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Clean energy deployment: addressing financing cost

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Abstract

New methods are needed to accelerate clean energy policy adoption. To that end, this study proposes an innovative financing scheme for renewable and energy efficiency deployment. Financing barriers represent a notable obstacle for energy improvements and this is particularly the case for low income households. Implementing a policy such as PACE—property assessed clean energy—allows for the provision of upfront funds for residential property owners to install electric and thermal solar systems and make energy efficiency improvements to their buildings. This paper will inform the design of better policies tailored to the creation of the appropriate conditions for such investments to occur, especially in those countries where most of the population belongs to the low–middle income range facing financial constraints.

Keywords: financing barriers, energy efficiency, solar photovoltaic, energy investments

1. Introduction

The diffusion of energy efficiency and renewable energy technologies and their contribution to meeting the world's energy needs hinges critically on how rapidly these markets can be scaled-up. This expansion, in turn, depends critically on the strength of government support. The Intergovernmental Panel on Climate Change notes that the future share of renewable energy applications will heavily depend on climate change mitigation goals and supporting policies (IPCC 2011). Energy improvements have a crucial role in moving towards a more sustainable energy path and with prevailing energy practices, the potential is large. At the household level, electricity and fuel prices have risen dramatically, pressuring the budgets of the poorest families. In Italy, prices for electricity have increased by more than 25% in the last five years while prices for heating gas have increased by approximately 16% since 2009 (AEEG 2010). An important part of the energy equation is determined by the residential sector, given that housing structures account for more than 35% of total energy use and almost 23% of electricity consumption in Italy (Department of Economic Development 2010). Italy is among the largest electricity consumers in Europe with structural dependency of 14% over the last 10 years as reflected in Italy's primary energy import (see note (i) in the appendix) being approximately 87.7% in 2009, compared to an EU average of 56% (AEEG 2010). From an economic point of view, the total energy import cost represents 3.3% of national GDP (see note (ii) in the appendix). According to Union Oil projections, in 2011 energy costs are expected to surpass 60 billion euros, the peak energy import cost for the country.

Reducing building energy consumption would change the picture significantly; energy standards and codes for new constructions have been effective tools in increasing energy efficiency levels in new buildings constructed. However, improving the efficiency of energy use in the existing building stock, which accounts for approximately 33 million units (Department of Treasury 2011) is also important. It is likely that 2020 European targets will be feasible with specific policies directed at reducing energy consumption in the existing stock of buildings and the promotion of renewable

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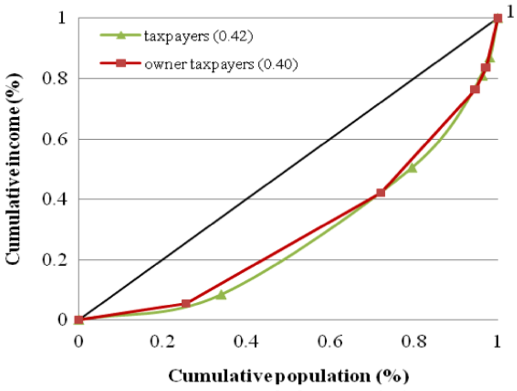

Figure 1. Lorenz curve for Italy in 2010.

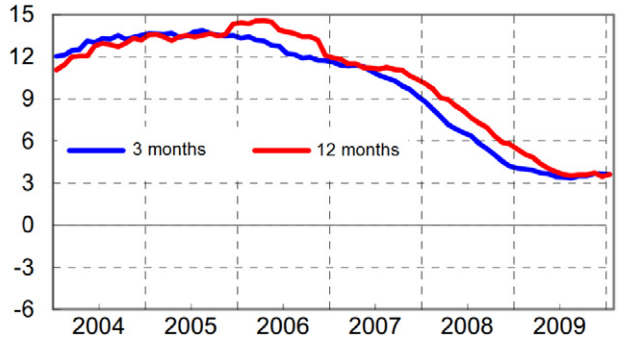

Figure 2. Households loan market, percentage trend. Blue line shows percentage reduction registered over 3 months and red line shows annual percentage reduction. Reproduced with permission from Bank of Italy (2010).

energy deployment as well. Despite the effort made, there is a substantial 'efficiency gap' between a consumer's actual investment in energy efficiency and those that appear to be made in the consumer's own interest (Golove and Eto 1996). This efficiency gap is defined as the difference between the highest implicit discount rate and the market rate of return associated with similar investments. Although most of the energy efficiency measures are cost-effective with a positive net present value, they are not implemented. Various reasons such as financial barriers, insufficient information/knowledge and analytical capacity (Sanstad and Howarth 1994), low priority of energy issues, transaction costs, uncertainty of savings, split incentives, liquidity constraints in capital markets (Blumstein *et al* 1980), and the need for investments in upfront costs explain the existence of an energy efficiency gap.

This paper discusses the potential application of PACE to the Italian context. To ensure the high impact of any policy, a key step is to identify the potential population which would benefit from it. We referred to Lorenz curve and Gini index to quantify the households belonging to the low–middle income (figure 1, see note (iii) in the appendix). The average income per capita is 18 900 € (taxpayer) and 22 700 € (owner taxpayer), consequently a typical energy investment with a value of 16 000 € would represent 85% and 70% of their annual income, respectively. The Gini coefficient (presented within figure 1 in the legend in parenthesis, see note (iv) in the appendix) in both cases analyzed in figure 1, exceeds 0.4 showing that income inequality is reasonably high in Italy. It is also important to keep in mind that Italy is characterized by north–south dualism, which reflects also in energy investments. The point in case is that the income gap between the average household in northern and southern Italy, accounts approximately 32% (ISTAT 2010, see note (v) in the appendix). For instance, the highest (Trentino Alto Adige) and the lowest (Campania) average household income accounted approximately 21.465 € and 12.432 €, respectively.

With regards to energy investments, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA 2010a, 2010b) reported that 71% of energy retrofits (e.g. windows replacement, solar thermal, building envelope and energy retrofits) were completed in the north whereas 16% and 13% were located in center and south, respectively (see note (vi) in the appendix). Similarly, the solar photovoltaic (PV) investments had comparable trend: the north leading with 56% of installations, followed by 17% and 27% in central and south, respectively (GSE 2011, see note (vii) in the appendix). The evidence reported suggests that the typical household investing in energy improvement is located in the well off economic regions in Italy predominantly found in the northern areas. The trend illustrated conflicts with the abundant insolation in southern Italy e.g. daily average equals to 5 kWh/m^2 compared to 4 kWh/m^2 in northern, ENEA database (see note (viii) in the appendix), which results in higher solar PV system performance as well as net present value (NPV) results, making investments in those regions more attractive. Thus, to address this economic dualism in relation to energy efficiency investments, it is imperative to move away from north to south, and appropriate financing policies are relevant to overcome the dichotomy in economic well being.

These features need to be considered with reference to the Italian credit context. The financial crisis, which started in August 2007, has worsened credit supply conditions in the country. Referring to the household data available, access to credit has decelerated from 2006 to 2009. Since 2006 consumers credit supply went down by 7.5% points (figure 2). The slowdown recorded has coincided with both the economic crisis and the deterioration of consumers' 'credit worthiness' in addition to the decrease of consumer spending and investments (Bank of Italy 2010). Such concurrence of events tightened consumers credit supply (Bank of Italy 2012).

Lower financing barriers in a country characterized by low income level (particularly relevant in southern Italy), high inequality and worsening consumers credit access, will potentially enable energy efficiency and renewable deployment on a large scale. A key issue emerging within the debate in previous years, is how policy can create the right conditions for such investments to occur.

This paper is structured as follows. Section 2 provides an overview of the proposed property assessed clean energy—PACE—policy with different scenarios modeled. Within section 3 we compare financing solutions relevant for residential energy projects. Section 4 is then used to draw an overall assessment of the findings presented in the paper.

2. PACE property assessed clean energy

A property assessed clean energy (PACE) policy focuses on the upfront cost in energy improvements and renewable energy deployment. It is structured to enable 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. The long repayment period and transferability of the payments allow property owners to invest in deeper energy savings and renewable projects that pay back over a longer period than many existing financing options allow (Fuller *et al* 2009b). In the United States, 27 states enacted legislation and programs that have been implemented through city, county and state-level initiatives (see note (ix) in the appendix). Significantly, local governments determine the eligible energy efficiency or renewable energy technologies for financing (see note (x) in the appendix). For instance, take the case of two cities: city of Berkeley (California) allowing solar PV installation and city of Babylon (New York) permitting solar PV, solar thermal and energy efficiency measures. In both cases, the program has diverse approaches according to the area and design. Indeed, the primary goal of PACE is to address financial barriers to energy investments and to encourage regional and national governments to integrate energy efficiency and renewable energy planning.

To assess the impact of PACE financing on residential customers, we have created a model to compare the net present value of annual cash flows over 25 years for energy retrofits (see note (xi) in the appendix). The financing calculator was designed in close collaboration between the University of California, Berkeley and the Polytechnic University of Marche, Italy. The following results are based on modeled data. In this respect, we designed a user-friendly tool to support homeowners in understanding the potential financial impact of financing solar PV, solar thermal, and energy efficiency (see note (xii) in the appendix). Model assumptions are summarized in table 1. Data for the Marche region are used as the baseline for the scenarios modeled. The final results obtained by the financing calculator are based on Marche average energy consumption and savings as well as the prevailing energy prices, solar irradiation and technological performances for that region. The Marche region was chosen because energy efficiency savings are greater in North Italy (due to energy consumption being significantly higher compared to other areas), while photovoltaic electricity production is higher in South Italy due to the better insolation. It is important to note that this case does not take into account differences among climate areas. At the same time Marche region has values similar to the average values across all of Italy (AEEG 2010).

For an average household in Italy, the net present value was computed for solar PV installation only and then for combined energy efficiency improvements and solar PV installation. Different scenarios are modeled and we took into account the year of installation (relevant to compute the solar PV incentive) as well as the electricity and gas price escalation (tables 2 and 3). Between 2005 and 2011, Italian nominal electricity rates rose by 25% and gas rates registered an increase of 16% in the last three years (AEEG 2010). Based on these changes, forecast scenarios including gas and electricity price escalation have a high probability of occurrence. Our analyses assumed the gas heating system, as the high electricity price in Italy makes electric heating in this country unlikely. The NPV values computed for combined energy efficiency improvements and solar photovoltaic installation are affected by gas price as energy efficiency improvements (e.g. windows replacement) impact on heating consumption. The main results obtained are sensitive to the cost of solar, which is influenced by PV module price as it is the main cost driver, representing 60% of total investment according to EPIA and Rocky Mountain Institute data (EPIA 2010, Rocky Mountain Institute 2010). Price escalation represents another sensitive variable in the assessment provided by the meter.

A version of the calculator used for the models is maintained online with the possibility to enter more updated assumptions and values summarized in table 1 (i.e. PV module price).

NPV results presented in table 2 have been computed using the following formula (1):

$$\mathrm{NPV} = \sum_{i=0}^{N} \frac{\mathrm{ACF_n}}{(1+d)^n} \qquad (1)$$

where ACF, annual cash flow; d, discount rate.

The annual cash flow is given by equation (2):

$$\mathrm{ACF} = \mathrm{energy\ savings\ EE} + \mathrm{energy\ savings\ PV} + \mathrm{FiT} + \mathrm{net\ metering} + \mathrm{tax\ credit} - \mathrm{FC} - \mathrm{OM} \qquad (2)$$

where energy savings EE, gas bill savings from energy efficiency; energy savings PV, electricity bill savings from solar PV; FiT, feed-in tariff incentive; net metering, net metering incentive; tax credit, tax credit rebate allowed for energy efficiency upgrades; FC, financing cost; OM, operation and maintenance costs. Those values are expressed by the following equations ((3)–(6)):

$$\mathrm{energy\ savings\ EE} = \mathrm{expected\ gas\ saved} \times \mathrm{gas\ price\ (€/m^3)} \qquad (3)$$

$$\mathrm{energy\ savings\ PV} = \mathrm{expected\ electricity\ saved} \times \mathrm{electricity\ price\ (€/kWh)} \qquad (4)$$

$$\mathrm{FiT} = \mathrm{kWh\ from\ solar\ PV} \times \mathrm{Tariff\ (€/kWh)\ of\ FiT\ (see\ note\ (xiv)\ in\ the\ appendix)} \qquad (5)$$

$$\mathrm{Net\ metering} = \min[E_\mathrm{e}; E_\mathrm{f}] + C_\mathrm{s} E_\mathrm{n} \qquad (6)$$

where E_e, electricity exported to the grid (electricity withdrawn from the grid); E_f, electricity fed into grid

Table 1. Model assumptions (Marche region's data baseline). (Note: a version of the calculator used for the models is maintained online for public use at http://rael.berkeley.edu/financing-italy-IV.)

	Model assumptions—Italy
Energy consumption	For the Marche case, consumption is based on 2009 ISTAT (see note (xiii) in the appendix) Environmental Data. Family (2–3 people) average consumption is 2700 kWh/yr and 1497 m^3/yr of natural gas.
Electricity price	The electricity price is based on AEEG residential rate of 0.1583 €/kWh (average rate for 2700 kWh/yr consumption)
Gas prices	The gas price is based on AEEG residential rate of 0.7234 €/m^3 (average rate for 1497 m^3/yr consumption)
Solar PV system	• Solar size depends on percentage supplied by solar PV with an installed cost of 4.00 €/W • Operation and maintenance costs are assumed 0.1%/year of installed cost
Solar power production	• According to UNI 10349 and UNI 8477—solar radiation • Default correction for Azimuth South and 30° tilt • Increase production of 20% relative to fixed system • General system losses of 20%
Solar performance	PV system life of 25 years, with a performance degradation of 0.83%/year
Inverter	Inverter replacement in year 12 for approximately 600 €/kW
Solar thermal system	Solar thermal size depends on the household size with an installed cost of 1000 €/m^2
Solar thermal production	• According to UNI 10349—solar radiation • Default correction for Azimuth South and 30° tilt • Designed according to Itaca Protocol • Inlet and outlet water temperature ranging from 15 to 40 °C, according to UNI 11300:2008
Solar thermal performance	Solar thermal system life of 25 years, with a performance degradation of 0.83%/year
Rebate (see note (xiv) in the appendix) and revenues (see note (xv) in the appendix)	• Feed-in tariff is paid for electricity produced by solar PV over a period of 20 years • 'Net metering incentive' is paid for energy exported to the grid • Minimum prices for electricity sold are guaranteed by law (GSE)
Tax credit (see note (xvi) in the appendix)	Tax rebate of 55% improvement cost is allowed for energy efficiency
Financial parameters	• Average inflation rate of electricity price of 3% • Average inflation rate of gas price of 5% • General inflation rate is not considered (zero) • Discount rate of 5% • Interest rate of 5.5% with a term of 20 years

(electricity injected into grid); C_s, service cost (distribution); E_n, net energy exchanged to the grid (see note (xiv) in the appendix). Under 'the net metering scheme', the electricity generated by solar PV system and injected into the grid can be used to offset the electricity withdrawn from the grid. The Italian Energy Agency (GSE, Gestore dei servizi elettrici) provides a contribution to the customer based on injections and withdrawals of electricity. Table 2 provides more information concerning electricity produced by solar PV, electricity consumed (e.g. average household consumption), electricity fed (electricity injected into the grid), electricity exported (electricity withdrawn from the grid) and electricity self-consumed (electricity consumed at the time of production). We assumed three time-ranges during the day in which the household consumes electricity (see note (xvii) in the appendix) (e.g. 7 am–9 am; 11 am–2 pm; 6 pm–10 pm). Electricity consumption is assumed to be constant in these time-ranges (a version of the financing calculator is maintained online with the possibility to enter more different time-ranges consumptions) (see note (xviii) in the appendix). Consequently, the electricity exported and fed into the grid derives from these assumptions (equations (7) and (8)):

$$\text{Electricity exported (withdrawn)} = \text{electricity produced} - \text{electricity consumed} \quad (7)$$

(If electricity produced ≥ electricity consumed);

$$\text{Electricity fed (injected)} = \text{electricity consumed} - \text{electricity produced} \quad (8)$$

(If electricity consumed ≥ electricity produced).

All the values needed to compute the feed-in tariff incentive are listed in table 1 and in the corresponding notes. Electricity produced by solar PV is awarded by tariff incentives over a period of 20 years (see note (xiv) in the appendix). Electricity fed and exported to the grid are quantified according to a net metering scheme over a period of 20 years (see notes (xiv) and (xv) in the appendix). Values

Table 2. Electricity produced by solar PV, electricity consumed and grid compensation.

Year	Electricity produced (kWh)	Average electricity consumed (kWh)	Electricity fed into the grid (kWh)	Electricity exported to the grid (kWh)	Electricity self-consumed (kWh)
2012	3985	2721	2792	1528	1193
2013	3952	2721	2762	1532	1190
2014	3919	2721	2732	1535	1186
2015	3885	2721	2703	1539	1183
2016	3852	2721	2673	1542	1179
2017	3819	2721	2643	1546	1176
2018	3786	2721	2614	1549	1172
2019	3753	2721	2584	1553	1169
2020	3719	2721	2554	1557	1165
2021	3686	2721	2525	1560	1161
2022	3653	2721	2495	1564	1158
2023	3620	2721	2466	1567	1154
2024	3587	2721	2436	1571	1150
2025	3553	2721	2407	1575	1147
2026	3520	2721	2377	1578	1143
2027	3487	2721	2348	1582	1139
2028	3454	2721	2319	1586	1135
2029	3420	2721	2289	1590	1131
2030	3387	2721	2261	1595	1127
2031	3354	2721	2232	1599	1122
2032	3321	2721	2203	1603	1118
2033	3288	2721	2174	1608	1114
2034	3254	2721	2145	1612	1109
2035	3221	2721	2117	1617	1104
2036	3188	2721	2088	1622	1100

Table 3. Net present value comparison, basic scenario (see note (xix) in the appendix). (Note: parenthesis indicate negative value.)

	Year of installation				
	I semester 2012	I semester 2013	I semester 2014	I semester 2015	I semester 2016
Solar PV	8199 €	5493 €	2299 €	(862) €	(4270) €
Solar PV and EE	8474 €	5768 €	2574 €	(587) €	(3995) €

are reported for 25 years as we assumed a PV system life of 25 years, relevant to assess electricity saved.

As shown in tables 3–5 and figures 3 and 4, most of the projected scenarios have a positive net present value, especially when energy improvements are completed in 2012 and 2013. It is important to note that the key factor affecting this result is a feed-in tariff scheme. Forecast scenarios under the highest tariff incentive (2012–13) will tend to provide positive net present values (the feed-in tariff scheme declines monthly in 2011 and every six months thereafter). A study conducted on the sensitivity of NPV to feed-in tariff rates highlights a huge effect. In 2013 feed-in tariff (tariff €/kWh produced) and net metering scheme will be replaced by the all-comprehensive tariff, which allows specific rates for electricity feed into a grid and different tariffs for electricity self-consumed. With the previous scheme the entire electricity produced by the solar PV system is incentivized and additional contribution is recognized to offset the net electricity exchanged with the grid (net metering scheme). The introduction of the all-comprehensive tariff will negatively affect NPV projects (figure 3 and tables 4 and 5). The analysis showed that the introduction of the all-comprehensive scheme resulted in an NPV reduction of 60% for years 2013/2014 and 2014/2015 and an impressive erosion of NPV value in 2016 getting negative value (solar PV case). In the case of solar PV installation and windows replacement, the NPV value will decrease by 55% and 77%, in 2013/2014 and 2014/2015 respectively, and an impressive erosion of NPV value will occur in 2016. In addition, the impact of a potential electricity and gas price escalation was studied (table 5). A projected increase in electricity and gas prices by 2%/yr resulted in an NPV value increase of 27% for solar PV only and of 42% for solar PV and EE (results computed derived from average increase registered in NPV project values).

Figure 4 shows the cash flow for the base case over 25 years. The high cash flow is mainly due to the 'Conto Energia' (see note (xx) in the appendix) incentive, corresponding to 0.274 €/kWh for the first semester in 2012 and the negative drop is driven by the cost of purchasing a new inverter (these inverters are expected to be replaced at this time). Income in the last five years is a direct consequence of the financing being repaid in 20 years. While interpreting these results, one should keep in mind that the Marche data is used as baseline and therefore the values provided are typical for central Italy.

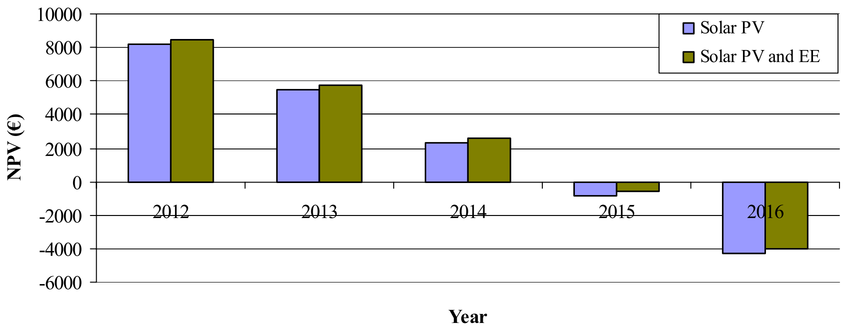

Figure 3. NVP comparison based on year of installation.

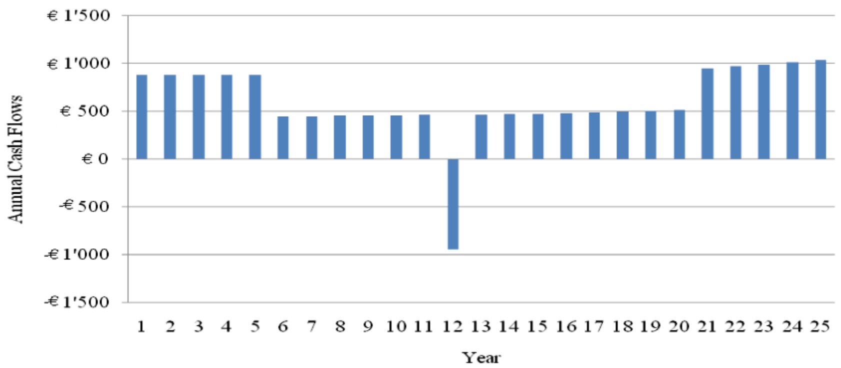

Figure 4. Annual cash flow projections for solar PV and EE installed first semester 2012.

Table 4. NPV and feed-in tariff comparison (2013–6). (Note: in 2013 the feed-in tariff scheme will be replaced by an all-comprehensive tariff. Consequently we are unable to compute the percentage tariff reduction of two different supporting schemes. Percentage reductions are computed referring to the first semester of each year. The NPV results presented have been computed using previous equations ((1) and (2)).)

	NPV and tariff % reduction with respect to solar PV installation in the previous year			
	2012/2013 (%)	2013/2014 (%)	2014/2015 (%)	2015/2016 (%)
NPV solar PV	−33.00	−58.15	−62.51	−395.36
NPV solar PV and EE	−31.93	−55.37	−77.20	−580.58
Tariff	—	−20.80	−25.93	−40.45

Table 5. Scenario for electricity and gas price escalation. (Note: NPV results presented have been computed using previous equations (equations (1) and (2)).)

	Year of installation						
	I semester 2012	I semester 2013	I semester 2014	I semester 2015	I semester 2016	Electricity price (%)	Gas price (%)
Solar PV	7855 €	5184 €	1955 €	(1207) €	(4615) €	+2	—
Solar PV and EE	7422 €	4716 €	1522 €	(1639) €	(5047) €	+2	+2
Solar PV	8597 €	5891 €	2697 €	(465) €	(3873) €	+4	—
Solar PV and EE	8602 €	5895 €	2702 €	(460) €	(3868) €	+4	+4

3. Comparison of financing solutions

Homeowners can opt for different solutions to finance energy improvements. To select the most cost-effective options we compared the NPV and the profitability index (which quantifies the amount of value created per unit of investment) (see note (xxi) in the appendix) for a typical energy package (figures 5–7). The NPV is the main financial tool for the evaluation of budgeting investment projects (Ross *et al* 1996). Quantifying in a single value the investment benefit allows comparisons with diverse options. Economic evaluation is a worthy method to select the most cost-effective way to finance our energy investments. This energy package has an assumed value of 16 000 € depending on how it is financed and it includes the solar PV and EE options (see note (xxii) in the appendix). We assumed an average investment value of

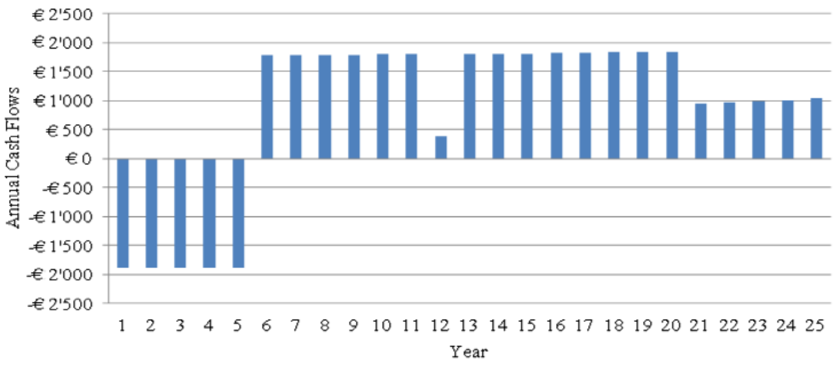

Figure 5. Annual cash flow projections based on a 5 year unsecured personal loan.

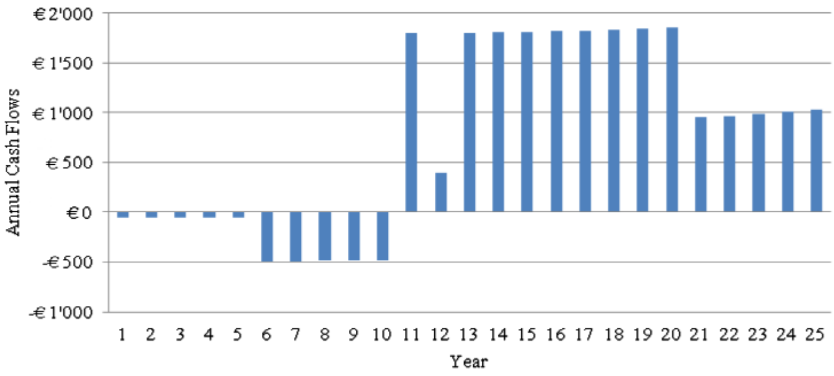

Figure 6. Annual cash flow projections based on a 10 year financing bank solution.

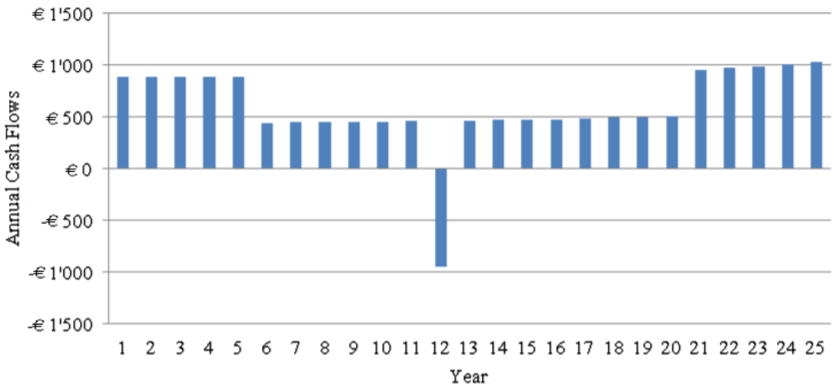

Figure 7. Annual cash flow projections based on a tax assessment PACE program.

12 000 € for solar PV system (3 kW system) and of 4000 € for windows replacement (according to ENEA, 45% of total energy efficiency projects regarded windows replacement in the range period 2007–10). Tax credit of 55% of the energy efficiency cost has been taken into account (tax credit is split over the first five years). Given the limited investment amount required, suitable financings provided by banks do not exceed 10 year terms. Solutions aimed at house purchases are typically characterized by long terms (i.e. 20 years). Alternatives are compared with the application of three different options (table 6):

- a 5 year unsecured personal loan at 8.97% (see note (xxiii) in the appendix);
- a 10 year financing bank solution for solar PV and EE (see note (xxiv) in the appendix) at 7.01% (see note (xxv) in the appendix);
- a 20 year tax assessment PACE program.

Figures 5–7 show the cash flow projections based on the alternative financing solutions. The negative pillars reflect the repayment obligation taking into account different repayment periods and interest rates (see note (xxvi) in the appendix). In the first five years, the negative impact of cash flows is compensated by the tax credit of 55% for energy efficiency retrofits. Note that the analysis has considered the most convenient options offered by financial institutes in Italy, but these are not always available and depend on the bank

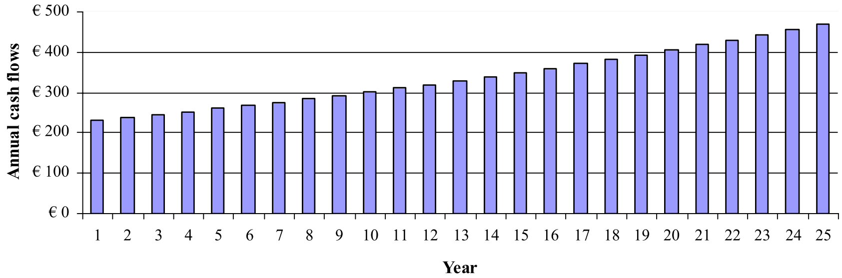

Figure 8. Annual cash flow projections based on loan for use. (Note: in this specific case, annual cash flows correspond to the electricity bill savings from solar PV. ACF = energy savings PV.)

Table 6. Comparison of financing options. (Note: NPV results presented have been computed using the previous equations (equations (1) and (2)).)

			Difference from best case	
Financing options	NPV	PI	NPV	PI
PACE program	8474 €	0.53	—	—
Unsecured personal loan	7364 €	0.46	1110 €	0.07
Bank package for solar PV and EE	7561 €	0.47	913 €	0.06

or financial institute's location. Our findings show that a well-designed PACE program is always superior to the other financing mechanisms as it provides a higher NPV and profitability index (PI). The closest option to PACE is the 10 year financing bank solution, where the gap accounts for about 913 € in NPV terms and 0.06 regarding the PI. The break-even interest rate, which is the value where the NPV of PACE program equals the NPV of other financing options, corresponds to 6.1% for the bank package and to 6.3% in the case of the unsecured personal loan.

Considering the financing solutions provided by the private sector, many companies (see note (xxvii) in the appendix) introduced the loan for use contract to support solar PV installations. In civil law, a loan for use agreement is defined as a free concession of anything, either movable or not movable, under a certain timeframe with the obligation to return the good received (Civil Code art. 1803-1812). It is important to note that this type of contract is available only for solar PV. Companies are responsible for all the project's aspects in terms of cost, installation and maintenance as well as beneficiaries' incentives. The homeowner will benefit from the electricity produced by the solar system. This formula is very attractive for companies which take advantage of generous feed-in tariff schemes over a period of 20 years. EE is not supported by a similar policy, and consequently it is less attractive business for firms. Greater uncertainty in savings added to limited profit margins are key issues in discouraging companies from designing suitable financial products for EE.

To provide a complete analysis of the financing solutions available on the market, we considered the 'typical loan for use contract' offered by some private companies (figure 8). This formula ensures positive cash flows given by the energy saved on monthly utility bills and the net present value derived is about 4175 €. Comparing this result to NPV based on PACE tax assessment (table 3), we registered a difference of about 4024 €. The gap computed is mainly due to the 'Conto Energia' incentive. The feed-in tariff scheme contributes for about 50–55% to positive annual cash flows and consequently to the NPV value. With respect to previous financing solutions (bank loan and PACE program), homeowners would be the beneficiaries of the feed-in tariff. In the case of private companies providing financial solutions, firms will profit by this incentive. Even though the financing formula provided by the private sector addresses upfront cost, it does not maximize NPV for customers.

4. Conclusion

A key issue emerging within the debate in previous years is how policy and programs may influence consumer perception and enable investment in energy efficiency. The aim of this study was to underline the importance and the need for new financing models to address the initial financing risks and cash flow barriers of clean energy projects. Given the high energy-saving opportunities in the residential sector, we referred to the Lorenz curve and Gini index to analyze the distribution of property owner wealth. Income inequality is reasonably high in Italy, where the Gini index assumes a value of 0.40 regarding owner taxpayers and 0.42 for taxpayers overall. This corresponds to 72% and 80% of the investigated population with an income lower than 26 000 €/yr, suggesting that due to the overall condition of Italians households, investment in energy projects is unlikely. A typical energy investment with a value of 16 000 € would represent 85% and 70% of their annual income. In addition, the financial crisis started in August 2007 has worsened the country's credit supply conditions. Lower financing barriers in a country characterized by low income levels (particularly relevant in southern Italy), high inequality and worsening consumer credit access, will potentially enable energy efficiency and renewable deployment on a large scale.

Table A.1. Source: Department of Treasury and ISTAT 2010.

	Taxpayers			Owner taxpayers		
Income range (€, euro)	Taxpayers number	Average income	Relative frequency	Owner taxpayers number	Average income	Relative frequency
<10 000	14 112 749	4 656	0.340	6 210 707	4 946	0.256
10 000–26 000	18 914 233	17 458	0.456	11 299 196	17 820	0.465
26 000–55 000	6 970 245	34 349	0.168	5 460 127	34 631	0.225
55 000–75 000	734 919	63 689	0.018	623 904	63 737	0.026
>75 000	790 908	129 973	0.019	696 533	130 249	0.029
Total	41 523 054		1.000	24 290 467		1.000

The implementation of a PACE program could represent the most cost-effective way to finance energy improvements. If well-designed, it could in principle ensure higher NPV to consumers than the other market options. Considering a break-even interest rate as the value where the NPV of PACE program equals the NPV of other financing options, it corresponds to 6.1% for the bank package and to 6.3% in the case of an unsecured personal loan. We also provided an analysis of the financing solutions available on the private market, considering a typical one loan for use contract offered by some companies. Even if private mechanisms address the upfront cost, they do not maximize NPV for consumers.

Unlocking the investment potential of the private sector and of individual consumers presents one of the major challenges for the country. A PACE program can be a powerful policy for regional governments in order to increase the accessibility of energy-saving measures. The economic benefits of energy cost savings are distributed over time, but an upfront cost is required to begin these improvements. This model corrects this disconnection and allows the costs of the clean energy installation to be distributed over time just as the benefits are. Local governments play a key role in creating the right framework conditions to improve energy performance in stock buildings. Meeting national energy needs and achieving climate targets will be possible only with a true understanding of clean energy investments and the methods that can be applied to finance them.

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Appendix. Notes

(i) Primary energy import = (net imports/final consumption).
(ii) Union Oil, Data Book 2011.
(iii) The Lorenz curve is based on the data listed in table A.1.
(iv) Mathematically it is based on the Lorenz curve by taking the ratio between the area enclosed by the line of perfect equality and the Lorenz curve and dividing this by the total area under the hypothetical line of equality. To compute the Gini index we used the following discretized formula.

$$G = 1 - \sum_{i=1}^{n} (X_i - X_{i-1})(Y_i + Y_{i-1}).$$

(v) Average household income by region (ISTAT 2010) (see table A.2).
(vi) Data on energy efficiency investments are shown in figure A.1 (ENEA database 2010a, 2010b).
(vii) Data on solar PV installations are shown in table A.3 (GSE database 2011).
(viii) ENEA database http://www.solaritaly.enea.it/.
(ix) Database of states incentives for renewable and efficiency, updated October 2011.
(x) There are no restrictions to special subset of population. The program aims to have the higher participation rate possible. According to Fuller's analysis (Fuller 2009) a relevant issue related to energy programs is the low participation rate. Despite the 150+ loan programs for residential energy efficiency in the United States, only a tiny

Table A.2. Note: regions are clustered in northern, central and southern Italy.

Regions	Average households income (€/year)
Piemonte	19 717
Valle d'Aosta–Vallée d'Aoste	20 814
Lombardia	20 122
Bolzano-Bozen	21 465
Trento	19 285
Veneto	19 123
Friuli-Venezia Giulia	20 254
Liguria	19 999
Emilia–Romagna	21 014
Toscana	19 472
Umbria	17 716
Marche	18 215
Lazio	18 833
Abruzzo	14 861
Molise	14 987
Campania	12 432
Puglia	13 159
Basilicata	14 187
Calabria	13 130
Sicilia	13 063
Sardegna	14 421

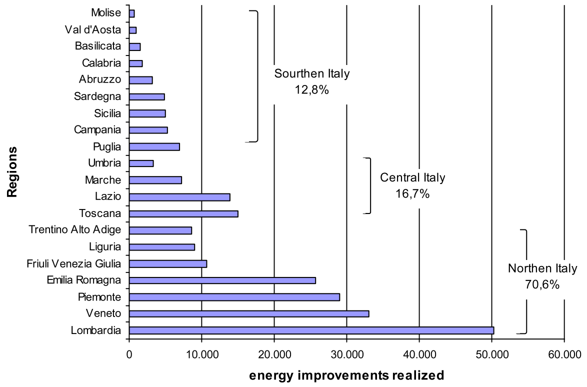

Figure A.1. Energy retrofits completed by region, 2010 (Italy).

Table A.3. Solar photovoltaic installations by region, 2011 (Italy).

Regions	No. installations	Installed capacity (MW)
Lombardia	48.692	1.322
Veneto	44.997	1.157
Piemonte	24.095	1.071
Emilia–Romagna	31.010	1.267
Friuli-Venezia Giulia	17.291	296
Liguria	3.212	54
Trentino Alto Adige	14.968	300
Toscana	17.479	469
Lazio	17.954	861
Marche	12.048	787
Umbria	8.007	319
Puglia	22.926	2.186
Campania	10.071	376
Sicilia	19.862	866
Sardegna	14.629	403
Abruzzo	7.346	452
Calabria	8.770	237
Basilicata	3.716	222
Val d'Aosta	1.118	14
Molise	1.605	117
Total	329.796	12.773

fraction of the population has been reached. She found a rate less than 0.1% of their 'potential' customers.

(xi) A version of the calculator used for the models is maintained online for public use at http://rael.berkeley.edu/financing-italy-IV. The financing calculator provides an estimate of the net present value of annual cash flows over 25 years of energy investments (solar PV, solar thermal and energy efficiency) selected by the user (PACE financing is included). The financing calculator deploys Marche data in relation to:

- *Electricity and gas consumption*. The user has to provide his energy (electricity and/or gas) monthly consumption. In the case the user is unable to provide data for the entire year, he has to at least enter energy consumption values for one month. The financing calculator will simulate the overall user energy consumption deploying the ratio between the monthly consumption provided and the corresponding monthly consumption based on the average household in Marche region according to ISTAT 2010, National Statistical System, Environmental Data.
- *Solar PV electricity production*. To compute electricity produced by solar system we considered Marche region irradiation.

(xii) The scenarios modeled in this paper do not consider the solar thermal system. A version of the calculator used for the models is maintained online for public use with the possibility to enter more assumptions. In this respect, users interested in solar thermal installation can include its assessment in the results provided by the meter. Assumptions related to solar thermal installation are listed in table 1.

(xiii) ISTAT is the national statistical system.

(xiv) 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. In 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 2011–6 (table A.4).

In 2013, feed-in tariff and net metering will be replaced by the all-comprehensive tariff. The mechanism will be based on two different tariffs (€/kWh): tariff for energy feed into grid and tariff for energy consumed (table A.5).

Reduction tariff (computed on tariff listed in table A.4):

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%)

(xv) Net metering scheme for photovoltaic system owner has taken in place in Italy. The scheme is regulated by 'ARG/elt 74/2008', Attachment A—Testo integrato dello scambio sul posto (TISP). This incentive is mathematically computed by the following formula:

$$\min[E_e; E_f] + C_s E_n$$

where:

E_e, electricity exported to the grid (electricity withdrawn (kWh) × electricity price (€/kWh));

E_f, electricity fed into the grid (electricity injected into the grid (kWh) × electricity price (€/kWh));

C_s, service cost (distribution cost (€/kWh));

E_n, net energy exchanged to the grid (kWh).

(xvi) Tax credit is given up of 55% of the energy efficiency cost investment (National Act law 27 December 2006 no. 296):

Table A.4. Feed-in tariff scheme (June 2011–6).

	Feed-in tariff in Italy (period June 2011–6)					
	June 2011		July 2011		August 2011	
Size (kW)	On building (€/kWh)	Other (€/kWh)	On building (€/kWh)	Other (€/kWh)	On building (€/kWh)	Other (€/kWh)
$1 \leq P \leq 3$	0.387	0.344	0.379	0.337	0.368	0.327
$3 < P \leq 20$	0.356	0.319	0.349	0.312	0.339	0.303
$20 < P \leq 200$	0.338	0.306	0.331	0.300	0.321	0.291
$200 < P \leq 1000$	0.325	0.291	0.315	0.276	0.303	0.263
$1000 < P \leq 5000$	0.314	0.277	0.298	0.264	0.280	0.250
$P > 5000$	0.299	0.264	0.284	0.251	0.269	0.238
	September 2011		October 2011		November 2011	
$1 \leq P \leq 3$	0.361	0.316	0.345	0.302	0.320	0.281
$3 < P \leq 20$	0.325	0.289	0.310	0.276	0.288	0.256
$20 < P \leq 200$	0.307	0.271	0.293	0.258	0.272	0.240
$200 < P \leq 1000$	0.298	0.245	0.285	0.233	0.265	0.210
$1000 < P \leq 5000$	0.278	0.243	0.256	0.223	0.233	0.201
$P > 5000$	0.264	0.231	0.243	0.212	0.221	0.191
	December 2011		I semester 2012		II semester 2012	
$1 \leq P \leq 3$	0.298	0.261	0.274	0.240	0.252	0.221
$3 < P \leq 20$	0.268	0.238	0.247	0.219	0.227	0.202
$20 < P \leq 200$	0.253	0.224	0.233	0.206	0.214	0.189
$200 < P \leq 1000$	0.246	0.189	0.224	0.172	0.202	0.155
$1000 < P \leq 5000$	0.212	0.181	0.182	0.156	0.164	0.140
$P > 5000$	0.199	0.172	0.171	0.148	0.154	0.133

Table A.5. All-comprehensive tariff in Italy (period 2013–6).

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

- energy retrofits, maximum cost allowed € 181 818.18 and maximum tax credit € 100 000;
- building envelope, maximum cost allowed € 109 090.90 and maximum tax credit € 60 000;
- solar thermal system, maximum cost allowed €109 090.90 and maximum tax credit € 60 000;
- replacement HVAC, maximum cost allowed €54 545.45 and maximum tax credit € 30 000.

Tax credit is split over the first five years.

(xvii) Consumption is based on 2009 National Statistical System (ISTAT)—Environmental Data. Family (2–3 people) average consumption is 2700 kWh/yr.

(xviii) We used the normal distribution to describe the daily solar production trend. The normal distribution is defined by two parameters, i.e. the mean, μ and the standard deviation σ. These parameters represent, respectively, factors of location and scale. Normal distribution is a very simple way to model solar PV daily production and it has been used in order to compute the net metering contribution, which covers part of the charges incurred by the customer for withdrawing electricity from the grid. This contribution ranges approximately from 300 to 350 €/yr, depending:

- time-ranges consumption;
- different values of normal distribution (e.g. mean and variance).

(xix) NPV calculations that assume the solar PV is installed in years 2013, 2014 or 2015 is calculated as a 25 year NPV starting from the year of installation.

(xx) Italy feed-in tariff scheme.

(xxi) PI quantifies the amount of value created per unit of investment. (Present value of future cash flows/initial investment.)

(xxii) Fuller *et al* (2009a).

(xxiii) Average interest rate applied by 20 banks.

(xxiv) After the introduction of feed-in tariff scheme, many banks offered specific packages for solar PV.
(xxv) Average interest rate applied by 10 banks which provided a specific energy package.
(xxvi) The cost of purchasing a new inverter is about 952 €. When we consider an 'unsecured loan' and 'financing bank solution' (figures 3 and 4), the repayment obligation period ends before year 12 when the inverter is expected to be replaced. Annual payments for the unsecured loan are about 4110 € and for the financing bank solution are about 2279 €. In both cases the annual payment is larger than the cost of the inverter. The charts (both cases) do not show negative pillars because revenues (feed-in tariff, net metering incentive) and energy bill savings compensate for these costs.
(xxvii) Private companies: Enel Green Power, Sorgenia, Enfinity.

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