Energy Poverty Zero

# Integration of financing mechanisms in a collective house retrofit aggregation tool

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## *Required information.*

Work Package 2

Deliverable D2.4 - Identification of financing tool for vulnerable populations

Organisation name of deliverable lead R2M solution

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# I. Preliminary information

## A. Executive Summary

It is well acknowledged that the building sector, in Europe, is a major energy consumer and emitter of greenhouse gases. Residential buildings, in particular, account for approximately 75% of the building sector's energy consumption, with non-residential buildings (e.g., offices, schools, hospitals) accounting for the remaining 25%. Efforts to improve energy efficiency, integrate renewable energy sources, and renovate existing buildings are critical to achieving the EU's climate and energy goals. In this direction, the EU has implemented various directives and regulations to address energy use and emissions in the building sector, such as the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED). The European Green Deal, in addition, aims to make Europe the first climate-neutral continent by 2050. These policies aim to improve energy performance, reduce consumption, and cut emissions: by 2030, the EU aims to cut greenhouse gas emissions by at least 55% compared to 1990 levels, with significant contributions expected from the building sector through enhanced energy efficiency and the use of renewable energy.

However, the path towards climate neutrality it is neither easy nor streamlined, and different challenges undermine the achievement of the set goals. The main challenges include the high cost of renovations, the need for skilled labour, the slow adoption rate of new technologies, difficult processes and bureaucratic procedures. Additionally, many buildings in Europe are old and not designed with energy efficiency in mind, making retrofits complex and expensive.

These issues and challenges are even more critical when it comes to vulnerable populations and people affected or at high risk of energy poverty. Among the main factors contributing to this problematic there are low incomes, i.e. households with limited financial resources often struggle to pay for energy bills, leading to energy poverty, high energy prices, i.e. rising energy costs can exacerbate energy poverty, especially in regions where energy prices are high, inefficient buildings, i.e. poorly insulated or inefficient buildings consume more energy to maintain comfortable living conditions, increasing energy costs, and aging infrastructure, namely older buildings often lack modern energy-efficient features, making them more expensive to heat and cool.

The LIFE Energy Poverty – 0 project, aims to fight energy poverty in vulnerable context, by means of renovation measures that embrace the EnergieSprong approach. The project is targeting different phases of the renovation process, as well as the engagement of different stakeholders, from public administration to communities and citizens.

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**In this framework, one of the main barriers for the adoption of renovation interventions is the initial investment and the financial and economic aspects that come with it.** Costs and financial variables can be huge demotivators for people willing to improve their building's energy efficiency, especially if they are already lacking initial capital and suffer from energy poverty. Loans and subsidies can be, on the other hand, significant drivers, but they need to be effectively communicated, easy to access, and easy to evaluate.

In T2.4 of this project, an EP-0 ICT tool is being developed in order to provide municipalities and social housing organizations, by delivering renovation scenarios that include solution packages, together with their environmental and cost assessment. This deliverable contributes to this latter goal: **the aim of *D2.4 - Identification of financing tool for vulnerable populations* is to develop a financing tool for vulnerable populations, which can provide an economic and financial pre-feasibility assessment based on investment costs and financial indexes of building's retrofit interventions. In addition, this tool integrates in the assessment available national subsidies and incentives, as output of D4.3, in order to be better tailored to the needs of vulnerable beneficiaries.**

The work presented in this document stems from a literature review of the main drivers and barriers that affect people's willingness to undertake a renovation investment. The review identifies financial challenges - such as high upfront costs, limited access to loans, and insufficient awareness of available subsidies - as significant deterrents to energy-efficient renovations. To address these, the deliverable proposes a financial assessment tool that integrates financial and economic indicators, subsidies, and incentives, supporting end-users in assessing both initial costs and long-term benefits of retrofits. As a part of the broader EP-0 ICT platform, the tool enables the user to perform a detailed financial assessment tailored to specific interventions. By offering clear financial metrics, such as Payback Period, Internal Rate of Return (IRR), and Net Present Value (NPV), the tool aims to facilitate informed decision-making, reducing barriers for social housing organizations and municipalities. The financing module's user-centric design is especially suited for non-expert users, allowing them to simulate scenarios optimal funding options, including subsidies and loans. This functionality aligns with the project's goals of addressing energy poverty and enabling inclusive, sustainable energy transition by making energy retrofits accessible and financially viable for all, particularly vulnerable populations.

This financing tool, that at this stage is presented in this document as a fully functioning module, will be integrated and interoperable within the final version of the EP-0 ICT tool, expected for August 2025.

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## B. Grant Agreement Expectations

In order to enable everyone to assess the suitability of the solutions for buildings and consider them for potential renovation projects, the second phase of WP2 involves detailing the characteristics of potential solutions to be adopted for renovation scenarios. This will include evaluating the manufacturing and installation costs, as well as all impacts and benefits, and will be included in *D2.2 - Presentation of the retrofit solutions*. From these solutions, as a first step, a preliminary cost analysis is provided: solutions are characterized by means of installation costs and maintenance costs thorough their life cycle. This will allow to offer future buyers a complete solution to meet their needs, simplifying the process.

As a further second step, as part of this deliverable, users will be able to perform a comprehensive cost analysis of the specific interventions, based on the specific area to be retrofitted and on the specific solution adopted. In this direction, this financing module shall allow to have a complete economic and financial assessment, starting from the initial overall investment costs and narrowing down the analysis to specific indicators. Finally, this module shall integrate financing options, in the form of subsidies and incentives, as identified in D4.3. In this way, with a two-level analysis, the user is provided i) with a preliminary basic evaluation of installation, maintenance costs and utility bills, ii) with a specific pre-feasibility evaluation of the economic significance of the investment, based on the building to be renovated and on the specific adopted solutions, and accounting for users' capital availability, finally showcasing economic and financial indicators, and including national subsidies.

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# II. Deliverable

## A. Introduction and objectives

The building sector in the European Union (EU) is responsible for 36% of greenhouse gas (GHG) emissions and 40% of the EU's final energy consumption. One contributing factor is that approximately 35% of the EU's buildings are over 50 years[1]. Improving the energy efficiency of these buildings, alongside increased use of renewable energy, could reduce final energy use by 75% by 2050, compared to 2010, and cut GHG emissions by 90%, if compared to 1990[2]. To achieve these reductions, the EU has enacted two key directives: the 2010 Energy Performance of Buildings Directive and the 2012 Energy Efficiency Directive. These directives, which apply to both new and existing buildings, aim to meet the EU's goals, such as a 40% reduction in GHG emissions by 2030 compared to 1990. The latest revised Energy Efficiency Directive (EU/2023/1791) significantly enhances the EU's commitment to energy efficiency. It establishes the 'energy efficiency first' principle as a core element of EU energy policy, granting it legal status, which requires EU countries to prioritize energy efficiency in all relevant policy-making and major investment decisions across both energy and non-energy sectors. This 2023 revision follows a proposal for a recast directive on energy efficiency introduced by the Commission in July 2021 as part of the EU Green Deal package, and further strengthened by the REPowerEU[3] plan presented in May 2022, which aims to reduce the EU's reliance on fossil fuel imports from Russia.

Full implementation of the Energy Efficiency Directive is crucial for the EU to meet its commitment under the Global Pledge to double the global rate of energy efficiency improvements from around 2% to over 4% by 2030. Additionally, it is important to mention that these directives and their potential outcomes not only target energy and emission goals, but they could lead to numerous additional co-benefits to individuals and society, e.g., increased employment in the construction sector, reduced reliance on energy imports, energy access and energy security for all, lower household energy bills, better indoor environmental quality in renovated homes, reduction in mortality and morbidity[4].

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[1] Available online at : https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings_en
[2] Available online at : https://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU%282016%29587326_EN.pdf
[3] Available online at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en
[4] Pistore L, Tintinaglia F, Pernetti R, Stivanello P, Pasut W. Indirect Effects of High-Performance Buildings at Household and Community Level: A Systematic Literature Review. *Energies*. 2023; 16(5):2499.

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According to the picture from the European Parliament[5], several positive impacts derive from the renovation of buildings in addition to energy savings, and they can be categorized as *Environmental*, *Economic*, and *Social* benefits, as summarized in Figure 1.


*Figure 1. Additional environmental, economic and social benefits deriving from buildings' renovation[4].*

Given these crucial potential advantages, energy efficiency in the building sector has clearly became a key focus for policymakers. However, the road towards the EU directives' goals is far from easy and streamlined, as several barriers subsist. Barriers and obstacles can be divided into *Financial*, *Technical*, *Process*, *Regulatory*, and *Awareness* clusters (Figure 2).

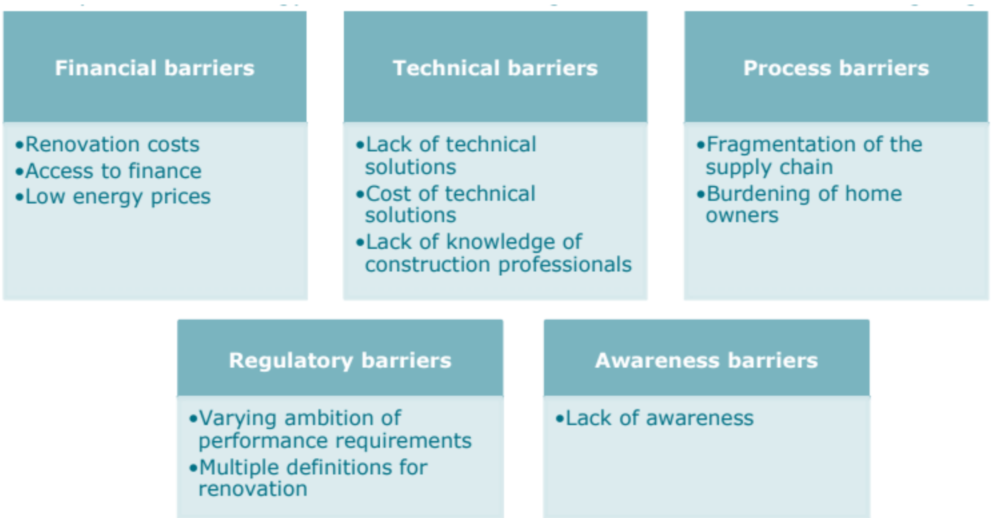


*Figure 2. Key barriers to energy renovation of buildings[4].*

For the scopes of this deliverable, the focus of the work has been put on the **financial barriers**, including aspects related to investment costs for renovation, but also access to finance, subsidies, incentives and tax credits, being on one hand the main obstacles for vulnerable people at risk of energy poverty for undertaking a renovation path, but on the other hand also a great opportunity for raising, boosting and supporting people's willingness to embark on such

[5] EU Parliament, DIRECTORATE GENERAL FOR INTERNAL POLICIES POLICY DEPARTMENT A: ECONOMIC AND SCIENTIFIC POLICY, Boosting Building Renovation: What potential and value for Europe?

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a journey. This, clearly, shall pass through people's education, engagement and awareness, by means of accessible and easy-to-implement regulations, simplified processes, and technical support.

When it comes to **economic and financial barriers**, costs play a major role. The overall costs associated with building renovation are split across the property owners, public authorities and tenants (when the buildings are rented or leased) as explained in Figure 3.


*Figure 3. Division of costs and burdens for buildings' renovation[4].*

As it can be noticed, costs and burdens are quite relevant and constitute a wide share of variables that can hinder the willingness and decision-making process of buildings' owners, landlords, as well as tenants, and public authorities. It is clear that, as already highlighted in the EU directives, the financial and economic part must become a solid piece in the buildings' renovation puzzle, allowing end-users, during the decisional phase, to have a clear idea of the economic feasibility of the foreseen interventions, to make financial assessments, and to easily include in their evaluation the weight of available national subsidies and incentives, that could be the needle of the scale in renovation resolutions, especially for vulnerable citizens' groups.

With these premises, **the objective of this deliverable is to develop and provide a financial tool for economic and financial pre-feasibility assessment of energy retrofit renovation scenarios, with the key inclusion of national subsidies and incentives** coming as outputs of the work in D4.3.

This tool, which at this stage is presented in this document a separate developed module, will be integrated as part of D2.3 - Industrialised retrofit potential assessment tool final version, in order to allow end-users to have an easy-to-use financial and economic assessment of the chosen interventions. The overall process is summarized in Figure 4.

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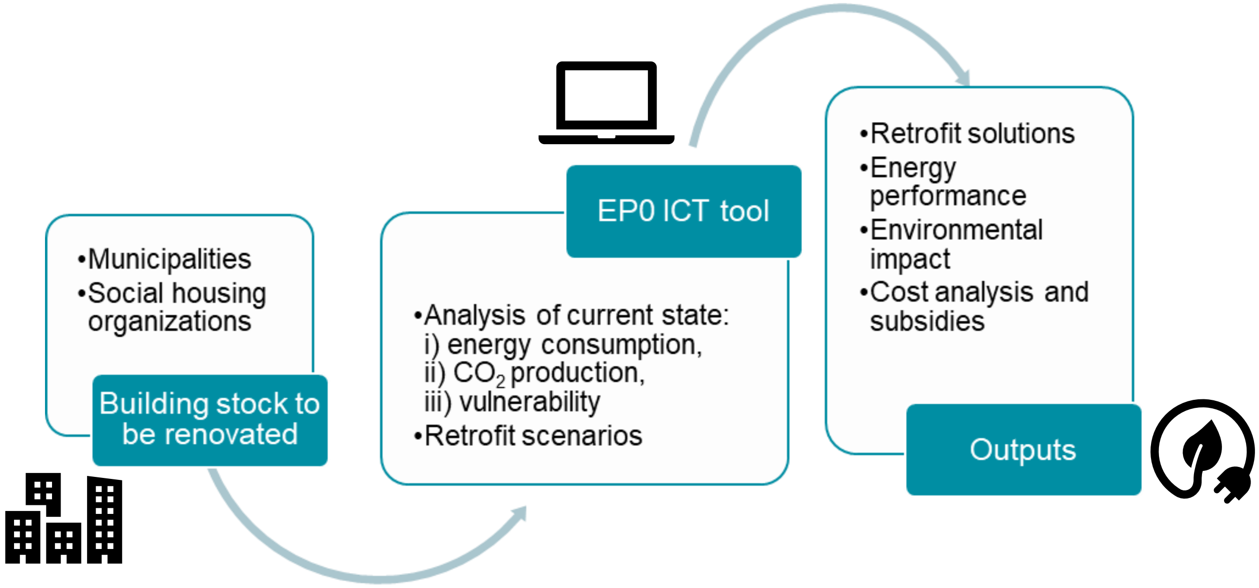


*Figure 4. Overall workflow scheme for the EP-0 ICT tool final version.*

**The final goal is to support the target user in the evaluation of retrofit intervention measures to be adopted, with a clear comprehensive overview of the financial and economic implications**.

To do so, a preliminary review of barriers that hinder energy renovation investments has been performed, and it is presented in Section ***Erreur ! Source du renvoi introuvable.***, *Review of factors, drivers and barriers towards energy renovation* investments.

## B. Context and state-of-the-art on drivers and barriers driving energy retrofit investments

### 1. Review of factors, drivers and barriers towards energy renovation investments

When it comes to the improvement of households' energy efficiency, different measures can be undertaken by either homeowners or tenants. Depending on the level of available budget, know-how, dedication, and target, **energy efficiency actions can be broadly categorized into i) non-investment measures and ii) investment measures**[6]. Non-investment measures generally involve habitual actions that can be easily implemented by any average user on a daily basis, such as turning off lights or appliances when not in use, i.e. actions stemming from current or modified habits. In contrast, investment measures are less frequent or one-time actions and imply securing an amount of money for upgrading systems, operational or constructive technologies that affect the energy use of a building. Several

[6] Gireesh N, Leif G, Krushna M. Factors influencing energy efficiency investments in existing Swedish residential buildings, Energy Policy, Volume 38, Issue 6, 2010, Pages 2956-2963, https://doi.org/10.1016/j.enpol.2010.01.033

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empirical studies on homeowners' adoption of non-investment and investment measures were conducted in the 1980s[7] and in the 2000s[8]. Surveys conducted in the UK and the US[9] indicated that more respondents tend to adopt non-investment measures than investment measures to reduce energy use, and this can be ascribed to various different factors related to the individual or a more societal sphere.

Several studies in social sciences and engineering highlight that energy-related decisions towards taking action are driven by a mix of factors, including social, psychological, and cultural influences. E. Shove[10] emphasizes that social norms and cultural factors heavily influence occupants' behaviours, suggesting a shift in focus from individual actions to transforming collective conventions. Two main perspectives in user-centered theories emerge: **environmental determinism** (the environment dictates behaviour) and **social constructivism** (social contexts shape attitudes). Vischer[11] argues for a balanced view, acknowledging that while the environment influences behaviour, it's also shaped by emotions, attitudes, and social contexts.

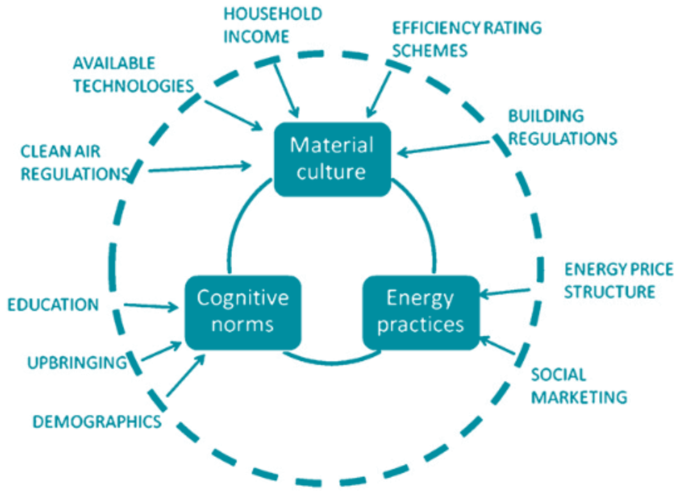


*Figure 5. Stephenson et al., Energy Cultures Framework.*

Cultural and social factors, such as household dynamics, community interactions, and organizational cultures, play a critical role in shaping energy practices. Watson et al.[12] identify mechanisms like management strategies and social norms that influence user behaviour. Acknowledging cultural and social diversity, lifestyle segmentation can offer a nuanced

[7] Black JS, Stern PC, Elworth JT, 1985. Personal and contextual influences on household energy adaptations. Journal of Applied Psychology 70, 3–21.
Stern PC, Gardner GT, 1981. Psychological Research and Energy Policy. American Psychologist 36, 329–342.
[8] Barr S, Gilg AW, Ford N 2005. The household energy gap: examining the divide between habitual-and purchase-related conservation behaviour. Energy Policy Poortinga, W., Steg, L., Vlek, C., Wiersma, G., 2003. Household preferences for energy-saving measures: a conjoint analysis. Journal of Economic Psychology 24, 49–64. 33, 1425–1444.
[9] Forstater M, Oelschlaegel J, Monaghan P, Knight A, Shah M, Pedersen B, Upchurch L, Bala-Miller P, 2007. What assures consumers on climate change? Switching on citizen power.
[10] Wilhite H, Shove E, "Understanding Energy Consumption: Beyond Technology and Economics," in ACEEE 1998 Summer Study on Energy Efficiency in Buildings, 1998.
[11] Vischer JC, 2008. Towards a user-centred theory of the built environment. Build Res Inform 36(3):231–240
[12] Watson KJ, Evans J, Karvonen A, Whitley T, 2016. Re-conceiving building design quality: a review of building users in their social context. Indoor Built Environment 35(3):509–523

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understanding of energy use. Stephenson et al.'s "Energy Cultures Framework"[13] categorizes behaviour by cognitive norms, energy practices, and material culture, providing a comprehensive method to identify opportunities for behavioural change (Figure 5).

Narrowing down the analysis to the factors that influence the adoption of investment measures, according to Kempton et al.[14], individuals may adopt non-investment measures due to the visible direct benefits, or simply because these actions stem from established habits, and **the absence of investment-related risks**. In fact, investment measures require financing, which can deter their adoption. For instance, in a study from Naturvårdsverket[15], about 74% of Swedes viewed the **higher costs as a barrier to purchasing environmentally and climate-friendly products**. However, since investment measures involve a one-time action, they can be easier to implement. Moreover, once these energy efficiency investments are made, the potential energy savings (excluding any possible rebound effect) are likely to be realized. **Energy efficiency investments have a greater potential for energy reduction compared to non-investment measures**[16].

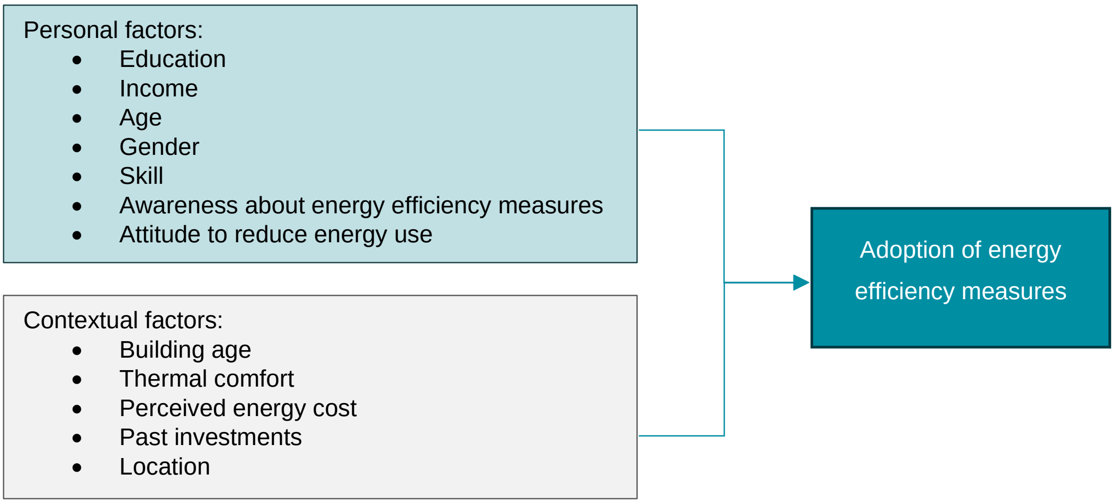


*Figure 6. Summary of main drivers influencing homeowners' adoption of energy efficiency measures.*

Several factors influence the adoption of energy efficiency investment measures, which can be categorized into **contextual and personal factors**. The first discriminating factor is

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[13] Stephenson J, Barton B, Carrington G, Gnoth D, Lawson R, Thorsnes P, 2010, Energy cultures: A framework for understanding energy behaviours, Energy Policy 38(10): 6120-6129

[14] Kempton, W., Harris, C., Keith, J., Weihl, J., 1985. Do consumers know 'What Works' in energy conservation? Marriage and Family Review 9, 115–133.
Kempton, W., Darley, J.M., Stern, P.C., 1992. Psychological research for the new energy problems: strategies and opportunities. American Psychologist 47, 1213–1223.

[15] Naturvardsverket, ˚ 2008. The general public and climate change Swedish Environmental Protection Agency, Stockholm.

[16] Stern, P.C., Gardner, G.T., 1981. Psychological Research and Energy Policy. American Psychologist 36, 329–342.

homeownership, i.e., the rental or ownership of a house[17]. Other key variables are summarized in Figure 6.

In another work by Baumhof et al.[18], the authors analysed the factors that determine the extent of house owners' energy-related refurbishment projects, adopting *Motivation-Opportunity-Ability* (MOA) *approach.* This MOA framework serves as a theoretical foundation, while structural equation analysis is used as an empirical research method, and it is frequently employed to analyse individual performances, enabling the testing of hypotheses within the context of its predictors. Specifically for this German-based study, it examines the impact of Motivation, Opportunity, and Ability on the extent of Energy Efficiency Renovation Measures (EERMs) undertaken by owner-occupiers of single and two-family houses. Furthermore, by using formative operationalized constructs, it also assesses the influence of various factors related to refurbishments on the three MOA predictors, thereby affecting the extent of EERMs.

Various studies[19] claim that **motivation** is, for example, influenced by how desirable a certain behaviour's result is. It is rooted in things like beliefs, attitudes and social norms, and is necessary to initiate action. **Opportunity** is influenced by outside variables that either simplify or complicate the execution of relevance. It refers to outside factors, such as a need for maintenance, a high energy bill, or a move to a new house, which create the setting for action. The **ability** to carry out the appropriate action is dependent on several factors, such as knowledge. People must have the ability to take action in terms of money, time and mental capacity to do so.

The factors and statements used in the equation modeling of this analysis were either drawn directly from the existing scientific literature in the context of EERMs and understanding house owners' decisions or were adapted for the scope, and they are summarized in Table 1.

[17] Black, JS, Stern, PC, Elworth, JT, 1985. Personal and contextual influences onhousehold energy adaptations. Journal of Applied Psychology 70, 3–21.
Costanzo, M, Archer, D, Aronson, E, Pettigrew, T, 1986. Energy conservation behavior: the difficult path from information to action. American Psychologist 41, 521–528.
Rehdanz, K, 2007. Determinants of residential space heating expenditures in Germany. Energy Economics 29, 167–182.
[18] Baumhof R, Decker T, Röder H, Menrad K, Which factors determine the extent of house owners' energy-related refurbishment projects? A Motivation-Opportunity-Ability Approach, Sustainable Cities and Society, Volume 36, 2018, Pages 33-41
[19] Ölander F, ThØgersen J. (1995). Understanding of consumer behaviour as a prerequisite for environmental protection. Journal of Consumer Policy, 18(4), 345–385.
Blumberg M, Pringle CD. (1982). The Missing Opportunity in Organisational Reseach: Some Implications for a Theory of Work Performance. Academy of Management Review, 7(4), 560–569.

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*Table 1. Factors determining homeowners energy-related refurbishment projects according in a MOA framework.*

| MOA targets | Factors |
|---|---|
| **Motivation** | Appearance of house |
| | Dependence on fossil fuels |
| | Energy costs |
| | Indoor comfort |
| | Structural condition |
| | Utilization of space |
| **Opportunity** | Clarity about the desired effects |
| | Complexity of regulations |
| | Complexity of the refurbishment |
| | Finding of craftsmen |
| | Gathering information |
| | Government incentives |
| **Ability** | Appreciation by neighbours |
| | Capabilities/skills |
| | Sensitivity regarding dust and dirt |
| | Support from family |
| | Willingness to take out a loan |

Using the MOA framework, authors were able to measure the influence of various factors on the extent of energy-related refurbishment projects undertaken by owner-occupiers. Factors such as **energy bill savings, a supportive social environment, willingness to take out a loan, and the intention to improve a building's structural condition positively impacted the extent of energy efficiency renovation measures** conducted or planned by owners of single and two-family houses. It was concluded that, **to encourage more extensive energy-related refurbishments in residential buildings, offering subsidized building structure assessments could be beneficial. These initiatives could motivate homeowners who are already inclined to undertake individual EERMs** (e.g., replacing old windows) to enhance their refurbishment efforts by identifying additional energy-related issues that might otherwise go unnoticed. Along with energy cost-saving forecasts, **such initiatives could also improve homeowners' attitudes towards taking out loans, due to higher energy savings and increased profitability from more comprehensive EERMs**. Additionally, **implementing these initiatives at the local or municipal level could create a positive multiplier effect within the community, encouraging more homeowners to take action.**

Regarding the topic of tax credits and the support these can give to users already inclined to EERMs, Nauleau[20], in her work, performed an econometric study assessing the efficiency of the income tax credit system introduced in France in 2005 on investment decisions for household retrofits, focusing on insulation measures.

[20] Nauleau ML, Free-riding on tax credits for home insulation in France: An econometric assessment using panel data, Energy Economics, Volume 46, 2014, Pages 78-92

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Among the numerous obstacles households encounter when retrofitting their homes[21], **market imperfections** particularly justify the use of incentives such as tax credits. Termed **"investment inefficiencies"** by Allcott and Greenstone[22], **these market failures largely stem from imperfect information, which can deter households from undertaking profitable energy efficiency investments**.

However, when researching the effects of tax credits on the probability of undertaking energy efficiency investments, it is important to mention the so-called free ridership effect: **free-ridership is defined as behaviour that occurs "when the agents targeted by the policy accept the incentives but would have made the investment regardless."**[23]Potential free-riders are also defined as those whose estimated marginal willingness to pay for a specific retrofit option exceeds the observed investment cost without the subsidy[24].

Findings from this work indicate that the French **tax credit system significantly and positively influenced household investment decisions, though this impact materializes with a delay of two to three years depending on the retrofit category**. After this initial delay, the average marginal effects of tax credits increase progressively, peaking in 2009 before slightly declining in 2011. These trends align with actual changes in tax credit rates and the typically slow decision-making process for investments. Regarding free-riders, **the estimated proportion of free-riders among tax credit beneficiaries ranges from 40% to 85% during the years when tax credits had a significant effect**, range that authors found consistent with literature values and highlights the prevalence of free-riding. Over time, the incidence of free-riding has gradually decreased. Similarly, Alberini et al. examined the impact of an Italian tax credit introduced in 2007. Considering region-al differences, they discovered that the tax credit led to a 37 to 40% increase in window replacement rates in colder climates. Additionally, **free-ridership varies based on socio-economic factors such as the dwelling move-in date and the socio-professional category of the households**.

From all the cited studies, a recurrent fact is that **homeowners' motivation to implement energy renovations derives from the benefits and barriers they perceive**[25]**.**

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[21] Jakob M, 2007. The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners. CEPE Working Paper (56).
[22] Allcott H, Greenstone M, 2012. Is there an energy efficiency gap? J. Econ. Perspect. Am. Econ. Assoc. 26 (1), 3–28.
[23] Alberini A, Bigano A, Boeri M, 2014. Looking for free riding: energy efficiency incentives and Italian homeowners. Energy Effic. 7 (4), 571–590
[24] Grösche P, Vance C, 2009. Willingness to pay for energy conservation and free-ridership on subsidization: evidence from Germany. Energy J. 30 (2), 135–153
[25] Azizi S, Nair G, Olofsson T, Analysing the house-owners' perceptions on benefits and barriers of energy renovation in Swedish single-family houses, Energy and Buildings, Volume 198, 2019, Pages 187-196.

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In the study from Bjørneboe et al.[26], focused on the refurbishment of single-family houses in Denmark, identified barriers and motivators for energy renovation are organized into a framework comprising three main categories (Information, Finance, and Process), each with a total of 14 sub-areas. The aim is to identify key changes for policy and regulations, in order to embrace critical concrete challenges that influence users willingness to undertake EERMs. In fact, according to the authors, while there is growing emphasis on energy efficiency and significant savings potential in the existing building stock, **it remains challenging to fully capitalize on this potential due to homeowners' reluctance. The primary barriers they face include lack of awareness, financial constraints, insufficient information, and the absence of a robust regulatory system.** Drivers, as above mentioned, range in a very wide spectrum, and savings and climate protection alone are not always effective as motivators for energy-efficient renovations. Putting aside for a moment social and cultural factors, among the common barriers highlighted by several studies, costs, economy, and decision-making processes are among the most recurrent.

Literature has identified various barriers and motivators, and in some cases, these have been categorized. Such categories can vary from one work to another, however, creating a framework for incentives and barriers remains valuable because it allows for a systematic evaluation of current policies in the field. Removing barriers has the potential to create the ability to renovate, while improving motivation can create the willingness to implement such actions.

In the work by Bjørneboe et al., incentives and barriers are grouped into three categories:

a) **Information**, which covers how communication and education can raise awareness to encourage energy renovation;
b) **Finance**, which deals with the economic aspects of renovation, including subsidies;
c) **Process**, which encompasses the physical and social context, decision-making, and regulation.

A summary of categories and sub-areas is offered in Figure 7.

For the scope of this deliverable, the focus is put on financial barriers and motivators.

[26] Bjørneboe M, Svendsen S, Heller A, Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators, Energy and Buildings, Volume 167, 2018, Pages 347-358.

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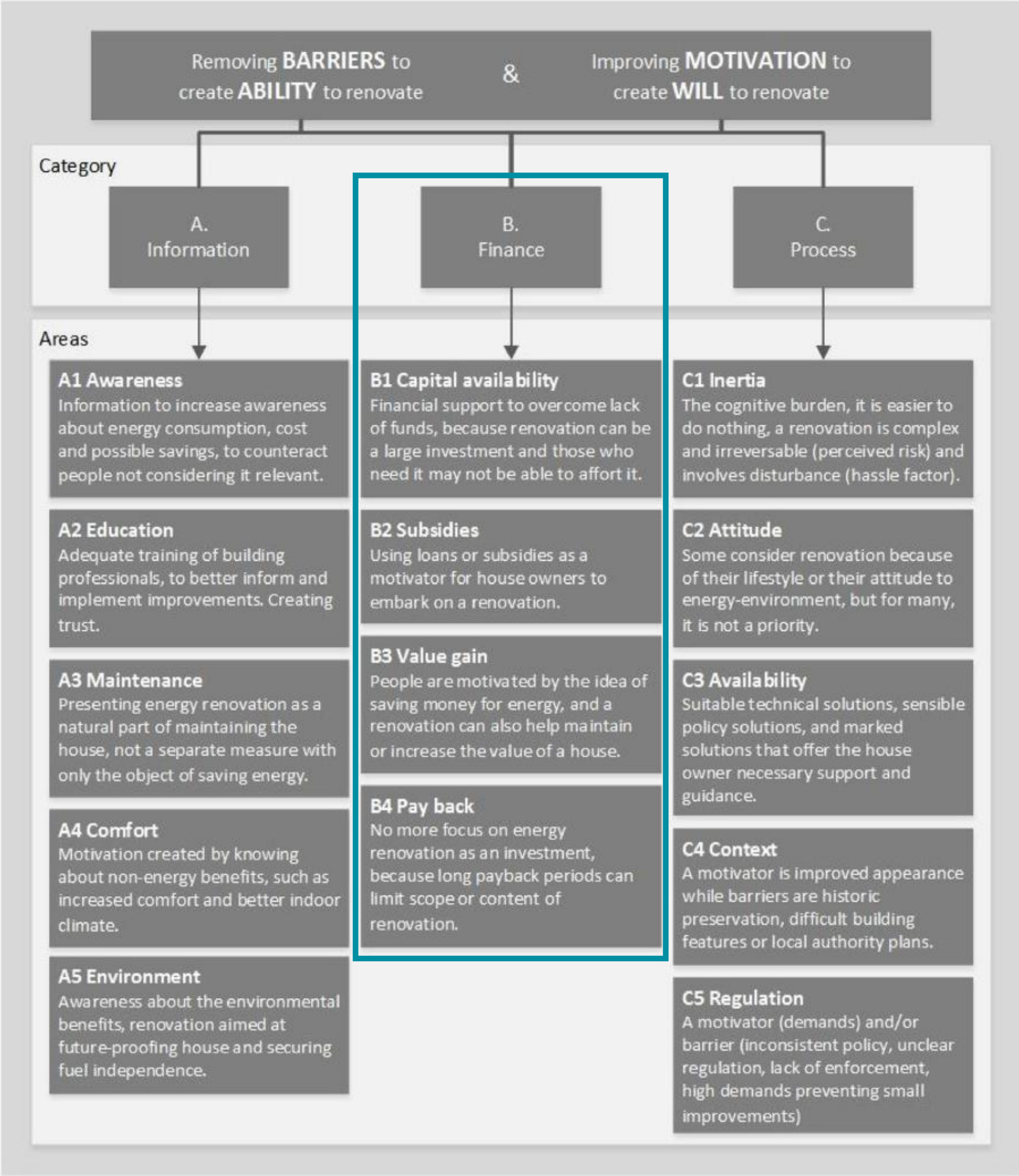


*Figure 7. The three main fields of barriers and motivators for energy renovation. In each field, relevant sub-areas are identified.[25]*

In the finance category (B, Figure 7), four relevant sub-areas were identified: Capital Availability, Subsidies, Value Gain, and Payback. One of the most significant barriers [27, 28] to

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[27] Watts C, Jentsch MF, James PAB, Evaluation of domestic energy performance certificates in use, Build. Serv. Eng. Res. Technol. 32 (2011) 361–376
Gram-Hanssen K, Existing buildings −users, renovations and energy policy, Renew. Energy 61 (2014) 136–140
Tuominen P, Klobut K, Tolman A, Adjei A, de Best-Waldhober M, Energy savings potential in buildings and overcoming market barriers in member states of the European Union, Energy Build. 51 (2012) 48–55
Jakob M, The Drivers of and Barriers to Energy Efficiency in Renovation Decisions of Single-family Home-owners, 2007
Zundel S, Stieß I, Beyond profitability of energy-Saving measures-Attitudes towards energy saving, J. Consum. Policy. 34 (2011) 91–105
[28] B. Boligejeranalyse , Bolius Boligejeranalyse 2017 (in Danish)

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energy renovation is the large investment required and the **lack of available capital**. This issue is particularly prevalent among younger homeowners (aged 25–39), with 72% considering it a primary barrier, who, on the other hand, are also the share of population most attentive to the topics of climate emergency and environmental impact. Also the topic of loans is crucial. A study by Zundel and Stieß[26] on German homeowners examined capital availability and found that **more people were unwilling to take out an additional loan**, while others claimed they lacked the financial means or had exhausted their home credit lines. **This indicates that even when loans for energy renovations are available, an aversion to borrowing prevents these individuals from prioritizing such projects.**

Given this context, **one way to motivate homeowners is through subsidies.** The Bolius survey[28] found that 35% of respondents indicated that **attractive subsidies could incentivize them to carry out energy renovations, making this a more frequent motivator than the need for necessary maintenance** (30%). Lack of financial support can keep people from embarking into a renovation process, whether cheap loans and effective grants can boost their willingness. In addition to this, energy renovations are frequently highlighted as a major motivator due to the **potential cost savings**. Such renovations can **lower the ongoing expenses** of a home and **boost its overall market value** during a sale[26, 29]. Energy renovation is frequently depicted as a financially sound investment that should yield returns relatively quickly. However, **long payback periods can pose a significant barrier, leading homeowners to dismiss such projects purely for economic reasons**[26, 28, 30].

Lastly, it is generally acknowledged that an effective strategy to encourage homeowners to undertake energy improvements is through regulation, but it must be implemented carefully to avoid pitfalls. **For regulations to be effective, they must be consistent**[26]**.** Inconsistencies can lead to unintended behaviours, and **prolonged discussions about incentives without implementation can impede progress**. Enforcement is also crucial; regulations lacking enforcement lose their effectiveness. Additionally, policymakers should be cautious of setting overly ambitious targets, as they may discourage smaller renovations by making improvements too costly and extensive[31].

[29] Knudsen HN, Jensen OM, Indoor climate perceived as improved after energy retrofitting of single-family houses, Proc. 13th Int. Conf. Indoor Air Qual. Clim. (2014) 4 40–4 47.
[30] Tommerup HM, Svendsen S, Energy savings in Danish residential building stock, Energy Build. 38 (2006) 618–626
[31] Galvin R, German Federal policy on thermal renovation of existing homes: a policy evaluation, Sustain. Cities Soc. 4 (2012) 58–66

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*FOCUS: Co-benefits of high performance measures and their economic value*

In the journey towards a carbon-neutral society, the building sector plays a crucial role and has significant potential for enhancement. Although a new generation of buildings is emerging and energy efficiency measures on the existing stock are strongly pushed by EU regulations and standards, this comes with additional technological and economic efforts. However, in order to present a comprehensive picture, raise awareness and engage end-users, when it comes to the quantification of the impacts of efficiency interventions, it is essential to consider both direct and indirect impacts. On the contrary, research over the past decade has primarily focused on direct effects, such as energy savings, whether the indirect impacts lack clear identification, terminology, and a defined list of impacts and methodologies for their quantification is still absent. **Understanding the real value of co-benefits could help users to undertake renovation measures, accounting for additional positive impacts for them, their household and society.** In this direction, in the work by Pistore et al.[3], the authors tried to establish some fundamental points as initial steps towards **incorporating indirect effects into the overall performance evaluation and business models** of high-performance buildings. Key achievements in this direction include: i) analysing the various terminologies used to describe the indirect effects of high-performance buildings; ii) developing a framework to classify these indirect effects based on the beneficiary or affected party (household/community) and category (user-centered and wellbeing, economic, environmental, social); iii) creating a list of potential impacts suitable for economic quantification; iv) reviewing current approaches and indicators available for **monetary quantification**. A review of impacts at household and community level is presented in Figure 8.

In the same work, a review of economic and monetary evaluation of the indirect effects from literature is presented. Among these, for example, health benefits, decrease in sick leave, decrease in mortality and morbidity, are presented as indirect positive benefits of energy efficiency measures, and quantified in **monetary (€ or $) gain for society, annual savings, or increase in rent or in the price of commercial assets**. The review aimed to establish a common foundation and a robust basis for future research in this area, which is essential for achieving economic quantification, supporting stakeholders in the building sector, and boosting homeowners to undergo renovation processes. Continued research will facilitate the market adoption of high-performance technologies and interventions, enabling comprehensive business models that consider both direct effects and a range of additional benefits.

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| | | | | |
|---|---|---|---|---|
| **Household** | **Direct effects** | • Reduction in energy consumption costs<br>(**Economic**) | | |
| | **Indirect effects** | • Thermal comfort<br>• Acoustic comfort<br>• Visual comfort<br>• Indoor air quality<br>• Building physics<br>• Health improvement<br>• Ease of use<br>• Safety<br>• Resilience to climate change<br>(**User-centered and wellbeing**) | • Lower energy bills<br>• Lower maintenance costs<br>• Increase in the value of the building<br>• Increase in productivity<br>(**Economic**) | |
| **Community** | **Direct effects** | • Reduction in $CO_2$ emissions<br>• Reduction in energy use<br>(**Environmental**) | | |
| | **Indirect effects** | • Lower cost of energy<br>• New business opportunities<br>(**Economic**) | • Reduction in atmospheric pollution<br>• Reduction in construction/demolition waste<br>• Environmental protection and enhancement<br>• Mitigation of climate change<br>(**Environmental**) | • Mortality/morbidity/hospitalization reduction<br>• Urban heat island mitigation<br>• Energy security<br>• Aesthetics of the building/neighborhood enhancement<br>(**Social**) |

*Figure 8. List of indirect effects divided into categories (in brackets), both at household and community level. Source: Pistore et al., 2023[3].*

## 2. Summary of drivers and barriers to be included in the financing tool for vulnerable people

From the review presented above, it is evident that, in order to have an effective spread of energy renovation measure, it is pivotal to account for the different drivers and barriers that can either boost or hinder homeowners willingness.

Both obstacles and motivators can raise from different factors, which could be categorized as contextual or personal factors, and their impact and correlation can be analysed my means of the Motivation-Opportunity-Ability framework in order to grasp the main aspects to be targeted by policies, regulations, and tools.

Among the barriers highlighted in several works, finance plays surely a strong role and can be the area in which the work of this deliverable can provide users with an easy-to-access and easy-to-use tool for a pre-feasibility of their intervention, with an economic and financial assessment supporting and speeding up building's owners decision-making process. If motivation is present, supporting the financial process can also support users' opportunities and abilities towards renovating.

In the financial process, different factors have been identified as crucial and are presented hereafter.

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- **Capital availability:** renovation can be a large and scary investment, especially for those vulnerable categories who do not have the means to undertake it. Financial support can be a mean to overcome the lack of funds.
- **Loans:** even if this instrument is available, people might not be willing to borrow money, especially if conditions are tight and risky and involve changing interests' rate, or if they already have another loan or have just extinguished one.
- **Subsidies:** also known as incentives, or tax credits, these have proven to be a strong motivator for owners for undergo building's renovation, also including those who are part of the free-riding effect.
- **Regulations and procedures:** they can be either motivators or barriers. Demands from national and EU governments can push renovations but, for regulation to be efficient, it must also be clear and consistent. In this direction, processes must be easy to access, easy to implement, and streamlined, whether too much bureaucracy can surely be an obstacle.
- **Value gain:** people are motivated by the idea of saving money and decreasing utility bills, but also by the increase in the monetary value of their asset.
- **Payback:** payback periods and return of investment can limit the scope or the magnitude of the intervention.
- **Maintenance:** it has proven not to be one of the main drivers for renovation, on the contrary people could be hold back from the fear of maintenance costs of new integrated technologies.
- **Additional benefits:** attitude, education and awareness can be a strong barrier if not addressed. Educating users to the value of also additional co-benefits, both at household and community level, and moving steps towards their economic quantification, can be an additional contribution to the spread of energy efficiency investments.

This review has been beneficial in order to have a clear identification of the aspects to be addressed in the financial tool conceptualization and development, as the financial and economic indicators will reflect, the most is possible, what is needed in the decision making process for renovation investments.

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## C. Conceptualization and development of a financing tool for financial and economic assessment of energy retrofit projects

### 1. Introduction and integration within the EP-0 ICT tool

In this section, the financing tool is conceptualized in order to, not only develop a mean for economic and financial assessment, but also and foremost to be deployed as an interoperable module within the EP-0 ICT tool (see D2.3 first version).

In the scheme below (Figure 9), the workflow is presented.

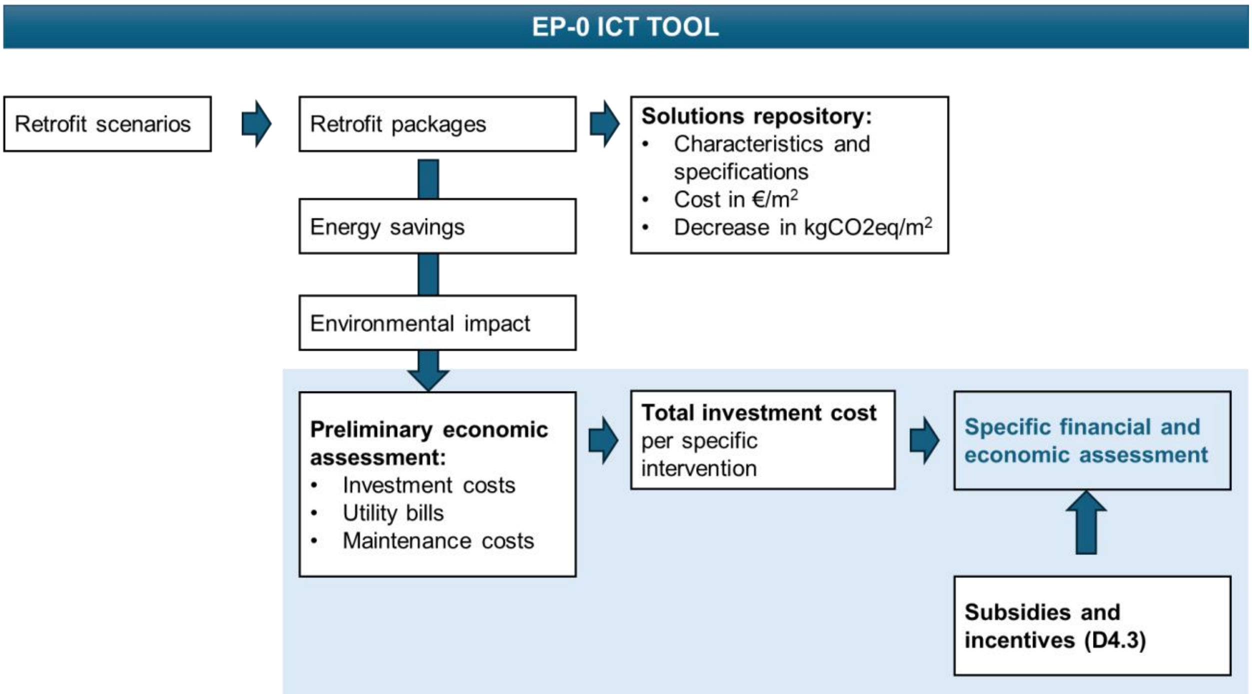


*Figure 9. Conceptualization of financing tool and integration in the EP-0 ICT tool final development.*

The financing tool foresees a two-levels analysis:

1. **Preliminary economic assessment:** a basic overview of average investment costs, utility bills and maintenance costs through life cycle, based on pre-simulated solution packages coming from the iNSPiRe[32] database.
2. **Specific financial and economic assessment:** a more in depth on-demand analysis, based on the specific intervention area and solution adopted, including subsidies and incentives, and providing specific financial indicators as outputs.

[32] Dipasquale Chiara, Fedrizzi Roberto, Bellini Alessandro, Gustafsson Marcus, Ochs Fabian, & Bales Chris. (2019). iNSPiRe FP7 - Retrofit solutions database [Data set]. Available in Zenodo.

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The inclusion of this specific financial tool in the project directly addresses the urgent need to tackle energy poverty, particularly affecting vulnerable segments of the population. By providing a concrete and simple-to-use solution, the tool will help local administrations, social housing operators and houseowners to implement energy efficiency interventions that not only reduce energy consumption and greenhouse gas emissions but also improve the quality of life in at-risk communities.

The primary goal of the tool is to function as a decision-making instrument, aimed at supporting these key users while delivering clear, actionable results. These results will be easily communicated to residents, helping them understand the economic implications, financial benefits, and potential subsidies available. This will raise awareness and empower them to take part in energy efficiency initiatives.
In vulnerable residential contexts, where financial resources are often scarce, public administrations and social housing companies play a crucial role in planning and executing energy retrofit projects. The tool will be essential in facilitating access to funding information and offering financial simulations customized to local and socio-economic needs. This will enable well-informed decisions, ensuring that interventions maximize long-term benefits. Specifically, the tool will integrate calculations for financial aids, such as subsidies, tax incentives, and favourable financing options, applicable to energy retrofit interventions. By combining these financial details, decision-makers will be able to evaluate the economic feasibility of projects and identify the most advantageous financing options for each case. This will help reduce financial barriers and optimize investments.

Furthermore, the tool will be designed to be user-friendly, even for non-experts, while handling the complexity of various financial scenarios. One of its core functions will be to accurately calculate the economic returns on energy efficiency investments, factoring in not only the direct costs but also the economic benefits from available subsidies and incentives in the participating countries—Italy, France, and the Netherlands. To achieve this, the tool will adapt to the specific regulatory and financial contexts of each country, aligning with inputs from the project's Work Package 4 (WP4). In this wat, the tool will enable users to simulate customized financial scenarios. Some main inputs will come from the tool's energy module, while others can be updated or refined by users to reflect changing costs, subsidies, or incentives. For the latter, the tool will integrate information from WP4 D4.3, which will provide detailed information on the latest available subsidies and incentives. This dynamic capability will allow users to model different financial scenarios and assess the impact of various parameters on the profitability of their investments, ultimately improving decision-making and reducing financial risks.

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In summary, the financial tool will be a multifunctional and versatile instrument designed to support energy retrofit projects from initial planning through to final investment evaluation. It will play a key role in advancing the goals of the Energy Poverty Zero project, contributing to a more equitable and sustainable energy transition while promoting social inclusion. Through its user-centric design and ability to handle complex financial scenarios, the tool will significantly enhance the effectiveness of energy poverty reduction policies in vulnerable urban contexts.

## 2. Tool architecture: inputs

The financial tool will be designed to handle a diverse range of inputs, essential for creating accurate and customized financial simulations. This flexibility will allow users to adapt the tool to the specific needs of their energy retrofit projects, ensuring that calculations reflect real-world conditions.

The inputs driving the tool's functionality can be categorized into three main groups:

- **Tool-generated inputs:** Data related to the building's characteristics, including geographic location (focused on Italy, France, and the Netherlands), building type and geometry, and projected energy and emissions savings.
- **User inputs:** Information provided by users, such as the type of retrofit intervention, technical details of the solutions being considered, budget limitations, and any adjustments or additional data needed to complement pre-filled inputs. Allowing the user to refine or modify some inputs can be also beneficial since often subsidies and incentives values are suddenly changed by local governments.[33]
- **Inputs from WP4 (D4.3):** Data related to national subsidies and incentives, sourced from Work Package 4 (WP4), specifically deliverable D4.3, which will offer a detailed analysis of available financial opportunities in the participating countries.

A key feature of the tool will be its ability to integrate national subsidies and incentives, using data from D4.3. However, to ensure immediate functionality and usability, the tool will initially allow users to manually input subsidy values. This will enable users to model their financial scenarios even before the full integration of WP4 data. Users will also have the option to modify these values, ensuring that the tool remains up-to-date with changing financial or regulatory conditions.

[33] This aspect will be furtherly discussed for the ICT tool management plan after the end of the project. However, allowing the user to refine values, is a first risk management action to avoid analysis and calculations to be performed with incorrect data.

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In addition to these inputs, the tool will enable users to configure several important economic parameters, such as interest rates on loans and the duration of financing, which will directly impact the calculation of return on investment (ROI) and net energy savings. Material and labor costs, which can vary by location and economic context, will also be configurable. This flexibility will ensure that financial simulations are as realistic as possible, allowing users to make well-informed, optimized decisions for their energy retrofit projects.

By managing this range of inputs, the tool will empower users to create precise financial simulations tailored to specific project needs and local conditions, ultimately improving decision-making and the economic feasibility of energy efficiency interventions.

## 3. Calculation logics

The calculation logic of the financial tool will be designed to ensure highly accurate and relevant results, based on the inputs provided by users. This logic represents the operational core of the tool, as it translates the entered data into useful and practical information for the planning and implementation of energy retrofit interventions.

The calculation process will begin with determining the **net cost of the intervention**. This cost will be obtained by subtracting the amount of available subsidies and incentives from the total initial cost of the intervention, collected by the Building data layer of the main tool according to the measure selected by the user from a drop-down menu. Subsidies and incentives are a fundamental component for reducing the financial burden on users, and their correct integration into the calculation is essential for providing a realistic estimate of the actual costs that the user will need to bear. The tool will therefore be designed to automatically apply the available subsidies and incentives based on the provided data, such as geographic location and type of intervention, ensuring that the net cost calculation is as accurate as possible.

The financing tool will leverage **annual energy savings** data obtained from the Building data layer of the main tool, specifically reflecting the impact of the retrofit intervention. This data is critical, as it directly affects both the payback period and the overall economic return of the investment. To ensure accuracy, the tool will incorporate advanced algorithms designed to estimate these savings, utilizing well-established energy performance models and empirical data from comparable past projects.

One of the tool's most powerful features will be its ability to run **simulations of different financial scenarios**, allowing users to explore the impact of various conditions and operational choices. For example, users will be able to manually modify key parameters such

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as the amount of subsidies, the duration of incentives, or the costs of materials, and observe how these variations affect the final results. This simulation functionality will provide users with a deeper understanding of the variables that influence the financial success of retrofit interventions, enabling them to optimize decisions based on real conditions and their own priorities.

In addition to determining the **return on investment (ROI)**, the tool will also calculate other key financial indicators, such as the **Payback Period**, the **Internal Rate of Return (IRR)**, and the **Net Present Value (NPV)** as explained below.

- **Payback Period**: This indicator will represent the time required to recover the initial investment through the energy savings generated by the intervention. It will be calculated as the period of time within which cumulative savings equal the net cost of the investment. A shorter Payback Period will indicate a quicker return on investment, making the intervention financially more attractive.
- **Internal Rate of Return (IRR)**: The IRR will be calculated to determine the expected percentage return on the investment. It represents the discount rate that makes the NPV of the investment equal to zero. A high IRR will indicate an investment with a high potential return, particularly useful for comparing different intervention options.
- **Net Present Value (NPV)**: The NPV will be calculated to determine the present value of future cash flows generated by the intervention, discounted at a specified discount rate. The NPV will provide a measure of the net profit of the investment, where a positive NPV will indicate a financially advantageous project. This indicator will be particularly useful for long-term investment decisions, as it accounts for the time value of money.

In summary, the calculation logic of the tool will be characterized by a methodical and flexible approach, capable of adapting to a wide range of situations and needs. Thanks to its ability to integrate economic and technical variables, simulate different scenarios, and provide key indicators such as ROI, Payback Period, IRR, and NPV, the tool will represent an indispensable instrument for the effective planning of energy retrofit interventions. This will significantly contribute to achieving the sustainability and energy poverty reduction goals promoted by the Energy Poverty Zero project.

Inputs and outputs of the financing tool are shown in Table 2, highlighting the source of inputs according to tool-generated, user and WP4 ones. In the INPUTS section, **X** identifies the primary source, **x** specifies those inputs that also the user will be allowed to modify or to choose among a drop-down list.

*Table 2. Inputs-outputs table for the financing tool. **X** identifies the main source; x identifies those inputs that also the user will be allowed to modify. Continues in the following page.*

| | INPUTS | | | | | | OUTPUTS | |
|---|---|---|---|---|---|---|---|---|
| **Category** | **Inputs required** | **Label** | **Unit** | **Tool-generated** | **User-input** | **WP4-input** | **Output (Generated by the tool)** | **Unit** |
| **Technical Data** | Building type (residential, social, public) | Building typology | Residential<br>Commercial<br>Industrial<br>Institutional<br>Cultural and Recreational<br>Transportation and Infrastructure<br>Agricultural<br>Mixed-Use | **X** | | | **Energy class improvement** | label |
| | Planned interventions (e.g., insulation, window replacement, installation of photovoltaic panels) | Type of intervention | Envelope insulation<br>Windows replacement<br>Air Handling Unit<br>Generation system<br>Distribution system | | **X with drop-down menu** | | | |
| **Geographical Data** | Building location (city, region, country) | Location | / | **X** | | | | |
| | Climate zone | Climate zone | / | **X** | | | | |
| **Economic Data** | Initial design and installation costs | Investment cost (average) | € | **X** | x | | **Net cost of renovations**: The tool calculates the final cost of the intervention, subtracting incentives and considering the financing. | € |
| | Available public incentives (e.g., local subsidies) | Incentives availability | Yes/No | | x | **X** | **Payback period**: Indicates the time required to recover the investment through energy savings. | years |
| | Interest rate on financing | Interest rate | % | **X** | x | | **IRR (Internal Rate of Return)**: Calculates the | % |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | economic profitability of the investment. | |
| | | | | | | | **NPV (Net Present Value)**: Indicates the present value of the cash flows generated by the intervention. | € |
| | | | | | | | **Total cost of financing**: The tool calculates the total cost of financing, including interest and other fees. | € |
| **Public Financing** | Value of available public incentives and subsidies | Incentives share | €/year<br>%/year<br>… | | x | X | **Net economic contribution of incentives**: The tool calculates the net contribution from applicable incentives, reducing the overall cost. | € or % |
| | Type of incentives (tax deductions, non-repayable grants) | Type of incentive | / | | x | X | **Incentive optimization**: The tool suggests how to maximize the use of available incentives. | / |
| | | | | | | | **Reduction of initial costs**: Calculation of the reduction in initial costs due to incentives. | € or % |
| **Financing Options** | Type of financing chosen (mortgage, subsidized loan, self-financing) | Financing scheme | Mortgage<br>Subsidized loan<br>Self-financing | | **X with drop-down menu** | | **Amortization plan**: Monthly or annual payments, including interest and principal. | / |
| | Loan duration | Loan duration | years | | X | | **Balance between energy savings and financing costs**: Evaluation of the balance between savings and financing costs. | / |
| | Loan amount | Loan amount | € | | X | | | |

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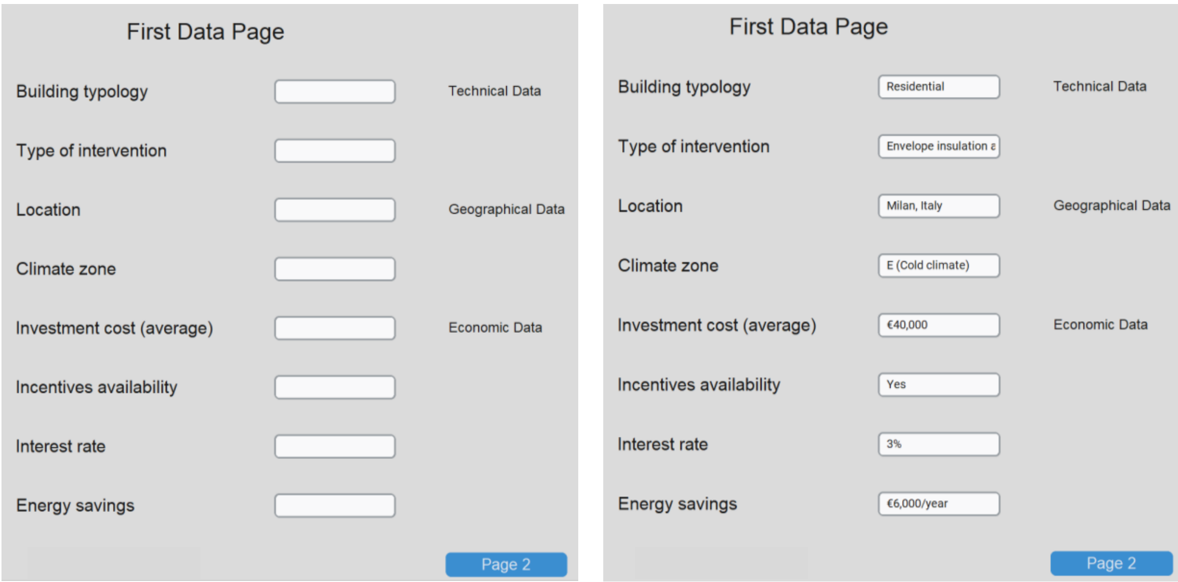
## 4. Concept and first mock-up

To provide an early understanding of the concept and a preview of the tool's functionality, we have developed an initial mock-up, which is presented below. This mock-up offers just a preliminary visualization of the tool's inputs and outputs and serves as a foundation for the finalized version that will be integrated into the EP-0 ICT tool, in line with the overall platform interface and in connection with all the various inputs to be fed from the other modules. The final version of the tool is scheduled to be included in Deliverable D2.3, due in August 2025.

Hereafter a first mock-up is presented, along with an example in order to showcase the potential use of the tool, key knowledge that it can provide and how to interpret it.




(a)

*Figure 10. Inputs for financing tool. Blanck (a); with an example (b).*

The first interface (Figure 10) is split into key input sections that are relevant for an in-depth assessment. According to Table 2, inputs are fed from different sources, tool-generated (T), user (U, or u if users can choose or modify), WP4 (WP4), and are explained below.

1. **Building typology (T):** specifies the type of the building undergoing retrofitting (residential, commercial, etc.).
2. **Type of intervention (U):** allows users to choose the nature of the retrofit activity (e.g., insulation, window replacements).

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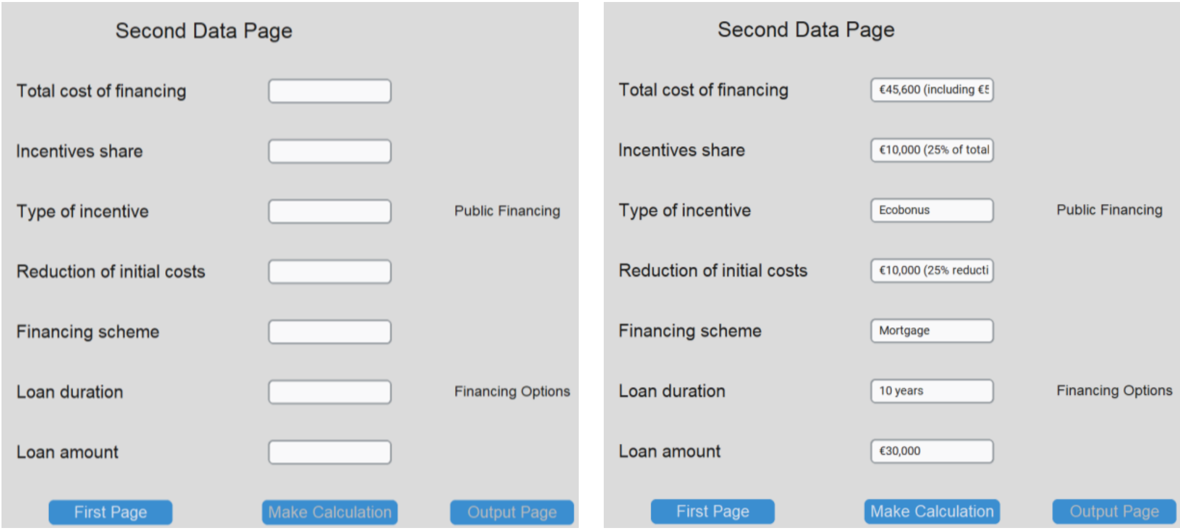
3. **Location and Climate zone (T):** these fields are associated with geographical data, helping to tailor the analysis based on local climate, which can affect energy performance and savings.
4. **Investment cost (average) (T-u):** in the economic data section, this input accounts for the average cost of the intervention, a crucial factor in return-on-investment analysis.
5. **Incentives availability (WP4-u):** here, users can display whether subsidies or financial incentives that could reduce the upfront cost of the retrofit are available.
6. **Interest rate (T-u):** This field is used to input the cost of financing, which is critical for calculating long-term savings and payback periods.
7. **Energy savings (T):** this field captures the expected energy savings from the intervention, directly affecting cost-benefit calculations.




(a) (b)

*Figure 11. Inputs/outputs for financing tool. Blanck (a); with an example (b).*

This second window (Figure 11) focuses on details regarding financing and public subsidies, essential for completing the economic analysis. As detailed in Table 2, some of these inputs are already outputs coming from backend calculations using inputs from the first section (Figure 10).

Here are the fields shown:

8. **Total cost of financing (output)**: this field captures the full cost incurred from borrowing funds for the retrofit project, including interest rate over time. It plays a central role in determining the financial burden over time.

9. **Incentives share (WP4)**: this input quantifies the portion of the total retrofit cost that is covered by financial incentives, such as grants or subsidies, which can significantly improve the investment's financial viability.

10. **Type of incentive (WP4)**: this specifies the kind of incentive that can be applied to the project (e.g., tax credits). It is categorized under "Public Financing", reflecting the external financial support available.

11. **Reduction of initial costs (output)**: this field allows users to input any immediate cost reductions resulting from incentives or other financial mechanisms, which lower the upfront capital required for the retrofit.

12. **Financing scheme (U)**: users can choose the structure of the financing arrangement, such as whether the retrofit is financed through loans, bonds, or other funding models.

13. **Loan duration (U)**: users specify the repayment period of the loan, which affects the long-term financial planning and the calculation of monthly or yearly payments.

14. **Loan amount (U)**: this field is for entering the principal amount borrowed to finance the retrofit, important for computing repayment schedules and overall project cost. These last two inputs are categorized as "Financing Options".

From this inputs/outputs framework, users are provided with the final economic and financial analysis, as shown in Figure 12.

| Output Page | |
|---|---|
| Energy class pre and post-intervention | From G to C (improvement by 3 levels). |
| Net cost of renovations | €30,000 (after €10,000 in incentives). |
| Payback period | 5 years (based on energy savings of €6,000/year). |
| IRR | 10%. |
| NPV | €12,000 (after 10 years at a 3% discount rate). |
| Net economic contribution of incentives | €10,000 (25% of initial costs covered by incentives). |
| Incentive optimization | Maximum Ecobonus applied to reduce upfront costs. |
| Amortization plan | 120 monthly payments of €380. |
| Balance between savings and financing | Energy savings cover financing costs within 5 years. |

*Figure 12. Financial and economic outputs using example above (see Figure 10-11 b).*

In the tested example of a good investment, results are the followings.

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a. **Energy class pre and post-intervention:** the retrofit improves the building's energy label from G to C, representing a significant enhancement in energy efficiency by three levels. This suggests a considerable reduction in energy consumption after the intervention.
b. **Net cost of renovations:** the total net cost of the retrofit is €30,000, which takes into account €10,000 in incentives from the initial investment cost. The incentives reduce the financial burden of the intervention, making it more affordable.
c. **Payback period:** the payback period is calculated at 5 years, based on annual energy savings of €6,000. This shows how quickly the investment will recover its costs through reduced energy expenses.
d. **Internal Rate of Return (IRR):** the IRR is shown to be 10%, indicating a strong financial return for the investment over time. The higher the IRR, the more attractive the investment, and 10% is generally considered a good benchmark for financial performance in retrofit projects.
e. **Net Present Value (NPV):** the NPV of the project is €12,000, calculated over a 10-year period at a 3% discount rate. A positive NPV signifies that the project is financially viable and will generate more value than its cost when accounting for the time value of money.
f. **Net economic contribution of incentives:** the economic impact of incentives is highlighted, with €10,000 covering 25% of the initial costs. This shows that incentives play a crucial role in reducing the upfront financial barrier for the project.
g. **Incentive optimization:** the tool indicates that the maximum bonus has been applied to optimize cost reductions. This suggests that the project has made full use of available subsidies to minimize initial expenditure.
h. **Amortization plan:** the amortization plan outlines 120 monthly payments of €380, which likely corresponds to the financing scheme used to fund the retrofit. This payment plan allows the building owner to spread the cost over time, making the investment more manageable.
i. **Balance between savings and financing:** The energy savings generated by the retrofit are projected to cover the financing costs within 5 years. This balance demonstrates that the project is sustainable, with savings from energy efficiency quickly offsetting the financial outlay.

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## D. Discussion

The development of the financing tool in the Energy Poverty Zero (EP0) project is aimed at **helping overcoming the financial barriers** that vulnerable populations face in energy retrofitting initiatives. The European building sector is a major contributor to energy consumption and greenhouse gas emissions, with a significant portion of the existing buildings being outdated and energy inefficient. In line with EU directives like the Energy Performance of Buildings Directive and the Energy Efficiency Directive, **efforts are being made to reduce energy consumption and emissions** by 2030, with further reductions targeted by 2050. **However, the high cost of renovations, limited access to financial resources, and bureaucratic hurdles are significant barriers to implementing these energy efficiency measures, especially for vulnerable populations.**

The EP-0 financing tool addresses these barriers by providing municipalities, social housing operators, and individuals with financial feasibility assessments of renovation scenarios, including subsidies. The conceptualized financing tool presents a significant step towards addressing energy poverty, especially in vulnerable populations. It is designed to be integrated into the comprehensive EP-0 ICT platform, which will provide two levels of analysis: a preliminary overview and a more specific financial and economic assessment tailored to local interventions. By offering both high-level and detailed analyses, **the tool helps stakeholders such as local administrations and social housing operators make informed decisions regarding energy retrofit projects**. The integration of financial aids, subsidies, and incentives makes this tool particularly valuable for **reducing financial barriers** in resource-constrained environments. The tool **empowers users** by offering clear financial simulations, including essential metrics such as Payback Period, Net Present Value (NPV), and Internal Rate of Return (IRR. This ensures that decision-makers can accurately evaluate the long-term financial benefits of retrofits, **making the requalification investments more appealing**. Furthermore, the user-friendly design allows for **easy interaction even for non-experts**, enabling users to run simulations, optimize financing options, and **assess the long-term economic viability of their projects,** including amortization plans and providing a clear understanding of the balance between savings and financing costs. This ensures that the tool not only supports the planning and implementation of energy-efficient interventions but also aligns with the broader goals of decarbonization, enhancing energy efficiency, while **fostering access to retrofit interventions and social inclusion**.

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# III. Conclusions

To promote energy-efficient renovations, particularly for vulnerable populations, it is crucial to **ensure that financing tools are accessible, simple to use, and transparent**. Many vulnerable households face significant barriers to undertaking energy renovations, including limited financial resources, complex loan systems, and a lack of awareness regarding available subsidies and incentives. By simplifying access to financial support and offering clear information on national and local incentives, **individuals can be empowered and organizations supported to make well-informed decisions about energy retrofits**. Streamlining bureaucratic procedures is also vital to reduce the burden of navigating complex financing processes, making it easier for vulnerable populations to access the necessary resources.

The financing tool developed as part of this deliverable, which successively will be integrated into the broader EP-0 ICT tool in its final version, provides a valuable solution by offering **a comprehensive financial pre-feasibility assessment**. This tool enables users, such as local authorities and social housing organizations, **to evaluate the costs, financial indexes, and subsidies associated with different retrofit interventions**. By doing so, it helps to **preliminary address financial barriers, offering insights into the availability of subsidies, tax credits, and potential financing plans, all of which are crucial in supporting low-income households**. Moreover, the tool allows users to adjust key economic parameters to assess the financial viability of their projects in line with up to date financial constraints, ensuring its viability also beyond the project lifespan.

As an additional recommendation, it is crucial to emphasize that educational initiatives focusing on financial and economic aspects should always support the use of tools. Such initiatives can **raise awareness among vulnerable populations, equipping them with the knowledge necessary to make informed decisions**. By highlighting the multiple benefits of energy retrofits -including enhanced indoor comfort, lower energy bills, and increased property value- these educational efforts can **motivate individuals to engage with the renovation process and seize available opportunities.** Such awareness is essential to driving higher adoption rates, as **households often underestimate the broader economic and social benefits of renovations. The combination of practical financing tools and outreach efforts is recommended, as it will help overcome resistance and ensure that more households, particularly those at risk of energy poverty, are empowered to undertake energy-efficient retrofits.**

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In conclusion, this deliverable plays a key step in addressing energy poverty by making energy-efficient renovations more accessible and financially transparent for municipalities and social housing organizations dealing with vulnerable populations, supporting in this way the undertaking of informed retrofit decisions, tackling EU's broader climate neutrality goals for cities and ensuring a just **energy transition for all segments of society**.

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