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The Linkage Between Income Distribution and Clean Energy Investments: Addressing Financing Cost

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Summary

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Keywords: Financing Barriers, Energy Efficiency, Solar PV, Energy Investments

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THE LINKAGE BETWEEN INCOME DISTRIBUTION AND CLEAN ENERGY INVESTMENTS: ADDRESSING FINANCING COST

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Abstract

With a focus on alternative methods for accelerating clean energy policy adoption, this study introduces 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. Limited access to credit, due to socio-economic status and the lack of guarantees, are key issues related to financing barriers. Implementing a policy such as PACE – Property Assessed Clean Energy – allows for the provision of up-front 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 when the lack of access to capital tends to stall them.

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Introduction

The diffusion of energy efficiency and renewable energy technologies and their contribution to meeting the world's energy needs hinges critically on the strength of government support. The IPCC notes that the future share of RE 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 2011). An important part of the energy equation is determined by the residential sector, given that housing structures account for more than 35 percent of total energy use and almost 23 percent 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[i] being approximately 87.7% in 2009, compared to an EU average of 56% (AEEG 2010). Economically, the total energy cost represents 3.3% of national GDP[ii]. According to Union Oil projections, in 2011 energy costs are expected to surpass 60 billion euros, the peak energy 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 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 energy deployment as well. Despite the effort taken, there is a substantial "efficiency gap" between a consumer's actual investment in energy efficiency and those that appear to be in the consumer's own interest (Andersson and Baker 1993). This efficiency gap is defined as the difference between the highest implicit discounted rate and the market rate of return associated with the consumer's decision process. Although most of the energy efficiency measures are cost-effective with a positive net present value, they are not implemented. There are various reasons that explain the existence of an energy efficiency gap which in turn hinders the realization of energy improvements. Such reasons include financial barriers, insufficient information/knowledge and analytical capacity (Sanstand e Howarth, 1994), low priority of energy issues, transaction costs, uncertainty of savings, split incentives, liquidity constraints in capital markets (Blumetein, 1990), and the need for investments in upfront costs. A key issue emerging within the debate in previous years, is on how policy and programs may influence consumer perception and enable investment in energy efficiency.

This study focuses on the initial costs and cash flow barriers to the implementation of renewable energy and energy efficiency deployment. Financing barriers are particularly relevant for low-income households who are unable to borrow at any interest rate due to their economic status or "credit worthiness". A key point is how policy can create the right conditions for such investment to occur, especially when the lack of access to capitals tends to stall them. This paper is structured as follows. In section 2 we analyze the distribution of wealth using a Lorenz Curve to assess the amount of income earners who may be liable to financing barriers. Section 3 provides an overview of the proposed PACE policy with different scenarios modeled. Within Section 3 we also compare three financing solutions relevant for residential energy projects. The concluding section is then used to draw an overall assessment of the findings presented in the paper.

Section 2: Distribution of wealth in Italy and access to credit

Lorenz curve and Gini coefficient are widely used in economics to estimate income inequality. In this study we extend the application of this metric to assess the accessibility of energy saving measures. The initial cost of credit could be overwhelming, especially for low income households who typically are unable to borrow at any interest rate as the result of their economic status or "credit worthiness". Considering tenure and the financing of owner occupied housing, table 1 shows that rented houses are characterized by low-income households and the ownership of houses leans toward the upper-income level. Tenure is associated with higher levels of income and wealth, as well as the possibility of access to credit. As shown in table 1, 21.9% of households in the top quintile have financed their house through a mortgage and this percentage decreases to 12.3% for the households in the mid-quintile and to 5% for the households in the lowest quintile. Given the strong link between real estate property and wealth distribution, financing costs represent a major barrier to house purchase. This is true for poor-households who have restricted access to credit. It is therefore improbable that many of these households will be able to invest in energy improvements.

Table 1: Households income quintiles and tenure for Italy in 2010 (in 100s)

Income quintiles	**Tenure**					**Total**
	Renter occupied	**Owner occupied**			**Usufruct**	
		Loan required	No loan	Total		
Lowest fifth	**25.8**	5.2	50.5	**55.7**	**18.5**	100.0
Second fifth	**23.3**	8.5	54.4	**62.9**	**13.8**	100.0
Middle fifth	**19.8**	12.3	55.7	**68.1**	**12.1**	100.0
Fourth fifth	**15.7**	19.2	55.1	**74.3**	**10**	100.0
Highest fifth	**9.9**	21.9	59.8	**81.7**	**8.4**	100.0
Total	**18.9**	**13.4**	**55.1**	**68.5**	**12.6**	**100.0**

Source: ISTAT 2010

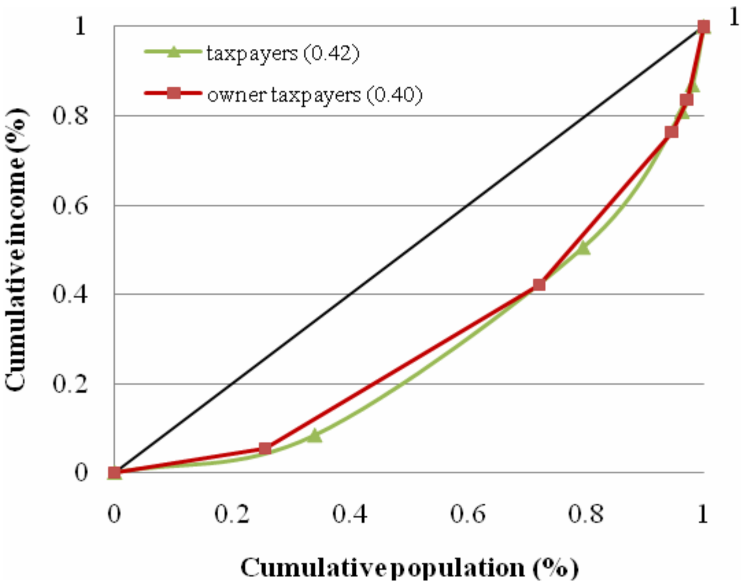
Considering our analysis focuses on addressing initial financing risks and cash flow barriers to residential energy projects, it is important to examine the wealth distribution of property owners (Table 2). The residential sector offers high energy-saving opportunities and financing mechanisms are a linchpin for clean energy deployment. Through the application of a Lorenz curve we have quantified the magnitude of accessibility issues in Italy. Lorenz curves are a graphical representation of the distribution of a good, based on income data of a group, city or country (Lorenz, 1905). We have estimated the distribution of wealth considering the income distribution for the cumulative percentage of taxpayers and the income distribution for the cumulative percentage of house-owner taxpayers (figure 1).

Table 2: Income distribution in Italy

Income range (euro)	Taxpayers			Owner taxpayers		
	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**

Source: Department of Treasury and ISTAT 2010

Figure 1: Lorenz Curve for Italy in 2010



With respect to taxpayers, the Lorenz curve shows that 80% of taxpayers receive 50% of national income, corresponding to 33 million people who declare less than 26.000 euros per year. Breaking down the figure, 34% of taxpayers (14 million people) receive less than 10.000 euro per year and 46% (18,9 million people) belong to the income range 10.000-26.000 euro per year. Considering the owner taxpayers, the inequality is slightly lower: 72% of owner taxpayers receive 42% of national income, corresponding to 17,5 million people who receive less than 26.000 euro per year; 6,2 million people (6 per cent of investigated population) declare less than 10.000 euro. It is important to note that despite the low income level, the lowest household quintile does have some properties. The Lorenz curve shows that there is a strong correlation between socio-economic status and tenure and that the growing level of income is associated to the ownership of property.

The Gini coefficient, (presented within figure 1 in the legend in parenthesis), provides a single measure of income distribution across the population. 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. The Gini index ranges from perfect equity among all members considered (G=0) to complete inequality (G=1). Formally, it is calculated as:

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

where X_i is the cumulated proportion of the population *i*/total population and Y_i is the cumulated proportion of the income *i*/total income with Y_i ordered from the lowest to the highest income level. In both of the cases analyzed in Figure 1 the Gini coefficient surpasses 0.4, and this shows that income inequality is reasonably high in Italy. Income status affects the accessibility of energy saving measures. For a typical energy package composed by solar PV and energy efficiency with investment value of 16,000 euro, the upfront cost represents a huge deterrent for most of the households in Italy where the average income per capita is 18,900 euros (taxpayer) and 22,700 euros (owner taxpayer)[iii].

Section 3: PACE *Property Assessed Clean Energy*

A Property Assessed Clean Energy (PACE) policy focuses on the upfront cost in energy improvements. 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, Kammen 2008). PACE addresses high initial cost 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 while ensuring broad financing contributions. In the United States, 27 states enacted legislation and programs that have been implemented through city, county, and state-level initiatives[iv].

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. The smart meter was designed in close collaboration between the University of California, Berkeley and the Polytechnic University of Marche, Italy. Model assumptions are summarized in table 2. Data for the Marche region is used as the baseline for the scenarios modelled. The final results obtained by the meter are based on Marche average energy consumption and savings as well as the prevailing energy prices, solar irradiation and technological performances for that region. This region has been chosen as while the energy-efficiency savings are greater in North Italy (due to energy consumption being significantly higher compared to other areas), photovoltaic electricity production is higher in southern Italy due to the better irradiation. It is important to note that this average case does not take into account differences between climate area. At the same time Marche region has typical values in reference to the Italian average (AEEG 2011).

For an average household in Italy, the net present value was calculated for solar photovoltaic installation only and then for combined energy efficiency improvements and solar photovoltaic installation. Different scenarios are modeled and we take into account the year of installation (relevant to compute the solar PV incentive) as well as the electricity and gas price escalation (tables 3 and 4). 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 2011). Based on these changes, forecast scenarios including gas and electricity price escalation have a high probability of occurrence. 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 percent of total investment according to EPIA and Rocky Mountain Institute data (2010). Price escalation represents another sensitive variable in the assessment provided by the meter.

Table 3: Model assumptions (Marche region's data baseline)

Model assumptions – Italy	
Energy consumption	For the Marche case, consumption is based on 2009 ISTAT[v] Environmental Data. Family (2-3 people) average consumption is 2'700 kWh/year and 1'497 m^3/year of natural gas.
Electricity price	The electricity price is based on AEEG[vi] residential rate of 0,1583 €/kWh (average rate for 2'700 kWh/year consumption)
Gas prices	The gas price is based on AEEG residential rate of 0,7234 €/m^3 (average rate for 1'497 m^3/year consumption)
Solar PV system	Solar size depends on percentage supplied by solar PV with an installed cost of 4,00 €/W
Solar power production	- According to UNI 10349 – 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 percent/year
Inverter	Inverter replacement in year 12 for approximately 600 €/W
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 from15°C 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 percent/year
Rebate and revenues	- 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	Tax rebate of 55 percent improvement cost is allowed for energy efficiency
Financial parameters	- Average inflation rate of electricity price of 3 percent - Average inflation rate of gas price of 5 percent - General inflation rate is not considered - Discount rate of 5 percent - Interest rate of 5.5 percent with a term of 20 years

NOTE: A version of the calculator used for the models is maintained online for public use at http://rael.berkeley.edu/financing-italy-IV

Table 4: Net present value comparison, basic scenario

	Year of installation				
	I semester 2012	I semester 2013	I semester 2014	I semester 2015	I semester 2016
Solar PV	8,199 €	5,493 €	2,299 €	(862) €	(4,270) €
Solar PV and EE	8,474 €	5,768 €	2,574 €	(587) €	(3,995) €

* Parenthesis indicate negative value

Chart 2 – Annual cash flow projections for solar photovoltaic and EE installed first semester 2012

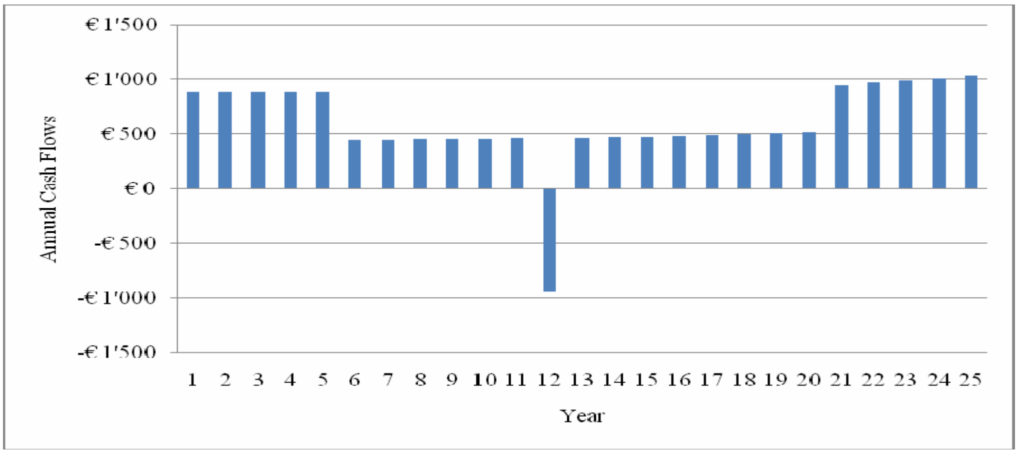


Table 5: Scenario for electricity and gas price escalation

	Year of installation					Electricity price	Gas price
	I semester 2012	I semester 2013	I semester 2014	I semester 2015	I semester 2016		
Solar PV	7,855 €	5,184 €	1,955 €	(1,207) €	(4,615) €	+2%	-
Solar PV and EE	7,422 €	4,716 €	1,522 €	(1,639) €	(5,047) €	+2%	+2%
Solar PV	8,597 €	5,891 €	2,697 €	(465) €	(3,873) €	+4%	-
Solar PV and EE	8'602 €	5'895 €	2'702 €	(460) €	(3'868) €	+4%	+4%

As shown in the previous tables, most of the projected scenarios have a positive net present value, especially when energy improvements are realized 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 (2012-2013) will tend to provide positive net present values (the feed-in tariff scheme declines in steps over time each month in 2011 and each semester in the next years). Chart 2 shows the cash flow for the base case over 25 years. The high cash flow is mainly due to the "Conto Energia"[vii] 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 Marche data is used as baseline and therefore the values provided are typical for Central Italy.

Homeowners can opt for different solutions to finance energy improvements. To select the most cost-effective options we compared the net present value and the profitability index (which quantifies the amount of value created per unit of investment) [viii] for a typical energy package (charts 3, 4, 5). This energy package has an assumed value of 16,000 euros depending on how it is financed and includes the solar PV and energy efficiency options [ix]. Alternatives are compared with the application of three different options (table 6):

- a 5 year unsecured personal loan at 8.97%[x];
- a 10 year financing banks solution for solar PV and energy efficiency[xi] at 7.01%[xii]; and
- a 20 year tax assessment PACE program.

Figures 3, 4 and 5 show the cash flows projections based on the alternative financing solutions. The negative pillars reflect the repayment obligation taking into account different repayment periods and interest rates. In the first five years, the negative impact of cash flows is lessened by the tax credit of 55 percent for energy efficiency retrofits during this period. 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 or financial institute 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 PI. The closest option to PACE is the 10 years financing bank solution, where the gap accounts for about 913 euros in NPV terms and 0.06 regarding the Profitability Index. 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.

Table 6: Comparison financing options

Financing options	**NPV**	**Profitability Index**	**Difference from best case**	
			NPV	PI
PACE program	8,474 €	0.53	-	-
Unsecured personal loan	7,364 €	0.46	1,110 €	0.07
Bank package for Solar PV and EE	7,561 €	0.47	913 €	0.06

Figure 3: Annual cash flows projections based on 5 years unsecured personal loan

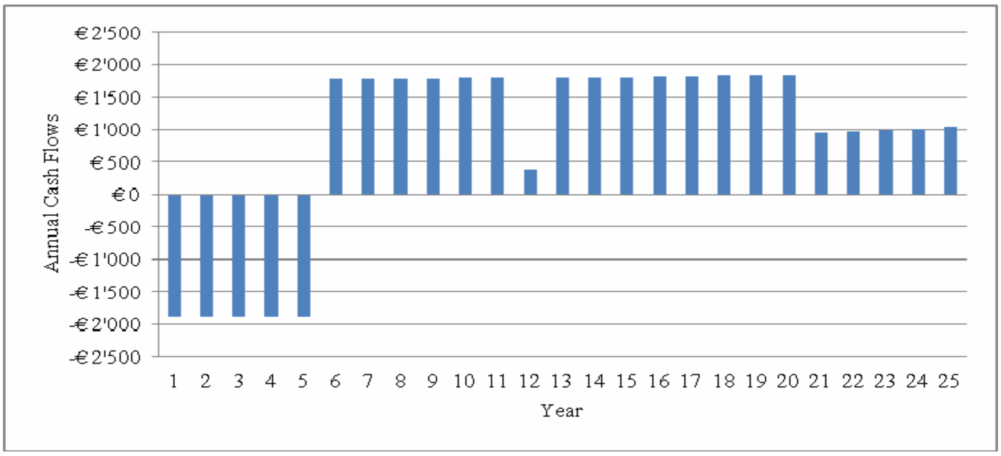


Figure 4: Annual cash flows projections based on 10 years financing banks solution

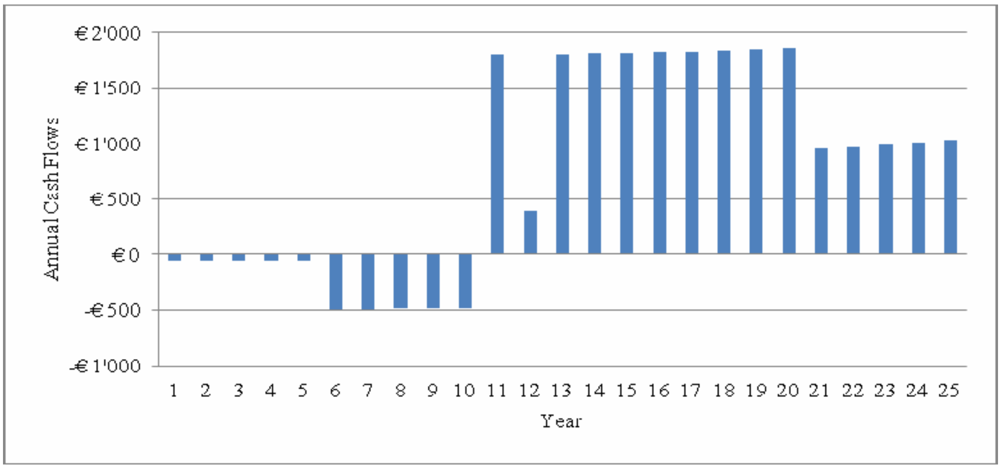
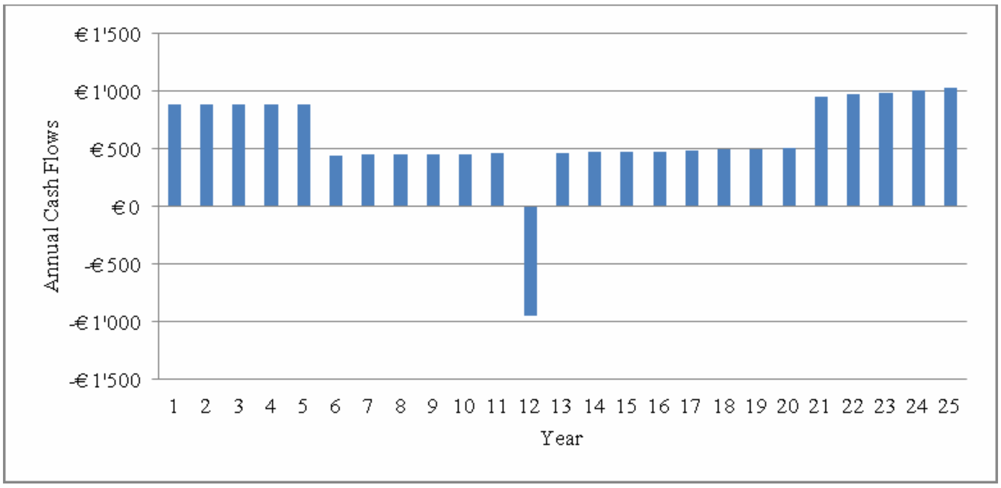


Figure 5: Annual cash flow projections based on tax assessment PACE program



Section 4: Conclusion

Overcoming the upfront cost of energy investments is a crucial step for addressing barriers to energy improvements in existing buildings which account for 33 million units in Italy. Financing barriers are particularly relevant for low-income households who have limited access to credit as the result of their economic status and the lack of guarantees that they can provide. The aim of this study was to underline the importance and the need for new financing models which address the initial financing risks and cash flow barriers of clean energy projects. In this respect, we have determined the extent of income inequality in Italy, in order to understand how it can affect the accessibility of energy saving measures.

Given the high energy-saving opportunities in the residential sector, we have examined the distribution of property owner wealth using a Lorenz curve. Our analysis showed that 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 investigated population receiving less than 26,000 euro/year. These rates of low income will affect the accessibility of energy saving measures. Offering affordable financing lowers barriers for many property owners: for a typical energy package composed by solar PV and energy efficiency with investment value of 16,000 euro, the upfront cost represents a huge deterrent in Italy where the average income pre capita is 18,900 euro (taxpayer) and 22,700 euro (owner taxpayer).

The implementation of a PACE program could represent the most cost-effective way to finance energy improvements, as when it is well-designed it ensures higher NPV 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 bank package and to 6.3% in the case of unsecured personal loan. Its implementation will assist in large scale deployment of energy efficiency and renewable energy measures, especially in a country where the percentage of low and middle households is substantial.

Unlocking the investment potential of the private sector and individual consumers presents one of 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 reach optimal energy performance in buildings. The Italian energy position remains vulnerable in several regards and energy security is a major concern: national energy needs and climate targets can be sustainably achieved only with an understanding of clean energy’s benefits and the methods that can be applied to finance it.

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NOTES

[i] Primary energy import =[Net imports/final consumption].
[ii] Union Oil, Data Book 2011.
[iii] Based on 2009 data analysis.
[iv] Database of States Incentives for renewable and Efficiency, updated October 2011
[v] ISTAT is the National Statistical System.
[vi] AEEG – Autorità dell'Energia Elettrica e del Gas, Italian Energy Authority.
[vii] Italy feed-in tariff scheme
[viii] Profitability index quantifies the amount of value created per unit of investment.
[Present value of future cash flows/ initial investment].
[ix] Fuller, Portis et Kammen, "Municipal Financing for Energy efficiency and Solar power"
[x] Average interest rate applied by 20 banks .
[xi] After the introduction of feed in tariff scheme, many banks offered specific packages for solar PV.
[xii] Average interest rate applied by 10 banks which provided specific energy package.

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