TRIPLE-A

Enhancing at an Early Stage the Investment Value Chain of Energy Efficiency Projects

Deliverable 3.2: Final Report on Risks of Energy Efficiency Financing and Mitigation Strategies Typology

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Preface

Triple-A has a very practical result-oriented approach, seeking to answer three questions:

- How to ***assess*** the financing instruments and risks an early stage?
- How to ***agree*** on the Triple-A investments, based on selected key performance indicators?
- How to ***assign*** the identified investment ideas with possible financing schemes?

The Triple-A scheme comprises three critical steps:

- ***Step 1 - Assess:*** Based on Member States (MS) risk profiles and mitigation policies, including a Web-based database, enabling national and sectoral comparability, market maturity identification, good practices experiences exchange, reducing thus uncertainty for investors.
- ***Step 2 - Agree:*** Based on standardised Triple-A tools, efficient benchmarks, and guidelines, translated in consortium partners' languages, accelerating and scaling up investments.
- ***Step 3 - Assign:*** Based on in-country demonstrations, replicability and overall exploitation, including recommendations on realistic and feasible investments in the national and sectoral context, as well as on short- and medium-term financing.

Who We Are

	Participant Name	Short Name	Country Code	Logo
1	National Technical University of Athens	NTUA	GR	EPU NTUA
2	ABN AMRO Bank N.V.	ABN AMRO	NL	ABN·AMRO
3	Institute for European Energy and Climate Policy Stichting	IEECP	NL	IEECP
4	JRC Capital Management Consultancy & Research GmbH	JRC	DE	jrc CAPITAL MANAGEMENT
5	GFT Italy srl	GFT Italy	IT	GFT
6	CREARA Consulting SL	CREARA	ES	creara
7	Adelphi Research Gemeinnützige GMBH	adelphi	DE	adelphi
8	Piraeus Bank SA	PB	GR	
9	University of Piraeus Research Center	UPRC	GR	TEESlab University of Piraeus Research Center
10	SEVEn, The Energy Efficiency Center	SEVEn	CZ	SEVEn
11	Public Investment Development Agency	VIPA	LT	VIPA
12	National Trust Ecofund	NTEF	BG	NATIONAL TRUST ECO FUND

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Executive Summary

An Energy Efficiency (EE) target of at least 32.5%, according to projections made in 2007 for the energy consumption, has been set in the European Union (EU) by 2030. Therefore, the EU Member States (MS) should adopt EE measures (EEMs) to reduce their annual energy consumption by about 4.4% until 2030. To achieve these targets, significant investments in EE projects have to be implemented. In particular, €1 trillion is planned to be mobilized for implementing sustainable energy investments during the current decade via the EU budget and related instruments.

However, the heterogeneity and the immaturity of the EE market are significant barriers for financial institutions (FIs) to enter the market, although EE projects are considered profitable. These projects tend to never get financed, even though there are plenty of project developers that are seeking funding for green development. This can be attributed to two main reasons. On the one hand, project developers often lack the expertise or resources to make a convincing financing case for investors. On the other hand, private investors suffer from the absence of knowledge on the way project developers implement their projects.

The proposed Triple-A scheme could assist in making EE investments transparent, predictable, and attractive for investors and financiers, by reducing uncertainty through the assessment of the relevant risks that could possibly emerge at an early stage of a project preselection/pre-evaluation.

In this context, the current report aims to identify the main EE sectors, project categories, as well as the main risks and barriers that affect the successful implementation of EE projects and their ability to get financed. It focuses on the financial bodies' perspective and on the development phase, where numerous EE project ideas and available capital to realize these projects exist. Moreover, it aims to cover the gaps identified in EE and sustainable financing and propose an approach for assessing the risks in EE investments. Finally, the key risk mitigation strategies for reducing the different types of risks, the main financing instruments, and financing programs for implementing EE investments are presented.

To identify the main risks existent in EE investments, a literature review in EU Taxonomy, EU sustainable financing, and other EE financing projects, scientific papers and working documents from key players of the financing sector, such as World Bank, Deloitte, ADBI, etc. was implemented. Risks reported by similar EE financing projects and studies, focusing on assessing the risks of EE projects, were highly considered. The rest of collected risks were subsequently filtered and classified into categories by evaluating them on the following set of criteria: (i) frequency of occurrence, (ii) minimization of overlaps, (iii) capacity to be quantified. Moreover, literature reviews were conducted for risk mitigation strategies with reference to the identified risks, financing instruments, and financing programs.

The key findings can be summarized into the following points.

- <u>Sectors</u>: The identified sectors in EE projects are: (i) Buildings, (ii) Manufacturing, (iii) Transportation, (iv) District energy networks, and (v) Outdoor lighting.
- <u>EE Project Categories</u>: The main EE project categories emerged are: (i) Building envelope retrofits, (ii) HVAC&R retrofits, (iii) Lighting appliances' retrofits, (iv) Automatic control retrofits, (v) Renewable energy sources (RES) installations, (vi) Construction of new buildings, (vii) Manufacturing-specific retrofits, (viii) Purchase of new vehicles, (ix) District energy networks retrofits/ expansion, and (x) Outdoor Lighting retrofits.
- <u>Risk categories</u>: The most referenced risk categories are: (i) Economic, (ii) Market, (iii) Behavioural, (iv) Regulatory, and (v) Organizational.

- Risk factors: The risk factors derived from the analysis, along with the respective category that they belong to, are: “Financial”: creditworthiness of the borrower, “Behavioural”: rebound effect, “Energy market & Regulatory”: energy prices and taxes volatility, request for issuing project permits, “Economic”: weak economic environment, “Technological, Planning and Operational”: technical complexity, low quality of initial savings assessment, implementation of low-quality equipment or poor project design, inadequate operation and maintenance (O&M). Risk factors can be classified into (i) borrower-specific (creditworthiness of the borrower), (ii) sector and project-category specific (rebound effect, technical complexity), (iii) country-specific (energy prices and taxes volatility, request for issuing project permits, weak economic environment), and (iv) project-specific (low quality of initial savings assessment, implementation of low-quality equipment or poor project design, inadequate O&M).
- Key Barriers: Access to capital and split incentives were identified as the most important barriers to the successful implementation of EE projects. Policy measures (e.g., financial incentives and tax credits) are considered as best practices for addressing access to capital, while for split incentives, regulatory measures (e.g., minimum performance standards) and financial mechanisms (e.g., financial and fiscal incentives) are recommended.
- Risk mitigation strategies: The key mitigation strategies arisen per each identified risk category are: (i) “Financial”: a careful study of the creditworthiness of the borrower, collaterals etc., (ii) “Behavioural”: consuming more efficiently, consuming differently, and consuming less , (iii) “Energy market & Regulatory”: hedging (forward contracts, future contracts, swaps, option contracts), fixed-price contracts etc., (iv) “Economic”: hedging (forward contracts, future contracts, swaps, option contracts), long term fixed interest rates etc., (v) “Technological, Planning and Operational”: energy savings guarantees or insurances, performance bonds or insurances etc.
- Financing instruments: The main financing instruments derived include debt-based financing (i.e., loans, bonds, leasing agreements, guarantees), equity-based financing, grants/subsidies, project financing, project aggregation, and EE auctions.
- Financing programs/models: The key financing programs are composed of energy service contracts (i.e., energy performance contracting and efficiency-as-a-service), third-party financing, soft loans, on-bill financing, property assessed clean energy, EE mortgages, crowdfunding, and cooperatives.

Results indicate that there are various risks which could affect the successful implementation and financing of an EE project. On the other hand, there is a clearer view of the main barriers to the successful implementation of EE projects. Various risk mitigation techniques are proposed by literature as a means of avoiding, reducing, transferring, and absorbing risk. The implementation of the Triple-A scheme will facilitate investors, financiers, and project developers to make use of the aforementioned risk mitigation strategies, so as to derisk EE investments. Additionally, there are several alternatives regarding the selection of a financing instrument or program, thus choosing the appropriate one can be critical for the success of the suggested EE investment.

This report is the final version of the previous deliverable D3.1: Draft Report on Risks of Energy Efficiency Financing and Mitigation Strategies Typology. The results of this report are used as direct input to Task 4.1: Standardized Triple-A Tools and Task 3.2: Assessment of Member States Risk Profiles, and they have been stored in the database developed under Task 3.3: Interactive Web-Based Database on Triple-A Investment. With regards to Task 4.1, in the Triple-A Standardized Tools, the EE investments from Task 5.1: Pipeline of Energy Efficiency financially attractive projects will be filtered by examining their compliance with the EU Taxonomy based on the identified sectors of this report. Furthermore, the total risk of these investments will be calculated based on the risk factors and categories arisen by this report and each project will be matched to specific mitigation strategies based on the ones identified on this report. With reference to Task 3.2., the risk of each case study country will be evaluated based on the country specific risk factors emerging from this report.

1 Introduction

1.1 Background

Energy Efficiency (EE) is one of the most cost-effective ways to deal with climate change and reduce its multi-level impacts [1]. Nowadays, EE has become a topic of interest due to the progressive reduction of the planet's natural resources and the severe global impact of their overuse. Governments around the world should deal with these issues and sustain the global economy [2].

In this context, G20 countries recognized EE as one of the most critical factors to stimulate sustainable economic growth in an increasingly resource confined planet [3]. However, towards the improvement of EE and the implementation of EE Measures (EEMs), the financing of EE project ideas and initiatives is considered vital.

To that end, the International Energy Agency (IEA) suggests that, by 2035, investments in EE need to approximate half of all the global energy investments so that the target "under the two-degree limit" will be reached [4]. In the same context, EE financing is an integral part of the International Finance Corporation's (IFC) focus on environmental sustainability and climate change [5].

All things considered, innovative financing mechanisms need to be put in place for unlocking the significant EE potential and overcoming the existing market failures [4]. Such innovative mechanisms include energy performance contracting schemes (EPCs) offered by the Energy Service Companies (ESCO), green bonds, etc.

1.2 EE Status in the EU

EE is one of the key elements of the EU energy policy. This is reflected in the EU's existing legislation and in its targets to be reached by 2020 and 2030 [4]. Specifically, the EU has set the clear commitment to become the first carbon neutral continent and remain the leader in the clean energy transition at a world-wide level as stated by the European Green Deal [6]. Within the 'Clean Energy for all Europeans package', ambitious EU energy and climate targets have been established for 2030 and beyond, being also in line with the climate goals arising from the Paris Agreement for limiting global warming to well below 2^{o}C or even below 1.5^{o}C [7].

In particular, the Revised EE Directive sets an EE target of at least 32.5% by 2030, according to projections made in 2007 for the energy consumption in 2030, based on which the EU MS have to adopt EE measures to reduce their annual energy consumption about 4.4% until 2030 [8], [9]. To achieve these targets, significant investments in EE projects have to be implemented. In particular, €1 trillion is planned to be mobilized for implementing sustainable energy investments during the current decade via the EU budget and related instruments [10]. Within the framework of the sustainable economic development and finance, referred as "green finance", environmental, social and governance aspects have to be taken into consideration during the investment decision making process [10].

The Action Plan on Financing Sustainable Growth, adopted by the European Commission in March 2018, aims to redirect capital flows towards sustainable investment in order to achieve sustainable and inclusive growth; manage the financial risks arising from climate change, environmental degradation, and social issues, and promote transparency and long-term financial and economic activity [11]. Following this action plan, the European Commission established a Technical Expert Group (TEG) on sustainable finance in July 2018, and in June 2019, a Technical report on EU Taxonomy has been published by the TEG. This report presented the technical screening criteria for activities contributing significantly to climate change mitigation, a methodology and related examples for the evaluation of the contribution to climate change adaptation, and guidance and case studies to support investors to apply the taxonomy [12]. In addition, another technical report on EU Green Bond Standard has been published by the TEG in order to increase transparency, comparability and credibility of the green bond market and the capital flow to issue and invest in EU green bonds [13].

Nevertheless, the **heterogeneity and the immaturity of the EE market are barriers for financial institutions (FIs) to enter the market, even though EE projects may be profitable and secure investments**. Overcoming such challenges in order to obtain viable financing for EE is a topic that interests private FIs, industry representatives and sector experts.

1.3 Triple-A Concept

Triple-A scheme aims to identify and mainstream EE investments focusing on the pre-screening process, where **no standardisation exists**, supporting the identification of attractive project ideas, as well as creating standardised tools and benchmarks. In general, investments shall be considered as "Triple-A projects" only if they have a relatively strong capacity to meet their financial commitments by attaining the expected sustainable performance targets.

The **'gap'** that Triple-A scheme tries to cover lays on the **development phase** of EE investments, where plenty of EE project ideas exist and there is available capital to realize EE projects as well. However, these projects tend to never get financed for various reasons. In this regard, Triple-A enables the transformation of EE project ideas to transparent, predictable, and attractive investments for investors and financiers by facilitating the identification of "Triple-A investments", i.e., investments which are considered profitable and of low risk.

According to sustainable banking analysts, many profitable business cases for EE investments in companies are not being pursued because **resource allocation** (mostly time and money) are being **focused on the primary processes** of a company and **not on non-core activities like EE**. In addition, the **absence of a stable and predictable tax/energy price mechanism** leads to 90% of potential projects **not being financeable**, thus, the remaining 10% are being neglected by analysts because they do not represent a profitable critical mass. In this context, a **clear long-term government tax policy on energy** would be an **effective risk-mitigating action**. It is also critical to examine the way EE projects are analyzed, either perceived as simply real estate investments (i.e., depending on the value of the underlying property and/or lease contracts etc.) or are analyzed separately (i.e., their own merits/business case).

On the one hand, **project developers** do not have the expertise or resources to make a convincing financing case for investors. They consume a great amount of working time on auditing the potential energy savings of an EE project, but in most cases, never actually implement this project. The reason is that they cannot convince investors to leverage the investment capital needed.

On the other hand, **private investors** suffer from a knowledge gap on the way project developers implement their projects, especially, at the early stage of project identification. At the same time, most of the **banking sector does not adopt EE-based criteria** for financing the most attractive projects, since the sole criterion remains the creditworthiness of the borrower, despite the fact that EE measures come along with multi-level advantages. Some of these benefits are linked with positive macro-economic impacts (higher gross value-added, employment), increased industrial productivity, improved health and well-being, reduction of local air pollution, the rise of property values etc. In the meanwhile, according to representatives of the banking sector, EE projects up to approximately €1 million are not financially attractive for bankers and there are hardly any people involved in the financing procedure, meaning that an automatic lending process takes place without taking into account the abovementioned EE benefits. What is more, the minimum €25-50 million thresholds that banks have set for the attractive project ideas **do not live up to mainstream EE financing**.

In addition, it is considered essential to mention that the phenomenon of "**greenwashing**" and the financing of buildings' renovation or upgrade, which, in essence, do not constitute "pure" EE investments, hamper further the real mainstreaming of EE investments and realization of sustainable energy development. Banks and rating agencies are currently "free" to define which project constitutes a "sustainable investment". However, the establishment of the EU taxonomy constitutes a decisive action from the EU aiming to establish a standardization system for sustainable energy investments and put a halt to "greenwashing", since a project will not be considered "green" unless it meets all the concrete criteria of the new classification.

With the aim to fill in the above-mentioned gap, **Triple-A methodology and tools** offer:

- ✓ Identification of **attractive EE project ideas** for bankers, funds and other FIs.
- ✓ Benchmarking of the EE projects and selection of the "**Triple-A" EE investments** which merit attention by the funding organizations.
- ✓ Proposal of **funding strategies** (warehouse lending, green Bonds, EE auctions) that better match with the examined investments and respective beneficiaries.

In addition, the Triple-A scheme could facilitate the reduction of uncertainty of both project developers and financiers through the evaluation and analysis of the risks affecting EE investments, the assessment of the impact of those risks on the economic viability of these investments and the mitigation of the risks that could possibly emerge at an early stage. The role of the stakeholders' consultation process is considered of paramount importance in order to assess the validity of the proposed methodology and extracted results.

1.4 Aim and Structure of the Report

The aim of this report is to support the identification of Triple-A projects and prepare input for the rating system for EE investment projects to be developed as part of the Triple-A scheme, which will lead to a **pre-screening of investment ideas** at EU level.

Particularly, within the "**Assess**" Tool of the Standardized Tools that are based on the Triple-A Scheme, project ideas will be collected and evaluated according to their perceived risk profile and factors. These profiles and factorswill be based on the outcomes of the present report.

To that end, the main target of this report is to compose a risk matrix and identify its components, namely the risks, sectors, and project categories in EE investments. Moreover, this report aims at covering the gaps identified in EE and sustainable financing and propose an approach to assess the risks in EE investments, as well as to present the key risk mitigation strategies, the main financing instruments, and the main financing programs regarding EE investments.

The current report builds upon D3.1 'Draft Report on Risks of Energy Efficiency Financing and Mitigation Strategies Typology' released in February 2020 and integrates the results of work undertaken since then. In particular, it considers the feedback from other work packages within the Triple-A project.

To identify the components of the risk matrix, the literature review for collecting and categorizing risk and uncertainty factors, which might reduce the profitability of investments and, in particular, endanger debt repayment, was expanded and recent reports from other projects were included. The renewed analysis led to a partially different classification of risk factors. Furthermore, a more fine-grained conceptual characterization of risk factors was introduced with respect to dependencies of risk factors, e.g., project specificity or country specificity. The specification of risk categories was also more detailed and refined.

For identifying the sectors and projects categories in EE investments, the EU Taxonomy was reviewed. This led to a shift of focus for project categorization away from beneficiaries towards sectors and the introduction of sub-sectors. The section on risk mitigation strategies was elaborated and two new sections introduced describing instruments and programs for financing EE projects.

The key questions to be answered through the final version of this report are the following:

- Which are the key risks affecting EE investments financing from the financing bodies (banks, investment funds, etc.) perspective?
- Which are the key sectors that the EE investments of interest for Triple-A lie in?
- Which are the main project categories for each of the identified sectors?
- Which are the main risk mitigation strategies for each risk factor identified in EE investments? How they are currently implemented, and which gaps emerge?
- How EE projects can be mainstreamed via innovative financing schemes (e.g., green bonds, EE auctions, warehouse lending, etc.)?

The structure of this report is the following:

- **Section 2** refers to the methodology for identifying the risk matrix's components.
- **Section 3** describes the literature review for collecting the risk matrxi's components.
- **Section 4** reports the identification of the risk matrix's components.
- **Section 5** summarizes the filtering and the assessment of EE projects based on the identified risk matrix's components.
- **Section 6** reports the risk mitigation strategies typology with reference to the identified risks.
- **Section 7** provides an overview of financing instruments**.**
- **Section 8** presents an overview of financing programs/models and their structure.
- **Section 9** provides concluding remarks and future perspectives.

2 Methodology for identifying the EE investments risk matrix's components

In order to provide the Triple-A tools and particularly the rating system for EE investment projects with the necessary input, a methodological approach was defined. The outcome of this approach was the risk matrix's formulation by identifying its components, namely the risk categories and factors, the sectors, and the project categories in EE investments. Following, the EE projects' risk assessment, i.e. what is the risk of the EE projects not to achieve the projected KPIs, can take place.

In this section, the approach for identifying the risk matrix's components, namely risks, sectors, and project categories is described. The first part comprises an extended literature review composed of three main parts:

a) review of scientific papers and business studies,
b) review of Horizon 2020 projects on sustainable and EE financing and other EE financing projects, and,
c) review of EU Taxonomy.

The a) and b) review sections aimed at collecting the risks in EE investments, while the review of EU Taxonomy at gathering the sectors and project categories in EE investments. Next, the risks collected were filtered and evaluated for identifying the final risk factors and their categories. The sectors and project categories gathered from EU Taxonomy were filtered by conducting an EE market analysis for recognizing the sectors and project categories of interest for Triple-A. Any sector derived from EE market analysis that was not covered by the EU Taxonomy was included in the final sample of sectors as well.

Figure 1 depicts the whole methodology for identifying the risk matrix's components.

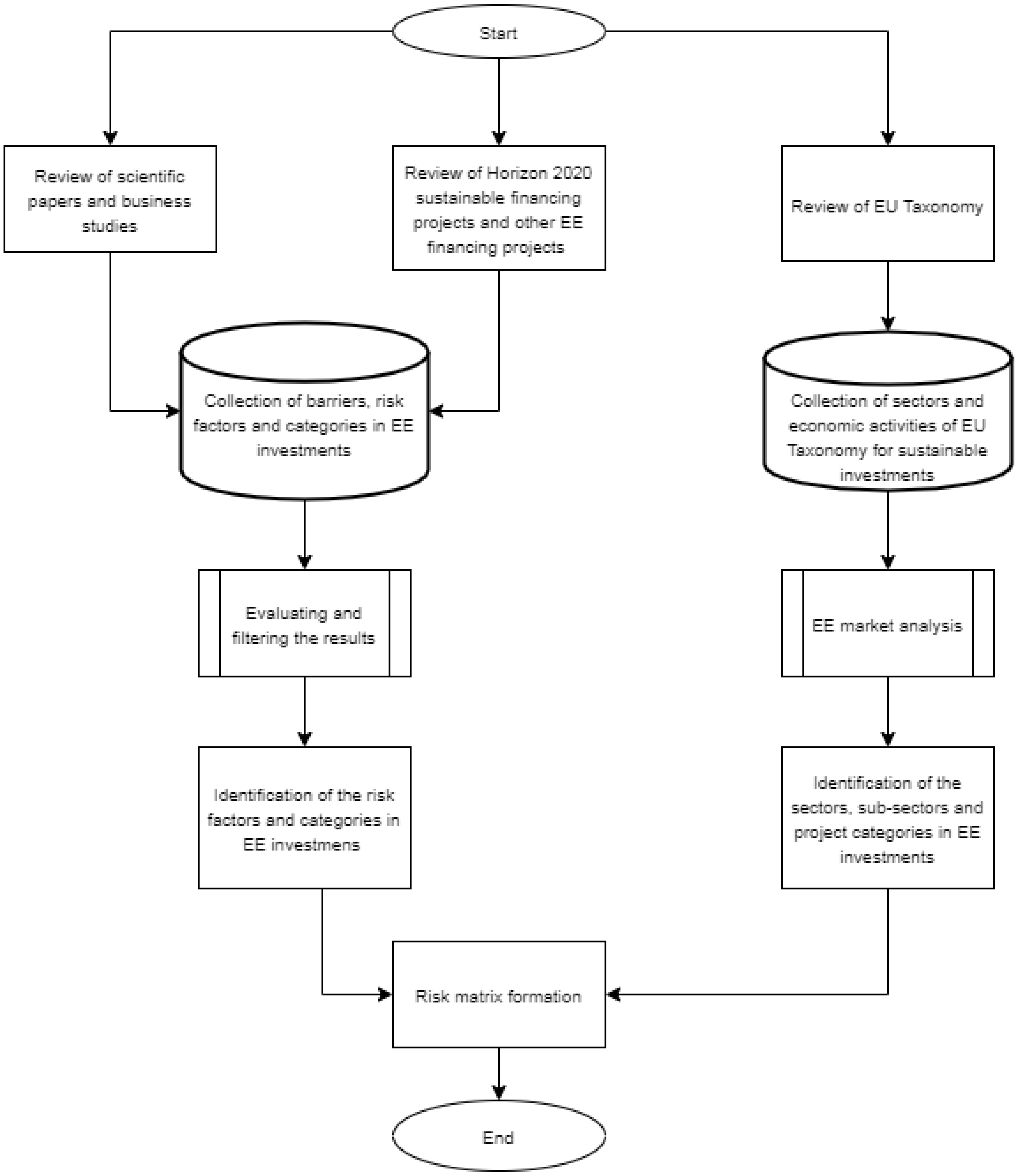

Figure 1: Flowchart of the methodology used for identifying the risk matrix's components

3 Literature review for collecting the EE investments risk matrix's components

3.1 Review of scientific papers and business studies

Methodology

This review section was based on applying search terms and keywords for collecting the total sample of scientific papers and business studies that identify risks and barriers to the successful implementation and finance of EE projects. **Table 1** presents indicative search terms used for gathering the literature sources.

Table 1: Indicative search terms for the aggregation of the literature sources

Search terms
Energy efficiency financing
Energy efficiency funding
Energy efficiency projects
Energy efficiency investments
Risks of energy efficiency investments
Risks of energy efficiency projects
Barriers to energy efficiency investments
Barriers to energy efficiency projects
Risk factors of energy efficiency investments
Risk factors of energy efficiency projects
Risk evaluation of energy efficiency investments
Risk evaluation of energy efficiency projects
Risk management of energy efficiency investments
Risk management of energy efficiency projects

Applying the above-mentioned search terms, a sample of eighty-one (81) scientific papers and business studies was created. These literature sources are presented in **Appendix A**.

Results

The outcome of this analysis was the development of a database that contains all the risk categories, along with the risk factors and barriers associated with them for each literature source of the final sample.

Overlaps were identified among the literature sources regarding the risk categories and risk factors reported. The literature sources contain one hundred and twenty (120) risk categories reported. The most frequently stated risk categories are the Economic, Market, Behavioural, Regulatory, Organizational and in a lower frequency of reference the Financial, Technology, Information and Policy. The detailed results of risk categories are depicted in **Figure 2**, along with the frequency that each risk category is reported by the literature, either distinctively or in combination with other risk categories. The results include the risk categories mentioned more than five (5) times and could be considered as generic categories.

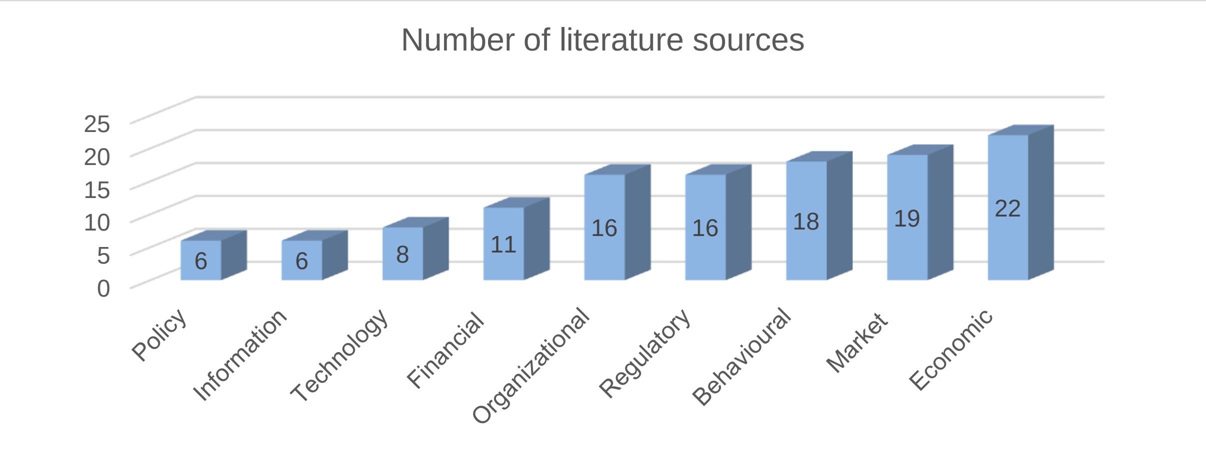

Figure 2: Results of the risk categories in EE investments

As far as the risk factors are concerned, a total of seven hundred and thirty-one (731) risks factors were determined. Among them, ninety (90) overlaps were spotted, regarding risk factors being mentioned identically in literature, limiting their sample to six hundred forty-one (641) unique risk factors.

It should be noted that some risk factors (e.g., bounded rationality), have a dual reference in literature. Some sources indicate them as risk factors, while other as independent risk categories. The high number of reported risk factors proves the wide variety of risks and barriers that can be identified in EE investments. Additionally, in literature, strict terminology is not always used to describe the same risk factors. In many cases, the same risk factor can be listed under a variety of similar terms. Therefore, many risk factors of the results, despite their different reference, are semantically similar to other risk factors, and they could be combined with other risk factors. Such instances are grouped under one designation, as it is described in **Section 4**.

Key barriers to mainstreaming EE investments

'Access to capital' has been the most frequently reported barrier in literature [14], [15]. It is related to the ability of the investor to leverage the required capital for the EE investment either from external funding or from the internal capital budget. Based on studies, the access to capital constitutes, from the policy maker's perspective, a risk factor to the extended implementation of EE investments. Policy measures, such as financial incentives and tax credits for EE investments are suggested in order to reduce the limitations in access to capital [16].

In addition, split incentives are a common barrier towards the extensive conduction of EE projects in buildings. Split incentives are identified when two parties have different incentives for a specific action [17]. A common example of this kind is the landlord-tenant problem when the landlords do not have any interest in investing in an EE project if they cannot convey the cost of the investment to the tenant. Respectively, tenants may not invest in EE if they plan to move out before the payback period of the investment.

Another example of split incentives within a company is that of a manager remaining in his position in the short-term. In these situations, the manager may have limited or even no incentives to initiate an EE investment with a payback period longer than the time period that he remains in his position [18], [19]. To deal with split incentives, regulatory measures and financial mechanisms like minimum performance standards, energy labelling, individual utility meters in multi-occupancy buildings, and financial and fiscal incentives can be put forward [16], [20].

Apart from the project-related risks of EE investments that may be mitigated via the adoption of appropriate actions by the project developers, there are several structural risks that are associated and impact the mainstreaming of EE investments. In general, a critical barrier and structural risk is that the existing databases lack detailed techno-economic data on EE projects, including, among others, capital leverage structure, size and stage of the project, beneficiaries etc. Moreover, even though the banks are financing several activities for the improvement and upgrade of equipment and appliances (e.g., in the industry sector), the EE proportion of the activities (‘green part’) is low compared to the other components of the activities.

3.2 Review of Horizon 2020 sustainable financing projects and other EE financing projects

Methodology

A review of the outcomes (i.e., reports) of other Horizon 2020 sustainable and EE financing projects was conducted. The projects were extracted from Horizon 2020 data hub [21] and were subsequently evaluated for deciding if they are relevant with sustainable or EE financing concepts. Moreover, relevant EU projects on sustainable financing proposed from Executive Agency for SMEs (EASME) were examined [22], as well as other projects in EE financing suggested from internal stakeholders consultation (such as the “Industrial Energy Accelerator” (IEA) project).

The main goals of this review section are (i) to better understand Triple-A’s contribution in the field of sustainable and EE financing in comparison with other relevant projects and (ii) to collect the risks reported by the other EE projects in our database. To achieve the first goal, an investigation of the identified projects was conducted, while regarding the second goal only the projects that focus on EE financing were considered, excluding projects in the sustainable financing spectrum.

Results

A table consisting of the most relevant projects was developed (see **Appendix B**), providing an overview of other projects’ outcomes related to sustainable or EE financing, the investigated perspective (i.e., who could invest in EE projects), the identified risks, barriers, sectors and risk mitigation strategies.

The total number of projects found from the above-described approach amounted to sixty-seven (67). Out of these projects, only fourteen (14) projects contained reports with identification of risks with eight (8) of them focusing on EE financing and six (6) belonging to sustainable financing. From these, the IEA, CRREM, I3CP are of most importance for Triple-A since they focus on EE and they examine the risk from the same perspective (FI or investor). In this light, their outcomes are highly considered in the final identification of risks. Some other projects consider also the FI or investor point of view for the evaluation of risk, but in combination with other perspectives too. These other perspectives include among others the project developer, end-client, SMEs, energy experts, government bodies, consumers etc. Moreover, IEA is the only project that examines the phases of the project, that the risks are connected to.

The main risks reported include credit risk, market risk, technology risk, repayment risk, O&M risk, and regulatory risk. The main barriers reported are financial, market, regulatory, technical, economic, administrative and social. Most of these projects refer to the residential sector, both public and private buildings, and to a lower degree, to other public and private sectors such as public and private services (tertiary), industry and transport. Only two (2) projects have focused on identifying EE project categories, and these are mainly building envelope, HVAC&R, and lighting appliances' retrofits. Risk mitigation strategies are proposed by five (5) projects.

It should be noted that only project reports covering specific EE financing risks were added to the literature sources derived from the above section, excluding reports containing risks related to sustainable financing. Thus, **Appendix A** contains ninety-four (94) literature sources.

3.3 Review of EU Taxonomy

EU Taxonomy aims to define which economic activities can be considered environmentally sustainable [23]. Thus, the EU Taxonomy was reviewed for collecting the sectors and project categories in EE investments. The reasons for selecting EU Taxonomy for this scope, are:

a) for aligning Triple-A with EU sustainable investments framework, and
b) for enabling the initial filtering of investments by checking their compliance with EU Taxonomy.

EU Taxonomy contains macro-sectors, connected to a number of related economic activities. For defining sectors, EU Taxonomy follows the NACE (Nomenclature of Economic Activities) European statistical classification of economic activities, enabling comparability of investments at European level and, in general, at world level, EU Taxonomy is in line with the United Nations' International Standard Industrial Classification (ISIC). For each economic activity, the EU Taxonomy provides technical screening criteria, such as eligible measures, specific criteria, and thresholds for mitigating climate change. An investment should comply with these criteria to be considered eligible. However, there also some activities that are considered as compliant without considering any criterion, such as Cogeneration of Heat/cool and Power from Concentrated Solar Power.

In **Appendix C,** the macro-sectors that EU Taxonomy contains along with the related activities of each sector are presented.

4 Identification of the EE investments risk matrix's components

4.1 Identification of the EE investments risks

Methodology

The first step for identifying the main sources of risk in EE investments was to extract the individual risk factors from the initial database that emerged from the literature review. The risk factors reported were prioritized according to the relevance of their sources. Two types of sources were considered as particularly important:

(i) projects related to the Triple-A concept (such as [24]), i.e., projects that try to calculate the total risk of an EE project from a FI point of view and

(ii) specialized studies in EE projects' risk assessment [25].

Risk factors from these sources were assessed apart from the rest of risk factors due to the high relevance of these sources with Triple-A. Most of these risk factors qualified for this evaluation stage, except for some cases that it was considered inappropriate to include them in the risk matrix.

The rest of the risk factors were evaluated by applying a set of criteria. The first criterion is the frequency of occurrence, namely how many times the risk factors are observed in the database, a criterion that has also been used in [26] to identify the benefits resulting from EE investments. The second criterion is the minimization of the overlaps among risk factors. The last criterion is the capacity to quantify the risk factors, either with the usage of open-source data or through a stakeholder consultation process.

It should be noted that many risk factors identified by other EE financing projects derived also from the literature review, either with an identical or a similar concept. In these cases, the most generic risk factors were selected.

The final step was to classify the identified risk factors into risk categories by merging them according to their conceptual characteristics. The risk categories used for classifying the risk factors identified belong to the most cited risk categories as they were presented above (see **Figure 2**).

Results

After applying the above-presented methodology, nine (9) risk factors belonging to five (5) risk categories (see **Table 2**) emerged. Table 2 presents the identified risk categories along with the risk factors that each of them contains.

Table 2: EE investment's risk factors and categories

Risk factors	Risk categories				
	Financial	Behavioural	Energy Market & Regulatory	Economic	Technological, Planning and Operational
Creditworthiness of the borrower	✓				
Rebound effect		✓			
Energy prices and taxes volatility			✓		
Request for issuing project permits			✓		
Weak economic environment				✓	
Technical Complexity					✓
Low quality of initial savings assessment					✓
Implementation of low-quality equipment or poor project design					✓
Inadequate Operation & Maintenance (O&M)					✓

As regards the ***Financial*** risk category, the factor ***"creditworthiness of the borrower"*** indicates the financial capacity of the borrower to pay off his debt, a critical factor from the perspective of a FI or bank when considering giving a loan [27], [28].

The second risk category ***(Behavioural)*** comprises the ***"rebound effect"***, which describes a specific behavioural bias. It affects the end-user and mostly emerges when the implementation of an EE project leads to lower costs for energy services combined with an increase in the demand for such services. Therefore, the project results in higher final consumption than the one anticipated. This may lead to energy savings being significantly lower than the ones that were initially anticipated [29].

The third main risk category addressed in the literature as the riskiest one [28], is the ***Energy market and regulatory***, which includes the ***"energy prices and taxes volatility"*** factor and the ***"request for issuing project permits"***. Energy prices and taxes volatility is associated with the price risk in EE investments. On the one hand, the uncertainty about energy prices influences the decision to undertake an EE investment as it may lead to unexpected monetary savings and therefore the return of the EE investment may differ from the initial estimation [30]. Furthermore, energy taxes are considered important as they affect the end-use price and thus the monetary savings of the EE investments. The request for issuing project permits signifies the legislative complexity for the completion of a project (e.g., construction permits/licences, protocols or other approvals under the provisions of law), which could lead to administrative risk in a specific country. The administrative risk could be a decisive factor for the selection of a country to implement a project [25]. Some instances of this risk factor are the request for issuing project permits/licenses for renovations of existing buildings, the installation of geothermal heat pumps, the change of the electromechanical equipment, etc.

The ***Economic*** risk category is the fourth of the identified ones. It is connected to the ***"weak economic environment"***. The weak economic environment is related to poor economic conditions that may exist in the country that the EE investment takes place. It is connected to, among other indicators, interest rates, inflation, availability of finance, etc. [31][32][32][32]. Weak economic environment can negatively influence the investment in many ways, such as affecting the investment's profitability through inflation or KPIs through interest rates. It should be noted that the economic category is also connected to other more specific risk factors (e.g., interest rates volatility) that are part of the weak economic environment, as reported by literature. To that end, the risk factor 'weak economic environment' was selected as a means of evaluating this risk category, as well as to take into consideration all the relevant risks for the calculation of the risk of this category.

The final risk category is the ***Technological, planning, and operational***. It is composed of the ***"technical complexity"***, the ***"low quality of initial savings assessment"***, the ***"implementation of low-quality equipment or poor project design"***, and the ***"inadequate O&M"***. The technical complexity is related to the complexity of the EEMs implemented from a technological point of view. It affects the chances for successful project implementation, by increasing the possibility that expected energy savings are not achieved. The implementation of low-quality equipment or poor project design refers to the equipment and design characteristics of the examined project. According to the quality of the equipment and the design, a level of technical risk can be defined. Inadequate O&M represents the uncertainty regarding the proper O&M of equipment. O&M is considered a crucial factor to achieve the expected energy savings. The low quality of initial savings assessment is associated with the capacity to predict accurately the expected energy savings, as well as to define properly the baseline energy consumption. Different practices are used for the estimation of energy savings, such as computational tools and simulation models from certified experts, empirical approaches and processes, and results from other similar EE projects [25].

Characterization of risk factors

Risk factors can be classified into the following categories according to their conceptual characteristics: (a) Borrower-specific ***(BRW)***, (b) Sector and Project-category specific ***(PSRS)*** (c) Country-specific ***(CSR)***, and (d) project-specific ***(PSR).***

Creditworthiness of the borrower, which is the only ***BRW*** risk factor, depends on the creditability of the applicant for the loan/ financing, being either a physical person or a company/ legal person. ***PSRS*** risk factors depend on the project's sector and the EEMs implemented. ***CSR*** risk factors depend only on the country that the investment takes place. Finally, the ***PSR*** risk factors depend on the ad-hoc characteristics of each project irrespectively of all the aforementioned ones. **Table 3** presents the classification of the risk factors to the above presented categories.

Table 3: Characterization of EE investment's risk factors

Risk categories	Risk factors	Risk factors characterization			
		BRW	PSRS	CSR	PSR
Financial	Creditworthiness of the borrower	✓			
Behavioural	Rebound effect		✓		
Energy Market & Regulatory	Energy prices and taxes volatility			✓	
	Request for issuing project permits				✓
Economic	Weak economic environment			✓	
Technological, Planning and Operational	Technical Complexity		✓		
	Low quality of initial savings assessment				✓
	Implementation of low-quality equipment or poor project design				✓
	Inadequate O&M				✓

4.2 Identification of the EE investments sectors

The base for identifying the sectors in EE investments was the EU taxonomy and the classification system that it follows. An EE market analysis in collaboration with WP5, that is responsible for collecting the EE investments in the context of Triple-A, was conducted for identifying the sectors of interest for Triple-A. To that end, each identified sector derived from the EU Taxonomy, while some of their related activities have also been selected. Moreover, except for these sectors, the Outdoor lighting sector was selected in spite of not being covered by EU Taxonomy, since it was considered that investments of interest belong to this sector.

In the context of Triple-A, the economic activities are named as sub-sectors. **Table 4** presents the identified sectors along with the corresponding sub-sectors that each one of them contains. The only sector without related subsectors is Outdoor lighting.

Table 4: Identified sectors and sub-sectors in EE investments

Sectors	Sub-sectors
Buildings	Residential
	Non-Residential
Manufacturing	Hydrogen
	Iron and Steel
	Aluminium
	Cement
	Low carbon technologies
	Fertilizers and Nitrogen
	Other organic basic chemicals
	Other inorganic basic chemicals
Transportation	Public Transport
	Passenger cars and light commercial vehicles
District Energy Networks	District Heating / Cooling Distribution
	Installation and operation of electric heat pumps
	Cogeneration of Heating / Cooling and Power
	Production of Heating / Cooling
Outdoor Lighting	-

Sectors and sub-sectors are related to the EEMs implemented, rather than the beneficiary of the investment, as the system that EU Taxonomy follows was adopted. In this regard, for example, in case the EEMs implemented are connected to the parts of a building or its appliances, or construction of a new building takes place, then the project belongs to the "Buildings" sector. For purchases of new vehicles, the project belongs to "Transportation" sector, while for retrofits that are connected to the manufacturing process (e.g., manufacturing machinery's retrofits), the project belongs to "Manufacturing" sector. For retrofits or expansion of district energy networks, the project's category is "District energy networks". Finally, for retrofits regarding outdoor lighting, projects belong to "Outdoor lighting" sector.

4.3 Identification of the EE investments project categories

After identifying the sectors for EE investments, the identification of project categories, i.e., the EEMs implemented, follows. For each sector of the identified ones, a part of the eligible measures as defined by EU Taxonomy were selected. This was decided by the EE market analysis conducted. To that end, project categories that are not included in the FIs' portfolios due to their low scale budget (e.g., vehicles' retrofits), were not taken into consideration. Moreover, in cases that there are not enough data for differentiating the risk calculation from one project category to another (e.g., retrofits and expansions of District Energy Networks), one generic project category was selected. The "Buildings" sector is the only from the identified ones, related to more than one project categories. **Table 5** presents the identified project categories along with the sectors that they belong to.

Table 5: Classification of project categories into sectors

Sectors	Project categories
Buildings	Building envelope retrofits
	HVAC&R retrofits
	Lighting appliances' retrofits
	Automatic control retrofits
	RES installations
	Construction of new buildings
Manufacturing	Manufacturing-specific retrofits
Transportation	Purchase of new vehicles
District Energy Networks	District Energy Networks retrofits/ expansion
Outdoor Lighting	Outdoor Lighting retrofits

5 Filtering and evaluating EE projects

5.1 Criteria for filtering EE investments

The first step for filtering the EE investments is going to be based on applying technical criteria of the EU Taxonomy. For each sub-sector, the technical screening criteria defined by the EU Taxonomy are going to be considered. These criteria are presented in **Appendix D**. If an investment does not comply with these criteria, it will be considered as a **No-Go** investment. For "Outdoor lighting", the respective outcome of PREMIUM LIGHT PRO project [33] is used for setting the requirements for the investments that lie in this sector.

5.2 Risk assessment of the identified risk factors

For calculating the total risk of EE investments, the evaluation of risk factors must precede. A methodology for evaluating each of the identified risk factors has been developed by using as input the risk factors identified in **Section 4**, utilizing either a qualitative or quantitative analysis. **Table 6** presents the type of assessment for each risk factor (qualitative or quantitative) and a short description of the methodology followed for each one of them.

Table 6: Assessment of identified risk factors

Risk factors	Type of assessment	Short description
Creditworthiness of the borrower	Qualitative	Assigning linguistic values out of the scale ("Low", "Medium", "High", "Unknown") for evaluating the creditworthiness of the applicant for the loan
Rebound effect	Qualitative	Assigning linguistic values out pf the scale ("Insignificant ", "Low ", "Medium", "High", "Very High") to each type of project based on literature review
Energy prices and taxes volatility	Quantitative	Calculating the coefficient of variation (CV) of monthly values of Consumer Price Index (CPI) for the last fifteen years (01/2005-12/2019), as reported by OECD
Request for issuing project permits	Qualitative	Considering the amount and type of project permits needed for the implementation of the project
Weak economic environment	Qualitative	Considering the credit ratings as provided by Standard & Poor's (S&Ps) for the case-study countries
Technical Complexity	Qualitative	Assigning linguistic values out of the scale ("Insignificant", "Medium", "Very high") to each type of project based on literature review
Low quality of initial savings assessment	Qualitative	Considering how the energy savings assessment and the baseline definition have been conducted
Implementation of low-quality equipment or poor project design	Qualitative	Considering the existence of proof about the quality of the equipment to be installed, the experience of the team for planning and implementing the project and who conducts the technical implementation of the project
Inadequate O&M	Qualitative	Considering the experience of the end-user in using and operating the proposed equipment, the existence of a maintenance plan, product warranties and M & V protocols and standards

After calculating the risk factors' values, the risk categories' values are calculated by averaging the values of the risk factors of which each category is composed of. The total project risk value is the weighted arithmetic mean of the risk categories' values and is calculated as follows:

$$\text{Project risk value} = \sum_{i=1}^{n} w_i \times R_i \quad (1)$$

w_i : $i = 1, \ldots, 5$ are each risk category's weight

R_i : $i = 1, \ldots,$ 5 are each risk category's value

The weights will emerge from the stakeholder consultation process, according to their estimated impact on EE projects. They will be the default weights of the **"**Assess**"** tool, part of the Task 4.1: Standardized Triple-A Tools, while bankers and investors will be able to modify these weights according to their preferences and inspect how the total project risk is adjusted.

In this regard, for example if an investor wants to invest in a specific country, he will be able to eliminate the country component from the total risk calculation. To do so, he will assign zero or very small weights to the corresponding country-specific risk categories, i.e., the "Energy Market & Regulatory" and "Economic" risk categories.

6 Risk Mitigation Strategies Typology

Ranking the risks according to their severity is a common strategy in risk management as it is almost impossible to deal with all possible risks that may occur in a project [34]. The most important risks that may appear in EE investments have been addressed in **Section 4**, where a typology of distinct risk factors is determined. In this section, mitigation strategies for the identified risk factors will be presented according to literature.

There are four main strategies to deal with risk (**Table 7**). Risk can be **reduced** or **eliminated**, **transferred, absorbed** or **accepted**, and **avoided** [34], [35]. Risk **reduction** or **elimination** suggests that remediation activities are planned in order to reduce the level of the risks' impact or probability of occurrence in the project [35]. Risk **transfer** means transferring the risk to another party (e.g., using insurance contracts). **Acceptance** or **absorption** of the risk means that no actions are taken to reduce the risk because the possible impact is acceptable in the context of the project [35]. Risk **avoidance** can be implemented by using quality control practices and procedures to ensure that when the probability of risk occurrence exceeds a preset threshold, the project is aborted [34]. Furthermore, this strategy can be taken into account when risks occur and their impact on the project is significant. In such cases, the project may be withdrawn or the project's objectives may change [35].

Table 7: Main risk mitigation strategies

Risk Mitigation Strategies
Risk reduction/elimination
Risk transfer
Risk acceptance/absorption
Risk avoidance

In the process of evaluating project proposals, it is important to audit the proposed risk management plan to ensure that it is founded on reasonable assumptions and covers all pertinent risks. This evaluation should take into consideration the selection of suitable strategies for the mitigation and transfer of risks, along with the possible impact of the accepted risks, while taking into account the regulatory conditions. Although each project is different from another, and risk mitigation strategies are formed specifically for each project, a literature review was conducted to identify key techniques and measures for risk reduction and transfer that can be implemented in EE investments to control the identified risk factors.

A highly cited technique used for risk reduction is hedging [36], [37]. Hedging can be characterized as a strategy that somebody employs in order to minimize or avoid losses, in case prices of an asset range unpredictably, and can be achieved mostly with the use of derivatives like future or forward contracts, swaps or options contracts [38]. Regarding EE investments, by hedging through buying or selling energy futures, it is possible to achieve a neutral overall result. Regarding the risk factors that have been identified (see **Section 4)**, hedging can be used to mitigate energy prices and energy taxes volatility [36]–[38], as well as interest rates volatility (interest rates are a key component of the risk factor weak economic environment) [29], [37]. Another risk reduction technique mentioned in the literature is the use of fixed-price contracts [38], while for interest rates volatility, it is suggested choosing a long-term fixed interest rate rather than a floating one [39].

As regards the mitigation of price risk, since a high proportion of the end-use energy price consists of taxes, a clear long-term government tax policy on energy could probably be considered as a risk mitigation strategy for the energy prices and taxes volatility risk factor, while investing at the same time in green electricity generation (e.g., photovoltaics) could also mitigate this risk as the price for the energy produced this way will be constant for several years.

A risk transfer technique in EE investments is to sign EPCs associated with energy-saving guarantees or insurances provided by ESCOs [23], [28]. In this way, the risk can be transferred from the building owner to the ESCO [40], [41]. Careful selection of the ESCO and use of a standardized EPC are critical factors for project risk reduction [24]. Additionally, performance bonds or insurances related to poor or faulty design, flaws in the implementation of EEMs, mistakes in the operation of measures etc., have been proposed as a means of managing performance risk [27], [37], [38], while diagnostics can be used in order to detect potential causes of underperformance and take measures early on. In the context of Triple-A, performance risk can be associated with the low quality of initial savings assessment, implementation of low-quality equipment or poor project design and inadequate O&M risk factors that have been identified in **Section 4**. Therefore, the aforementioned techniques can be considered as risk mitigation measures for these factors.

Moreover, other types of insurance can be used to mitigate technical risks, such as equipment insurances, which fully replace the value of equipment in case of loss or damage, or insurances required by the law that may be considered necessary from time to time [42]. Considering the measurement and verification of energy savings, which is a key component of the inadequate O&M risk factor, it is recommended that FIs follow standardized M&V processes to minimize the risk of not achieving the expected energy savings and to establish trust among all involved actors [24]. Such procedures are included in protocols, such as the International Performance Measurement and Verification Protocol (IPMVP).

Considering the behavioural risk category, the rebound effect is considered a major challenge in EE investments and the literature mentions a variety of mitigation measures for this risk factor. A comprehensive study about how to manage the rebound effect in EE investments suggests three general strategies based on the consumption context: consuming more efficiently, consuming differently, and consuming less [43]. Other references to the mitigation of the rebound effect propose the examination of the required energy taxes needed to offset the rebound effect [44], as well as policy instruments to reduce rebound effects like information provision, price regulation, subsidies and tradable permits [45]. Furthermore, other strategies aim to introduce efficiency standards, eco-taxes, absolute caps, and sustainability communication [46], as well as discuss policy measures considering the design, evaluation and performance of policy and economic instruments along with new business models, sustainable lifestyles and consumer behaviour, and raising awareness and promoting education in business, technology and innovation [47].

Reducing the risk of default of the borrower requires a careful study of the credibility of the borrower in the negotiation stage [35]. Furthermore, the literature review did not reveal specific measures that can be employed for the mitigation of the risk factor associated with the request for issuing project permits. However, it is common sense that the rules and regulations of the market should assist in the mitigation of possible risks in order to promote the implementation of EE investments. The adoption of **codes** and **standards** in buildings, appliances, and equipment, can also be employed as a strategy to enhance their implementation [16].

Also, other mitigation strategies, linked with the financing instruments and models used for the financing of the EE projects should be considered. Project aggregation (see **Section 7**) is a risk reduction method, which can be used as a means of bundling together small-scale projects, decreasing in this way their overall transaction costs [4]. Loan guarantee mechanisms can lower the risk of EE loans provided by banks, promoting the development and deployment of EE credit lines [24]. Furthermore, with regards to the creditworthiness risk factor, collaterals can be used to mitigate the risk of default of the borrower. Off-balance sheet financing solutions, e.g., through the creation of a Special Purpose Vehicle (SPV), could help parent companies avoid credit risk, as the financial terms offered to the SPV are in general more attractive than those offered to the parent company [24]. Additionally, grants and subsidies (see **Section 7**) can decrease financial risk since the equity and debt shares in the capital structure of the investment are lowered.

Focusing on certified service providers and accredited equipment can contribute to the reduction of technical and performance risks of EE projects, and of the reputational risks of participating FIs [24]. The certification of EE projects (e.g., the "Investor Ready Energy Efficiency – IREE" certification provided by the Investor Confidence Project) is considered crucial for creating an accurate energy baseline for the examined fields of EE action, reducing due diligence costs, increasing investors' confidence and promoting a standardized framework for creating attractive portfolios of highly profitable projects.

Finally, EE projects have multiple benefits (e.g., environmental, economic, social, non-energy benefits etc.) for the consumer, reducing the investment risk overall [48]. **Table 8** provides an overview of the proposed risk mitigation measures for each identified risk factor and category.

Table 8: Risk mitigation measures with respect to the identified risk factors

Risk category	Risk factor	Risk Mitigation Strategy
Financial Risk	Creditworthiness of the borrower	Careful study of the creditworthiness of the borrower and/or the ESCO in the negotiation stage, collaterals
		Other financial risk mitigation strategies are project aggregation, loan guarantee mechanisms, off-balance sheet financing, grants and subsidies
Behavioural Risk	Rebound effect	Consuming more efficiently, differently, and less Energy taxes information provision, price regulation, subsidies and tradable permits, EE standards, eco-taxes, absolute caps, sustainability communication, design, evaluation and performance of policy, economic instruments, new business models, sustainable lifestyles and consumer behaviour, raising awareness and promoting education in business, technology and innovation
Energy Market & Regulatory Risk	Energy prices and energy taxes volatility	Hedging (forward contracts, future contracts, swaps, option contracts), fixed-price contracts
	Request for issuing project permits	-
Economic Risk	Weak economic environment	Hedging (forward contracts, future contracts, swaps, option contracts), long term fixed interest rates
Technology, Planning & Operational Risk	Technical Complexity	-
	Low quality of initial savings assessment	Energy savings guarantees or insurances, diagnostics
	Implementation of low-quality equipment or poor project design	Performance bonds or insurances, equipment insurances, insurances required by the law, diagnostics
	Inadequate O&M	Performance bonds or insurances, diagnostics, standardized M&V processes

7 Financing Instruments

A literature review was conducted to provide an overview of the available financing instruments, as well as financing models/programs and their structure. **Section 7** presents the financing instruments and **Section 8** presents the financing programs/models that can be used in terms of financing EE investments. A categorization of financing instruments and financing programs/models with respect to their project characteristics, their contract characteristics, as well as their budgetary and asset characteristics is presented in **Section 8.8.** Specifically, this categorization considers factors, such as the typical size of the project, which refers to liquidity needed, the typical duration of the project, which determines the payback period, source of the budget (OpEx or CapEx), and the source of collateral, which can be considered as a risk mitigation strategy (see **Section 6**). Furthermore, the categorization considers also aspects related to risk, such as the party that bears the performance risk, and contractual risk, i.e., the complexity of the contract structure.

In this report, financing instruments are considered as tradable assets and could be either debt- or equity-based. Debt-based financial instruments can be considered in general as a loan provided by an investor to the owner of the asset. On the other hand, equity-based financial instruments are considered representative agreements of ownership of an asset. In addition, grants and subsidies can also be considered as financial instruments. Debt-based and equity-based financing are described below. Also, in this Section, other financing methods, such as project financing, project aggregation through the warehouse credit facility, and EE auctions are summarized.

Debt-based financing

The following financing instruments are debt-based [49]:

- Loans
- Bonds
- Leasing agreements
- Guarantees

Loans are the most frequently used financing instruments for EE investments [50]. They can be secured or unsecured, namely being backed by property (asset) collateral or not. This instrument is characterized as a traditional one. As regards this instrument, a FI lends capital to an individual to implement an EE investment. The borrower has the obligation to repay the capital in a certain period with the addition of a predetermined interest rate -fixed or floating- that has been set by the FI. This instrument is easily manageable and can be characterized as a low-risk instrument but in most cases, FIs prefer well-established practices and do not provide loans to risky ventures [50].

Loans can be either recourse or non-recourse. In the case of recourse loans, the FI has a claim also in other assets except for the collateral asset of the loan in the event of borrower's default. In non-recourse loans, the FI has a claim only in the collateral asset of the loan. This means that in case of borrower's default and that the collateral does not cover the remaining borrowed capital, the FI must cover the difference.

Syndicated loans emerge when a borrower wishes to lend an amount of capital that a FI is not willing to provide. In this case, a syndicate of FIs is constructed where each of the lending parties provides a portion of the amount requested [49].

Bonds are debt instruments, which entail the issuing of debt securities so that the borrower can receive capital from investors. A bond is characterized by a predetermined floating or fixed interest rate and a predetermined maturity, while the issuer of the bond is mainly a corporate or governmental entity. The interest rate serves as remuneration to the investor and its level is determined by the risk profile of the issuer. The aim of the entity is to raise capital in order to fund its projects or activities [51]. In this case, the issuer of the bond is the borrower and the holder is the lender/investor. The interest rates are represented from the coupon that the borrower is obligated to pay to the lender.

Green Bonds are financing instruments operating like traditional bonds but aiming to raise capital to fund exclusively green investments that generally promote climate and environmental sustainability, like EE projects, RES projects, pollution prevention projects etc. As described in the Report on EU Green Bond Standard (EU GBS) developed by the Technical Expert Group on Sustainable Finance, other innovative characteristics of Green Bonds include tracking, impact reporting and external reviews [13]. According to Green Bond Principles (GBP) published in 2018 by the International Capital Market Association (ICMA) there are four major types of Green Bonds [52]:

- Standard Green Use of Proceeds Bond
- Green Revenue Bond
- Green Project Bond
- Green Securitized Bond

Green Bonds have been issued with an increasing rate, i.e., representing 4.4% of global bond issuances in the last quarter of 2018 [13]. This creates additional benefits in the bond market as the issuers of Green Bonds are committed to a great level of transparency and reporting with regards to their Green Projects, hence investors are starting to be more interested in Green Bond issuers.

Regarding ***EU Green Bonds***, the TEG developed the EU GBS as a voluntary standard for transactions and issuers of Green Bonds [13]. This standard aims to reinforce the effectiveness, transparency, comparability, and credibility of Green Bonds. According to the TEG, EU Green Bonds can be either listed or unlisted bonds, issued by European or international parties, which should comply with EU GBS.

If the issuer decides to follow the EU GBS, the compliance should be verified by an EU accredited external verifier. The EU GBS consists of four core components, namely the Green Projects, the Green Bond Framework (GBF), reporting, and verification [13].

- *Green Projects:* The proceeds derived from EU green bonds should be allocated to projects and/or activities that contribute to at least one of the EU Taxonomy objectives, i.e., they should not significantly harm any of the other objectives, comply with the minimum social safeguards, and regarding projects and/or activities with specific technical screening criteria, these should be satisfied.
- *Green Bond Framework (GBF):* The GBF is a comprehensive document that informs investors and market participants about future issuances and types of projects that will be financed. The overall objective of the GBF is to provide information relevant to the alignment of the issuer's strategy with the environmental objectives, the proposed use of proceeds, processes, and reporting.
- *Reporting:* Two kinds of reports must be formulated under the EU GBS: the allocation of funds and the impact report. Both reports should be available on the issuer's website or other communication channels.
- *Verification:* Under the verification process an external reviewer should verify the GBF and the final allocation report.

The main advantages of green bonds are [53]:

1. Significant amounts of capital with low interest rates. Good design for portfolios of small-scale projects.
2. Full control of proceeds and flexible terms
3. High publicity for organizations

The main disadvantages of green bonds are [53]:

1. Requirement for custom structuring of bond terms
2. Issuers should frequently negotiate with investors to ensure capital abundance. Reporting requirements for allocation of funds and their impact.
3. Transactions cost are added due to the coordination with many parties.

Leasing agreements are contracts that allow an individual to use an asset without purchasing it. The parties that participate in a leasing agreement are the lessee and lessor, representing the borrower and the lender of the asset, respectively. The period covered from the contract is less than the asset's useful life and the lessor is the one responsible for its maintenance [49]. Leasing can be used for EE equipment, but it entails high transaction costs for the borrower, hence increasing the risk of the lender. In general, leasing is considered suitable for projects, which need a lot of physical assets [54].

Regarding debt-based financing instruments, different kinds of ***guarantees*** and ***insurances*** were discussed in **Section 6** of this report.

Equity-based Financing

Equity-based financing refers to receiving capital by issuing stocks or to the acquisition of equity in private companies. In EE projects, equity-based financing can relate to an ESCO issuing shares in a primary or secondary public offering in order to raise capital [49].

Grants/Subsidies

Grants and Subsidies are provided to fill the financial gap when the market cannot fully support EE investments [54]. The funding of grants and subsidies mainly come from national and regional resources and in a smaller extent from EU funding [55].

Project financing

Project financing is based on the project's cash flows and not in the company's or the individual's creditworthiness, thus can be considered an appropriate financing solution for EE investments [54]. Projects implemented by ESCOs are mainly project-financed. The project finance structure is based on the project debt and equity. It can involve both equity investors and FIs, which provide mainly non-recourse loans using the project assets as collateral [49].

In project financing, the debt to equity ratio is generally higher than corporate financing and fluctuates around 70-80% for debt and 20-30% for equity. The establishment of a SPV is a common strategy used to facilitate off-balance sheet project financing. SPVs can be also used to facilitate securitization and leasing [49]. Due to high transaction costs generated from the several contracts among the different actors required in the project financing structure, project financing can be considered appropriate for relatively high investments of 10 million Euro and above [49]. Project finance loans can usually last for an extended period up to 15 years.

Project aggregation

Project aggregation is crucial for the scalability of a financing strategy [56]. The warehouse credit facility is a method of aggregated financing used to reduce transaction costs. It is a short-term credit facility which entails the assembly of a portfolio of loans into a security to be sold, thereby replenishing capital to be lent again [56]. Aggregation methods such as the warehouse credit facility are instrumental to increase the attractiveness of small-scale EE projects. Small-scale EE projects are bundled to become attractive enough to be sold then to large investors or to be financed through bonds [57].

EE auctions

Auctions are widely used processes comprising buying and selling goods and/or services. Generally, auctions are considered very cost-efficient procedures, however, auctioning as a support scheme for the promotion of EE is less common [58]. ***EE Auctions*** or reverse auctions are a policy instrument, designed with an aim to reduce the levelized cost of saved energy, avoiding deadweight effects related to financial support [58] and identify the lower incentive amount of the participating customers. Awareness and flexibility are considered as key elements that participants should possess to participate successfully in auctions. Overall, EE Auctions can reduce the overall costs of EE, allowing for flexibility in customizing EE projects to meet the needs of the participants [59].

8 Financial Programs and Models

There are various financial programs, models and contracts that can be used to finance EE investments. An overview of their structure, advantages and disadvantages is provided in this Section. The choice of the appropriate financing mechanism is made upon the type and size of the EE investment, the preferences of the lender regarding the undertaking of risk and the market applicability [60].

8.1 Energy service contracts

EPC

EPC is an innovative financial model that allows funding for EE investments to be repaid from the reduction of the cost of energy use [61]. Under an EPC arrangement the EPC provider, usually an ESCO, undertakes all stages of an EE project (financing, audit, planning, installation, monitoring, O&M, etc.), depicted in **Figure 3,** and uses the cost savings from the saved energy to repay the project cost. After the contract expires, the cost savings remain to the customer [62].

Figure 3: ESCO's services

There are two EPC models, the Shared and the Guaranteed Savings model. The Shared Savings model can be considered as a third-party investment, where the ESCO finances the EE investment, and energy savings are split between the ESCO and the customer in a specific ratio for a predetermined period of time, thus the risk is undertaken both by the ESCO and the customer [50]. As regards the Guaranteed Savings model, the ESCO guarantees a certain level of energy savings, hence takes on the performance risk, i.e., in case energy savings are less than those guaranteed, the ESCO covers the difference [62].

Insurance agreements can be combined with the EPC Guaranteed Savings model and be used to mitigate risks of either the ESCO or the customer. The ESCO can agree on insurance and in case the expected savings are not achieved, then the insurance company must compensate the customer accordingly [63]. In this way, the performance risk is transferred to the insurance company. Insurances can also be utilized to transfer the risk of payment default from the customer to the ESCO [64].

Under an EPC agreement, the capital needed for the EE intervention can be provided by a FI (third-party) directly to the customer or to the ESCO, or the ESCO can use its own capital (see **Figures 6** and **7** in **Section 8.2**). The main advantages of EPC are [65]:

1. Reduced performance risk from EE projects as they are managed by the EPC provider in the Guaranteed Savings model.
2. EPC provider can use the savings guarantee to facilitate financing.
3. Expertise of EPC providers

The main disadvantages of EPC are [65]:

1. Focus on short payback periods
2. Increased transaction costs
3. Lack of standardization

The SENSEI project, an initiative funded from the European Commission under H2020 programme, aims to combine EPC with pay-for-performance arrangements, mainly applied in the United States of America (USA) [66], and develop a new business model to facilitate the implementation of EE investments while expanding the use of EPCs [67].

Efficiency-as-a-Service

Efficiency-as-a-Service (EaaS) is a pay-for-performance financing solution that allows the customer to receive the benefits of an EE investment without paying the upfront cost of the investment. In this scheme, the provider of the agreement undertakes the implementation and financing of the project while the customer pays for the service after the implementation and based on the savings. Two common types of the EaaS scheme are described below.

Under an ***Energy Service Agreement (ESA)***, the provider and the customer sign a contract with a duration of typically five to fifteen years [68]. The provider of the ESA, which may be an ESCO, finances and implements the EE project that remains in his possession. The customer receives more efficient equipment that results in reduced energy bills and is obliged to pay the ESA provider an amount for their services, as well as pay their reduced energy bills, which when added to the ESA payment are lower than the customer's initial energy bill [68]. The ESA provider bears the performance risk. When the contract expires, the customer can either buy the equipment, extent the agreement or return the equipment [69].

The provider of the ESA usually derives the capital needed for the EE investment by establishing a SPV that interacts with the provider, who must return the capital to the SPV. In the case of lower energy savings than estimated, the ESA provider will not be able to reimburse the SPV as the customer's payments to ESA are based on the achieved energy savings [64]. In **Figure 4**, an overview of the ESA structure is provided.

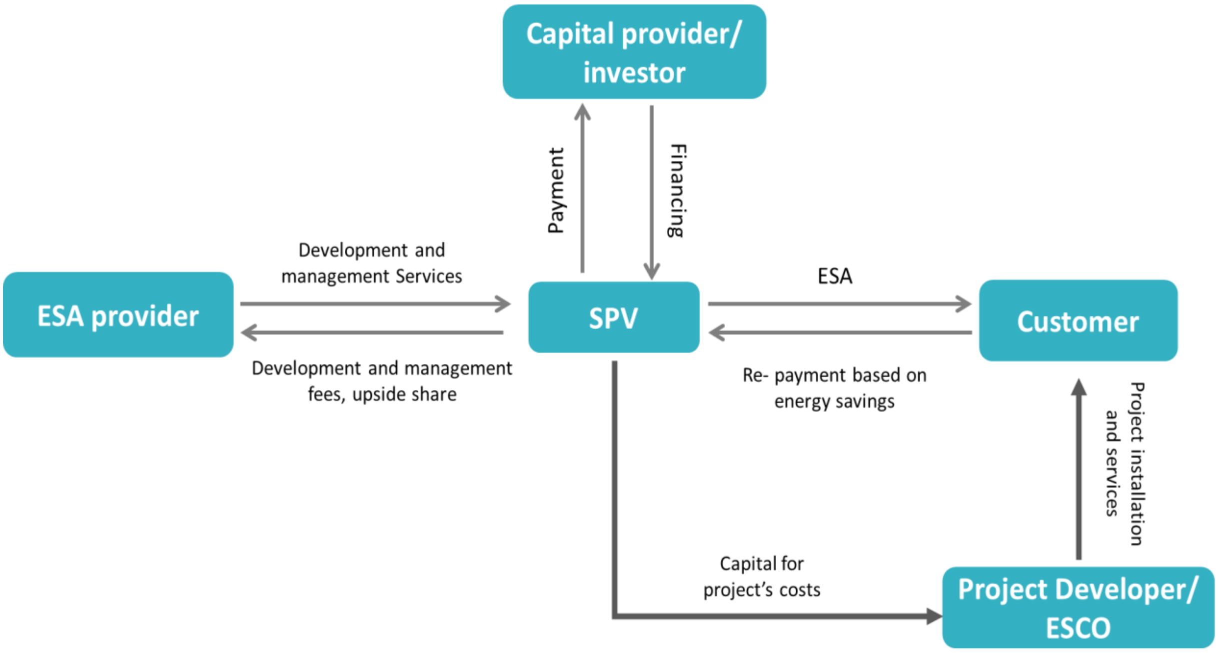

Figure 4: The ESA Structure

Source: **[70]**

The main advantages of ESA are [65]:

1. Not affected by common EE barriers, e.g., split incentives
2. CAPEX is not needed from customer and incentives for the project developer, the customer and the investor are aligned.

The main disadvantages of ESA are [65]:

1. Not suitable for small projects as it presents high transaction costs.
2. Lack of standardization

The ***Managed Energy Service Agreement (MESA)*** is a modification of ESA. The difference between the two models is that in MESA, the provider of the agreement is responsible for the payment of the utility instead of the customer [71]. Similarly to the ESA model, the project developer could be an ESCO. In this scheme, the payments of the customer to the MESA provider are determined upon their historical data on energy consumption [64].

The MESA provider should not be involved in the selection of the utility as a conflict of interest may emerge, due to the fact that MESA providers do not have an interest in choosing the utility with the most competitive price [64]. Thus, the customer undertakes all the negotiations with possible utility providers and choose the one of his interest [64]. The MESA provider bears the performance risk. In **Figure 5**, an overview of the MESA structure is provided.

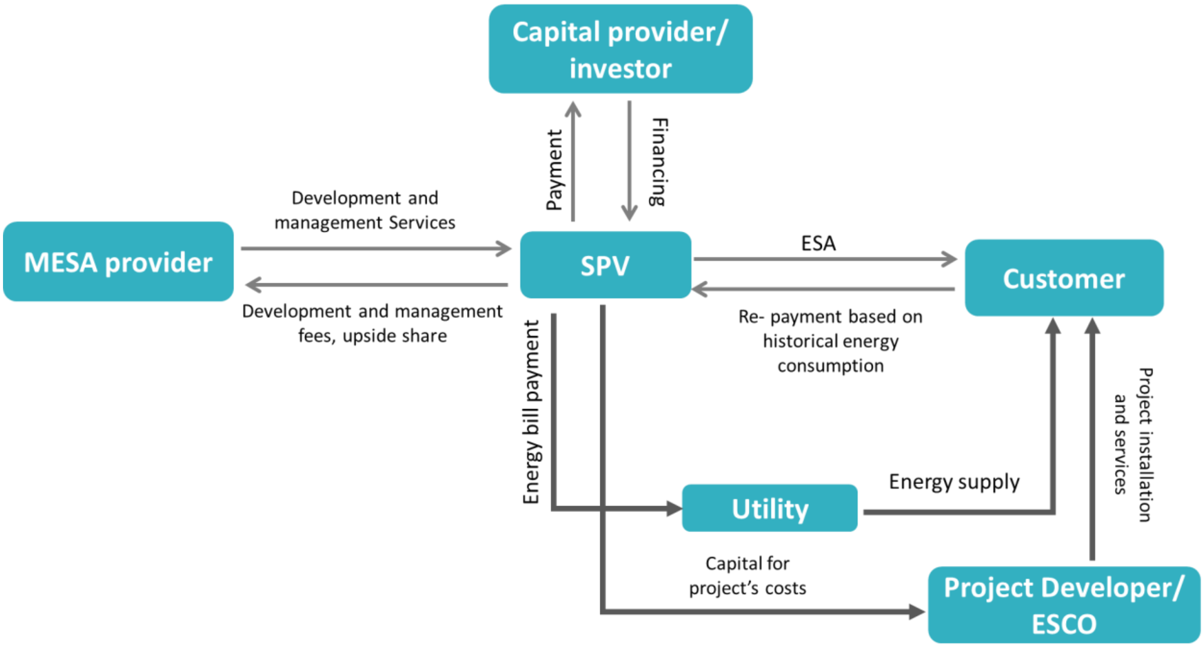

Figure 5: The MESA structure

Source: **[71]**

In **Table 9**, the key points of the ESA and MESA models are compared.

Table 9: Key comparison points between ESA and MESA

	ESA	MESA
Duration	5-15 years	5-15 years
Suitability	Large properties	Large properties
Utility bill payment	Customer	MESA provider
Payments to the ESA/ MESA provider	Based on energy savings	Based on historical energy consumption
Performance risk	ESA provider	MESA provider
Transaction Costs	High	High

8.2 Third party financing

Third party financing (TPF) or third-party investment is an innovative financing scheme in the form of debt financing, where the funding comes from an external source. The third-party could be a FI, an investor or an ESCO, which is not the beneficiary of the EE improvement.

In TPF, a third-party provides the lender with debt and the latter is obliged to repay the capital provided usually with an interest [72]. In this way, the performance risk is undertaken by the lender. On the other hand, in "third-party investment", the EE investment is not carried out by the customer but by the investor, hence the third-party has a claim on the investment and undertakes the investment risk. The TPF scheme can be split into two categories as presented in **Figures 6** and **7**: in the first one, the ESCO is the borrower and in the second the customer is the borrower [73]. In the second type of the presented third-party arrangement, where the customer undertakes a debt obligation, the ESCO also provides an energy savings guarantee (Guarantee Savings model).

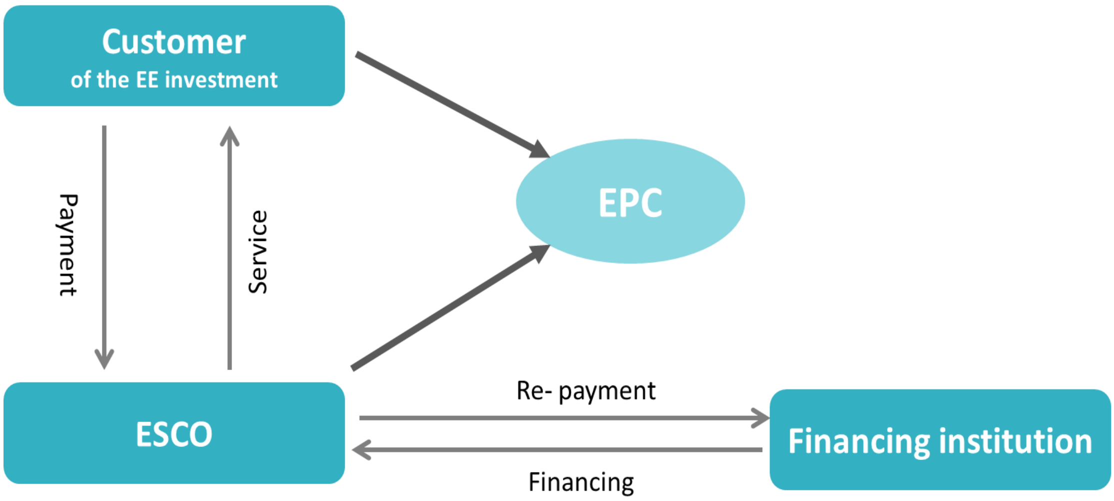

Figure 6: TPF alongside with an EPC agreement with the ESCO as the borrower

Source: **[74]**

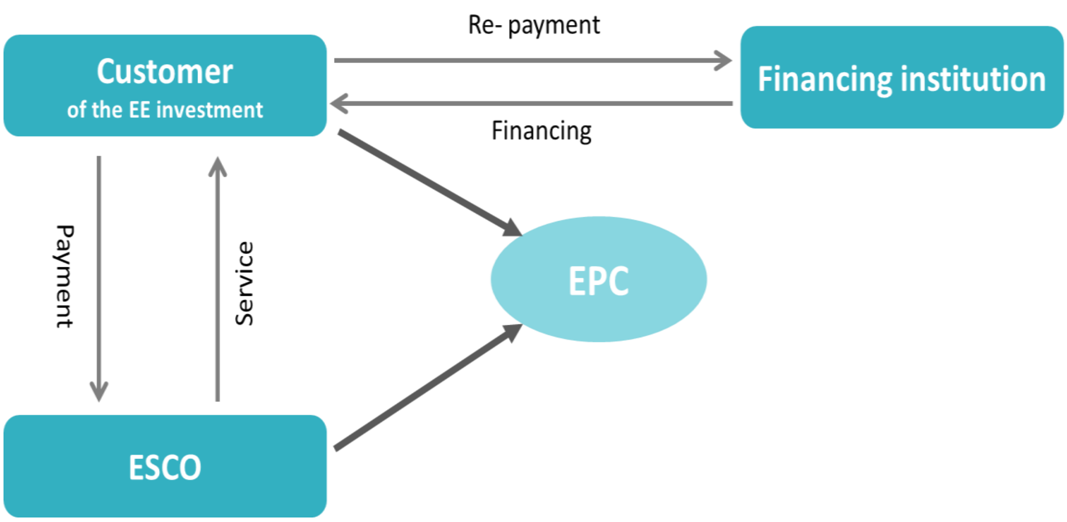

Figure 7: TPF alongside with an EPC agreement with the customer as the borrower

Source: **[74]**

8.3 Soft loans

Soft loans are loans offered with favourable terms, i.e., by decreasing the cost of debt through the subsidization of interest rate with public funds provided by governments or public authorities. Thus, through public funding, soft loans can leverage private funding [65]. Soft loans could possibly entail even zero interest rates at the initial period of the agreement, longer maturity, longer grace period regarding the debt repayment, and lower administrative or insurance costs [75]. This financial instrument has been proven as an efficient financing solution for building renovations especially for the housing sector [72]. The 2015 EEFIG' s report regarding the project finance of EE investments mentions that the relative success of soft loans mainly derives from their retail distribution through private banks [65]. Soft loans can also be distributed by local authorities through revolving funds [63]. It should also be mentioned that soft loans can trigger other incentives for the beneficiaries, e.g., technical assistance for homeowners [75]. The main advantages of soft loans are [65]:

1. Higher leverage effect[1] (between 4 and 10) compared with traditional grants
2. Large flexibility, i.e., applicable both for compound and individual EEMs
3. Capacity of linking with other supporting mechanisms, e.g., revolving funds
4. Easy implementation in contrast to subsidies and grants that are often subject to extensive bureaucracy

The main disadvantages of soft loans are [65]:

1. Dependence on the owner's willingness for debt uptake, which varies between countries
2. Dependence on the risk aversion of the banker, who calls for public funds
3. Risk of greenwashing

8.4 On-bill financing

In ***on-bill financing (OBF)***, the lender (e.g., utilities, the state, or third-parties) provides capital to the borrower for the implementation of an EE or RES investment, while the repayments are usually determined upon the existing bill. The customer's bill will remain the same or decrease as the cash flows generated from the energy savings are equal or greater than the predetermined repayment [76]. This is also known as "bill neutrality", i.e., the end-user will not pay higher utility bills after the implementation of the EE investment. The bill neutrality concept is usually not followed, as it results in longer payback periods for the utility or the FI, which in turn may result in smaller loan amounts [64].

On-bill programs have various structures making it difficult to form a common definition for this mechanism, thus the term "on-bill financing" can be considered as an umbrella term for all these different structures. The RENONBILL EU-funded project, which aims to promote the development and implementation of on-bill schemes, has classified the on-bill mechanisms (i) based on the source of financing, (ii) whether the scheme is associated with the property's meter and whether the utility can be disconnected in case of no payments [64]. Considering the source of financing, two broad categories are found, OBF and on-bill repayment (OBR). Regarding OBF (**Figure 8**), the utility provides the upfront capital needed for the EE investment using own or public funds. The applicable EE investments are usually predetermined, and an energy savings assessment is implemented by the utility [64].

1 The leverage effect is the effect of debt on the return on equity.

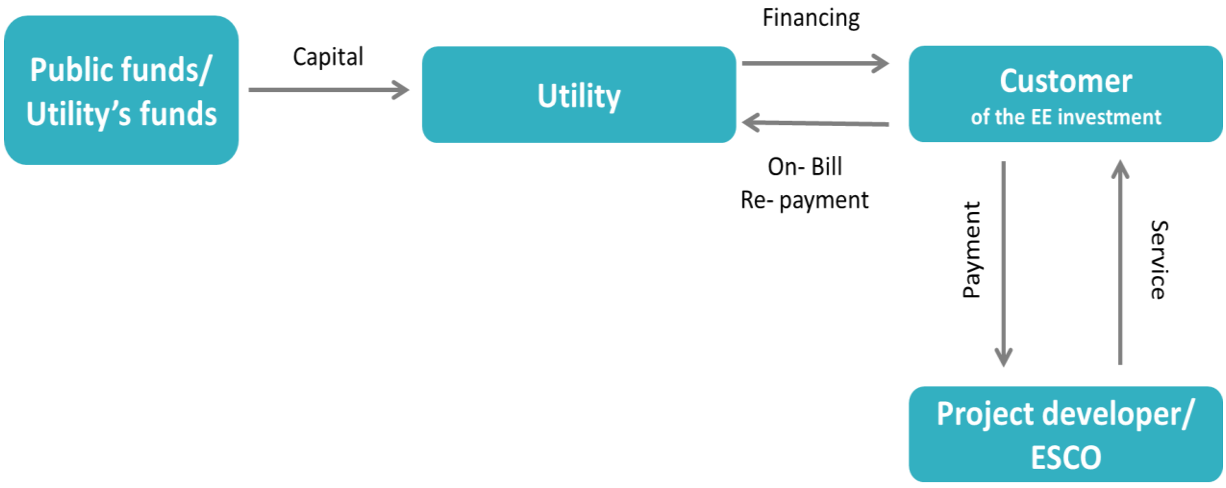

Figure 8: OBF mechanism

Source: **[53]**

As regards OBR, the capital comes from a third-party investor and not the utility, which has the role of the intermediary. Under this scheme, three sub-categories can be identified considering the timing and the way that the third-party financier is involved. In the first category (**Figure 9**), the utility (program administrator) uses a warehousing methodology to receive the funds needed. After providing loans to the customers to implement EE investments, the utility aggregates the loans and sells them to an investor e.g., FI, which can then sell them to financial markets. The loan repayments are handed over to the investor by the utility, which acts as an intermediary [64].

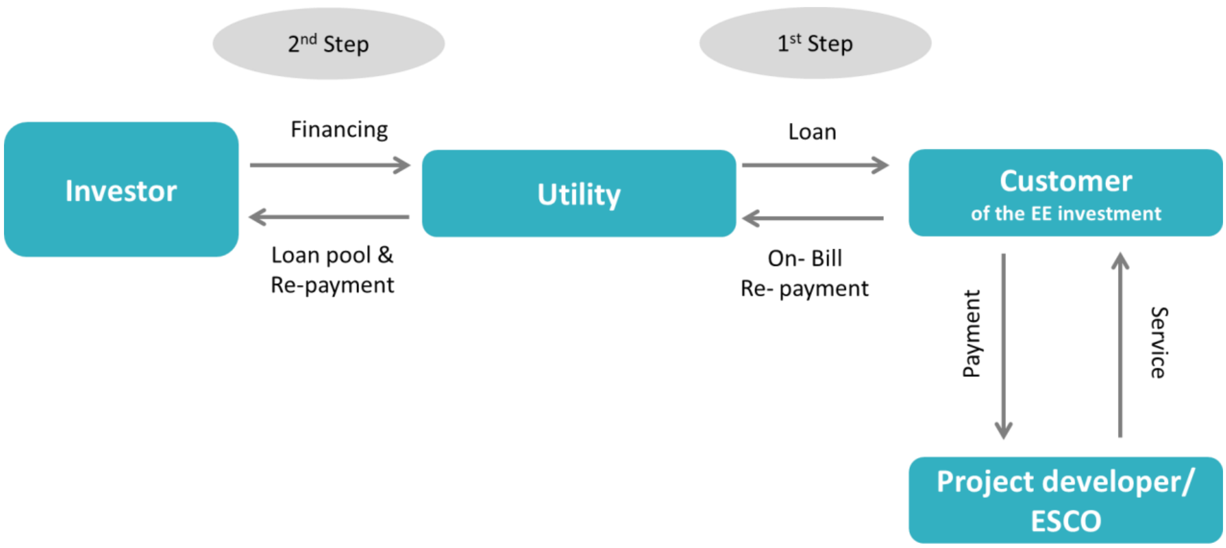

Figure 9: OBR 1st category- warehousing model

Source: **[64]**

In the second category (**Figure 10**), the utility raises capital and then allocates it to OBR requests as loans to facilitate the implementation of EE investments. In this case, the capital needed can be raised through bond issuing by the utility, thus the utility does not use its own capital at all. The loan repayments, collected by the utility through the energy bills, are used to pay back the investors. Similarly, the utility acts as an intermediary [64].

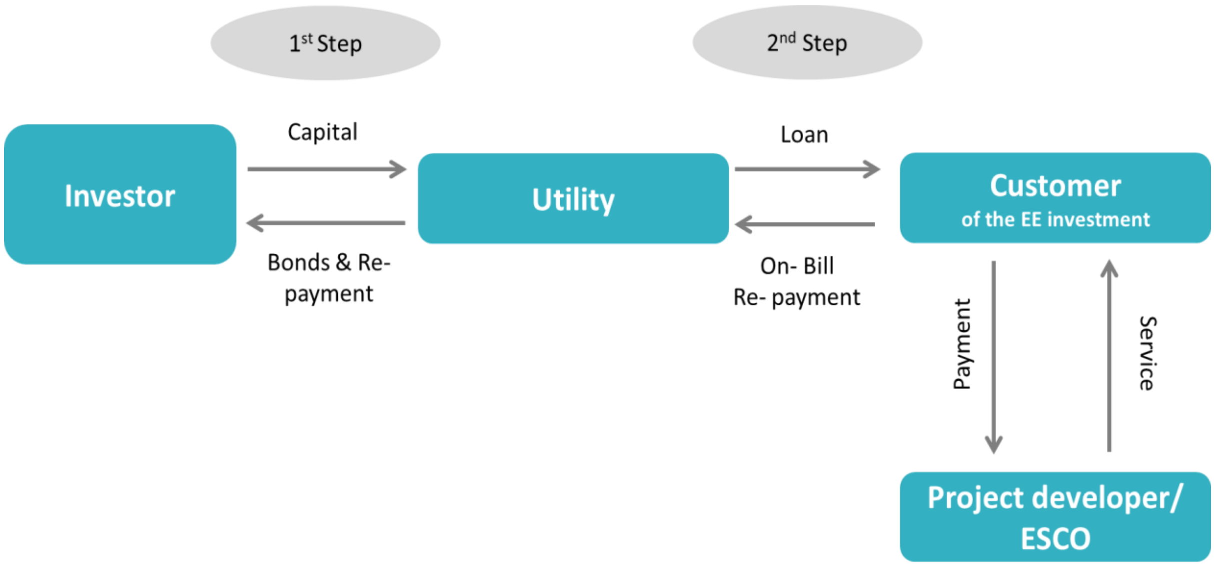

Figure 10: OBR 2nd category- bonds model

Source: [64]

The third category is the open market model (**Figure 11**), where the FI provides loans directly to the customers and then the utility bill is used as the repayment vehicle [64]. An additional coordination agent is needed for the function of this model.

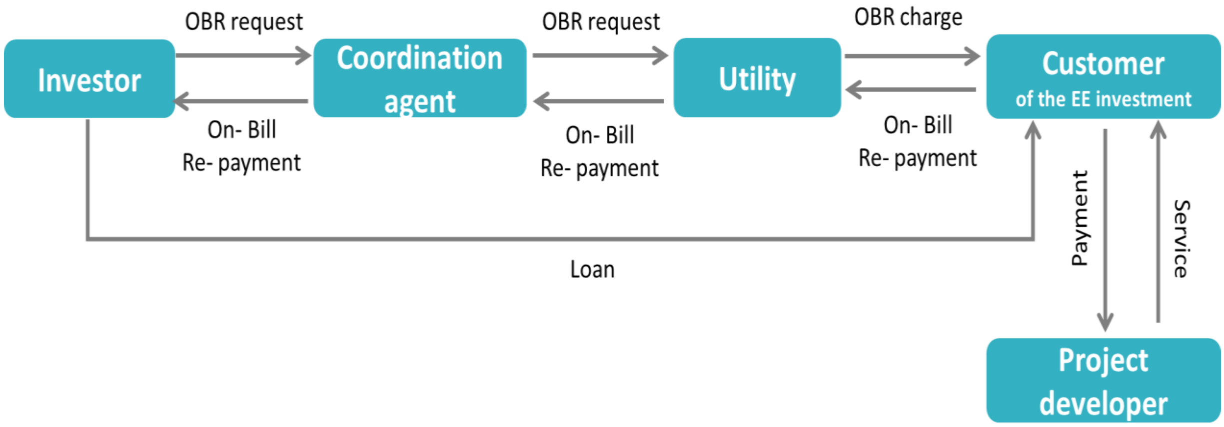

Figure 11: OBR 3rd category- open market model

Source: [64]

The second categorization of the on-bill schemes can be made upon the association with the property's meter and whether the utility service can be disconnected. Three types of schemes are identified by the RENONBILL project. In the 'tariff on-bill' scheme, the utility provides the capital needed for the investment and charges a tariff based on the property's meter. The utility has the right to disconnect the service in case of no payment by the customer. As the tariff is connected to the property, this scheme facilitates the maintenance of the OBF mechanism, even if the property is sold or the tenant changes.

In the context of the 'on-bill loans' scheme, loans are not connected to the property but to the individual who undertakes the loan. The repayments are made through the end-user utility bill and as in the tariff on-bill scheme the utility reserves the right to disconnect the utility service in case of no payment. The third scheme is the 'line item billing', where the repayment is made through the utility bill. The repayments are not based on the property's meter but on the end-user and the utility has no right to disconnect them. In case of no repayment, the FI (loan provider) or the utility reserve the right to recoup their losses according to the contract terms. The main advantages of OBF are [53], [64]:

1. Convenient repayment structure. There is only one bill for the customer to pay. The energy savings are connected to energy bills and so the repayment mechanism is considered easy enough to understand.
2. Low-to-zero interest rates. Flexible repayment terms ranging from 2 to 15 years
3. It can facilitate the cases where split incentives exist as it is tied with the property meter and not the occupant.

The main disadvantages of OBF are [53]:

1. Difficult to implement project aggregation
2. Suitable only for small-scale projects
3. May result in utility disconnection in case of non-repayment

8.5 Property Assessed Clean Energy

Property Assessed Clean Energy (PACE) is an innovative financing model that allows loan repayment through the property tax bill. PACE relates to the property where an EE investment is implemented and not to the individual who implements it. The advantage of this feature lies in the transferability capability, i.e., in case the property is sold, the remaining repayments will be transferred to the next owner.

The capital needed for the implementation of the EE investment is provided either by municipalities or other local administrators, or investors in the form of loans that will be repaid through the property taxes. The duration of this scheme could be over 20 years, resulting in long pay-back periods [77].

There are two main models of PACE programs. The first is the "Municipal Bond Funded" model (**Figure 12**), in which municipalities or governments issue bonds to raise the required capital that will be afterwards turned into loans for EE projects [78]. Then, the payback of the loans is made through property tax repayments of the customers [57].

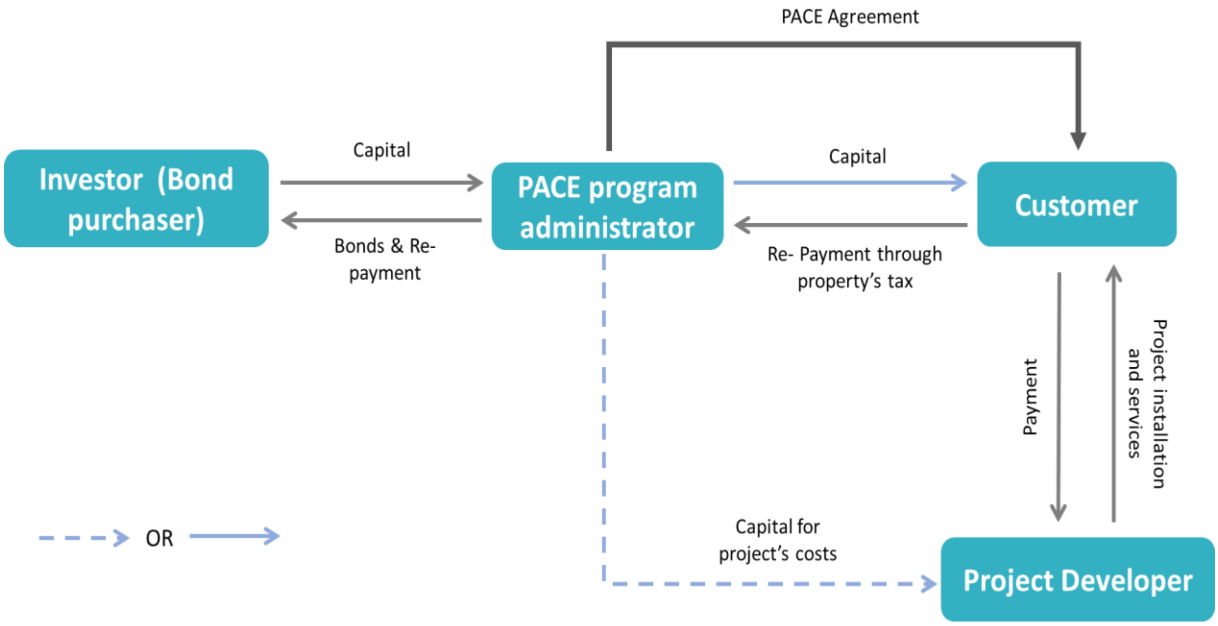

Figure 12: Municipal Bond Funded model structure

Source: **[57]**

The second is the "Privately Funded model" (**Figure 13**), in which capital providers are financing the projects directly and the repayment is conducted through the property's tax [79].

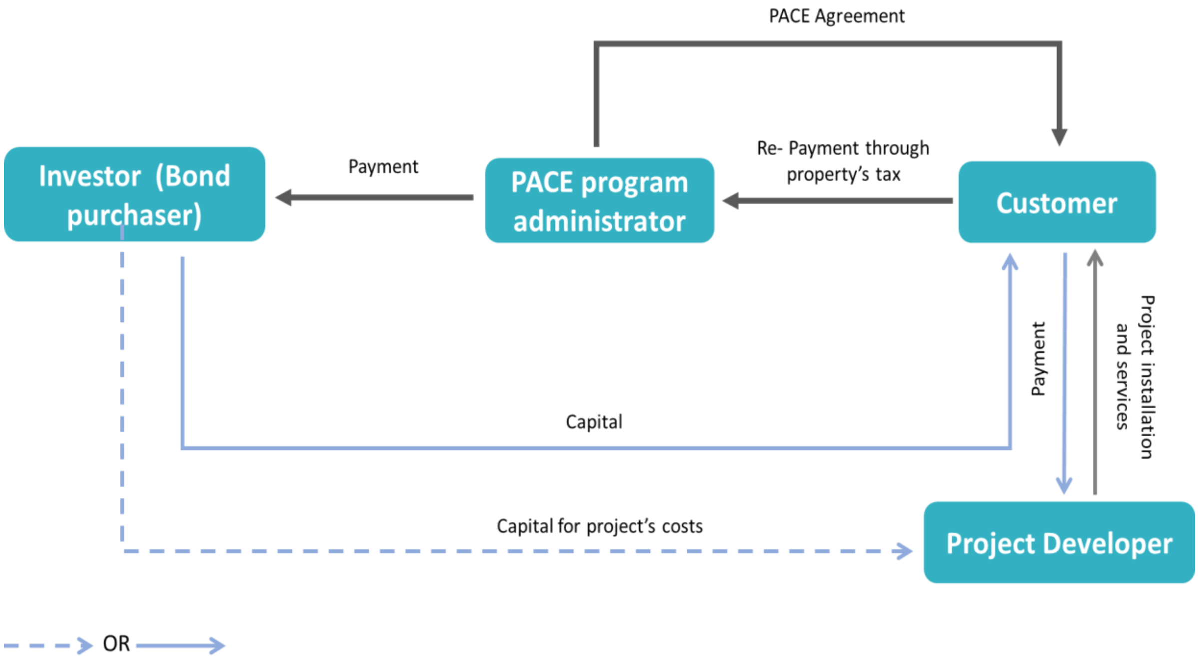

Figure 13: Private Funded Model structure

Source: **[57]**

The PACE scheme is currently implemented in the USA [64]. An initiative that aims to promote the implementation of the PACE mechanism in the EU is the H2020 EuroPACE project [80]. A pilot implementation of the scheme has taken place in Olot, Spain. Furthermore, more pilot regions (i.e., Austria, Belgium, Italy, Poland, Romania) that display more appropriate regulatory frameworks for the implementation of PACE have been identified [81]. The main advantages of PACE are [65]:

1. The customer does not concern about upfront expenditures.
2. No split incentives between the user and the owner, since the scheme is connected to the property
3. Reduces the default risk, as taxes are senior debt
4. Can be implemented using either public or private funds
5. Tied with property, thus in case of sale the loan moves to the next owner

The main disadvantages of PACE are [65]:

1. Occurrence of legal complications regarding lien of the property
2. Mortgage lending could be an issue since, in case of default, PACE loans are paid off before mortgage loans.

8.6 EE Mortgages

EE Mortgages are loan products oriented to facilitating EE investments. There is no uniform structure of EE Mortgages as lenders can present different alternatives to the borrowers [70]. These are usually preferential term offers for mortgages for the purchase of EE properties or the extension of existing mortgages in case the borrower undertakes an EEM. Additionally, EE Mortgages can be used to finance the purchase of houses that will undergo EE renovations [82].

The idea behind EE Mortgages is that after the EE investment the borrower's monthly expenditures for energy will be reduced and so their monthly capacity to repay the loan will be increased. Established savings in utility bills increase the borrower's income, making them eligible for larger loans, because of the decreased debt-to-income ratio [83]. Furthermore, due to the reduced risk of default of the borrower, lenders can offer lower interest rates [70].

An initiative aiming to standardize EE Mortgages in Europe took place under the EU-funded Horizon 2020 EeMAP project [84]. In the context of EeMAP, a pilot scheme was developed to evaluate the implementation of EE Mortgages. The main advantages of EE Mortgages are [82]:

1. Improve the repayment capacity of the borrower
2. Provide access to low-cost capital

The main disadvantages of EE Mortgages are [82]:

1. High transaction costs regarding small-scale projects
2. Require high collateral commitment

8.7 Crowdfunding and cooperatives

Crowdfunding comprises the effort of raising funds to support a project idea collecting investments from many individual investors [61]. Crowdfunding mainly uses web platforms named crowdfunding platforms (CFPs). CFPs are used to present different projects, facilitate the engagement and communication with potential investors, and act as the channel for a donation of capital [85]. Using this financing scheme, actors that may not be eligible for traditional financing solutions like loans can receive funding for their project [86].

There are four different models of crowdfunding: i) donation and ii) reward-based crowdfunding, which are non-financial crowdfunding models, and iii) debt and iv) equity crowdfunding, which are financial crowdfunding models [87]. In donation crowdfunding, the donor does not receive anything in return for his donation, while in reward-based crowdfunding, the crowd investor receives a non-monetary return. In debt crowdfunding, the crowd investor receives a repayment of the lent capital with an interest determined by the risk of the project, and in equity crowdfunding the crowd investor receives a share of profits originated from the financed project, equity in the financed company, etc. [88]. In addition, hybrid crowdfunding models exist through platforms that allow investors to have access to multiple models.

Crowdfunding platforms may follow two different strategies in case the capital target is not reached. They can either return the contributed capital to the various investors or allow the entity that has initiated the crowdfunding campaign to keep the raised capital [89]. In EE investments the most common-used crowdfunding model is the debt model where a certain investment target is set, varying from very small to very large amounts [82]. Debt financing is mainly offered as a subordinated loan which actually shifts the risk of the project to the investors [88]. A typical crowdfunding process is presented in **Figure 14** [88].

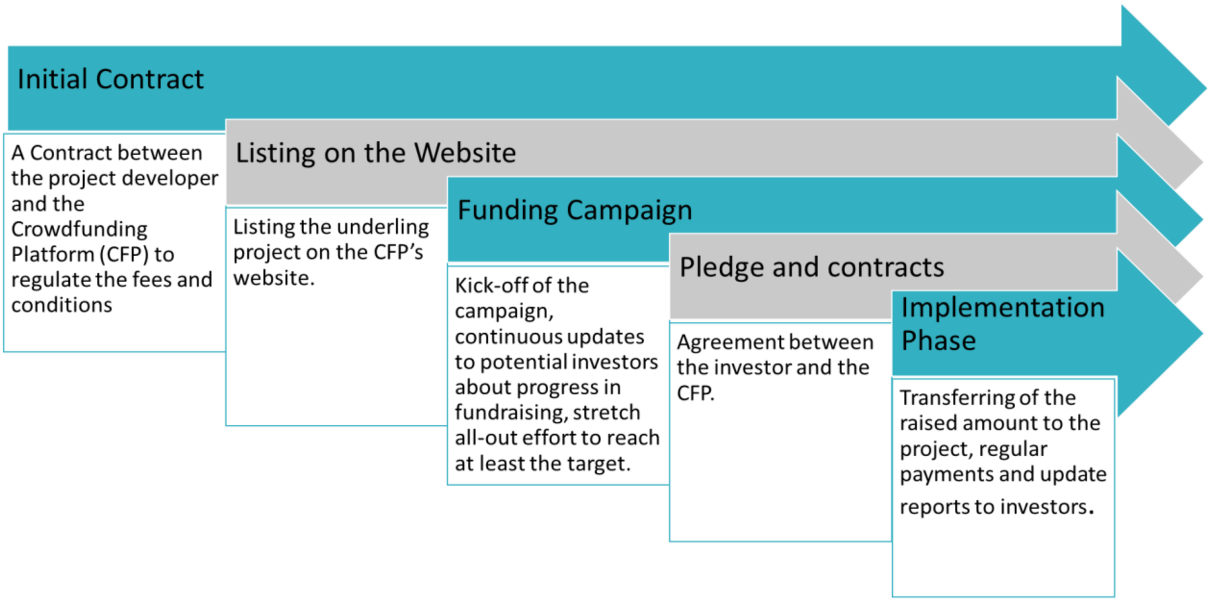

Figure 14: Crowdfunding campaign process

Source: **[88]**

In **cooperatives**, the local community contributes to raising capital and supports EE projects. This scheme is very similar to crowdfunding with the main difference being that energy cooperatives raise capital based on the specific project of the local community. However, cooperatives can use crowdfunding platforms to facilitate the procedure of raising the amount needed so the lines between these two financing schemes are often very soft [82]. The main advantages of crowdfunding and cooperatives are [82], [88]:

1. Crowdfunding's design is considered simple and can be easily disseminated to potential investors since the internet helps for widest market outreach and fund attraction.
2. Both models provide access to finance for consumers not eligible for traditional financing options.

The main disadvantages of crowdfunding and cooperatives are [82]:

1. There is difficulty in reaching funding targets.
2. Investments may be risky, considering the weak regulatory framework for participants.
3. Sometimes, investments are limited to small projects due to very short payback periods.

8.8 Categorization of financing instruments and models

A categorization of the abovementioned financing models and instruments was conducted to compare them according to their project characteristics, namely the type of project, the applicable sectors for the implementation of the project, and the typical size of the project in thousand dollars (**Table 10**), their contract characteristics, i.e., the complexity regarding their contract structure, the involved parties in the contract, the type of payment, the party that undertakes the performance risk, and their typical duration (**Table 11**), as well as their budgetary and asset characteristics, namely the source of budget (operating or capital budget), the ownership of the equipment, and the source of the collateral (**Table 12**).

Table 10: Project characteristics of financing instruments and models

Source: **[53]**

	Project Type	Applicable Sectors	Typical Project Size (thousand dollars)
OBF / OBR	EE RESOther Generation projects	Buildings: Residential & Non-residential Commercial & Industrial, Non-profit, Private Universities/ Schools/ Hospitals Sometimes: Multifamily, Affordable Multifamily[2]	5 - 350
EaaS	EE	Commercial & Industrial, Private Universities/Schools/Hospitals, Multifamily, Non-profit Less Common: Affordable Multifamily, Government	250+ Smaller projects may also be served
EPC	EE	Common: Government, Private Universities/Schools/Hospitals Less Common: Commercial & Industrial, Non-Profit, Multifamily, Affordable Multifamily	1000+ 5000+ may preferred by providers
PACE	EE RES Other Generation projects	Common: Commercial & Industrial, Multifamily, Affordable Multifamily, Non-Profit, Private University/School/Hospital	250+ Some programs

2 Affordable housing refers to housing units that are affordable by that section of society whose income is below the median household income.

		Less Common: Government	serve smaller markets
Commercial Loans	EE RES Other Generation projects	All	Any
Soft Loans	EE RES Other Generation projects	Common: Affordable Multifamily, Non-profit, Private Universities/Schools/Hospitals Less common: Government Uncommon: Commercial & Industrial, Multifamily	Any
Capital Lease	EE RES Other Generation projects	All	Any
Operating Lease	EE RES Other Generation projects	All	Mainly smaller projects, no explicit restrictions
Green Bonds	EE RES Other Generation projects	Common: Commercial & Industrial, Government, Multifamily, Affordable Multifamily Less common: Non-Profit, Private University/School/Hospital	Any (typical minimum issuance 10000)

Table 11: Contract characteristics of financing instruments and models

Source: **[53]**

	Contract Complexity	Parties Involved	Payment Type	Performance Risk	Typical Duration (years)
OBF / OBR	Low	Customer Utility Contractor/ESCO Private Financier (if OBR) Government Funder (if OBF)	Fixed	Borne by customer	2-15
EaaS	Medium	Customer	Variable	Borne by provider	5-15, generally

		EaaS Provider, Contractor/ESCO	Fixed in some structures		does not exceed useful life of the equipment
EPC	High	Customer ESCO Lender/Investor	Fixed Variable payments to ESCO when savings are split, depending on realized savings)		10-20
PACE	Medium; contracts are simple except for the requirement of mortgage lender consent	Building Owner Local Government PACE Administrator Contractor/ESCO Investor(s)	Fixed Variable in some programs	Borne by customer	10-20, shorter terms in some cases, may not exceed the useful life of the equipment
Commercial Loans	Low	Customer Lender	Fixed Variable payments sometimes available	Borne by customer	3-5, flexible
Soft Loans	Medium; depends on program requirements	Customer Lender	Fixed	Borne by customer	3-5, flexible
Capital Lease	Low	Customer Contractor/ESCO Lessor	Fixed	Borne by customer	3-5, flexible
Operating Lease	Low	Customer Contractor/ESCO Lessor	Fixed	Borne by customer	3-5, flexible
Green bonds	High	Customer, Lender, Underwriter, Contractor, Third-party, Certifier and/or Monitor	Typically fixed, but sometimes with flexibility for variable payments	Borne by issuer	3-25

Table 12: Budgetary and asset characteristics of financing instruments and models

Source: **[53]**

	Budget Source	Equipment Ownership	Collateral Source
OBF / OBR	OpEx	Internal[3] unless treated as off-balance sheet	Equipment Service termination
EaaS	OpEx	External[4]	Equipment Discontinuation of service (sometimes) Non-payment of utility bill (MESA)
EPC	CapEx (mainly) OpEx (sometimes)	Internal unless underlying financing is off-balance sheet	Equipment Other customer assets if financed with recourse debt
PACE	CapEx (mainly) OpEx (sometimes)	Internal unless treated as off-balance sheet	Tax Assessment Lien
Commercial Loans	CapEx	Internal	Equipment (non-recourse loan) Mortgage or other assets in addition to equipment (recourse loan)
Soft Loans	CapEx	Internal	Equipment
Capital Lease	CapEx	Internal	Equipment
Operating Lease	OpEx	External	Equipment
Green bonds	CapEx	Internal	Listed in bond terms, sometimes mortgage or other assets

3 Internal refers to equipment typically owned by the customer during the financing term.
4 External refers to equipment typically owned by an outside party, such as the lender or contractor, during the financing term.

9 Conclusions

In the context of the current report, an extended literature review was conducted in order to identify and categorize risk and uncertainty factors that might reduce the profitability of investments and in particular endanger debt repayment. Moreover, a literature review on risk mitigation strategies was conducted to identify relevant risk reduction techniques with respect to risk. Additionally, a literature review of financing instruments and programs was conducted to categorize them with respect to risk, as well as to project, contract, budgetary, and asset characteristics.

This report presents the main EE financing risks and their respective mitigation strategies in five (5) distinct categories: *(i) financial, (ii) behavioural, (iii) energy market and regulatory, (iv) economic, and (v) technology, planning and* operational***.*** The main sectors identified in EE projects include buildings, manufacturing, transportation, district energy networks, and outdoor lighting. The primary project categories are composed of building envelope retrofits, HVAC&R retrofits, lighting appliances' retrofits, automatic control retrofits, RES installations, construction of new buildings, manufacturing-specific retrofits, purchase of new vehicles, district energy networks retrofits/expansion, and outdoor lighting retrofits. Risks are classified into borrower-specific (creditworthiness of the borrower), sector and project category-specific (e.g., rebound effect), country-specific (e.g., energy prices and taxes volatility), and project-specific (e.g., low quality of initial savings assessment), according to their conceptual characteristics. The key findings documented in this report help to establish a clear, unambiguous, and non-overlapping categorization of risk factors that can be quantitatively or qualitatively assessed.

As far as the key barriers to the successful implementation of EE projects are concerned, access to capital and split incentives were identified as the most important ones. Policy measures, such as financial incentives and tax credits for EE investments can be used as a means of dealing with access to capital, while for split incentives regulatory measures and financial mechanisms, like minimum performance standards and financial and fiscal incentives, are recommended.

Regarding the review of risk mitigation strategies, the outcome of this procedure was a risk mitigation typology, which proposes suitable measures for the identified risk factors and risk categories. Indicative measures include collaterals, project aggregation, designing business models regarding energy consumption, hedging, energy savings insurances, etc.

The review of financing instruments showcased that except for debt financing, equity-based financing, and grants/subsidies, alternative financing instruments that should be considered in EE financing are project financing, project aggregation, and EE auctions. Considering EE financing, energy service contracts, TPF, soft loans, OBF, PACE, EE mortgages, crowdfunding, and cooperatives are innovative programs/models that can be put forward to mainstream EE investments.

From the above results, it is evident that there are a plethora of risks with different nature that prevent the profitability and finance of EE projects. Some risk categories are composed of a single risk factor, while others comprise a set of risk factors, requiring a comprehensive analysis. On the other hand, there is a greater consensus regarding the main barriers to the implementation of EE projects. Also, the right selection of risk mitigation measures, financing instruments, and financing programs is considered crucial for successfully implementing EE projects.

This report comprises the final version of the previous deliverable D3.1: Draft Report on Risks of Energy Efficiency Financing and Mitigation Strategies Typology. The results of this report are used as direct input to Task 4.1: Standardized Triple-A Tools and Task 3.2: Assessment of Member States Risk

Profiles and they have been stored in the database developed in Task 3.3: Interactive Web-Based Database on Triple-A Investment.

Regarding Task 4.1, the EE investments from Task 5.1: Pipeline of Energy Efficiency financially attractive projects, are filtered by examining if they are compliant with EU taxonomy based on the identified sectors and project categories of this report. Moreover, the total risk of these investments is calculated based on the risk factors and categories arisen by this report. Additionally, each project is matched to specific mitigation strategies based on the ones identified in this report. As far as Task 3.2. is concerned, the risk of each case study country is evaluated based on the country-specific risk factors identified in this report.

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Appendix A

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Appendix B

Review of Horizon 2020 sustainable financing projects and other EE financing projects

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
LAUNCH	EE financing	Creation of standardized material to promote financing of Sustainable Energy Assets by developing a risk assessment protocol to help project developers to gain access to capital and make investment grade financing contracts	Investor, Project Developer, End-client	**Risks:** exogenous, regulatory, market, energy price, currency, endogenous, technical, performance, O&M, interface, pipeline, prepayment, occupancy, management, construction	EE Finance sector	Hedging the energy price risk, obtaining and maintaining equipment insurances, purchasing performance insurances
IEA	EE financing	Fostering the reduction of banks' perception of risks associated with EE projects and improving such projects' finance-ability by improving their ability to identify, analyze and mitigate risks related to EE	FIs	**Risks**: **Quality of cash flow prediction:** 1. *Development phase*: • Low quality of initial savings assessment • Badly defined baseline 2. *Implementation phase*: • Implementation of low-quality equipment or poor project design 3. *Operation phase*: • Inadequate O&M • Savings cannot be verified • Inadequate risk Sharing • No end-user Participation **Exploitation of cash flows:** • Financial difficulties of contractual partner	Industrial sector	**Removing the risk source**: Accreditation And certification of equipment and suppliers, ESCOs and EPCs: Quality assurance and standardization **Reducing the risk likelihood**: Off balance-sheet-financing and SPVs, Measurement and Verification (M&V) **Sharing the risk**: Insurance Coverage, Guarantee mechanisms

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
				Value and exploitation of assets (technical EE equipment): • Low collateral value		
SPEEDIER	EE financing	Address the barriers that keep low the uptake of energy audits and the implementation of energy conservation measures (ECM) among SMEs by providing a self-financing outsourced energy management service to SMEs	SMEs, energy experts, technology installers, landlords, finance providers	**Barriers**: lack of finance, difficulty in choosing which ECMs to implement, Lack of knowledge regarding procurement of ECMs, lack of time, no control of building.	Manufacturing, services, education, energy, commercial, hospitality, other	
I3CP	EE financing	Unlocking access to financing for the building, industry, district energy and street lighting markets by standardizing how EE projects are developed, documented and measured	Investor (facility owner, energy service company, finance firm, insurance provider, and utility programme)	**Risks**: Contractual risks, budget risks, programme risks/time delays, risks associated with third parties (e.g., equipment suppliers, installers), selection of poor-quality equipment, loss of income generation (e.g., RES generation incentives)	Buildings, industrial sector, district energy sector	
NOVICE	EE financing	Development and demonstration of a new business model in building renovation for the better monetization of EE by consolidating services and subsequent revenue streams from both energy savings and demand response	Energy Service Companies (ESCOs)	**Risks**: **general/debt risk**: credit risk, market risk, cultural norms, currency risk, management risk, pipeline risk, regulatory risk, **performance risk**: repayment risk, technology risk, O&M risk, interface risk, energy price risk.	Buildings	

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
PRODESA	Sustainable financing	Showcase EE and RES projects, utilizing innovative financial tools and attracting private investments	Municipalities	**Risks**: risk of delayed payments, non-compliance with the agreed terms in the EPC, delays in scheduled programs, lack of trained staff for EPC in the public, complex procedure/bureaucracy, standard procedure for validation in the savings, credit risk of the public sector. **Market, legislative and regulatory, information & awareness, financial, technical barriers:** lack of standardized procurement procedures for EPCs in the public sector, lack of financing, lack of best practices examples/implemented projects, no historic data on energy consumption, difficulty on setting the energy baseline.	Public buildings, street lighting	Guarantees in the payment mechanism, low interest rate, insurance of the project or/and of the energy savings
PROSPECT	Sustainable financing	Enablement of peer to peer learning in regional and local authorities in order to finance and implement sustainable energy plans	Cities/ municipalities	**Financial, legal and capacity barriers**: higher upfront cost investments, principal agent issues, lack of information among investors, energy-efficient products are still unfamiliar. **Risks**: risk exposure, Discount rate problems, external benefits are hard to quantify, lack of technical capacity to implement projects, lack of experience on EE technologies	Public and private sector (public and private buildings, transport, cross-sectoral)	
QualitEE	EE financing	Quality certification frameworks for EE services to scale up responsible investment in the building sector	Public and private clients of EE services, facilitators of EE services, ESCOs,	**Regulatory and administrative barriers**, **structural barriers**, **financial barriers:** complexity of concept/lack of information, mistrust of the ESCO industry, raising affordable financing, standardization of M&V, lack of support from the government	Public and private sector	

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
			FIs, government bodies etc.			
BUILDINTEREST	sustainable financing	Enhancement of the attractiveness of investments in EE and sustainability in buildings	Consumers	**Financial/economic barriers**: a) access to capital: initial cost, b) risk exposure, c) discount rate, d) payback time, e) flawed financial models/evaluation issues, f) short term thinking, g) reluctance to finance on-balance sheet, h) asset-based culture in financing, i) low collateral asset value, **Institutional & administrative barriers**: a) high transaction costs, b) large number of decision makers/ market fragmentation / multistakeholder issues, c) burdensome procedures, d) small project size, e) energy prices, f) split incentives, g) conservative construction sector, h) disincentives or vested interests in the status quo.	Buildings Sector	
			Financiers	**Societal barriers**: a) behavioural economics (personal priorities), b) information failure, c) uncertainty associated with energy savings, d) limited insight in current energy performance of buildings, **Policy barriers**: a) lack of enforcement of building energy codes, b) unstable policy, c) lack of administrative capacity to develop EE legislation, d) internal procedures and rules of public budgeting, **Technological barriers**: a) solutions not available yet, b) uncertainty with regard to performance.		

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
CITYnvest	EE financing	Increase of the cities' capacities for Innovative Financing in EE	Local authorities	**Technical know-how barrier**: too little awareness and understanding of the financial support that the EU can provide, **Regulatory/ governance barriers**: high investment volumes for smaller municipalities, pre-studies needed to prepare technical assistance applications are expensive and often local authorities lack the right skills and expertise to prepare the applications on their own. Applications can be only submitted in a limited number of EU languages, **Financial/ regulatory barrier**: structures for connecting different local authorities at national level require financial resources, **Regulatory barriers**: the social benefits provided by Renewable Energy Cooperatives (REScoops) often not recognised and are not considered in tendering processes. This lack of a regulatory framework to encourage local authorities to team up with REScoops does not support the wide replication of this model, **Political barriers.**	Local authorities	

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
EeMAP	EE financing	Creation of a standardised “energy efficient mortgage”, according to which building owners are incentivised to improve the EE of their buildings or to acquire an already EE property	Mortgage receivers	**Market Barriers**: *Customer Experience & Bank Processes*: lack of awareness among consumers/borrowers and lending institutions about EE and the potential value and risk implication of energy performance, potential complexity of journey and additional process costs, lack of coordination of and between all relevant partners, *Asset Eligibility / Impact Reporting*: lack of harmonised framework for impact reporting, fragmentation of energy performance criteria and targets, current lack of robust quantitative evidence linking EE to value and risk, regulatory inconsistencies, *Data & IT*: lack of publicly available and accessible EPC data in a digital format, lack of quality and representative data (limited data history), lack of data tagging, harmonisation (definitions & methodologies) and comparability between financial, valuation & building performance data, dynamic data monitoring and analysis of non-bank data (energy savings and real-time energy consumption), IT system updates and implementation costs	Residential sector	
			Banks	**Risks:** credit risk, market risk, liquidity risk, interest rate, foreign exchange risk, solvency risk, operational risk, hidden risk		

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
ET RISK	Sustainable financing	Provision of research and tools for the assessment of the financial risks and opportunities associated with the transition to a low-carbon economy	Company	**Macroeconomic factors**: price of commodities, GDP per capita growth, exchange rates and interest rates, **external factors**: taxation, regulation and geopolitical changes (such as tax policy changes, strikes or war), investors' confidence and market sentiment, expectations that might change rapidly and without notice, depending on developments specific to individual industries, political uncertainty, changes in general economic conditions that adversely affect the level of demand for the company's products or services, changes in foreign exchange markets, changes in international and domestic financial markets and in the competitive environment, and other factors relating to the foregoing	Automotive sector, Steel sector, Electric Utilities	
			Industry	a) Production & technology, b) Market prices, c) Policy mandates, c) incentives & taxes, d) Unconventional risks		
SEAF	Sustainable financing	Development of a holistic IT Platform to bridge the gap between contractors and investors in Sustainable Energy Assets (SEA)	Asset's owner	**Regulatory barriers:** Accounting Rules for EE Finance in the Public Sector, Energy Performance of Buildings Directive**, Electricity Market Design:** Capacity Mechanisms, EUROSTAT accounting rules to the finance of public projects	Buildings sector (Sustainable energy assets)	Building automation and control (crucial component of demand response), Smart Financing, reduction of transaction costs and risks, enhancement of bankability, enhancement of investors' confidence through innovative and relevant asset valuation methodologies
CRREM	sustainable financing	Development of a tool that will allow investors in the commercial real estate sector	Investor	**Transition risks:** Policy and legal, technology, market, reputation, **Physical risks:** Acute, chronic	Commercial real estate sector	Implementation of a retrofit project to reduce energy consumption (real estate

EU Horizon 2020 Projects	Topic	Project Description	Perspective	Risks/Barriers	Sectors	Risk Mitigation Strategies
		to analyse the risks of stranded assets due to low energy performance and to reallocate investment into more energy efficient buildings				investment perspective), insurance contracts, diversification of the assets that are at risk of becoming stranded due to regulatory changes, not investing in inefficient properties that need retrofitting, or even disposing of inefficient assets

Appendix C

List of economic activities covered by EU Taxonomy

NACE Macro-sector	Activities
Agriculture, forestry and fishing	Growing of perennial crops Growing of non-perennial crops Livestock production Afforestation Rehabilitation, Restoration Reforestation Existing forest management
Construction and real estate activities	Construction of new buildings Renovation of existing buildings Individual renovation measures, installation of renewables on-site and professional, scientific and technical activities Acquisition of buildings
Electricity, gas, steam and air-conditioning supply	Production of Electricity from Solar PV Production of Electricity from Concentrated Solar Power Production of Electricity from Wind Power Production of Electricity from Ocean Energy Production of Electricity from Hydropower Production of Electricity from Geothermal Production of Electricity from Gas Combustion Production of Electricity from Bioenergy Transmission and Distribution of Electricity Storage of Energy Manufacture of Biomass, Biogas or Biofuels Retrofit of Gas Transmission and Distribution Networks District Heating/Cooling Distribution Installation and operation of Electric Heat Pumps Cogeneration of Heat/cool and Power from Concentrated Solar Power Cogeneration of Heat/cool and Power from Geothermal Energy Cogeneration of Heat/cool and Power from Gas Combustion Cogeneration of Heat/cool and Power from Bioenergy Production of Heat/cool from Concentrated Solar Power Production of Heat/cool from Geothermal Production of Heat/cool from Gas Combustion Production of Heat/cool from Bioenergy Production of Heat/cool using Waste Heat
ICT	Data processing, hosting and related activities Data-driven solutions for GHG emissions reductions

NACE Macro-sector	Activities
Manufacturing	Manufacture of Low carbon technologies
Manufacturing	Manufacture of Cement
Manufacturing	Manufacture of Aluminium
Manufacturing	Manufacture of Iron and Steel
Manufacturing	Manufacture of Hydrogen
Manufacturing	Manufacture of other inorganic basic chemicals
Manufacturing	Manufacture of other organic basic chemicals
Manufacturing	Manufacture of fertilizers and nitrogen compounds
Manufacturing	Manufacture of plastics in primary form
Transportation and storage	Passenger rail transport (interurban)
Transportation and storage	Freight rail transport
Transportation and storage	Public transport
Transportation and storage	Infrastructure for low carbon transport
Transportation and storage	Passenger cars and commercial vehicles
Transportation and storage	Freight transport services by road
Transportation and storage	Interurban scheduled road transport
Transportation and storage	Inland passenger water transport
Transportation and storage	Inland freight water transport
Transportation and storage	Construction of water projects
Water, sewerage, waste and remediation	Water collection, treatment and supply
Water, sewerage, waste and remediation	Centralized Wastewater treatment systems
Water, sewerage, waste and remediation	Anaerobic Digestion of Sewage sludge
Water, sewerage, waste and remediation	Separate collection and transport of non-hazardous waste in source segregated fractions
Water, sewerage, waste and remediation	Anaerobic digestion of bio-waste
Water, sewerage, waste and remediation	Composting of bio-waste
Water, sewerage, waste and remediation	Material recovery from waste
Water, sewerage, waste and remediation	Landfill gas capture and energetic utilization
Water, sewerage, waste and remediation	Direct Air Capture of CO_2
Water, sewerage, waste and remediation	Capture of Anthropogenic Emissions
Water, sewerage, waste and remediation	Transport of CO_2
Water, sewerage, waste and remediation	Permanent Sequestration of captured CO_2

Appendix D

Checklists with the technical screening criteria

Checklist for "Buildings"

EU taxonomy defines:

- Individual building renovation measures:

The individual building renovation measures are eligible if compliant with the energy performance standards set for individual components and systems in the applicable building regulations transposing the Energy Performance Building Directive (EPBD).

- Major Renovations:

A renovation is compliant with energy performance standards set in the applicable building regulations for major renovations transposing the Energy Performance of Buildings Directive (EPBD) or the renovation achieves energy savings of at least 30% in comparison to the baseline performance of the building before the renovation.

- Construction of new buildings:

A new building is eligible when it meets national requirements for the nearly zero-energy buildings (NZEB) and its level of energy performance equivalent to the EPC rating of B (or above).

Is your investment Taxonomy compliant? Yes No

Checklist for "Manufacturing of hydrogen"

EU taxonomy defines:

The following thresholds need to be met:

- Direct CO_2 emissions from manufacturing of hydrogen: 0.95 tCO_2e/t Hydrogen
- Electricity use for hydrogen produced by electrolysis is at or lower than 50 MWh/t Hydrogen
- Average carbon intensity of the electricity produced that is used for hydrogen manufacturing is at or below 100 gCO_2e/kWh

Metrics:

- GHG emissions per unit of production: tCO_2e/t Hydrogen
- Performance for electricity use: MWh/t Hydrogen
- Emissions factor, GHG emissions per unit of production for the electricity used: gCO_2e/kWh

Is your investment taxonomy compliant? Yes No

Checklist for "Manufacturing of iron and steel"

EU taxonomy defines:

- Manufacture of iron and steel is eligible if the GHG emissions associated to the production processes are lower than the values of the related EU-ETS benchmarks:
    1. Hot metal = 1.328 tCO_2e/t product
    2. Sintered ore = 0.171 tCO_2e/t product
    3. Iron casting = 0.325 tCO_2e/t product
    4. Electric Arc Furnace (EAF) high alloy steel = 0.352 tCO_2e/t product
    5. Electric Arc Furnace (EAF) carbon steel = 0.283 tCO_2e/t product
- All production of steel in Electric Arc Furnace (EAF) using at least 90% of scrap steel is considered eligible.

Metrics:

- *GHG emissions: (tCO_2e) / t product*
- *GHG emissions must be calculated according to the methodology used for EU-ETS benchmarks*

Is your investment taxonomy compliant? Yes No

Checklist for "Manufacturing of aluminium"

EU taxonomy defines:

- Manufacture of primary aluminium is eligible if:
    1. Direct emission for primary aluminium production is at or below 1.514 tCO_2e/t.
    2. Electricity consumption for electrolysis is at or below 15.29 MWh/t.
    3. Average carbon intensity of the electricity that is used for primary aluminium production (electrolysis) is at or below 100 g CO_2e/kWh.
- No thresholds apply on manufacture of secondary aluminium (i.e., production of aluminium from recycled aluminium).

Metrics:

- *GHG emissions per unit of production: tCO_2e/t aluminium (Direct emissions)*
- *Energy Efficiency for the electrolysis: MWh/t primary aluminium production*
- *Average GHG emissions associated to the electricity production per unit of electricity used: gCO_2e/kWh (Indirect emissions)*

Is your investment taxonomy compliant? Yes No

Checklist for "Manufacturing of cement"

EU taxonomy defines:

Thresholds for cement Clinker (A) are only applicable to cement clinker plants that are not producing finished cement (no cement mills). All other plants need to meet the thresholds for cement (B). For production of alternative binders only threshold (B) needs to be met.

- Cement clinker (A): Specific emissions associated to the clinker production processes are lower than 0.766 tCO_2e/t of clinker.
- Cement (B): Specific emissions associated to the clinker and cement production processes are lower than 0.498 tCO_2e/t of cement.

- GHG emissions must be calculated according to the methodology used for EU ETS benchmarks.

Metrics:

(A) Specific emissions (tCO_2e/t of clinker)

- *(B) Specific emissions (tCO_2e/t of cement or alternative binder)*
- *GHG emissions must be calculated according to the methodology used for EU ETS benchmarks.*

Is your investment taxonomy compliant? Yes No

Checklist for "Manufacturing of low carbon technologies"

EU taxonomy defines:

Manufacture of vehicles, fleets and vessels must meet the following criteria:

- Passenger cars, light commercial and Category L vehicles: zero tailpipe emission vehicles (e.g., electric, hydrogen) or vehicles with tailpipe emission intensity of max 50 g CO_2/km (WLTP) (Until 2025).
- Heavy Duty Vehicles (N2 and N3 vehicles as defined by REGULATION (EU) 2018/858): Zero direct emission heavy-duty vehicles that emits less than 1g CO_2/kWh (or 1g CO_2/km for certain N2 vehicles)
- Low-emission heavy-duty vehicles with specific direct CO_2 emissions of less than 50% of the reference CO_2 emissions of all vehicles in the same sub-group.
- Rail Fleets: Zero direct emissions trains.
- Urban, suburban and interurban passenger land transport fleets: Zero direct emissions land transport fleets (e.g., light rail transit, metro, tram, trolleybus, bus and rail).
- Water transport: Zero direct emissions waterborne vessels.

Manufacture of energy efficient equipment for buildings and their key components must meet the following criteria:

- High efficiency windows (U-value better than 0.7 W/m^2K)
- High efficiency doors (U-value better than 1.2 W/m^2K)
- Insulation products with low thermal conductivity (lambda <= 0.045 W/mK, external cladding with U-value < 0.5 W/m2K and roofing systems with U-value < 0.3 W/m2K).
- Hot water fittings, household appliances, high efficiency lighting appliances, highly efficient space heating and domestic hot water systems, highly efficient cooling and ventilation systems rated in the top available class as defined by the respective European regulation.

Metrics:

- WLTP: Worldwide Harmonized Light Vehicle Test Procedure
- CO_2 emissions per vehicle kilometer: gCO_2/km
- CO_2 emissions per kilowatt-hour: gCO_2/kWh
- Watts conducted per meter, per degree of temperature difference (Kelvin) between one side and the other: W/mK
- Watts conducted per meter squared, per degree of temperature difference (Kelvin) between one side and the other: W/m^2K)

Is your investment taxonomy compliant? Yes No

Checklist for "Manufacturing of fertilizers and nitrogen compounds"

EU taxonomy defines:

- Manufacture of nitric acid is eligible if the GHG emissions associated to the production processes are lower than 0.302 tCO_2e/t.
- Manufacture of ammonia is eligible if the two following thresholds are met:
  1. Scope 1 emissions lower than 1 tCO_2/t Ammonia and
  2. Combined CO_2 emissions (scope 1 emissions and scope 2 emissions, from electricity consumed) lower than 1.3 tCO2/t Ammonia

Metrics:

- *Emission factor Nitric acid: tCO_2e/t Nitric acid*
- *Ammonia:*
  a. *Scope 1 emissions: tCO_2/t Ammonia*
  b. *Combined CO_2 emissions (scope 1 emissions and scope 2 emissions, from electricity consumed): tCO_2/t Ammonia.*
- *Scope 1 emissions: All Direct Emissions from the activities of an organisation or under their control.*
- *Scope 2 emissions: Indirect Emissions from electricity purchased and used by the organisation.*
- *GHG emissions must be calculated according to the methodology used for EU-ETS benchmarks.*

Is your investment taxonomy compliant? Yes No

Checklist for "Manufacturing of other inorganic basic chemicals"

EU taxonomy defines:

- Manufacture of carbon black and soda ash are eligible if the GHG emissions associated to the production processes are lower than the values of the related EU-ETS benchmarks:
  1. For carbon black: 1.954 tCO_2e/t
  2. For soda ash: 0.843 tCO_2e/t
- Manufacture of chlorine is eligible if the two following thresholds are met:
  1. Electricity use for chlorine manufacturing is at or lower than 2.75 MWh/t Chlorine.
  2. Average carbon intensity of the electricity that is used for chlorine manufacturing is at or below 100 gCO_2e/kWh.

Metrics:

- *Carbon black and soda ash:*
  - *GHG emissions (tCO_2e)/t product*
  - *GHG emissions must be calculated according to the methodology used for EU-ETS benchmarks*
- *Chlorine:*
  - *Electricity use: MWh/t Chlorine*
  - *Carbon intensity of the electricity that is used for chlorine manufacturing: gCO_2e/kWh*

Is your investment taxonomy compliant? Yes No

Checklist for "Manufacturing of other organic basic chemicals"

EU taxonomy defines:

- ETS product benchmarks for the manufacturing of the chemicals covered in this activity (except for the organic metals) are:
    1. for HVC: 0.702 tCO_2e/t
    2. for aromatics: 0.0295 tCO_2e/t
    3. for vinyl chloride: 0.204 tCO_2e/t
    4. for styrene: 0.527 tCO_2e/t
    5. for ethylene oxide/ethylene glycols: 0.512 tCO_2e/t
    6. for adipic acid 2.79 (allowances/t).
- For organic metals the following criterion shall apply:
    a. the manufacturing of the organic chemicals shall be wholly or partially based on renewable feedstock and,
    b. the carbon footprint shall be substantially lower compared to the carbon footprint of the same chemical manufactured from fossil fuel feedstock, calculated in accordance with ISO 14067:2018 and validated by a third party.

Metrics:

- *Emission factor: GHG emissions (tCO_2e) / t product*
- *GHG emissions must be calculated according to the methodology used for EU-ETS benchmarks.*

Is your investment taxonomy compliant? Yes No

Checklist for "Public Transport"

EU taxonomy defines:

<u>Public transport:</u>

- Zero direct emissions land transport activities (e.g., light rail transit, metro, tram, trolleybus, bus and rail) are eligible.
- Other fleets are eligible if direct emissions are below 50 gCO_2e/pkm until 2025 (non-eligible thereafter).

Metrics:

- *CO_2 emissions per passenger - kilometre: gCO_2e/pkm*

Is your investment taxonomy compliant? Yes No

Checklist for "Passenger cars and light commercial vehicles"

EU taxonomy defines:

<u>Passenger cars and light commercial vehicles:</u>

- Zero tailpipe emission vehicles (incl. hydrogen, fuel cell, electric) are automatically eligible.

- Vehicles with tailpipe emission intensity of max 50 g CO_2/km (WLTP) are eligible until 2025.
- From 2026 onwards only vehicles with emmission intensity of 0gCO_2/km (WLTP) are eligible.

Category L vehicles (2- and 3-wheel vehicles and quadricycles):

- Only zero tailpipe emission vehicles (incl. hydrogen, fuel cell, electric) are eligible.

Metrics:

- *CO_2 emissions per vehicle kilometre: gCO_2/km*
- *WLTP: Worldwide Harmonized Light Vehicle Test Procedure*

Is your investment taxonomy compliant? Yes No

Checklist for "District heating/cooling distribution"

EU taxonomy defines:

Construction and operation of pipelines and associated infrastructure for distributing heating and cooling is eligible if the system meets the definition of efficient district heat/cool systems in the EU Energy Efficiency Directive.

The EU Energy Efficiency Directive defines "efficient district heating and cooling" as a district heating or cooling system using at least 50% renewable energy, 50% waste heat, 75% cogenerated heat or 50% of a combination of such energy and heat.

Is your investment taxonomy compliant? Yes No

Checklist for "Installation and operation of electric heat pumps"

EU taxonomy defines:

The following thresholds need to be met:

- Refrigerant: GWP <10
- SCOP > 3.33

Metrics:

- *GWP: Global Warming Potential*
- *SCOP: Seasonal Coefficient of Performance: the overall coefficient of performance of the unit, representative for the whole designated heating season, calculated as the reference annual heating demand divided by the annual electricity consumption for heating.*

Is your investment taxonomy compliant? Yes No

Checklist for "Cogeneration of Heating/Cooling and Power"

EU taxonomy defines:

Any combined heat and power generation technology is eligible if the facility is operating at less than the weighted cogeneration threshold and it can also be demonstrated, using an ISO 14044-compliant Life Cycle of Emissions (LCE) assessment.

- The Weighted Cogeneration Threshold is calculated from the relative production of heat and power, and based on the declining power generation threshold of 100 gCO_2e/kWh_e, and a notional heat threshold of 30 gCO_2e/kWh_{th}
- Weighted CHP threshold: $(30 * P_{th} + 100 * P_e) / (Pth+ P_e)\ gCO_2e/kWh_{th+e}$

**Concentrated solar power is always eligible.*

Metrics:

a. *Thermal energy (P_{th}): thermal Kilo-watt-hours (kWh_{th})*
b. *Electricity (P_e): electric Kilo-watthours (kWh_e)*
c. *CO_2 emissions per 1 kWh of thermal energy: g CO_2e/kWh_{th}*
d. *CO_2 emissions per 1 kWh of electricity: g CO_2e/kWh_e*
e. *CO_2 emissions per 1 kWh of thermal energy and electricity: g CO_2e/kWh_{th+e}*

Is your investment taxonomy compliant? Yes No

Checklist for "Production of Heating/Cooling"

EU taxonomy defines:

Any heating or cooling generation technology is eligible* if life cycle impacts for producing 1 kWh of thermal energy are below 30g CO_2e/kWh, declining to 0 g CO_2e/kWh by 2050 and it can also be demonstrated, using an ISO 14044-compliant Life Cycle of Emissions (LCE) assessment.

**Concentrated solar power is always eligible.*
**Recovery of waste heat is always eligible.*

Metrics:

CO_2 emissions per 1 kWh of thermal energy: g CO_2e/kWh

Is your investment taxonomy compliant? Yes No

Checklist for "Outdoor Lighting"

The following thresholds need to be met:

- The Power Density Indicator (PDI) of the renovated system should be at least 40% lower than the one of the existing system.
- The Annual Energy Consumption Indicator (AECI) of the renovated system should be at least 500% lower than the one of the existing system.
- Luminaire energy efficiency:
  - If colour temperature ≥ 4000K: Luminaire energy efficiency ≥ 120 lm/W
  - If colour temperature ranges between 2700K – 3000K: Luminaire energy efficiency ≥ 105 lm/W
  - If colour temperature ≤ 2000K: Luminaire energy efficiency ≥ 80 lm/W
- LED module energy efficiency ≥ 160 lm/W
- Power factor:
  - For full load: cos phi ≥ 0.9
  - For 50% of load: cos phi ≥ 0.8
- Colour temperature:
  - For domestic areas and mainly pedestrian areas: Colour temperature ≤ 3000 K

  - For main roads, motorways and areas with mixed traffic: Colour temperature ≤ 4000 K
- Colour rendering (R_a):
  - For roads with mixed traffic including cyclists and pedestrians: $R_a \geq 80$
  - For main roads and motorways: $R_a \geq 70$
- Colour consistency: within 5 MacAdams-Ellipses at the time of putting into operation.
- Luminance and illuminance, light distribution: according to EN13201
- Average rated life, rated life and time to abrupt failure: better than L80 ≥ 60,000h, L80B10 ≥ 60,000h
- LED Luminaire lifetime: ≥ 60.000 hrs (min L80B10 & F10)

Metrics:

- Luminaire/LED energy efficiency: Lumens per Watt (lm/W)
- Colour temperature: Kelvin (K)

Sources:

1. Road lighting - Part 5: Energy performance indicators, CSN EN 13201-5, 2015
2. LED Street Lighting Procurement & Design Guidelines– Austrian Energy Agency, 09/2017 developed for "Premium Light Pro" Project, received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 695931

Is your investment compliant? Yes No