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Investment grade energy audit: a financial tool for the cost-effective renovation of residential buildings

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Abstract

The renovation of the existing building stock is a top priority for the European Union. In order to reach the ambitious goal of decarbonization by 2050, new financial instruments, incentives or grants and loans to support energy efficiency should be implemented, especially for public bodies. The proposed method aims to be a tool to stimulate cost-effective deep renovations. The results of its application to a multi-owner building show the benefits of using Energy Service Companies and Energy Performance Contracting to finance renovations and implement plans to maintain or improve energy efficiency in the long term.

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Keywords: Deep retrofit; Energy Audit; Energy Service Company (ESCo); Energy Performance Contract (EPC).

1. Introduction

Europe is facing an unprecedented challenge: the renovation of existing buildings to reduce the final energy consumption, decrease energy imports and, at the same time, limit climate changes and overcome the economic crisis [1].

In particular, the Italian building stock is characterized by dwellings with very poor energy performance: about 80% of them were built before the 1980s, when energy issues were not considered important; in addition, more than half of these buildings have never undergone any renovation or maintenance [2].

Nowadays, however, energy retrofit does not seem to be a priority for homeowners: first, because of insufficient economic resources; second, because they show distrust of investments in the energy field [3].

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In this context, the activity of an Energy Service Company (ESCo) can be an effective tool for mobilizing investment on buildings with a view to improve their energy performance by means of cost-optimal measures [4].

Different techniques for the evaluation of the investment can be applied to this optimization. Net Present Value (NPV) is commonly used by many authors in retrofit project [5, 6] and for the design of new buildings [7, 8]. Others [9, 10] use a method called Cost of Conserved Energy, similar for some aspects to NPV method.

The proposed methodology, based on NPV method, defines the operative/financial conditions under which an ESCo can work, taking into account economic benefits both for the homeowner and for the company.

2. Lombardy Geocluster characterization

The term "geo-cluster", coined by the European Union in the multi-annual roadmap for sustainable development [11], is used to identify buildings linked by common indicators as climate, environment, construction typologies, etc.; in this context, unified retrofitting tools can be implemented effectively [12].

In Lombardy, a northern Italian region, there are more than 1.5 millions buildings: about 88% of them are residential, according to the national building stock.

Focusing on the number of dwellings, as shown in Table 1, more than 67% are located in multi-storey buildings (more than 3 dwellings/building), while only 33% are family houses (1 or 2 dwellings/building). In addition, more than half of dwellings in residential buildings (57%) were erected in the period 1946-1981, because of the economic boom following the Second World War [2].

Despite the buildings are more than 30 years old, only about 59% of the dwellings built in this period were refurbished, without necessarily an improvement of their energy performance.

Proof of this can be detected by means of the analysis of energy certificates presented in Lombardy since 2007, as shown in Table 2: more than 95% of these concern buildings constructed in the same range of years specified above, and they declare an energy class worse than the limit of performance imposed by the legislation for new buildings [13].

Table 1. Residential buildings by period of construction and number of dwellings in the building [2].

Building Age	From 1 to 2	From 3 to 4	From 5 to 8	From 9 to 15	More than 16
Before 1919	251,102	105,335	84,700	57,511	66,119
From 1919 to 1945	142,360	57,562	46,189	47,085	107,391
From 1946 to 1961	210,505	85,050	73,528	85,630	247,831
From 1962 to 1971	275,376	103,947	86,109	110,458	353,929
From 1972 to 1981	230,269	83,284	86,131	102,451	208,339
From 1982 to 1991	128,003	51,452	62,545	62,341	137,362
After 1991	105,593	50,177	69,328	61,524	104,749
TOTAL	1,343,208	536,807	508,530	527,000	1,225,720

Table 2. Number of energy performance certificates by period of construction and energy class [13].

Building Age	A+	A	B	C	D	E	F	G
Before 1930	46	184	1,719	3,961	6,689	9,669	11,376	67,451
From 1930 to 1945	14	53	644	1,516	3,015	4,510	6,284	33,668
From 1946 to 1960	25	117	1,211	2,741	4,877	8,743	12,763	74,531
From 1961 to 1976	39	209	2,311	5,329	10,758	20,668	32,494	169,677
From 1977 to 1992	24	104	1,242	4,564	11,609	18,413	22,155	71,410
From 1993 to 2006	18	128	3,659	18,100	34,967	37,865	31,909	47,163
After 2006	234	1,647	14,741	16,991	11,051	6,294	3,568	3,824
TOTAL	400	2,442	25,527	53,202	82,966	106,162	120,549	467,724

3. Energy Service Company and Energy Performance Contract

Therefore, in the short or medium term, these buildings should be refurbished by maintenance or by increasing the energy performance of their technical elements.

Considering the last possibility, the homeowner can choose to retrofit the building by means of a traditional approach, having to manage:

- the choice of the designer and the general contractor to which to entrust the redevelopment;
- financing all initial costs;
- paying energy bills and maintenance costs throughout the remaining life of the property.

Alternatively, the homeowner could rely on an ESCo, Energy Service Company, a concept born in the United States following the rapid increase in energy prices due to the two oil crises in 1973 and 1979.

The first clear definition of ESCo is contained in the Directive 2006/32/EC [14], which says: "*a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria*".

The activities and responsibilities of an ESCo are generally organized according to an Energy Performance Contract (EPC): their main objective is the recovery, by means of energy savings, of the investments required to reduce the consumption. A further feature is that the ESCo is obligated by contract to take the risk of construction, management and maintenance of the building; at the same time, it has the opportunity to get its profit if the expected improvement in terms of energy efficiency is really achieved. The compensation for its services is a monthly fee paid by the owner to the company: it is determined as a function of the energy savings and the duration of the contract ("first-out" or "shared-savings" models).

The use of ESCo is particularly suitable for public bodies characterized by a housing stock with high energy consumption and obsolete equipment, and especially by limited financial resources to carry out energy retrofitting.

The Directive 2012/27/EU asks to Member States to "*ensure that, as from 1 January 2014, 3% of the total floor area of heated and/or cooled buildings owned and occupied by its central government is renovated each year to meet at least the minimum energy performance requirements that it has set in application of Article 4 of Directive 2010/31/EU*". Moreover, to guarantee the high quality and the cost-optimality of the energy retrofits, Member States should "*use, where appropriate, energy service companies, and energy performance contracting to finance renovations and implement plans to maintain or improve energy efficiency in the long term*".

So, the Public Administration should ensure the energy efficiency, even if only for informational purposes; and these tasks must be configured as institutional activities assigned by the law.

4. Methodology and evaluation process

The proposed methodology implements the first steps of the EPC (diagnosis/energy audit, project design, procurement of funding) according to the following actions.

- <u>Preliminary evaluations</u>: a theoretical model, representative of a widely diffuse type of building, has been created by means of the collection of historical data available for the building type, energy consumption and habits of the tenants: it faithfully represents the real building and its conditions of use. At this stage, all design alternatives for retrofit have been proposed considering their operational feasibility, the needs of the client or any other constraints.
- <u>Calculation of consumption</u>: the final thermal energy for each combination of measures previously identified has been calculated by dynamic simulation (Trnsys [15] – Transient System Simulation Tool) and optimization/automation (GenOpt [16] – Generic Optimization Program); to complete the following step also the primary energy has been calculated.
- <u>Economic analysis</u>: costs of construction, operation and maintenance have been defined by means of quotation requests; possible incentives have been also taken into account.

- Financial evaluation: the financial ratios useful to define the most cost-effective solution have been calculated (APV – Adjusted Present Value [17]; IRR – Internal Rate of Return; PBT – Pay Back Time) by a financial plan, developed for each technology package.

The starting point of the evaluation process is to set three financial plans to apply to each combination of measures or technological alternatives, with the aim to determine the best financial solution. Therefore, financial assessments have been conducted for the owner, in the case of energy retrofitting by means of a traditional approach or by means of ESCo, and for ESCo, to assess if the particular investment project creates value for the company.

The energy bill, which is the cost of gas and electricity for heating set by the studies on the trend of prices conducted by the European Commission [18], has always been assumed as paid by the homeowner to provide continuity of supply when the EPC will be closed. At the same time, it avoids disputes resulting by changes in the prices of energy carriers due to different market economies of the stakeholders.

The fundamental hypothesis of the evaluation process is that all building components have reached the end of their useful life.

Moreover, the financial evaluations have been carried out also for a situation where the owner wants to refurbish the building without any energy improvements. This hypothesis, called “case zero”, allows quantifying the “inevitable costs”, i.e. direct or indirect costs that the homeowner must support by the day after purchasing (this concept is clear to the consumer for limited value assets and with short economic life, such as an automobile – maintenance, tire change, etc. – but often absent for greater value assets and with longer useful life, such as buildings).

Obviously, the financial ratings of “case zero” have been conducted under the exclusive assumption that the building is redeveloped by a traditional approach: in fact, it makes no sense to think that the owner entrusts the refurbishment to an ESCo, by means of an EPC.

Therefore, the financial assessments conducted for the homeowner are relative assessments: in fact, the cash flows associated with them are discounted by the cash flow of the “zero case”. In this way, the payback of the investments is evaluated considering only the costs that give a contribution from an energy point of view; in other words, it is possible to calculate the extra-cost in energy efficiency compared to a simple maintenance of the building components.

Focusing on the process, the first evaluations are conducted for the owner that retrofits according to a traditional approach. They allow ordering all design alternatives considering their APV.

Therefore, after choosing the best solution according to the highest value of APV (the solution that creates more value for the homeowner), it has been possible to obtain, by means of an iterative process, the condition with the maximum APV calculated for the owner by ESCo equal to the maximum value obtained by a traditional approach.

The variable that solves the equation described above is the sum that the client must anticipate to the ESCo before starting the energy improvement. This sum, calculated as a percentage of the contract value, is the initial outlay that creates indifference for the owner between a traditional retrofit and an ESCo. This indifference is just financial, while it is not sure that the technological measures are the same in both approaches.

In numerical terms:

$$O_{max} \mid max(APV_T^O) = max(APV_E^O), \text{ where:} \quad (1)$$

- O_{max} = maximum initial outlay by owner to ESCo
- APV_T^O = adjusted present value calculated for the owner by a traditional retrofit
- APV_E^O = adjusted present value calculated for the owner by an ESCo

Therefore, it is possible to analyze the investment for the ESCo.

It is necessary to consider the same technological measures that create more value for the owner operating by means of an ESCo. Therefore, fixing the building envelope components and the systems that optimize the investment for the owner and considering the value of the initial outlay defined above, it is possible to calculate for the ESCo the APV and the IRR.

The first represents the maximum return on investment that the ESCo can aim for, because higher values of the initial outlay could lead the owner to choose a traditional retrofit.

However, it is possible to determine, for the same design package, the minimum initial payment that the ESCo must receive by the owner to ensure that the investment does not lose value to the company.

This value corresponds to the minimum outlay that the owner must anticipate to the ESCo so that the APV of the project, calculated on the ESCo side, is equal to zero or, in other words, so that the IRR coincides with the unlevered cost of capital of the ESCo.

Mathematically:

$$O_{min} | \, APV^E = 0, \text{ where:} \tag{2}$$

- O_{min} = minimum initial outlay by client to the ESCo
- APV^E= adjusted present value calculated for the ESCo

In conclusion, the initial payment that the ESCo must receive so that the project creates value for the company must be between the minimum and the maximum value of the initial outlay defined above.

The contractual negotiations will define it case by case in practice.

5. Application of the method

In order to validate the proposed methodology and extend the results of the individual case to a variety of situations, the process has been applied to a building owned by ALER (Lombard Agency for Residential Buildings, a public housing body), built in 1976 in Colico, a small town located in Lombardy region near Lecco. This building has been chosen because it represents a widespread type in the territory. In fact, it was realized on a standard project developed by ALER for optimizing the building process while containing costs: its 12 dwellings are characterized by the combination of 3 standard modules and general tender specifications replicated in Lecco for 8 other buildings, whose 6 are shown in the Figure 1 [19].

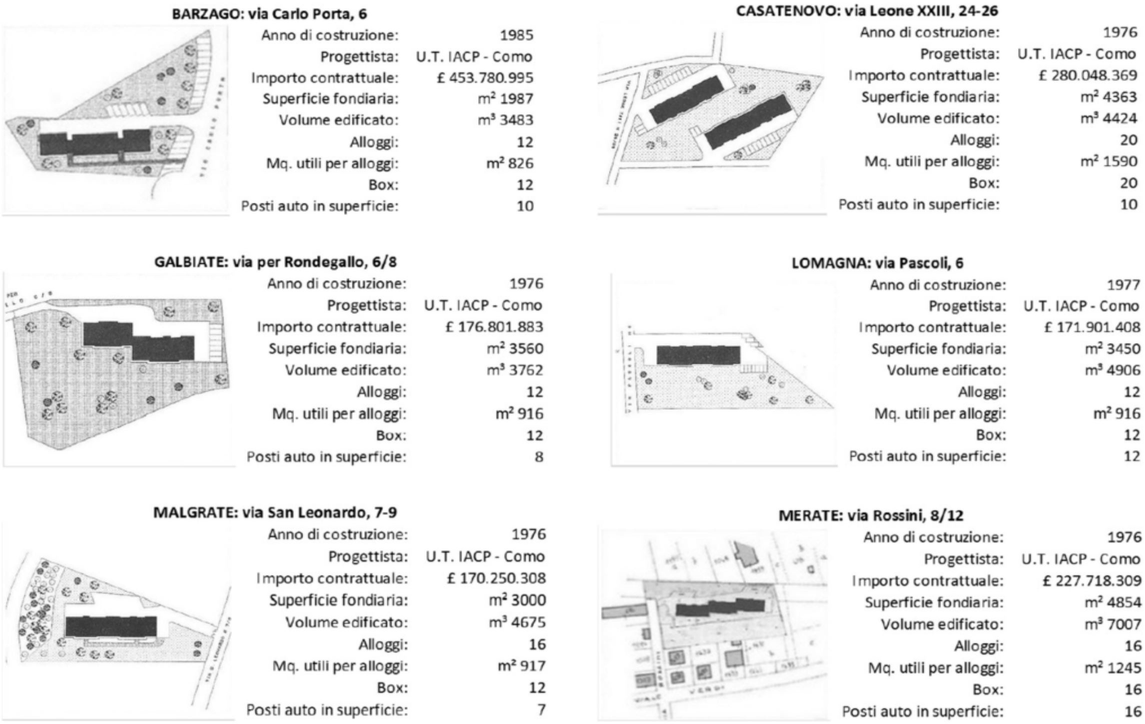

Fig. 1. Real estate developments in Lecco based on the standard project.

The method allows the identification of the cost-effective building envelope combination in relation with heating systems: in particular, heat pumps (air to water) have been taken into account in combination with solar photovoltaic panels and condensing gas boilers.

Focusing on the entire evaluation process, the following steps have been developed.

- Validation of the theoretical model: to ensure the energy assessments are as representative as possible of the real behavior of the building, a theoretical model developed in Trnsys. The resulting validation process has been subordinated to the calculation of the "basic consumption", considering the average energy bill (for the last 3 years) associated with the actual degree-days and multiplying it by the theoretical degree-days taken from the meteorological file *.tm2. Considering the average price of natural gas in this period and its lower calorific value it has been possible to determine the real thermal energy demand of the building. Finally, the model has been calibrated adjusting the internal loads and the habits of tenants until the difference between the theoretical thermal energy demand from the real one was less than 1%.

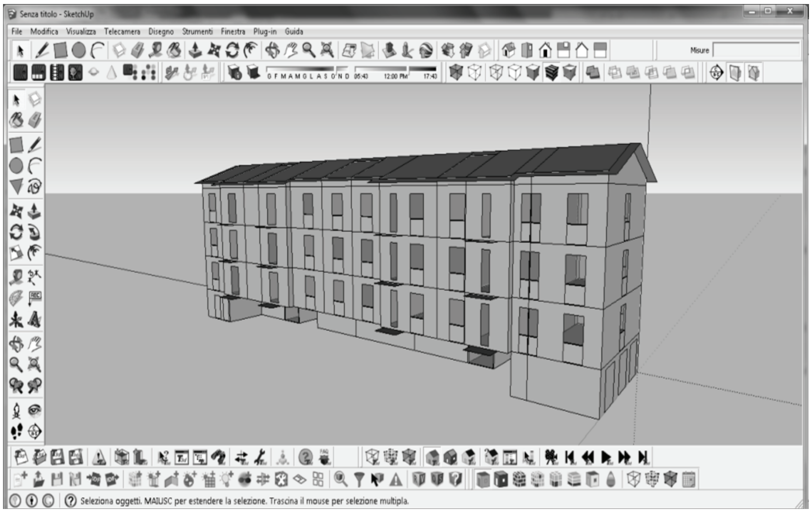

Fig. 2. Geometrical model for Trnsys by means of Google SketchUp.

- Definition of energy efficiency measures and packages: considering the needs of the customer and regulatory requirements for the definition of heating systems (heat pumps - air to water - in combination with condensing gas boilers, thermostatic valves and heat metering on existing cast iron radiators), technological alternatives for building envelope have been proposed according to the following types:
  exterior facades: EPS coat (λ = 0.035 W/mK), with thickness from 80 mm to 200 mm;
  floor to box/outdoor atrium: EPS external insulation (λ = 0.035 W/mK), with thickness from 80 mm to 200 mm;
  windows: PVC frame (U_f = 1.4 or 1.0 W/m^{2}K) and low-emissivity glazing (U_g = 1.4 or 1.1 or 0.6 W/m^{2}K).
  ceiling to attic: cellulose flakes (λ = 0.039 W/mK), with thicknesses of 120 mm, 150 mm, 200 mm and 250 mm.
  A photovoltaic system, with power ranging from 3 kWp to 15 kWp, was also considered.
  All the different measures have been combined considering both natural ventilation and mechanical ventilation (HVAC), for a total of 10,000 energy efficiency packages.
- Calculation of thermal energy demands and theoretical energy bills: GenOpt has been used to change automatically the proposed building technologies and to facilitate the calculation of the thermal energy demand in dynamic mode. Secondly, by applying the UNI TS 11300.2 standard [20], the final energy for the consumer has been calculated.
  Multiplying the final energy by the unit price of energy carriers set by the market, the theoretical energy bill for each design alternative has been estimated.
  Finally, by the difference between the energy bill paid before and after the refurbishment, the license fee to devolve to the ESCo when the owner wishes to use this company for the retrofitting has been obtained. In case of

"shared saving model" this value has to be reduced by a percentage (10% - 20% - 30% - 40%) which is left to the consumer.

- Determination of construction and maintenance costs: the assessment of construction costs is based on requests for quotation (to the market) of all energy efficiency measures and their technological alternatives. Resulting estimates, known as "prime costs", have been discounted by a percentage varying between 5% and 10% to take into account for commercial negotiation during the closing of the contract, and increased by 15% and then 15% to take into account for overheads and for the company's profit ("indirect costs"). Design costs, estimated at around 10% of the "first costs", and the VAT in case they constitute a cost have been also considered.
  In line with the definition of the construction costs, the maintenance costs have been determined by requests for quotation, subsequently discounted, to which the VAT has been added if it is considered a cost.
- Estimate of residual value of the building: it is the value of the property at the end of the financial assessment and it has been considered when the building is owned by the consumer. It has been calculated considering only the increase of value resulting by energy savings due to energy efficiency [21], divided by the average nominal rate of real estate appreciation [22].

To complete the input by drawing up the three financial plans of the evaluation process, the opportunity cost of capital and the duration of the financial evaluation have been defined. In particular:

- Estimation of opportunity cost of capital: considering the homeowner, the starting point for its determination has been the request to the market of the average interest rate for a mortgage (4.00%): in fact, it represents a possible alternative of real estate investment. Secondly, a percentage, ranging between 0% and 2%, has been added if the owner wishes to undertake the retrofit by ESCo (cost of capital equal to 4.00%) or according to a traditional approach (cost of capital equal to 6.00%). It takes into account the risk associated with the type of investment.
  Considering the ESCo, the estimate of the unlevered cost of capital is more difficult. It is based on the CAPM method [23] and leads to the definition of an opportunity cost of capital equal to 8.00%;
- Choice of the duration of the financial evaluation: considering the homeowner, cash flows for a period of 10 years have been considered. In this time it has been assumed that all new components constituting the building envelope reach the end of their life; about systems, it has been assumed to further renew them in the sixteenth year, as recommended in literature [17].
  Considering the ESCo, however, cash flows with the same duration of the energy performance contract were considered.

Table 3. Typical financial plan compiled in the case of financial evaluations, ESCo side (entered data is not relevant).

	T_0	T_1	T_2	……	T_{n-1}	T_n
1 Energy bill						
2 Licence fee		€ 11,232.51	€ 11,742.73	……	€ 14,350.03	€ 14,458.26
3 Maintenance costs		-€ 2,565.36	-€ 2,611.54	……	-€ 2,958.90	-€ 3,012.16
4 Depreciation of systems		-€ 6,016.54	-€ 6,016.54	……	-€ 6,016.54	-€ 6,016.54
5 GROSS PROFIT		€ 2,650.61	€ 3,114.65	……	€ 5,374.59	€ 5,429.56
6 Tax		-€ 832.29	-€ 978.00	……	-€ 1,687.62	-€ 1,704.88
7 Incentives		€ 12,383.76	€ 12,383.76	……	€ 0.00	€ 0.00
8 NET PROFIT		€ 14,202.08	€ 14,520.41	……	€ 3,686.97	€ 3,724.68
9 Depreciation of systems		€ 6,016.54	€ 6,016.54	……	€ 6,016.54	€ 6,016.54
10 Construction cost	-€ 199,034.96					
11 Residual value						
12 NCF (Equity)	-€ 199,034.96	€ 20,218.62	€ 20,536.95	……	€ 9,703.51	€ 9,741.22
13 Repayment		-€ 9,951.75	-€ 9,951.75	……	-€ 9,951.75	-€ 9,951.75
14 Residual debt	€ 99,517.48	€ 89,565.73	€ 79,613.98	……	€ 9,951.75	€ 0.00
15 Bank interest		-€ 4,478.29	-€ 4,030.46	……	-€ 895.66	-€ 447.83
16 Tax saving		€ 1,406.18	€ 1,265.56	……	€ 281.24	€ 140.62
17 NCF (Debt)	€ 99,517.48	-€ 13,023.85	-€ 12,716.64	……	-€ 10,566.17	-€ 10,258.96
18 PV (Equity+Debt)	-€ 99,517.48	€ 7,194.77	€ 7,820.31	……	-€ 862.66	-€ 517.74

6. Results

Table 4 and Table 5 plot the best technical solution under a financial profile considering 10,000 combinations of technological alternatives. For each group, the logic of representation is the following:

- Line 1: owner-side evaluations according to the traditional approach, considering the initial contribution by third parties equal to zero;
- Line 2: where the maximum outlay by owner to ESCo is defined (O_{max}); it makes indifferent the choice for the owner between a traditional retrofit and an ESCo;
- Line 3: ESCo-side evaluation, considering the maximum outlay by owner to ESCo (O_{max});
- Line 4: where the minimum outlay by owner to ESCo is defined (O_{min}); it is the minimum contribution that the ESCo can receive by the owner so that the project creates value for the company.

In particular, ten-years EPC have been considered according to models "first out" or "shared savings", firstly without any kind of incentives for the energy retrofitting.

Table 4. Financial evaluations, without incentives, considering ten-years EPC and "first-out" or "shared saving" models.

EPC	Outlay [%]	Window [U_f - U_g]	Wall [cm]	Ceiling [cm]	Floor [cm]	Systems [type]	HVAC [yes-no]	PV [kW_p]	EPh [kWh/m^2]	APV [€]	IRR [%]	PBT [years]
First-out 100% - 0%	0.00%	1.40 - 1.10	12.0	12.0	12.0	IMP.3	NAT	0	24.52	€ 123,893	11.61%	14.00
	76.10%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 123,893	11.70%	15.00
	76.10%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 41,342	59.88%	2.00
	64.09%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 0.00	8.00%	10.00
Shared-saving 90% - 10%	0.00%	1.40 - 1.10	12.0	12.0	12.0	IMP.3	NAT	0	24.52	€ 123,893	11.61%	14.00
	79.15%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 123,893	11.15%	15.00
	79.15%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 45,264	111.9%	2.00
	66.00%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 0.00	8.00%	10.00
Shared-saving 80% - 20%	0.00%	1.40 - 1.10	12.0	12.0	12.0	IMP.3	NAT	0	24.52	€ 123,893	11.61%	14.00
	82.20%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 123,893	10.70%	15.00
	82.20%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 49,186	--*	1.00
	67.91%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 0.00	8.00%	10.00
Shared-saving 70% - 30%	0.00%	1.40 - 1.10	12.0	12.0	12.0	IMP.3	NAT	0	24.52	€ 123,893	11.61%	14.00
	85.24%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 123,893	10.33%	15.00
	85.24%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 54,235	--*	1.00
	69.81%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 0.00	8.00%	10.00
Shared-saving 60% - 40%	0.00%	1.40 - 1.10	12.0	12.0	12.0	IMP.3	NAT	0	24.52	€ 123,893	11.61%	14.00
	88.29%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 123,893	10.01%	15.00
	88.29%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 59,335	--*	1.00
	71.72%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 0.00	8.00%	10.00

Focusing on "shared savings" EPC (ESCo 80% - 20% owner), the effects of Italian incentives for energy retrofitting have been evaluated. In particular, both the incentives provided by the GSE [24] and tax deductions for the year 2014 have been taken into account [25].

Table 5. Financial evaluations, with and without incentives, considering ten-years EPC and "shared saving" model (80% - 20%).

EPC	Outlay [%]	Window [U_f - U_g]	Wall [cm]	Ceiling [cm]	Floor [cm]	Systems [type]	HVAC [yes-no]	PV [kW_p]	EPh [kWh/m^2]	APV [€]	IRR [%]	PBT [years]
No incentives	0.00%	1.40 - 1.10	12.0	12.0	12.0	IMP.3	NAT	0	24.52	€ 123,893	11.61%	14.00
	82.20%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 123,893	10.70%	15.00
	82.20%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 49,186	--*	1.00
	67.91%	1.40 - 1.10	12.0	15.0	14.0	IMP.3	NAT	0	23.50	€ 0.00	8.00%	10.00
GSE	0.00%	1.40 - 1.10	14.0	20.0	16.0	IMP.3	NAT	0	21.60	€ 196,740	17.71%	6.00
	63.34%	1.40 - 1.10	14.0	25.0	18.0	IMP.3	NAT	0	20.92	€ 196,740	--*	1.00
	63.34%	1.40 - 1.10	14.0	25.0	18.0	IMP.3	NAT	0	20.92	€ 43,590	39.47%	3.00
	49.36%	1.40 - 1.10	14.0	25.0	18.0	IMP.3	NAT	0	20.92	€ 0.00	8.00%	10.00
Tax deduction 2014 (65%)	0.00%	1.40 - 1.10	10.0	15.0	10.0	IMP.3	NAT	0	25.68	€ 215,573	19.12%	7.00
	60.85%	1.40 - 1.10	16.0	25.0	18.0	IMP.3	NAT	0	20.19	€ 215,573	--*	1.00
	60.85%	1.40 - 1.10	16.0	25.0	18.0	IMP.3	NAT	0	20.19	€ 29,881	19.92%	6.00
	33.82%	1.40 - 1.10	16.0	25.0	18.0	IMP.3	NAT	0	20.19	€ 0.00	8.00%	10.00

* IRR cannot be calculated because its cash flow does not have one and only one change of sign

In a global view of economic growth the choice of an average value between O_{max} and O_{min} makes the approach particularly interesting for stakeholders because it creates profitable margins for the owner and for the ESCo.

Table 6. Financial evaluations, with and without incentives, considering ten-years EPC and "shared saving" model (80% - 20%).

EPC	Outlay [%]	Window [U_f - U_g]	Wall [cm]	Ceiling [cm]	Floor [cm]	Systems [type]	HVAC [yes-no]	PV [kW_p]	EPh [kWh/m^2]	APV [€]	IRR [%]	PBT [years]
No incentives	0.00%	1.40 - 1.10	14.0	15.0	16.0	IMP.3	NAT	0	22.25	€ 122,711	11.31%	15.00
	75.05%	1.40 - 1.10	14.0	15.0	16.0	IMP.3	NAT	0	22.25	€ 149,336	14.91%	11.00
	75.05%	1.40 - 1.10	14.0	15.0	16.0	IMP.3	NAT	0	22.25	€ 26,796	40.65%	3.00
GSE	0.00%	1.40 - 1.10	16.0	25.0	18.0	IMP.3	NAT	0	20.19	€ 195,881	17.17%	7.00
	56.35%	1.40 - 1.10	16.0	25.0	18.0	IMP.3	NAT	0	20.19	€ 222,874	--*	1.00
	56.35%	1.40 - 1.10	16.0	25.0	18.0	IMP.3	NAT	0	20.19	€ 26,354	23.69%	4.00
Tax deduction 2014 (65%)	0.00%	1.40 - 1.10	18.0	25.0	20.0	IMP.3	NAT	0	19.39	€ 195,074	16.83%	7.00
	47.33%	1.40 - 1.10	18.0	25.0	20.0	IMP.3	NAT	0	19.39	€ 258,933	--*	1.00
	47.33%	1.40 - 1.10	18.0	25.0	20.0	IMP.3	NAT	0	19.39	€ 20,106	13.75%	8.00

Table 6 shows that, for the owner, the NPV obtained in case of awarding the work to the ESCo is always higher than the NPV obtained by a traditional redevelopment, considering the same technological solution. Otherwise for the ESCo, the cash flow generated by the investment project creates positive returns with IRR significantly higher than any other form of investment on the market.

The generalization of the results obtained on the building in Colico to the other ones built according to the standard project, shows a return on investment (in 30 years) for ALER by means of ESCo of about € 275,000 higher than the traditional approach, even without any incentives.

Considering the ESCo the same project generates revaluation of its portfolio (in 10 years) of about € 280,000, to which the profit obtained by the work of General Contractor is added (€ 610,000 that is the 15% of the cost of energy retrofitting).

7. Conclusions

The renovation of the existing building stock is a priority in Europe, but the lack of economic resources makes its implementation slower than required by climate protection plans.

In this context, the research has produced a technical/economic simulation model easily adaptable depending on the type of building: by means of new model in Trnsys and considering the geometry of the new type of building, taking into account the same technological alternatives, or others, it is possible to retrace the process in different situations.

The methodology can define the action with higher added value in terms of: technological choices, performance efficiency, investment costs, debt ratios and payback time, subsequent costs of operation and maintenance.

This innovative methodology, with a different approach from the market, shows:

- The opportunity for owners to support retrofitting at limited investment costs, especially in cases where heating systems are complex;
- The opportunities for an ESCo working according to an integral refurbishment approach (deep retrofit).

It could also be a valuable tool to spread the energy efficiency as an opportunity to increase the profitability of the property. In particular, in the public sector, it can stimulate market transformation towards more efficient buildings and services, trigger behavioral changes in energy consumption by citizens and enterprises, as well as free up public resources for other purposes.

* IRR cannot be calculated because its cash flow does not have one and only one change of sign

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