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Framework for Evaluating Financial Impacts of Technical Risks Related to Energy-Efficient Renovation of Commercial Office Buildings †

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Abstract: Energy efficiency in the building sector is a priority of the EU Commission to achieve carbon neutrality by 2050. Renovation of the existing buildings, which are currently responsible for approximately 40% of EU energy consumption and 36% of the greenhouse gas emissions can lead to significant energy savings. This paper presents the EEnvest calculation method for evaluating the financial impacts of technical risks related to energy-efficient renovation of commercial office buildings. The evaluation method aims to increase investors' confidence and boost investments in the renovation of the existing building. Through a series of Key Performance Indicators (KPI), the technical and financial risks impact is evaluated. The results are strictly connected to building features, climatic conditions, solution sets and mitigation measures specific to the building energy efficiency project.

Keywords: energy renovation; existing buildings; investment; energy efficiency; financial risks; technical risks

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1. Introduction

Buildings are responsible for approximately 40% of EU energy consumption and 36% of the greenhouse gas emissions [1]. The renovation trend of the existing buildings is quite low, still below 1.2% yearly on average [2], due to technical, regulatory and financial barriers, combined with low knowledge and lack of vision of the possible benefits [3]. Considering the technical and financial risks means managing the risk perception of investors and reducing these impacts in renovation projects means to favor the mainstreaming of sustainable energy finance. The H2020 EEnvest—Risk Reduction for Building Energy Efficiency Investments—project has developed and tested a structured assessment method to evaluate the impact of technical and financial risks on building energy efficiency investments. The EEnvest project aims to develop a digital platform where different stakeholders (owners, investors and building developers) can be connected, and new opportunities for the building stock renovation investments are activated.

2. De-Risking Energy Efficiency in the Building Renovation Sector

After an investigation on existing methods for the technical risk evaluation, the EEnvest de-risking analysis started with the application of:

- Failure Mode and Effect Analysis (FMEA) [4], a systematic approach used in the engineering sector and for the decomposition of the building in its constitutive elements; each energy renovation measure (building component) has been associated with potential failure modes (problems/occurrences), with unique effects (impacts–probability) and mitigation measures.

- Analytic hierarchy process [5], a qualitative approach used to estimate the technical risks impact and frequency through a risk score which integrates feedback in the form of several opinions of experts in the building construction sector [6].
- ISO 31000 standard [7] for risk management, which provides principles and a steps framework: context definition, risk identification, analysis process and mitigation measures identification.

According to the risk evaluation methods presented above, the renovation process of existing buildings was analyzed. The results show a high level of complexity due to the multiple aspects that play an important role in the renovation project, which depend on:

- Objectives of the renovation project (e.g., economic and energy efficiency, functional, aesthetics);
- Building features (such as architectonic characteristics) and boundary conditions;
- Renovation phases (from design to construction): requirements and goals, role of involved stakeholders and used tools;
- Renovation measures adopted for the building envelope and technical plants;
- Implemented mitigation measures (e.g., verification protocols, certification or monitoring process);
- Stakeholders involved (i.e., owners, tenants, building professional, constructors, investors).

2.1. EEnvest Key Performance Indicators

The risk estimation in building energy efficiency investments plays an important role in the investor decision-making process. Deviation from the expected renovation investment performance depends on several issues, as reported in Figure 1.

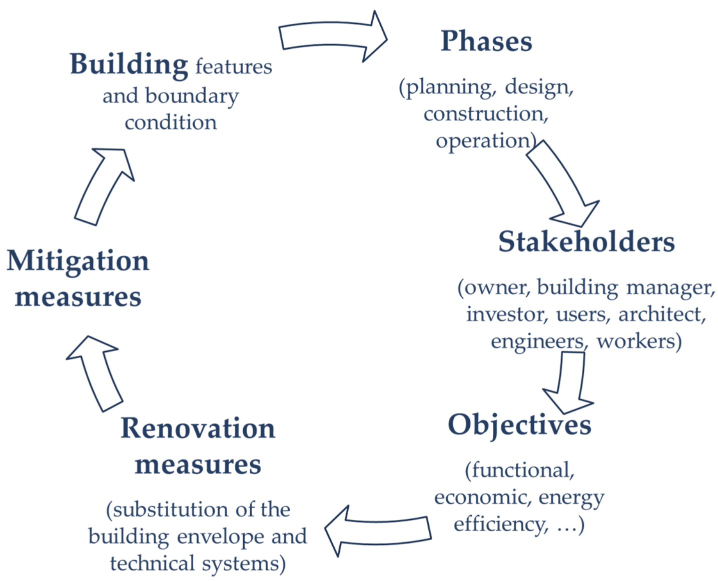

Figure 1. De-risking analysis: decomposition of the renovation process.

The EEnvest framework identifies two main technical indicators, which are used to assess the technical riskiness of the investment, as well as a series of financial indicators that assess the financial riskiness of the investment, as shown and detailed in Table 1. One specific feature of the EEnvest methodology is that each indicator is expressed in terms of expected value and probability distribution.

Table 1. Technical and financial KPIs.

Technical indicators		
Damage	Deviation due to technical failures, malfunctions or breakages of the building elements.	% of investment
Energy gap	Deviation between predicted and measured energy consumption	% of energy savings
Financial indicators		
Payback time	The payback period refers to the amount of time an investment took to recover the initial cost, when the length of an investment time reaches a breakeven point.	Year
Maturity	The total duration of the project.	Year
Internal Rate of Return	The Internal Rate of Return (IRR) is the discount rate that makes the net present value (NPV) of a specific project equal to zero.	%
Net Present Value on Investment	The Net Present Value (NPV) is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present. The Net Present Value on Investment (NPV/INV) is a ratio between the Net Present Value (NPV) and the Investment (INV). It gives a measure of the profitability of the project.	%
Debt–Service Coverage Ratio	Debt–Service Coverage Ratio (DSCR) is an indicator of the project's ability to repay a debt. It is calculated as the ratio between the operative cash flows generated by the project and the cash flows for debt, lease or other obligation (debt service, both for interests and principal payment) due in one year.	%

2.2. Identification of the Technical Risks

For each building element (envelope and technical systems), the relative technical risks have been identified, meaning the negative effects that can occur for both KPIs (energy performance gap and damage), as well as four different levels of impact (null, low, medium and high) and the relative probability. In parallel, the mitigation measures have also been collected and included in the EEnvest technical risk database. Figure 2 reports the analysis of window elements.

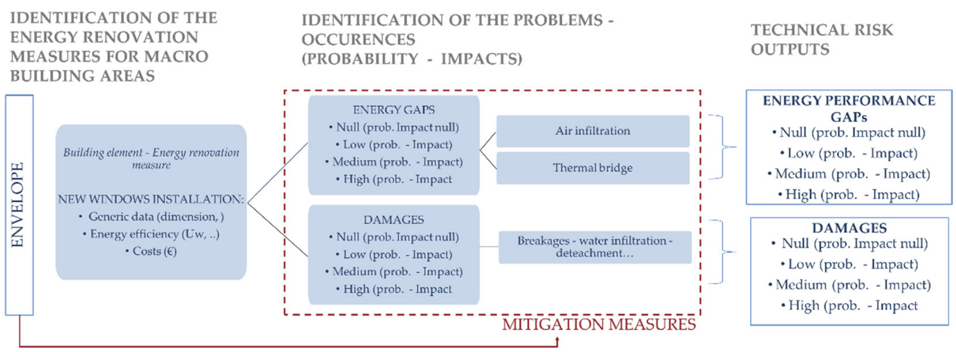

Figure 2. Database of probability—impacts. Source: EURAC.

2.3. Financial Risks in Building Renovation Process

Technical risks indicators are then used, as inputs, in the financial risk calculation. Figure 3 shows the calculation process of the financial risk indicators. Through a series of Monte Carlo simulations, the following inputs were combined:

- Probability distribution of technical risks: output from technical risk analysis, it includes the probability distribution of the "energy performance gap" and of the "damage", as defined in Table 1.

- Probability distribution of energy prices and Heating Degree Days (HDD): these two variables are calculated from historical series, extracted from external databases, and are then used to calculate the impact of the variability of energy prices and external temperature on the financial performance.
- Other inputs from the user: investment costs, financial structure, loan interest rate, etc.

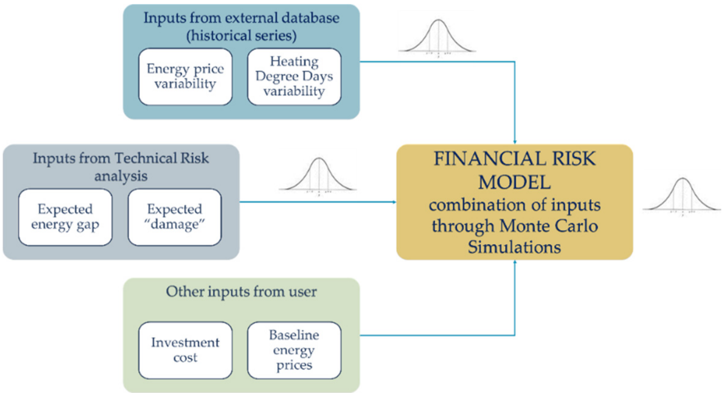

Figure 3. Financial risk calculation. Source: SINLOC.

By extracting a series of random values from several probability distributions and combining them together, Monte Carlo simulations allow the probability distribution of the financial performance of the renovation project to be defined. The results are obtained by first calculating the probability distribution of the expected economic savings and then, using a common Discounted Cash Flow (DCF) model, calculating the probability distribution of financial indicators such as payback time, IRR and NPV.

2.4. EEnvest Platform Framework

The EEnvest platform implements the innovative framework as a search and match web platform, allowing investors to search for the proper investments in building energy efficiency projects without the burden of dealing with technical aspects. After a user completes the technical description of a new project, the evaluation of the financial performance (with an accounting for technical risks) happens behind the scenes. In this way, the platform can provide, to any interested investor, a clear and time-saving report with KPIs and recommendations on the specific project.

Figure 4 presents the full EEnvest methodology, which also includes multiple benefit evaluations.

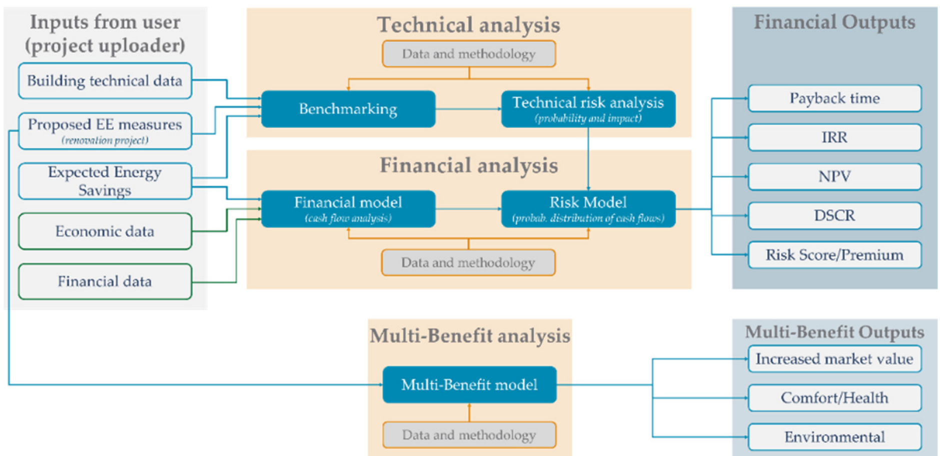

Figure 4. Framework for evaluating the financial impacts of technical risks related to energy-efficient renovations of commercial buildings.

3. Conclusions

The proposed financial risk evaluation model is an innovative approach to support the decision-making process of investments in energy efficiency, both for private investors and building developers, which validates the investment riskiness level of energy renovation projects for commercial buildings, through a solid and structured assessment method.

The EEnvest framework is currently in a testing phase. Within the EEnvest project, the calculation method has been tested in two different case studies, and for each demo case, two energy renovation scenarios have been analyzed, with and without renovation measures. The results obtained are an estimation of the technical and financial KPIs.

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