

Article

Is the Energy Transition of Housing Financially Viable? Unlocking the Potential of Deep Retrofits with New Business Models

Ezio Micelli ^{1,*} , Giulia Giliberto ²  and Eleonora Righetto ³ ¹ Department of Architecture and Art, Università Iuav di Venezia, 30135 Venice, Italy² Department of Civil, Environmental Engineering and Architecture, University of Cagliari, 09123 Cagliari, Italy; giulia.giliberto@unica.it³ Department of Management Engineering and Real Estate Economics, University of Padua, 36100 Vicenza, Italy; eleonora.righetto.2@phd.unipd.it

* Correspondence: micelli@iuav.it

Abstract: The transition to energy-efficient buildings is a priority of the European EPBD (Energy Performance Building Directive) and requires deep retrofits to reduce consumption and emissions. However, their financial viability remains underexplored. This research assesses the financial feasibility of deep retrofit interventions through innovative business models, focusing on the Managed Energy Services Agreement (MESA), which is considered the most effective for residential buildings. Additionally, we integrate off-site production from the Energiesprong model, which optimizes costs and time through long-term contracts and industrialized retrofit technologies. The analysis targets two investment profiles—owner/tenant and developer/entrepreneur—in Italian urban contexts with different market dynamics. A static analysis evaluates retrofits based on existing costs and technologies, while a dynamic analysis considers future profitability improvements because of cost reductions enabled by off-site production. The results indicate that, under current conditions, residential retrofitting is not financially sustainable without public subsidies. However, cost reductions driven by off-site technologies improve profitability, making large-scale retrofits feasible. Moreover, real estate market characteristics affect financial sustainability: in smaller cities, deeper cost reductions are necessary for retrofit interventions to become viable.



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Keywords: business models; energy efficiency retrofit; green premium price; Energiesprong; building energy efficiency; value proposition; off-site construction; learning function

1. Introduction

Climate change is an unavoidable issue because of its impact on ecological and social systems [1,2]. Globally, the building stock contributes 38% of CO₂ emissions and 36% of greenhouse gas emissions, and the expected growth in urbanization will exacerbate these figures [3].

The European Union stands out as a regulatory leader in the energy transition. Since the Paris Agreement, reducing greenhouse gas emissions has been the basis of major public policies [4]. However, to date, 75% of buildings in Europe are still energy inefficient [5].

The European Union has introduced specific directives over the years to reduce greenhouse gas emissions. The most recent of these, the Energy Performance of Buildings Directive, approved on 15 April 2024, sets out measures to improve the energy performance of buildings, with the final goal of decarbonizing the building stock by 2050 [6].

In addition to aligning with global climate targets, the directives represent an opportunity for the development of green buildings with environmental and economic benefits [7,8]. Residential buildings with high energy performance contribute substantially to optimizing the consumption of energy resources and reducing greenhouse gas emissions [9,10]. Reduced energy consumption, in turn, translates into lower costs for households and businesses, a factor that the real estate market reflects as an increase in property value [11–13].

However, the transition to energy-efficient buildings requires significant investments. Under current market conditions, some research argues that the costs of retrofitting existing building stock exceed the market benefits, making financial support from the public sector essential [14–16].

On the other hand, numerous studies have highlighted the crucial role of business models (BM) in promoting and disseminating technological innovations [17–19] and energy transitions [20,21], which can effectively integrate economies of scale and learning in production processes [22,23].

Among the various BMs studied in the literature, the Managed Energy Service Agreement (MESA) model is particularly effective. Its distinguishing features include the guarantee of energy performance of retrofit measures and the assumption of responsibility for payment of the energy bill through an energy supply contract, thus managing the entire energy provision and procurement process for the customer [24].

Among the variants of the Managed Energy Service Agreement (MESA) business model, the Energiesprong proposal emerges as a particularly efficient solution, as it guarantees net-zero energy performance and industrialized production processes capable of increasing the long-stagnant productivity of the construction industry [25,26].

The research aims to assess whether deep energy retrofit interventions in the residential sector, through the adoption of the MESA business model and enhanced by off-site production processes, a distinctive feature of Energiesprong's approach, can deliver a value proposition that exceeds the retrofit costs, making them financially viable.

The analysis focuses on two urban markets in Northern Italy, which are representative of real estate markets differing in dynamism and values. It examines the value proposition linked to the improvement of buildings' intrinsic characteristics and their energy performance. Through a dynamic analysis, the research considers the profitability of retrofit interventions in terms of cost reductions resulting from economies of scale and learning effects.

The financial feasibility of such interventions is crucial to make them feasible at a large scale, with positive effects on reducing energy consumption [27], increasing living comfort [28], and the value of buildings.

The decision to focus on Italy as a case study is driven by economic and environmental considerations. From an economic perspective, the nation's building stock, comprising approximately 25 million dwellings, constitutes over 50% of the total cost savings of Italian households [29,30]. From an environmental perspective, according to the EU's Directive 2024/1275, the building stock is inefficient mainly, with approximately 75% of dwellings falling into the least efficient energy classes [6].

The article is organized into five sections. The first section considers the main theoretical references regarding the value proposition and business models adopted in the field of real estate retrofitting, with particular attention to the MESA model. The second section examines the research methodology linking investment perspectives to the positions of the stakeholders involved. The third section presents data and financial models, detailing cost and revenue items for each business model. The fourth section presents the results of the research, while the fifth section provides a discussion of the evaluations carried out.

2. Literature on Value Proposition and Business Models for Residential Retrofit

The energy transformation of the building stock is a crucial element in achieving the European Green Deal target of zero net emissions by 2050 [31–33].

Environmental sustainability is becoming increasingly important in the field of property valuation, with a growing number of studies analyzing the influence of energy efficiency on property values and the impact of Energy Performance Certificate (EPC) policies on consumer choices [34].

Improving energy performance represents a significant investment for households and businesses, but it is also an important feature of house value formation. The price premium of properties with better energy performance has been verified and estimated in numerous international studies [12,35–40].

The appreciation of energy-efficient properties is related to two factors. First, properties with superior energy efficiency benefit from lower operating costs, which, when capitalized, result in a recognizable price premium in the market [41,42]. Second, increasingly stringent energy performance regulations may limit the ability to sell or rent non-compliant properties, leading the market to reward properties in the most efficient energy classes.

The empirical estimation of price premiums related to the energy characteristics of dwellings has mainly been conducted at the level of individual countries or cities. In Europe, significant research has focused on markets in the Netherlands [43], Ireland [44], Denmark [45], the United Kingdom [46], Wales [12], and Spain [47].

In Italy, further studies have examined the impact of energy performance on the market value of residential properties in different cities [48–52]. Research conducted by Ruggeri et al. [53] and Micelli et al. [54] revealed an average price premium in northern Italy of 14% in metropolitan cities and 28% in medium-sized cities when comparing properties from Class G to Class A on the EPC scale. Research conducted by the Bank of Italy on a national scale found an average increase of 25% in the value of energy-efficient dwellings, with significant regional variations: the price premium varies from 12% in more temperate climatic zones to 37% in colder ones, a variation attributed to the higher energy upgrading costs required in areas with a harsh climate [55].

The increase in property values thus represents an opportunity for households and developers. The adoption of appropriate BMs becomes crucial to capture the energy price premium at costs that make retrofits of existing residential stock financially viable [17,19].

The efficiency of BMs depends on the specificities related to the application area and process considered [56,57]. These particularities are reflected in the core components, which include the value proposition, supply chain, customer interface, and financial model [58–62].

Most studies that analyze BMs for residential retrofit focus on the production processes of individual companies, neglecting to consider the entire process and the specific challenges of retrofitting residential buildings [63–68]. Moschetti e Brattebø [69] and Brown [24] comprehensively review the existing academic and grey literature, identifying the main barriers to retrofitting residential buildings.

To date, the atomized market model is still dominant in the retrofit sector. This model involves individual interventions and technologies installed by separate contractors. As a result, retrofits are generally incomplete and inefficient, as the customer must manage the entire project individually, coordinating all parties involved in the process. This increases the potential for abandonment of the initiative with outcomes of limited efficiency and effectiveness [70].

On the front of the models considered most effective, the MESA model contemplates a single specialized company capable of managing the entire retrofit process, from design to verification of energy cost savings. In contrast to the atomized model, in the MESA model, the supplier deals directly with energy bills and monitors consumption, passing on the financial cost savings achieved to the customer (Figure 1).

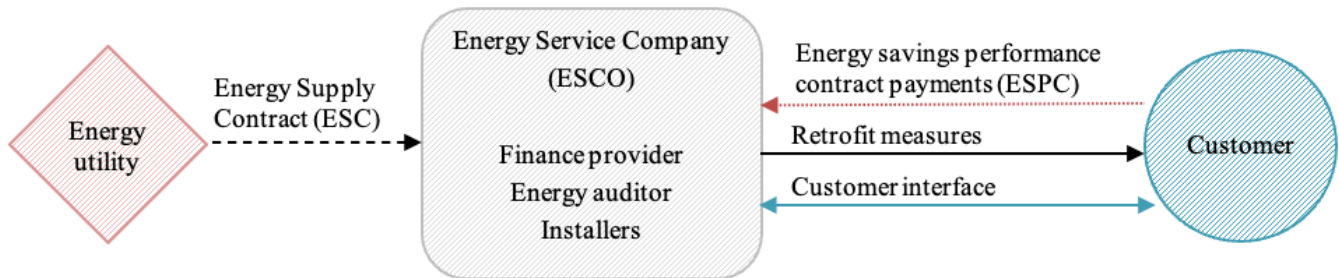


Figure 1. Managed energy services agreement (MESA).

The MESA model combines transformative interventions with a significant set of services for the benefit of ownership and can both take over existing technologies and promote innovation in the specific area of technological and production solutions [71].

Among the various articulations of the MESA model, the solutions promoted by Energiesprong in several European countries are distinguished as advanced solutions for the technologies employed. Initially developed in the Netherlands, Energiesprong functions as a market intermediary, promoting innovation in business models dedicated to residential retrofitting. The Energiesprong BM is based on a net-zero energy performance contract, an integrated and industrialized supply chain, a single customer interface, and a financial model based on increasing the value of the house and the cost savings related to energy performance improvements [72].

Energiesprong is distinguished by its industrial character, which is based on the off-site production of prefabricated components. This approach has significant effects on reducing the time and cost of interventions [26]. Energiesprong envisages rapid, efficient, and scalable whole-home energy upgrades that can achieve high standards of quality and environmental sustainability at decreasing costs due to learning and scale economies [73–75].

Off-site production, in addition to reducing installation time to less than a week in some cases, is distinguished by the possibility of carrying out interventions without requiring the temporary relocation of tenants during the works, thus minimizing disruption and eliminating associated costs. This approach encompasses the prefabrication of elements such as insulated facades and modules integrated with heating systems and renewable energy production [25,70,76–79].

Technical innovation is integrated with new models of economic and financial feasibility based on the concept of Total Cost of Ownership (TCO) and the guarantee of long-term performance [80].

The Energiesprong model, in addition to guaranteeing a 30-year net zero energy balance, significantly improves the intrinsic characteristics of buildings, resulting in an aesthetic and functional impact—termed “*kerbside appeal*”—that can stimulate a growing demand for building retrofits [24].

This is of particular importance, as benefits related to living comfort, such as more efficient thermal insulation and superior indoor air quality, are perceived by owners to be of similar importance to cost savings related to energy consumption [81]. The heightened emphasis on indoor comfort has become particularly evident in the post-pandemic era, as many households have expressed an increasing propensity to invest in enhancing the

thermal and acoustic conditions of their dwellings despite the substantial costs associated with such interventions [82].

In addition, the possibility of customizing interventions and improving a building's overall aesthetics makes energy retrofits of relevant interest. Aesthetic features have been shown to have a significant impact on the marketability of energy-efficient buildings, thereby enhancing their desirability and consequently stimulating demand [83].

Under current market conditions, some research argues that the costs of upgrading existing assets outweigh the market benefits of improving their energy efficiency [84,85]. In light of the current market dynamics and the values involved, the necessity for financial support from the public sector is evident [14–16].

The high number of residential buildings requiring retrofit interventions makes it desirable to invest in new technologies and new production processes to increase productivity in the construction sector and to reduce the costs of interventions to make them more economically feasible [86–89]. This aspect is crucial in a traditionally low-tech and often innovation-resistant sector such as the construction industry [65,68].

For these reasons, the research carries out a dynamic analysis concerning the possible evolutionary path of the retrofit sector to determine the financial feasibility conditions of retrofit interventions for the two investment profiles and urban and territorial contexts characterized by different real estate dynamics.

Assuming the adoption of a MESA BM enriched with advanced technological solutions capable of reducing production time and costs, the retrofit could, over time, become economically feasible and not require any public contribution for its implementation.

The research proposes an evaluation of the economic feasibility of the retrofit by integrating three key components for the first time: the value proposition linked to the energy efficiency of the building, the MESA business model, and the optimization of the production chain through the economies of scale and learning inherent in the variant promoted by the Energiesprong model.

3. Methodology

The methodology we adopted aimed to offer the financial feasibility of retrofit interventions on the existing residential stock, the main recipient of European energy efficiency regulations and, in Italy, largely characterized by modest energy efficiency [90]. According to data provided by the ENEA [91], approximately 4 million residential buildings in Italy, representing 68.6% of the total, are classified within the least efficient EPC energy Classes E/F/G.

The research considers two investment profiles, representative of the main actors involved in the energy retrofit of the residential sector: the owner–tenant, a person who carries out retrofit work on their home to improve its energy and aesthetic performance, and the entrepreneur–developer, an economic operator who carries out the work to increase the value of the property and then to capitalize on it by selling it.

The two profiles analyzed consider distinct time horizons determined by the different purposes pursued. The first profile, associated with the owner–tenant, considers a long-term period of twenty years. This is linked to the desire to capture all the economic and financial benefits deriving from the retrofit intervention, taking full advantage of the guarantee period provided by Energiesprong. Conversely, the second profile, typified by the real estate developer, is associated with a more limited time horizon, spanning a mere two years.

On the supply side, the methodological hypothesis is that both profiles are aimed at companies adopting the BM MESA, enriched by the use of off-site technologies to optimize property transformation processes [92,93].

The assessment of the economic feasibility of the retrofit intervention was carried out using discounted cash flow analysis (DCFA), which is the main procedure for evaluating real estate investments in both academic and professional practice [94–96]. Discounted cash flow analysis allows the determination of the net present value (NPV) of the investment by discounting future cash flows over a given time horizon, considering in a single model the costs of implementing the retrofit (hard costs, which include materials, equipment rental, and transportation), the associated operating costs (soft costs, such as design, consultancy, contingencies, and administrative fees), and the expected value from the sale of the property.

Data on revenues, costs, and discount rates were obtained through market analysis and consultation with the main reference manuals specific to retrofits in the real estate sector. The costs of retrofits considered in the valuation model are derived from the *Energiesprong France* report [97], which provides a detailed analysis of the current costs of residential retrofits carried out according to the *Energiesprong* model.

The reason to refer to data from the French context is motivated by the lack of clear and reliable estimates of the specific costs of retrofits carried out according to the *Energiesprong* model in the Italian market, together with information on the evolution of production volumes and cost trends.

Energiesprong renovations are characterized by an off-site production process and the use of prefabricated components, resulting in relatively stable costs internationally. This differentiates them from traditional building renovations, whose costs are strongly influenced by on-site variables, with significant local fluctuations. In the two cities under analysis, building costs are higher than the Italian national average and in line with French costs, which are slightly higher than Italian costs [98].

Therefore, we assume here the full transferability of the cost values and technological processes to the Italian context because of the great similarity between France and Italy in terms of industrial structure, building stock characteristics, and the substantial convergence of construction and renovation costs in the two countries [99].

To ensure accurate comparability, the cost values in the report have been appropriately updated using the French Total Cost Index (CCI) for the period 2021–2023 to put these data in context with the current economic landscape [100].

The report also includes projections of possible cost reductions as the number of renovated buildings increases because of economies of scale and learning. The process has been widely studied in the literature. Since Wright's [101] study of airplanes, the systematic relationship between unit production costs and cumulative output has been recognized: unit costs tend to fall by a constant factor each time cumulative output doubles [102]. This relationship, known as the learning curve, has been widely used to predict cost reductions from the adoption of innovative technologies. A significant example in this field is the market for photovoltaic panels, whose prices have decreased by 99.6% since 1976 [103,104].

The benefits associated with retrofitting interventions are economic and financial, differentiated according to the profiles studied. For the owner–tenant, the economic benefit relates to the increase in the asset value of the property because of the improved energy performance and maintenance status of the dwelling unit, while the financial benefit includes the reduction in energy costs and the elimination of the costs associated with temporary relocation during retrofitting interventions.

The valuation of the price premium is based on the hedonic pricing model, a widely used method for assessing the impact of EPC certification on property values. The underlying assumption is that the value of an asset, in this case, a property unit, depends on its characteristics. Consequently, the method is used to determine the contribution of positional and performance characteristics to the overall value of the property [105,106].

The analysis is based on a representative sample of a given geographical area, which allows the application of multivariate regression analysis to the observed market values [107]. The evaluations obtained make it possible to assess the increase in value of an energy-efficient property compared with a less efficient one.

The financial benefits to the owner–tenant fall into two main categories. The first is the cost savings made by eliminating the costs of moving and paying rent for a replacement property. The Energiesprong model allows retrofits to be carried out while keeping the owner or tenant in the home during the retrofit, eliminating the need for temporary relocation. In addition to eliminating the costs associated with temporary relocation to another dwelling, continuity of housing also supports the emotional and social well-being of residents during the retrofit process [25].

The second category of financial benefits relates to the reduction in energy and maintenance expenses over the 20 years following the intervention. More precisely, energy expenses are reduced to zero thanks to the net-zero nature of the Energiesprong interventions, while maintenance expenses are postponed until the end of the 20-year warranty period offered by Energiesprong, which covers both the energy and structural performance of the building [108–110].

For the entrepreneur–developer, the valuation is made on the assumption that the retrofitting intervention is carried out on a property owned by him/her, without tenants, to sell it two years after the investment. In this case, the only benefit of the intervention is financial, and it consists of the cash flow generated by the sale of the property at a higher value as a function of the improved energy characteristics and the overall upgrading of the property.

Table 1 delineates the benefits of the retrofit intervention for both investment profiles, classifying them into economic benefits related to changes in asset value and financial benefits related to direct and immediate cash flows.

Table 1. Economic and financial benefits of retrofitting with off-site technologies according to the Energiesprong model for the two investment profiles.

	Owner–Tenant	Entrepreneur–Developer
Economic benefits	Δ price premium from G and habitable to Class A and renovated	-
	-	Δ price premium from G and habitable to Class A and renovated
Financial benefits	Avoided cost of energy consumption	-
	Avoided the cost of moving	-
	Avoided the cost of rent for the alternative accommodation	-
	Avoided cost of extraordinary maintenance	-

The price premium associated with energy retrofitting turns out to be very different in cities of different sizes, real estate market dynamics [54], and climatic environments [55]. It seems crucial to carry out a more spatially sensitive comparative investment analysis. The selected cities are Milan and Udine, both located in Northern Italy but with different urban dimensions and market dynamics.

Milan, a metropolitan city with 1.3 million inhabitants, is recognized as the main economic center of Italy. The city has a highly dynamic real estate market with positive growth indicators, both economic and social [111]. On the other hand, Udine, with 98,040 inhabitants, is a representative city of medium-sized Italian cities, where more than 40% of the population lives [112].

According to the climatic classification of Italian municipalities established by current legislation [113], both cities fall within climate zone E, the area on which this research focuses. Zone E is characterized by a continental climate known to be one of the harshest in Europe [114], with a number of degree-days between 2101 and 3000. Buildings in the cities of this zone are characterized by high energy demand, resulting in significant annual costs for the inhabitants, which are only lower than in the Alpine area in the north of the country.

4. Data Selection and Source

The development of the DCFA model requires the identification of the financial costs and benefits of retrofits. For the developer-investor, the change in value associated with improved energy and intrinsic property characteristics is the most important benefit.

The price premium associated with superior energy efficiency was estimated using a dataset of offer prices. There are several reasons for using asking prices rather than actual sales and purchase values. First, asking prices ensure greater data availability and wider access to information on energy performance certificates (EPCs). In Italy, the collection of data on actual transactions is often hampered by legal constraints related to privacy and significant restrictions on access to such information [107]. It is no coincidence that the scientific literature has consequently used asking prices because of their availability, as evidenced by numerous studies that have confirmed their usefulness for analyzing real estate market trends [115] and for investigations very similar to the one developed in this research [53–55].

Asking prices were collected from Immobiliare.it [116], the leading real estate asking platform in Italy, which provides a large database of detailed information from both real estate agencies and private sellers [117].

Data collection followed a systematic process, with random sampling within the administrative boundaries of the urban areas of the cities under research. A total of 873 asking prices were collected for Milan and 404 for Udine. For each asking price sampled, eight variables were collected relating to the geographical location and the intrinsic, typological, and technological characteristics of the property. This information was collected in July 2023.

The descriptive and frequency statistics show a homogeneous picture in terms of typological characteristics and maintenance status (Appendix A—Tables A1 and A2). The data analysis revealed a predominant dwelling in the sample, located in a semi-central area with little infrastructure. The predominant dwelling consists of flats of approximately 70 square meters, with only one bathroom, which can be classified as ordinary class properties belonging to Class G on the EPC scale.

The methodology used to determine the price premium involves the use of the hedonic price model. The regression used to estimate the hedonic price can take several functional forms [118,119]. The literature does not provide clear guidance on the most appropriate functional form to represent the complexity of value formation. In this research, we choose to use a semilogarithmic function, which has been widely adopted for its properties, including its ability to reduce the problem of heteroscedasticity [120] and to highlight the nonlinear relationship between property prices and the characteristics that explain their value [121].

The regression model uses the natural logarithm of the unit market value as the dependent variable. Formally, the model used is as follows:

$$P_i = \beta_0 + \sum_{i=1}^I \beta_i X_i + e_i \quad (1)$$

where:

- P_i is the natural logarithm of the price of a dwelling expressed in EUR/sqm;
- β_0 is the constant of the model;
- β_i represents the marginal price of the characteristic;
- X_i is the numerical value of the observed variables, including EPC;
- e_i represents a random error.

The regression models for Milan and Udine show a coefficient of determination (R^2) of 62.6% and 42.9% and an adjusted R^2 of 62.3% and 42.0%. The statistical reliability of the models was further confirmed by the F-test, whose p -value was less than 0.005 in both cities (Table 2).

Table 2. Models.

Model	R^2	Rq Adjusted	F	df1 ^a	df2 ^b	p -Value
Milan	0.626	0.623	192.859	7	807	<0.001
Udine	0.429	0.420	49.7	6	397	<0.001

^a df1: regression; ^b df2: residual.

Table 3 presents the results of the regression model, together with the analysis of the Variance Inflation Factor (VIF), which is used to assess the degree of multicollinearity between the independent variables. In both cases analyzed, the VIF values are close to one, indicating a low correlation between the variables and confirming their independence.

Table 3. Regression models.

Predictors x_i	x_i	Milan		Udine	
		β_i	VIF	β_i	VIF
K		10.306	-	8.421	-
Zone	2	-0.314	1242	-0.041	1.11
Proximity to infrastructure	3	-0.076	1061	-	-
Typology	1	-	-	-	-
Property class	3	-0.17	1408	-0.132	1.34
Number of bathrooms	1	0.064	2413	0.150	2.01
Surface	70	-0.001	2496	-0.002	1.96
Energy class	12	-0.027	1409	-0.037	2.13
Maintenance status	3	-0.036	1381	-0.103	2.29

According to the analysis presented in Table 4, the difference in value between a Class G property and a Class A property is estimated to be 21.90% for Milan and 38.26% for Udine.

For the owner-tenant, the increase in value has only an economic significance and is therefore not considered in the evaluation, while other benefits are considered in the evaluation of the investment: cost savings on energy costs, reduction in costs for extraordinary maintenance, and elimination of the costs of moving and renting alternative accommodation during an ordinary renovation.

Table 4. Difference in value for energy efficiency.

	Milan	Udine
Vm ante unit: Class G and habitable	4925 EUR	1312 EUR
Vm post unit: Class A and renovated	6003 EUR	1814 EUR
Vm ante: Class G and habitable	344,723 EUR	91,844 EUR
Vm post: Class A and renovated	420,204 EUR	126,979 EUR
From G and habitable to Class A and renovated	75,481 EUR 21.90%	35,135 EUR 38.26%

The cost of energy consumption (C_e) was determined concerning the typical building previously identified in the sample using the following formula:

$$C_e = (EP_{gl,nren} \times P_g + EP_{gl,ren} \times PUN) \times S \quad (2)$$

where:

- C_e is the cost of energy consumption;
- $EP_{gl,nren}$ is the overall non-renewable energy performance index (kWh/sqm year);
- P_g is the price of non-renewable energy (EUR/kWh);
- $EP_{gl,ren}$ is the overall renewable energy performance index (kWh/sqm year);
- PUN is the price of renewable energy (EUR/kWh);
- S is the surface area of the building unit (sqm).

Unit energy prices have been determined based on the average of historical prices recorded over the last 15 years to obtain a representative value of market dynamics and to reduce the influence of short-term economic fluctuations. The average cost of non-renewable energy (P_g) was determined from data provided by the Gestore dei Mercati Energetici [122], the main institution responsible for managing the Italian electricity market. The cost of renewable energy (PUN), on the other hand, was obtained from information published by the Regulatory Authority for Energy Networks and the Environment [123], which is responsible for regulating and controlling the energy and water sectors. In summary, the annual cost of the energy consumption of the typical building is 1745 EUR (Appendix—Table A3).

The retrofit intervention with off-site technology proposed by Energiesprong guarantees the tenants' continuity of living during all phases of the intervention. This feature eliminates the cost of moving, estimated at around 3000 EUR, as well as the costs associated with renting alternative accommodation. The avoided rental costs have been estimated over four months, the average duration of a complete renovation not carried out off-site. The amount of avoided costs depends on the local real estate market: 4150 EUR in Milan and 1500 EUR in Udine [116,124].

Further financial benefit comes from the possibility of postponing extraordinary maintenance costs thanks to the investment made and the 20-year guarantee on the technological and engineering features and performance offered by the Energiesprong model. Dividing these costs into annual installments allows a saving of 0.25% per year on construction costs [109].

The hard and soft costs associated with deep retrofitting are identical in the two assessments for the two investment profiles considered. The hard costs, represented by the expenses for implementing the retrofit using off-site technology, were estimated at 1150 EUR/sqm in 2021 in France [97]. The 21% increase recorded by the French Overall Cost Index (CCI) between 2021 and 2024 results in an updated renovation cost of 1400 EUR/sqm [100].

The soft costs, i.e., the additional costs associated with retrofitting, were estimated through a comparative analysis of their incidence in traditional renovation projects to the specificities of the off-site model of Energiesprong [109]. The analysis was necessary because the official reports of Energiesprong do not provide any information on this. The incidence of soft costs in the off-site retrofit is reduced due to greater efficiency and streamlining of the design and construction phases. Detailed values of financial benefits and intervention costs are given in Appendix A—Table A4.

The discount rate used for the economic evaluation is determined using the Weighted Average Cost of Capital (WACC), which weights the cost of debt and equity capital. The cost of debt capital is set at 3.06%, which is the average value of green mortgages offered by the main Italian banks [125] (Appendix A—Table A5). This value, which is lower than the rates applied to ordinary building interventions, reflects the favorable conditions offered by banking institutions to projects promoting energy efficiency and environmental sustainability.

The cost of equity capital varies according to the development scenario considered. For the owner–tenant, the financing structure makes greater use of debt capital than in conventional configurations, given the plausible propensity of households to maximize leverage by taking advantage of the favorable conditions offered by green mortgages. On the contrary, in the case of the developer, the financing structure adopts an ordinary structure with lower debt leverage and higher equity contribution because of the higher return expectations and risks typically associated with such projects [109,126]. Details on the WACC and its decomposition into its components can be found in Appendix A—Table A6.

The assessment of the economic feasibility of the retrofit intervention considers a time horizon of 2 years for the developer and 20 years for the owner–tenant.

The first assessment is based on current retrofit costs and technologies. It aims to determine the financial feasibility of the retrofit investment by the two investor profiles identified in the different urban contexts studied. A second assessment was carried out to verify how the economies of scale and learning associated with the increasing number of retrofits—a particular aspect of the BM Energiesprong examined in this research—affect the profitability of the investments.

5. Analysis and Results

The assessment of the financial feasibility of the retrofit intervention, based on the BM Energiesprong, was carried out on the previously defined dwelling. The retrofit intervention aims to improve the energy efficiency of a 70 sqm building in the case of the maximum performance gap to transform a building from energy Class G to Class A on the EPC scale while at the same time improving its intrinsic characteristics. The evaluation was carried out by discounting the costs (Table 5) and the financial and economic returns of the investment, considering the time perspective of each investment profile (Appendix A—Table A4).

Table 5. Unit and total costs, both undiscounted, of the retrofit intervention with off-site technologies according to the Energiesprong model for the dwelling in Milan and Udine for the two investment profiles.

	Owner–Tenant		Entrepreneur–Developer	
	Unit Value [EUR/sqm]	Total Value [EUR]	Unit Value [EUR/sqm]	Total Value [EUR]
Hard costs	1400	98,000	1400	98,000
Soft costs	168	11,760	224	15,600
Total costs	1568	109,760	1624	113,600

The financial feasibility assessment was carried out by estimating the NPV of the investment. The results obtained indicate that, under current cost conditions, retrofit interventions have a negative NPV for both investment profiles and urban contexts analyzed.

For the owner–tenant profile, the values obtained show a similarity between the two cities analyzed. In Milan, the NPV shows a negative unit value of -890 EUR/sqm and a total of $-62,000$ EUR for the whole investment. Similarly, in Udine, the unit NPV is -930 EUR/sqm, and the total is $-64,860$ EUR.

The costs and benefits of the retrofitting intervention are largely independent of the specificities of the local real estate markets, except for the lost costs of renting an alternative accommodation during the intervention phases. In metropolitan cities such as Milan, rents are high, and their absence, even for a short period associated with the renovation of the property, reduces the investment deficit but does not significantly affect the final NPV.

The situation is different for the entrepreneur–developer who sells the dwelling after the retrofit. In this case, the NPV values for Milan and Udine show a significant divergence. In Milan, the NPV of the unit is negative at -536 EUR/sqm and a total of $-37,500$ EUR for the whole investment, while in Udine, the NPV of the unit is -1112 EUR/sqm and a total of $-77,900$ EUR for the dwelling.

This difference is due to the immediate capitalization at the time of sale of the price premium resulting from the improved energy and maintenance quality of the retrofit. In metropolitan cities, where property values are generally higher, the change in value because of the improvement in energy efficiency is also significantly higher. The NPV in the simulation carried out for Milan is, therefore, higher than that developed for the city of Udine for the same type of intervention and retrofitting costs.

At this point, it is possible to determine the public contributions necessary to make the investment financially viable. In the hypothesis of upfront contributions to the different investor profiles considered, the results elaborated based on the financial models' return mirror values regarding the financial performance considered previously.

For the owner–tenant, the financial contribution required to make the retrofit investment financially feasible amounts to 57% of the total investment value in Milan and 59% in Udine. These values, in line with those found for the NPV, indicate the need for a contribution of more than half of the investment for the retrofit with BM Energiesprong. The case of the entrepreneur–developer is different: the required upfront contribution is 27% in Milan, while in Udine, it is more than double, reaching 65% of the total investment (Figure 2). In Milan, the higher property values allow the developer to obtain a greater absolute price premium after retrofitting. This means that, for the same intervention cost, the resale value of the upgraded property covers a greater proportion of the investment. As a result, the financial gap to be filled by public support is smaller.

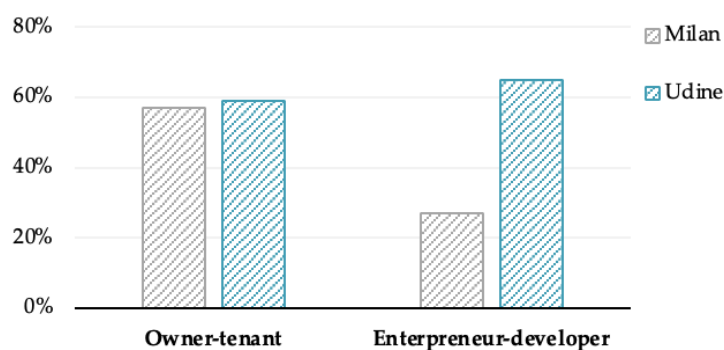


Figure 2. Amount of upfront financial contribution (%) compared with the total amount of financial investment required to make a retrofit financially feasible for the two investment profiles in Milan and Udine.

Udine, on the other hand, has a lower value and is a less dynamic market. Although the percentage increase in value from retrofitting is significant, the absolute gain is much smaller. This makes it more difficult for the developer to recoup the investment through resale, and therefore, a higher public contribution is needed to ensure financial feasibility.

At current cost levels, retrofits are not financially feasible for the profiles examined, and significant public intervention is required to attract the interest of owners and developers. However, the research aims to test whether the Energiesprong BM can be financially feasible in the future, taking into account the cost reductions associated with increasingly efficient off-site production, which is a distinctive aspect of the Energiesprong model.

The function of hard costs of retrofits as a function of production volume was developed using data provided by Energiesprong France, the only source that provides clear and reliable estimates of cost reductions per production volume for retrofits carried out according to the Energiesprong model [97].

As illustrated in Table 6, three distinct functional forms were examined, namely the Power Law Model [101], the Learning Curve Model [127], and the Logarithmic Cost Function [128]. These models are frequently employed to approximate cost as a function of production quantity, incorporating the concepts of economies of scale and learning.

Table 6. Comparison of three cost reduction models—Power Law, Learning Curve, and Logarithmic Cost Model—showing their mathematical formulation and typical industrial applications.

Model	Functional Form	Typical Application
Power Law Model	$C(Q) = C_0Q^b$	Strong economies of scale, manufacturing, and industrial production [23,101]
Learning Curve Model	$C(Q) = C_0Q^{\log_2(1-r)}$	Learning effect in production costs, renewable energy, and aerospace [127,129,130]
Logarithmic Cost Function	$C(Q) = a + b \ln(Q)$	Gradual cost reduction, industrial processes with limited scalability [128,131]

A considerable amount of research in the industrial sector has revealed that the decline in cost is more likely to be a function of a logarithmic trend as opposed to a pure power function [128]. The logarithmic function is characterized by a more gradual decrease in production cost compared with the power function, which renders it more suitable for sectors where large-scale production does not result in significant cost reductions. Consequently, for building retrofit projects, where fixed costs and learning variables are less pronounced than in manufacturing, the logarithmic reduction may be more realistic.

The logarithmic function provides a useful representation of the cost reduction, which decelerates over time. The dynamics of economies of scale have a strong initial impact, which then tends to stabilize. In comparison to the conventional learning curve, which assumes a constant rate of reduction for each duplication of production, the logarithmic function facilitates the modeling of scenarios in which learning is non-uniform.

As outlined in the preceding paragraph, the relationship between cost and production volume is described in this case by the logarithmic functional form because of the reasons stated and the ability to interpolate data obtained from Energiesprong France [97] (Figure 3—see the black dots).

The cost function, which has been elaborated, is based on a limited number of surveys and thus suffers from a significant level of approximation. However, it represents, at present, the most accurate interpolation obtainable based on the extant empirical evidence of the Energiesprong off-site production model.

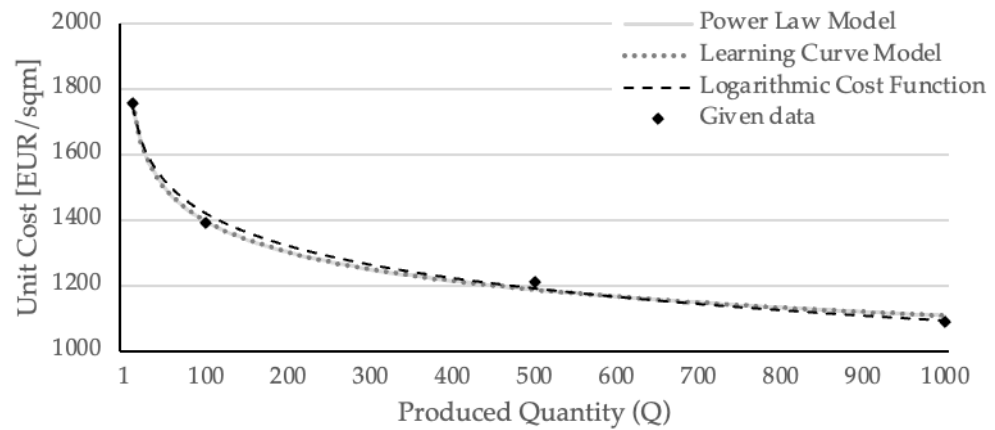


Figure 3. Cost reduction trends for different production quantities, comparing the Power Law Model, Learning Curve Model, and Logarithmic Cost Model. The Power Law model (light grey) predicts strong economies of scale, leading to rapid cost declines. The Learning Curve model (dotted grey line) incorporates experience-driven cost reductions commonly observed in high-tech and renewable energy industries. The Logarithmic Cost Model (dashed black line) represents industries where cost decreases occur more gradually over time. The black dots indicate the observed data points used to fit the models.

The estimated cost reduction is conservative when compared with values identified in previous studies on learning curves of other industrial products. Studies conducted on the production of photovoltaic panels, for example, have shown an average production cost reduction of between 20% and 32% for each doubling of production [103,104].

Based on the elaborated cost function, with a cumulative production of 50,000 units, the cost of a deep retrofit intervention would be around 500 EUR/sqm, an estimated 60% reduction compared with the current cost of 1400 EUR/sqm reported by Energiesprong France (Figure 4). The reference value is normalized to 100 for the current cost of 1400 EUR/sqm, while the initial intervention cost of 125 reflects an initial value of 1750 EUR/sqm recorded with lower production volumes.

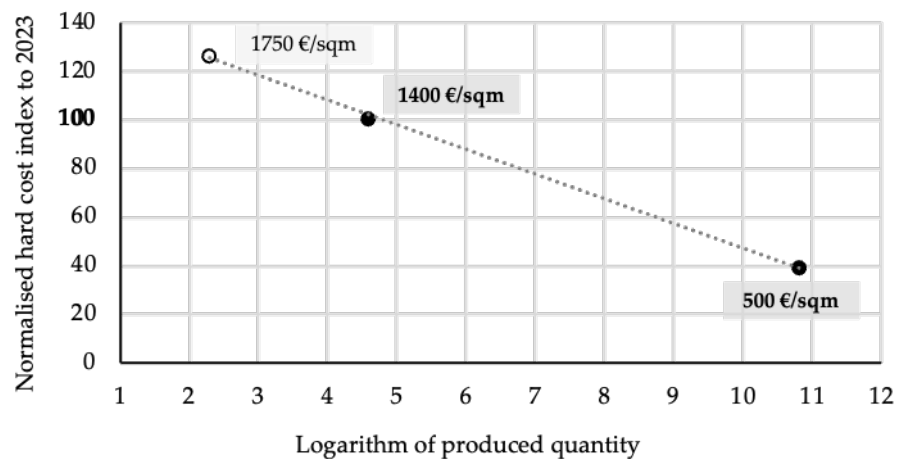


Figure 4. Unit cost function of retrofitting with off-site technologies as a function of the logarithm of the number of units produced, based on data from Energiesprong France.

The reduction function of the identified intervention costs, with unchanged soft costs, enables the correlation of the development of production with the financial models for the two identified profiles. The objective is to ascertain the cost threshold value for which the Energiesprong retrofit intervention is financially feasible without the necessity for public contribution.

The cost reduction leads to a progressive increase in the net present value (NPV) of the investment for both the considered profiles and the investigated urban contexts. For the owner–tenant, the feasibility of retrofit investments is ensured for cost values around 500 EUR/sqm in both high-property-value cities such as Milan and low-property-value cities such as Udine (see Figure 5).

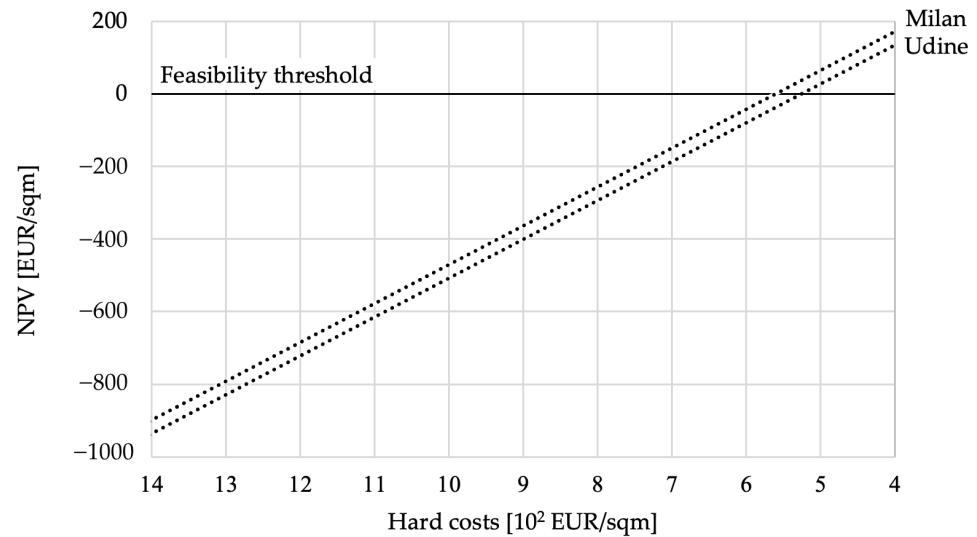


Figure 5. Variation in the unit NPV of the investment as a function of the reduction in the cost of the retrofit intervention using off-site technologies in Milan and Udine for the tenant owner.

Nevertheless, the conclusions drawn for the developer entrepreneur differ. In Milan, the investment in retrofitting is feasible for much lower values than in Udine. The immediate capture of the price premium value by the developer determines, in the simulation carried out on the values of Milan’s real estate market, profitability conditions that ensure the feasibility of the retrofit investment with a hard cost of approximately 900 EUR/sqm (Figure 6).

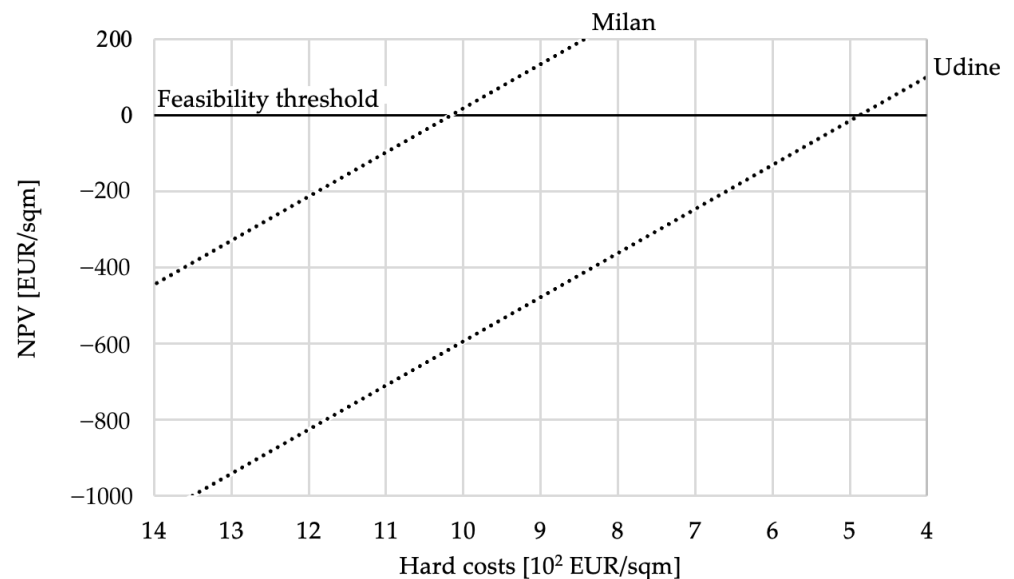


Figure 6. Variation in the unit NPV of the investment as a function of the reduction in the cost of the retrofit intervention using off-site technologies in Milan and Udine for the entrepreneur–developer.

In the case of lower price premiums, as is the case of the Udine real estate market, the conditions of feasibility of the investment are reached with hard costs of approximately 500 EUR/sqm (Figure 6).

6. Discussion of the Results

The results highlight some important aspects. First, evaluations conducted at current costs and technologies show that, to date, the economic and financial benefits of retrofitting are lower than the costs incurred. For the owner–tenant, about 60% of the investment is not compensated by the benefits, while for the developer, the share of the investment not recovered varies from 30% in metropolitan cities to 70% in medium-sized cities.

This finding aligns with the extant literature [83,84], which suggests that the financial benefits associated with enhancing the energy efficiency and inherent characteristics of residential properties, even when considering the full range between Class G and Class A properties, are inadequate to ensure the economic and financial feasibility of the investment.

The retrofit sector—strategic for the decarbonization of the built environment—is therefore not financially feasible and must rely on public subsidies to increase an otherwise inadequate return. Direct subsidies are a key mechanism, but alternative policy measures such as tax incentives, levies, an increased carbon tax, and the promotion of green mortgages can also play a crucial role in bridging the financial gap and incentivizing long-term investment in energy-efficient retrofits.

Nevertheless, the values that emerged from the research indicate that upfront contributions intended for the transition of the building stock should only cover a part of the retrofit investment and not its entirety. In some states, the public contribution has instead been integral and not partial [132]. The Italian legislator, for example, has in recent years supported a policy aimed at promoting energy efficiency investments by financing them in full, while an adequate return would have been achieved even with only a partial contribution to the total investment.

The second point that deserves to be discussed concerns the dynamic nature of the sector, examining the new technologies that characterize the MESA Energiesprong model.

The interest of this model lies in the possibility of considering a progressive reduction in the costs of retrofit interventions following a learning curve that has already characterized many other industrial sectors, including those related to retrofits, such as photovoltaic panels [104].

The analyses conducted, although based on data referring to only one state, France, and referring only to early trends, show an important trend of decreasing costs because of learning and scale economies linked to the development of new off-site production processes and industrialized construction. The reduction in hard costs assumed in the research because of economies of scale and learning is essentially half of the current construction cost. Consequently, retrofit investments become financially feasible, and no public subsidy is required for households and companies.

To achieve this objective, the major production of several tens of thousands of dwellings is expected compared with the current production volumes of industrialized construction [26]. While this production volume may appear ambitious, it should be noted that it represents a modest fraction of the overall building stock in need of modernization by the European deadlines set by the EPDB Directive for 2050. In a single state, such as Italy, the number of buildings in need of action exceeds 4 million, a number that grows further when considering the European building stock.

Cost reduction could have a significant impact on the affordability of retrofit interventions. As the analyses demonstrate, even with a reduction of a few tens of percentage points in the hard cost component alone, the feasibility of retrofit investments could be ensured

without depending on any public contribution, at least in those areas where premium prices can make building retrofit investments more profitable.

In many states—and this is particularly the case in Italy—policies have adopted technology and construction costs as unchangeable data. As a result, the leverage used to make interventions financially feasible has been to contribute to households and support them to invest in upgrading their dwellings. The MESA Energiesprong model demonstrates how a different path is possible by supporting not only demand but also capable companies, thanks to the industrialization path of construction that allows an increase in productivity and results in lower unit costs.

Such a path of increasing the efficiency of the retrofit sector makes it possible to consider the gradual decrease in public support for the decarbonization of the existing building stock, with retrofitting becoming a distinct segment of the construction market, independent of public contributions. The development of off-site technologies on a European scale, rather than a national scale, renders it highly probable that construction costs will decline and the consequent emergence, progressively over time and depending on the specificities of territories and local real estate markets, of renewed conditions of economic feasibility of interventions to decarbonize the European residential stock.

Third, the financial feasibility of retrofit interventions is subject to variation according to the territorial context. In large cities characterized by larger real estate markets, the price premium derived from retrofit intervention at the time of sale, in absolute value, is higher. In contrast, cities with less substantial real estate markets encounter greater challenges in transitioning to energy-efficient assets, a problem that is especially pronounced in the context of private conveniences.

This conclusion raises a question regarding the distributive justice of the burdens associated with energy transition. The financial feasibility of interventions, given the same typology and costs, appears more onerous, in relative terms, in territories where the amount of the price premium is limited, as shown in a small–medium-sized city such as Udine compared with a metropolitan city such as Milan.

The energy transition does not invariably have a uniform effect on assets. Indeed, the transformation of building stock imposes a greater burden in relative terms on properties in cities already marked by lower market values. This dynamic deserves special attention, as it could fuel discontent and resistance to the transition itself, motivated more by economic aspects than theoretical or ideological reasons [133,134].

In addition to the disparities between cities of different ranks and characterized by important gaps in real estate values, there are also differences related to the climatic characteristics of the territories. Research shows how the price premium related to the technological upgrade of the property varies depending on the geographical area considered.

Public incentives and contributions should take into account the different prominence of energy costs and the price premium attributed to the characteristics of each property for the proper allocation of public resources [135]. The current policy of uniform national contributions is likely to demonstrate inefficiency and inadequacy in the distribution of public resources [53,55,136].

In the future, therefore, policies should provide incentive instruments appropriately tailored to the territorial context and characteristics of local markets to ensure the optimal allocation of available resources.

7. Conclusions and Policy Implications

The energy transition and decarbonization require a deep transformation of the building stock, in line with the net zero emissions targets set by the European Green Deal. The

challenge is crucial for Italy, where 70% of the building stock belongs to the least efficient EPC energy classes.

The research analyses the financial feasibility of deep energy retrofit interventions in the residential sector, adopting the BM MESA, which is recognized as the most effective for its integrated service offering and simplifies the customer experience [24]. The proposed methodology integrates BM MESA principles with the off-site production processes typical of the Energiesprong offering.

The evaluations consider two investment profiles: an owner–tenant who renovates the dwelling for private use and an entrepreneur–developer who renovates the property to sell it, capitalizing on the increase in value. The analysis was conducted in two distinct urban contexts: Milan, a metropolitan city, and Udine, a small–medium-sized city.

The findings indicate that, despite the presence of relevant benefits represented by a price premium linked to superior energy efficiency, the renewed quality of the property, and the cost savings on energy costs, retrofits are not financially feasible with current costs and technologies without external upfront contributions.

The research indicates, however, that the development of off-site technologies, a distinctive aspect of the MESA Energiesprong model, may lead to a substantial reduction in hard costs due to learning economies and economies of scale. Despite the absence of fully reliable data on the reduction in costs as a function of production volumes, it is reasonable to assume that, particularly in large cities characterized by higher price premiums in absolute terms, the retrofit sector may eventually represent an autonomous and independent sector of the real estate construction industry without the public contribution being a diriment support.

Future research may cover several areas. First, the development of new players capable of giving substance to the MESA Energiesprong model appears to be of great importance. While the model has been delineated [24] and can be considered a virtuous and efficient evolution of the construction and real estate sector, its affirmation in concrete national markets remains to be demonstrated. Therefore, it appears central to verify its concrete development in the different national markets; otherwise, the virtuous and efficient development of the housing stock retrofit market will not be achieved.

Second, it appears necessary to pay the utmost attention to the evolution of retrofit costs operated with off-site production technologies, inseparable from the Mesa Energiesprong model considered in this research. Since these technologies, in any case, have a significant presence of the labor factor, it seems hardly credible to assume the same cost reductions as for buildings that are entirely mass-produced and, therefore, susceptible to the greatest economies of scale and learning. The development of off-site retrofit volumes will, therefore, provide crucial insight into the development of a strategic component of European construction.

Finally, a very important issue concerns public policies aimed at supporting the achievement of the EPBD 2050 in the building stock and housing stock. The research has highlighted the need to investigate not only demand-support policies, differentiating these for contexts characterized by very different conditions of the economic viability of the retrofit, but also those aimed at supply, supporting the use of technologies capable of ensuring increasing technical and economic efficiency to the processes of energy and real estate requalification of the residential building stock. The optimal combination of these policies could usefully contribute not only to the efficient use of public resources in the sector but also to the concrete achievement of European objectives on the decarbonization of the built environment.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Frequency analysis.

Variables	Categories	Milan		Udine	
		n	%	n	%
Zone	Central zone	209	23.9	151	37.4
	Semicentral zone	224	25.7	160	39.6
	Suburban zone	440	50.4	93	23.0
Proximity to infrastructure	Up to 200 m	265	30.4		
	From 201 to 500 m	518	59.3		
	Over 500 m	90	10.3		
Typology	Villa	0	0.0	24	5.9
	Apartment	873	100.0	380	94.1
Property class	Luxury	53	6.1	15	3.7
	Prestigious	469	53.7	152	37.6
	Ordinary	283	32.42.2	222	55.0
	Economic	19		15	3.7
Number of bathrooms	One bathroom	489	56.0	179	44.3
	Two bathrooms	295	33.8	193	47.8
	Three bathrooms	86	9.9	32	7.9
	Four bathrooms	2	0.2	-	-
Energy class	A4	7	0.8	21	5.2
	A3	8	0.9	2	0.5
	A2	12	1.4	5	1.2
	A1	11	1.3	4	1.0
	A+	6	0.7	8	2.0
	A	24	2.7	4	1.0
	B	22	2.5	26	6.4
	C	20	2.3	31	7.7
	D	87	10.0	52	12.9
	E	130	14.9	91	22.5
F	182	20.8	91	22.5	
G	362	41.5	69	17.1	
Maintenance status	New—under construction	48	5.5	31	7.7
	Excellent—renovated	346	39.6	116	28.7
	Good—habitable	357	40.9	234	57.9
	Poor—to be renovated	110	12.6	23	5.7

Table A2. Descriptive statistics.

Variables	Milan					Udine				
	n	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max
Unit value	873	6324.9	2999	1307	21,883	404	1655.4	649.8	523.0	4063
Zone	873	2.26	0.821	1	3	404	1.8564	0.765	1	2
Proximity to infrastructure	873	1.80	0.606	1	3	0	-	-	-	-
Typology	873	1.00	0.000	1	1	404	0.9406	0.237	0	1
Property class	824	2.33	0.628	1	4	404	2.5866	0.626	1	4
Number of bathrooms	873	1.54	0.680	0	4	404	1.6361	0.625	1	3

Table A2. Cont.

Variables	Milan					Udine				
	n	Mean	S.D.	Min	Max	n	Mean	S.D.	Min	Max
Energy class	871	10.36	2.270	1	12	404	9.2995	2.756	1	12
Maintenance status	861	2.61	0.778	1	4	404	2.6163	0.711	1	4
Surface	873	108.09	57.371	19	482	404	128.73	66.716	23	490

Table A3. Total energy consumption cost for a residential property in climate zone E, with floor area between 50 and 100 sqm and energy Class G.

Energy Consumption	
$Ec = (EPgl,nren \times Pg + EPgl,ren \times PUN) \times S$	
EPgl,nren	313.6 kWh/sqm·y ¹
EPgl,ren	5.8 kWh/sqm·y ¹
Pg	0.078 EUR/kWh ²
PUN	0.081 EUR/kWh ³
Surface (S)	70 sqm
Ec	1745 EUR·y

¹ [137]; ² [123]; ³ [122].

Table A4. Financial benefits and total costs, both undiscounted, of the retrofit intervention with off-site technologies according to the Energiesprong model for the dwelling in Milan and Udine for the two investment profiles.

	Owner–Tenant				Entrepreneur–Developer			
	Milan [EUR/sqm]	Udine [€]	Milan [EUR/sqm]	Udine [€]	Milan [EUR/sqm]	Udine [€]	Milan [EUR/sqm]	Udine [€]
Hard costs	1400	98,000	1400	98,000	1400	98,000	1400	98,000
Soft costs	168	11,760	168	11,760	224	15,600	224	15,600
Total costs	1568	109,760	1568	109,760	1624	113,600	1624	113,600
Δ price premium from G to A	1078	75,481	502	35,135	1078	75,481	502	35,135
Avoided cost of rent for the accommodation	59	4147	21	1496	-	-	-	-
Avoided cost of moving	43	3000	43	3000	-	-	-	-
Avoided cost of energy consumption	499	34,907	499	34,907	-	-	-	-
Avoided cost of extraordinary maintenance	70	4870	70	4879	-	-	-	-
Financial benefits	1749	122,405	1134	79,409	1078	75,481	502	35,135

Table A5. Fixed rates for 20-year green mortgages offered by major Italian banks in 2022 [125].

Bank	20-Year Green Mortgage Fixed Rate [%]
Casa Banca delle Terre Venete Credito Cooperativo	2.70
Banca delle Terre Venete Credito Cooperativo—Gruppo Bancario Cooperativo Iccrea	2.70
Banca Monte dei Paschi di Siena	3.50
Banca Sella—Gruppo Banca Sella	2.99
Banco BPM—Gruppo Banco BPM	3.40
Banco di Desio e della Brianza—Gruppo Banco Desio	3.40
Banco di Sardegna—Gruppo BPER	2.80
Bcc Milano—Gruppo Bancario Cooperativo Iccrea	3.50
BNL—Gruppo BNP Paribas	2.80
BPER Banca—Gruppo BPER	3.06
CrediFriuli—Gruppo Bancario Cooperativo Iccrea	2.70
Crédit Agricole Italia—Gruppo bancario Crédit Agricole Italia	2.60
ING	3.20
Intesa Sanpaolo—Gruppo Intesa Sanpaolo	3.20
UniCredit	3.40
Average rate	3.06

Table A6. Financing structure and calculation of WACC (Weighted Average Cost of Capital) for the two investments in Milan and Udine.

	Owner–Tenant		Entrepreneur–Developer	
	Equity [%]	Debt [%]	Equity [%]	Debt [%]
Financial structure	20	80	30	70
Capital weight	3.81 ^a	3.06	8.00	3.06
WACC	3.21		4.54	

^a Italian BTPs—May 2024.

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