates reported in the EPIA report (2011) that forecasts an increase by 40% compared to 2012 level in terms of European installed capacity. Our assumptions by 2020 are:

- *photovoltaic modules*: learning factor of 20% has been assumed for doubling of cumulative installation;
- *inverter*: learning factor of 20% was taken into consideration. The learning factor is based on the realized price reductions in the PV industry since 1980–1990 (EPIA, 2011);
- *structural components and operating costs*, such as cables and mounting structures: considering the European photovoltaic roadmap over the next ten years, it has been assumed that they would reduce to



Year	Installed capacity [MW]	
	per year	cumulative
2007	87	87
2008	344	431
2009	713	1,144
2010	2,326	3,470
2011	9,303	12,773
2012	3,660	16,433

Fig. 3. Cumulative installed PV capacity [MW] in Italy.
GSE (2013).

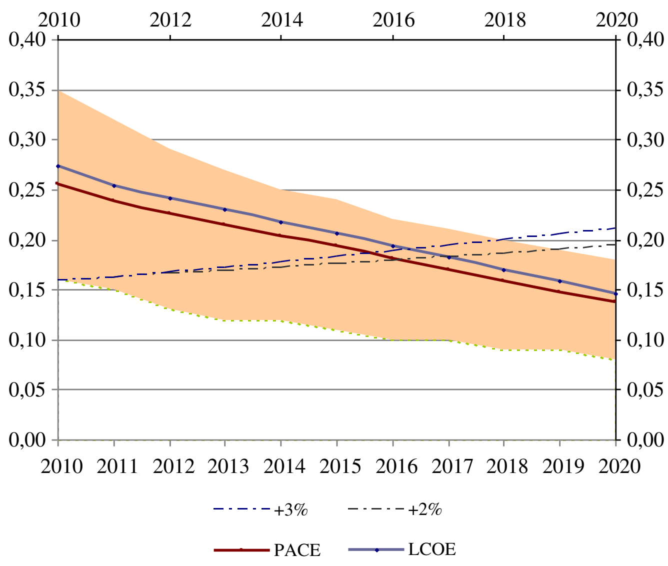


Fig. 4. LCOE projections 2010–2020.

Table 5
Levelized cost of electricity versus Property Assessed Clean Energy.

	LCOE [€/kWh]	PACE [€/kWh]	% reduction
2011	0.274	0.256	6.30%
2012	0.254	0.238	6.61%
2013	0.242	0.226	6,52%
2014	0.230	0.215	6.42%
2015	0.218	0.204	6.31%
2016	0.206	0.193	6.70%
2017	0.194	0.181	6.59%
2018	0.182	0.170	6.47%
2019	0.170	0.159	6.33%
2020	0.158	0.148	6.16%
Average reduction			6.44%
Sample assumptions			
Average project cost			€12,000
Number of projects			1,000,000
Funding required			€12,000 million

Table 6b
Program budget 2013–2020 [€ million].

	2013	2014	2015	2016	2017	2018	2019	2020
Program design	27	–	–	–	–	–	–	–
Administration services*	139	137	136	134	132	131	130	128
Finance services	365	280	280	280	280	280	280	280

* Marketing costs are included in this assessment. These costs will experience economies of scale and we assume an average reduction of 5% each year.

approximately 30% of the total solar PV system cost (EPIA, 2011). Part of their costs are influenced by PV module efficiency as those cost components are a function of efficiency module improvements, the higher the efficiency, the fewer structural components are required (EPIA, 2011);

- *financing costs*, PACE program implementation has been taken into account. The PACE scheme is assumed to be implemented with a term of 20 years and interest rate of 5.5% against 10 year financing terms offered by banks at 7.01%.

Table 4 and Fig. 4 show projected scenarios of cumulative installed capacity until 2020 according to previous assumptions and analyses. A comparison with estimates of grid parity's achievement available in the literature puts our results into perspective. According to EPIA (2011), the projected LCOE is expected to be 0.180 ± 0.08 €/kWh (orange area in Fig. 4). The range value is quite broad given that EPIAs' study on LCOE assumes competitive cross-European hardware prices (modules, inverters, structural components) as well as competitive development prices. These uniform prices for all countries are based on German data as the leading "mature" PV market in Europe, assuming that future prices and margins in other countries will converge to German levels in the next years (EPIA, 2011). The range also considers different photovoltaic installations including residential (3 kW), commercial (100 kW), industrial (100 kW) and utility scale (2.5 MW). Conversely, our results are more specific based on the Italian case study.

The aim of the study is to determine the breakeven-point for solar PV. To do that, we assumed two different electricity price escalations (+2%/year and +3%/year). Between 2005 and 2011, however, Italian nominal electricity rates rose by 25% (AEEG, 2011). Based on these changes, our forecast scenarios are very conservative.

The LCOE (blue line) will gradually decrease in the next years and the grid parity should be achieved in 2017 approximately. With policy intervention based on the PACE scheme (red line) the parity target

Table 6a
Sample program budget (first year).

	Average cost or % per project in year [€]	One-time setup costs [€ M]	Initial fixed costs [€ M]	Initial cost based on volume [€ M]	Annual fixed costs [€ M]	Annual costs based on volume [€ M]	Total [€ M]
Program design							
Program design & manage local govt approval process	18	18					18
Application processing system setup	9	9					9
Estimated design and preparation for launch							27
Administration services							
Education & marketing	35				35		35
Customer service	20		17	3			20
Review application and project	70		17	53			70
Printing, reproduction & shipping	14			14			14
Estimated administration							139
Finance services							
Legal and financing expenses	2.13%	60		180		15	255
Lien recordation	55			55			55
Bond paying and transfer agent	0.21%	10				15	25
Tax collection	0.25%					30	30
Estimated finance							365
Estimated total							€531 m
Annual cost per project							€531

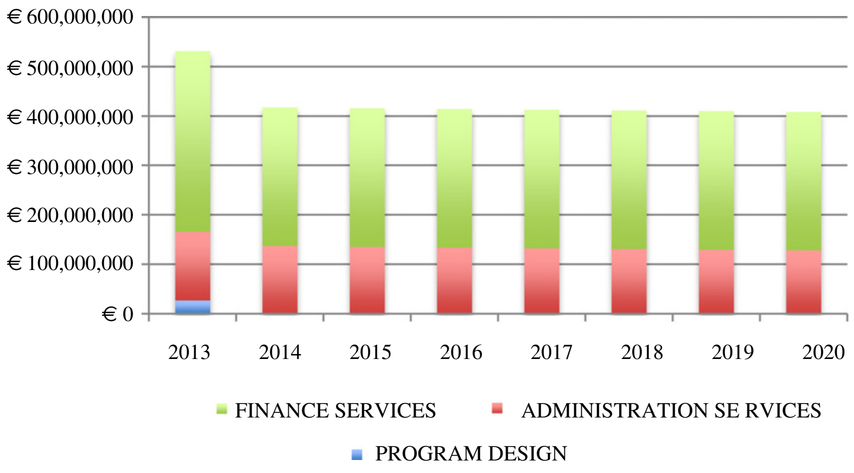


Fig. 5. Program budget 2013–2020 [€ million].

Table 7
Total spending on feed-in tariff in Italy from 2006 to 2012.
GSE (2013).

Total spending on feed-in tariff Million €/year	
2006	0.9
2007	19.2
2008	89.9
2009	303.6
2010	743.4
2011	3173.9
2012	6478

appears closer. The grid parity will be reached by 2015/2016; the break-even point for residential projects will be achieved approximately one year in advance compared to the baseline scenario (blue line). We did not take into account additional economies of scale and externalities that could occur if the public financing mechanism attracted further privately financed energy investments.

Table 5 summarizes the sensitivity analysis for LCOE with respect to a range of financial factors. We find that a well-designed financing scheme can promote PV competitiveness, by accelerating convergence toward grid parity. The analysis shows that supporting energy investment through PACE financing resulted in LCOE average annual reduction of 6.44% compared to financing through a traditional bank loan and in current interest-rates reduction of over 1.5% on average.

Finally, based on the existing programs in United States, we provide a hypothetical budget to assess the type and scale of expenses that policymakers might expect as a fiscal cost to implement the PACE program (Fuller et al., 2009b). The sample budget assumes 1,000,000[7] projects financed in a year with an average project cost of €12,000 for a total of €12 billion funding required (Tables 6a and 6b, Fig. 5). The costs include set-up costs, initial expenses that tend to be linked to volume (though some of these categories will see economies of scale, such as marketing — Fig. 5), and ongoing costs that are based on volume (these are costs related to the annual processing of payments).

According to our assumptions, applied nationwide to fund solar PV installations, the PACE program can leverage private capital for approximately 12 billion Euros per year by 2020 to support solar PV investments. The proposed scheme is likely to be less of a burden for public budgets (Table 6b) and can thus become a long-term financial solution to market failures hindering investments in energy efficiency and renewables. This mechanism would enable households to access financing for energy-efficiency improvements or renewable energy technologies, thanks to government guarantees. Local government acting as an intermediary to guarantee repayment of private loans would mitigate the first cost for energy retrofits (Ameli and Kammen, 2012; Fuller et al., 2009a).

Feed-in tariff impact on national budget

Our analyses did not take into account FiT in order to provide a real measure of photovoltaic technologies competitiveness. This seems appropriate because as financial instability continues in Italy and recovery from the recession remains slow, innovative financing mechanisms are needed to continue the growth of the industry without putting undue burden on public finances.

2011 and 2012 have been complex years for the Italian solar energy industry, given the high uncertainty surrounding the national regulatory framework and the uncontrolled growth of the market. After the first three-month period in 2011, the III Conto Energia[8] was soon replaced by IV Conto Energia (June 2011), expected to be in force until December 2016. This new feed-in tariff schemes set a target to 23 GW as well as a cap of 6.7 billion €/year (Ministerial Decree 05/2011), however the sustained solar installations, pushed policymakers to draft a new FiT law. The V Conto Energia entered into force by August 2012, cutting tariffs by approximately 20% compared to the previous one, while keeping the same cap (Ministry Decree 07/2012). The challenge was to reduce subsidies to a more acceptable level for national budget, while engendering a driver for solar investments. However, at the end of 2012, the cost of subsidy programs has already surpassed €6.4 billion (GSE, 2013, Table 7), which is almost equivalent to the entire budget allocated to feed-in tariffs before its removal.

Within this regulatory framework, future patterns are affected strongly by the policy uncertainty regarding the cap for different sizes of solar system, mechanism control and tariff levels. Currently in Italy, photovoltaic production accounts for approximately 3.4% of national electricity consumption (TERNA, 2012).

According to the cap set by the Ministry of Economic Development (Ministerial Decree 05/2011), the feed-in tariff scheme has been

[7] The sample budget takes into account our assumptions. Solar PV installations must grow roughly 3 GW per year by 2020, to reach the target of 40 GW.

[8] Italian feed in tariff system.

withdrawn in August 2013, leaving the country without a long-established tool for the solar energy sector.

Recognizing this funding gap, public actors should become increasingly interested in implementing new tools to leverage private capital investment in climate change projects.

Conclusion

This study shows that novel financing tools for renewable energy investments are becoming increasingly important. A well-designed PACE financing scheme would improve the competiveness of PV as financing costs are shown to have a relevant effect on the LCOE. PACE lowers the average LCOE by 6.45% compared to a traditional bank loan. For instance, in Italy the break-even point for residential projects could be achieved in early 2015/2016 if policies remain favorable.

Moreover, as financial instability continues in Italy and recovery from the recession remains weak, a challenge is to promote solar investments without overly burdening tight public budgets. According to the cap set by the Ministry of Economic Development (Ministerial Decree 05/2011), the feed-in tariff scheme has been withdrawn in August 2013, leaving the country without a long-established tool for the solar energy sector. In this respect, the PACE loan program is a novel public–private financing mechanism, likely to be less of a burden for public budgets given the involvement of private sector.

Our analysis shows that new financing schemes that reduce costs could provide a major boost to accelerating the movement toward price parity between solar energy and conventional sources as well as a long-term financial sustainable growth. This is fundamental as stability is a key to creating markets.

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