Energy communities, a new tool for sustainability

Idiano $D'Adamo$[1], Massimo $Gastaldi$[2], and Alessandro $Vigiano$[3]

[1] Department of Computer, Control and Management Engineering, Sapienza University of Rome, Rome, Italy
[2] Department of Industrial and Information Engineering and Economics, University of L'Aquila, L'Aquila, Italy
[3] Sapienza University of Rome, Rome, Italy

Introduction

The literature increasingly focuses on Sustainable Development Goals (SDGs), emphasizing sustainable education, energy independence, and green economy subsidies. Energy communities, supporting SDGs 7, 11, 13, and 17, empower end-use customers but face challenges in implementation and trust. Renewable Energy Communities (RECs) is an association that produces and shares renewable energy autonomously, reducing CO2 emissions and energy waste. REC development hinges on policy choices, with economic analyses highlighting the significance of political incentives in evaluating profitability amid evolving policy and market dynamics.

Materials and method

This work aims to propose an economic analysis of residential photovoltaic systems within a REC according to different incentive and market scenarios. For this scope, the Net Present Value (NPV) is used in both baseline and alternative scenarios (*Figure 1*) showing a very good profitability, confirmed by sensitivity, scenario and risk analysis (*Figure 2 and Figure 3*). It is therefore evident how the avoided cost in the bill has a decisive impact on the result and how this is amplified by virtuous behaviour in consumption synchronous to the production phase. Subsequent analyses concern how the profits obtained are divided among the prosumers and it is shown that revenues shared according to a partial energy consumption profile may be the right compromise. This study considers the Italian context, as an example of a mature photovoltaic market, in which the new incentives envisaged by the REC Decree 2023 are applied and evaluates how profitability varies as a function of several critical variables such as the percentage of self-consumption, the avoided energy cost in the bill, the energy selling price and the investment cost beyond the value of the incentive.

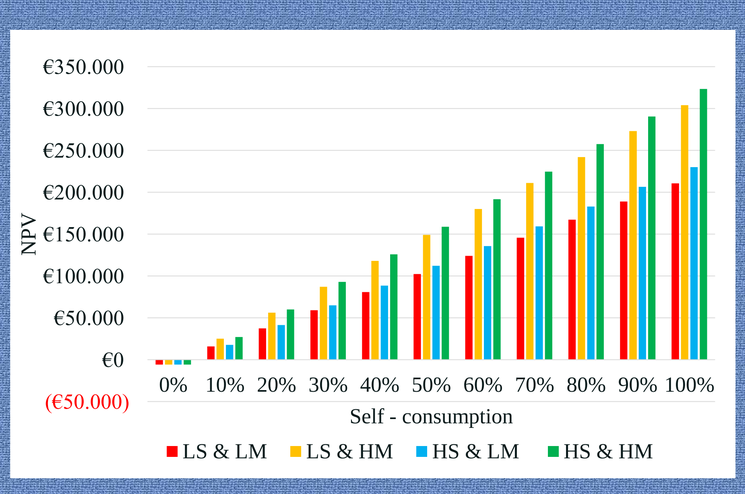

Figure 1: Profitability analysis

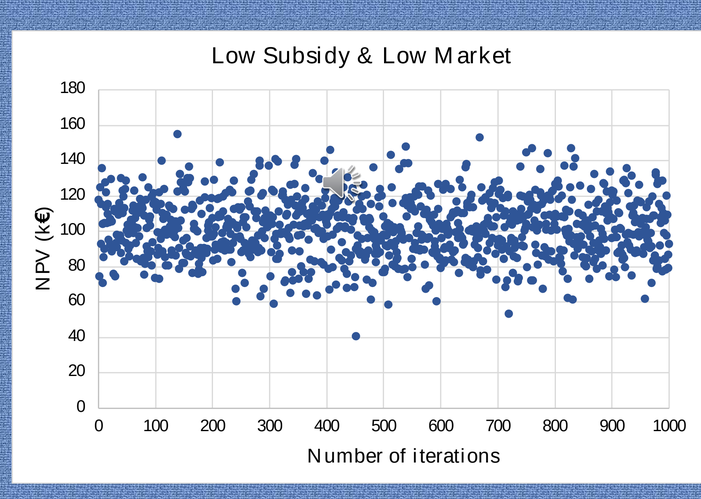

Figure 2: Risk analysis for a specific scenario

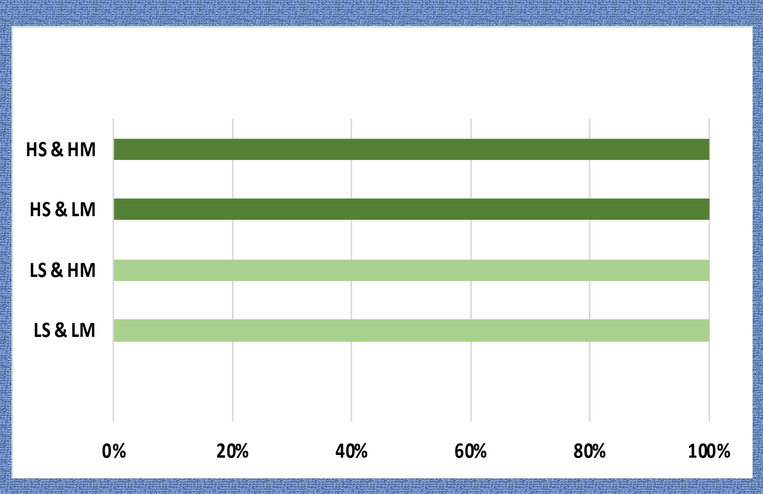

Figure 3 : Risk analysis for different scenarios

Results and conclusion

RECs are proposed as a social model to foster the green transition, placing the figure of the prosumer at the centre of change. The results show that the profitability is confirmed all considered scenarios and it is therefore concluded that building a residential PV system within a REC leads to significant economic returns and low levels of risk. The incentive provided plays an important role in this outcome, and clear and consistent planning over time can give investors security.

Another decisive parameter in a profitability analysis is the percentage of self-consumption. In accordance with the literature, scenario models have been analysed in which the profits from the implementation of a residential PV system within a REC can be divided up, and the model of revenues distributed according to a partial energy consumption profile (*Table 1*) seems to be the most suitable from an optimisation point of view. Here the other limitation of this work emerges; on the operational side, it could be useful to identify a model that calculates the efficient energy exchange price. Indeed, this aspect could reduce the management issues between the different RSCs.

Incentive decrees, defined in advance and lasting over time, are able to reduce risk and attract investors. They are also a tangible sign of a government's focus on green issues. Currently, RECs concern small realities but the challenges of the smart city require their development also in the context of large urban centres. Joining a REC would lead citizens to be part of a change that is not simple but strategic for the challenges of the future.

	RSC 1	RSC 2	RSC 3	RSC 4	Total
Energy produced (kWh)	9749	9749	9749	9749	38,996
Self-consumed energy (kWh)	7799	6337	3412	1950	19,498
Energy not self-consumed (kWh)	1950	3412	6337	7799	19,498
Partial self-consumed energy (kWh)	4874	4874	3412	1950	15,111
Partial not self-consumed energy (kWh)	1950	3412	4874	4874	15,111
Energy Exchange (kWh)	2925	1462	1462	2925	8774
Scenario p^c 350 €/MWh p^s 120 €/MWh and p^{ex} 235 €/MWh					
Avoided costs in the bill (€)	1706	1706	1194	682	5289
Energy sales (€)	234	409	585	585	1813
Energy Exchange (€)	687	344	344	687	2062
Revenues (€)	2627	2459	2123	1955	9164
Percentage distribution of benefits	28.7%	26.8%	23.2%	21.3%	100%
Scenario p^c 500 €/MWh p^s 120 €/MWh and p^{ex} 310 €/MWh					
Avoided costs in the bill (€)	2.437	2.437	1.706	975	7.555
Energy sales (€)	234	409	585	585	1.813
Energy Exchange (€)	907	453	453	907	2.720
Revenues (€)	3.578	3.300	2.744	2.466	12.089
Percentage distribution of benefits	29.6%	27.3%	22.7%	20.4%	100%

Table 1: Revenues allocated with a partial energy consumption profile

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