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SUPER-i

D3.3 Implementation of financial schemes for social housing – first version

1.1.1. Authors: Paola Zerilli (UoY), Ahmed Djeddi (UoY), Tom Staw (ELE), Dolores Mainar Toledo (CIRCE), Daniel Galera Alquegui (CIRCE), Martina Di Gallo (CIVI)

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2. Technical references

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0.3	25/08/2022	CIVI	Review
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3. Executive Summary

This deliverable describes the SUPER-i project methodology finalised to the implementation of relevant financial schemes tailored to the specific needs of the proposed energy efficiency interventions for the SUPER-i project pipelines. The SUPER-i analysis is implemented at 3 levels:

1. Energy savings
2. Financial
3. Environmental and Social.

The report is organised as follows:

- **Section 1** covers the creation of a data form in partnership with the SUPER-i coalition housing associations, that would allow us to assess the energy savings that proposed improvements to their buildings would produce. We then discuss the creation of a model to generate energy usage estimates from this data, its methodology, data sources, validation, and additional outputs that can be output by the model, including fuel and country specific cost and emissions savings.
- **Section 2** investigates and evaluates the profitability and viability of the PPP initiatives in Italy, Denmark, and Slovenia, using Discounted Cash Flow approach, which summarises the cash in flow and cash out flow of each PPP initiative, the Net Present Value of each investment in each country, to determine the profitability and viability of the PPP investment, and the Return on Investment to check the prospect, explore potential returns, assist in understanding and measuring the financial benefits of the PPP investments, and lastly the benefit-cost analysis of the energy and CO2 emission savings for 10 years, and 30 years.
- **Section 3** usage phases (LCA stages) are analysed before and after implementing the proposed solutions for the SUPER-i project pipelines. This analysis is introduced by a brief overview of the application of the Life Cycle Assessment in the different pipelines' countries.

4. Introduction

4.1. Scope of the deliverable

This deliverable focuses on assessing the potential energy efficiency gains through a range of retrofits and upgrades across the SUPER-i pipelines. In this comprehensive analysis, we discuss the modeling of the associated costs and benefits of these interventions and explore additional steps to further reduce energy costs and enhance the standard of living. While detailed discussions on the latter interventions are pending with the pipeline consortia due to potential challenges in planning, technical aspects, costs, and resident disruptions, they have been meticulously modeled and compared alongside the selected interventions.

4.2. Objectives of the deliverable

- Develops and examine a building energy model capable of evaluating the potential savings achievable by the pipeline schemes through the SUPER-i proposed Energy Efficiency (EE) refurbishments. The model will be made publicly accessible on the SUPER-i website, facilitating housing associations (HAs) across Europe to evaluate the economic case for renovations within their respective building stocks.

- Conducts a comprehensive financial analysis of the profitability of implementing the proposed SUPER-i EE renovations in Italy, Denmark, and Slovenia, focusing on the application of PPP funding scheme to raise the necessary funds to cover the investment costs of implementing the energy efficiency (EE) projects. The assessment employs a Discounted Cash Flow (DCF) approach, considering cash inflows and outflows, Net Present Value (NPV), Return on Investment (ROI), and cost-benefit analysis of energy and CO_2 emission savings over 10 and 30-year windows. The DCF formula is utilized, incorporating the weighted average cost of capital as the discount rate. This method estimates the present value of profits from investing in EE renovation projects.

- Provides an overview of the study, focusing on the Life Cycle Assessment (LCA) stages before and after implementing proposed solutions for different pipelines. The analysis encompasses the application of LCA in various countries with a brief prelude to the results. This deliverable examines the usage phases (LCA stages) of different pipelines, considering the period before and after implementing proposed solutions. It offers insights into the sustainability assessment of buildings by evaluating various environmental and social aspects.

4.3. Main findings of the deliverable:

The results presented for the pipelines illustrate the potential impact of energy efficiency interventions. In Denmark, where triple-glazing and decentralized heat recovery systems are proposed, estimated savings range from €60 to €240 per dwelling per year. In Italy, renovations of 50-year-old buildings are expected to result in significant thermal efficiency improvements, with heating demand reductions of 35-40% for walls, 15% for windows, and 10% for roofs. In Slovenia, a 2005 housing block, already reasonably thermally efficient, could benefit from added insulation to the walls, saving around a third of the energy used for heating.

In Italy the financial analysis outlines a positive financial gain, with DCF, NPV, and ROI supporting the profitability of EE initiatives. Montasio 31 and Boito 5 show substantial net cash flows, highlighting positive investment returns. In Denmark, the financial analysis indicates a need for additional funds to cover total investment costs. Various financial schemes, including BetterHome and the National Building Fund, are explored as potential funding sources. In Slovenia a positive outcome from DCF, ROI, and NPV analyses suggest the viability and profitability of the PPP initiative, particularly in energy efficiency. Furthermore, the findings underscore positive returns, highlighting the economic and environmental benefits of such initiatives. Cost-benefit analyses further support the financial soundness of energy-saving measures, promoting sustainable and economically viable EE projects.

5. Energy Savings

5.1. General introduction

A range of retrofits and upgrades to the buildings across the SUPER-i pipelines. Here, we discuss our modelling of the potential costs and benefits of those interventions, and further steps that might be taken to reduce the energy costs and increase the standard of living. These latter interventions have yet to be discussed in detail with the pipeline consortia, and may be difficult to implement for planning, technical, cost, resident disruption reasons, but are modelled and compared to the selected interventions.

For the SUPER-i project, we have developed, tested, and validated a building energy model which can assess the potential savings that might be achieved by the pipeline schemes through their proposed improvements in terms of:

- kWh - that is fuel saved
- cost - the value of the saved fuel, and
- carbon - the CO_2 emissions avoided

and then deployed by other housing associations (HAs) to establish the economic case for renovations to their stock. By the end of the project, we will host this model on a publicly accessible website, available to HAs across Europe, allowing them to assess the case for investing in energy efficiency in their buildings. This model draws on Element Energy's extensive experience of developing buildings energy models, and has been designed so that that it:

- returns meaningful results given basic, non-technical information
- can be run for specific years, allowing calibration of the model and assessment of interannual variation
- allows calculation of heating and cooling demand using the same architecture.

Developing a template

Our first step was to determine a minimum set of data needed to model the energy demand of a given building, and from that to produce a data template HAs could complete simply, requiring no technical expertise, that would capture sufficient information about their stock to give meaningful modelled savings. This tool examines only the effect of thermal performance - that is, heating and cooling - appliance savings, and those associated with upgrading hot water and cooking appliances are simple for the HAs to calculate themselves. This model draws on Element Energy's deep understanding of energy use in buildings and the real-world impact of energy efficiency and fuel-switching measures.

Modelling

Methodology

As only very basic heating, and no cooling, data were available from the pipelines, we decided to develop a model that would calculate the amount of heat lost (or, in the case of cooling, gained) per unit temperature difference between the environment and the building. We include a comfort zone of between 15.5° and 22° to model the temperature range in which no heating or cooling is required. The external air temperature can then be read from an API, allowing us to determine the total heating demand.

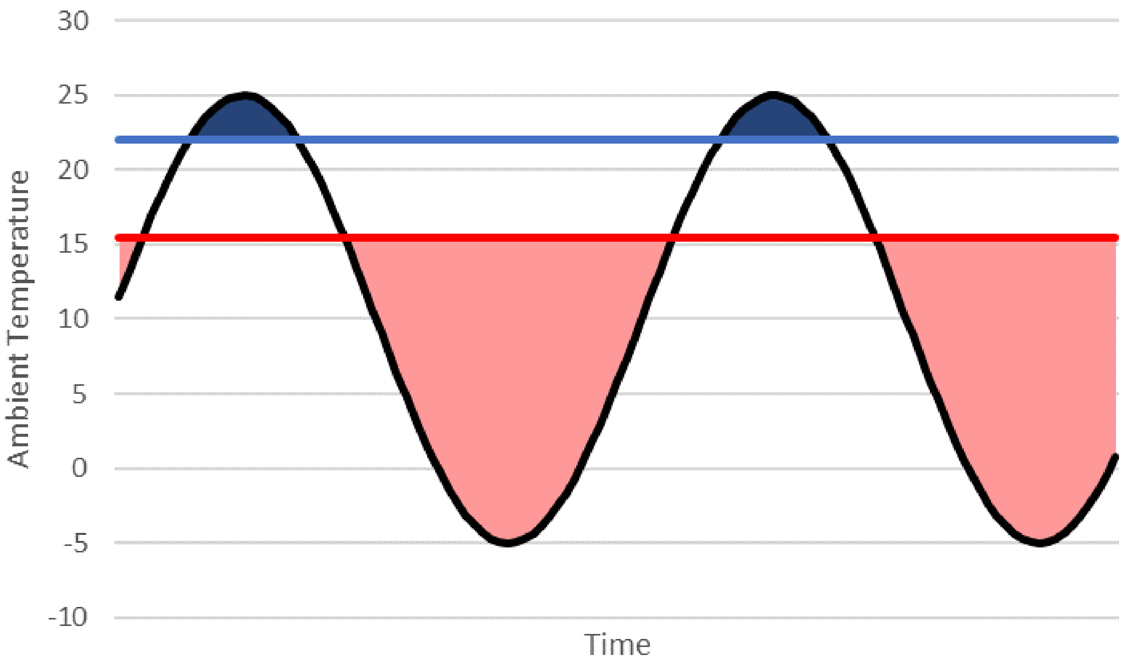

Figure 1. Heating degree and cooling degree days are given by the pink and blue areas respectively

We also account for solar gains; some of the sunlight which falls on the building will heat it to some degree - this varies with the colour and material of the building, for example buildings with large windows will experience higher solar gains.

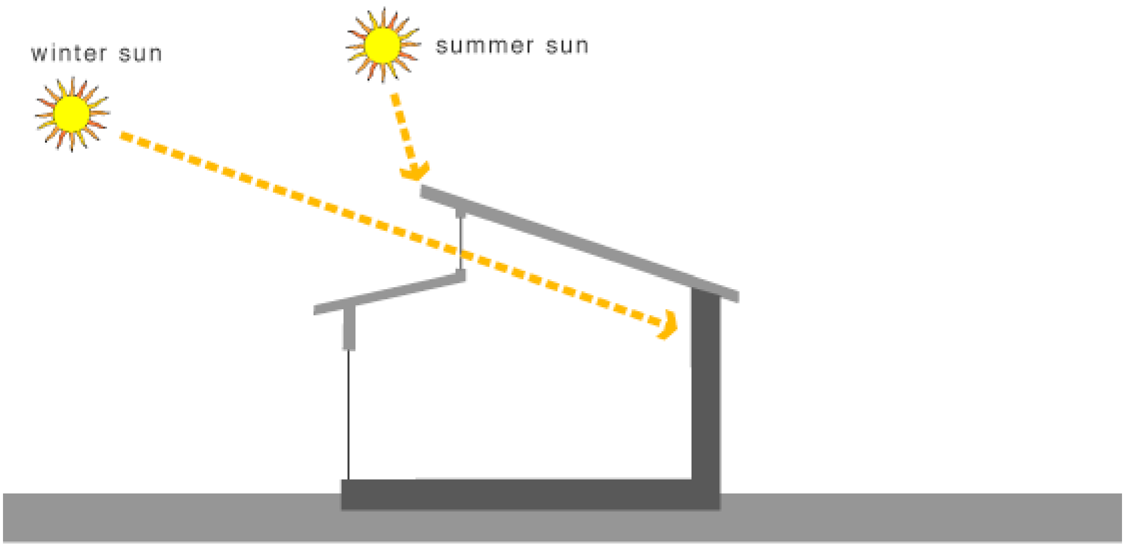

Figure 2. Solar gains are a function of building materials, orientation, geometry and solar position

In concert with the pipelines, we established that a minimum specification that HAs could report that would allow us to complete our calculations comprised:

- the dimensions of the building(s), including roof angle
- the orientation of the building(s)
- the fraction of the building(s) that is glazed (covered in windows)
- the materials of which the walls, floor, roof and windows are made
- the proposed improvements to the building.

In some cases, representative values for each MS can be used where the user cannot establish them, for example; roof angles are typically higher in northern (30-50°) and lower in southern (12-25°) Europe. The possibility of determining the geometry and glazed proportion automatically from photographs has also been investigated, though we have not implemented this so far.
Our tool turns the building material data into a set of U-values - a measure of how much heat flows through a m^2 of the building per degree of temperature difference. By summing over the areas and adjusting for their U-values we arrive at this expression for the total heat loss (or gain) per unit time for a given ΔT - the difference between the minimum (or maximum) acceptable user temperature.

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

We use the table of representative U-values taken from the CIBSE materials tables in the Domestic Heating Design guide 2020-21 to convert between the qualitative descriptions provided by the pipelines and the quantitative U-values for each component. For the pipelines this mapping was done manually, in the next tool iteration users will perform it automatically from a drop-down list.

	U-value (W/m² K)
Windows with wood or PVC-U frames	
Single	4.8
Double	2.8
Double, low-E glass	2.3
Double, low-E glass, argon filled	2.1
Triple	2.1
Triple, low-E glass	1.7
Triple, low-E glass, argon filled	1.6
Windows with metal frames	
Single	5.7
Double	3.4
Double, low-E glass	2.8
Double, low-E glass, argon filled	2.6
Triple	2.6
Triple, low-E glass	2.1
Triple, low-E glass, argon filled	2.0
Doors	
Solid wooden door	3.0
Wooden door with 25% single glazing	3.7
Wooden door with 50% single glazing	4.4
Wooden door with 25% double glazing	2.9
Wooden door with 50% double glazing	2.8

Figure 3. CIBSE Data Tables: Representative U-values for Windows[1]

Users who have a more technical understanding of their buildings thermal performance, for example from EPC certification, can include that data and return a more bespoke estimate of their potential energy savings.

We can also calculate the associated carbon emissions and fuel cost - once users specify how heat is provided to their buildings, we can adjust for efficiency[2] and calculate:

- the cost of the heating fuel that is saved for their market, and
- the carbon emissions avoided through more efficient heating.

As the data are time series indexed, we can calculate these values even where those may vary during the year; for example, the price and carbon intensity of grid electricity will vary during the course of the day and year, as the generation mix changes. Where buildings are electrically heated (or, more commonly, cooled) we multiply the hourly power price and emissions intensity with our savings to come up with a representative annual figure. Longer term cost and emissions savings will require projected prices for all fuels and may also need future grid CO_2 emissions intensity values where electrical heating and/or cooling are included in the projected savings.
As a result of this process, we have a template and web form which captures the data needed to model annual heating and/or cooling demand, and the savings that may be achieved through energy efficiency improvements. The included data are summarised below.

[1] CIBSE - Domestic Heating Design Guide, 2020-21

[2] E.g. Modern gas boilers are typically around 85-90% efficient, with some heat lost to the exhaust.

PARAMETER	Use in model	How Assessed
Hourly weather data time series	This allows us to calculate the difference between the external temperature and comfort range in the building's location. Other parameters are also relevant, e.g. insolation data allows us to calculate solar gains.	Users' latitude and longitude are looked up from their city name, and their weather data are read from the LARC API.
Building Thermal Performance	Determines the heat loss (or gain) per degree of external temperature difference.	Users provide basic information on the dimensions, geometry and material composition of their buildings. We map the latter onto a set of U-values using CIBSE data, and sum over the buildings walls, roof, floor and windows to find the total heat loss/gain value.
Fuel use, cost and carbon emissions	Allows us to calculate market specific cost and CO_2 emissions associated with heating and cooling.	Users report their heating and cooling technologies. We adjust fuel use for efficiency using typical efficiency values, and then parse the (potentially time-variable) cost and carbon intensity of the fuel.

By running the model for the building as currently constituted, and with the set of proposed upgrades, we arrive at "before" and "after" annual heat and cooling values, and so can calculate the fuel, cost and CO_2 savings of a set of energy efficiency improvements. We can run the model for a subset of, or individual, improvements, allowing users to suggest a portfolio of upgrades, and then select only the most impactful. Given data on the cost of the improvements, users can also calculate secondary information, such as payback periods or return on investment.

Results

Denmark

The Danish pipeline comprises 15 buildings across 3 schemes. A range of upgrades are proposed across these schemes; building fabric standards in Denmark have been high since the 1970s, so the energy improvements focus on fitting triple-glazing and, in some cases, installing a decentralised heat recovery system. There are insufficient details on the heat recovery system to model this accurately, but we have calculated the thermal improvement associated with upgrading the windows, shown below. These schemes are heated by a municipal heat network, so it is not clear what the unit price of heat is, or how it will change in future given the current dramatic increase in European gas and electricity prices, however, at current gas prices of very roughly 1 DKK/kWh[3]. These improvements correspond to savings of between €60 and €240 per dwelling per year.

Building name	Saving (MWh)	Saving (%)
Housing Areas Børglumparken	142	14%
Afdeling Søndergade	26	14%
Vaevergaarden	51	14%
Storgaarden	77	14%
Afdeling 9	146	14%
Hammerthor	32	14%
Frisenborgparken	16	14%
Afdeling 20 Hvalpsundvej, Aalborg	229	14%
Afdeling 21, Næssundvej, Aalborg	288	14%
Afdeling 23, Vildsundvej, Aalborg	195	14%
Afdeling 24, Oddesundvej, Aalborg	350	14%
Afdeling 40, Fredrik Bajersvej, Aalborg	202	14%
Afdeling 35, Runddyssen, Svenstrup	193	14%
Afdeling 36, Runddyssen, Svenstrup	247	14%
Afdeling 37, Hellekisten, Svenstrup	150	14%

Italy

In Italy, the pipeline buildings are not built to modern standards, being 50 years old. As such, the renovated buildings will be significantly more thermally efficient, using less than half as much as the old buildings. We estimate the improvements to the walls will reduce heating demand by 35 - 40%, windows by around 15%, and roofs by around 10%.

	Montasio	Boito
Wall	40%	35%
Window	14%	15%
Roof	9%	10%

There are currently no plans to install cooling equipment in the new blocks - average summer temperatures in Trieste are around 25°C - but as temperatures rise there may also be benefits to the blocks remaining cooler in the heat.

[3] https://www.dst.dk/en/Statistik/emner/miljoe-og-energi/energiforbrug-og-energipriser/el-og-naturgaspriser

Slovenia

The Slovenian pipeline building, a 4-unit housing block in Trbovlje, was built in 2005, and is already reasonably thermally efficient. The proposed adding of insulation to the walls appears the best option to improve the thermal efficiency of the block - achieving a U-value of 0.45W/m^{2}K would save around a third of the energy used for heating. In addition, we have looked at adding a layer of insulation under the reinforced concrete floor, though the benefit here appears marginal, with an annual energy saving of around 4%.

	Improvement
Wall	34%
Floor	4%

6. Financial evaluation

6.1. General Introduction

This section evaluates the profitability of the PPP initiatives in Italy, Denmark, and Slovenia, using a Discounted Cash Flow approach, which summarises:

- the cash inflow and outflow of each PPP initiative
- the Net Present Value (NPV) of each investment,
- the Return on Investment (ROI)
- the cost-benefit analysis of the energy and CO2 emission savings for 10 and 30 year windows.

to provide a comprehensive assessment of the financial benefits of the PPP initiatives, incorporating the environmental impact.

The **Discounted Cash Flow (DCF)** is given by:

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_N}{(1+r)^N}$$

where CF is the Cash Flow, and r is the discount rate based on the weighted average cost of capital. This approach estimates the present value of the profits that the investor receives from investing in EE renovation projects.

The **Net Present Value (NPV)** is given by:

$$NPV = \frac{NCF_N}{(1+r)^N}$$

where NCF is the Net Cash Flow, which is Cash Inflow minus Cash Outflow. The NPV provides either a positive or negative value where a positive NPV indicates positive financial return from the investment, and a negative NPV indicates the value lost from the investment.

The **Return on Investment (ROI)** is given by:

$$ROI = (Gross\ Return - Cost\ of\ Investment) / \ Cost\ of\ Investment$$

The ROI is a ratio that compares the gain or loss from an investment relative to its cost. It is useful in evaluating the current or potential return on an investment.

Italy

Table 1 summarises the project's key figures; the investment made by developers and sponsors amounts to €3,379,000 for Montasio, including €2,162,560 (64%) of equity raised by National Grants and €1,216,440 (36%) equity raised by Private Savings of homeowners. The amount per dwelling is

€13,462. For Boito, the investment made by developers and sponsors amounts to €1,598,000, 100% of which comprises equity raised by National Grants. The cost per dwelling is €99,875. As the plan for Boito is to demolish the building and build a new one, the cost per dwelling is higher compared to Montasio.

Building name	Floor area m²	Period	investment cost	Building cost	equity (Grant)	equity (P.S.)	cost per unit
Montasio 31	22,888	1 Year	3,379,000	3,379,000	2,162,560	1,216,440	13,462
Boito 5	552.16	2 Years	1,598,000	1,598,000	1,598,000	-	99,875

Table 1. Key project figures

Tables 2 and 4 present a summary of the financial indicators and mechanisms for each building, when we consider the financial benefits of energy efficiency, and without considering the financial benefits of energy efficiency respectively.

According to Table 2 and 4, the total investment cost is €3,379,000 consisting of all costs related to building and refurbishment for Montasio 31 with duration of 1 year, while for Boito 5 the total investment cost is €1,598,000 for 2 years. The Total Operating costs and expenses is €512,471 for Montasio 31, consisting of 60,240 operating costs, 11,295 other costs, 356,000 maintenance costs, and 84,336 other expenses, while for Boito 5 the total Operating costs and expenses is €30,326 consisting of 3,840 operating costs, 720 other costs, 20,390 maintenance costs, and 5,376 other expenses.

The Total revenues for Montasio 31 is €981,551.6 consisting of 444,000 in operating revenues (Rent), 206,000 other revenues, 64,000 other revenues, and 267,551,60 discounted in energy savings for 30 years, while for Boito 5 the total revenues for the two years are €125,310 consisting of 27,500 operating revenues, 10,790 other revenues, and 80,520 discounted revenues from energy savings for 30 yrs. Lastly, PPP funding is a combination of 64% based on national grants amounting to €2,162,560, and €1,216,440 (36%) from current dwelling owners in Montasio 31, while for Boito 5 its fully funded by National Grants €1,598,000 over 2 years.

In sum, according to these figures from tables 2 and 4, the PPP initiative of going with energy efficiency projects shows a substantial gain financially for each building when considering the savings in energy costs for the next 30 years.

	MONTASIO 31	BOITO 5
Buildings Cost	3,379,000.00	1,598,000.00
Furnishings	-	-
Start-up costs	-	-
Change in working capital	-	-
TOTAL INVESTMENT	**3,379,000.00**	**1,598,000.00**
Operating costs and expenses		
Operating cost	60,240.00	3,840.00
Other costs	11,295.00	720
Maintenance cost	356,600.00	20,390.00

Interest expenses	-	-
Other expenses	84,336.00	5,376.00
TOTAL OPERATING COSTS AND EXPENSES	**512,471.00**	**30,326.00**
Operating revenues and income		
Operating revenues	444,000.00	27,500.00
Other revenues	206,000.00	10,790.00
Energy savings	267,551.60	80,520.00
Interests income	-	-
Other income	64,000.00	6,500.00
TOTAL OPERATING REVENUES	**981,551.60**	**125,310.00**
Funding sources		
National grants	2,162,560.00	1,598,000.00
Private savings		
Equity	3,379,000.00	1,598,000.00
Debt		
TOTAL FUNDING SOURCES	**3,379,000.00**	**1,598,000.00**

Table 2. Investment, operating costs and revenues, funding sources (Green Impact)

Tables 3 and 5 present the findings of the financial evaluation methods applied in this section, which are DCF, NPV, ROI, and Net Cash Flow analysis. Table 3 provides the findings when we include the financial impact of energy savings and CO_2 emissions for the next 30 years discounted to this year's value of money, while Table 5 provides the financial findings when the savings from energy efficiency is not considered. According to the Net cash flow of Montasio 31 is €408,840.60 when energy and CO_2 emission savings are considered compared to €141,289 when they are not considered highlighting the importance and financial viability in the long run of going EE. To sum, the Net Cash Flow for Montasio 31, provides a clear picture of the positive cash flowing in from the PPP initiative indicating a positive investment for all parties of the initiative (private and public partners), while for we arrive at a similar conclusion for Boito 5.

The Discounted Cash Flow analysis indicates that both Montasio 31 and Boito 5 provides positive financial benefits of €4,268,772.98, and 1,669,284.71 respectively when considering the financial gains from implementing the EE renovations compared to €4,006,852.67, and 1,591,288.9 respectively. Therefore, the DCF analysis indicates a viable and profitable PPP investment to refurbish and rebuild Montasio 31 and Boito 5 especially when we consider the impact of going EE in the long run.

The Return on Investment of Montasio 31 and Boito 5 indicate a large financial gain from the EE benefits with RO1 12.10%, and 5.70% compared to 4.18% and 0.66% for Montasio 31 and Boito 5 respectively. This positive ROI confirms the findings of DCF and Net Cash Flow analysis, as a positive ROI indicates a positive return of 12.10% on investment from Montasio 31, and 5.70% from Boito 5. Similarly, the positive Net Present Value indicates the viability and profitability of the PPP initiatives in Italy.

	Montasio 31	Boito 5
Total operating revenues	981,551.60	125,310.00
TFS	3,379,000.00	1,598,000.00
TOTAL INFLOWS	**4,360,551.60**	**1,723,310.00**
Total operating costs	572,711.00	34,166.00
Investment	3,379,000.00	1,598,000.00
TOTAL OUTFLOWS	**3,951,711.00**	**1,632,166.00**
GNET CASH FLOW	**408,840.60**	**91,144.00**
GDCF	**4,268,772.98**	**1,669,284.71**
GROI (PCT)	**12.10%**	**5.70%**
GNPV	**400,235.54**	**88,286.66**

Table 3. Net Cash Flow, ROI, and NPV valuation (Green Impact)

	Montasio 31	Boito 5
Buildings Cost	3,379,000.00	1,598,000.00
Furnishings	-	-
Start-up costs	-	-
Change in working capital	-	-
TOTAL INVESTMENT	**3,379,000.00**	**1,598,000.00**
Operating costs and expenses		
Operating cost	60,240.00	3,840.00
Other costs	11,295.00	720
Maintenance cost	356,600.00	20,390.00
Interest expenses	-	-
Other expenses	84,336.00	5,376.00
TOTAL OPERATING COSTS AND EXPENSES	**512,471.00**	**30,326.00**
Operating revenues and income		
Operating revenues	444,000.00	27,500.00
Other revenues	206,000.00	10,790.00
Energy savings	-	-
Interests income	-	-
Other income	64,000.00	6,500.00
TOTAL OPERATING REVENUES	**714,000.00**	**44,790.00**
Funding sources		
National Grants	2,162,560.00	1,598,000.00
Private Savings	1,216,440.00	0

Equity	3,379,000.00	1,598,000.00
Debt	0	0
TOTAL FUNDING SOURCES	**3,379,000.00**	**1,598,000.00**

Table 4. Investment, operating costs and revenues, funding sources

	Montasio 31	Boito 5
Total operating revenues	714,000.00	44,790.00
TFS	3,379,000.00	1,598,000.00
TOTAL INFLOWS	**4,093,000.00**	**1,642,790.00**
Total operating costs	572,711.00	34,166.00
Investment	3,379,000.00	1,598,000.00
TOTAL OUTFLOWS	**3,951,711.00**	**1,632,166.00**
GNET CASH FLOW	**141,289.00**	**10,624.00**
GDCF	**4,006,852.67**	**1,591,288.99**
GROI (PCT)	**4.18%**	**0.66%**
GNPV	**138,315.22**	**10,181.49**

Table 5. Net Cash Flow, ROI, and NPV valuation

Cost-Benefit analysis (Energy savings from a financial point of view)

Table 6, presents the findings of energy savings and CO_2 emission savings for the next 10 years, and 30 years using NPV_1 and NPV_2 respectively. This section uses the future price of natural gas obtained from a reliable source (statista.com) in 10 years which is €4.365/MWh, and €6.7 per MWh in 30 years. However, for CO_2 emission price per tonnes we consider three scenarios: Voluntary market scenario, Hybrid scenario, and Science Based Targets initiatives (SBTI) scenario (For more information about each scenario [Carbon Offset Prices Could Increase Fifty-Fold by 2050 | BloombergNEF (bnef.com)]). Table 6 shows the result of CO_2 emission savings in 10 years and 30 years using the Hybrid scenario, where the future price in year 2032 is approximately €10.67, and €45.59. According to the NPV1 and NPV2 the financial benefit is 72,390 in 10 years and 267,551 in 30 years from the energy savings and CO_2 emissions from Montasio 31, and 2693.7 in 10 years, and 80520.2 in 30 years for Boito 5. Therefore, the benefit to cost ratio = total cash inflows (Green)/total cash outflows (Green)= 1.1, which indicates a positive benefit to cost analysis.

Italy	Energy savings (MWh)		CO_2 emission savings (tonnes)		Value of energy savings		Value of CO_2 emission savings		NPV1	NPV2
	10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS		
Montasio 31	6899.8	20699.3	1276.5	3829.4	30117.5	138741.2	59431.8	367734.5	72390.0	267551.6

Boito 5	256.7	20699.3	47.5	142.5	1120.7	138741.2	2211.5	13683.7	2693.7	80520.2

Table 6. Energy and CO_2 emission savings in 10 years and 30 years

6.1.1.1. Possible Financial schemes

1. One of the main funding participants of PPPs are banking foundations. Recently, PPPs have designed and organised several social housing projects that has a common feature: a bank foundation and the Municipal Authority share the role of promoters, while a property fund participates in the initiative as a financial sponsor (Antonini et al., 2014). One example is the Sustainable Housing Project in Turin, which was funded by Turin Saving Bank (CRT) up to 91%, and 8.9 % was funded by a local financing institution called Oltre Venture, which is aimed at investing venture capital on behalf of new social enterprises.

2. Another funding source for social housing is the Fondazione Housing Sociale FHS. The FHS is not a Banking Foundation, it is a traditional foundation that uses its own resources to fund social missions. In 2004 the FHS created the Fondazione Cariplo which is considered one of the world's main philanthropic organisations, whose mission is to act as a funding resource that helps social and civil organisations. As of 2021 this Integrated fund system consists of a national fund and the investment fund for Housing worth €2.028 Bn.

3. Public grant programs are used in almost all MSs to support EE projects (Economidou et al., 2018; Economidou & Bertoldi, 2014). In Italy, these are mostly used to reduce initial costs for the purchase and the installation of equipment, as well as provision of advice and certification services.

4. European Investment Bank is the largest multilateral lender and borrower in the world, it provides funds for over 450 projects per year in 160 countries. The main focus of EIB financing is in SMEs with over €30bn per year. EIB provides several financing instruments for the social housing sector which are characterised as investment loans, Framework Loans direct to a city, Framework Loans via an intermediary, and equity funds. Note that EIB Social Housing Lending support in Italy is €2 bn. which comprises 13.98% of the total EIB global social housing funds.

Denmark[4]

Table 7 summarises Denmark's pipeline's key financial data. The total investment cost amounts to €3,546,327 consisting of 770,900 for Borglumparken, 370,302 for Afedling, 292,068 for Vaevergaarden, 633,735 for Strogaarden, 1,162,190 for Afdeling 9, 40,799 for Hammerthor, and 276,332.94 for Frisnborgparken, while the available funds according to given data are €1,387,599 for all buildings consisting of €556,400 for Borglumparken, 97,500 for Afedling, 179,400 for Vaevergaarden, 162,500 for Strogaarden, 273,000 for Afdeling 9, 40,799 for Hammerthor, and 78,000 for Frisnborgparken. These data indicate the need for extra funds to cover the required total investment costs for the PPP pipeline project in Denmark. Table 7 also provided equity values for

[4] We are unable to provide accurate analysis due to missing financial data.

each building as well as associated debt for each building. The table indicates a very high ratio of debt to equity for these buildings. The cost per dwelling is 7,484 for Børglumparken, 23,144 for Søndergade, 8,113 for Vaevergaarden, 15,843 for Storgaarden, 3,598 for Afdeling 9, 1,407 for Hammerthor, and 9,211 for Frisenborgparken.

Building name	Floor area m²	Period	investment cost	Building cost	equity	Debt	cost per unit
Housing Areas Børglumparken	6,640	0.5 years	770900	-	10988121.3	10582353.08	7,484
Afdeling Søndergade	1,293	0.5 years	370301.75	-	1750288.02	1533411.1	23,144
Vaevergaarden	2,417	0.5 years	292068.14	-	2957547.06	2822819.61	8,113
Storgaarden	2,919	0.5 years	633735.44	-	4738570.46	4572863.62	15,843
Afdeling 9	14,346	0.5 years	1162189.6	-	26969536.62	26653901.17	3,598
Hammerthor	2,557	0.5 years	40799.2	-	4436459.17	4337597.81	1,407
Frisenborgparken	2,417	0.5 years	276332.94	-	2210728.91	2158487.24	9,211

Table 7. Key project figures

Table 8 summarises the financial mechanisms and indicators for the pipeline project in Denmark. According to the table, the other expenses are very high compared with the energy savings revenue, which is currently the only source of revenue. The total costs for all pipelines are 8 to 10 times larger than the respective total revenue of each pipeline. Also, as mentioned earlier, the current available funding does not cover the total investment costs + the total operating costs and expenses, as the generated revenues do not cover the gap between the funding and the total investment costs.

	Housing Areas Børglumparken	Afdeling Søndergade	Vaevergaarden	Storgaarden	Afdeling 9	Hammerthor	Frisenborgparken
Buildings Cost	-	-	-	-	-	-	-
Furnishings	-	-	-	-	-	-	-
Start-up costs	-	-	-	-	-	-	-
Change in working capital	-	-	-	-	-	-	-
TOTAL INVESTMENT	**770,900.00**	**370,301.75**	**292,068.14**	**633,735.44**	**1,162,189.60**	**40,799.20**	**276,332.94**
Operating cost	-	-					

Other costs	-	-					
Maintenance cost	-	-					
Interest expenses	155,668.89	63,136.19	99,041.93	149,214.65	730,164.11	185,817.84	59,361.64
Other expenses	531,429.99	127,240.75	153,959.78	159,492.06	895,227.84	112,198.58	86,577.27
TOTAL OPERATING COSTS AND EXPENSES	**687,098.88**	**190,376.94**	**253,001.71**	**308,706.71**	**1,625,391.95**	**298,016.42**	**145,938.91**
Operating revenues	-	-	-	-	-	-	-
Energy savings	80,668.80	14,763.70	29,288.40	43,787.60	83,440.30	18,142.80	8,960.40
Interests income	-	-	-	-	-	-	-
Other income	-	-	-	-	-	-	-
TOTAL OPERATING REVENUES	**80,668.80**	**14,763.70**	**29,288.40**	**43,787.60**	**83,440.30**	**18,142.80**	**8,960.40**
Funding	556,400.00	97,500.00	179,400.00	162,500.00	273,000.00	40,799.20	78,000.00
equity	10,988,121.30	1,750,288.	2,957,547.	4,738,570.46	26,969,536.62	4,436,459.17	2,210,728.91
Debt	10,582,353.08	1,533,411.1	2,822,819.	4,572,863.62	26,653,901.17	4,337,597.81	2,158,487.24
TOTAL FUND SOURCES	**11,544,521.30**	**1,847,788.0**	**3,136,947.**	**4,901,070.46**	**27,242,536.62**	**4,477,258.37**	**2,288,728.91**

Table 8. Investment, operating costs and revenues, funding sources

Possible Financial schemes

1. **BetterHome** is a successful OSS in Denmark that offers predefined renovation packages to private homeowners. They rely partially on automated and customised services, allowing the future client to pre-inform the installers and pre-select the measures via the website and app. However, as a next step, the homeowner is in a direct and responsive relationship with the technical team. This allows tailoring of the exact package—as much the technical, as the financial terms—to the exact needs of the homeowner. BetterHome has local craftsmen that carry out the actual work, who get training and tools to ensure quality services, and BetterHome carries out promotion, quality assurance, monitoring, and in general, all

customer care tasks. Over 200 projects were completed in 2016 and have been expanding since then (Boza-Kiss & Bertoldi, 2018).

2. Another source of funding is the **National Building Fund** (LBF) established in 1967 and is financed by tenant rents from the social and affordable housing provided by non-profit housing organisations. When mortgage loans for dwelling construction have been repaid, tenants pay rents at the same level, with the extra going into the LBF as a saving. This fund finances the expansion of new affordable and social housing and renovation of existing properties. This includes improvements of both inside and outdoor areas, modernization of buildings to include access for elderly and disabled people, and energy improvements. The fund is also able to finance the demolition cost in vulnerable social housing areas, and to support infrastructural changes. LBF provides a useful mechanism to ensure self-financing in the social and affordable housing sector. Savings are recycled to help maintain and improve dwellings and provide additional housing. It thereby provides a sealed finance circuit, reducing government need to reinvest in new social housing, and facilitates long-term planning for social housing funding. It also helps to even out variations in the financial strength of different social housing providers, in the costs of developing different estates, and thereby in rents charged which reflect development costs.

The purpose of the Fund is to build socially cohesive, safe, and sustainable communities. A particular focus is investments in social activities and rental price reductions. Efforts are organised in local partnerships such as schools, municipalities or NGOs, aiming to promote tenant employment opportunities and educational performance. The Fund is managed by a nine-member board, including representatives of housing organisations, tenants and the two largest municipalities in Denmark. However, its budget must be approved by the housing minister. The Danish government wants LBF to increase investments in energy-efficiency renovations, to play a key role in meeting climate goals and post-COVID-19 economic recovery.

Slovenia

Table 9 summarises the pipeline's key figures. The investment made by developers and sponsors amounts to €200,000 for **Neža 26 a in b** funded by equity raised by National Grants. The Total investment cost consists of €190,000 building costs, and €10,000 start-up costs, and the cost per dwelling is €7,692.

Building name	Floor area m^2	Period	investment cost	Building cost	equity(funds)	Cost per unit
Neža 26 a in b	1,806.00	2 Years	200,000	190,000	200,000	7,692

Table 9. Key project figures

Tables 10 and 12, presents a summary of the financial indicators and mechanisms for each building, when we consider the financial benefits of energy efficiency, and without considering the financial benefits of energy efficiency respectively. According to Table 10 and 12, the total investment cost is

€200,000 consisting of all costs related to building and refurbishment with a duration of 2 years. The Total Operating costs and expenses is €19,200, consisting of 14,400 operating costs, and 4,800 maintenance costs.

The Total revenues for the pipeline is €48,460.80 consisting of 21,600 in operating revenues (Rent), and 26,860.8 in energy savings and CO_2 emission financial benefits of the next 30 years discounted to this year's value of money using the discount rate obtained by WACC. Lastly, PPP funding is 100% based on national grants over 2 years.

To summarise, according to these figures from tables 10 and 12, the PPP initiative of going with energy efficiency projects shows a substantial gain financially for the building when considering the financial savings in energy costs for the next 30 years.

	Neža 26 a in b
Buildings Cost	190,000.00
Furnishings	-
Start-up costs	10,000.00
Change in working capital	-
TOTAL INVESTMENT	**200,000.00**
Operating costs and expenses	
Operating cost	14,400.00
Other costs	-
Maintenance cost	4,800.00
Interest expenses	-
Other expenses	-
TOTAL OPERATING COSTS AND EXPENSES	**19,200.00**
Operating revenues and income	
Operating revenues	21,600.00
Energy savings	26,860.80
Interests income	-
Other income	-
TOTAL OPERATING REVENUES	**48,460.80**
Funding sources	
National Grants	-
Private Savings	-
equity	200,000.00
Debt	-
TOTAL FUNDING SOURCES	**200,000.00**

Table 10. Investment, operating costs and revenues, funding sources (Green Impact)

Tables 11 and 13 present the findings of the financial evaluation methods applied in this section, which are DCF, NPV, ROI, and Net Cash Flow analysis. Table 11 provides the findings when we include the financial impact of energy savings and CO_2 emissions for the next 30 years discounted to this year's value of money, while Table 12 provides the financial findings when the savings from energy efficiency is not considered. According to the Net cash flow which is €29,260.80 when energy and CO_2 emission savings are considered compared to €2,400 when they are not considered highlighting the importance and financial viability in the long run of going EE. To sum, the Net Cash Flow, provides a clear picture of the positive cash flowing in from the PPP initiative indicating a positive investment for all parties of the initiative (private and public partners).

The Discounted Cash Flow analysis indicates that the pipeline provides positive financial benefits of €241,236.25 when considering the financial gains from going EE compared to also a positive financial benefit of €2,307.26 when the benefits from EE is not considered. Therefore, the DCF analysis indicates a viable and profitable PPP investment especially when we consider the impact of going EE in the long run.

The Return on Investment indicates a large financial gain from the EE benefits with ROI 14.63% compared to 1.2%. This positive ROI agrees with the previous findings of DCF and Net Cash Flow analysis, as a positive ROI indicates a positive return of 14.63% on investment. Similarly, the positive Net Present Value indicates the viability and profitability of the PPP initiatives in Slovenia.

	Neža 26 a in b
Total operating revenues	48,460.80
TFS	200,000.00
TOTAL INFLOWS	248,460.80
Total operating costs	19,200.00
Investment	200,000.00
TOTAL OUTFLOWS	219,200.00
GNET CASH FLOW	29,260.80
GDCF	241,236.25
GROI (PCT)	14.63%
GNPV	28,409.98

Table 11. Net Cash Flow, ROI, and NPV valuation(Green Impact)

	Neža 26 a in b
Buildings Cost	190,000.00
Furnishings	-
Start-up costs	10,000.00
Change in working capital	-
TOTAL INVESTMENT	200,000.00
Operating costs and expenses	
Operating cost	14,400.00
Other costs	-
Maintenance cost	4,800.00

Interest expenses	-
Other expenses	-
TOTAL OPERATING COSTS AND EXPENSES	**19,200.00**
Operating revenues and income	
Operating revenues	21,600.00
Energy savings	
Interests income	-
Other income	-
TOTAL OPERATING REVENUES	**21,600.00**
Funding sources	
National Grants	-
Private Savings	-
equity	200,000.00
Debt	-
TOTAL FUNDING SOURCES	**200,000.00**

Table 12. Investment, operating costs and revenues, funding sources

	Neža 26 a in b
Total operating revenues	21,600.00
TFS	200,000.00
TOTAL INFLOWS	**221,600.00**
Total operating costs	19,200.00
Investment	200,000.00
TOTAL OUTFLOWS	**219,200.00**
GNET CASH FLOW	**2,400.00**
GDCF	**215,156.48**
GROI (PCT)	**1.20%**
GNPV	**2,330.21**

Table 13. DCF, Net Cash Flow, ROI, and NPV valuation

To conclude, the Financial evaluation methods used all indicate profitable and viable PPP investments in Italy, and Slovenia, and the importance of considering Energy efficiency applications on the financial as well as the environmental aspect.

Cost-Benefit analysis (Energy savings from a financial point of view)

Table 14, present the findings of Energy savings and CO_2 emission savings for the next 10 years, and 30 years using NPV1 and NPV2 respectively. This section uses the future price of natural gas obtained from a reliable source (statista.com) in 10 years which is €4.365 per Mwh, and 6.7 per Mwh in 30 years. However, for CO_2 emission price per tonnes we consider three scenarios: Voluntary market scenario, Hybrid scenario, and Science Based Targets initiatives (SBTI) scenario

(For more information about each scenario Carbon Offset Prices Could Increase Fifty-Fold by 2050 | BloombergNEF (bnef.com)). Table 14 shows the result of CO_2 emission savings in 10 years and 30 years using the Hybrid scenario, where the future price in year 2032 is approximately €10.67, and €45.59. According to the NPV1 and NPV2 the financial benefit from the energy savings and co2 emissions are €7043.2 in 10 years, and 26860.6 in 30 years respectively. Therefore, the benefit to cost ratio = total cash inflows (Green)/total cash outflows(Green)= 1.13, which indicates a positive benefit to cost analysis.

Slovenia	Energy savings (MWh)		CO_2 emission savings (tonnes)		Value of energy savings		Value of CO_2 emission savings		NPV1	NPV2
	10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS		
Building 1	661	1983	122	367	2884.7	13288.9	5692.5	35222.4	7043.2	26860.6

Table 14. Energy and CO_2 emission savings in 10 years and 30 years

Possible funding schemes

1. The **Housing Fund** was founded in 1991 to finance and implement a legislated national housing programme which operates on five-year cycles. The objectives of the Fund focus on the construction, renovation and maintenance of apartments and residential buildings, targeted at groups with particular needs such as families, young people, the elderly, and Roma populations. The main instruments used to achieve this have involved co-financing with long-term favourable loans and interest rate subsidies, and investments in new innovations and international research.

   The Housing Fund actively invests directly in housing and also co-invests in local community housing programmes, complementing the efforts of municipalities and non-government organisations. It also purchases land and houses directly on the market. Currently the Fund directly owns 3,042 non-profit rental housing units and a further 787 dwellings which are let at cost-based rents. Two companies owned by the fund own another 2,056 apartments, which they rent out at non-profit rent. These dwellings are located throughout Slovenia. The Fund is intensively building affordable rental apartments throughout Slovenia, and by 2023 it will provide 2,194 new public rental apartments. Between 2017 and 2020, its activities have included Financial incentives for housing in the form of soft loans; Sustainable construction and complete renovation of the housing stock for all products and programmes of the Fund; Cooperation in development projects in housing construction; Strengthening and implementing the Fund's development role in housing.

2. **European Investment Bank** is the largest multilateral lender and borrower in the world, it provides funds for over 450 projects per year in 160 countries. The main focus of EIB financing is on SMEs with over €30bn per year. EIB provides several financing instruments for the social housing sector which are characterised as investment loans, Framework Loans direct to a city, Framework Loans via an intermediary, and equity funds. Note that EIB Social

Housing Lending support in Slovenia is €331.4 million. which comprises 2.48% of the total EIB global social housing fundings.

7. Environmental impact

7.1. General introduction

In this section the usage phases (LCA stages) will be analysed before and after implementing the proposed solutions for the different pipelines. Previously to the results a brief overview of the application of the Life Cycle Assessment in the different pipelines' countries is included.

7.2. Sustainability assessment of the pipelines

For the purpose of analysing in detail the sustainable performance of the pipelines the following aspects should be covered.

System boundaries

System boundaries include the three fundamental phases to estimate the degree of sustainability of the building/s under study: namely A, B, C, and D, with A being the phase before the use stage, B the use stage, C the end-of-life stage and D the benefits and burdens beyond the system:

A- Before the usage phases (LCA stages):

- A0: the non-physical processes of the pre-construction stage.
- A1-A3: the manufacturing stages: extraction of materials, transport and manufacture, and procurement, from the cradle to the grave for materials and services for the construction.
- A4-A5: the stages of the construction process, including the physical processes prior to construction such as transport of materials or demolition of previous structures, including the process from the gate to the end of the construction phase.

B- usage phases (LCA stages) (usage phases (LCA stages) of the building/s, including maintenance, refurbishment, operation and users activities):

- B1-B5: Impacts and aspects from the use of the building components, and the production and transport of the components and auxiliary products used in the maintenance/refurbishment and cleaning as well as the processes for the maintenance/refurbishment, and waste management and end of life of the disposed materials and components.
- **B6-B7: Energy and water flows in service (from the operation), as well as aspects and impacts coming from the building itself.**

  Energy used for the integrated systems in the building to satisfy the needs associated with the defined use of the building: heating, hot water supply, air conditioning, ventilation, lighting and auxiliary energy for pumps, and others such as monitoring and control.
  Water use includes all the water used and its treatments (before and after the use), excluding the maintenance, substitution or refurbishing, including the whole life cycle of the building.

- B8: Aspects and impacts as a consequence of the users activities, excluding the energy consumption which is included in B6.

C: End of life stage:

- C1: Aspects or impacts of the dismantling or demolition, including deconstruction, dismantling and demolition.
- C2-C4: waste management for reuse, recycling or other valorisation alternatives and waste disposal (included), including waste transportation.

D: Benefits and loads:

- D1: net flows for the reuse, recycling, energy valorisation and other added value activities such as filling.
- D2: Exported services beyond the system boundaries.

At this stage, according to the methodology followed in BuildHeat project, to assess the impact on the use stage of a social residential building, the main entries should have been the final energy consumption for heating, cooling, hot water and lighting in kWh per m^2 per year, as directly connected with the refurbishing proposals from the pipelines and the modelling achieved for the purpose of comparing them; and CO_2 emissions for heating, cooling, hot water and lighting in kg CO_2 per m^2 per year.
For the purpose of the analysis at SUPER-I current stage, the building's stage to analyse is focused on the B6 stage, taking only into account the energy used for heating the building as there is missing data on the energy consumption in the rest of the systems, namely cooling, hot water and lighting.

Functional unit

For each of the pipelines the target under study is the group of buildings where the refurbishment is going to take place, which are residential buildings, with a lifespan of 50 years.
The functional unit in use is one square metre of useful residential surface. Alternatively, results can be also given in absolute terms for one building in the 50-years analysis period. **In this analysis the environmental performance is done based on one square metre and the entire building/s under study for social analysis.**
Aspects and impacts of user activities associated with the use of the built asset (user activities) are included in the assessment according to the requirements of EN 15978, EN 16309 and EN 16627, for buildings.

Environmental impact categories to be included:

Measuring the environmental performance of a construction site during its life cycle includes parameters such as, when detailed analysis is done:

- water use
- primary, renewable and non-renewable energy use
- use of primary, secondary, renewable and non-renewable materials
- waste generation
- emissions to air

- emissions to land
- emissions to water
- radiation
- consequences for local ecology and biodiversity
- land use
- landscape disturbance
- impact on biodiversity

Taking into account the number of indeterminacies inherent in the parameters assessed

Social impact categories to be included

Based on the UNE-EN_16309:2014 Standard, the evaluation of the social dimension is focused on the aspects and impacts of the usage phases (LCA stages). In this sense, a set of variables is defined to evaluate the comfort and wellbeing of users:

- *Accessibility*
  - Accessibility to building facilities (approach to the building)
  - Access and movements in the building

- *Adaptability to the users needs, versatility to be adapted to the use*
  - Health and comfort
  - Thermal features
  - Indoor air quality features
  - Noise features
  - Visual comfort features
  - Others

- *Loads for the neighbourhood including*
  - Heat
  - Noise
  - Emissions
  - vibrations including glare and light;
- *Safety, climate change resilience, accidents, vandalism security, supply disruption*
- *Maintenance*
- *Stakeholders' implication including*
  - *relations with local society and building end users*
- *Jobs creation*
- *Cultural heritage protection*

Further info has been obtained considering the special needs and situation for end users of social housing:

Energy poverty

- Energy costs

- Comfort

The assessment has been performed with the Software SimaPro 9.3.0.3 Multiuser and the Ecoinvent 3.8 Base data.

Denmark

Environmental impact assessment for the improvement implementation

Table 15 includes the impact categories avoided because of the annual energy savings per square metre, after the wall and windows improvement considering only the energy consumption for heating in the usage phases (LCA stages) of the buildings, considering natural gas as fuel considering an average of Europe. Four impact categories have been included, the ones that are related with the climate change potential and the resources and land use, specifically Global Warming potential in kg CO_2 eq, land use in m^2 a crop eq, fossil resource scarcity in kg oil eq and water consumption in m^3.

Building name	Global warming (kg CO2 eq)	Landuse (m2a crop eq)	Fossil resource scarcity (kg oil eq)	Water consumption (m3)
Housing Areas Børglumparken	5.99	0.0317	2.16	0.00319
Afdeling Søndergade	5.63	0.0298	2.03	0.003
Vaevergaarden	5.91	0.0312	2.13	0.00314
Storgaarden	7.39	0.039	2.67	0.00393
Afdeling 9	2.85	0.0151	1.03	0.00152
Hammerthor	3.5	0.0185	1.27	0.00186
Frisenborgparken	1.85	9.8	0.67	0.000986
Afdeling 20 Hvalpsundvej, Aalborg	5.1	0.0269	1.84	0.00271
Afdeling 21, Næssundvej, Aalborg	4.96	0.0262	1.79	0.00264
Afdeling 23, Vildsundvej, Aalborg	5.27	0.0278	1.9	0.0028
Afdeling 24, Oddesundvej, Aalborg	6.32	0.0334	2.28	0.00336
Afdeling 40, Fredrik Bajersvej, Aalborg	4.84	0.0256	1.75	0.00257
Afdeling 35, Runddyssen, Svenstrup	4.81	0.0254	1.74	0.00256
Afdeling 36, Runddyssen, Svenstrup	5.02	0.0266	1.81	0.00267
Afdeling 37, Hellekisten, Svenstrup	5.42	0.0287	1.96	0.00288

Table 15. Table 15. Environmental impact assessment of the usage phases (LCA stages) of Danish pipelines for energy savings for each building per square metre of useful area (functional unit: total energy savings/m2.year)

Looking at the results most of the buildings avoid around 5 kg CO_2 eq, except Storgaarden which obtains higher reduction of impacts and Afdeling 9, Hammerthor and Frisenborgparken, which obtain around half reduction of the impacts in comparison with the rest of buildings.

Social analysis for the improvements implementation

Denmark pipeline was asked to answer some of the questions covered by the EN_UNE 16309:2014, only answers from Housing Areas Børglumparken and Fruehoejgaard Social Housing Company were received. Conclusions obtained from the answers are included:

Accessibility to building facilities, approach to the building:

- there is no parking accessible for special needs people
- there is no picking up point for special needs people
- there is no curb ramp to the entrance of the building

Accessibility and movements in the building:

- there are no accessibility measures to permit the entrance and the continuity of access and movements inside the building

Health and comfort:

- The user has the possibility to open the windows to improve the air quality of the dwelling
- The user has the possibility to access the temperature control of their home through thermostats
- There is a ventilation system in the building in the kitchen and bathrooms

Regarding energy poverty:

- The % of total spent of residents, on average is from 6 to 10%
- The % of total income of residents, on average is from 4 to 8%
- The % of households unable to afford to keep their home adequately warm, on average is 0%

After analysing these data there is room to improve some aspects of the building in terms of social impact in the residents, namely considering including accessibility aspect inside and outside the building, as well as to implement a training to residents regarding correct use of the ventilation and the temperature control to improve their comfort and avoid any unnecessary energy cost.

Slovenia

Environmental impact assessment for the heating system improvement implementation

The Table 16 includes the impact categories avoided because of the annual energy savings per square metre, after the wall and windows improvement considering only the energy consumption for heating in the usage phases (LCA stages) of the buildings, considering natural gas as fuel considering an average of Europe. Four impact categories have been included, the ones that are related with the climate change potential and the resources and land use, specifically Global Warming potential in kg CO_2 eq, land use in m^2a crop eq, fossil resource scarcity in kg oil eq and water consumption in m^3.

Building name	Global warming (kg CO2 eq)	Landuse (m2a crop eq)	Mineral resource scarcity (kg Cu eq)	Fossil resource scarcity (kg oil eq)	Water consumption (m3)
Neza 26 a in b	10.3	0.0542	0.00519	3.7	0.00545

Table 16. Environmental impact assessment of the usage phases (LCA stages) of Slovenian pipelines for energy savings for each building per square metre of useful area (functional unit: total energy savings/m2.year)

Social analysis for the improvements implementation

Slovenian pipeline was asked to answer some of the questions covered by the EN_UNE 16309:2014, answers from Neza 26 a in b were received. Conclusions obtained from the answers are included:

Accessibility to building facilities, approach to the building:

- there is parking accessible for special needs people
- there is no picking up point for special needs people
- there is curb ramp to the entrance of the building

Accessibility and movements in the building:

- there are no accessibility measures to permit the entrance and the continuity of access and movements inside the building

Health and comfort:

- The user has the possibility to open the windows to improve the air quality of the dwelling
- The user has the possibility to access the temperature control of their home
- There is a ventilation system in the building in the bathroom

Regarding energy poverty:

- The % of total spent of residents, on average is 20%
- The % of total income of residents, on average is from 15%
- The % of households unable to afford to keep their home adequately warm, on average is 80%.

After analysing these data there is room to improve some aspects of the building to improve the social impact in the residents, namely considering including accessibility aspect inside and outside the building, as well as to implement a training to residents regarding correct use of the ventilation and the temperature control to improve their comfort and avoid any unnecessary energy cost.

Italy

Environmental impact assessment for the heating system improvement implementation in Italy

The Table 17 includes the impact categories avoided because of the annual energy savings per square metre, after the wall and windows improvement considering only the energy consumption for heating in the usage phases (LCA stages) of the buildings, considering natural gas as fuel considering an average of Europe. Four impact categories have been included, the ones that are related with the climate change potential and the resources and land use, specifically Global Warming potential in in kg CO_2 eq, land use in m^2a crop eq, fossil resource scarcity in kg oil eq and water consumption in m^3.

Building name	Global warming (kg CO2 eq)	Land use (m2a crop eq)	Mineral resource scarcity (kg Cu eq)	Fossil resource scarcity (kg oil eq)	Water consumption (m3)
Montasio 31	2.89	0.524	0.0163	0.798	1.67
Boito 5	4.45	0.808	0.0251	1.23	2.58

Table 17. Environmental impact assessment of the usage phases (LCA stages) of Italian pipelines for energy savings for each building per square metre of useful area (functional unit: total energy savings/m2.year)

For Italian pipelines, Montasio 31 would reduce quite more the environmental impacts with the renovation than Boito 5.

Social analysis for the improvements implementation

Denmark pipeline was asked to answer some of the questions covered by the EN_UNE 16309:2014, only answers from Montasio 31 and Boito 5 were received. Conclusions obtained from the answers are included:

Montasio

Accessibility to building facilities, approach to the building:

- There is parking accessible for special needs people, there is a large private parking zone all around the buildings and there is also a garage; parking spaces are not assigned. There will be no problems in dedicating parking spaces to special needs people.
- There is no picking up point for special needs people, but could be improved
- There is no curb ramp to the entrance of the building, the buildings lie on sloping ground and at the moment there are no ramps that allow access to special needs people; Buildings 23-25-31-33-35-37 have flat development and are easily implemented with ramps.

Accessibility and movements in the building:

- There are accessibility measures to permit the entrance and the continuity of access and movements inside the building, the buildings are equipped with elevators that allow disembarkation on the floor.

Health and comfort:
- The user has the possibility to open the windows to improve the air quality of the dwelling in all the rooms
- The user has the possibility to access the temperature control of their home, there is already a thermoregulation system managed by the user
- There is no ventilation system in the building in the kitchen and bathrooms

Regarding energy poverty:
- The total spent of residents, on average is €600/year
- The % of total income of residents, on average is from €13,000
- The % of households unable to afford to keep their home adequately warm, on average is 15%

Boito

Accessibility to building facilities, approach to the building:
- there is no parking accessible for special needs people
- there is no picking up point for special needs people, but could be improved
- considering that the building will be demolished, i will be rebuilt without architectural barriers

Accessibility and movements in the building:
- Considering that the building will be demolished, it will be rebuilt without architectural barriers. Inside there will be elevators to reach the various floors

Health and comfort:
- Autonomous systems are planned for the project, so the user will have full control and management of their heating system, and ventilation

Regarding energy poverty:
- The total spent of residents, there is no data available
- The % of total income of residents, on average is from €4,780
- The % of households unable to afford to keep their home adequately warm, on average is 60%

In general terms the Slovenian pipeline will reduce more the environmental impact per square metre than the rest of pipelines and impacting very positively from the point of view of the residents, as it is directly related to the energy savings obtained, as well as because the improvements proposed from the point of view of accessibility and comfort to be applied in the future.

8. Conclusions

In conclusion, the financial evaluation methods employed in this study provide a comprehensive analysis of the profitability of implementing the SUPER-i proposed EE renovations using Public Private Partnership (PPP) initiatives as funding source for covering the investment costs in Italy, Denmark, and Slovenia. The Discounted Cash Flow (DCF) approach, Net Present Value (NPV), Return on Investment (ROI), and Cost-Benefit analysis were utilized to assess the financial benefits over a 10 and 30-year period. For Italy, the financial indicators for Montasio 31 and Boito 5 consistently show positive results. Tables 2 and 4 demonstrate that the PPP initiatives, especially when considering energy efficiency, lead to substantial gains financially for each building. The Net Cash Flow, DCF analysis, ROI, and NPV consistently indicate the viability and profitability of the PPP investments in Italy, supporting the decision to go green in energy efficiency. In Denmark, the financial analysis reveals challenges, especially regarding the gap between available funds and total investment costs. The high ratio of debt to Equity raises concerns, and the total costs significantly outweigh the revenues, emphasizing the need for additional funding. The financial schemes, such as BetterHome and the National Building Fund (LBF), could be potential solutions to address the funding gap. For Slovenia, the Neža 26 a in b project exhibits positive financial outcomes, as shown in Tables 11 and 13. The Net Cash Flow, DCF, ROI, and NPV analyses indicate a substantial positive impact when considering energy efficiency. The Return on Investment of 14.63% suggests a lucrative venture, supporting the financial viability of the implementation of EE renovations in Slovenia.

Furthermore, the SUPER-i project has undertaken a comprehensive assessment of potential retrofits and upgrades to buildings across the pipelines, focusing on energy efficiency improvements. The model calculates heat loss or gain per unit temperature difference, incorporating factors like solar gains and external weather data. By considering various parameters, including building thermal performance and fuel use, cost, and carbon emissions, the tool produces meaningful results for both non-technical users and those with a more in-depth understanding of their building's thermal performance. The outcome of the analysis shows that the Danish pipeline focuses on triple-glazing and heat recovery systems, resulting in estimated savings of between €60 and €240 per dwelling per year. In Italy, renovations to 50-year-old buildings are expected to significantly improve thermal efficiency, reducing heating demand by 35-40% for walls, 15% for windows, and 10% for roofs. The Slovenian pipeline, a relatively modern construction, explores the addition of insulation to walls and floors, with a notable 34% improvement for walls and a marginal 4% for floors.

Finally, the sustainability assessment of the pipelines involves a comprehensive analysis of the environmental and social impacts at various stages of the life cycle of buildings. The focus on the usage phases (LCA stages) delves into the environmental impact categories such as energy use, water consumption, material use, waste generation, emissions, and their consequences on local ecology and biodiversity. The results of the analysis cover parameters like water use, energy consumption, material use, waste generation, emissions to air, land, and water, as well as various social aspects affecting user comfort, safety, and well-being. The detailed analysis of specific pipelines in Denmark, Slovenia, and Italy highlights the environmental impact reductions achieved through heating system improvements. In Denmark, while environmental impact reductions are observed across buildings, social analysis indicates potential improvements in accessibility and user awareness regarding ventilation and temperature control. Slovenia shows a considerable impact reduction, especially in energy poverty, but also suggests opportunities for enhancing accessibility and user training. Italy exhibits varied outcomes among buildings, emphasizing the need for tailored solutions based on distinct characteristics.

9. Acronyms

API: American Petroleum Institute
BL: Boligselskabernes Landsforening
CRT: Turin Saving Bank
DCF: Discounted Cash Flow
EE: Energy Efficiency
EIB: European Investment Bank
ENEA: Italian National Agency for New Technologies, Energy and Sustainable Economic Development
EPC: Energy Performance Contracts
ESCO: Energy Service Company
EU: European Union
FHS: Fondazione Housing Sociale
GHG: Greenhouse Gas
GPP: Green Public Procurement
HAs: Housing Associations
HFRS: Housing Fund of the Republic of Slovenia
IEA: International Energy Agency
LBF: National Building Fund
LCA: Life Cycle Assessment
LCC: Life Cycle Cost
MS: Member State
NCF: Net Cash Flow
NGO: Non-Governmental Organisations
NPV: Net Present Value
PPPs: Public-Private Partnerships
ROI: Return on Investment
SBTI: Science Based Targets Initiatives
SLCA: Social Life Cycle Assessment