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SUPER-i

D1.3 Report "Evaluation of existing financial schemes"

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2. Technical references

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3. Executive summary

This deliverable reports:

- the current financial instruments available to social housing associations for financing Energy Efficiency (EE) refurbishments in Italy, Denmark, and Slovenia.
- the evaluation methodology to measure the impact of implementing the proposed SUPER-i EE renovations on energy poverty of social housing residents, and overall financial profitability of investing in EE projects.

This deliverable is organised as follows:

i. **General introduction on overcoming financing barriers for EE renovations in social housing:** The application of energy efficiency in social and residential buildings faces significant obstacles, primarily related to the challenge of securing adequate financing. Building owners and investors often prioritise measures with short to medium payback periods, resulting in savings below the levels required by energy and climate policies. European communities, lacking financial solutions for large-scale building renovations, seek alternative financing instruments to boost the yearly renovation rate. Various mechanisms, both public and private, have been developed across Europe to provide viable financing solutions for energy efficiency programs in social and residential buildings. The IEA suggests that Public-Private Partnership (PPP) mechanisms could offer solutions. *This report focuses on PPP mechanisms in Italy, Denmark, and Slovenia, exploring their financial implementation and evaluation methods*. By examining successful PPP models, valuable insights can be gained to address financing barriers and promote energy efficiency in social and residential buildings, aligning with broader energy and climate policy objectives.

ii. **Financial Instruments**: this section provides a comprehensive description of the available funding sources accessible by social housing associations in SUPER-i pilots. The Public-Private Partnerships (PPP) are pivotal in addressing the financial challenges associated with energy infrastructure projects. PPPs offer substantial advantages, including ensuring necessary investments, improving public resource management, timely service provision, and leveraging private sector expertise. However, drawbacks include potential cost escalation, delayed public sector payments, prolonged procurement procedures, and the complexity of long-term agreements. To bolster energy efficiency initiatives, various PPP financing mechanisms have emerged such as Dedicated Credit Lines (DCL), Guaranteed savings contract, Shared savings contract, Risk-Sharing Facilities (RSF), Energy Saving Performance Contracts (ESPC), and Chauffage Contracts. This deliverable also considers other funding solutions to PPPs, for example the traditional financial instruments such as grants and subsidies, tax incentives, loans, asset-based financing, hire purchase, energy efficiency obligations (EEO), and energy services agreements (ESA). Each instrument is analysed in terms of its advantages and limitations. The new innovative funding sources such as On-Bill Finance (OBF), One-Stop Shops (OSS), and Crowdfunding.

iii. **Evaluation Methodology**: This deliverable reports the methodology and evaluation of Public-Private Partnership (PPP) initiatives in social housing and energy efficiency across Europe. The objective is to assess the economic and financial feasibility of energy efficiency measures and explore their impact on market prices and rents. This section reviews existing studies, highlighting conflicting findings in terms of financial perspectives and emphasising the need to consider environmental externalities and non-monetary community benefits. The Financial implementation considers partners' balance sheets, extracting investment, expenses, and revenues related to the initiatives. Evaluation methods include Discounted Cash Flow (DCF), Net Present Value (NPV), Return on Investment (ROI), and Cost-Benefit Analysis. The Discounted Cash Flow method, in particular, uses the discount rate to assess investment decisions, with the Net Present Value offering insight into the financial viability of projects. The assessment model aligns with international valuation standards, utilising long-term interest rates provided by central banks for discounting the monetary value of expected future cash flows from the EE projects. It addresses challenges such as reliable cash flow projections, discount rate estimation, uncertainty, and risk.

4. Introduction

One of the main obstacles in the application of energy efficiency in social and residential buildings is the availability of sufficient financing and funding to run these projects Bullier and Milin (2014). Building owners and investors tend to focus on measures with short to medium payback periods (less than 10 years), which usually generate less than 30% savings, while energy and climate policies require saving up to 80% energy in social and residential buildings. Also, most European communities lack the financial solutions to address the large-scale renovation of the building stock on their territory. Therefore, alternative financing instruments are needed to unlock this obstacle and increase the yearly reno-vation rate of potential social buildings for deep renovation. Several Financing mechanisms have been developed, or are currently being developed, by public authorities and private sectors across Europe, to pro-vide adequate financing solutions for social and residential buildings with applicable energy efficiency programs.

According to the International Energy Agency ***(Joint Public-Private Approaches for Energy Efficiency Finance, 2011***) (IEA) financing barriers arise because energy users are not encouraged to invest in Energy Efficiency projects as they prioritise higher-profit investment options for their funds. Most energy users, including large industrial firms, small and medium enterprises (SMEs), commercial sector energy users, and public agencies, seek external financing for their Energy Efficiency (EE) projects. Hence, banks and financial institutions are generally discouraged to provide loans even for highly profitable Energy Efficiency projects due to their lack of information and expertise, and their perception of high risk with respect to Energy Efficiency projects. SMEs are affected much more by the disconnect between the financing needs and the lending practices of Local financial institutions than large corporations with substantial assets and available funds. New funding mechanisms must be developed to scale up lending to SMEs for the implementation of EE projects. Large companies are unwilling to take on additional debt for financing EE projects because of the potential effect on their borrowing capacity for other types of investments.

Financing Energy Efficiency in social housing projects may not appear to be much different than financing other types of investments such as business expansion and development of new products, or sales and marketing. However, EE characteristics are unique and negatively influence their attractiveness to Financial Institutions for funding. Limaye (2011) grouped the characteristics under five major types of financing barriers:

- Availability of funds for investing in EE projects.
- Information, awareness and communication.
- Project development and transaction costs.
- Risk assessment and management.
- Lack of capacity.

Lately, IEA suggests that PPP mechanisms might provide solutions to these barriers especially when applied to EE financing. Hence this report will focus on the PPP mechanisms available in Italy, Denmark, and Slovenia, and the financial implementation and evaluation methods.

4.1. Purpose of this document

This deliverable provides a comprehensive overview and analysis of diverse financial instruments utilised in social and affordable housing across Italy, Denmark and Slovenia with a focus on describing various financial instruments, particularly within the context of Public-Private Partnerships (PPP), aimed at promoting and financing energy efficiency projects. The primary objectives of this document are as follows:

- *Definition and Understanding of PPP:* Provide a comprehensive understanding of Public-Private Partnerships (PPP) by defining the concept and highlighting its significance. This includes distinguishing between purely contractual PPPs and institutionalised PPPs, emphasising the fundamentals that include long-lasting relationships, cost-sharing, task assignment, and risk transfer from the public to the private sector.
- *Importance of PPP in Energy Infrastructure:* Examine the pivotal role of PPP in accessing finance and reducing capital expenditure for energy infrastructure projects. Explore the increasing significance of PPP, especially during times of economic recession and limited national budget spending, to bridge the financial gap between public and private funding.
- *Overview of PPP Development:* Present an overview of the development and implementation of P Furthermore, This deliverable provides a comprehensive overview and analysis of diverse financial instruments utilised in social and affordable housing across Denmark, Slovenia, and Italy.PP and project finance across European countries, with a focus

on major players such as the UK, Spain, France, Germany, Italy, and Portugal. Discuss the market trends, growth, and challenges faced by PPP initiatives.

- *Benefits and Disadvantages of PPP:* Analyse the advantages and disadvantages associated with PPP. Highlight the potential benefits, such as ensuring necessary investments, effective public resource management, timely provision of services, and leveraging private sector expertise. Simultaneously, address the drawbacks, including potential higher costs, delayed public sector payments, prolonged procurement procedures, and the inflexibility of long-term agreements.
- *PPP Financing Mechanisms*: Delve into specific financing mechanisms employed within PPP for energy efficiency projects. This includes an exploration of Dedicated Credit Lines (DCL), Risk-Sharing Facilities (RSF), Energy Saving Performance Contracts (ESPC), Chauffage Contracts, and Super ESCOs.
- *Business Models for ESCOs:* Explore different business models for Energy Service Companies (ESCOs), emphasising their role in energy efficiency improvements. Discuss the pros and cons of various ESCO models, including Energy Supply Contracts (ESCs), Energy Performance Contracts (EPCs), shared savings models, and guaranteed savings models.

By addressing these objectives, this deliverable aims to equip stakeholders, policymakers, and industry players with a comprehensive understanding of the financial instruments and PPP strategies essential for promoting sustainable energy efficiency initiatives. Overall, this deliverable aims to share insights and best practices in addressing social and affordable housing challenges, providing valuable lessons for policymakers and stakeholders in different countries.

5. Financial Instruments

5.1. Public-Private Partnership (PPP)

OECD (2008) defines PPP as a long-term agreement between the government and a private partner where the service delivery objectives of the government are aligned with the profit objectives of the private partner. The European Commission (2004) distinguishes between purely contractual PPP, such as concession-based project finance transactions, and institutionalised PPP, namely the mixed equity companies. Fundamentals of PPP are: long lasting relationship between public and private partners; investment costs sharing; multiple tasks assigned to private entities; risk transfer from public to private sector so each risk shall to be assumed by the subject who is identified as more able to control it.

The potential of Private Public Partnerships (PPPs) for accessing finance and reducing capital expenditure (capex costs) of energy infrastructure projects becomes more and more important in a time of shrinking financial resources, which have widened the gap between public and private funding. Economic recession has limited national budget spending and the lending capacities of commercial banks for the realisation of infrastructure projects in the field of energy generation, transmission and distribution. These, as capital intensive projects, require high up-front investment and long-term commitment with variable returns into the future. The private and public sectors can reach a mutually beneficial agreement through a PPP: the private sector needs guarantees to face risks entailed in the time gap between the project's planning phase and its actual implementation, whereas the public sector needs capital investment and management expertise. Over the span of the past two decades, PPP and project finance specifically have developed across European countries, most of all in UK, Spain, France, Germany, Italy, and Portugal, accounting together more than 90 per cent of European PPP's market from 1990 to 2009 (Kappeler and Nemoz, (2010)). The IEA foresees $260 billion of investments in new transmission and distribution lines through 2035. With approximately $71 trillion in managed assets, institutional investors such as insurance companies or pension funds are a promising source of funding. However, during the last years PPP transactions have been progressively slowed down, in European countries by unfavourable conditions emerging in capital markets, as highlighted by rising cost of debt capital provided by lenders (Antonini et al., 2014).

PPP offers several benefits such as: Ensure the necessary investments into public sector and more effective public resources management; Ensure higher quality and timely provision of public services; Mostly investment projects are implemented in due terms and do not impose unforeseen public sectors extra expenditures; A private entity is granted the opportunity to obtain a long-term remuneration; Private sector expertise and experience are utilised in PPP projects implementation; Appropriate PPP project risks allocation enables to reduce the risk management expenditures; In many cases assets designed under PPP agreements could be classified off the public sector balance sheet. However, PPP disadvantages are: Infrastructure or services delivered could be more expensive; PPP project public sector payments obligations postponed for the later periods can negatively reflect future public sector fiscal indicators; PPP service procurement procedure is longer and more costly in comparison with traditional public procurement; PPP project agreements are long-term, complicated and comparatively inflexible because of impossibility to envisage and evaluate all particular events that could influence the future activity.

5.2. PPP financing mechanisms

5.2.1. Dedicated credit lines (DCL)

DCL were introduced by public entities such as government bodies, non-profit organisations and banking foundations, to provide funding sources for EE projects by a private financial institution. In general, the private financial institutions could be banks or investment funds that provide additional financing, co-financing, for the EE projects. This financing mechanism utilises government, international financial institutions (IFIs) or donor agency funds to leverage an increase in lending by Large Financial Institutions (LFI) for EE projects. They address the issue of insufficient (or non-existent) lending to EE projects due to the LFIs' lack of knowledge and understanding of the characteristics and benefits of such projects. By providing funds to the LFIs (generally at a low interest rate), the public partner gives an incentive to the private-sector LFIs to on-lend funds for EE projects. Because the on-lending is at a higher interest rate (most of the World Bank credit lines are on-lent at market rates), the LFI can earn a profit on the loan transactions. The agreement between the public and private partners generally requires the LFI to co-finance the loans, thereby leveraging and increasing the amount of financing available (see, for example, the World Bank, 2008).

5.2.2. Risk-sharing facilities (RSF)

RSF refers to partial risk/ partial credit guarantee programmes that were introduced by a public entity to reduce the risk from EE project financing to the private sector by sharing the risk through a guarantee mechanism, hence enabling increased private sector lending to EE projects. This mechanism addresses the perception of LFIs that EE projects are more risky than their conventional lending. Such a perception of high risk prevents the LFIs from large scale commercial financing of EE projects. Under the risk-sharing facility, the public agency provides a partial guarantee that covers a portion of the loss due to loan defaults. By sharing the risk, the public partner reduces the risk to the private-sector LFI, thereby motivating the LFI to increase its lending to EE projects (Mostert, 2010).

5.2.3. Energy Saving Performance Contracts (ESPC)

ESPC refers to public-sector initiatives, in the form of legislation or regulation, established by one or more government agencies to facilitate the implementation by energy services companies (ESCOs) of energy performance-based contracts for improving EE in the public sector using private-sector financing. This mechanism addresses a number of barriers related to implementation of EE projects in the public sector. Under the ESPC concept, ESCOs or other types of energy service providers provide a broad range of services, including providing or arranging commercial financing, to public agencies, industries, housing associations etc. under a performance-based agreement, in which guarantees are provided for the energy savings achieved. In the context of PPPs, ESPCs are involved in implementation of EE in the public sector. The public agency makes payments to the ESCO only upon the satisfaction of the guarantees, thereby eliminating much of the technical and performance risk from the agency (Singh et al., 2010).

5.2.4. Chauffage contracts

Chauffage contracts are longer contracts between ESCOs and building owners (typically 10-30 years) in which the ESCO provides complete energy management, including all maintenance, upgrades and operation. Chauffage contracts have a savings guarantee, meaning the fee will be smaller than any energy savings (the new energy cost compared to the approximate cost if the changes by the ESCO were not made).

5.2.5. Super ESCOs

Super ESCOs are institutions, often established and backed by governments, that act to coordinate large-scale energy efficiency projects (<10,000s buildings). Typically, a very large quantity of energy efficiency measures (e.g. energy efficient lighting) are bought from suppliers at a discounted rate and installed in all appropriate buildings. Super ESCOs operate mainly or fully for buildings in the public sector (hospitals, schools, government buildings etc.), but can be utilised in the private sector. Super ESCOs overcome many of the problems faced by independent ESCOs as their backing from government, as well as size and credibility, mean they are more easily able to generate contracts and therefore revenue to maintain stability as an organisation. Contracting with a Super ESCO may be able to surpass procurement processes as they are government-backed entities.

e.g. Etihad ESCO (Dubai), Tarshid (Saudi Arabia) and The Indian Super ESCO Energy Efficiency Services Limited (India). **1.**

Energy service companies are businesses which provide energy to clients for a fee and therefore have an incentive to improve energy efficiency.
ESCOs are experts in energy efficiency improvements and are therefore often better placed than consumers to choose energy efficiency measures. ESCOs are paid a fee, sometimes dependent on energy savings they make, and hold the performance risk for any energy efficiency measures. Therefore, they are incentivised to maximise energy efficiency savings for minimal cost.
As ESCOs are not a fully established industry in many countries, they can struggle to generate enough contracts to generate profit as consumers are often unaware of their benefits. Undeveloped ESCO markets and their lack of standards can also mean ESCOs can be inconsistent in ability to generate energy savings.

PROS	- Energy efficiency measures are selected by the ESCO, who have expertise and will focus on the most significant energy efficiency improvements.

	- Can be used for any energy efficiency improvements. - ESCOs are often paid a set fee for their services, so are incentivised to maximise energy efficiency savings for minimum cost.
CONS	- ESCOs have struggled to raise awareness of their business model and benefits and have therefore struggled to grow. - Not all countries have consistent standards for ESCOs. - ESCOs can struggle to obtain finance and contracts while they grow and can therefore be risky for building owners agreeing to long contracts.

There are several different business models for ESCOs, discussed below.

5.2.6. ESCO - Energy supply contracts (ESCs)

Energy supply contracts (ESCs) are the ESCO business model most similar to traditional energy suppliers. Building owners choose to install energy efficiency measures and pay for them through their energy or utilities bill. For ESCs, the debt typically stays with the metre, meaning that if the building owner sells the building, the new building owner takes on the contract.
In the UK, consumers have the right to change energy suppliers at any time which conflicts with the ESC business case that involves long contracts between consumers and energy suppliers.

PROS	- Payments made on utility bills, so accessible for consumers. - Upfront cost paid for by the energy supplier. - Can be used for any energy efficiency improvements.
CONS	- Can create a conflict with other regulations, including the right to freely switch energy suppliers in the UK.

5.2.7. ESCO - Energy performance contracts (EPCs)

Energy performance contracts (EPCs) are an ESCO business model that focuses on the delivery of final energy services (i.e. maintaining heating/lighting levels) for a monthly/annual fee. For example, consumers can pay ESCOs a set fee to ensure their building is consistently heated. In an EPC such as this, the ESCO pays for the energy used and the energy efficiency improvements and is therefore incentivised to maximise savings as cost-effectively as possible.

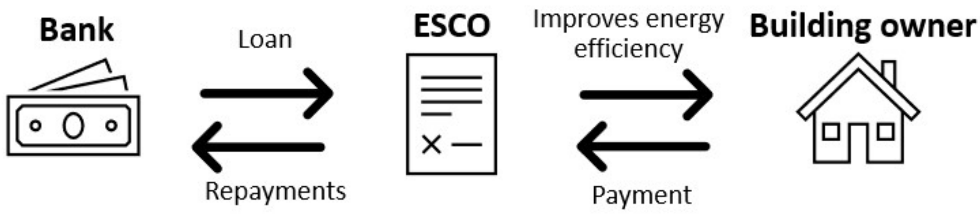
PROS	- ESCOs are incentivised to maximise energy efficiency with savings guarantees. - Can be used for any energy efficiency improvements.
CONS	- Low awareness of the business model and benefits can act as a barrier for ESCOs.

There are two primary business models for EPCs, shared savings and guaranteed savings. These models differ by which parties take the financial and performance risk. See below for an overview of these two business models and their relative merits:

5.2.8. Shared savings

In the shared savings EPC model, the ESCO takes out a loan from a financial institution or bank, which is used to make energy efficiency improvements to a client's building. The building owner repays the ESCO via a monthly/annual fee. The ESCO takes on the financial risk, which could be high if the building owner is less credit-worthy.

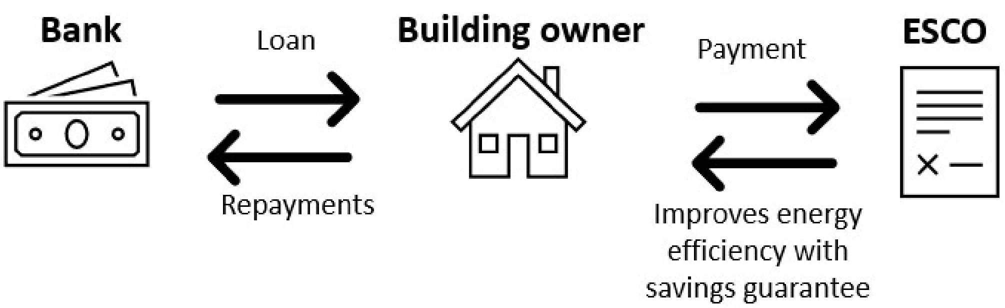
Contract lengths are typically 5 - 10 years.



5.2.9. Guaranteed savings

In the guaranteed savings model, the building owner takes out a loan from a financial institution or bank which is used to pay the ESCO. The ESCO provides energy efficiency improvements and also gives a savings guarantee, meaning that the maximum fee the ESCO charges must be less than the energy savings made by improvements implemented by the ESCO (the new energy cost compared to the approximate cost if the changes by the ESCO were not made).

Contracts are typically shorter than in the shared savings model, as financial risk is now with the building owner, but can be up to 20 years for larger measures.



Broadly, the two finance options for energy efficiency improvements are through a loan or facilitated by an ESCO. For loans, the energy efficiency improvements are selected by the building owner, often from an approved list of measures. This means that, without the support and expert opinion an ESCO can provide, the measures chosen are not always the most effective use of finance for energy efficiency.

ESCOs are experts in energy efficiency measures and are incentivised to maximise energy efficiency savings for minimum cost, sometimes through a savings guarantee. There are however barriers to the ESCO model, including low public awareness of their benefits, that can prevent them from having a wide impact. This means that ESCOs can struggle to generate profits unless a large number of contracts are won. This issue is avoided for larger ESCO business models.

Super ESCOs can offer more stable business models, particularly in markets without an established ESCO industry. These larger ESCO business models are particularly appropriate for building owners with a large building stock (e.g. social housing). Energy efficiency improvements can be made to an entire building stock as cost-effectively as possible, without the risk of the ESCO collapsing as super ESCOs are supported by governments and have financial certainty from their larger contracts.

5.3. Traditional financial instruments

In this subsection we discuss other financial instruments to the PPPs:

5.3.1. Grants and subsidies

Grants and subsidies, such as direct investment subsidies, are used by governments when optimal levels of investments cannot be fully provided by the market alone. They can partly contribute to overcoming the upfront cost barrier since they directly fill an immediate financial gap and, hence, enable a temporary shift in the market (Newell et al., 2019). For energy efficiency, grants and subsidies can also raise awareness and trust in EE projects, improve cash flow, and increase investors' access to debt finance (Bertoldi & Rezessy, 2010). These forms of support are usually included in policy mixes covering further fiscal and financial instruments such as feed-in tariffs and tax breaks (Polzin et al., 2019). Their main limitation, however, is budget restrictions as they are typically linked to public resources and can thus neither offer a sustainable solution nor support massive market uptake programs. Moreover, the effectiveness of a subsidy program can be difficult to assess because of rare monitoring processes of the share of free riders—beneficiaries that would have implemented their economically sound projects even without access to subsidies (Bertoldi & Rezessy, 2010).

Public grant programs are used in almost all member states to support EE projects (Economidou et al., 2018; Economidou & Bertoldi, 2014). In the EU, these are mostly used to reduce initial costs for the purchase and the installation of equipment, as well as provision of advice and certification services. More and more these schemes, however, support comprehensive renovations with energy performance criteria attached to them, rather than individual interventions. Examples include the Estonian energy renovation subsidy program supported through carbon emission trading funds between 2010 and 2014. This program was based on three main innovative pillars: The introduction of technical consultants for apartment associations to help make the correct decisions and steer a rather complex renovation process; the process review for a developed design by third-party experts to ensure the fulfilment of all technical requirements and the adequate quality of design documents; and the commissioning of ventilation requirements using measuring protocol (Kuusk & Kalamees, 2016).

5.3.2. Tax incentives

Taxation can be also a powerful tool to stimulate EE by giving incentives through tax exemptions, allowances, or benefits, and through incentive regimes related to, for example, capital gain tax, property tax, VAT, and accelerated or free depreciation. Tax benefits may be more effective than subsidies (McInerney & Bunn, 2019). Tax schemes directed toward energy renovations of buildings have been used in Denmark, Italy, among other EU countries. Eligible measures cover all intervention types in buildings: Envelope improvements, building technical systems, connection to district heating, renewable heat, and electricity generation systems.

Another form of tax allowance is the tax credit, whereby a percentage of the investment cost of approved technologies can be used to offset taxes. Italy has established tax credits as a policy to promote EE. Although being administered via income tax declaration, these have the effect of a direct grant. Tax schemes can have a positive impact on new, innovative technologies. By allowing for frequent updates of the eligible measure list, the schemes can promote the market introduction phase of new technologies if the innovative technologies are considered in the list (Ruijs & Vollebergh, 2013).

Differentiated VAT may encourage efficiency improvements, for example, it can be reduced on efficiency equipment and/or services. While, in certain circumstances, the owners might not be stimulated in refurbishing their homes because of property tax regimes. Swedish property tax is calculated upon five categories, including Energy Efficiency. Therefore, the property tax is higher for good performances of the property. In Italy, the "Ecobonus" scheme (Law no. 145 of December 31, 2018) allows a tax deduction up to 85% of the sustained EE costs (to be received in 10 years; Formisano, Vaiano, & Fabbrocino, 2019). Suggestion to include the EE in the fiscal policy are provided by several studies, as the one of Villca-Pozoa and Gonzales-Bustos (2019), who proposed two measures focused on a personal Income Tax (PIT) linked to improve energy rating of housing and on improved regulations for Real Estate Tax (RET) and Tax on Building.

5.3.3. Loans

Under this model, capital is given to building owners to make energy efficient improvements, often for pre-agreed equipment. Loans can be from banks, finance providers or equipment suppliers and can be secured against other assets. To access a loan, the business owner must be creditworthy, and take on both the financial risk of the investment as well as the performance risk of the energy efficiency improvements.

Energy efficiency loans can be more affordable for building owners than traditional loans, with interest-free or below-market interest loans available through equipment providers and government funded programmes. Loans are a simple business model to understand that consumers are already familiar with.

PROS	- Simple and accessible to building owners. - A widely known business case with minimal contractual complexity. - Loans can be secured against other assets (e.g. building), which can open access to larger loans or reduce interest rates. - Can be used for any energy efficiency improvement.
CONS	- Required building owner needs to be creditworthy. - Building owner takes on all equipment performance and financial risk. This means that there is often no incentive for the loan provider to maximise energy efficiency savings for the investment.

5.3.4. Asset-based financing

Asset-based financing is a business model that allows a building owner to take out a loan with contractual conditions based on the value of the energy efficiency asset, rather than the credit rating of the building owner. The loan can be secured by invoice financing, which allows the building owner to raise finance against outstanding payments it is owed (e.g. by tenants). Asset-based financing can be available through banks, finance providers and specialist companies, as well as through crowdfunding. This business model allows building owners with lower credit scores to access funding for energy efficiency improvements that would not otherwise be available.
Due to the increased financial risk to the loan provider, building owners with lower credit scores will be able to take on more debt than they would have with a traditional loan. Building owners also take on both the financial risk of the investment as well as the performance risk of the energy efficiency improvement.

As the energy efficiency improvements are secured against the assets, this type of financing is only available for assets that can be easily removed if needed (e.g. solar PV), not for those that cannot (e.g. insulation).

PROS	- Allows building owners with lower credit scores to access capital. - Easier to access than a loan and can have more flexible contractual terms.
CONS	- Cost of debt is typically higher than a traditional loan, especially compared to zero or low interest loans. - Funding available is usually lower than a traditional loan. - Not applicable for all energy efficiency measures, particularly if funding is secured against the asset. - Building owner takes on all equipment performance and financial risk. This means that there is often no incentive for the loan provider to maximise energy efficiency savings for the investment.

5.3.5. Hire purchase

Hire purchasing is a contractual agreement between the leasing company and a building owner. Assets are leased to a building owner for a set period of time, at the end of which ownership of the asset is transferred from the leasing company to the building owner.

Hire purchasing removes the upfront cost of assets, increasing accessibility to energy efficiency improvements. Building owners also take on both the financial risk of the investment as well as the performance risk of the energy efficiency improvement. During the rental agreement, the asset is owned by the leasing company, who therefore take on some performance risk during this period. In some countries, the rental payments can be tax deductible, improving the value of this business model.

As the energy efficiency improvements are secured against the assets, this type of financing is only available for assets that can be easily removed if needed (e.g. solar PV), but not for those that can not (e.g. insulation).

PROS	- No upfront capital cost for the building owner. - Rental payments can be considered deductible expenditure for tax in some countries.
CONS	- Asset is not owned by the building owner, so there is increased risk for the leasing company during the rental agreement. - Not applicable for all energy efficiency measures, particularly if funding is secured against the asset. - Building owner takes on financial and performance risk. This means that there is often no incentive for the loan provider to maximise energy efficiency savings for the investment.

5.3.6. Energy efficiency obligations (EEO)

The principle behind EEOs is that the obliged energy companies are required to prove that they have achieved energy savings with activities that promote or fund EE improvements in the premises of end-users. In 2017 the number of EEOs grew from five schemes to 16, because of the introduction of the EU Energy Efficiency Directive (EED) in 2012 (Rosenow & Bayer, 2017). EEOs mandated to different energy market actors have been used until today in Denmark, Italy, among other EU countries (Rosenow, 2012) and recently, According to Article 7 of the EED (Directive 2012/27/EU), in other MSs (Fawcett et al., 2019). After some unsuccessful trials, an EEO was also put in place in Poland (Fawcett et al., 2019). In some member states such as Italy, since energy-saving obligations are combined with tradable white certificates (WCs), the accredited parties (not just the obliged energy providers) can earn WCs which can be subsequently traded (Bertoldi et al., 2010; Bertoldi & Rezessy, 2008). EEOs deliver several economic, energy, environmental, and social benefits, such as reduction of energy consumption and GHG emissions, improvement of thermal comfort conditions, and air quality of indoor and outdoor spaces, bill savings, and reduction costs in transmission and distribution. Since EEOs schemes may often overestimate actual energy savings achieved (Moser, 2017), it is very difficult to accurately estimate cost and savings of EEOs in Europe (Rosenow & Bayer, 2017; Rosenow & Galvin, 2013).

Under an EEO, eligible measures for the building sector, which are delivered in advance by the monitoring and verifying authorities, may cover the building envelope, technical building systems, renewable heat, and electricity generation systems. To deliver their obligations, energy companies mainly establish contracts with third parties within the EE market such as insulation companies, retailers of appliances, manufacturers, and heating installers. Implementing an obligation on energy suppliers has the advantage of not placing a burden on the national budget as the obliged bodies can recover their costs via the consumers' energy bills or through regulated tariffs in the case of regulated distribution companies. As funding is not dependent on public expenditure, the schemes are not affected by any budget cuts.

5.3.7. Energy services agreement (ESA)

Like EPC, an ESA is a contract able to combine different EE measures giving a service to building owners that pay for through a charge based on realised energy savings without having to provide the upfront cost (Kim et al., 2012). Since, in the ESA model, payments are based on actual energy units saved, ESA providers give performance guarantees assuming the risk that expected savings will occur. The project developer then operates and maintains the EE measures during the term of the ESA, while the customer pays for the energy saved as a service. When the ESA contract ended, the project costs were paid, the building owners continued to pay reduced bills and energy savings became their profits. Sometimes, when the ESA provider pays a facility's energy bill and in turn bills the customer for the energy efficiency services this is known as "managed energy services agreement" or MESA. The advantage of ESAs is that they allow customers to finance these improvements "off-balance sheet" which can be useful for tax purposes or in cases where existing mortgages are attached to restrictive terms.

5.4. New Financial instruments

5.4.1. On-bill finance (OBF)

OBF lowers first-cost barriers by linking repayment of EE investments to the utility bill. Therefore, customers are able to pay back part or all costs of EE investments over time (Brown, 2009). It is an effective approach to address the split incentives barrier and can be, therefore, suitable for EE investments in multi-family or rented properties. The funds used to support these investments can originate from utilities, the state, or third parties including commercial banks. Energy savings accruing from the installed EE measures, must be large enough, so that the total post-renovation utility bill does not exceed the pre-renovation bill (Henderson, 2012). Given possible challenges that this type of instrument may pose on utility core business models as well as complex tendencies of energy efficiency markets, other policies need to complement this innovative financing mechanism (Mundaca & Kloke, 2018). On-bill loans and on-bill tariffs are the two categories on-bill finance programs can be categorised in. With lower interest rates than market-rate lending options, on-bill loans mainly differ from on-bill tariffs in the fact that the former must be paid off in case of ownership transfer, on-bill tariffs assign the obligation to the property/metre, hence, they allow for a transfer of the repayments to the next tenant or buyer and the treatment of the charge as part of the utility bill (Jewell, 2009).

5.4.2. One-stop shops (OSS)

One-stop shops (OSS) are independent, government-led, or industry-linked advisors that offer services that cover the whole or at least most of the renovation value chain. The specific mixture of their offer may change, but these include general awareness raising, assessment of the energy performance, organisation of the renovation project, technical assistance, or even implementation, structuring and provision of financial support (often from a third party), and the monitoring of savings (Boza-Kiss & Bertoldi, 2018).

The key benefit of working with OSSs is that through their services, they overcome many barriers related to residential building renovation. On one hand the OSS acts as an intermediary that simplifies the fragmented offer of renovation suppliers, for example, designers, suppliers, installers, financiers into a single offer to the homeowners (Balson et al., 2016). At the same time, an OSS helps the supply side of building renovation by mediating with the potential clients (Boza-Kiss & Bertoldi, 2018) using techniques such as organising offer packages, pooling the projects, organising the project, and so on. OSSs are well-placed to facilitate the implementation of locally developed projects and strong and trustworthy partnerships between homeowners, local actors (e.g., SMEs, financial institutions, energy agencies), and even local governments. These include most of the financing instruments discussed in this paper, such as national and local grants, commercial and preferential loans, EPC or EEO sources, and so on. The EuroPACE project under H2020 is testing property-tax based financing, too. A few OSS may be able to offer their own resources, too. Five out of 60 OSS around Europe offer their own financing for all or most projects, while four only sometimes. These OSSs employ EPC for homeowners, that is, provide a guarantee, linking their remuneration to the savings, and working together on the implementation of the project, too (Boza-Kiss & Bertoldi, 2018).

The European Commission has increased its interest in the OSS business model for residential buildings renovation, with OSS becoming a critical element of the “Smart financing for smart buildings” initiative (EU COM, 2016). The Directive 2018/844/EU, which amends the Directive 2010/31/EU on the Energy Performance of Buildings (EPBD) and Directive 2012/27/EU on Energy Efficiency (EED) also calls for OSSs as an element toward increased renovation of the European building sector.

BetterHome is a successful OSS in Denmark that offers predefined renovation packages to private homeowners. They rely partially on automated and customised services, allowing the future client to pre-inform the installers and pre-select the measures via the website and app. However, as a next step, the homeowner is in a direct and responsive relationship with the technical team. This allows tailoring of the exact package—as much the technical, as the financial terms—to the exact needs of the homeowner. BetterHome has local craftsmen that carry out the actual work, who get training and tools to ensure quality services, and BetterHome carries out promotion, quality assurance, monitoring, and in general, all customer care tasks. Over 200 projects were completed in 2016 and have been expanding since then (Boza-Kiss & Bertoldi, 2018).

5.4.3. Crowdfunding

A new form of financing that, using internet-based platforms, connects investors directly with borrowers (without involving other traditional financial organisations) is crowdfunding (Miller & Carriveau, 2018; Oxera, 2015). In the last few years, crowdfunding has become an alternative means of financing renewable energy projects (Dilger et al., 2017), playing a key role to finance the early stages of projects (Lam & Law, 2016). Crowdfunding can be categorised in four types depending on the funding purpose and investment method: Donation-based, Reward-based, that can be collectively referred as “community crowdfunding”, Equity-based, or Lending-based, that can be defined as financial return crowdfunding or investment crowdfunding.

In the European context, the CrowdFundRES[1] project promotes the use of crowdfunding for financing the acceleration of renewable energy growth. The CrowdFundRES project involves three main actors: renewable energy project developers, public actors interested in investing in projects, and crowdfunding platforms to link public and project developers (facilitating the financial transaction).

5.4.4. Non-profit provision of social and affordable housing

Non-profit provision is commonly used to provide affordable housing, particularly in Western Europe where a variety of institutions provide social rented housing. These include municipalities, public housing agencies and government-owned companies, charities, non-profit and limited-profit housing associations, community interest companies and cooperatives. These non-profit social housing providers use many different finance sources in differing combinations to support housing provision.

The capital cost of social housing provision shows that social housing providers may operate on a not-for-profit basis and have favourable tax status. Furthermore, equity funding is often used to fund new social housing developments. This is most often sourced from social landlords’ own reserves and grants from government, but sometimes from the private sector. Debt finance is usually the main source of capital funding for social house building or purchase, borrowed from banks, capital markets, pension funds, private investors, government lenders and non-profit lenders such as Sparkasse or household savings schemes. These borrowings are usually sourced from the private sector, meaning government equity contribution can help unlock significant additional private finance. Sometimes this is supported by provision of free land or land leased by the government or a specialist land-banking agency.

[1] http://www.crowdfundres.eu/

For governments and affordable housing promotion, non-profit housing provision has advantages over for-profit housing provision. It can be an important and stable source of housing supply and ensure that households unable to secure free-market housing get access. It can also ensure that health or social care support is provided in addition to housing. This shows that these benefits arise from non-profit agencies not extracting profit from housing but reinvesting any surplus in the new housing provision or improved tenant services. Therefore, over the long term, non-profit social housing provision can provide a cheaper source of housing than for-profit housing providers which must generate profit to pay shareholders. Promoting affordability and providing long-term secure housing is the main mission of most non-profit social housing providers. Many are stakeholder organisations, with a strong community and resident focus, so they manage and grow their housing assets to serve a community purpose and address local housing needs.

Despite these advantages, since the 1980s, the financial model of non-profit housing providers has been undermined in several countries – for example, public funding cuts have reduced new housing production. A recent EU report revealed a EUR 7 billion annual investment gap in social and affordable housing in member states - investment in this sector must increase by 25% to address well evidenced housing needs. Privatisation has limited non-profit housing providers' opportunity to reinvest surpluses in new housing. For instance, sale of social housing to tenants at below market value in Ireland has reduced the size of the social housing sector because replacements must be procured at full current market prices. In England, United Kingdom, recent legislation allows for profit housing providers to provide social housing and benefit from subsidies previously available only to social landlords such as provision of land and dwellings at below cost via the land use planning system.

This limits subsidised land and dwellings available to non-profit social housing providers, potentially undermining their financial model. Government capital subsidies for social house building have also been reduced in many countries and only partially replaced with revenue subsidies which has reduced new social housing output However, it also important that governments and regulators monitor social housing landlords to ensure they are financially secure, managing in the best interest of tenants and those in need of social housing, and that surpluses are reinvested to protect these interests. Some social housing landlords in European countries have become insolvent, and housing rents have increased and excluded lower income groups. In some countries, maintenance under-investment has led to dwellings becoming so run down they have been demolished.

Denmark

In Denmark social housing is a central part of Danish welfare society. It is non-profit and universal, to maintain a wide-spectrum tenant social mix for individual and societal benefit. Its main purpose is to deliver affordable housing for all in need. Today almost 1 million people in Denmark live in the social and affordable housing sector, that is, one in six people and 600,000 housing units and the share of social housing provided per person is growing.

The National Building Fund (LBF) is a cornerstone of the Danish affordable and social housing model, ensuring a high housing stock standard and better tenant well-being. It also plays a role in countercyclical efforts, such as the COVID-19 recovery stimulus. LBF was established in 1967 and is financed by tenant rents from the social and affordable housing provided by non-profit housing organisations.

When mortgage loans for dwelling construction have been repaid, tenants pay rents at the same level, with the extra going into the LBF as a saving. This fund finances the expansion of new affordable and social housing and renovation of existing properties. This includes improvements of both inside and outdoor areas, modernization of buildings to include access for elderly and disabled people, and energy improvements. The fund is also able to finance the demolition cost in vulnerable social housing areas, and to support infrastructural changes.

LBF provides a useful mechanism to ensure self-financing in the social and affordable housing sector. Savings are recycled to help maintain and improve dwellings and provide additional housing. It thereby provides a sealed finance circuit, reducing government need to reinvest in new social housing, and facilitates long-term planning for social housing funding. It also helps to even out variations in the financial strength of different social housing providers, in the costs of developing different estates, and thereby in rents charged which reflect development costs.

The purpose of the Fund is to build socially cohesive, safe, and sustainable communities. A particular focus is investments in social activities and rental price reductions. Efforts are organised in local partnerships such as schools, municipalities or NGOs, aiming to promote tenant employment opportunities and educational performance.

The Fund is managed by a nine-member board, including representatives of housing organisations, tenants and the two largest municipalities in Denmark. However, its budget must be approved by the housing minister. The Danish government wants LBF to increase investments in energy-efficiency renovations, to play a key role in meeting climate goals and post-COVID-19 economic recovery.

Case Study of AlmenBolig+ 2014:
This project, Tenant owned non-profit housing, of Almenbolig is a new type of not-for-profit affordable housing commissioned and managed by the tenant owned non-profit housing manager KAB. The project sprang from Lord Mayor Ritt Bjerregaard's promise of creating 5000 new houses for the working-class families in Copenhagen for whom the city's housing prices had become untenable.

One of the advantages of this project is creating affordable housing, as the development offers a 23% less rent than other non-profit housing projects. This was made possible by focusing on energy optimization and replacing traditional costly crafting methods with pre-fad units. The sustainable construction system is not only cheaper than conventional concrete structures, but it has also cut resource consumption in half.

Slovenia

The Housing Fund of the Republic of Slovenia is a public real estate fund. It was founded in 1991 to finance and implement a legislated national housing programme which operates on five-year cycles.

The objectives and specific targets of the Fund have evolved, but remain focused on the construction, renovation and maintenance of apartments and residential buildings, targeted at groups with particular needs such as families, young people, the elderly, and low-income populations. The main instruments used to achieve this have involved co-financing with long-term favourable loans and interest rate subsidies, and investments in new innovations and international research.

The Housing Fund is a public authority and actively invests directly in housing and also co-invests in local community housing programmes, complementing the efforts of municipalities and non-government organisations. It also purchases land and houses directly on the market. Since 2006, non-profit dwellings regulated under the Housing Act have been let at relatively regulated low rents. Consequently, they are in high demand among prospective tenants, but have proven less attractive to investors. With its own construction and purchase projects on the market, the Fund provides an additional quota of publicly available rental housing, tying rent calculation to the real estate investment or purchase value. It offers eligible tenants a stable rental relationship under pre-set conditions for an indefinite period. In 2019 CEIB provided the Fund with a long-term loan of EUR 50 million.

Currently the Fund directly owns 3,042 non-profit rental housing units and a further 787 dwellings which are let at cost-based rents. Two companies owned by the fund own another 2,056 apartments, which they rent out at non-profit rent. These dwellings are located throughout Slovenia. The Fund is intensively building affordable rental apartments throughout Slovenia, and by 2023 it will provide 2,194 new public rental apartments.

The Fund is now focusing on effective administration for public rental dwellings. Thus, between 2017 and 2020, its activities have included; Co-investment in new public rental housing units, including residential units, under a co-financing programme; Establishment and operation of the Public Service for Rental Management and Records system; Management of mixed portfolio of formerly non-profit, commercial, and sheltered housing; Providing new public rental housing units for young people, young families and the elderly, the utilisation of rental buying-in and shared ownership instruments; Development of new projects on land owned by the Fund; Financial incentives for housing in the form of soft loans; Sustainable construction and complete renovation of the housing stock for all products and programmes of the Fund; Technical standards for the home-building industry; Cooperation in development projects in housing construction; Strengthening and implementing the Fund's development role in housing; Efforts to obtain funding from EU funds; Acquiring assets for and in the framework of partner projects.

Case study of Novo brdo, Ljubljana:

The Novo Brdo neighbourhood project, which also marks the Housing Fund's 30th anniversary, was carried out in cooperation with the Ljubljana Municipality and is the largest among the projects that recently provided a total of 1,887 new housing units. Located in the south-western part of the city, it is set to become one of Ljubljana's largest neighbourhoods, where 498 vulnerable families and individuals are to be housed. According to Črtomir Remec, the director of Slovenia's Housing Fund, the Novo Brdo estate is "the second part of a trilogy of investments" made possible by a EUR 50 million loan from the Council of Europe Development Bank.

Italy

The introduction of Social Home led to a shift in housing policies and impacted the definition of social housing too. It extended the boundaries of the social rental market by allowing private developers to build social rental housing on private land with the purpose of supporting investments in this sector through the provision of government incentives such as tax exemptions and land-use concessions.

In 2009, the national government approved the ‘*Piano Nazionale per l’Edilizia abitativa*’ (National Social Housing Plan), establishing the ‘*Integrated System of Funds*’ (SIF), which enabled a structured financial solution to the national need for low-rent homes.

The SIF set up the activation of the *’Fondo di Investimenti per l’Abitare*’ (FIA, Investment Fund for Housing) nationwide, which made €2bn available and generated the establishment of a number of local ethical funds. The local funds have then engaged in several social and affordable housing projects, each promoted and supported by local actors committed to advance the public interest, such as local councils, banking foundations, housing providers, social enterprises, non-profit organisations and estate operators. As of December 2016, there were 31 approved local funds spread throughout Italy with nine different local asset management companies. They have the potential to execute more than 270 housing-related projects, including community and neighbourhood services.

Currently, innovative solutions for structuring, financing, constructing and managing social and affordable housing initiatives that are economically sustainable and not dependent on grants. These new models have not only opened the social rental sector to private and public/private investments but have also provided a new and meaningful picture of how a virtuous intersection of the three crucial policy dimensions – housing, urban and social policies – can help redraw the boundaries of local welfare. The model’s main novelty consists in the synergy of three innovative elements: the ethical real estate fund, the **PPP** and the collaborative governance model established in the new housing settlements. The **PPP** is the one that fits best to what many observers have started to point out as a ‘renaissance of the collective’, a paradigm shift in social values produced in reaction to the global real estate and financial crisis’ impact on everyday life.

Case study of Cenni di Cambiamento:

Cenni di Cambiamento is the most important social and collaborative housing project ever built in Italy within the SIF. It hosts 122 social and affordable homes, rented out to mostly young people with different incomes. There are residential services for people with special needs, common spaces for tenants, public spaces for the neighbourhood as well as shops. Despite being inhabited only from

2013, it already has a long record of accomplishments. Furthermore, being the first project realised within the SIF, it has been widely recognised as a leading project of what is considered a new season of social and affordable housing in Italy.

6. Methodology for financial evaluation

6.1. SUPER-i energy savings model

This evaluation methodology presents the proposed SUPER-i energy savings model for evaluating energy efficiency renovations in buildings, with a focus on the operational aspects of the model. This methodology involves comprehensive calculations and procedures to accurately assess various factors influencing energy consumption and potential savings. The model's operation is structured around several key components, each of which plays a crucial role in computing energy demands and estimating potential savings:

1. **Heat Loss/Gain Calculation**: The model starts by quantifying the hourly heat loss or gain per unit temperature difference between the building and its surroundings. This calculation is based on a predefined comfort range (typically set between 15.5°C to 22°C) and takes into account regional variations in thermal comfort expectations. The formula used for this calculation is:

$$\Theta_{building} = U_{walls}A_{walls} + U_{windows}A_{windows} + U_{floor}A_{floor} + U_{roof}A_{roof}$$
$$\Delta Q = \Theta_{building} \cdot \Delta T$$

   Here, ΔQ represents the total heat loss or gain per unit time, $\Theta_{building}$ denotes the total heat loss or gain per degree of external temperature difference, and ΔT signifies the difference between the internal and external temperatures.

2. **Solar Gains Incorporation**: Solar gains, influenced by various building characteristics such as colour, material, orientation, and geometry, are integrated into the model. Although challenges may arise in obtaining relevant data from project pipelines, efforts are made to incorporate solar gains into the calculations wherever possible.

3. **Minimum Specification Consideration:** Collaboration with housing authorities (HAs) establishes minimum building specifications necessary for accurate calculations. These specifications include dimensions, orientation, glazed fraction, and materials. In cases where user-provided data are lacking, representative values are employed to ensure the continuity of the analysis.

4. **U-Value Integration:** Understanding the thermal performance of building materials and their respective U-values is essential. The model utilises these values to determine the rate of heat transfer across different building components. By summing up the heat transfer coefficients weighted by their respective areas, the total heat loss or gain per unit time is computed.

5. **Model Implementation:** The model is implemented using three primary data classes: BuildingGeometry, Location, and Building. These classes facilitate various calculations related to

building characteristics, location-specific data retrieval, and considerations regarding heating technology.

6. **Output Calculation:** Output calculations involve determining hourly heating and cooling demands while considering factors such as fuel cost and emissions. Time-resolved data enable precise estimations of energy demand variations over time, allowing for a comprehensive analysis of energy consumption patterns.

7. **Validation and Calibration:** Model validation entails comparing the model's estimates with real-world energy use data, considering factors such as occupancy patterns and heating system controls. The coefficient (c) quantifies the deviation between real and model-predicted space heating demands, thereby providing insights into the model's accuracy and reliability.

In summary, the model's operation involves a systematic approach to compute energy demands, estimate potential savings, and validate the results against real-world data. By leveraging advanced computational techniques and considering various factors influencing energy consumption, the model provides valuable insights into the effectiveness of energy efficiency renovations in buildings.

6.2. Financial analysis of the investment gap

The evaluation methodology adopted to perform a comprehensive financial analysis of the investment gap between the financial needs of implementing the EE renovations and the currently available funding sources is structured as follows:

1. **Data Collection:**
    - *Financial Data Gathering*: Collect detailed financial information related to energy efficiency renovation projects in social housing buildings across Italy, Slovenia, and Denmark. This includes data on investment costs, funding sources, operating expenses, and projected revenues.
    - *Investment Needs Analysis:* Conduct a comprehensive analysis to determine the specific investment requirements for energy efficiency renovations in social housing buildings. This involves assessing costs associated with materials, labour, technology upgrades, and any additional expenses incurred during the renovation process.
    - *Funding Sources Identification:* Identify and document available funding sources at both the EU and national levels. This includes grants, subsidies, loans, and other financial instruments aimed at supporting energy efficiency initiatives in the housing sector.
2. **Categorization of Investment Needs:**
    - *Sectoral Categorization*: Categorise investment needs based on different aspects requiring funding, such as building retrofitting, energy system upgrades, infrastructure improvements, and sustainable transportation initiatives.
    - *Quantification of Investment Needs*: Quantify the investment needs for each sector by estimating the total financial requirement for energy efficiency renovations in social housing

buildings. This involves conducting cost-benefit analyses and feasibility studies to determine the scope and scale of investment needed in each area.

3. **Assessment of Available Funding:**
   - *EU-Level Funding Analysis*: Assess available funding from EU initiatives and programs supporting energy efficiency projects. This includes analysing funding mechanisms such as the Cohesion Fund, Next Generation EU, and Horizon Europe to determine the amount of financial support allocated to the housing sector.
   - *National Funding Evaluation:* Evaluate funding provided by national governments and local authorities for energy efficiency initiatives. This involves reviewing budget allocations, grant programs, and incentives aimed at promoting energy-saving measures in social housing buildings.
4. **Calculation of Financial Gap:**
   - *Financial Gap Determination*: Calculate the financial gap by subtracting the total investment needs from the available funding. This involves comparing the projected costs of energy efficiency renovations with the amount of funding allocated to support these initiatives.
   - *Magnitude Assessment*: Assess the magnitude of the financial shortfall to understand the extent of the gap in financing energy efficiency renovations in social housing buildings. This involves quantifying the difference between required funding and available resources.
5. **Strategic Planning and Collaboration:**
   - *Strategy Development*: Develop strategies to address the identified financial gap and optimise resource utilisation. This includes exploring alternative funding sources, and implementing cost-saving measures to maximise the impact of available resources.
   - *Stakeholder Engagement:* Foster collaboration between EU institutions, national governments, local authorities, housing associations, and other stakeholders to coordinate efforts and mobilise support for energy efficiency initiatives. This involves facilitating dialogue, sharing best practices, and leveraging collective expertise to achieve common goals.
6. **Monitoring and Evaluation:**
   - *Progress Tracking:* Establish mechanisms for monitoring and evaluating progress in reducing the financial gap and implementing energy efficiency projects. This involves setting key performance indicators (KPIs) and tracking project milestones.
   - *Impact Assessment:* Assess the impact of funding allocation and resource utilisation on energy savings, cost reductions, and environmental benefits. This involves conducting regular evaluations to determine the effectiveness of financial gap reduction efforts and identify areas for improvement.

6.3. Financial analysis of innovative funding solutions

6.3.1. Modelling of energy prices

To conduct the proposed evaluation methodology examining the financial implications of implementing the SUPER-i proposed energy efficiency (EE) renovations, we undertake simulations of natural gas prices over the next 25 years, encompassing three scenarios: a worst-case scenario (with high natural gas prices), a neutral scenario (with stable natural gas prices), and a best-case scenario (with low natural gas prices). The simulation methodology adopted in the SUPER-i project utilises the Monte Carlo simulation approach, employing the GARCH-MIDAS model developed by Engle et al. (2013). This model enables the modelling of high-frequency datasets (daily) using macro and microeconomic variables observed at lower frequencies (monthly, quarterly, semi-annually, etc.).

The SUPER-i simulation method is executed as follows:

1. We collect daily natural gas prices spanning the last 25 years (from January 1, 1999, to January 31, 2024).
2. Monthly data on inflation rates, economic uncertainty indices, and global production of natural gas indices for the same period (January 1999 to January 2024) are obtained.
3. The natural gas price is modelled using the GARCH-MIDAS model, with macroeconomic indicators serving as independent variables.
4. Utilising the fitted GARCH-MIDAS model for natural gas prices over the period 1999-2024, we conduct an out-of-sample analysis to estimate future natural gas prices for the period 2024-2048.
5. The average of simulated future natural gas prices for the period 2024-2048 is calculated.
6. Steps 3-5 are repeated three times for each scenario:
    - Worst-case Scenario: Rapid increases in inflation rates and economic policy uncertainty, especially during periods of global economic crisis (such as the Enron crisis, Middle East conflicts, Financial crisis, COVID-19, and recent energy crises in the EU), are considered.
    - Neutral Case Scenario: Stable inflation rates and economic policy uncertainty levels are assumed, with equal multipliers applied to both economic distress and boom periods.
    - Best-case Scenario: Stable or decreasing inflation rates and economic policy uncertainty are anticipated over the next 25 years, with higher multipliers assigned to periods of global economic boom or increasing growth rates.

6.3.2. Financial analysis of PPP funding contracts

In the SUPER-i project we develop a comprehensive financial and statistical analysis for the major PPP financing schemes available in Europe to fund energy efficiency renovation projects in Italy, Slovenia and Denmark.

1. Using a developed energy saving model, we model the expected energy savings from each proposed intervention for each building (shown in subsection 6.1).

2. Using the GARCH-MIDAS model, we simulate future values for:

    - Energy market bid price (as shown in subsection 6.3.1)

- Inflation rate
- Interest rate on debt
- Property value growth rate
- Rent growth rate
- Default rate on rent
- Corporate taxes

3. Using the simulated inflation rate and interest rate on debt variables, we obtain the continuous discount rate:

$$real\ interest\ rate_t = \frac{(1+interest\ rate\ on\ debt_t)}{(1+inflation\ rate_t)} - 1$$

$$Continuous\ discount\ rate = exp^{\{-\ real\ interest\ rate_{t}*\ T\}}$$

where T is the expected lifetime of the EE interventions.

4. Using the energy savings model findings, the simulated financial variables, and the continuous discount rate we analyse the financial impact of the interventions for each building separately. Using:

- *Return on Investment (ROI):*

$$ROI_t = \frac{Net\ cash\ flow_t}{investment\ cost_t}$$

- *Net Cash Flow (NCF):*

Step1: We calculate the Cash inflow of the project for each involved party in the PPP funding scheme:

$$Cash\ Inflow_t = \frac{revenue\ from\ rent_t + growth\ from\ increased\ building\ value_t + Profitshare\ from\ energy\ savings_t}{(1+\ discount\ rate)^t}$$

where then $Profit\ share\ from\ energy\ savings$ is changing according to the characteristics of each PPP funding scheme for more information refer to section 3 of the deliverable.

Step 2: We calculate the Cash outflow of the project as follows:

$$Cash\ Outflow_t = \frac{Operating\ cost_t + maintenance\ cost_t + cos\ \ of\ running\ EE\ technologies}{(1+discount\ rate)^t}$$

where the cost of running EE technologies is covered by a specific party depending on the PPP funding scheme.

Step 3: Net cash flow is given by:

$$Net\ Cash\ flow_t\ =\ Cash\ in\ flow_t\ -\ Cash\ out\ flow_t$$

<u>*Risk adjusted extra return*</u> is given by:

$$Risk\ adjusted\ extra\ return\ =\ \frac{E(ROI)\ -\ Risk\ free\ rate}{\sigma_{ROI}}$$

where $E(ROI)$ is the expected value of ROI which is approximated by the sample average, σ_{ROI} is the standard deviation of the ROI, which is obtained by taking the square root of the variance of ROI's, where the variance is given by:

$$variance(ROI) = E[(ROI -\ E(ROI))^2]$$

The table below reports the ranking approach for risk adjusted extra returns.

Ranking for risk adjusted extra returns (RP)		
0.75 < RP < 0.95	5	reasonable
0.95 < RP < 1.5	6	very reasonable
1.5 < RP< 2	7	good
2 < RP < 3	8	very good
RP > 3	9	excellent

5. Compare the findings against investing in the benchmark (S&P500 index).
6. We rank the funding solutions based on the Risk adjusted extra returns.

7. Conclusions

Financial instruments play a crucial role in facilitating the implementation of energy efficiency (EE) projects, particularly in the context of Public-Private Partnerships (PPP). PPPs provide a framework for collaboration between the public and private sectors, aligning government service delivery objectives with the profit motives of private partners. While PPPs offer various benefits such as efficient resource management, timely project implementation, and risk-sharing, they also come with drawbacks, including potentially higher costs and longer procurement procedures. Within the realm of PPP financing mechanisms, various tools aim to address challenges in funding EE projects. Dedicated Credit Lines (DCL) leverage funds from government or international financial institutions to encourage private financial institutions to invest in EE projects. Risk-sharing facilities (RSF) mitigate perceived risks associated with EE projects, encouraging increased lending by private-sector institutions. Energy Saving Performance Contracts (ESPC) and chauffage contracts offer avenues for public agencies to collaborate with Energy Service Companies (ESCOs), providing financing for EE projects with a focus on performance-based agreements. The introduction of Super ESCOs, backed by governments and capable of coordinating large-scale EE projects, addresses some challenges faced by independent ESCOs, such as difficulty in generating contracts and obtaining financing. ESCOs, despite their expertise in energy efficiency improvements, face hurdles in raising awareness and standardising practices in some countries, hindering their growth. Different business models for ESCOs, including Energy Supply Contracts (ESCs) and Energy Performance Contracts (EPCs) with shared or guaranteed savings, offer flexibility in project financing. ESCOs, driven by incentives to maximise energy efficiency savings, provide valuable expertise. However, challenges like low awareness and inconsistent standards can impede their widespread adoption. Furthermore, the traditional and innovative funding methods play pivotal roles in promoting energy efficiency. Traditional tools like grants, subsidies, and tax incentives address upfront costs but face challenges like budget restrictions and assessment difficulties. Loans, asset-based financing, and hire purchase provide accessible funding but involve creditworthiness considerations and risks for building owners. Energy efficiency obligations demonstrate benefits but struggle with accurate cost and savings estimations. Among new financial instruments, on-bill finance effectively tackles split incentives, while one-stop shops simplify the renovation process and facilitate partnerships. Crowdfunding emerges as an innovative means for financing renewable energy projects, and non-profit provision of social housing proves valuable despite challenges such as funding cuts and privatisation.

The SUPER-i evaluation methodology to analyse the economic feasibility of EE refurbishment projects in social housing buildings involves analysing the PPP initiatives in Italy, Denmark, and Slovenia using the **discounted cash flow method, net present value approach, return on investment approach, and cost-benefit approach**. This methodology is aligned with established practices in investment appraisal and property valuation, emphasising the importance of factors such as discount rates, net present value, and internal rate of return. The analysis acknowledges inherent uncertainties and risks, emphasising the reliable projection of cash flows and the estimation of discount rates. Ultimately, this rigorous methodology and evaluation framework provide insights into the financial implications of energy efficiency measures within PPP initiatives. It contributes to understanding the economic viability, profitability, and the financial weight of energy efficiency in the context of social housing, facilitating informed decision-making for future projects.

In summary, as the world seeks sustainable solutions for energy consumption, the effective use of financial instruments and collaborative models like PPPs are crucial for overcoming barriers in implementing EE projects. Addressing challenges and enhancing awareness are essential for realising the full potential of these financial mechanisms and achieving significant strides in energy efficiency.

8. Acronyms

DCF: Cash Flow method
DCL: Dedicated Credit Lines
EE: Energy Efficiency
EED: Energy Efficiency Directive
EEO: Energy Efficiency Obligations
EPBD: Energy Performance of Buildings Directive
EPCs: Energy Performance Contracts
ESA: Energy Services Agreement
ESCOs: Energy Services Companies
ESCs: Energy Supply Contracts
ESPC: Energy Saving Performance Contracts
EU: European Union
FIA: Investment Fund for Housing
GHG: Greenhouse Gas
IEA: International Energy Agency
IFIs: International Financial Institutions
LBF: National Building Fund
LFIs: Large Financial Institution
MESA: Managed Energy Services Agreement
NGOs: Non-governmental organisations
NPV: Net Present Value
OBF: On-Bill Finance
OSS: One-Stop Shops
PPP: Public-Private Partnership
ROI: Return on Investment
RSF: Risk-Sharing Facilities
SIF: Integrated System of Funds
SMEs: Small and Medium Enterprises
VAT: Value-Added Tax
WCs: White Certificates

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