The Financial Costs in Energy Efficient District. Alternative Scenarios from the Demo Sites of the CITyFiED Program

Simona Barbaro(✉) and Grazia Napoli(✉)

University of Palermo, viale delle Scienze ed. 14, 90127 Palermo, Italy
{simona.barbaro,grazia.napoli}@unipa.it

Abstract. The European Union's environmental policies actively promote the transition to a low-carbon society and to sustainable energy systems that improve people's quality of life and do not negatively impact the natural environment. To achieve these goals, the European Union funded several programs to pilot energy efficiency measures for buildings and districts and, lately, launched the European Green Deal. The results of these experimentations have shown that often the economic feasibility of retrofitting interventions is not achieved without public grants. This contribution aims to analyze the influence of financial parameters on the profitability of projects of energy efficient districts. The study is based on the data from the demo sites of the CITyFiED program (Soma in Turkey and Laguna de Duero in Spain) that are reworked according to new several alternative scenarios, differentiated by cost financing and amount of public grants.

Keywords: Energy retrofit · Economic feasibility · Energy efficient district · CITyFiED program

1 Introduction

The European Union's (EU) key climate and energy objectives were set out in both the *2020 Climate & Energy Package* and the *2030 Climate & Energy Framework* [1] and since their promulgation, the EU has outlined various strategies to actively promote the transition to a low-carbon society, while creating a sustainable energy sector that improves the quality of life for EU citizens and does not impact the environment. Furthermore, UE has adopted the *17 Sustainable Development Goals* (SDGs), promoted by the United Nations (UN) with the *2030 Agenda for Sustainable Development*, and signed the *Paris Agreement* on climate change.

The attention to the rising needs of sustainability has recently been confirmed by the presentation of the *European Green Deal*, which has strengthened the willingness to support energy efficiency and retrofitting actions at urban and building scales. In fact, the *Renovation Wave Strategy*, published in October 2020, aims to double the rates of renovation in the next ten years to reduce the consumption of energy and resources in buildings [2]. In addition, the EU also intends to update the rules to facilitate the

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necessary public and private investment in the ongoing green transition, as well as to increase financing opportunities and credit schemes to support the implementation of effective energy retrofit projects. However, to do this it is necessary to conduct adequate evaluations for productively investing the resources made available.

Evaluating the performance of energy retrofitting projects, and any measure of any project, is a complex process, as it requires the simultaneous verification of environmental, social and economic sustainability [3]. In retrofitting projects, the primary objectives are to reduce energy consumption, increase the use of renewable resources and reduce CO_2 emissions. It is usually also included the overall environmental sustainability of the project, which must generate the least possible impact on the environment during the entire life cycle. This latter aspect is assessed through different types of environmental certification (e.g. BREEAM - Building Research Establishment's Environmental Assessment Method, LEED - Leadership in Energy & Environmental Design, etc.).

Social sustainability is also a key factor in achieving energy efficiency results and implies the direct involvement of residents, because they play an active role in the management phase of the intervention and many measures could be ineffective in real implementations without their collaboration [4].

Economic evaluations contribute to defining the performance of an energy retrofitting intervention and play a central role in their implementation since private entrepreneurs and/or owners are willing to invest when they expect the project to be profitable. Moreover, public administrations have the role of providing social welfare, in terms of the comfort of citizens in the short term, and of preserving the environment in the long term. So, they have to manage the allocation of public funds in the environmental sector in order to reconcile effectiveness and efficiency, and to achieve the environmental objectives set by the European Union for 2030 but using the available resources most efficiently [5].

The economic assessment of an investment analyzes the flow of costs and revenues during the economic life of a work and expresses the economic feasibility through a set of indicators, e.g. Net Present Value (NPV), Internal Return Rate (IRR), Payback Period (PB), etc. The values of the indicators depend on numerous technical (type of intervention, building materials, etc.), financial (financing sources, interest rates) and economic (energy price, building cost, etc.) elements and also on the degree of uncertainty associated with the time frame of 20–25 years [6–8].

The topics of economic and financial analysis applied to energy efficiency projects at different scales (building, neighbourhood, city) have been widely studied. These analyses have been diversified to adapt them to the measures that can be implemented and are differentiated by intervention type, building typology, technology and urban context. Some approaches focused on generating and evaluating scenarios on retrofit solutions according to the energy conservation measures adopted [9] or to different climatic conditions [10]. Other studies focused on the evaluation of energy retrofit interventions of different types of existing buildings [11–13], even in highly densified urban [14] or historical-architectural values contexts [15, 16]. Economic-financial analyses often integrate spatial and geo-referenced planning processes [17, 18] or combine financial evaluations with multicriteria evaluations, in order to support the decision-making process [19–21].

This study aims to provide a contribution to the scientific debate on the economic and financial analysis of energy retrofit interventions, meanwhile, the EU is promoting a massive investment plan for the ecological transition through the *European Green Deal*. In particular, some critical issues of economic evaluation that affect the economic feasibility of a project are analysed, concerning the type of financing and public grants. The projects of the European Program CITyFiED [22] were chosen as a case study and a total reworking of the economic evaluation was made. Some alternative scenarios were assumed, each of them corresponds to different funding parameters, in order to evaluate how the main economic indicators NPV and IRR may respond and, consequently, how the decision to implement the project may vary. In fact, even if economic feasibility cannot be considered a strict constraint for this type of projects, since the financial cash flow does not include environmental externalities, nevertheless it is necessary to know the measure of the social and economic price that is paid to achieve greater environmental sustainability.

2 The European Programs of 'My Smart City District'

The European Union has funded numerous programs intending to test the economic and administrative-procedural feasibility promoted within many EU climate and energy initiatives and regulations. Smart cities, which have always been the catalyst for EU policies, have been chosen as testers and promoters of the most interesting initiatives. However, what makes a city smart is not uniquely determined and is still a matter of debate.

According to the Organization of Economic and Cooperation Development (OECD), smart cities are those cities capable of promoting initiatives that use digital and technological innovation to make the provision of urban services more efficient, increase the well-being of citizens and at the same time make living spaces more sustainable and inclusive [23]. The variegated field of application of smart cities programs can be narrowed down to six main domains: Natural Resources and Energy (regarding the wise management of natural resources and the efficient use of energy); Transport and Mobility (referring to the reduction of traffic and polluting emissions); Buildings (related to the efficient management of energy consumption); Living (in terms of quality of life); Governments (referring to the importance of enacted policies); Economy and People (including urban measures that favour an increase in the economic availability of citizens) [24]. Smart cities may also deeply differ in their strategic approaches so, with a spatial reference, four strategic choices can be identified: national versus local strategies; strategies for new versus existing cities; hard versus soft infrastructure-oriented strategies; sector-based versus geographically-based strategies [25]. Furthermore, in the ongoing trends for smart cities of the future, the idea of energy smart cities is the one that is emerging the most [26].

Among the European smart energy cities initiatives, the *My Smart City District* (MSCD) programs have been considered particularly interesting as they have tested neighbourhood-scale energy efficiency strategies and measures in different European socio-economic contexts [22].

These programs are: R2CITIES - *Residential Renovation Towards Nearly Zero Energy Cities*; EU-GUGLE - *European cities serving as Green Urban Gate towards*

Leadership in sustainable Energy; ZenN - *Nearly Zero Energy Neighborhoods*; CITyFiED - *Replicable and Innovative Future Efficient Districts and Cities*; Sinfonia - *Low Carbon Cities for a better quality of life*; City-Zen - *City Zero (Carbon) Energy*; Celsius Initiative; READY - *Resource Efficient cities implementing ADvanced smart citY solutions* (Fig. 1).

Fig. 1. The European Programs of the *My Smart City District* group.

Each program was granted by the *Seventh Framework Program* (FP7/2007–2013) in order to promote the *Net Zero-Energy District* (NZED), share experiences and know-how, and facilitate large-scale replication of neighbourhood-scale energy efficiency interventions. The projects lasted five years each (the last one was concluded in November 2019) and were developed separately; later they merged into the *My Smart City District* (MSCD) group, in order to strengthen content sharing and increase the synergy of the proposed measures.

For this reason, the programs have significantly different characteristics in terms of coordinating entity, strategic approach, area of intervention, primary energy savings, intended use of the buildings involved, stakeholders, share of European funding and other types of funding. The common elements were, however, the intention to promote an energy renewal strategy for cities and communities that leads to large-scale replicability of successful energy efficiency solutions, as well as the willingness to test these strategies in real case studies. In total, energy efficiency interventions have been completed in 27 neighbourhoods of 25 cities in 13 different European countries.

Although different from each other, the outcomes of the programs within the specific case studies were on average very positive and each of them was able to highlight strengths and weaknesses of the applied technical, economic, social and procedural strategies. A fundamental common element for each program was the European funding, which covered from 54% to 64% of the cost of the measures of all the energy efficiency projects and played a key role in achieving the economic feasibility of the interventions (Fig. 2).

By analysing the MSCD programs, some economic considerations may be made. For example, one of ZenN's goals was to provide a financial plan to support the involvement of community groups, who lack financial resources, in the energy efficiency of their neighbourhood. The study of these plans highlighted that some critical factors can affect the achievement of the economic feasibility of energy retrofitting projects, facilitating or hindering their implementation. The main critical factors are as follows: ownership structure, availability of public incentives or funds, and role of private investors [28].

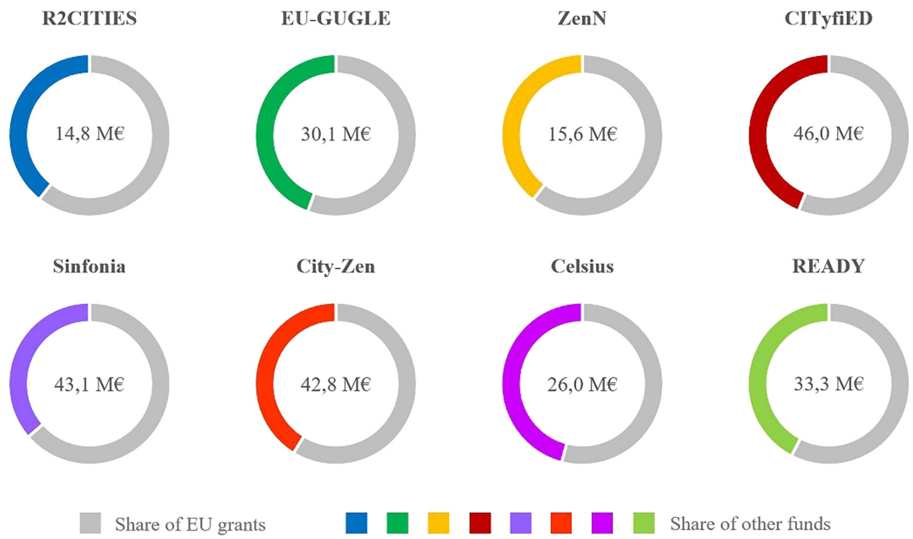

Fig. 2. Funding of European Programs of the *My Smart City District* group.

Instead, CITyfiED, which is the program that required the largest overall investment, is interesting because it focused on business models and financing schemes that would overcome the difficulty of dealing with high initial investment costs.

3 The CITyFiED Program

The CITyFiED (*Replicable and Innovative Future Efficient Districts and Cities*) project was developed from 2014 to March 2019 [22] with the aim of providing a replicable, systemic and integrated strategy to transform the European cities into *Smart Cities*, focusing on the reduction of energy demand and greenhouse gas emissions and increasing the use of renewable energy sources. CITyFiED defined, also, a cost-effective methodology to plan and implement energy efficient retrofitting actions at the neighbourhood scale (Fig. 3).

From a technical and scientific point of view, CITyFiED focused on the development of technologies and solutions that are useful to optimize the redevelopment of residential districts, improve electricity distribution and integrate district heating systems and renewable energy sources. On the other hand, from an economic point of view, CITyFiED drew up business models aimed at supporting the transformation of peculiar urban areas into Net Zero-Energy Districts (NZED).

Three demonstration sites located in different European countries were chosen to test its models within neighbourhood-scale urban renewal scenarios diversified by building types, ownership patterns, technological solutions and socio-economic contexts. The three selected neighbourhoods were: Manisa in Soma (Turkey), Torrelago in Laguna de Duero (Spain) and Linero in Lund (Sweden).

Fig. 3. CITyFiED's objectives.

The demonstration action in the three cities involved the energy efficient retrofitting of 190,462 sq.m of living space and of 2,067 homes, as well as the improvement of the quality of life of more than 5,700 citizens. All the main technological aspects (such as building retrofitting, district heating system and low-voltage distributed generation) were addressed through a systemic approach to achieve significant energy savings, very low energy buildings and minimum CO_2 emissions. At the end of the project, in fact, more than 13,000 MWh per year of final energy savings and over 1,600 t-CO_2-eq per year of emission reductions were achieved (Table 1).

Table 1. Energy performance of the CITyFiED program.

European program	Final energy savings (MWh per years)	Primary energy savings (MWh per years)	CO_2 saving (tCO_2 per years)
CITyFiED	13,261	14,288	1,699

Another key element of the program's strategy was the creation of a *City Cluster* of 11 cities and a *Community of Interest* of 44 other cities in order to maximize the potential replication of the project results by disseminating knowledge about the benefits of energy efficiency in the urban environment and sharing both building energy solutions and business models for urban retrofitting.

CITyFiED required a total investment of more than 46 M€, of which 25,828,319 € are European funds. Approximately 39 M€ was allocated to the three demonstration sites of Soma, Laguna de Duero and Lund and are divided into funds from private or public companies and grants from the European Commission (EC) (Table 2) [22].

Table 2. Funding for the three demonstration sites.

Demonstrative site	Partner	Own funds (M€)	EC grants (M€)	Total investment (M€)
Soma	SEAŞ	2.20	2.30	4.50
	MIR	2.00	2.30	4.30
	Others	1.80	2.40	4.20
	Total	**6.00**	**7.00**	**13.00**
Laguna de Duero	3IA	7.70	7.10	14.80
	VEO	2.20	0.76	3.00
	Others	0.60	0.64	1.20
	Total	**10.50**	**8.50**	**19.00**
Lund	LKF	3.80	2.00	5.80
	Lund	0.23	0.52	0.75
	KEAB	0.32	0.12	0.44
	Total	**4.40**	**2.60**	**7.00**

3.1 Soma (Turkey)

Soma is a medium-sized city in western Turkey. The Manisa demonstration site consists of 82 buildings that were constructed in 1982 (79 residential buildings, 2 guest houses and 1 conference centre). In the district there are one-, two-, three-storey and duplex buildings, with a total of 346 dwellings and 80,980 sq.m of floor area, including 7,037 sq.m of conditioned area. The predominant heating system is coal stoves (70%) as the buildings are only partially heated by boilers.

The owner of the neighbourhood was SEAŞ (SOMA Electricity Generation & Trading Company), a public company that took care of the management of the buildings and also dealt with the rental of houses and the management of the housing and the conference centre. But after the work began, ownership was transferred passed to EÜAŞ (Electricity Generation Company of Turkey).

From a technical point of view, the interventions consist of: the adaptation of the building envelope (installation of thermal insulation for the walls, replacement of windows, etc.); the refurbishment of heating systems (installation of low-temperature radiant heating systems); the implementation of the use of renewable sources (installation of solar thermal systems); the implementation of ICT solutions; the installation of energy management and control systems (installation of a DEMS - District Energy Management System, a BEMS - Building Energy Management System and a HEMS - Home Energy Management System). In addition, other interventions were also planned, such as the installation of a Building Integrated Photovoltaics (BIPV) and a district heating system. However, due to the Turkish administrative processes and some political events, the works were significantly delayed and EÜAŞ decided to stop the works. Obviously, this event affected the business model of the project, making it impossible to definitively achieve the initial goals.

The project was supposed to have 53.16% RES (Renewable Energy Sources) contribution and allow 56.16% energy savings. In fact, the initial investment was to be 13 M€, of which 7 M€ were to be granted by the European Commission, but after the events related to the transfer of ownership of the district the investment decreased significantly.

The main partners of the project were SEAŞ, Manisa Metropolitan Municipality (MAN) and MİR Research and Development Inc (Table 2).

3.2 Laguna de Duero (Spain)

Laguna de Duero is one of the municipalities surrounding the metropolitan area of the city of Valladolid, capital of the province of the same name in the autonomous community of Castile and León. The Torrelago demonstration site consists of 31 private buildings that were constructed between 1977 and 1981 and provided with district heating. The buildings are inhabited by 3,858 people and are all 12 floors with 4 dwellings each, for a total of 1,488 dwellings and 140,000 sq.m of conditioned area.

The main distinguishing feature of this case is the building ownership. In Torrelago, in fact, there is one private owner per dwelling grouped in two legal entities, i.e. two Communities of Owners representing 576 and 912 owners respectively.

From a technical point of view, the interventions concerned: the adaptation of the building envelope (placement of an ETICS - Exterior Thermal Insulation Composite System); the renovation of existing facilities (renovation of the district heating system, partial replacement of gas boilers, etc.); the implementation of Information Communication Technology (ICT) solutions; the establishment of energy management and control systems (installation of DEMS, BEMS and HEMS).

The project was carried out with 57.32% RES contributions and allowed 38.72% energy savings. The total investment was 19 M€, of which 8.5 M€ were granted by the European Commission. The financial scheme was based on a private risk-sharing model between an Energy Service Company (ESCO) and a construction company: the initial investment to pay for the cost of the interventions was supported by the private companies, to be then paid back by the homeowners through monthly fees established by a multi-year contract.

The two main partners in the project were 3IA, responsible for retrofitting the facades, and VEO, responsible for renovating the energy heating system (Table 2).

3.3 Lund, Sweden

Lund is a medium-sized college town where nearly 90% of the heat demand is supplied by district heating. The Linero demonstration site consists of the *Eddan* building block and two buildings in the *Havamal* block, both constructed in the early 1970s, for a total of 28 buildings of three levels each.

The buildings are owned by the public housing corporation Lunds Kommuns Fastighets (LKF) and contain 681 apartments with approximately 2,000 tenants. The CITyFiED project involved only 16 of the 28 buildings, for a total of 379 homes and 40,400 sq.m of conditioned area.

From a technical point of view, the interventions concerned: the adaptation of the building envelope (installation of thermal insulation for the walls, replacement of windows, etc.); the renovation of existing systems (improvement of the ventilation system, restructuring of the district heating system, etc.); the implementation of the use of renewable energy sources in the buildings (installation of photovoltaic systems); the implementation of ICT solutions; the installation of energy management and control systems (installation of DEMS, BEMS and HEMS).

The project was carried out with 70.8% RES contributions and allowed 30.8% energy savings. The total investment was 7 M€, of which 2.6 M€ were granted by the European Commission. The upgrading of the buildings was carried out by LKF under a contract with a construction company; while the renovation of the district heating network was developed by LKF and carried out by Kraftringen AB (KEAB), another public company in Lund.

The main partners in the project were Lund Municipality, LKF and KEAB (Table 2).

4 Scenarios of Economic Feasibility in the Demo Sites of Soma and Laguna de Duero

The investment analysis conducted by CITyFiED aimed to evaluate the economic feasibility of the different energy saving measures (ECMs) that were implemented in the three demonstration sites. The economic analysis was made by applying the most commonly and widely used indicators, namely Net Present Value (NPV), Internal Rate of Return (IRR), Return on Investment (ROI) and Static Payback Period (SPP). There were very different results in the three sites, since two investments were profitable while one was not profitable.

Of course, the values of the indicators depend on: design (choice of retrofitting measures such as building insulation, solar thermal domestic hot water system, control system equipment, lighting control system, etc.), technologic (energy efficiency of the measures), economic (time frame, fuel cost, etc.) and financial factors (discount rate, cost of financing, etc.).

Starting with the data of the CITyFiED reports, a study was conducted to assess how the type of capital and other financial elements may affect the economic indicators NPV and IRR of the interventions, assuming new alternative scenarios. Most of the original data remain unchanged, while the data related to the type of capital invested and other financial parameters vary.

The NPV represents the value of all revenues calculated after costs:

$$NPV = \sum_{t=1}^{n} \frac{(R_t - C_t)}{(1+r)^t} - C_0 \tag{1}$$

Where: Rt - revenues for the year t; Ct - costs of the year t; r - discount rate; n – period of analysis; C_0 – initial investment.

The IRR is the discount rate that makes the NPV of revenues and costs equal to zero:

$$\sum_{t=1}^{n} \frac{(R_t - C_t)}{(1+IRR)^t} - C_0 = 0 \tag{2}$$

The feasibility conditions can, therefore, be summarized as follows:

– NPV greater than zero;
– IRR at least equal to the discount rate.

When these conditions are met, the cash flow of the project is sufficient to cover the initial investment and to recover the capital contributed by all parties involved in the investment. Annual costs include operation costs and capital-related costs. Revenues include cost savings, i.e. savings resulting from the increased energy efficiency of the building that implies a reduction in energy demand and bills, and cost avoidance, related to interventions to prevent higher costs in the future.

The projects of the CITyFiED program obtained grants from the European Commission (Table 2), so if the economic analysis of the project is done from the perspective of the investor, the grants are a revenue that reduces the private investment. Whereas if the economic analysis is done with the aim of assessing the cost effectiveness of the intervention, the grants are not included in the cash flow.

Although they were not used in our study, there are other economic indicators of investments such as ROI, SPP and DPP (Dynamic Payback Period). The ROI is a ratio of profit to the investment cost. The SPP is referred to the time required to recover the investment cost and is calculated by dividing the initial investment by the average net cash flow, while the DPP is the numbers of years required to recoup the initial investment based on the discounted cash flow.

4.1 Alternative Scenarios of Economic Analysis in the Demo Site of Soma

The retrofitting interventions in Soma demo site include the following measures: Insulation of buildings, Domestic hot water system, Building Integrated PV system, LED lighting, Low temperature heating system, District heating system and Monitoring.

To evaluate the NPVs and IRRs of each measure, the following original data from the demo site reports are used:

– Total investment (euro);
– Maintenance costs (euro);
– Energy savings (MWh);
– Electricity prices and coal prices (assuming an annual increase of 0.05%);
– Waste heating costs per year;
– Time frame of 15 years (10 and 25 years respectively for LED lighting and Low temperature heating system measures).

As public European and national administrations often give incentives to projects to achieve the reduction of energy consumption and the reduction of greenhouse gases, several new scenarios are defined according to different compositions between risk capital and grants to verify what are the results of the investment of public resources at the district scale. The NPVs are recalculated applying a discount rate that ranges from 0 to 6% under the following scenarios:

– 100% funds - 0 grants;
– 75% funds - 25% grants;
– 50% funds - 50% grants;
– 25% funds - 75% grants.

The results in Fig. 4 show that the NPVs of the measures have very different curves in position and shape and that they are affected to varying degrees by grants. Three measures, namely *Insulation of buildings*, *Domestic hot water* and *LED lighting*, have always positive NPVs both in presence and in absence of grants, so these types of measures are cost-effective and do not need to be supported financially. The other measures are profitable only applying very low rates (from 0 up to 2%) without any grant, but they reach good economic feasibility if the grant covers 25% of the investment cost. The *District heating system measure*, in particular, would benefit greatly from a grant, because the very high initial cost of the intervention would be significantly reduced by a grant of 25% or even more.

The IRRs of the scenarios reflect the same differences between the seven measures that are described above and show the strong influence of a hypothetical increasing share of grants especially towards those measures that need to be supported (Table 3). For instance, if the investment of *Low temperature heating system* is totally covered by a private company (or homeowner) and the IRR is just 1.68%, then this measure is not profitable because the IRR is lower than the discount rate (2%) that was set in the Soma report, whereas it increases up to 8.49% when the grants cover 50% of the investment cost.

4.2 Alternative Scenarios of Economic Analysis in the Demo Site of Laguna de Duero

The economic analysis developed on the demo site of Laguna de Duero differs from that of Soma mainly for the financing of the retrofitting project. In this site, indeed,

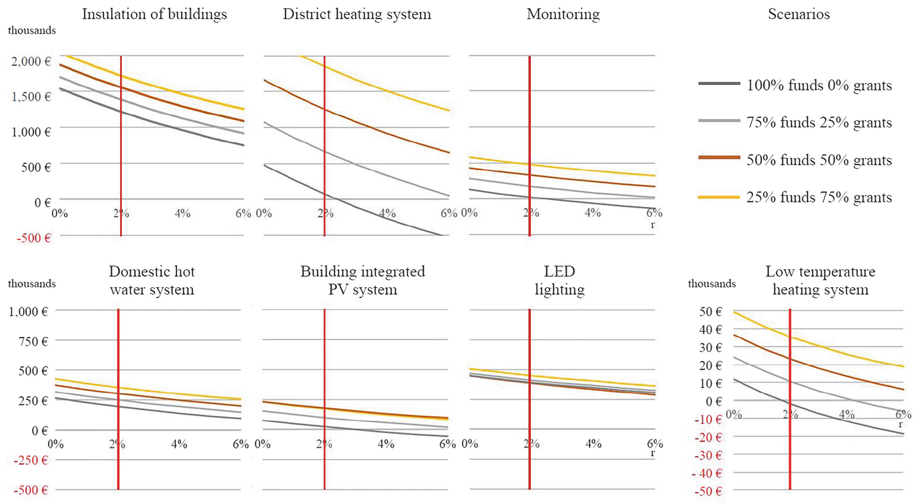

Fig. 4. The NPVs by measures and scenarios in the demo site of Soma.

Table 3. The IRRs by measures and scenarios in the demo site of Soma.

Intervention measures	Scenario 100% funds 0% grants	Scenario 75% funds 25% grants	Scenario 50% funds 50% grants	Scenario 25% funds 75% grants
Insulation of building	20.29%	28.05%	42.73%	85.39%
District heating system	2.37%	6.48%	13.44%	30.76%
Monitoring	2.45%	6.59%	13.06%	31.08%
Domestic hot water system	12.20%	18.12%	28.87%	58.76%
Building integrated PV system	3.03%	7.42%	14.97%	34.31%
LED lighting	68.32%	91.31%	>100%	>100%
Low temperature heating system	1.68%	4.22%	8.49%	19.09%

about 48% of the cost is granted by the European Commission while the remaining costs are covered by an ESCO (Energy Service Company) and other private companies. The community of owners will pay the financing fee to the companies in 20 years.

To evaluate the NPVs and IRRs of the project of Laguna de Duero, the following original data from the demo site are used:

– Private investment (euro);
– Annual cost in the baseline period (before the intervention) (euro);
– Annual cost in the reporting period (after the intervention) (euro);
– Time frame of 25 years;
– EC grant of 50%.

In this case study, the scenarios are diversified by the capital structure, that is a combination of debt and equity, as the amount of a requested loan could be lower than 100% of the investment, like it was set in the contract between the companies and the Community of owner in Laguna de Duero, so that the shared risk will decrease the financing cost.

The NPVs are evaluated applying a discount rate that ranges from 0 to 6% and for a rate of financing cost that varies from 1% to 3%, according to the following new scenarios:

– 100% loan - 0 funds;
– 75% loan - 25% funds;
– 50% loan - 50% funds;
– 25% loan - 75% funds.

The results (Fig. 5) indicate that the elasticity of the NPV with respect to the discount rate varies significantly among the various scenarios according to the distribution of the cost between the present and the future (obviously, NPV is greater for the scenario with the lowest financing share).

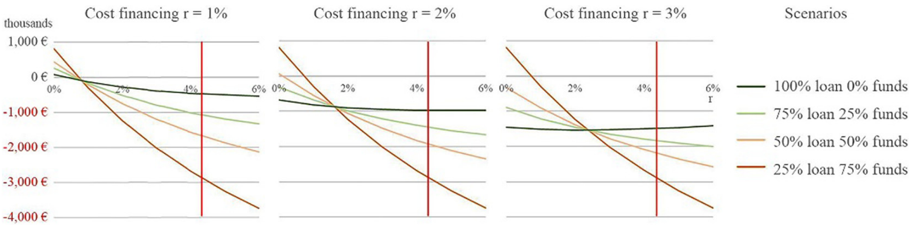

Fig. 5. The NPVs by cost financing and scenarios in the demo site of Laguna de Duero.

However, the intervention does not achieve affordability, as the NPVs are negative as well as all the IRRs are negative or lower than 1% (Table 4). Only if the rate of the financing cost is 1% and the discount rate is close to zero the project reach a very weak profitable, but, since the CITyFiED report applied a discount rate of 4.3%, the private companies can be involved in the project only if the EC grant exceeds 50% of the investment cost.

Table 4. The IRRs by cost financing and scenarios in the demo site of Laguna de Duero.

	Scenario 100% loan 0% funds	Scenario 75% loan 25% funds	Scenario 50% loan 50% funds	Scenario 25% loan 75% funds
Cost financing r = 1%	0.34%	0.58%	0.65%	0.69%
Cost financing r = 2%	−2.54%	−0.67%	0.10%	0.48%
Cost financing r = 3%	−4.81%	−1.90%	−0.48%	0.27%

5 Conclusions

The analysis of the interventions of the CITyFiED program has shown that variability in both characteristics of neighbourhoods and planned measures of energy efficiency may be so great as to generate results at opposite ends in terms of economic feasibility. Indeed, some interventions are very profitable, as in the case of the demo site of Soma, whereas other interventions do not reach the minimum cost-effectiveness, even if the grant covers 50% of the investment cost.

An important issue that may influence the economic feasibility of energy efficiency measures but was not included in this analysis is energy poverty. Energy-poor households do not have energy bills corresponding to their needs, so very low energy bills may cause a mismatch between the ante and post assessments of energy measures and affect the results. A preventive step of analysis of the households' energy bills should be envisaged to verify if they are in line with the satisfaction of basic needs and the attainment of acceptable indoor comfort.

Also, the financial parameters play a central role that condition the involvement of private companies and homeowners. The results of the scenarios defined in this study indicate that the financing cost and risk sharing influence both NPV and IRR, even if they are not able to radically change the economic performance of a project when it is very bad. Instead, the public grants make it possible to appreciate the flow of cost savings and cost avoidance in the medium term by directly reducing the initial investment. This is especially relevant in the case of infrastructural projects at urban scale, e.g. district heating plant, whose initial costs can be very high. Indeed, the NPV graph of the district heating system intervention at the Soma demo site shows that a high incidence of grants contributes greatly to achieving economic feasibility.

The amount of grants to be paid is, however, both a political and an economic issue, as the cash flow does not include all of the negative externalities (pollution, climate impact, etc.) that are avoided by means of the energy efficiency project, nor the change in indoor comfort of the dwellings, potentially resulting in better health of the inhabitants and lower public health expenditure. Therefore, it may be considered fair for the European Commission and/or the national governments to pay a share to reduce such social and environmental damage and invest in the health of citizens.

However, determining what is the maximum price that a community should pay for the reduction of CO_2 emissions and what is a fair distribution of public grants remain both unsolved issues. For example, the original project of Soma had obtained 7 M€ of grant, equal to 50% of the cost of the intervention, but, given the good values of the NPVs (applying a discount rate of 2% as that used in the CITyFiED report), granting 25% of just 4 measures (which is equal to about 835,000 euros) would have been enough to obtain stable economic feasibility of the overall intervention; whereas, it would have been necessary to provide an additional share of grant in the case study of Laguna de Duero.

Therefore, financial and economic evaluations can support the preventive analysis of the performance of a project through the definition of alternative scenarios. This allows to identify the best combination of characteristics and parameters (including the financial ones) and to obtain strong economic feasibility for projects of energy retrofitting of buildings and districts.

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